Tresham Garden Village:
A natural capital impact assessment

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Publication date: December 2017

Version: Final

Recommended citation: Rouquette, J.R. (2017) Tresham Garden Village: A natural capital impact assessment. Natural Capital Solutions.

Executive summary

- This report presents the results of a project to carry out a natural capital and ecosystem services assessment of Tresham Garden Village, a proposed major housing and community development in East Northamptonshire. The proposed development includes 1500 houses, a primary and secondary school, employment zones, and associated infrastructure. It also incorporates a significant amount of interconnected green space and is to be partly buffered by large areas of new woodland.

- Natural capital is the stock of natural assets (e.g. soils, water, biodiversity) that produces a wide range of ecosystem services that provide benefits to people. These benefits include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as recreational opportunities. The principles of natural capital and ecosystem services have been adopted by policy makers at international and UK Government levels, and efforts are underway to incorporate these ideas into the planning and development process. Locally, ecosystem services have been incorporated into the North Northamptonshire Joint Core Strategy 2011-2031 and are being fully integrated into a forthcoming Supplementary Planning Document on Place Shaping. But how will an assessment of natural capital and ecosystem services work in practice for a major development? This project attempts to address that question.

- Natural capital was mapped across the site under the baseline (pre-development) condition and under a draft masterplan (spring 2017 version) produced by the Tresham Garden Village design team. The capacity of the natural environment to deliver 11 different ecosystem services was then modelled and mapped at high resolution across the site. These were carbon storage, carbon sequestration, air purification, noise regulation, water flow, water quality, pollination, accessible nature, agricultural production, timber production, and biodiversity (two different scores). These services were considered to include all of the most important services provided by the natural environment at Tresham. The demand for air purification, noise regulation, and accessible nature services was also mapped.

- Prior to development the site is dominated by arable farmland and is only providing very limited benefits. Only one part of the site is currently delivering a wide range of ecosystem services and that is Langley Coppice, an area of ancient woodland at the edge of the proposed main village.

- Under the proposed masterplan, the delivery of almost all ecosystem services is predicted to increase, with the exception of agricultural production, which declines by more than half, and water flow and biodiversity score 2, representing a slight decline. A decline in agricultural production is inevitable, as more than half the arable fields are to be built on or converted to other land uses, but the slight declines in the latter two services can be explained and addressed. The increase in scores for all remaining ecosystem services is in large part due to the new woodland plantings adjacent to the main built zone. Large areas of accessible greenspace are also particularly important for enhancing benefits.

- The proposed development will also significantly increase demand for air purification, noise regulation, and accessible nature. This highlights that the site should not be simply maintaining capacity at baseline levels, but needs to increase capacity just to meet the increased demand. The location of natural capital is also important in relation to demand, with, for example, trees and woodland adjacent to main urban roads particularly important for air pollution regulation.

- The assessment of accessible nature has highlighted the importance of providing large areas of greenspace that are close to peoples' homes, and making these as natural as possible. This is further supported by monetary valuation studies elsewhere, which have found that the monetary benefits of recreation and health and wellbeing are extremely high and considerably more valuable than all other benefits.

- A workshop (26th June 2017) was held with stakeholders representing a range of local government, statutory agency and third sector organisations with environmental interests in the development. The workshop raised awareness of the natural capital and ecosystem services assessment approach being taken at Tresham, including presenting some of the results of the assessment. Stakeholders' priorities, in terms of which ecosystem services they considered to be important at Tresham, were established. Participants then engaged in an exercise to alter the design of the masterplan with the aim of enhancing the delivery of ecosystem services.

- Stakeholders considered all ecosystem services to be of at least moderate importance at Tresham, but water quality, water flow, habitat for biodiversity, and accessible nature were highlighted as the most important. They suggested changes to the design, which were incorporated into a new masterplan. In particular, the amount of semi-natural grassland, parkland, fruit and vegetable growing areas, and water features were increased, and public access to greenspace was enhanced. The ecosystem service models were then run again to determine the impact of these modifications on outcomes.

- The provision of all ecosystem services, apart from agricultural production, increased under the new masterplan compared to the original masterplan. However, the increases were generally modest, with a median increase from the original masterplan to the new masterplan of 1.6%. The exception was accessible greenspace, which showed by far the largest increase of 80%, driven by increasing public access to greenspace, thereby also creating larger accessible areas, rather than increasing the naturalness of the habitats.

- The masterplan is delivering a net increase in ecosystem services, but these benefits could be increased further. It is recommended that the changes suggested during the stakeholder workshop should be included in the final version of the design. Further recommendations are provided based on the outcomes of the assessment. These are focused around adding street trees, especially along the main roads in the village, enhancing public access and connections between the surrounding greenspaces, fully integrating SuDS into the detailed design, and restoring Langley Coppice to good condition.

- This project has demonstrated how a natural capital and ecosystem services approach can be applied to the planning and development process in regard to a major development. It has been useful at raising awareness and demonstrating the multiple benefits that can be achieved by fully considering the natural environment in development plans, engaging with stakeholders, highlighting how the masterplan design can be improved to enhance benefits, and ultimately, providing an assessment of the net impact of the development on the natural environment and the benefits that it provides.

- Implications and applications for the planning and development process are discussed. An assessment can be carried out at a number of different stages of the planning process including at the optioneering stage, to assess the performance of an outline masterplan, or to support a full planning application, with different outcomes and advantages at each stage.

- Potential next steps for this project are outlined briefly, including performing a monetary valuation of the costs and benefits of the green infrastructure elements of the development, through a natural capital accounting framework, producing guidance for the planning and development sector, and developing a mapping portal to enable an initial baseline assessment to be carried out for any location, without the need for further data collection or additional analyses.

Contents

1. Introduction

The concepts of natural capital and ecosystem services are being increasingly recognised by the public and private sectors. They are backed by a number of local, national and international policies, which are encouraging more joined-up and sustainable decision making and planning. Adopting the natural capital and ecosystem services approach is a key policy objective of the UK Government (and worldwide) and central to Defra's new 25-year environment plan. Meanwhile, the National Planning Policy Framework places sustainable development at the heart of England's planning policy, which requires a careful balance between social, economic and environmental considerations. The evaluation of natural capital and ecosystem services provides an appropriate framework to inform these requirements.

At a more local level, the concept of ecosystem services is starting to be incorporated into local planning policy, such as the North Northamptonshire Joint Core Strategy (2016). For example, Policy 1 – Presumption in Favour of Sustainable Development, states that Local Planning Authorities will work:

> *"…to secure development that improves the economic, social and environmental conditions in the area meeting the challenges of climate change and protecting and enhancing the provision of ecosystems services."*

However, there remains a big gap between policy and practice with little knowledge about how to apply the approach in practice. An assessment of ecosystem services (ES) can be extremely informative at guiding planning and development but as yet, there are no examples of the practical application of such an approach in the planning and development sector.

The proposed Tresham Garden Village development on the site of the disused Deenethorpe Airfield, presented an ideal opportunity to develop and demonstrate such an approach and so guide best practice both locally and nationally. To that end, this project fits with one of the key aims of the Tresham Garden Village development, that it will be an exemplar for planning and development. It also fits with the wider interests of the owners (Brudenell Estates) to use best practice to develop a sustainable community fit for the future. Tresham Garden Village was selected as one of 14 proposed garden villages to receive government backing and funding from the Department for Communities and Local Government (January 2017). As part of that funding, Natural Capital Solutions was commissioned by East Northamptonshire Council (the competent planning authority for the development) to carry out an assessment of the impact of the proposed development on natural capital and ecosystem services.

The overall aim of this project was to carry out a natural capital and ecosystem services assessment of the proposed development, comparing the situation before and after construction, to determine potential impact. Engagement with stakeholders was also a key part of the project, with stakeholders taking part in an interactive workshop aimed at modifying the masterplan to enhance the delivery of ecosystem services. Feedback from this work is being used to demonstrate best practice in the assessment of natural capital and ecosystem services for new developments, demonstrating an approach that we will be advocating in the new Supplementary Planning Document on design and access. There is also the opportunity to extend this work by undertaking natural capital accounting and producing step-by-step guidance for both a local and national audience.

1.1 The natural capital and ecosystem services framework

The natural environment underpins our wellbeing and economic prosperity, providing multiple benefits to society, yet is consistently undervalued in decision-making. Natural Capital is defined as "*..elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans*" (Natural Capital Committee 2014). It is the stock of natural assets (e.g. soils, water, biodiversity) that produces a wide range of ecosystem services that provide benefits to people. These benefits include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities (Fig. 1).

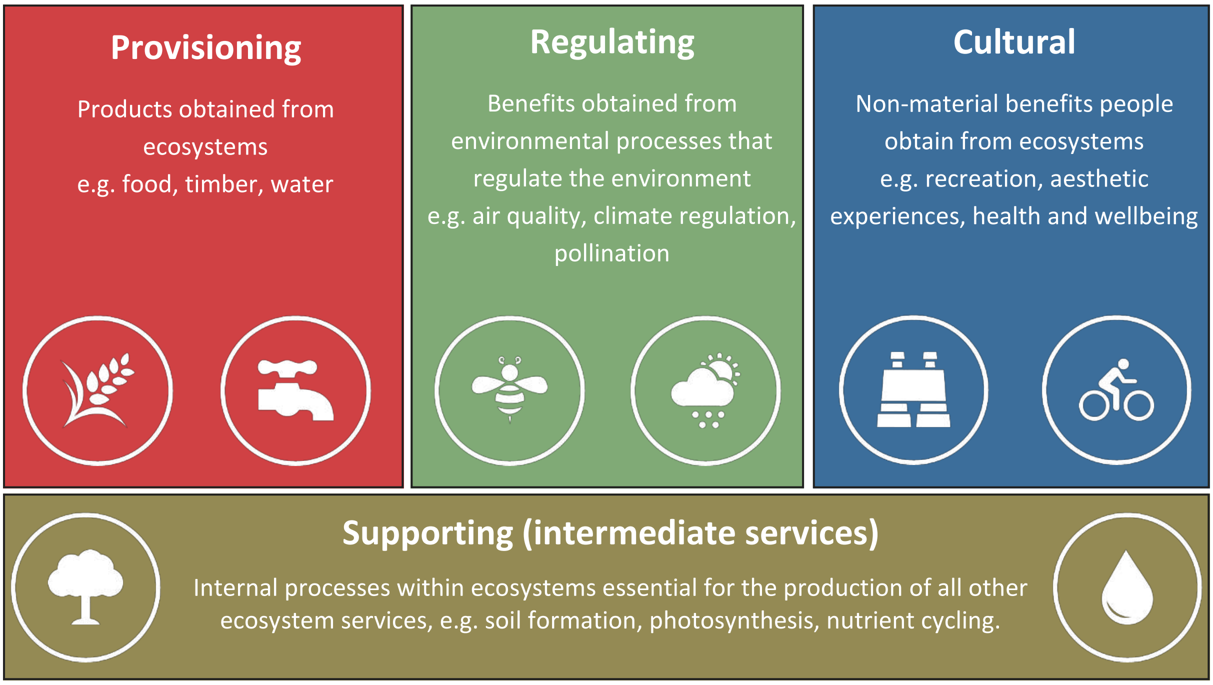


Figure 1: Key types of ecosystem services (based on MEA 2005)

Much work is progressing on how to deliver the natural capital and ecosystem services approach on the ground and how to use it to inform and influence management and decision-making. One of the most important steps is to recognise and quantify ecosystem service delivery (the physical flow of services derived from natural capital). It is also possible to examine how this will change following development, and hence determine the potential impact of the proposal. Additional insight can be gained by taking a spatial perspective on the variation in ecosystem service supply and demand across a study area using a Geographic Information System (GIS). Maps are able to highlight hotspots and coldspots of ecosystem service delivery, highlight important spatial patterns that provide much additional detail, and are inherently more user friendly than non-spatial approaches.

1.2 Outline of approach

This project attempts to answer a number of key questions:

- How can a natural capital and ecosystem services assessment be carried out for a major development?
- What will be the impact of the development on natural capital and ecosystem services?
- Can the masterplan be improved to deliver more?

- What lessons can be learned to guide the design of Tresham Garden Village and, more generally, the uptake of the approach in the planning and development process?

In light of this, the approach taken is shown in Figure 2. An assessment of the natural capital assets under the current situation and after the proposed development has taken place is described in Section 2 of this report. Section 3 models and maps the flow of ecosystem services before and after development, to highlight the potential impact. Section 4 then describes the outcomes of a stakeholder workshop, including stakeholder priorities for Tresham Garden Village, and suggested changes to the design of the masterplan to enhance outcomes. Section 5 then analyses the impact of the new design on ecosystem service delivery, before Section 6 provides conclusions and recommendations for Tresham Garden village itself, and for incorporating natural capital and ecosystem services assessments into the planning and development process.

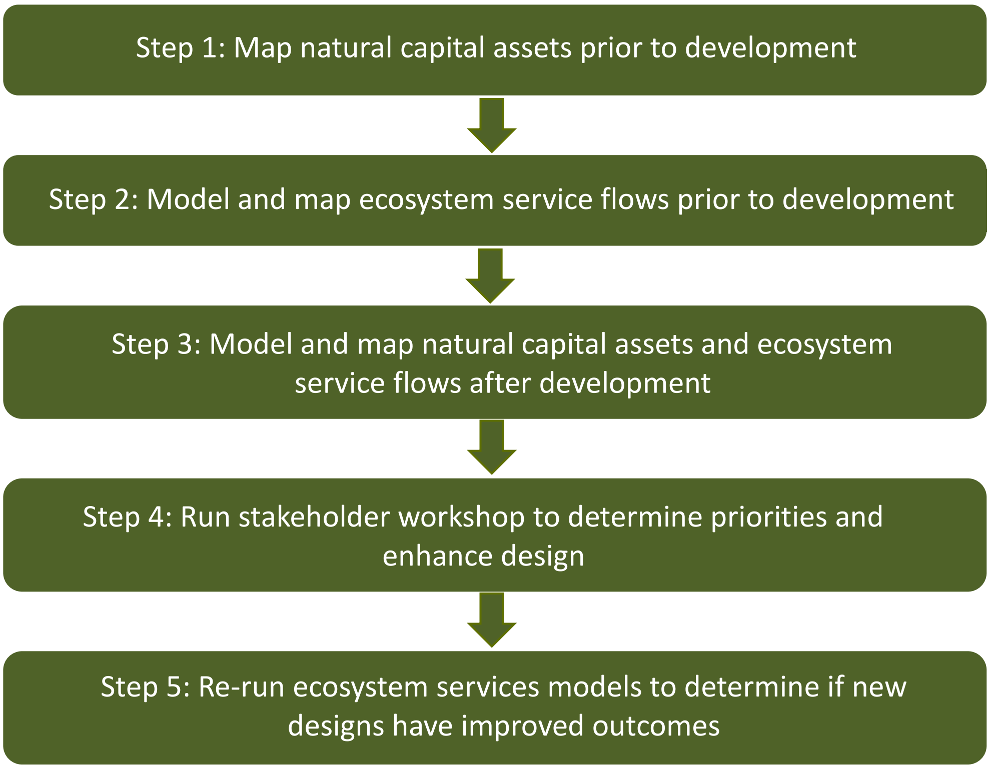


Figure 2: Outline of the assessment approach

2. Natural capital assets – baseline and masterplan

2.1 Tresham Garden Village

Tresham Garden Village is a proposal for a garden village style community to be built on the site of an old airfield close to the village of Deenethorpe, in East Northamptonshire, near Corby. The proposed development includes 1500 houses, a primary and secondary school, employment zones, and associated infrastructure. But significantly, it also incorporates a large amount of interconnected green space and is to be partly buffered by large areas of new woodland plantings. The latest masterplan makes use of the existing airfield layout, for example, retaining but reducing the width of the existing main runway, which will provide a tree-lined avenue stretching north of the built zone. The team leading the proposal have put together a large number of documents concerning the background, site analysis and design, and have commissioned numerous technical reports providing details on all aspects of the site and the proposal, and these should be referred to for more information.

