

Landscape Connectivity Analysis

Habitat and species connectivity multi-scale analysis
across the wider Chilterns National Landscape



November 2024

Executive Summary

The Landscape Connectivity Analysis for the Chilterns National Landscape, conducted by Nature Data Solutions, identifies theoretical habitat connectivity bottlenecks across the region and identifies priority areas for enhancing functional connectivity through habitat creation and connection. This analysis aims to support biodiversity by improving habitat connectivity, which is essential for species movement, climate adaptation, and resilience against environmental pressures.

Using the Condatis modelling tool, the study assessed four broad habitat types—woodlands, wetlands, grasslands, and chalk grasslands—at three spatial scales: regional, landscape, and the Central Chilterns farm cluster.

Severe connectivity bottlenecks were most pronounced in woodlands and woody habitats, with other severe bottlenecks identified for grassland and chalk grassland habitats. This highlights the need for targeted habitat creation and enhancement to alleviate habitat fragmentation.

Key findings include:

- **Severe Bottlenecks:** Significant bottleneck zones are mostly within the Chilterns National Landscape, clustered in the north for woodlands, central for grasslands, and across the length of the Chilterns National Landscape, intersecting the north of the North Wessex Downs National Landscape.
- **Strategic Areas for Improvement:** The outputs have identified priority zones for habitat creation and areas for habitat expansion that intersect with network enhancement and expansion zones.



Executive Summary

- Farm Cluster opportunity: Bottlenecks across the habitats within the Central Chilterns Farm Cluster present an opportunity for strategic habitat creation with current members and highlight priority areas for new engagement.
- Multi-scale Significance: Assessing at the Regional and Landscape-scale is important to capture the dominant resources of habitat that support species movement through the landscape, particularly so for Chalk Grassland, which is disproportionately within the North Wessex Downs National Landscape.

This analysis highlights multi-scale interventions to enhance biodiversity connectivity and underscores the necessity of integrating habitat connectivity considerations into broader regional planning. It also outlines a useable methodology that can be applied across various scales to identify spatially strategic opportunities for functional connectivity. The findings offer actionable insights for ecological restoration initiatives across the Chilterns and align with national goals to increase land for nature.



Contents

<u>Executive Summary</u>	2
<u>Introduction and Objectives</u>	6
Introduction	
Objectives	
Condatis overview	
<u>Methodology</u>	9
Habitat Maps and datasets	
Dispersal distance and reproduction rates	
Direction of Movement	
Bottlenecks	
Habitat Creation and Restoration Zones	
Limitations	
<u>Results</u>	15
Bottlenecks	
Habitat Connectivity Opportunity	
<u>Discussion</u>	30
Connectivity Opportunity for Woodlands	
Connectivity Opportunities for Chalk	
Grassland and Grassland	
Summary of Connectivity Opportunities	
Regional and Landscape Scale Comparison	
Next Steps and Recommendations	
<u>References</u>	37

Acknowledgements

This work was funded by the Chalk, Cherries and Chairs Landscape Partnership, to support the connectivity of our important landscapes to allow nature to recover and flourish.



Chilterns
National
Landscape

The area of this analysis sits within the landscape-partnership **Big Chalk**. Big Chalk is a cross-landscape collaboration amongst all National Landscapes, eNGOs and landowners that are within the southern extent of Chalk in England.

The partnership aims to support, restore and create more chalky habitats across the country, while also preserving and enhancing the rare and fragile chalk grassland habitat - a habitat the UK has the most of globally. Find out more about Big Chalk here: <https://www.big-chalk.org>

Introduction

Biodiversity across the world is in decline (WWF, 2024). On average, species abundance in England has declined by 32% since 1970 (State of Nature Partnership, 2023). As identified in the Making Space for Nature report (Lawton et al., 2020), a contribution to this decline is the systemic fragmentation of nature in the UK. As a result, our rarest and most vulnerable species and habitats are limited to a broken patchwork of protected sites and nature reserves. As species must adapt to climate change with range shifts through the landscape, its essential connectivity between core habitats is created, enhanced and prioritised to reduce the current decline of biodiversity in England.

The Chilterns National Landscape supports a rich mosaic of habitats, including woodlands, wetlands, grasslands including chalk grassland, and contains a number of protected sites. Alongside this, farmed land is a vital part of the working landscape, covering ~60% of the Chilterns area. As such, the Chilterns National Landscape has been working with farm clusters to restore nature.

Ensuring the right kind of habitat creation and enhancements are undertaken in locations which are most effective at supporting connective pathways is essential for the functionality and resilience of the wider landscape. As such, identifying key spatially strategic opportunities would be useful to target and support nature recovery across the National Landscape. As demonstrated by other studies (Gutierrez-Arellano et al., 2024), the Condatis model has been effective at mapping ‘bottlenecks’ in connectivity across landscapes to identify the most impactful opportunities for targeted improvements. When applied at different scales, this can assess the effects of different habitat densities and configurations on species and provides the decision-making tools to support delivery. Furthermore, this provides scope to evaluate theoretical opportunities for connecting habitats for both current and future species needs when adapting ranges in response to climate change.

Objectives

To identify theoretical opportunities for connecting wildlife-rich habitats across the Chilterns National Landscape, this report will trial a habitat-connectivity modelling methodology using **Condatis** to identify key bottlenecks in Woodland, Grassland, Chalk Grassland and Wetland habitats.

This method will be applied across 3 spatial scales;

- Farm Cluster (Central Chilterns Farm Cluster), including a 5km buffer
- Landscape (Chilterns National Landscape) , including a 10km buffer
- Regional (Chilterns National Landscape and North Wessex Downs National Landscape), including a 10km buffer

Figure 1 shows for a map of the boundaries of spatial scales assessed.

This report will consider the opportunities for habitat connectivity and creation produced at the different scales relative to existing habitat enhancement and expansion opportunities. In addition, this report will assess the relative benefits of different configurations for improving connectivity of wildlife-rich habitat.

Condatis

[Condatis](#) is a tool created by the University of Liverpool, that aims to support decision making by identifying the best places for habitat intervention to enhance and increase habitat connectivity. The tool allows exploration of where the restrictions in species mobility exist for habitat types across a landscape, for defined dispersal and reproduction rates, and dispersal directions. The tool has been used to support a number of projects, including PlantLifes B-Lines (Rothwell, Lantham and Hodgson, 2014), Connectivity of Woodland Protected Areas in Wales (Rothwell, Latham and Hodgson, 2014), an assessment of using bottlenecks for nature recovery projects (Gutierrez-Arellano et al., 2024) and as an indicator for habitat connectivity for the Outcome Indicator Framework for the 25 Year Environment Plan (Mancini, Hodgson and Isaac, 2022).

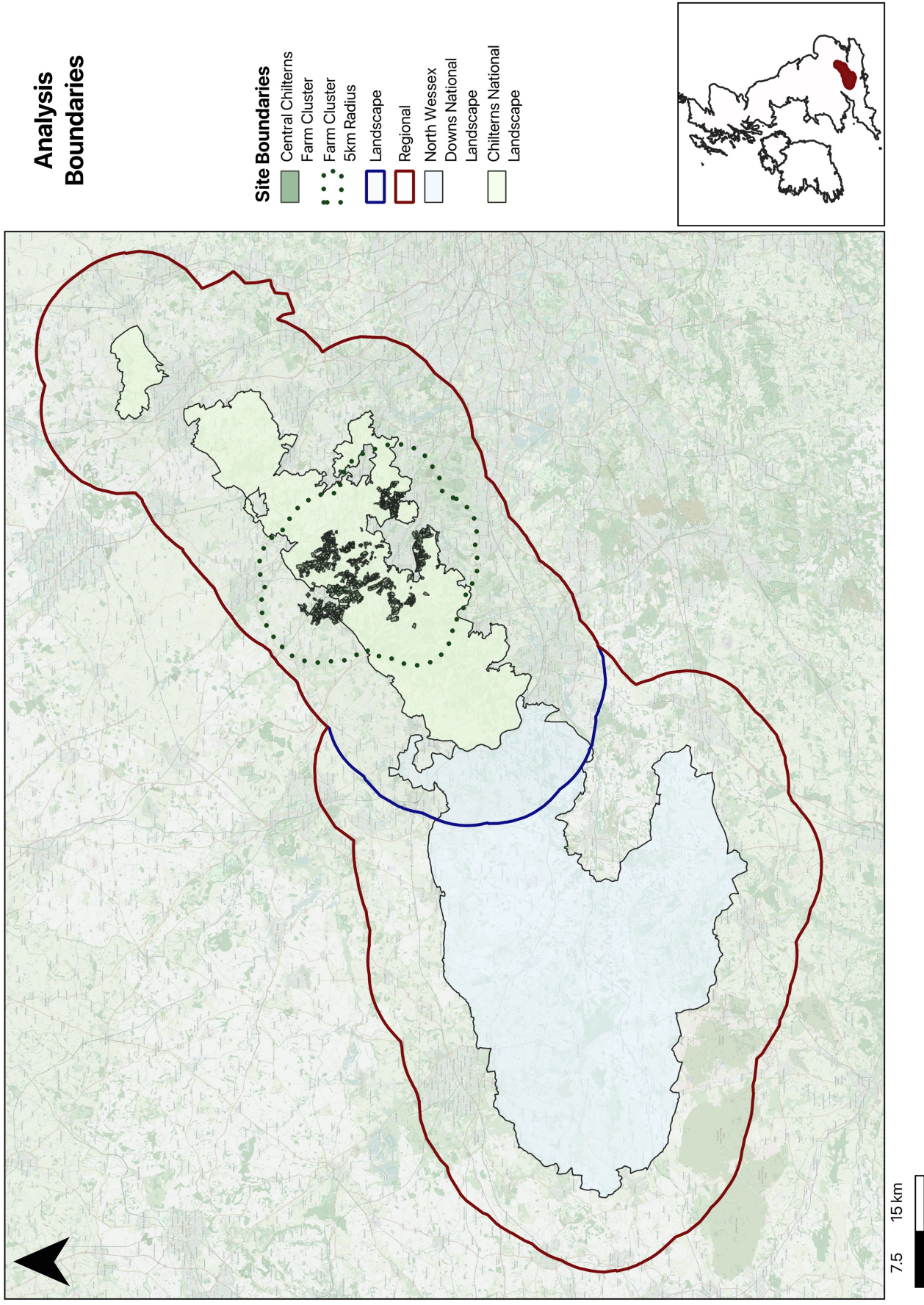


Figure 1: Map of areas assessed within analysis. Red boundary is the Regional area that includes Chilterns National Landscape and North Wessex Downs National Landscape area, the blue boundary is the Landscape area that covers the Chilterns National Landscape area, the dotted line is the Farm Cluster area. Within the Farm Cluster area, the Central Chilterns Farm Cluster parcels are highlighted dark green. The map also shows the Chilterns National Landscape in light green, and the North Wessex Downs National Landscape in light blue.

Methods

Below is the methodology to set up model runs in Condatis and conduct relevant post-processing and analysis of bottleneck results. Condatis v1.2 online modelling platform was used for this analysis.

Habitat Maps

Four sets of habitat types were explored in this analysis: **Wetlands, Grasslands, Chalk grassland and Woodlands.**

To create habitat maps for wetlands, grasslands and chalk grassland, subsets of the Priority Habitat Inventory (PHI) were abstracted. For woodland habitat maps, the National Forest Inventory 2022 (NFI) was filtered to the woodland category. An additional **woody** habitat was also assessed which included a combination of the NFI woodlands and hedgerows, as mapped by the Centre for Environment and Hydrology (CEH). Table 1 provides a breakdown of the geospatial layers used to create the habitat groupings.