2.2 Creating a habitat basemap

Before the flow or value of ecosystem services can be calculated and mapped, it is necessary to obtain an accurate assessment of the natural capital assets currently present in the study area and how these will change under the planned development masterplan. The most important component of this was to create a habitat basemap for the current situation and a comparable map for the proposed masterplan.

The habitat basemap was created using EcoServ GIS, a toolkit developed by the Wildlife Trusts, with a number of bespoke modifications. This approach uses MasterMap polygons as the underlying mapping unit and then utilises a series of different data sets to classify each polygon to a detailed habitat type and to associate a range of additional data with each polygon. This basemap was created as part of the Nene Valley Nature Improvement Area Project, and full details of the methods and underlying data used to construct the map are provided in the technical report of that project[1]. However, this map was created for the whole of the Nene catchment, covering most of Northamptonshire and Peterborough, and was not ground truthed for accuracy. When working at the scale of a single site, such as Tresham Garden Village, it was felt necessary to update and check the details of the map, using site survey data.

The Tresham study area has been the subject of a number of surveys as part of the development process, which were used to verify and improve the accuracy of the basemap, in particular, the extended Phase 1 habitat survey of the area, produced by Lockhart Garrett in 2016. Therefore, the basemap was extensively checked and altered to incorporate this more detailed data. A separate layer showing Public Rights of Way and access routes was also used, and altered in light of site specific information. Note, that a secondary objective of this project was to determine the accuracy of the original basemap and if it could be used in future site assessments without additional ground truthed data, and this is reported on in the Appendix.

A site such as Tresham Garden Village will be impacted by, and have impacts on, a much wider area than simply the site boundary. People are expected to travel to nearby towns, and *vice versa*, people from nearby towns may travel to Tresham to use accessible greenspaces and other facilities. For Tresham Garden Village, it was felt that the towns of Corby to the west and Oundle to the east were likely to

[1] Rouquette, J.R. (2016). Mapping Natural Capital and Ecosystem Services in the Nene Valley. Report for the Nene Valley NIA Project. Natural Capital Solutions. Available here

influence ecosystem service flows, especially demands for ecosystem services. Therefore, the basemap was created, and all ecosystem services were mapped for a much larger area, centred on the Tresham site boundary, but approximately 20 km by 10.8 km in dimension. This included the whole of Corby to the west and Oundle in the east, and from Brigstock in the south, to beyond Gretton and Woodnewton in the north.

2.3 Baseline habitats and quality

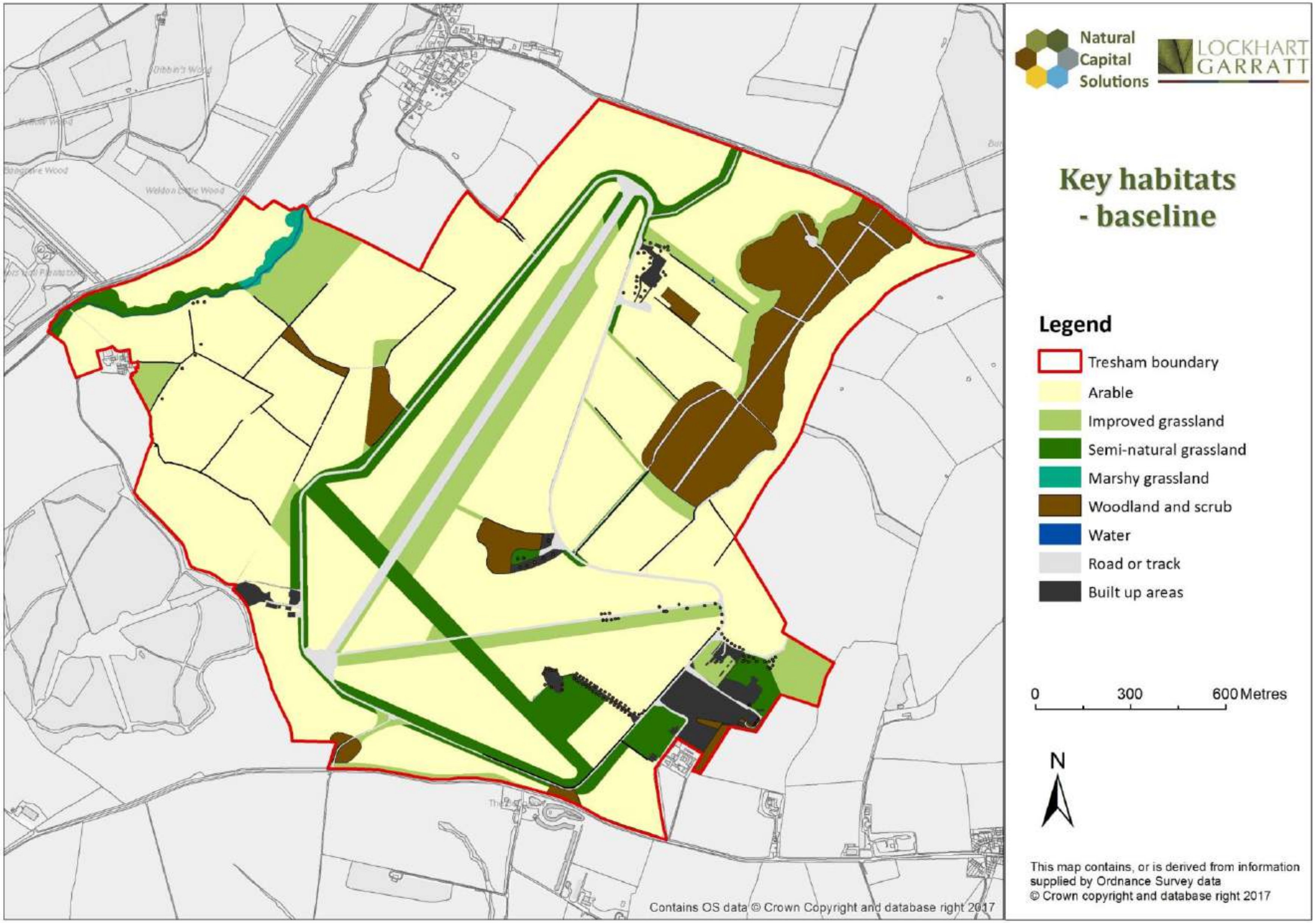
A map showing the key habitats within the Tresham Garden Village boundary area under the baseline (current) situation is shown on the next page (Map 1), and the area of each broad habitat type is shown in Table 1. The Tresham Garden Village boundary area is 370 ha in size and is currently dominated by arable land, making up 248 ha or 67% of the area. The remaining area largely consist of improved grassland (36.4 ha, 9.8%), semi-natural grassland (28 ha, 7.5%) and broadleaved woodland (26.8 ha, 7.2%). Much of the improved and semi-natural grassland is located in strips adjacent to the old runway and peripheral roads and tracks. The majority of the broadleaved woodland is located to the north-east of the runways, in Langley Coppice, with a few small patches elsewhere.

Table 1: Area and percentage cover of broad habitat types under the baseline and proposed masterplan for Tresham Garden Village.

Broad habitat type	Baseline		Masterplan		Change
	Area (ha)	% cover	Area (ha)	% cover	Area (ha)
Arable	248.1	67.0	105.7	28.5	-142.5
Improved grassland	36.4	9.8	23.7	6.4	-12.7
Mixed use (amenity) grassland	0.3	0.1	9.9	2.7	9.6
Semi-natural grassland	28.0	7.5	14.0	3.8	-14.0
Marshy grassland	1.2	0.3	2.5	0.7	1.4
Allotments	0.0	0.0	1.9	0.5	1.9
Orchard	0.0	0.0	1.5	0.4	1.5
Trees / Parkland	0.4	0.1	28.3	7.6	28.0
Scrub	3.8	1.0	1.2	0.3	-2.6
Broadleaved woodland	26.8	7.2	62.1	16.8	35.4
Coniferous woodland	0.0	0.0	2.6	0.7	2.6
Water	0.3	0.1	1.8	0.5	1.5
Built up areas	14.6	4.0	41.4	11.2	26.7
Infrastructure	9.0	2.4	47.1	12.7	38.0
Garden	0.0	0.0	25.9	7.0	25.9
Hedgerows	1.4	0.4	0.9	0.3	-0.5

None of the land within the Tresham Garden Village boundary area is subject to any nature conservation designations, although Weldon Park woodland, adjacent to the site on the south-west, is a Site of Special Scientific Interest (SSSI). Sites that do not meet the criteria for SSSI designation, but that are considered to be high quality semi-natural habitats are classed as Biodiversity Action Plan (BAP) habitats. Langley Coppice, within the study area, is classed as BAP habitat, along with Weldon Little Wood, which is immediately to the west of the study area, and Burn Coppice to the north-east. The western part of the site (but outside the main built zone), is within the Nene Valley Nature Improvement Area (NIA) boundary.

Map 1: Key habitats present under the baseline (pre-development) condition at Tresham Garden Village



According to Natural England data, all of the agricultural areas of the site are classified as Grade 3 agricultural land, indicating that it is of moderate quality. The Tresham site sits on a plateau of land, with different sides of the site draining into three different streams, although all are ultimately part of the Nene catchment. The largest stream is the Willow Brook, which flows inside the western edge of the site. The north-eastern part of the site, including much of the disused airfield, drains into the Southwick Brook, whilst the southern edge of the site drains onto the Glapthorn Brook. According to the most recent assessment in 2016, the overall quality (ecological status) of these water bodies have been classified by the Environment Agency under the Water Framework Directive as moderate for the Willow Brook and Southwick Brook and poor for the Glapthorn Brook.

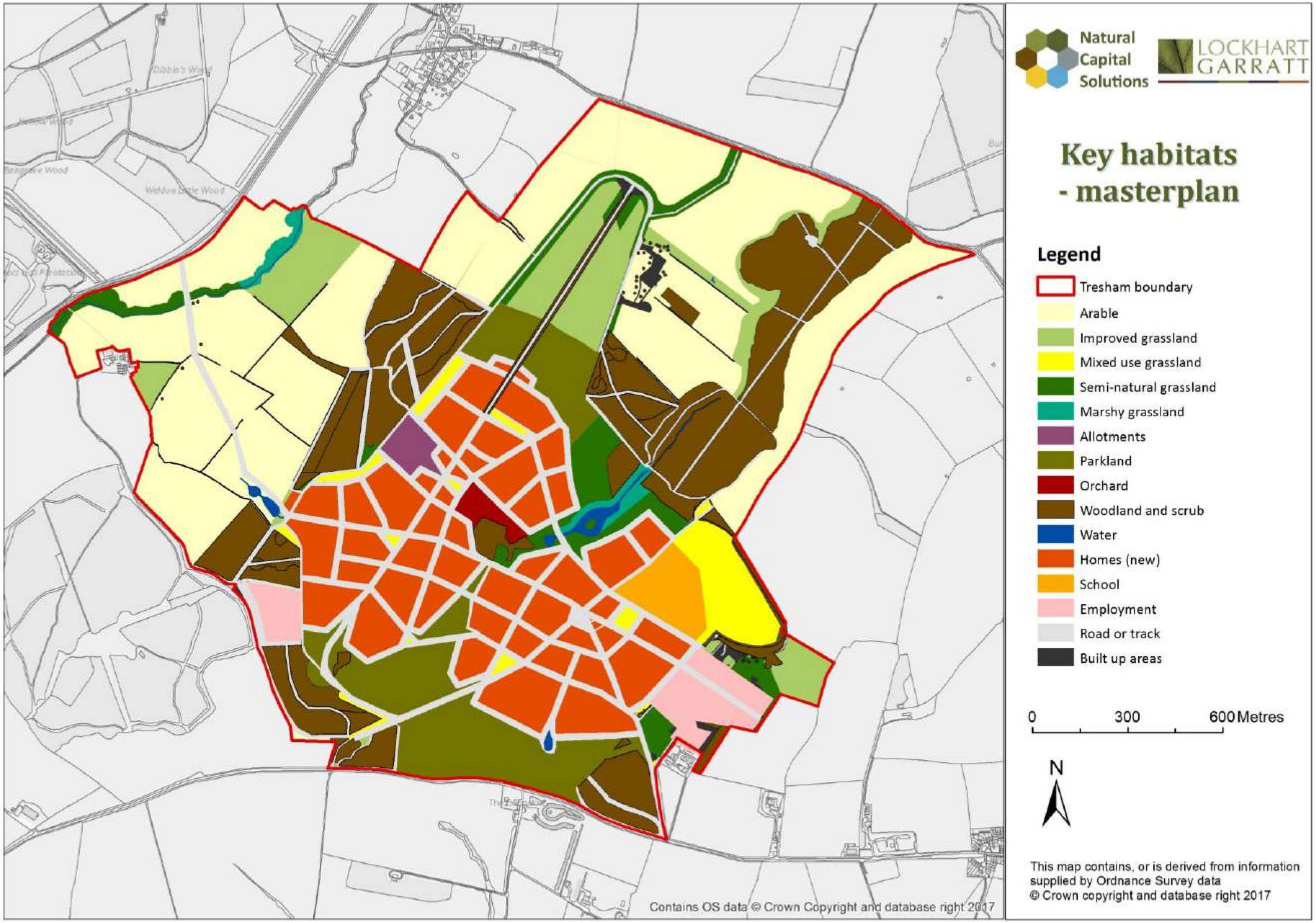
2.4 Creating a masterplan map

To analyse the flow of ecosystem services after the planned development it was important to create a map of the habitats under the proposed masterplan in exactly the same format as the basemap. The Tresham Garden Village design team had created an outline masterplan in CAD format and this was georeferenced in GIS. There was also a separate GIS layer showing the new woodland plantings planned for the area immediately surrounding the core built zone. These were used to create a GIS version of the masterplan and each polygon was classified into a detailed habitat type, compatible with the original version of the basemap. Following discussion with the design team, areas marked as "homes" were assumed to consist of 50% buildings (houses) and 50% gardens and a simple grid including 1500 of each was created for these locations. Once the GIS version of the Mastermap had been created, it was effectively cut and pasted into the original basemap. Creating a fully compatible GIS version of the masterplan was one of the most time-consuming parts of the assessment process. A number of other data sets also had to be created or changed to represent the new situation under the masterplan for the ecosystem services models, and these are listed in Section 3 of this report.

2.5 Masterplan habitats

Map 2 (overleaf) shows the key habitats projected under the proposed masterplan, and the area of each broad habitat type is shown in Table 1, along with the change in area compared to the baseline. Under the proposed masterplan, the area of arable land will fall considerably to 106 ha or 28.5% of the total site area – a loss of 142.5 ha or 57% of the pre-development area. Improved grassland (now 23.7 ha, 6.4% of the total area) and semi-natural grassland (14 ha, 3.8%), also decline, mostly due to loss of the strips adjacent to the airfield runways and roads. Large areas of new woodlands are planned in several compartments surrounding the core built zone, and these increase the overall woodland cover by 38 ha to 64.7 ha, or 17.5% of the site (an increase by a factor of 2.3). Parkland will also take up 28.3 ha or 7.6% of the area. Built-up areas, gardens and infrastructure (roads, pavements and paths) will together make up 114 ha, which is 30.9% of the land area. The houses are due to be constructed in three areas, with employment zones and a school area (primary and secondary) on the edges. The three housing areas are surrounded and interconnected by various types of green infrastructure. Although the largest elements of green infrastructure consist of woodland and parkland, there are also planned to be smaller patches of semi-natural grassland (species-rich meadow), marshy grassland, mixed-use (amenity) grassland, allotments and an orchard. At the same time, significant SuDS water features (retention ponds), which will collect rainfall running through the site, are planned.

Map 2: Key habitats present under the proposed masterplan at Tresham Garden Village



3. Modelling and mapping ecosystem services

Once a detailed habitat basemap had been created for both the baseline and masterplan, it was then possible to quantify and map the benefits that these habitats (natural capital) provide to people. The following benefits (ecosystem services) have been assessed for this project:

- Carbon storage
- Carbon sequestration
- Air purification
- Noise regulation
- Water flow
- Water quality
- Pollination
- Agricultural production
- Timber production
- Accessible nature
- Biodiversity

The list of services assessed was considered to capture all of the most important services provided by the natural environment and this was confirmed during the stakeholder workshop (see Section 4). A variety of methods were used, and these are described for each individual ecosystem service in the sections below. In all cases the models were applied at a 10m by 10m resolution to provide fine scale mapping across the area. The models are based on the detailed habitat information determined in the basemaps, together with a variety of other external data sets (e.g. digital terrain model, UK census data 2011, open space data, and many other data sets and models mentioned in the methods for each ecosystem service). Note, however, that many of the models are indicative (showing that certain areas have higher capacity or demand than other areas) and are not process-based mathematical models (e.g. hydrological models). In all cases the capacity and demand for ES is mapped relative to the values present within the study area.

For every ecosystem service listed, the capacity of the natural environment to deliver that service – or the current supply – was mapped. For air purification, noise regulation, and accessible nature, it was also possible to map the local demand (the beneficiaries) for these services. The importance and value of ecosystem services can often be dependent upon its location in relation to the demand for that service, hence capturing this information and how it changed under the proposed masterplan, provided useful additional insight. Mapping demand was not, however, possible, for the other services where there was no obvious method to apply, or local demand is not relevant, such as food or timber production.

Assessing ecosystem services under the proposed masterplan

For the purposes of this assessment, it was assumed that Tresham Garden Village was complete and fully occupied, and that all new habitats had established successfully. Evaluating the flow of ES under the proposed masterplan required certain additional information to be estimated, in addition to the masterplan habitat map. Key datasets amended, and the underlying assumptions are listed here:

- *Population data* – Tresham Garden Village will consist of 1500 new houses. Household occupancy (2.44 people per house), total village population (3655) and age structure of the population, was estimated based on average figures for the whole of Northamptonshire, taken from the UK Census 2011.
- *Index of Multiple Deprivation (IMD)* – as above, IMD scores were estimated for Tresham by calculating and applying the average scores across all IMD categories for Northamptonshire as a whole.
- *Roads* – a new layer showing all new roads within the development, and their classification, was created and merged with the existing roads layer.
- *Green infrastructure* – all green spaces around Tresham, were identified as publicly accessible or not.
- *Public Rights of Way and core paths* – new paths created as part of the development were added to this dataset.

3.1 Carbon storage capacity

What is it and why is it important?

Carbon storage capacity indicates the amount of carbon stored naturally in soil and vegetation. Carbon storage and sequestration is seen as increasingly important as we move towards a low-carbon future. The importance of managing land as a carbon store has been recognised by the UK government, and land use has a major role to play in national carbon accounting. Changing land use from one type to another can lead to major changes in carbon storage, as can restoration of degraded habitats.

How is it measured?

The EcoServ GIS carbon storage model was used. This model estimates the amount of carbon stored in the vegetation and top 30cm of soil. It applies average values for each habitat type taken from a review of a large number of previous studies in the scientific literature. As such it does not take into account habitat condition or management, which can cause variation in amounts of carbon stored. It is calculated for each 10m by 10m cell across the study area. Scores are scaled on a 0 to 100 scale, relative to values present within the mapped area.

In all the ecosystem services maps that follow, the highest amounts of service provision (hotspots) are shown in red, with a gradient of colour to blue, which shows the lowest amounts (coldspots). Maps were created based on both the existing habitat and on the habitat projected to occur under the proposed masterplan for the site.

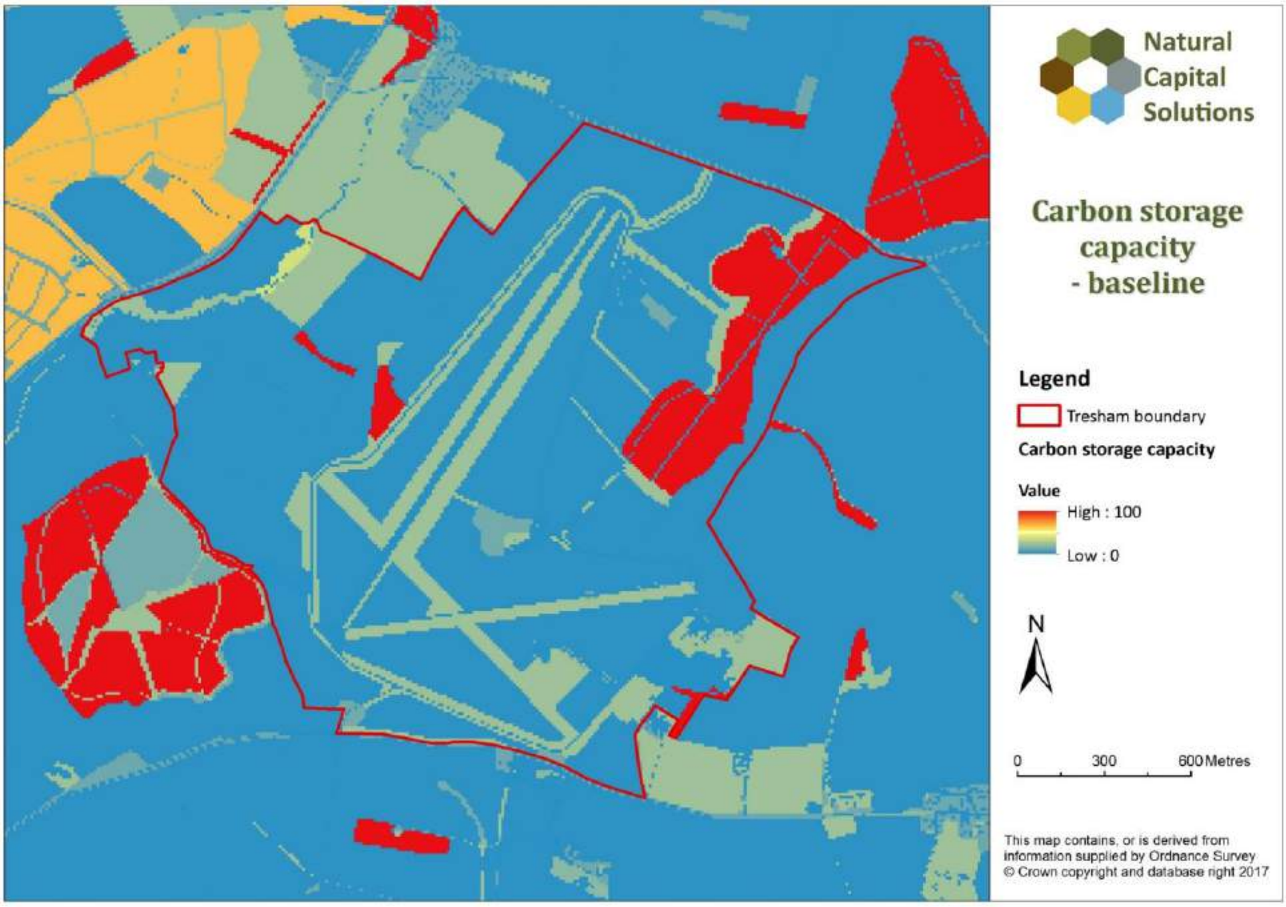
Results for Tresham

Maps 3 and 4 (overleaf) show carbon storage across the study area for the baseline and masterplan respectively. The predominant carbon store in the Tresham area is provided by woodland, with broadleaved woodland, shown in red on the maps, typically storing more carbon than coniferous woodland. Arable farmland and urban sealed surfaces provide the least capacity for carbon storage and are shown in dark blue. In the baseline area, Langley Coppice is apparent as the most significant carbon store, with much of the remaining area providing little capacity as it is dominated by arable land. Under the original proposed masterplan, although the urban areas provide little in the way of carbon storage, the new areas of woodland planting will provide significant increased storage potential. Overall, therefore, the capacity for carbon storage is expected to increase following development.

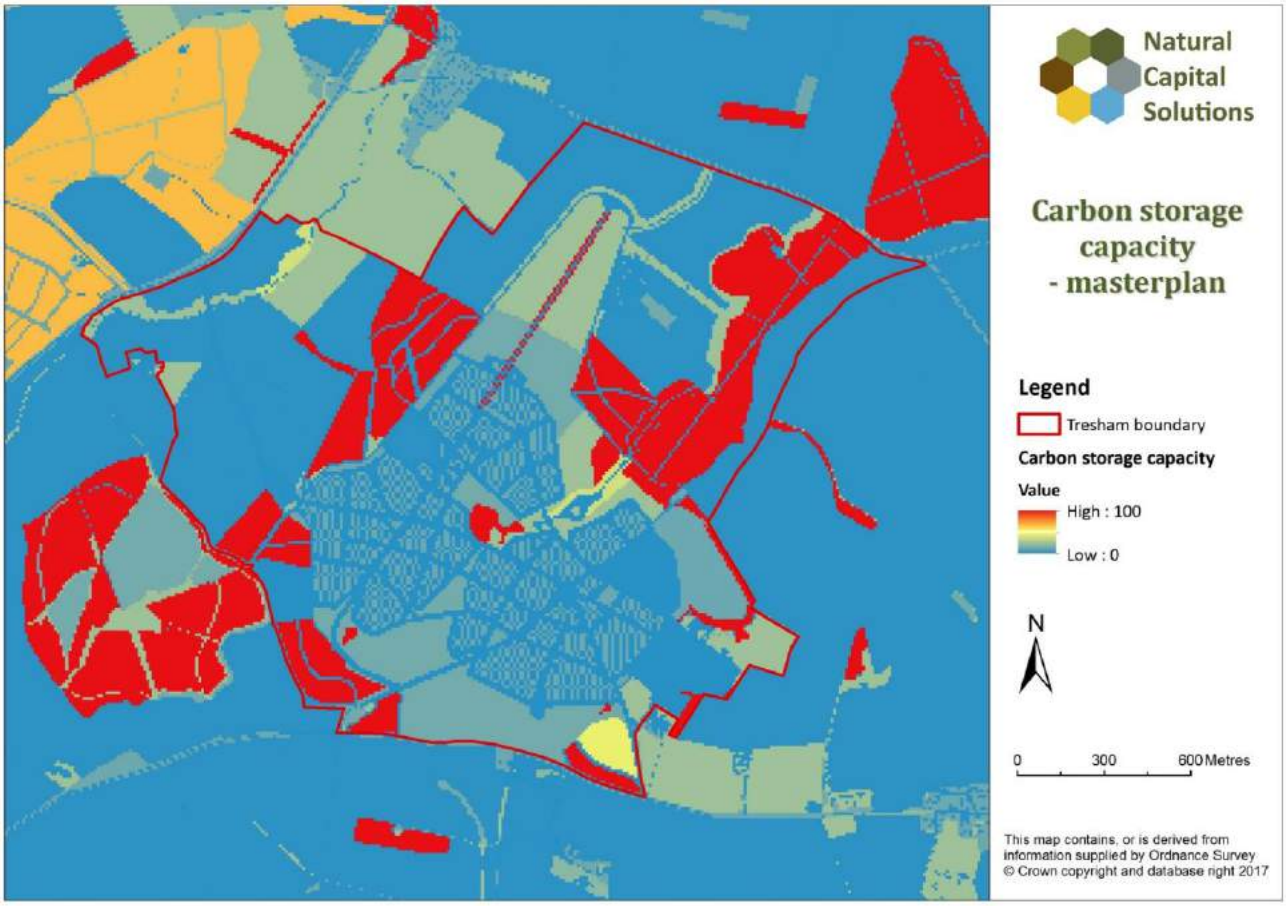
The scores below show the average carbon storage capacity for the whole of the area within the Tresham Boundary line (outlined in red on the maps). The score is out of a maximum possible of 100 (in this case, if the whole area was covered in broadleaved woodland).

Baseline score = 12.5 **Masterplan score = 22.6** **Change = 10.1**

Map 3: Carbon storage capacity for the baseline (pre-development) condition at Tresham Garden Village



Map 4: Carbon storage capacity under the proposed masterplan at Tresham Garden Village



3.2 Carbon sequestration

What is it and why is it important?

Carbon is sequestered (captured) by growing plants. Plants that are harvested annually (e.g. arable crops, improved grassland) will be approximately carbon neutral over the course of a year as the sequestered carbon is immediately harvested. There is very little information about sequestration in other habitats (apart from woodland), but these are likely to be very low. Therefore, estimates are solely based on woodland carbon sequestration. Carbon sequestration is increasingly being given a monetary value and forms the basis of Payments for Ecosystem Services (PES) schemes such as the UK Woodland Carbon Code.

How is it measured?

The Deenethorpe Airfield Woodland Creation Plan (2016) contains detailed information on the species mix, yield class and planting regime for each compartment of new woodland planned in the area. It also contained enough information on the existing areas of woodland on the site to ascertain this information. The UK Woodland Carbon Code Lookup Tables were then used to obtain estimates of average carbon sequestration rates per hectare per year for each separate compartment, based on the individual species mix and characteristics of each compartment. Values were calculated over 100 years for broadleaved woodland, and over 60 years for coniferous woodland, to reflect the likely rotation length of the different types of woodland.