The vector shapefiles were then clipped to the areas of analysis, then converted to raster files for Condatis input. To manage computation time and data size, 250m by 250m rasters were created, with values between 0-1 denoting the habitat coverage within each 250m grid square. Figure 2 provides maps of habitat percentage coverage across the three spatial scales.

Dispersal Distance and Reproduction Rate

Condatis requires a species' dispersal distance within its lifetime to map where dispersion is possible across the landscape. Given the variety of species that reside in the four habitats assessed, a spectrum of dispersal distances was tested, prioritising the generalist over specialists for representative values.

Using the species-specific dispersal distances outlined in Travers (2022) and similar to those applied in other Condatis studies (Gutierrez-Arellano et al., 2024; Rothwell, Lantham, and Hodgson, 2014; Robins, Evans, and Hodgson, 2014), a Low Dispersal of 1 km and a Moderate Dispersal of 3.4 km were inputted. Reproduction Rates were kept at the generic rate of 1000 individuals.

Table 1: This table details what broad habitat categories were assessed, the types of habitat data categories used to represent these broad habitats, and the sources of these datasets.

Broad Habitat	Dataset habitats included	Dataset source
Woodlands	Woodland category habitats	National Forestry Inventory 2022 (NFI), Forestry Commission
Woody	Hedgerows Woodland category habitats	UKCEH Land Cover Plus: Hedgerows 2016-2021 (England), Centre for Environment and Hydrology (CEH) National Forestry Inventory 2022 (NF), Forestry Commission
Grassland	Lowland calcareous grassland Lowland Meadows Lowland dry acid grassland Lowland heathland Semi-improved grassland Wood pasture and parkland	Priority Habitat Inventory (PHI), Natural England
Chalk Grassland	Lowland Calcareous Grassland	Priority Habitat Inventory (PHI), Natural England
Wetland	Reedbeds Purple moorgrass and rush pasture Lowland fens	Priority Habitat Inventory (PHI), Natural England

Direction of Movement

Condatis also models the movement of species in a defined direction, from source to target. By assessing this, the model can assess how well a species can use the patches of habitat across the landscape in a specified direction of travel, to assess where connective links between habitats are effective, or if limited pathways along this direction causes bottlenecks. The directions modelled in this report are outlined in Table 2. For directions outside the pre-defined options within the Condatis model, source and target rasters were created per the methodology applied by Hodgson *et al* (2024).

Table 2: This tables outlines direction of movement applied to each of the scales assessed.

Scale	Direction of Movement
Regional	South - North (SN)
Landscape	South to North (SN)
Central Chilterns Farm Cluster	North - South (NS) East - West (EW) Northwest - Southeast (NWSE) Northeast - Southwest (NESW)

Bottlenecks

Using the inputs, Condatis can then run the model to identify areas between habitats where mobility is constricted by calculating the flow between habitat patches. 100 Bottlenecks were computed for each run. Once the model runs were completed for each direction and area of interest combination, the bottlenecks were classified into ‘scores’ using methods applied by Gutierrez-Arellano *et al* (2024). From the scores, the bottlenecks were then classified into ‘Severe’, ‘Major’ and ‘Minor’:

Severe Bottlenecks: Scores >50
Major Bottlenecks: Scores >5 - =<50
Minor Bottlenecks: Scores >1 - <5

Severe bottlenecks were then buffered using half the length of the bottleneck polyline to create ‘Severe Bottleneck Zones’.

Bottlenecks and Severe Bottleneck Zones: How it works and what it means

Condatis highlights pathways that allow both dispersal and reproduction of species across a landscape. The model assigns **flow** to each habitat cell, that gives an indicative number of individuals moving through that cell that will colonise the defined target. A higher flow of a habitat cell means it is important for connectivity between source and target. Areas of high flow are conservation priorities, representing an important route for species mobility through a landscape.

The strength/power of the links between habitats depends on the time the population takes to move across – the model also represents this as 'resistance'. If there is high resistance in one of these links but it forms a route to the best available habitat, this produces a **Bottleneck**. These are locations within the landscape that, if the habitat were created/restored along or around this bottleneck location, would support a significantly higher flow of species movement across the landscape habitat network.

From the Bottleneck scores, the most **severe** resistance locations can be identified and produced into a **severe bottleneck zone**. This zone maps out an effective area for habitat creation/restoration, in a location that would significantly increase the efficiency of species movement across the landscape in the defined direction by adding a suitable pathway.

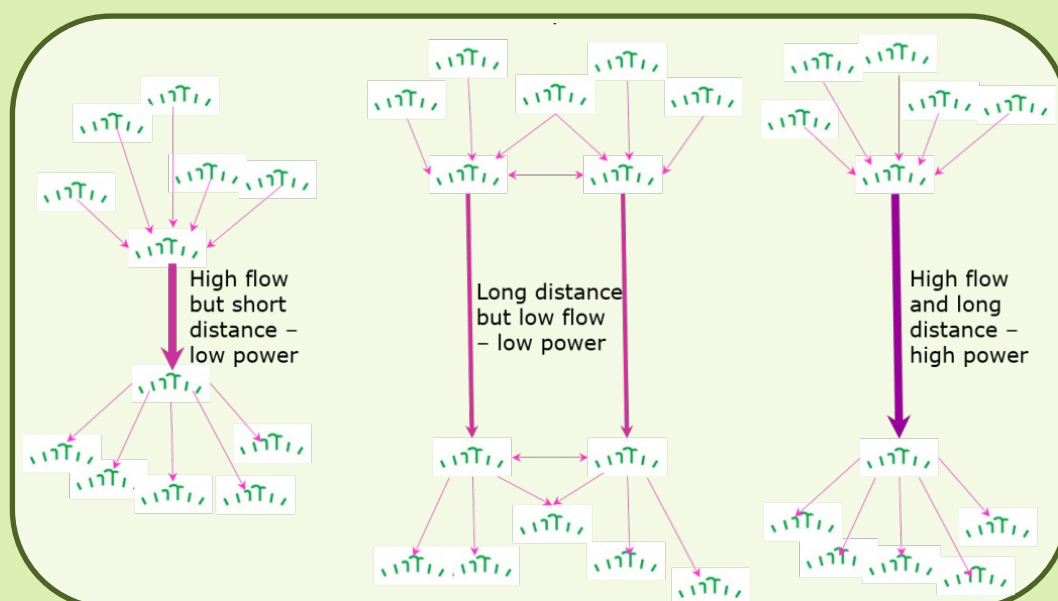


Figure adapted from [How Condatis Works webpage](#). Diagram shows how high power links occur when there is limited choice in habitat connections across large areas of the landscape that form an essential route for species.

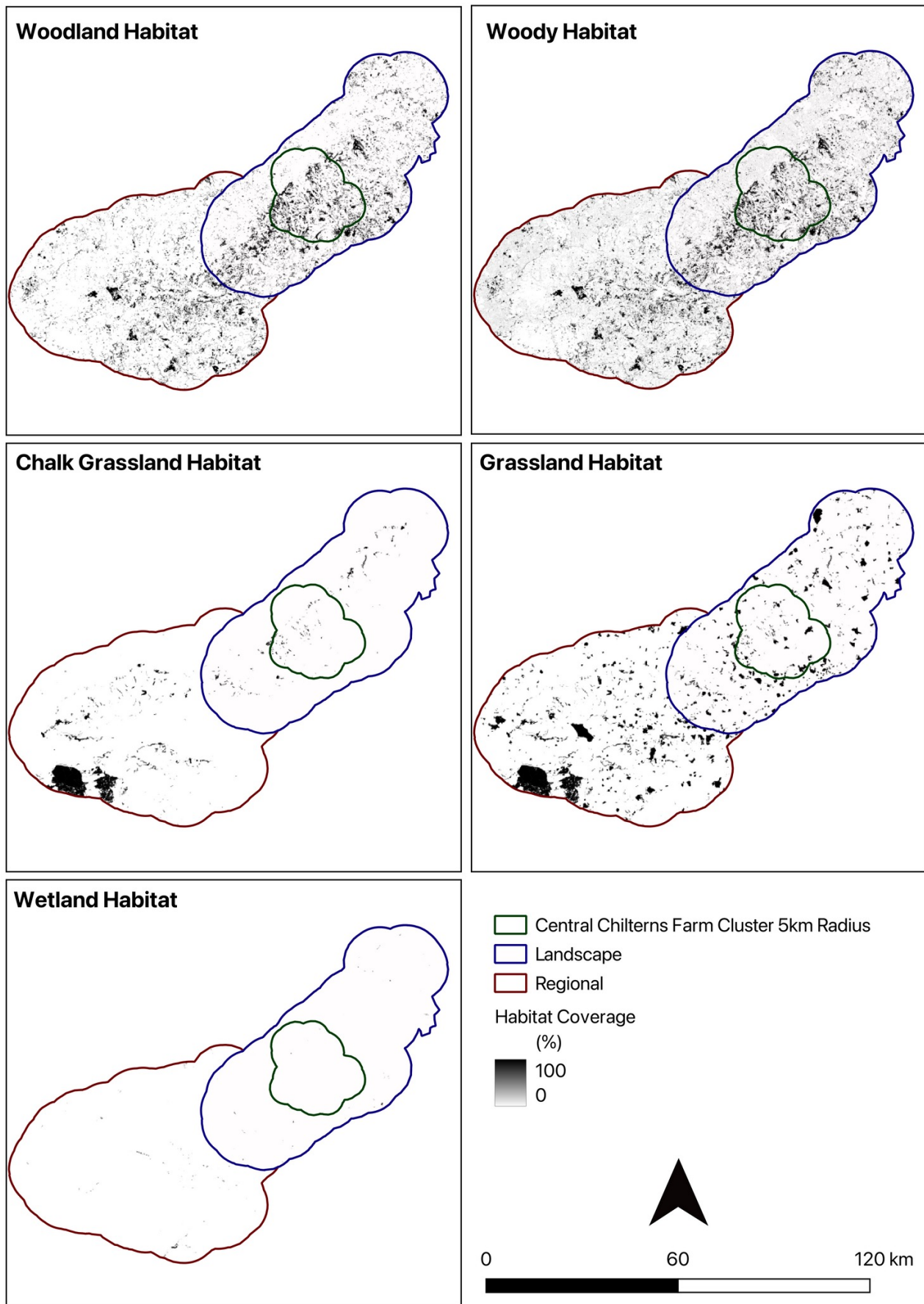


Figure 2: This figure shows maps of percentage habitat coverage for each broad habitat assessed in the output form of the 250x250m Raster inputted to Condatis. The three scales of analysis are also outlined as red (Regional), blue (Landscape) and green (Central Chilterns Farm Cluster) outlines.

Habitat Creation and Restoration Opportunities

The Severe Bottleneck Zones were overlaid and compared to the Network Expansion and Enhancement Zones layers within the Habitat Network datasets produced by Natural England to identify the most effective locations for habitat creation and restoration. These datasets have been developed to identify areas where action can support enhanced ecological resilience. For more information on the datasets, components and mapping guidance, see [here](#). This comparative analysis was used to consider bottlenecks in connectivity relative to areas identified for habitat enhancement and expansion.