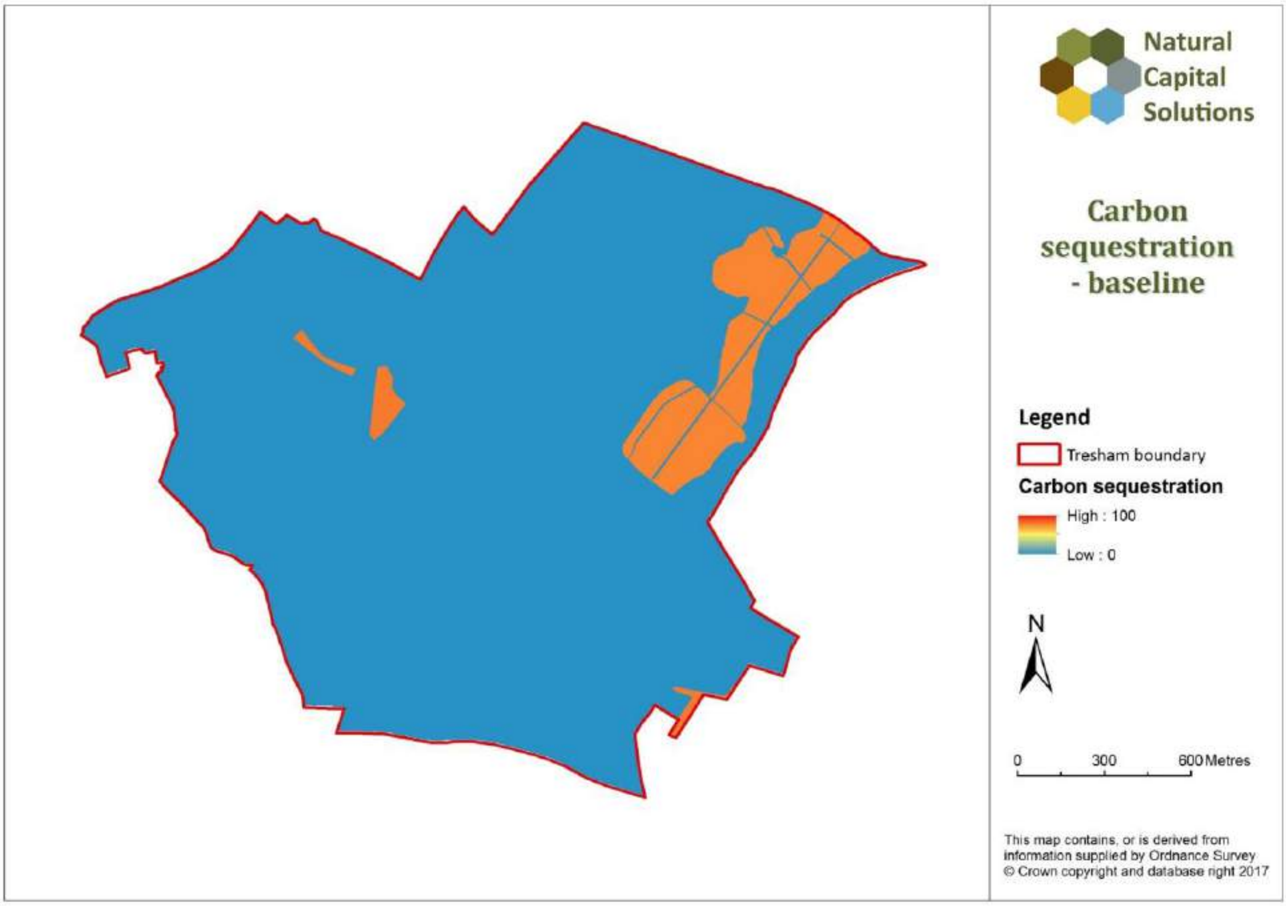
The annual average sequestration rates were then mapped in GIS and, to maintain compatibility with the other ecosystem services maps, the scores were scaled on a 0 to 100 scale, relative to values present within the mapped area.

Results for Tresham

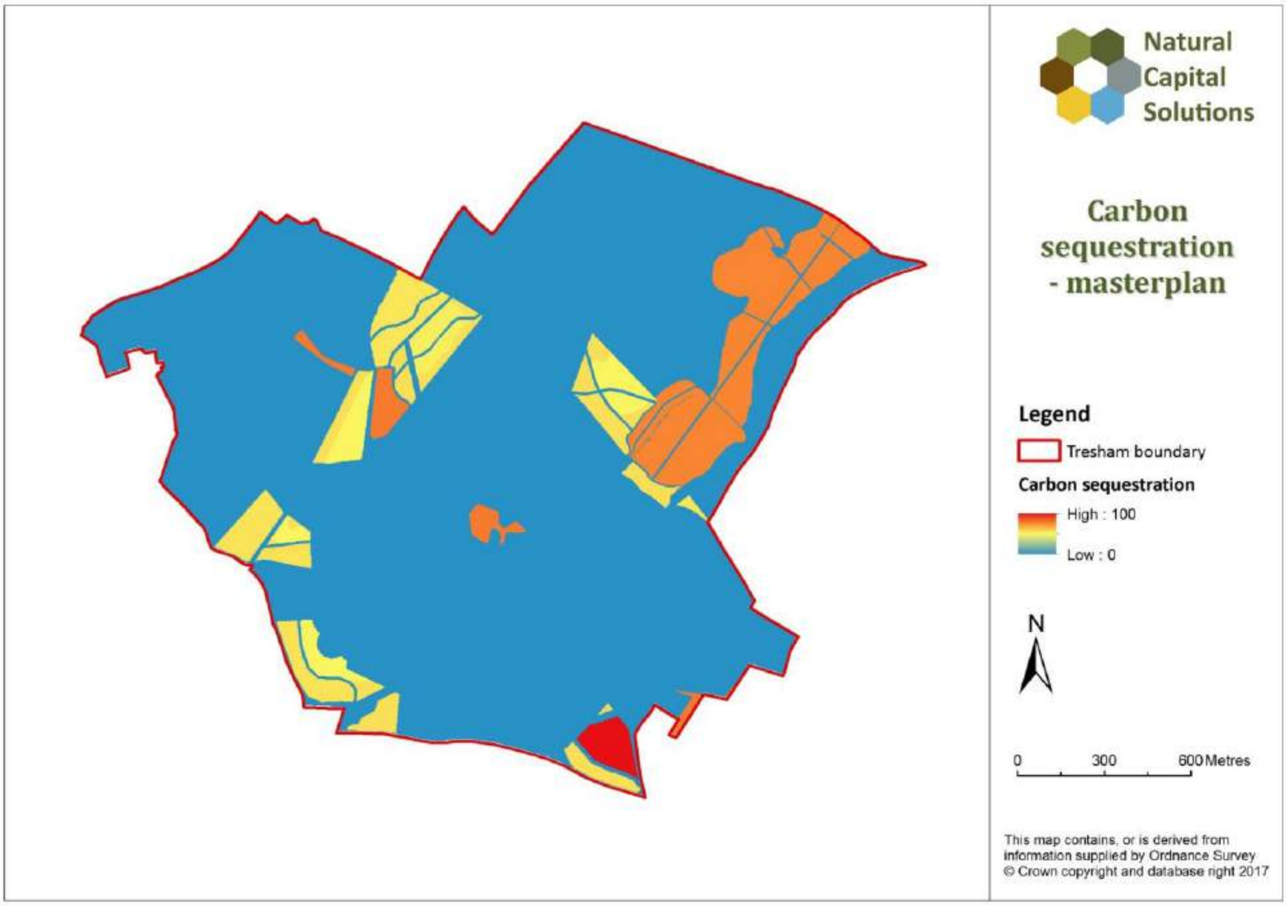
The existing woodlands are sequestering (capturing) carbon at a rate of approximately 5.78-5.95 tonnes of CO_2 equivalent per hectare per year. Langley Coppice, which is dominated by ash, is the main location of carbon sequestration at present. Under the masterplan for the site, several new areas of woodland will provide increased carbon sequestration capacity. The majority of these compartments consist of broadleaved woodland, which will sequester carbon at an average rate of 3.85-5.60 tCO_2e per year. One area is due to be planted with productive conifers (principally Douglas Fir), and this area will have the highest average sequestration rate of 7.52 tCO_2e per year. Overall, the carbon sequestration capacity of the site will almost double under the proposed masterplan, as illustrated through reference to Maps 5 and 6 overleaf.

Baseline score = 5.5 **Masterplan score = 10.8** **Change = 5.3**

Map 5: Carbon sequestration capacity for the baseline condition at Tresham Garden Village



Map 6: Carbon sequestration capacity under the proposed masterplan at Tresham Garden Village



3.3 Air purification capacity (air quality regulation)

What is it and why is it important?

According to the World Health Organisation, air pollution is the greatest environmental health risk in Western Europe and globally. In the UK alone, it is estimated to have an effect equivalent to 29,000 deaths each year and is expected to reduce the life expectancy of everyone in the UK by 6 months on average, at a cost of around £16 billion per year (Defra 2015). Air pollution also contributes to climate change, reduces crop yields, and damages biodiversity.

Air purification capacity estimates the relative ability of vegetation to trap airborne pollutants or ameliorate air pollution. Vegetation can be effective at mitigating the effects of air pollution, primarily by intercepting airborne particulates (especially PM_{10} and $PM_{2.5}$) but also by absorbing ozone, SO_2 and NO_X. Trees provide more effective mitigation than grass or low-lying vegetation, although this varies depending on the species of plant. Coniferous trees are generally more effective than broadleaved trees due to the higher surface area of needles and because the needles are not shed during the winter.

How is it measured?

Local climate regulation capacity was mapped using a modified version of the EcoServ model. The model assigns a score to each habitat type representing the relative capacity of each habitat to ameliorate air pollution. The cumulative score in a 20m and 100m radius around each 10m by 10m pixel was then calculated and combined. The benefits of pollution reduction by trees and greenspace may continue for a distance beyond the greenspace boundary itself, with evidence that green area density within 100m can have a significant effect on air quality. Therefore, the model extends the effects of greenspace over the adjacent area, with the maximum distance of benefits set at 100m. **Note that the model does not take into account seasonal differences or differences in effect due to prevailing wind direction**.

The final capacity score was calculated for each 10m by 10m cell across the study area, and was scaled on a 0 to 100 scale, relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to trap airborne pollutants and ameliorate air pollution.

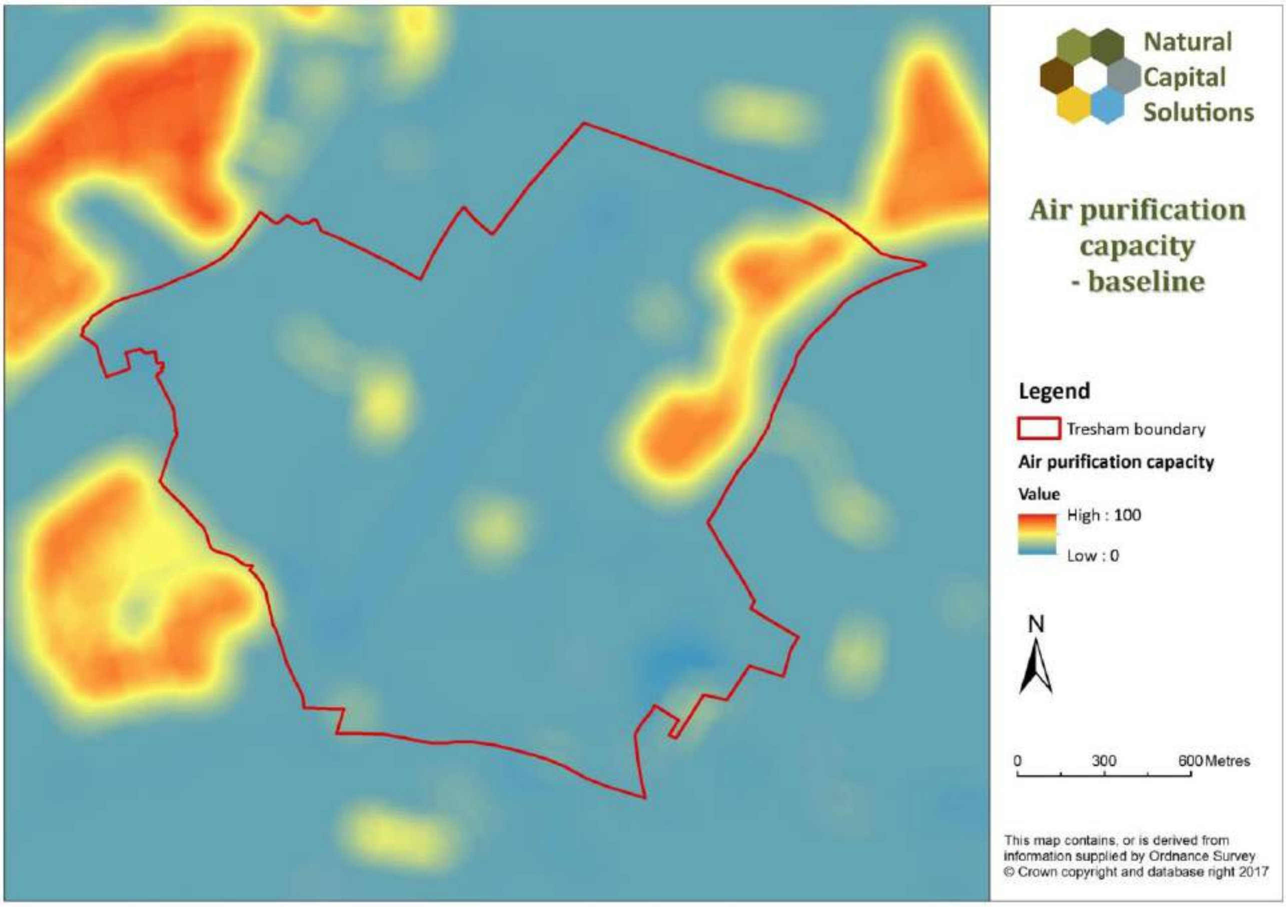
Results for Tresham

Woodland is by far the best habitat at intercepting and absorbing air pollution, with the very highest scores from coniferous forests. The lowest scores (dark blue) are from man-made sealed surfaces and water features which effectively have zero capacity to ameliorate air pollution.