Limitations

While this study offers valuable insights, several limitations should be considered when interpreting the results. The data used to input the habitat coverage information for Condatis was based on datasets that have not been fully ground-truthed. Furthermore, similar habitats that would support habitat connectivity, may not have not been included due to meeting the priority habitat specifications. Habitat coverage for wetlands was significantly lower than other habitats assessed, compromising the model's effectiveness in identifying wetland bottlenecks and making meaningful conclusions. At the Central Chilterns farm cluster scale, the wetland habitat was too low for the model to complete a run and, as such, it was excluded. Due to the size of the raster dataset for woody habitats at a regional scale, it was too large to run within the cell limit of the Condatis set-up. As a result, only woodlands mapped in the NFI were assessed at the regional scale.

While the resolution chosen was suitable for the size of most habitats assessed and within computational limits for the areas considered, it generalises habitat coverage within a 250m-by-250m area, which could have removed some of the habitat coverage detail. Other inputs to the model, including dispersal distance and reproductive rates, were chosen to represent generalists within the habitats assessed. This assumption for the species characteristics may not be true for this region as it was informed by national-scale averages. This may also misrepresent specialist species. Additionally, the model is based on several assumptions, which are outlined by Travers *et al.* (2022).

Results

Bottlenecks

Regional and Landscape Scale Bottlenecks

Bottlenecks across all habitats at regional and landscape scales are almost exclusively clustered within the Chilterns National Landscape area. Severe bottleneck zones are only present across woodland/woody, grassland, and chalk grassland habitats. Wetland habitat bottlenecks were only scoring more than one for 3.4km dispersal, producing Major bottlenecks for both Regional and Landscape scales (Figure 6), occurring within the Chilterns National Landscape.

Woodland and woody severe bottleneck zones produced the largest area coverage of severe bottleneck zones. As evidenced in Figure 3, woodland and woody severe bottleneck zones exist in the northern limits of the Chilterns National Landscape buffered area, except for one small 1km dispersal severe bottleneck zone at the landscape scale that exists at the southern end of the Chilterns National Landscape area. Woodland severe bottleneck zones cover 273.7km², with 74% of this area resulting from 3.4km dispersal bottlenecks. The severe bottleneck zones follow similar coverage at the landscape scale, with an additional 4% in area coverage. The severe bottleneck zones for woody habitats (woodlands and hedgerows) at the landscape scale exist within the same area as woodland habitat severe bottleneck zones in the northwest of the area. The 3.4km dispersal distance severe bottleneck zone for woody is up to 4681.26m wider than the woodland equivalent. Severe woody bottleneck zones in the north of the landscape are smaller in size relative to the severe woodland bottleneck zones.

Grassland bottlenecks in Figure 4 are classified as Major and Severe at both scales and for both 1km and 3.4km dispersal distances. Severe bottleneck zones for 3.4km dispersal have a total coverage of 83.94km² at the regional scale and a total of 84.9km² coverage at the landscape scale.

1km dispersal distance bottlenecks at the regional scale have a total area of 73.36km² and 33.88km² at the landscape scale. Grassland bottlenecks occur exclusively within the Chilterns National Landscape, clustered in the northern/central area.

At the regional scale shown in Figure 5, chalk grassland bottlenecks extend across both the Chilterns and North Wessex Downs National Landscapes, covering a linear distance of 92.22km. The 3.4km severe bottleneck zone at the regional scale is the only severe bottleneck zone that intersects the North Wessex Downs National Landscape. The Chalk grassland bottlenecks at the landscape scale cluster around a linear distance of 78.9km. Landscape-scale chalk bottlenecks scored more than one for 3.4km dispersal only, for which all were scored as Major. Chalk grassland bottlenecks at the regional scale scored Major and Severe for both 1km and 3.4km dispersal. The largest severe bottleneck zone is for 3.4km dispersal.

Central Chilterns Farm Cluster Scale Bottlenecks

The Central Chilterns farm cluster bottlenecks shown in Figure 7 demonstrate woody (hedgerows and woodlands) bottlenecks classified as Severe for 3.4km dispersal and Major and Severe for 1km dispersal. Most of the severe bottleneck zones cluster around the outer limits of the Central Chilterns farm cluster zone. The largest severe bottleneck zone area coverage was for a 3.4km dispersal with an NE-SW direction of movement, covering 77.68km². Severe bottleneck zones covered an area of 13.83km² of farm cluster parcels.

Figure 8 shows grassland bottlenecks that occur mostly as Major at 3.4km dispersal distances for movement directions NWSE and NESW. The severe bottleneck zone for NWSE overlaps with the 1km dispersal and NWSE chalk grassland severe bottleneck zone.

Only one chalk grassland bottleneck was ranked as severe. This was for a 1km dispersal and NW-SE direction of movement (Figure 9). The severe bottleneck zone covers an area of 4.83km². Chalk grassland bottlenecks intersect more of the farm cluster parcels than other habitats tested.

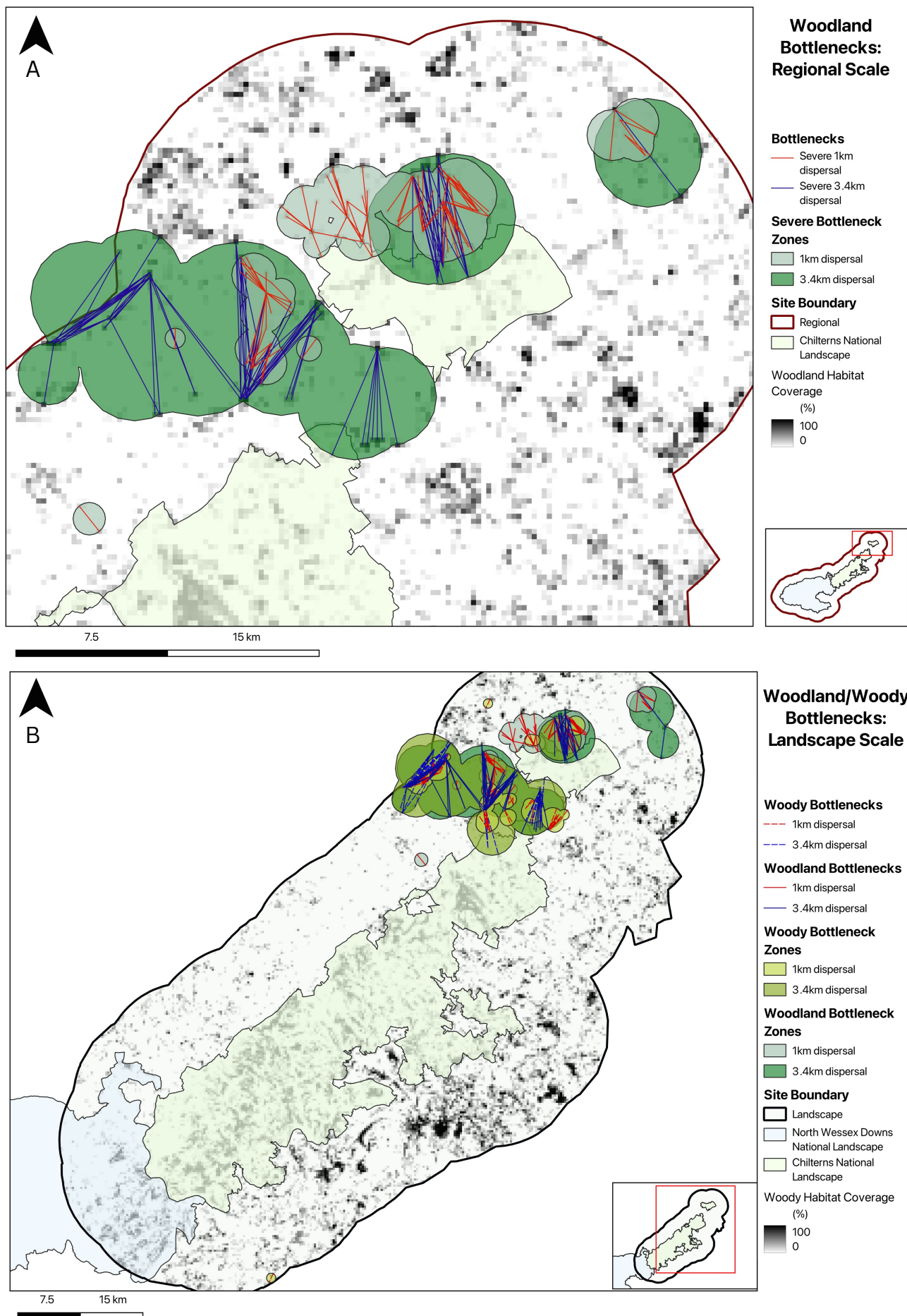


Figure 3: These maps show the bottleneck outputs ranked by their scores and the severe bottleneck zones produced from the bottlenecks. (A) shows the outputs for woodland bottlenecks at the Regional scale. (B) shows the outputs for woodland and woody bottlenecks at the Landscape-scale.

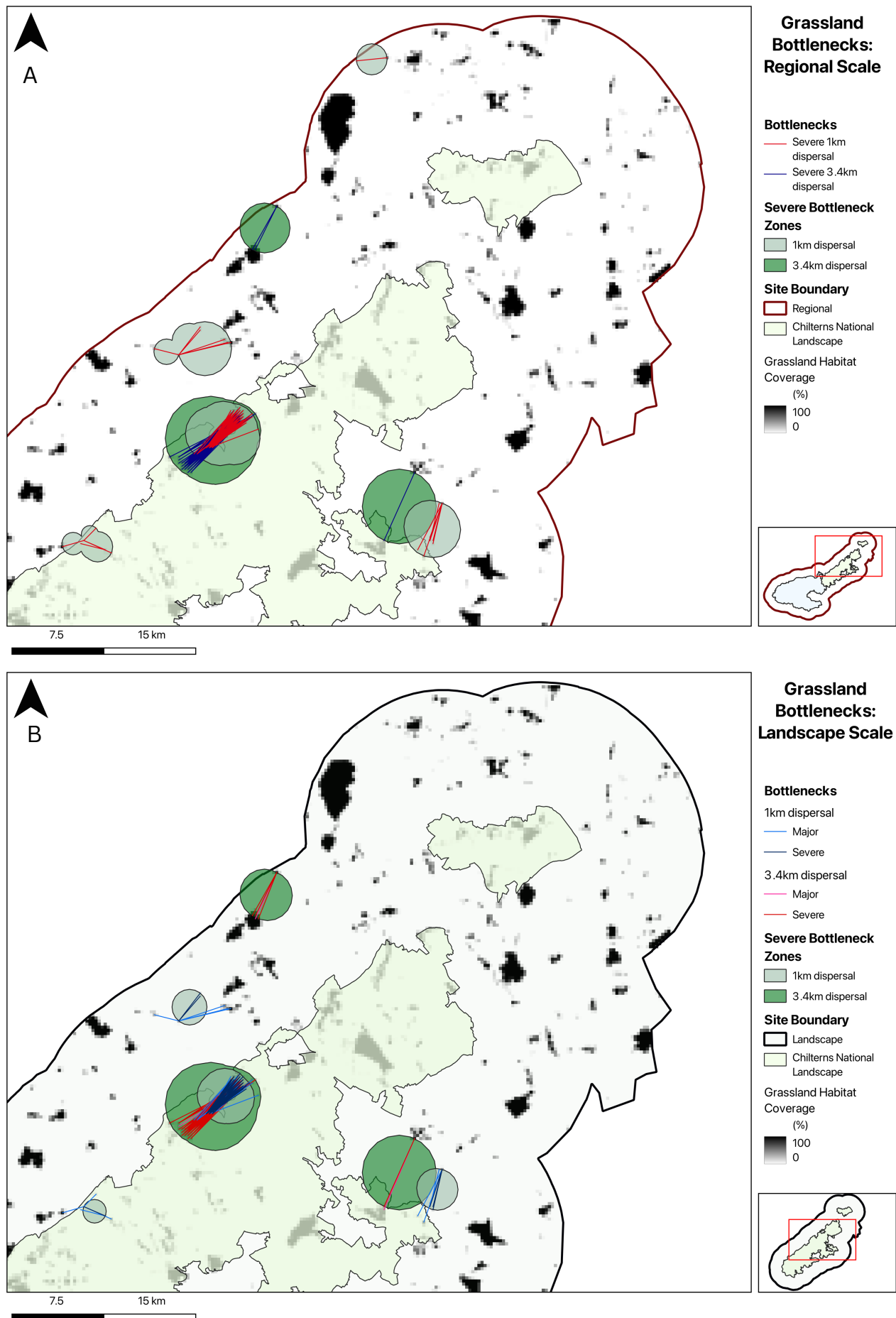


Figure 4: These maps show the bottleneck outputs ranked by their scores, and the severe bottleneck zones produced from the bottlenecks. (A) shows the outputs for grassland bottlenecks at the Regional scale. (B) shows the outputs for grassland at the Landscape scale.

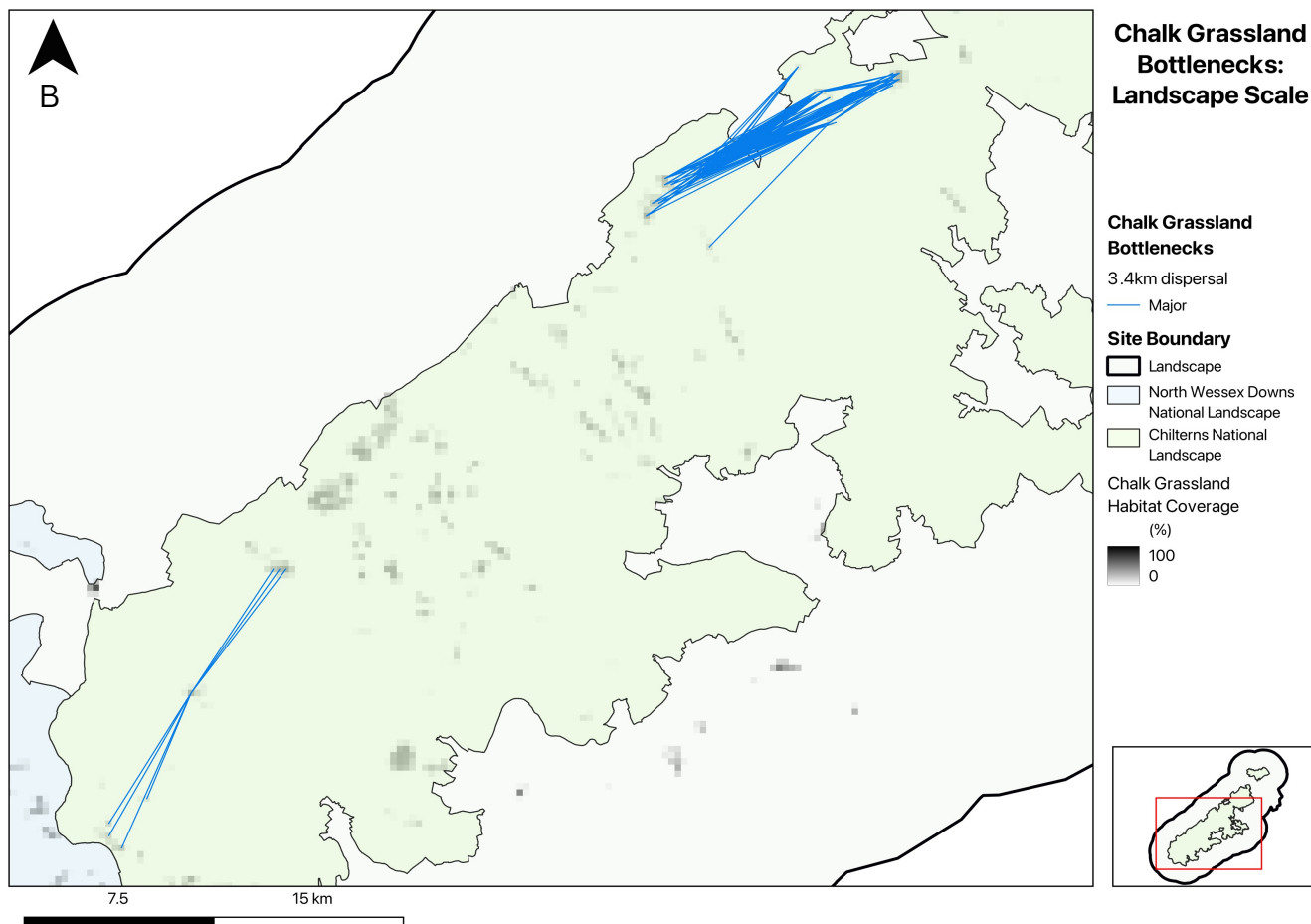
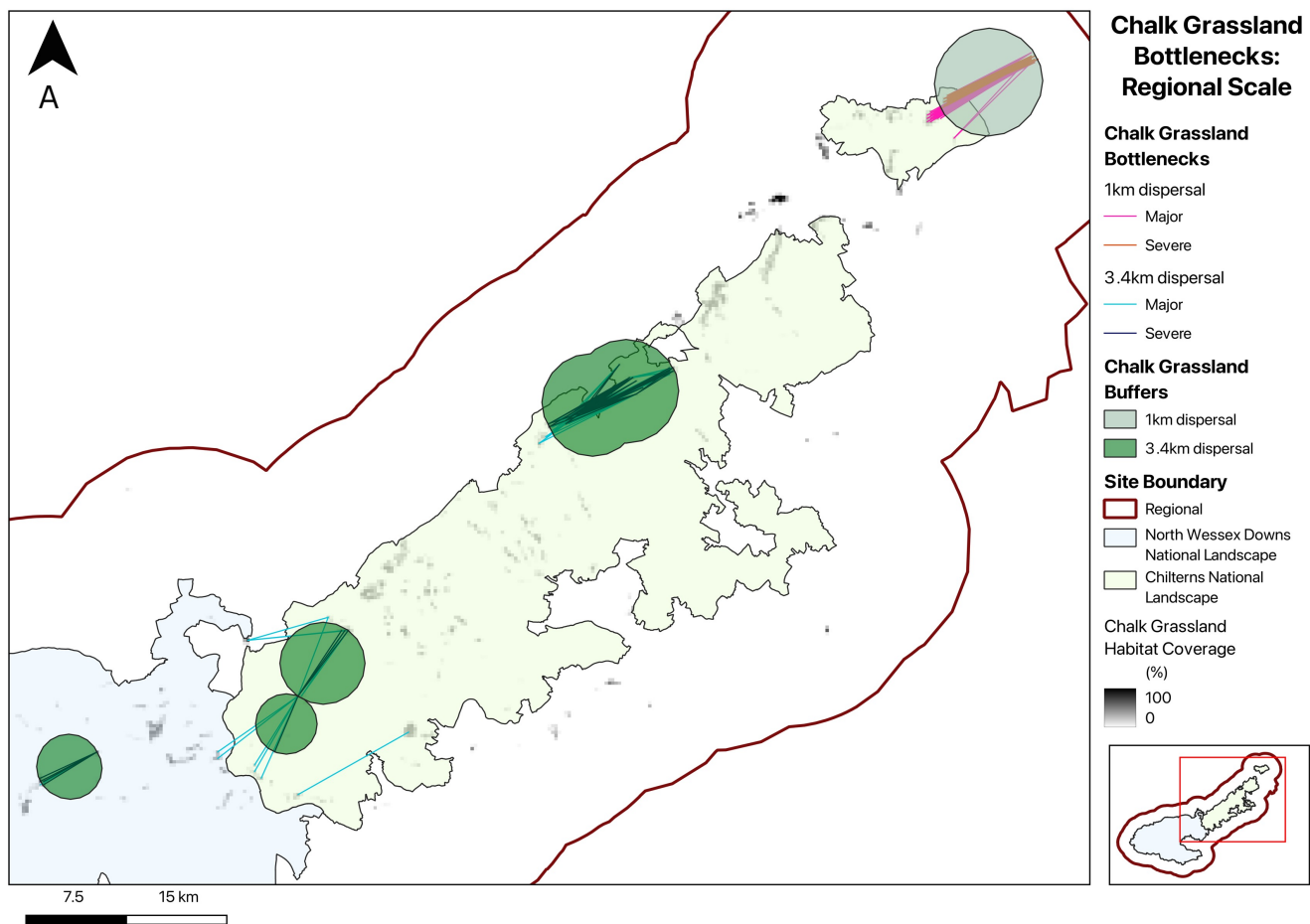


Figure 5: These maps show the bottleneck outputs ranked by their scores, and the severe bottleneck zones produced from the bottlenecks. (A) shows the outputs for chalk grassland bottlenecks at the Regional scale. (B) shows the outputs for chalk grassland at the Landscape scale.

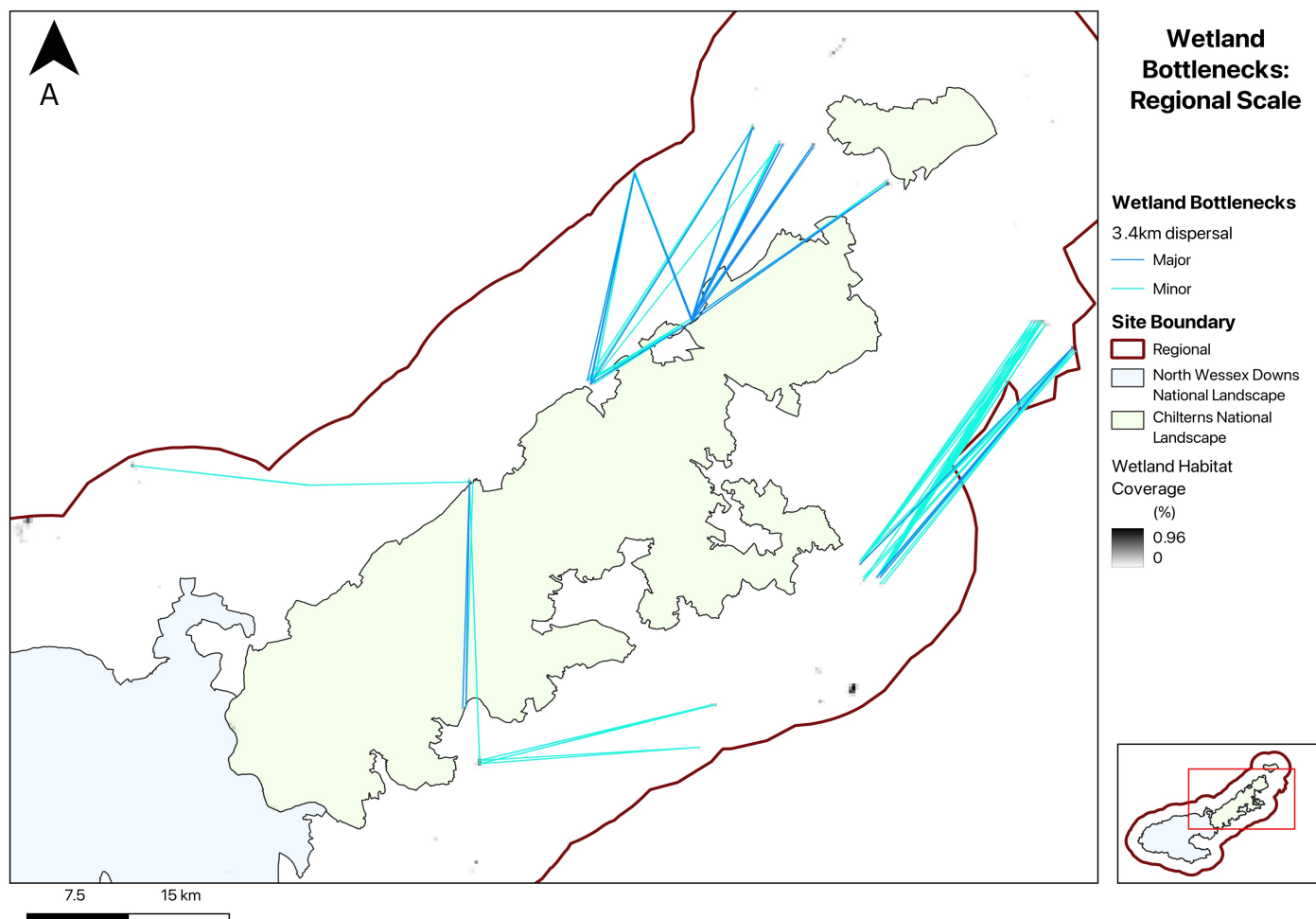


Figure 6 These maps show the bottleneck outputs ranked by their scores. (A) shows the outputs for wetland bottlenecks at the Regional scale. (B) shows the outputs for wetland at the Landscape scale.