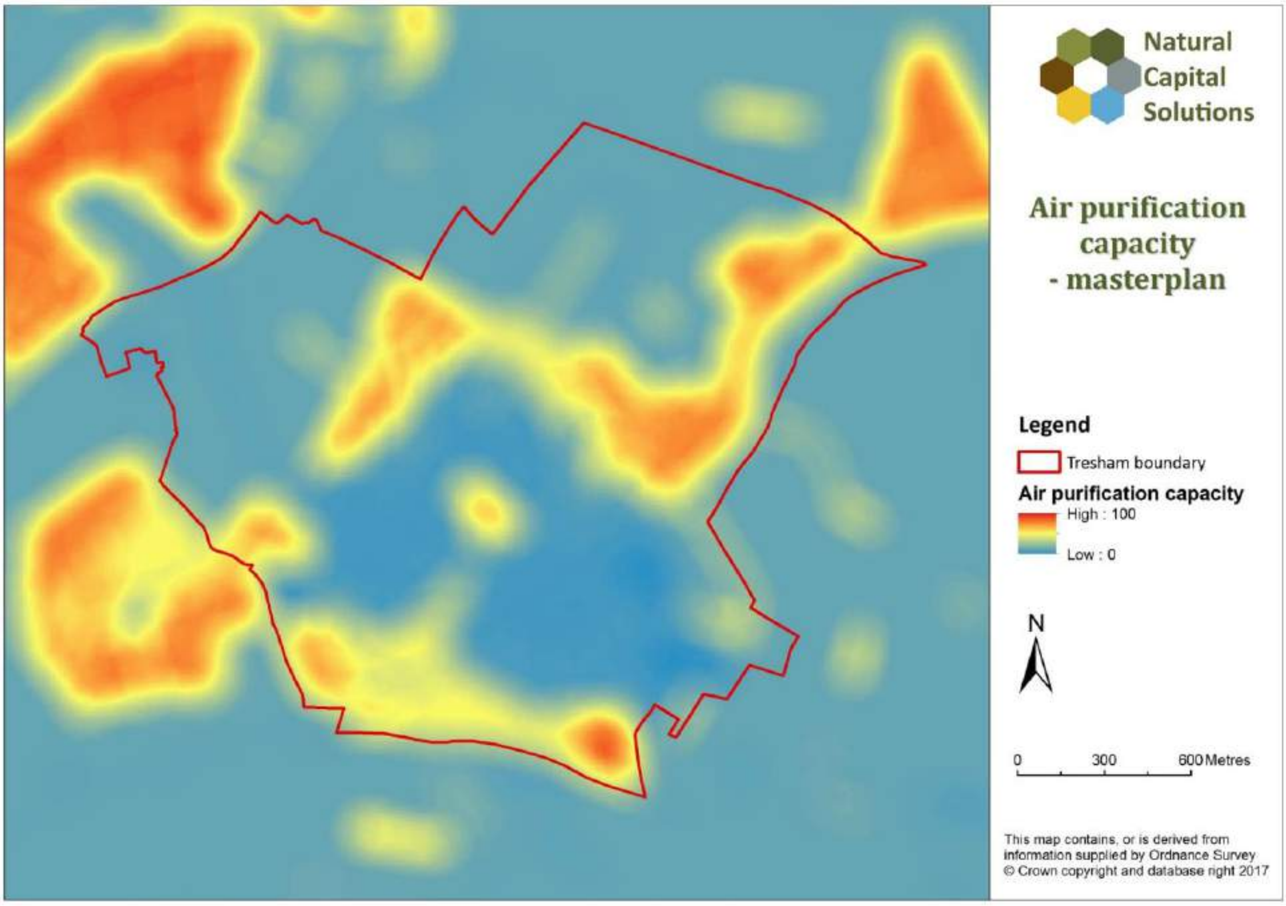
In the baseline, Langley Coppice is apparent as the most effective area at ameliorating air pollution. Under the proposed masterplan, the urban areas are projected to be worse than at present, but the overall impact will be offset by the new areas of woodland planting (see maps 7 and 8). Overall, therefore, the capacity for air purification is expected to increase following development. See the next section for further discussion.

Baseline score = 15.8 **Masterplan score = 23.8** **Change = 8.0**

Map 7: Air purification capacity for the baseline (pre-development) condition at Tresham Garden Village



Map 8: Air purification capacity under the proposed masterplan at Tresham Garden Village



3.4 Air purification demand

What is it and how is it measured?

Air purification demand estimates societal and environmental need for ecosystems that can absorb and ameliorate air pollution. Demand is assumed to be highest in areas where there are likely to be high air pollution levels and where there are lots of people who could benefit from the air purification service.

The model combines two indicators of air pollution sources (log distance to roads, and % cover of sealed surfaces) and two indicators of societal need for air purification (population density, and Index of Multiple Deprivation health score). The scores for each indicator were normalised and combined with equal weighting. The final score was then projected on a 0 to 100 scale, relative to values present within the study area.

Results for Tresham

Air purification demand is highest in urban centres as these have both higher air pollution levels and higher populations that would benefit from better air quality. The main road network is also clearly visible as a major pollution source, and where these main roads pass through built up areas, there is increased demand for air purification.

On Maps 9 and 10, the main orange/yellow area denotes the nearby town of Corby[2]. Under the baseline condition there is very little demand for air purification across the study area, except for low demand along the main roads at the very edge of the site. The masterplan map shows that the new development will create substantial new demand, through both increased pollution and increased people. However, it is expected that the demand will be considerably lower than in Corby.

Baseline score = 1.6 **Masterplan score = 24.4** **Change = 22.8**

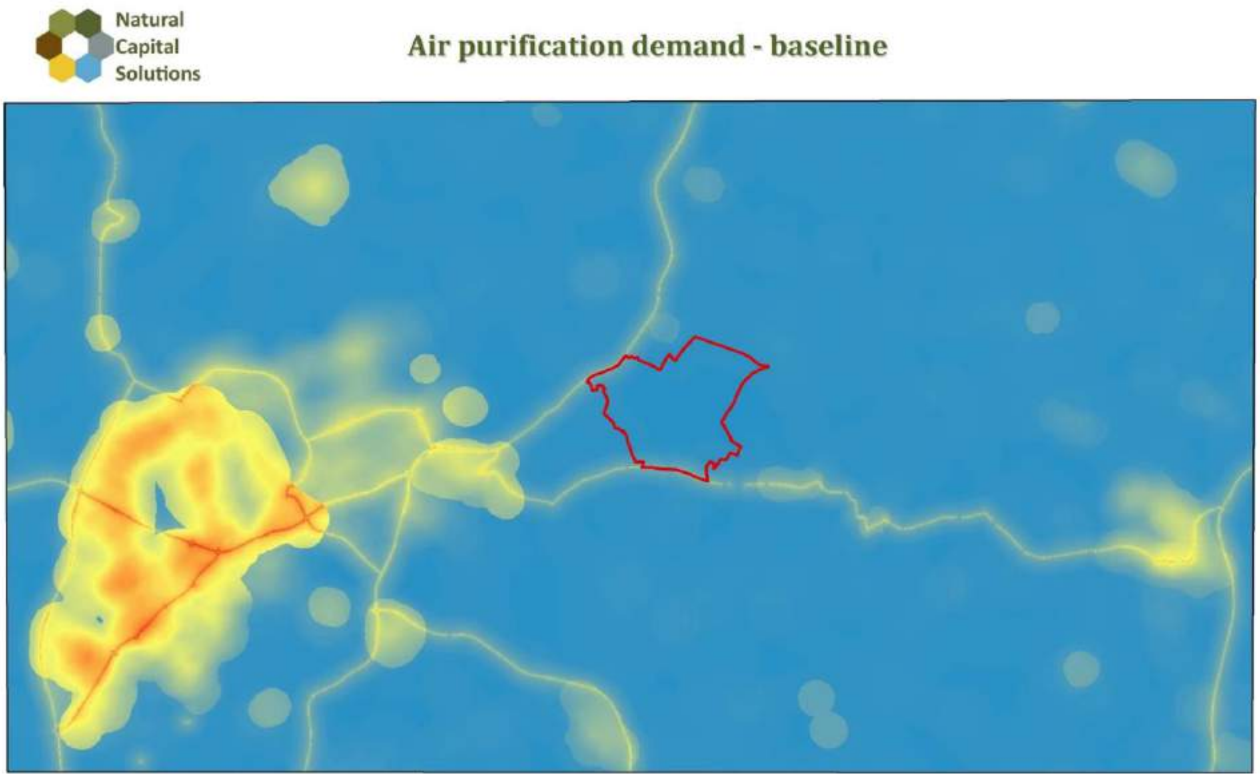
Balancing supply and demand for air purification services

By considering both the air purification capacity and demand maps (Maps 7-10), it is clear that planting (or maintaining) trees and woodland close to main roads and other pollution sources in built-up areas would be highly beneficial, with considerable benefits to society possible. Air pollution can be very localised, hence it is also important to consider the specific location of trees to gain the maximum benefit of this service.

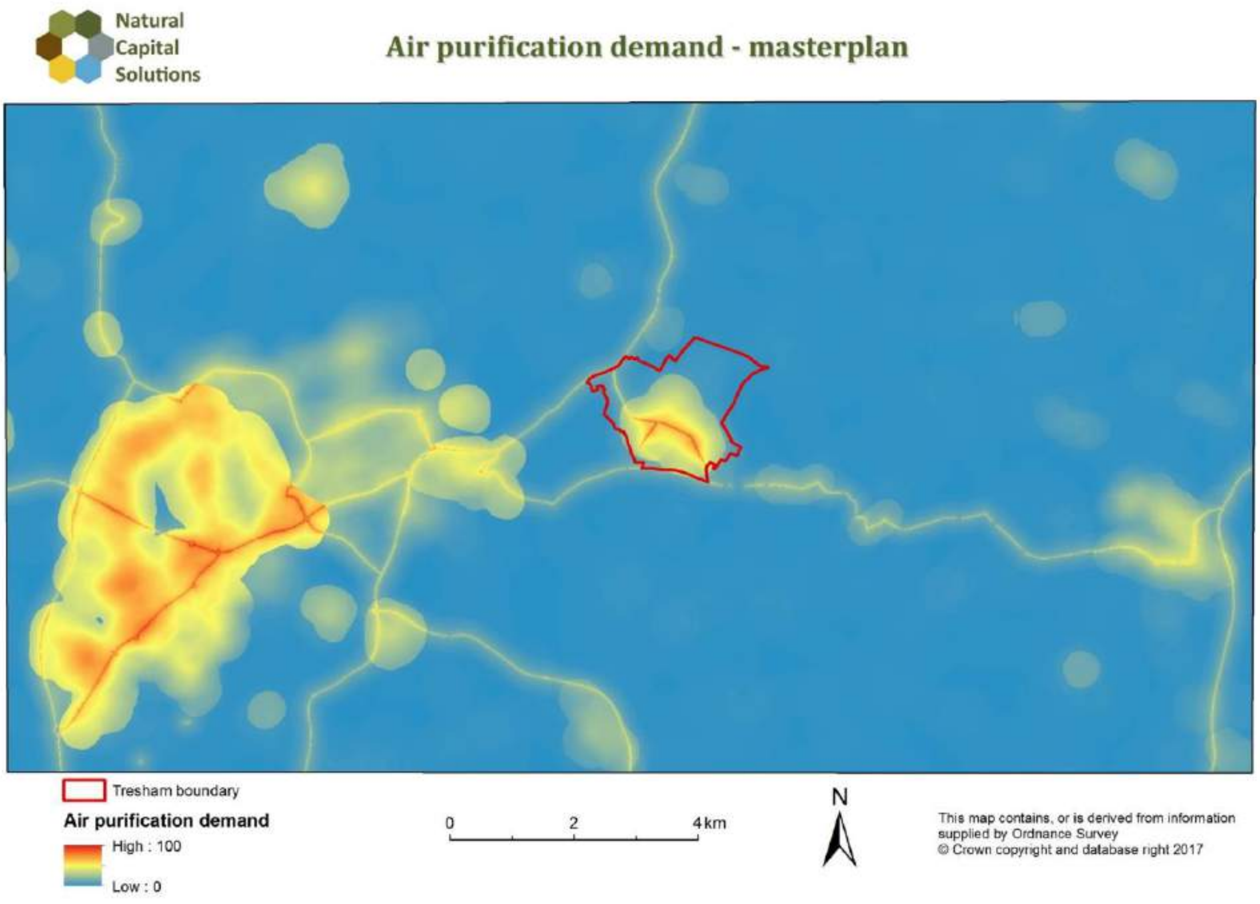
Trees are very effective at mitigating the effects of air pollution. However, there are major difference in the ability of different species to intercept pollution. The location of trees relative to pollution sources also determines how effective they are at removing pollutants, with trees close to sources being the most effective. Urban woodland is particularly effective as it has high capacity to absorb pollution and is also situated in locations likely to have high demand for the service. Street trees, which are not included in the masterplan, would be a beneficial addition as they can be very important at absorbing air pollution adjacent to busy urban roads at a local level. It is important that the right types of trees are planted in the right places, and databases are available that indicate the effectiveness of different species at absorbing air pollution. Other factors should also be taken into account when planting street trees, such as carbon sequestration ability, resilience to urban conditions, growth form and so on.

[2] Note that the demand maps are shown at a broader scale than the previous capacity maps, to highlight demand across the landscape and particularly in relation to Corby

Map 9: Air purification demand for the baseline (pre-development) condition at Tresham Garden Village



Map 10: Air purification demand under the proposed masterplan at Tresham Garden Village



3.5 Noise regulation capacity

What is it and why is it important?

Noise regulation capacity is the capacity of the land to diffuse and absorb noise pollution. Noise can impact on health, wellbeing, productivity and the natural environment and the World Health Organisation (WHO) have identified environmental noise as the second largest environmental health risk in Western Europe (after air pollution). It is estimated that the annual social cost of urban road noise in England is £7 to £10 billion (Defra 2013). Major roads, railways, airports and industrial areas can be sources of considerable noise, but use of vegetation can screen and reduce the effects on surrounding neighbourhoods. Complex vegetation cover such as woodland, trees and scrub is considered to be most effective, although any vegetation cover is more effective than artificial sealed surfaces, and the effectiveness of vegetation increases with width.

How is it measured?

The EcoServ noise regulation model was used, with some modifications. First, the capacity of the natural environment is mapped by assigning a noise regulation score to vegetation types based on height, density, permeability and year round cover. Next, the noise absorption score in 30m and 100m radii around each point was modelled and the scores combined, which results in wider belts of vegetation receiving a higher score. The score was calculated for each 10 m by 10m cell across the study area, and is scaled on a 0 to 100 scale, relative to values present within the mapped area.