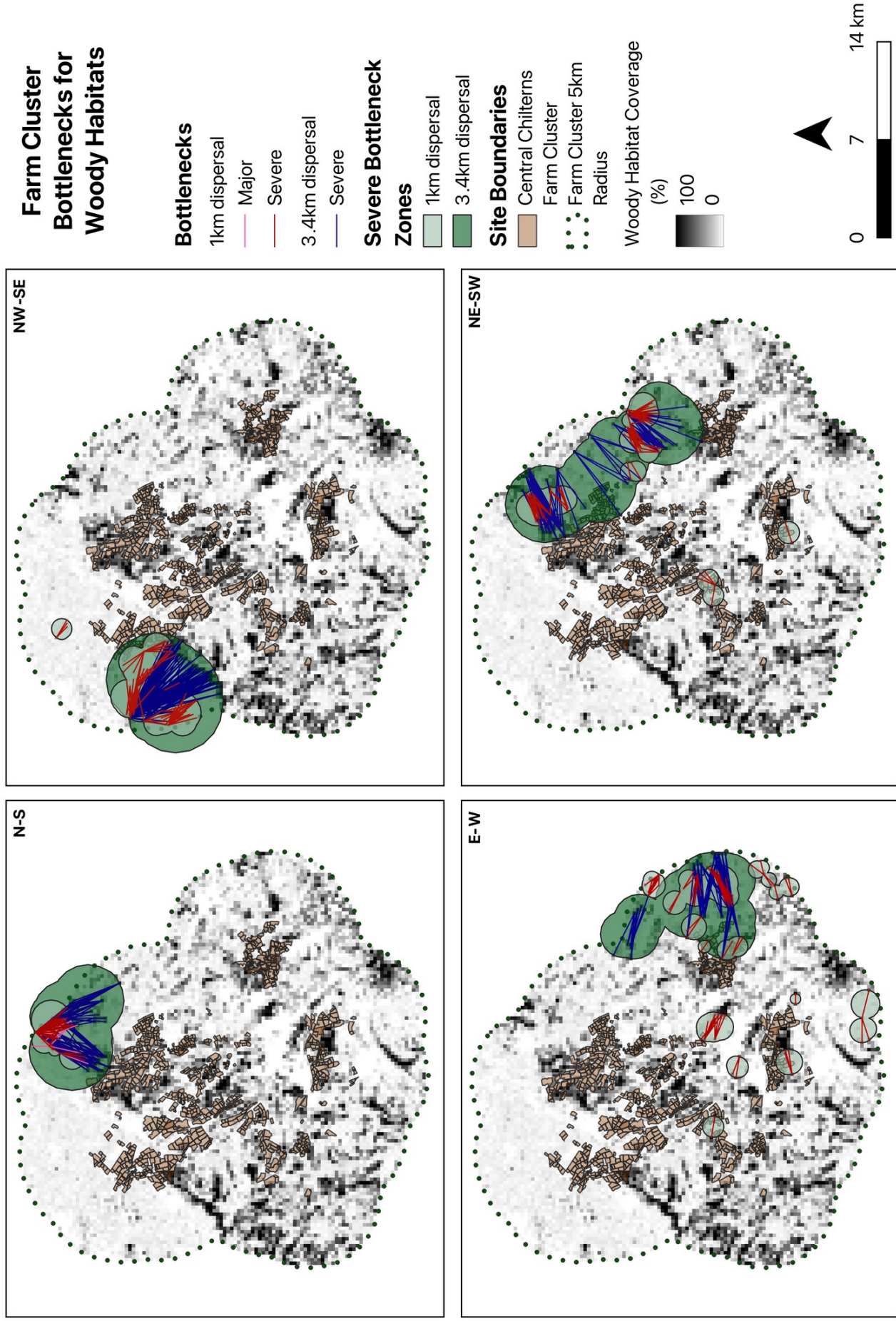


Figure 7: These maps show the bottleneck outputs ranked by their scores, and the severe bottleneck zones produced from the bottlenecks for woody habitats at the Central Chilterns Farm Cluster scale. The maps are split by the different direction of movements tested. Farm cluster parcels are shown on the map as brown polygons.

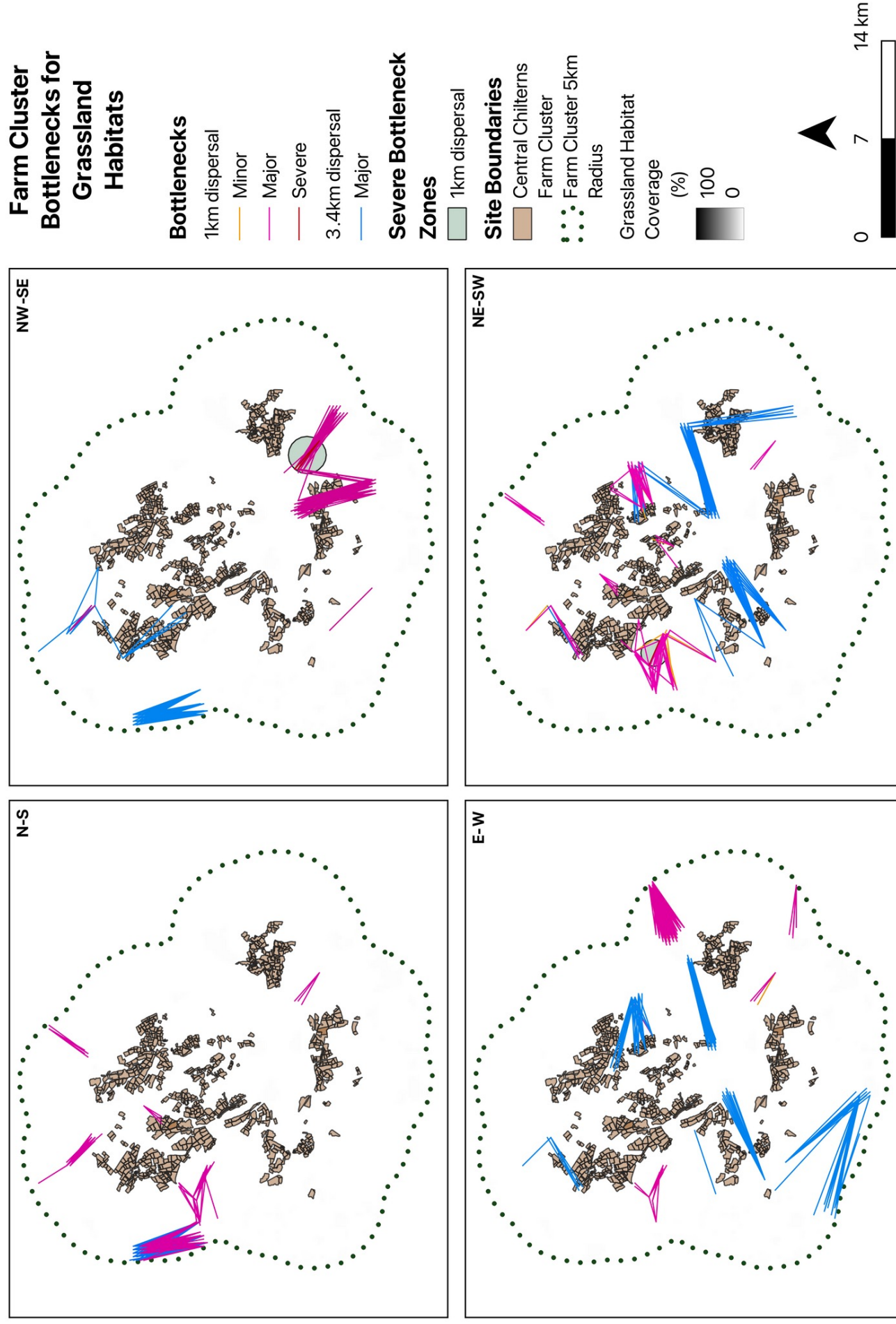


Figure 8: These maps show the bottleneck outputs ranked by their scores, and the severe bottleneck zones produced from the bottlenecks for grassland habitats at the Central Chilterns Farm Cluster scale. The maps are split by the different direction of movements tested. Farm cluster parcels are shown on the map as brown polygons.

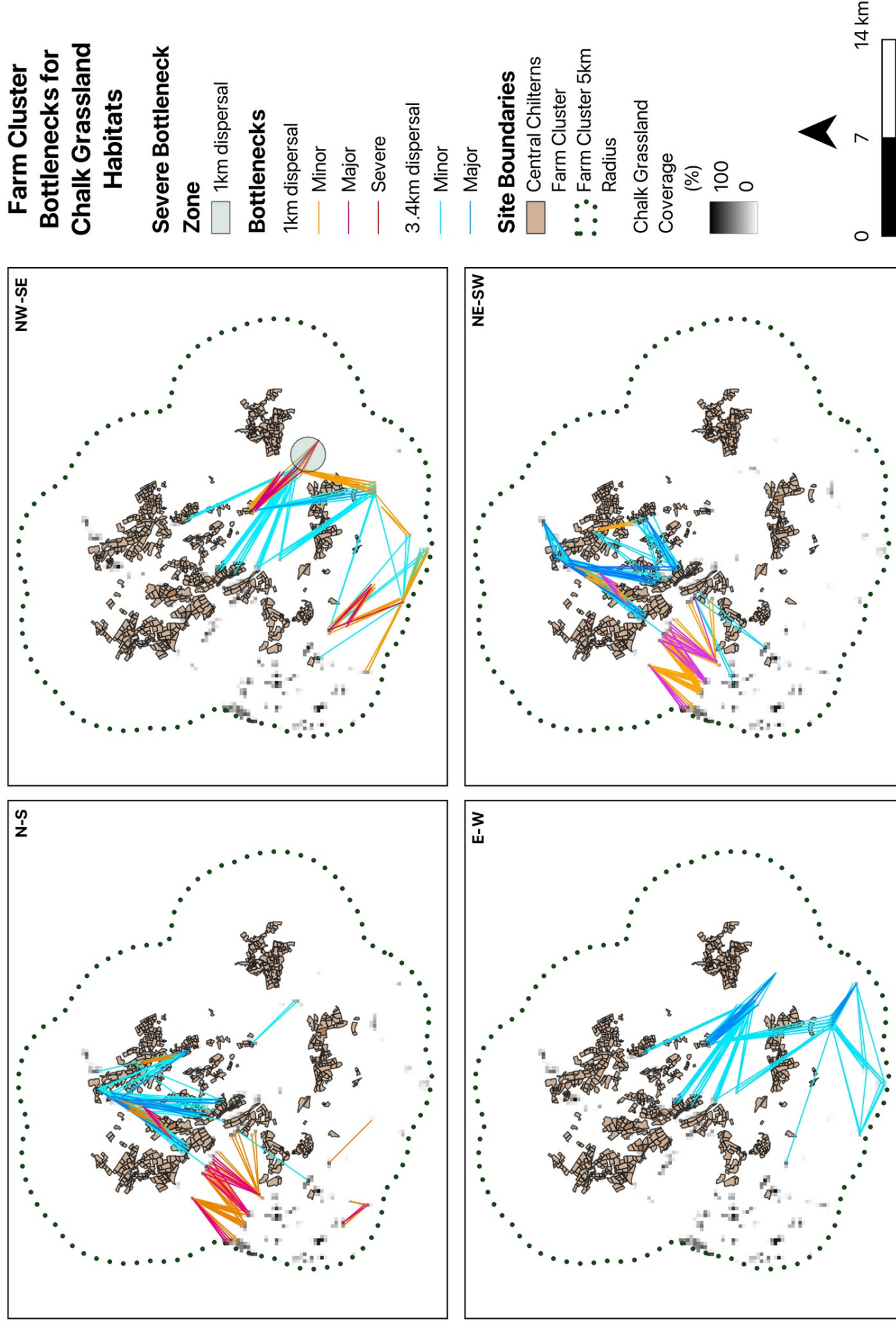


Figure 9: These maps show the bottleneck outputs ranked by their scores, and the severe bottleneck zones produced from the bottlenecks for chalk grassland habitats at the Central Chilterns Farm Cluster scale. The maps are split by the different direction of movements tested. Farm cluster parcels are shown on the map as brown polygons.

Habitat Connectivity Opportunity

Regional and Landscape Scale Opportunity

Chalk grassland severe bottleneck zones at the regional scale cover 40.47km² of the chalk grassland habitat network enhancement and expansion zone. 29.73km² of this intersected enhancement and expansion zone exists within the Chilterns National Landscape (Figure 11).

The cluster of woodland and woody severe bottleneck zones that occur in the north of the regional boundary, intersects with 17.5km² of the ancient and semi-natural woodland enhancement and expansion zone. 23.91km² of the Chilterns National Landscape is covered by a severe bottleneck zone for woody and woodland habitats (Figure 10).

Grassland severe bottleneck zones cover an area of 4.44km² of lowland meadow habitat enhancement and expansion zone, 1.67km² of lowland dry acid grassland habitat enhancement and expansion zone, 16.7km² of chalk grassland habitat enhancement and expansion zone, and 17.36km² of wood pasture and parkland habitat enhancement and expansion zone (Figure 12).

Central Chilterns Farm Cluster Scale Opportunity

Severe bottleneck zones for woody habitats cover 120.83km² of the Ancient and semi-natural woodland habitat network enhancement and expansion zone. The intersected area network enhancement and expansion zone covers 9.53km² of the farm parcels (Figure 13).

The grassland and chalk grassland severe bottleneck zones cover 5.78km² of the grassland habitat network enhancement and expansion zone, all of which is chalk grassland. The intersected enhancement and expansion zone or the severe bottleneck zones cover no parcels within the farm cluster. Both severe bottleneck zones are within the Chilterns National Landscape (Figure 14).

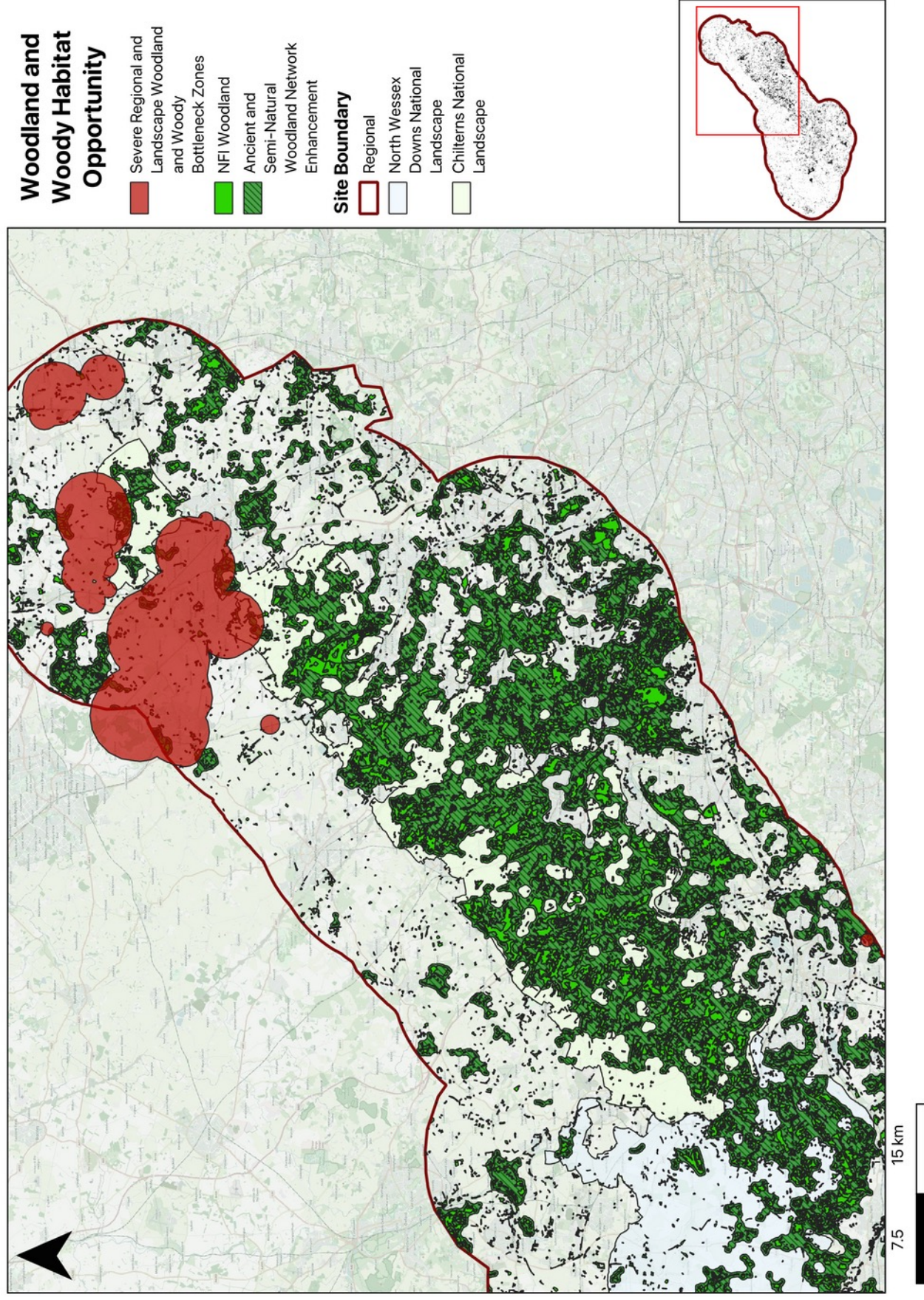


Figure 10: This map highlights the location of severe bottleneck zones for woody and woodland habitats at Regional and Landscape scale. The zones overlay the Habitat Enhancement and Expansion Zone layer for Ancient and Semi Natural Woodland, alongside NFI woodland habitat. The Chilterns National Landscape is shown in light green and the North Wessex Downs National Landscape is shown in light blue.

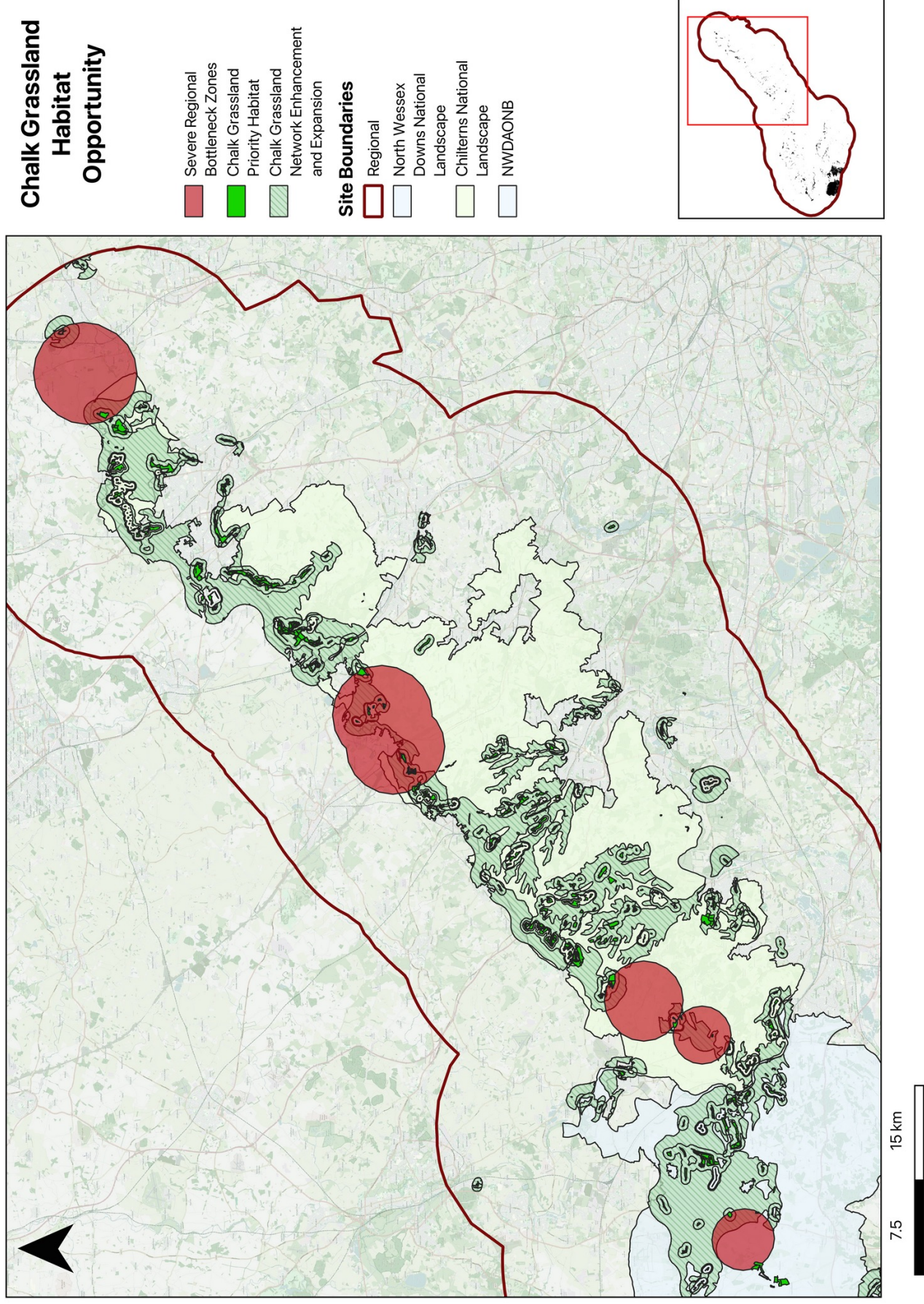


Figure 11: This map highlights the location of severe bottleneck zones for chalk grassland habitats at Regional and Landscape scale. The zones overlay the Habitat Enhancement and Expansion Zone layer for chalk grassland, alongside PHI chalk grassland habitat. The Chilterns National Landscape is shown in light green and the North Wessex Downs National Landscape is shown in light blue.