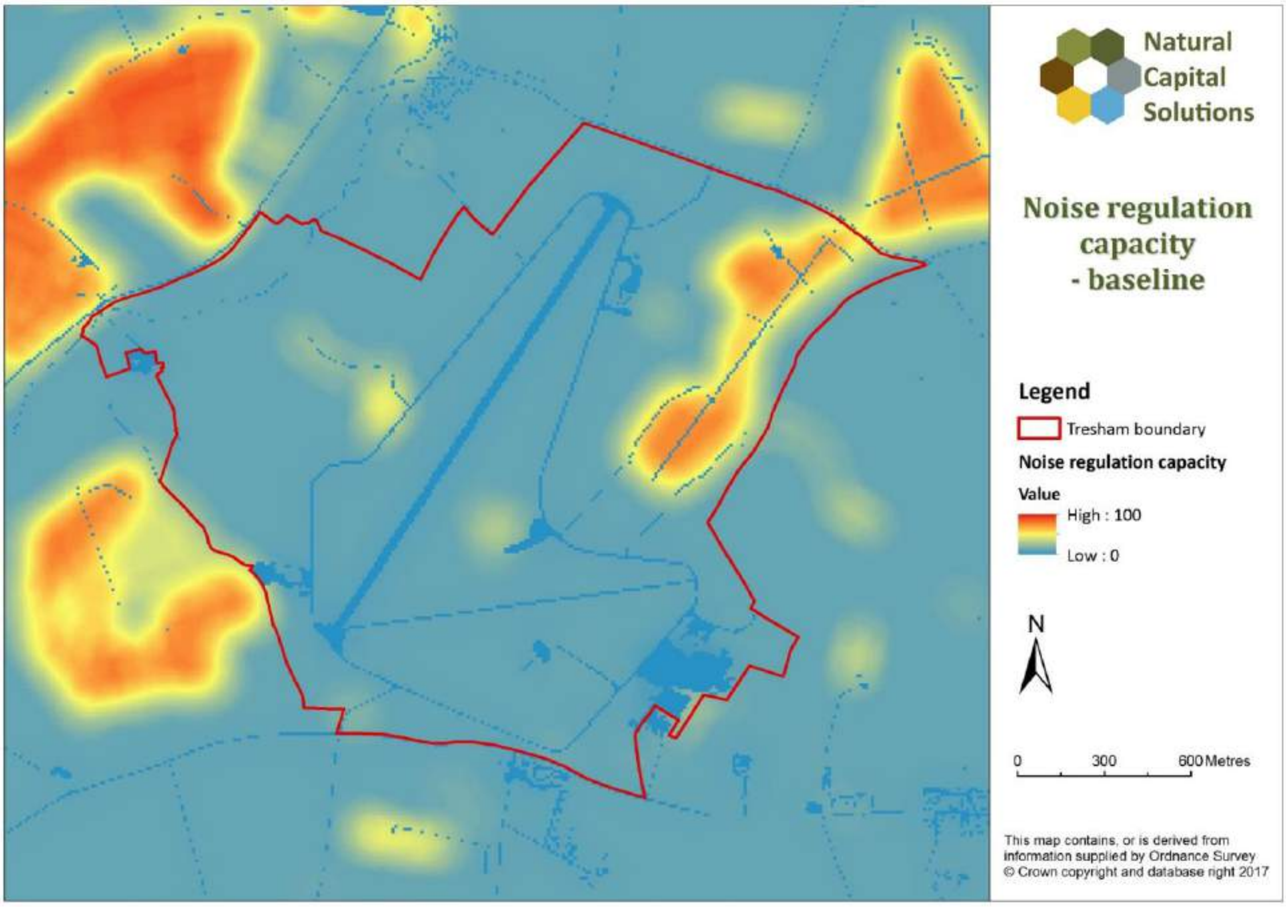
High values (red) indicate areas that have the highest capacity to absorb noise pollution.

Results for Tresham

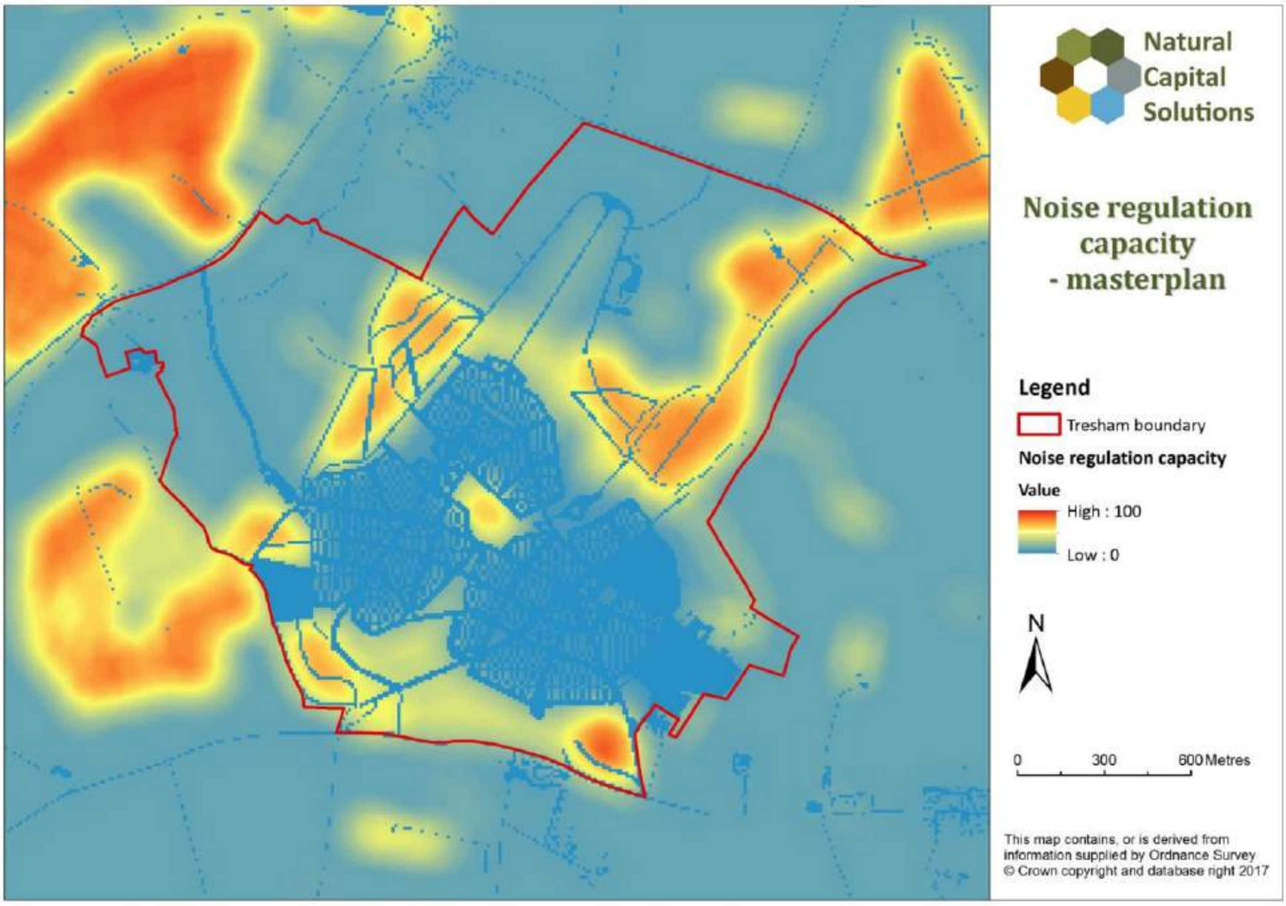
Woodland is by far the most effective habitat at absorbing noise. However, the effects are modest, with reductions of 2-4 dB typically recorded across dense tree belts. Similar to air purification, Langley Coppice is the most effective area at absorbing noise pollution under the baseline condition (Map 11). Noise absorption capacity decreases in the built-up parts of the site under the existing masterplan, but this is offset by increases in capacity in the new woodland plantings surrounding the built area (Map 12). Overall, therefore, the noise regulation capacity of the landscape is expected to increase following development.

Baseline score = 14.7 **Masterplan score = 19.4** **Change = 4.7**

Map 11: Noise regulation capacity for the baseline (pre-development) condition at Tresham Garden Village



Map 12: Noise regulation capacity under the proposed masterplan at Tresham Garden Village



3.6 Noise regulation demand

What is it and how is it measured?

Noise regulation demand estimates societal and environmental need for ecosystems that can absorb and reflect anthropogenic noise. The model combines one indicator that maps noise sources (inverse log distance to different road classes and railways) and two indicators of societal demand for noise abatement (population density, and Index of Multiple Deprivation health scores). Scores are on a 1 to 100 scale, relative to values present within the study area.

Results for Tresham

Maps of noise regulation demand are shown on the next page. To better highlight the areas and distances over which there is demand for this service, the maps only show areas where there is a demand (scores from 1 to 100), with areas with zero demand shown as white. Demand is greatest in urban areas close to major roads, as these contain large populations, with potentially poor health scores, that would benefit from noise abatement from the main roads. The maps also highlight the main road and rail networks.

Similar to air purification demand, Corby provides the greatest demand for this service across the wider area. Under the baseline condition (Map 13), there is little demand for noise regulation across the Tresham study area, apart from along the main roads at the edge of the site.

The masterplan map (Map 14) shows that the new development will create substantial new demand, with both increased noise sources and increased people requiring noise abatement, with maximum new demand adjacent to the main roads within the new built-up area.

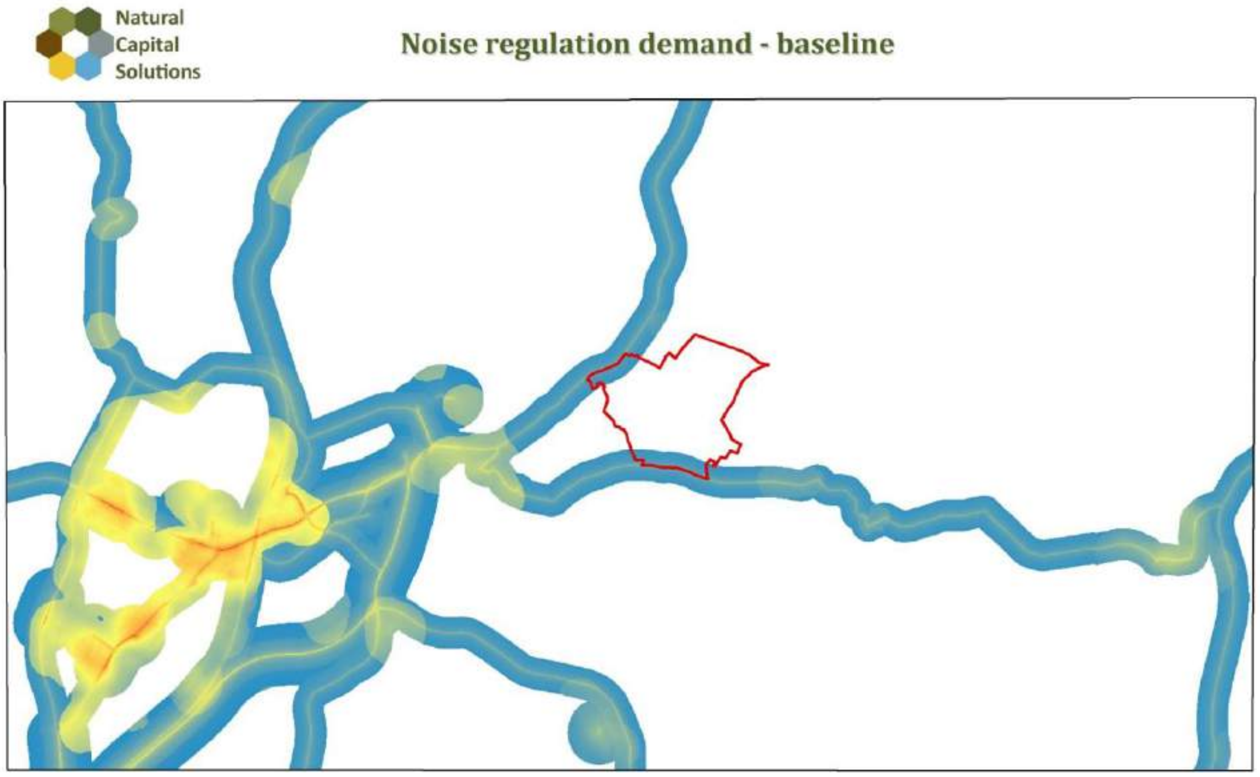
Baseline score = 0.8 **Masterplan score = 11.0** **Change = 10.2**

Balancing supply and demand for noise regulation services

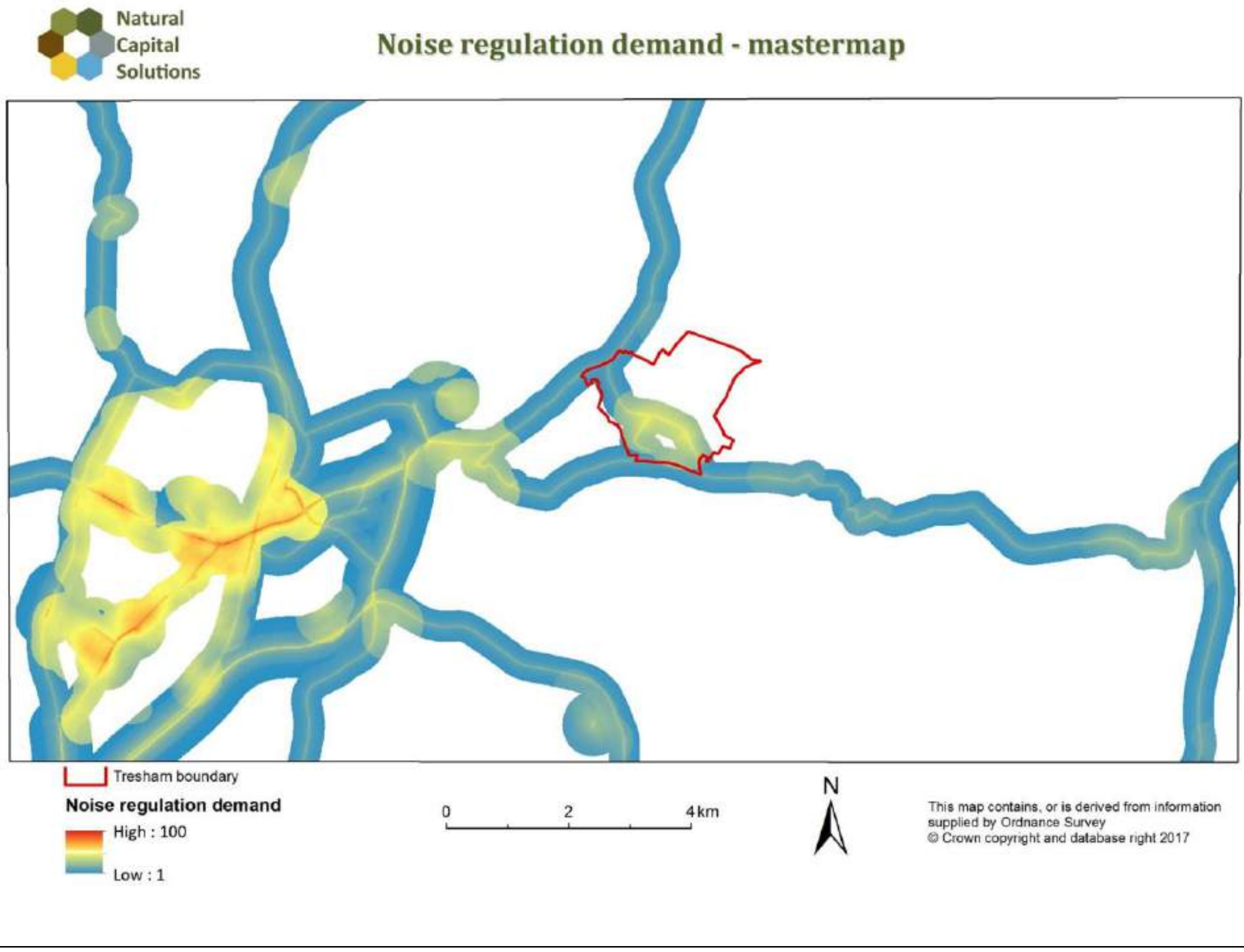
The pattern of supply and demand for this service is rather similar to that of air purification. In both cases demand is localised, especially around the urban road network, and in both cases trees provide the best form of amelioration. Again, planting trees close to main roads and other noise sources would be the most effective mitigation.

Studies in many countries have shown that densely planted tree belts can reduce noise levels, but the effects are modest, with reductions of 2-4 dB typically recorded. Note however, that there is some evidence to suggest that the presence of vegetation blocking views of a noise source such as a road can enhance the perception of noise reduction. Densely planted and complex vegetation cover such as trees mixed with scrub is considered to be most effective, although any vegetation cover is more effective than artificial sealed surfaces.