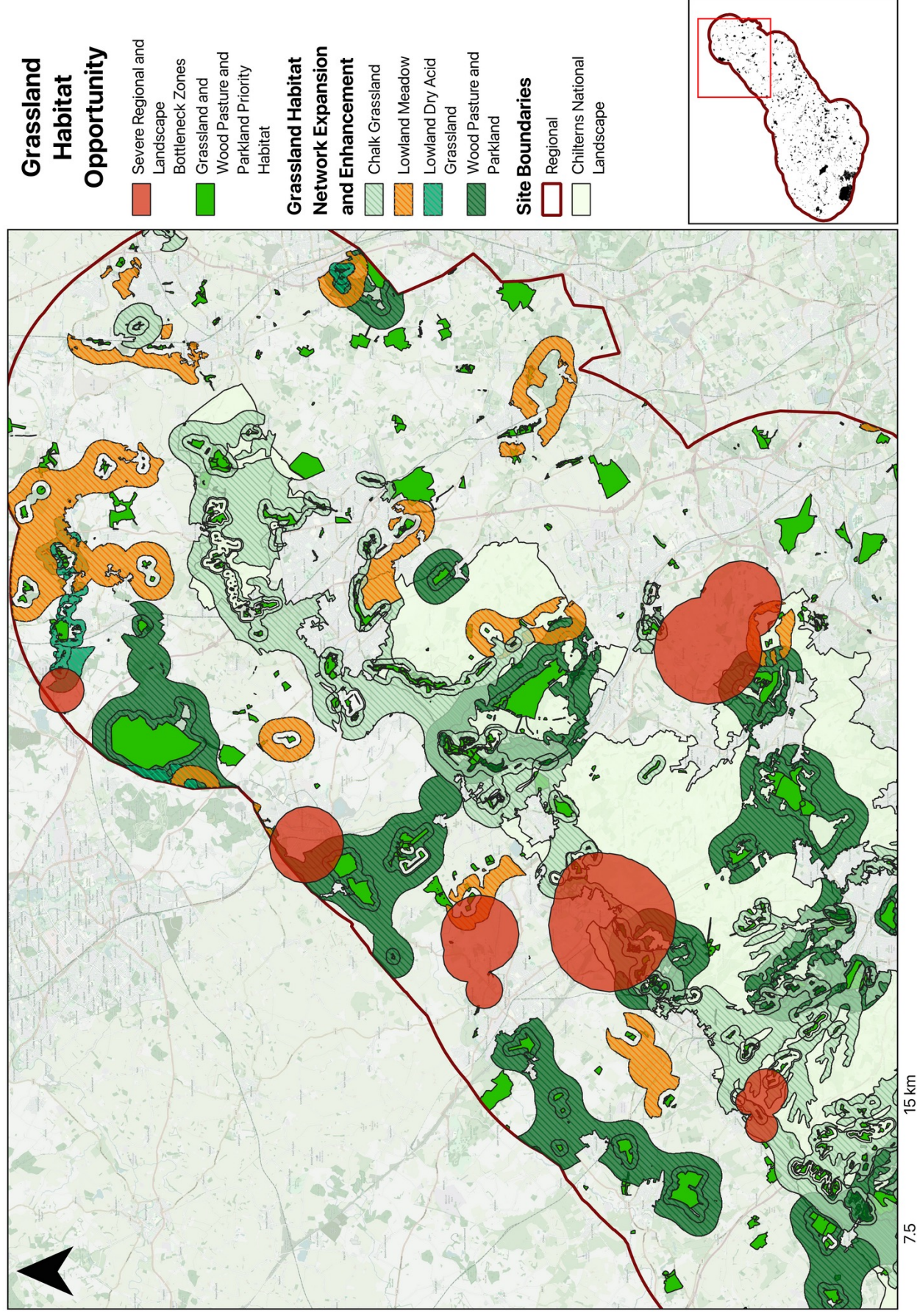


Figure 12: This map highlights the location of severe bottleneck zones for grassland habitats at Regional and Landscape scale. The zones overlay the Habitat Enhancement and Expansion Zone layer for different grassland habitats, alongside PHI grassland habitats. The Chilterns National Landscape is shown in light green and the North Wessex Downs National Landscape is shown in light blue.

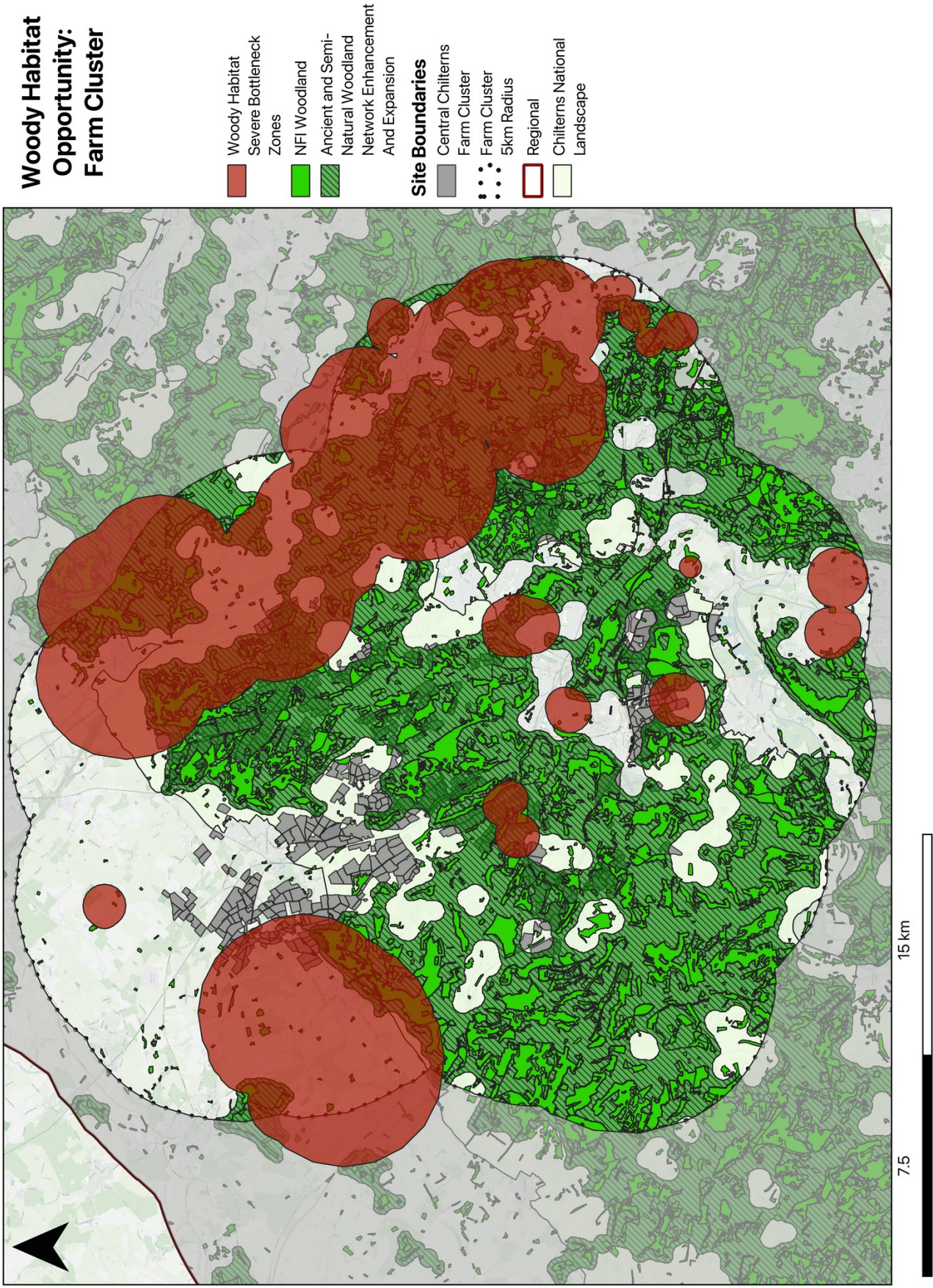


Figure 13: This map highlights the location of severe bottleneck zones for woody habitats at the Central Chilterns Farm Cluster scale. The zones overlay the Habitat Enhancement and Expansion Zone layer for Ancient and Semi Natural Woodland, alongside NFI woodland habitat. The Chilterns National Landscape is shown in light green and the Central Chilterns Farm Cluster parcels are shown in grey.

Grassland Habitat Opportunity: Farm Cluster

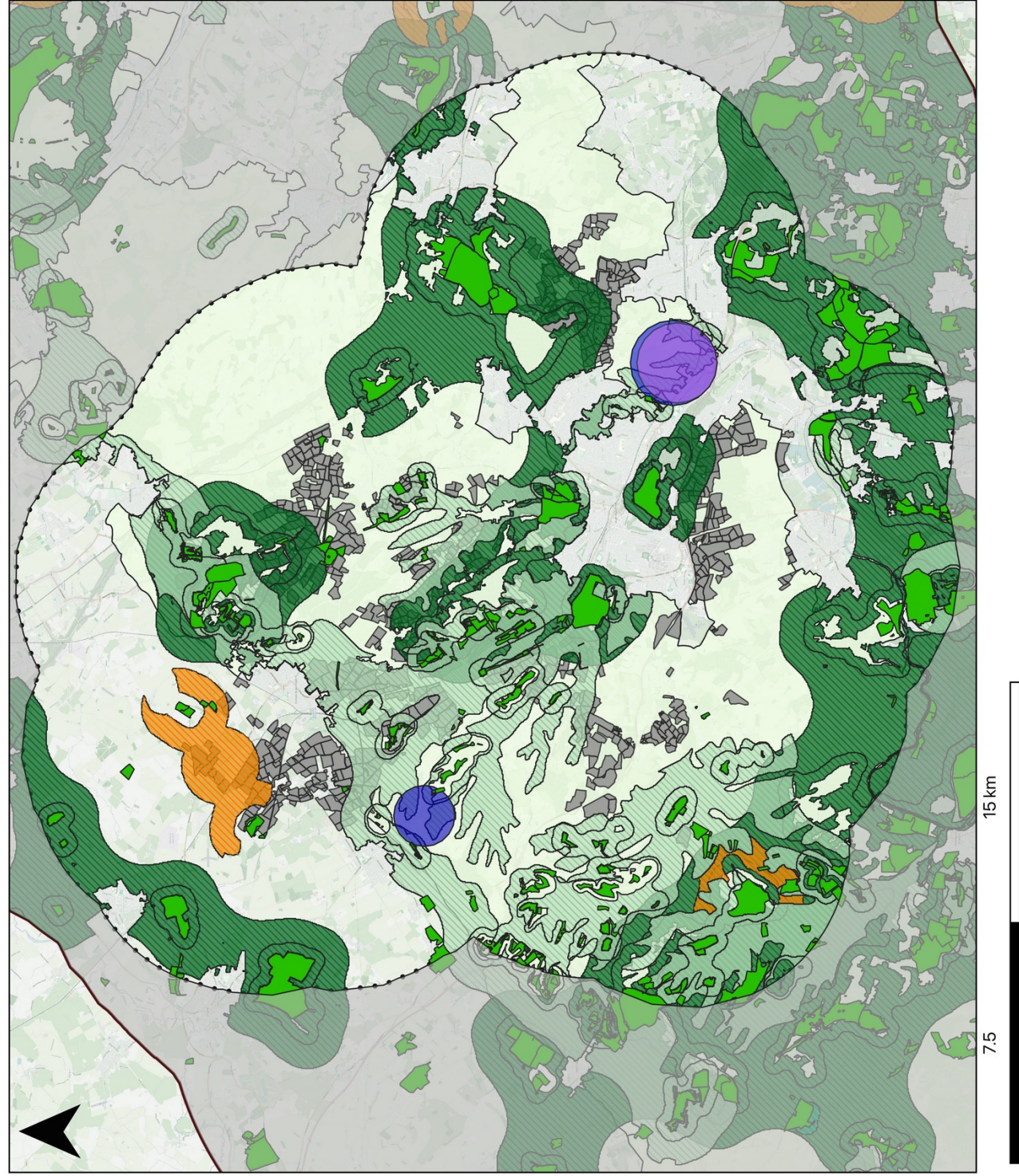


Figure 14: This map highlights the location of severe bottleneck zones for grassland (and chalk grassland) habitats at the Central Chilterns Farm Cluster scale. The zones overlay the Habitat Enhancement and Expansion Zone layer for several grassland habitats, alongside PHI grassland habitats. The Chilterns National Landscape is shown in light green and the Central Chilterns Farm Cluster parcels are shown in grey.

Discussion

Connectivity Opportunities for Woodlands

This report has highlighted sizeable theoretical opportunity areas for broad habitats that would be the most effective locations to support functional connectivity. Woodlands and woody habitats have produced the largest severe bottleneck zones of all the habitats assessed on all spatial scales considered.

Regional and Landscape Scale

At the regional and landscape scale, it is evident that severe bottlenecks occur largely due to the sparse coverage of woodlands in the northern area of the landscape, limiting pathway choices for species movement through the landscape. As such, this limits the use of enhancement and expansion network zones. This area will likely become more important with climate change-induced northern range shifts, given the northern extent. Ensuring the densely wooded core that runs through the North Wessex Downs and Chilterns National Landscapes can extend its function further up the landscape would support a Lawton approach to woody habitat connectivity.

Central Chilterns Farm Cluster Scale

At the Central Chilterns farm cluster scale, two clear zones have been highlighted as woody habitat connectivity opportunities and several discrete sites within the farm cluster area. The larger zone that covers the northeastern boundary of the area covers a large area of enhancement and expansion zone. Hence, much of the woodland connectivity could be achieved by buffering the existing woodland network with woodland creation or other suitable habitats that can still create a connectivity passage for woodland species. For example, hedgerows, tree planting, wood pasture and parkland or other appropriate woodland mosaic habitats. Areas that do not fall within the expansion and enhancement zone appear to cover smaller patches of woodland habitat.

Therefore, expanding these smaller woodlands could contribute to enhanced functional connectivity. The western area's second large severe bottleneck zone is mostly outside the enhancement and expansion zone. Woodland coverage in this area is a sparse patchwork of small habitat areas. Sitting on the edge of the densely wooded area, the bottlenecks indicate a need to expand this wider to encourage connectivity across the landscape. Given the scale of the zone and the lack of nearby large areas of woodland, integrating woodland mosaics, trees, and hedgerows into existing habitats would support a connected woody landscape.

Connectivity Opportunities for Chalk Grassland and Grassland

Regional and Landscape Scale

Chalk grassland habitat connectivity opportunity zones extending across national landscapes from a regional and landscape-scale analysis present a network of spatially strategic locations to connect existing chalk grassland habitat cores. Figure 10 outlines theoretical areas where chalk grassland restoration would effectively enhance functional connectivity for this habitat. Given the scale of existing chalk grassland patches that need connecting, the size of restoration sites would likely be sufficient at a similar scale. For the central severe bottleneck zone that is intersected by a chalk grassland enhancement and expansion zone, expanding the current chalk grassland sites within this zone would likely support connectivity within this identified bottleneck.

Regional and Landscape-scale grassland severe bottleneck zones in Figure 11 also map out strategic sites that would theoretically enhance connectivity. All the severe bottleneck zones intersect an area of enhancement and expansion zone for a specific grassland habitat, which can, therefore, provide the foundation for habitat expansion from existing habitat cores.

Central Chilterns Farm Cluster Scale

Figure 13 highlights two severe bottleneck zones for theoretical grassland connectivity opportunities and an overlapping severe bottleneck zone for chalk grassland intersecting with the enhancement and expansion zones.

These areas identified have relatively lower grassland habitat coverage, intersecting smaller habitat patches relative to the wider area. Chalk grassland restoration in these sites would be effective through existing chalk grassland expansion or by providing additional habitat areas to this network to enhance connectivity. While the severe bottlenecks do not overlap with the current Central Chilterns Farm cluster, it may provide a means of targeted engagement to bring in new landholdings. Proximity to urban areas and the railway line for the southwestern severe bottleneck zone may also bring new opportunities for grassland restoration in public greenspace or as linear connective features along the surrounding infrastructure.

Summary of Connectivity Opportunities

The analysis highlights significant connectivity opportunities across the Chilterns National Landscape, particularly in enhancing the connectivity of woodland, grassland, and chalk grassland habitats. Each habitat type presents the potential for targeted restoration and habitat creation to improve overall ecological resilience and species movement within the landscape at regional, landscape and farm cluster scales.

Woodland connectivity opportunities were most substantial at both regional and landscape scales. Severe bottlenecks were identified primarily in the northern Chilterns, where woodland habitats are relatively sparse. Expanding woodland in these areas, particularly through buffer zones, hedgerows, and woodland mosaics, could substantially improve habitat continuity. At the Central Chilterns farm cluster scale, specific zones along the northeastern boundary offer valuable areas for woody habitat enhancement. Addressing these bottlenecks would support species movement in response to climate-induced shifts, reinforcing the wooded core that spans the North Wessex Downs and Chilterns landscapes.

Strategic connectivity opportunities for chalk grassland are concentrated in regions where isolated patches of chalk grassland habitat could be linked to form larger, contiguous areas. By expanding chalk grassland in central severe bottleneck zones, these connectivity efforts could establish a more extensive network supporting species that rely on grassland habitats.

Grassland opportunities in the north of the Chilterns intersect with the existing zones identified for enhancement and expansion, suggesting the expansion from existing grassland habitats would be effective at supporting species connectivity. Opportunities at the Central Chilterns farm cluster level for grassland and chalk grassland also intersect with critical enhancement zones, suggesting that targeted chalk grassland restoration could strengthen connectivity pathways and enhance the ecological network in the wider Chilterns area.

These connectivity opportunities offer targeted theoretical locations for enhancing habitat continuity by focusing on critical bottlenecks. Intervention in these locations could contribute to achieving a more interconnected and resilient landscape across the Chilterns, supporting biodiversity and adaptive responses to climate change.

Regional and Landscape Scale Comparison

This methodology has highlighted the potential of mapping theoretical opportunities for habitat connectivity and evidencing the role of spatial scale in this analysis. Woodland habitats show a correlation between the location and extent of bottlenecks at both regional and landscape scales. The only notable bottleneck difference is an expanded northeastern severe bottleneck zone for the landscape scale analysis. While this may suggest a change in connective pathway configuration at the different scales, given that there is mostly symmetry in the bottlenecks identified at both scales, it is unlikely this difference in scales significantly impacts modelling woodland habitat connectivity with Condatis.

Comparing the regional and landscape-scale bottlenecks for chalk grassland showed notable differences in score and distribution. At the Regional Scale, severe bottleneck zones cover a wide area, intersecting the North Wessex Downs National Landscape and the Chilterns National Landscape. Chalk grassland bottlenecks produced at the landscape scale have no severe bottleneck zones and only score above 1 (Major) for 3km dispersal.

These differences may be due to the distribution of chalk grassland split unevenly between the two National landscapes. Most of the chalk grassland coverage exists at the southern end of the North Wessex Downs National Landscape, providing a large foundation area from which species can move. However, further north as relative chalk grassland habitat coverage reduces, as does the relative number of suitable pathways, resulting in bottlenecks across the landscape. Whereas the bottlenecks at the landscape scale do not include the source of relatively large chalk grassland habitat resource at the southern end of the North Wessex Downs, as such, the carrying capacity is relatively lower, and there is less strain on the limited pathways. This indicates that in addition to supporting habitat creation in severe bottleneck zone locations to alleviate these connectivity pressures, it is also important to enhance and protect the valuable chalk grassland habitat resource within the North Wessex Downs National Landscape, supporting a species dispersal foundation.

Grassland habitat bottlenecks also exhibited differences in distribution and strength at the two scales. At the regional scale, grassland bottlenecks extended further north and ranked higher in strength. Again, this suggests changes in habitat configuration to support species connectivity which are different at these two scales to the extent that areas become restricted in connective pathway function.

Due to the limited coverage for wetland habitats applied in this analysis, no meaningful comparison can be made for wetland bottlenecks across regional and landscape scales.

Overall, this analysis has highlighted the significance of different scales when identifying bottlenecks within the connective habitat context. This is particularly true for chalk grassland habitats, which may have different configurations of connective habitat pathways at these two scales. Therefore, outputs from both scales should be used together to inform decision-making.

Next Steps and Recommendations

This analysis has produced a set of outputs that can support landscape-scale habitat restoration decision-making. This is alongside identifying site-specific projects on a Central Chilterns farm cluster scale that can support undertaking meaningful habitat restoration and creation in locations that enhance functional connectivity. In addition, this analysis also presents other opportunities for application and development of the findings;

- Integrating local habitat data and other ground-truthed habitat survey data to ensure habitat coverage is accurate and comprehensive to represent connectivity and bottlenecks fully.
- Test the methodology with priority species for the habitats and region(s) of interest, applying accurate dispersal and reproduction rates to get outputs of their specific connectivity needs.
- Cooperate with the North Wessex Downs National Landscape to enhance important pathways that enable species to move across habitat networks into the Chilterns National Landscape.
- Explore the connectivity pressures in the context of the protected site network. To work towards achieving 30% of land for nature by 2030, designating more protected sites is a route to contributing to this target. Identifying where there are bottlenecks within the protected site network can help inform where future protected areas for habitat connectivity are best placed. This is explored on a national scale by Travers *et al* (2022).
- Explore results in the context of other opportunity datasets to identify other overlaps in priority for specific habitat restoration and creation needs. For example, overlaying severe bottleneck zones in woodland habitats with England Woodland Creation Offer (EWCO) priority areas would help understand other ecosystem services that benefit in addition to habitat connectivity, which would support unlocking more funding for action.

- Apply this methodology to other farm clusters to identify more habitat connectivity projects within the cluster area. This would be useful to view alongside existing agri-environment scheme options to understand where certain habitat restoration and creation actions have been undertaken relative to severe bottlenecks. This can assess whether this aligns with the scale and location of the connectivity needs or if new options would be more effective at addressing these needs.
- Support other spatially strategic plans for nature, e.g., the Local Nature Recovery Strategy, to highlight the importance of the identified severe bottleneck zones and increase accessibility for funding and potential Biodiversity Net Gain uplift.
- Use tools and outputs dynamically with new habitat coverage datasets (for example, [Natural England Living England map 2022-2023](#)), that could provide additional granularity to the habitat networks assessed. This would be particularly useful for Wetlands, which would benefit from a more comprehensive habitat coverage within the Living England map relative to the Priority Habitat Inventory and would therefore likely have more effective outputs from Condatis.

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