Map 13: Noise regulation demand for the baseline (pre-development) condition at Tresham Garden Village



Map 14: Noise regulation demand under the proposed masterplan at Tresham Garden Village



3.7 Water flow capacity

What is it and why is it important?

Water flow capacity is the capacity of the land to slow water runoff and thereby potentially reduce flood risk downstream. Following a number of recent flooding events in the UK and the expectation that these will become more frequent over the coming years due to climate change, there is growing interest in working with natural process to reduce downstream flood risk. These projects aim to "slow the flow" and retain water in the upper catchments for as long as possible. Maps of water flow capacity can be used to assess relative risk and help identify areas where land use can be changed.

How is it measured?

A bespoke model was developed, building on an existing EcoServ model and incorporating many of the features used in the Environment Agency's catchment runoff models used to identify areas suitable for natural flood management. Runoff can generally be assessed based on three factors: land use, slope and soil type and so the following indicators were developed and mapped for each 10m by 10m cell across the Nene Valley and buffer area:

- **Roughness score** – Manning's Roughness Coefficient provides a score for each land use type based on how much the land use will slow overland flow.
- **Slope score** – based on a detailed digital terrain model, slope was re-classified into a number of classes based on the British Land Capability Classification and others.
- **Standard % runoff** – was obtained from soil data and modified to reflect soil hydrological properties and their sensitivity to structural degradation from agricultural use. This was integrated with a layer showing impermeable areas where no soil was present (sealed surfaces, water and bare ground).

Each indicator was normalised from 0-1, then added together and projected on a 0 to 100 scale, as for the other ecosystem services. Note that this is an indicative map, showing areas that have generally high or low capacity and is not a hydrological model.

High values (red) indicate areas that have the highest capacity to slow water runoff.

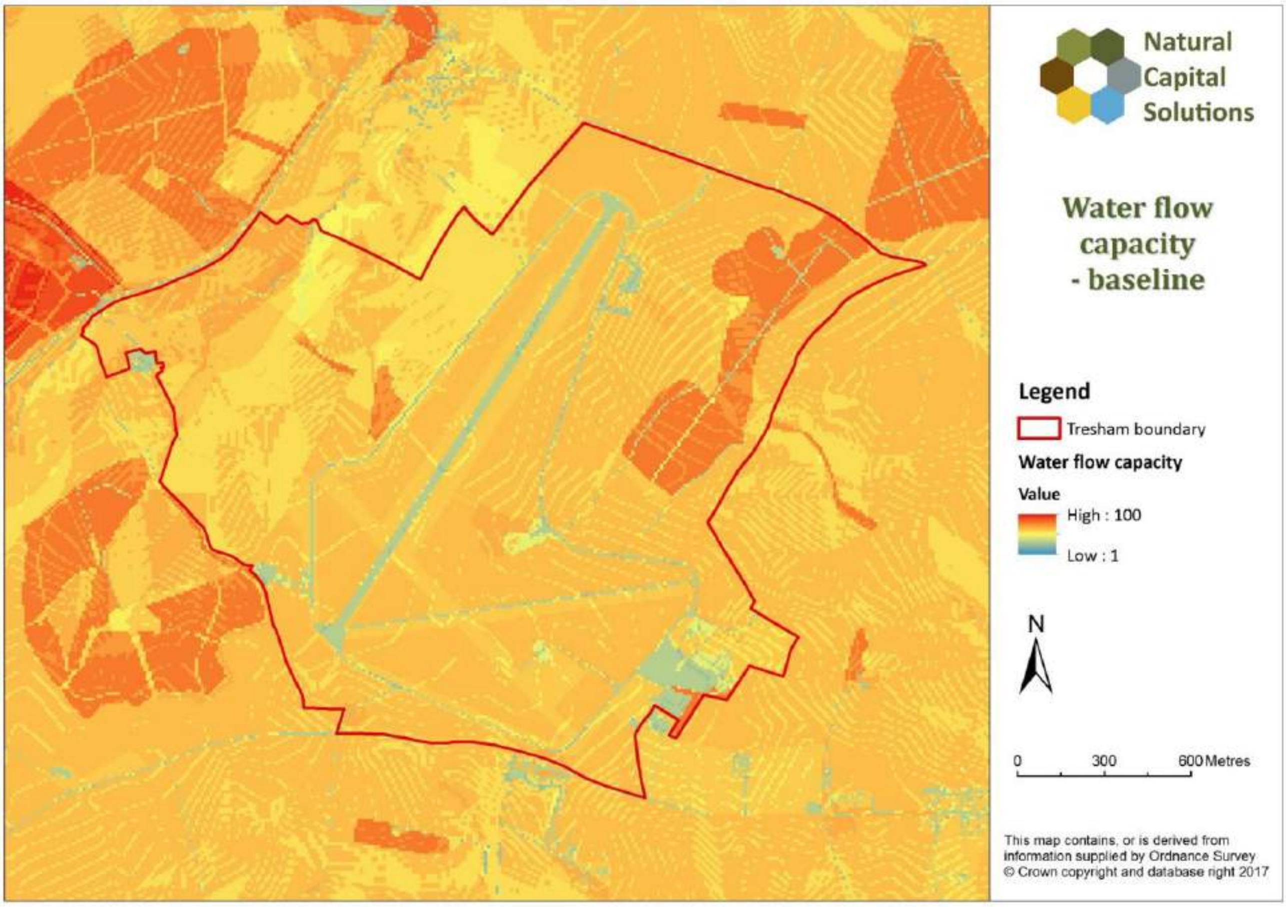
Results for Tresham

The best locations for slowing water runoff are areas of woodland on flat land and permeable soils. The worst areas (blue on the map) are areas of impermeable surface. In the baseline (Map 15), Langley Coppice once again provides the greatest level of service provision, with the old runways and other sealed surfaces being the worst. Under the proposed masterplan m(Map 16), there is a big increase in sealed surfaces (roads and houses), although note that green roofs, permeable paving and other small-scale SuDS features are not included in the analysis. But new woodland planting increases capacity in the adjacent areas.

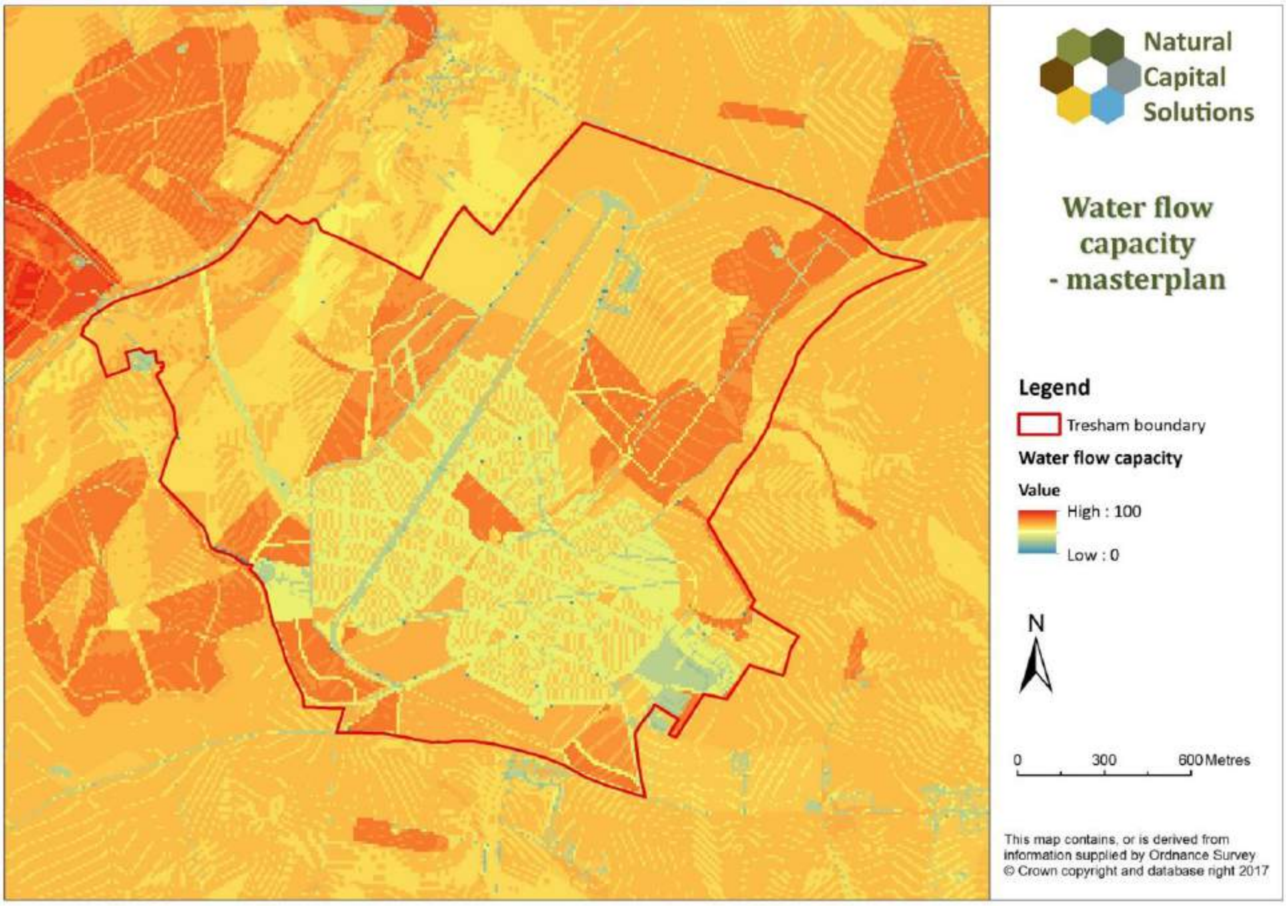
Overall, the capacity for slowing water runoff is expected to show a very slight decrease following development.

Baseline score = 61.2 **Masterplan score = 59.7** **Change = -1.5**

Map 15: Water flow capacity for the baseline (pre-development) condition at Tresham Garden Village



Map 16: Water flow capacity under the proposed masterplan at Tresham Garden Village



3.8 Water quality capacity

What is it and why is it important?

Water quality capacity maps the risk of surface runoff water becoming contaminated with high pollutant and sediment loads before entering a watercourse, with a higher water quality capacity indicating that water is likely to be less contaminated. Note that although urban diffuse pollution is partially captured in the model at catchment scale, the focus is on sedimentation risk from agricultural diffuse pollution, hence built-up areas are not particularly well accounted for in the existing model.

How is it measured?

A modified version of an EcoServ model was developed, which combines a coarse and fine-scale assessment of pollutant risk.

At a coarse scale, catchment land use characteristics were used to determine the overall level of risk. The percentage cover of sealed surfaces and arable farmland in each sub-catchment was calculated and the values were re-classified into a number of risk classes. There is a strong link between the percentage cover of these land uses and pollution levels, with water quality particularly sensitive to the percentage of sealed surfaces in the catchment.

At a fine scale, a modification of the Universal Soil Loss Equation (USLE) was used to determine the rate of soil loss for each cell. This is based on the following three factors:

- **Distance to watercourse** – using a least cost distance analysis, taking topography into account.
- **Slope length** – using a flow accumulation grid and equations from the scientific literature. Longer slopes lead to greater amounts of runoff.
- **Land use erosion risk** – certain land uses have a higher susceptibility to erosion and standard risk factors were applied from the literature. Bare soil is particularly prone to erosion.

Each of the three fine scale indicators and the catchment-scale indicator were normalised from 0-1, then added together and projected on a 0 to 100 scale. As previously, this is an indicative map, showing areas that have generally high or low capacity and is not a process-based model. High values (red) indicate areas that have the greatest capacity to deliver high water quality.

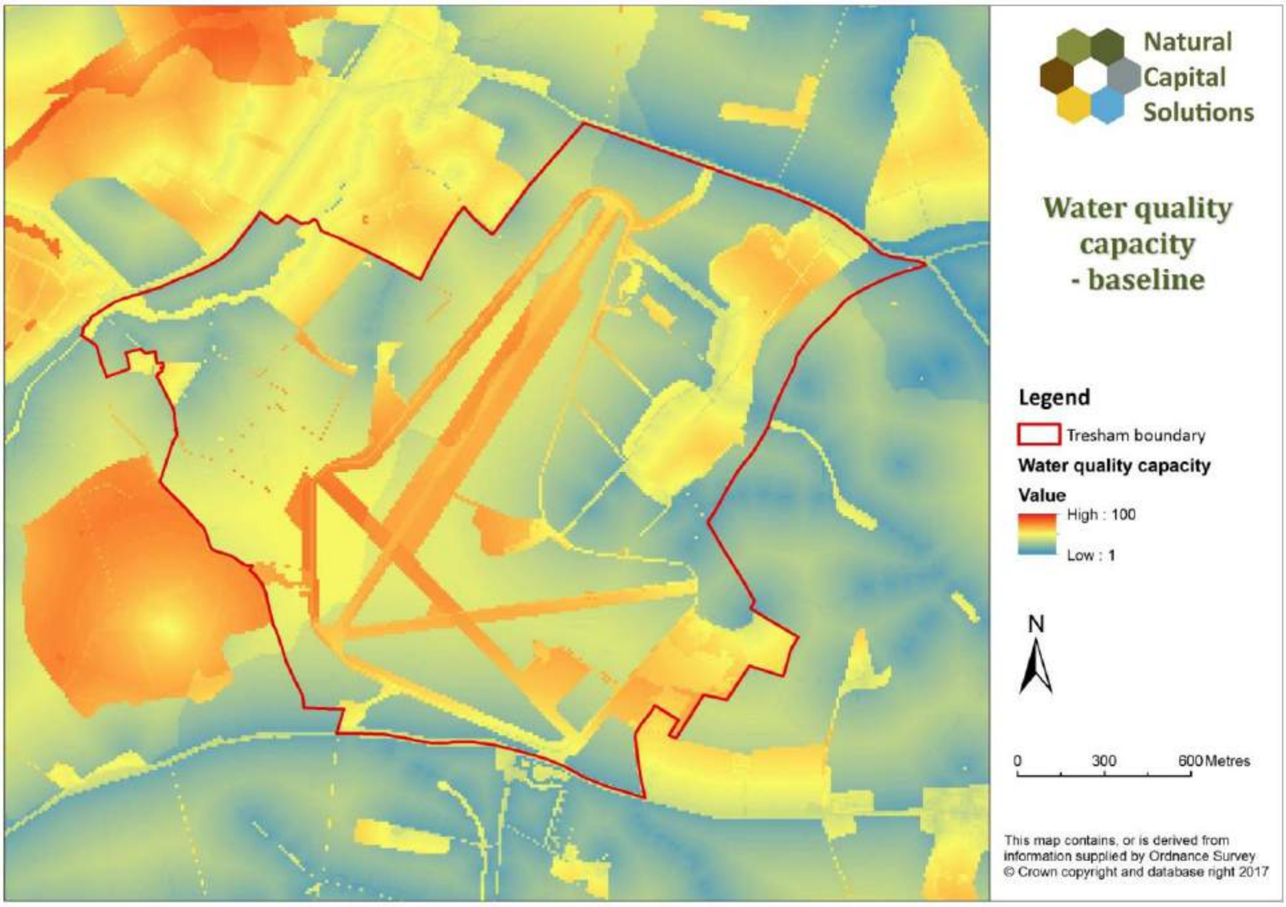
Results for Tresham

Differences in the model that are apparent at a site scale are almost entirely driven by the fine scale modelling of soil loss. Therefore, arable fields, and especially those parts on slopes and close to the watercourses score least well. The remainder of the site scores better, especially as the centre of the site does not contain any watercourses and is relatively flat. Under the baseline condition (Map 17), semi-natural grassland in the centre and west of the site is the highest scoring feature.

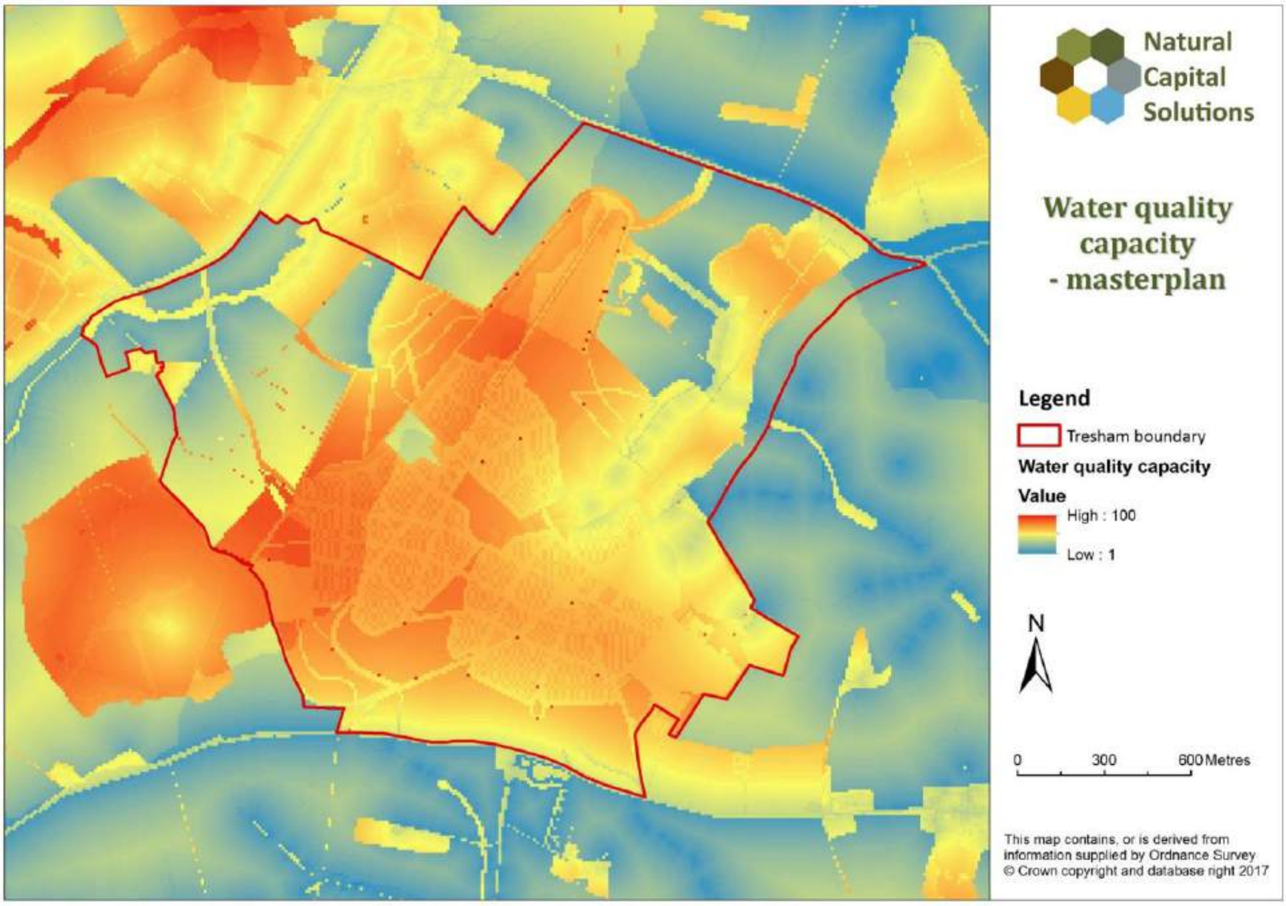
Under the proposed development (Map 18), water quality capacity generally increases (which means that sedimentation risk decreases), as many of the low scoring arable fields, which present a high risk of sedimentation, are replaced with habitats with year-round plant cover, such as parkland, woodland and gardens. Again, the highest scoring area is to the west and centre of the site, on flat land furthest from watercourses, and the lowest scoring areas are the remaining areas of arable land, especially to the east.

Baseline score = 41.4 **Masterplan score = 50.7** **Change = 9.3**

Map 17: Water quality capacity for the baseline (pre-development) condition at Tresham Garden Village



Map 18: Water quality capacity under the proposed masterplan at Tresham Garden Village



3.9 Pollination capacity

What is it and why is it important?

Insect pollinators are essential for human survival and for the natural environment. They pollinate 75% of the native plant species in Britain and directly contribute an estimated £603 million per annum to the British economy through the pollination of agricultural crops. They also pollinate orchard, allotment and garden fruit and vegetables and are essential to the continuing existence of most wild plant species. They have high cultural value, both in their own right and through the maintenance of our countryside and gardens.

Pollination capacity measures the capacity of the land to provide pollination services by estimating the probability that wild insect pollinators will visit each particular pixel of land.

How is it measured?

Pollination capacity was measured using an extension of an EcoServ model, which is itself based on pollination mapping work undertaken across Europe. Pollination capacity was modelled in the following steps:

1. A map of all potential pollinator nesting habitats was produced. This combined:
   - Full habitats – all areas under these habitats potentially provide pollinator habitat and includes semi-natural grasslands, scrub, gardens, and hedgerows.
   - Edge habitats – only the edges of these habitat types are considered to provide suitable pollinator nesting habitats and includes all woodland types. For these habitats only the outer 10m was selected as habitat.
2. The next step was to calculate for each 10m grid square the distance to the potential pollinator habitats identified above.
3. Finally, the visitation probability to each 10m grid square was calculated based on the typical foraging distances of insect pollinators.

The end result was normalised and displayed on a 0-100 scale relative to values present within the study area. High values (red) indicate areas that have the highest probability of visits by insect pollinators.

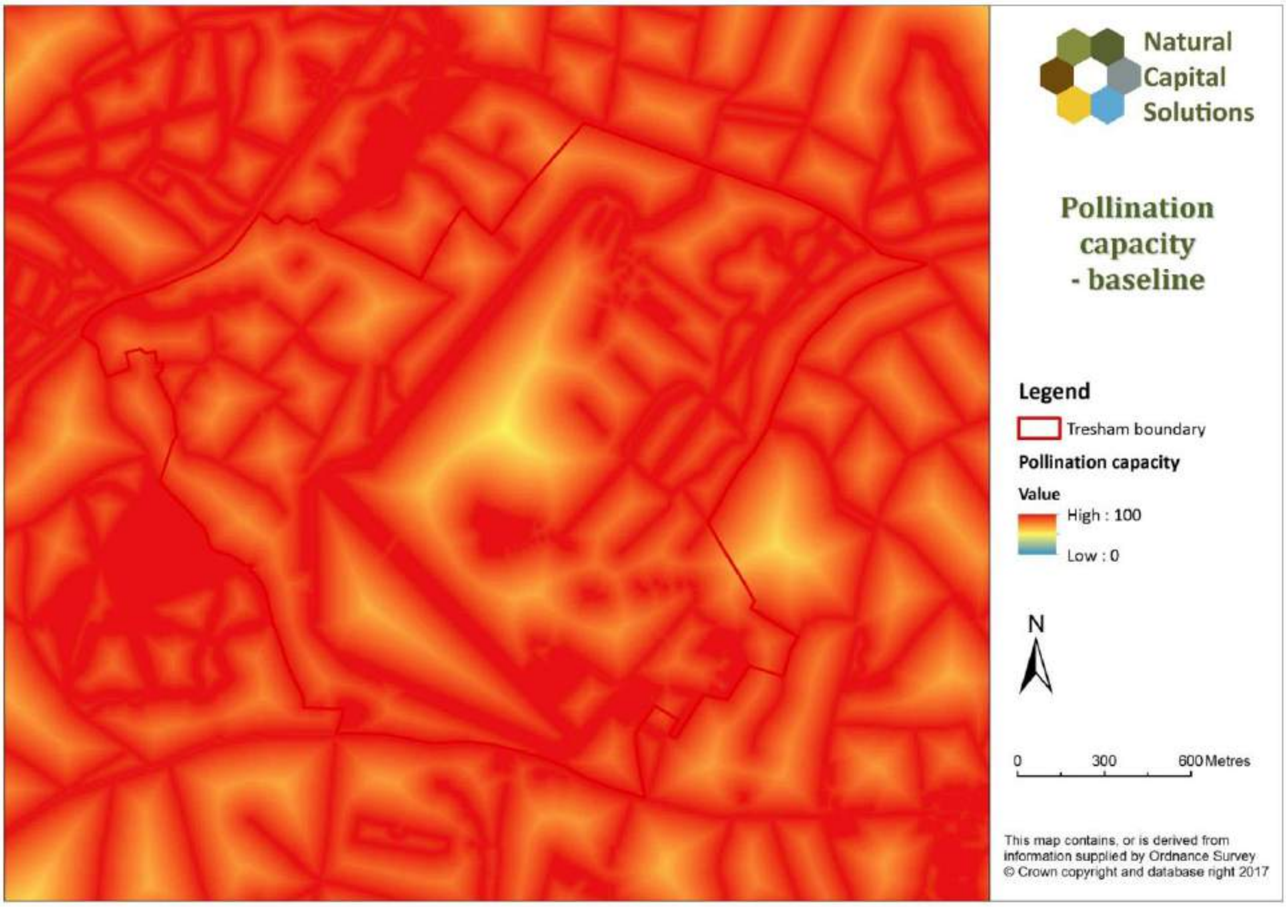
Results for Tresham

Pollinator capacity at Tresham prior to development is high, indicated by the predominately red colours on Map 19, and showing that most of the area is potentially well served by pollinators. Insects are likely to be utilising the strips of semi-natural grassland around the airfield, the hedgerow network and the edges of woodlands. Arable fields and improved grassland do not provide suitable habitat, although field edges can be important.

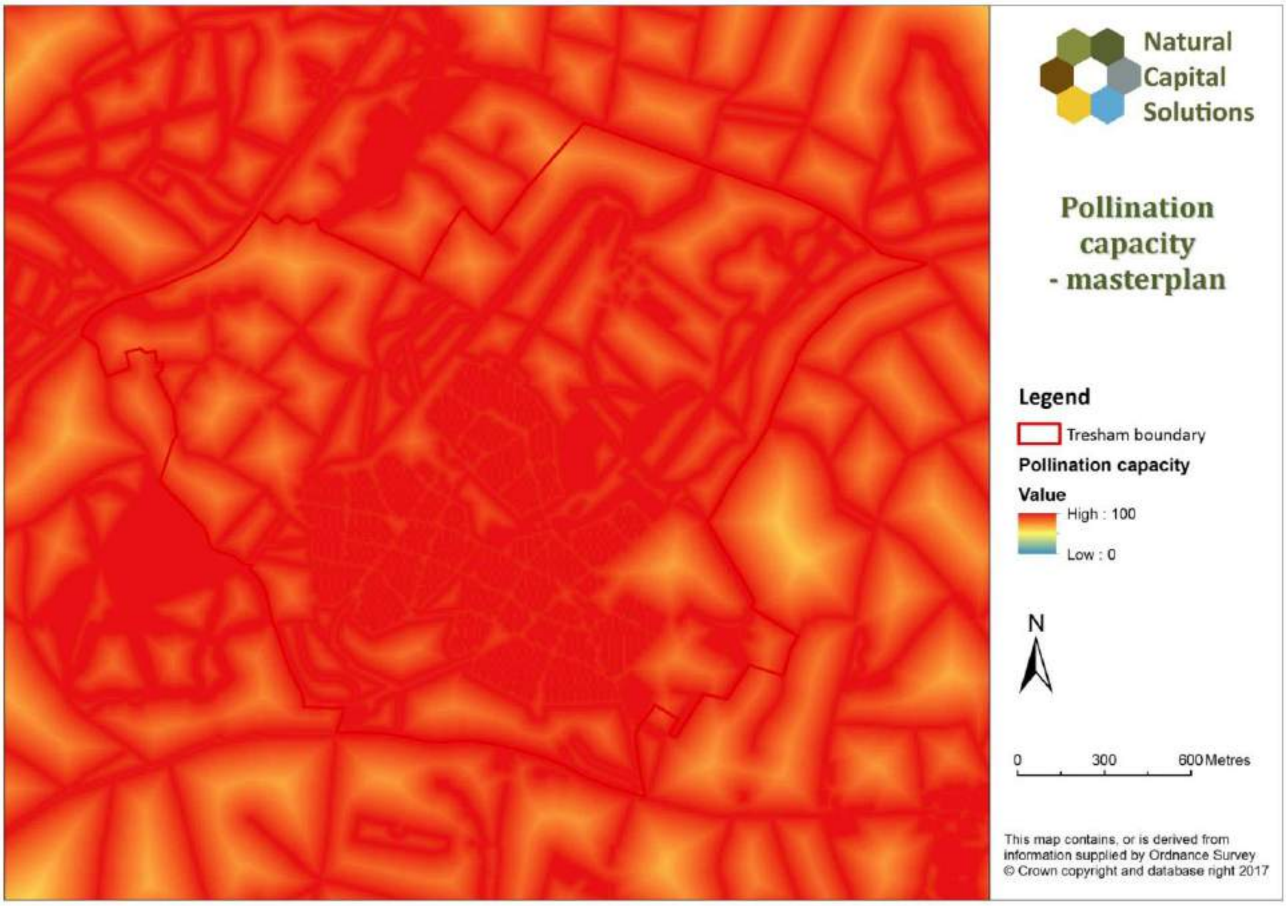
Pollinators are also able to utilise gardens, hence under the proposed masterplan, there is actually an increase in pollination capacity and the area is projected to be almost fully served by pollinators after development (Map 20).

Baseline score = 91.1 **Masterplan score = 95.4** **Change = 4.3**

Map 19: Pollination capacity for the baseline (pre-development) condition at Tresham Garden Village



Map 20: Pollination capacity under the proposed masterplan at Tresham Garden Village



3.10 Accessible nature capacity

What is it and why is it important?

Access to greenspace is being increasingly recognised for the multiple benefits that it can provide to people. In particular there is strong evidence linking access to greenspace to a variety of health and wellbeing measures. Research has also shown that there is a link between wellbeing and perceptions of biodiversity and naturalness. Natural England and others have published guidelines that promote the enhancement of access, naturalness and connectivity of greenspaces.

The two key components of accessible nature capacity are therefore public access and perceived naturalness. Both of these components are captured in the model, which maps the availability of natural areas and scores them by their perceived level of "naturalness".

How is it measured?

An EcoServ model was used to map accessible nature capacity. In the first step, accessible areas are mapped. These are defined as:

- Areas 10m either side of linear routes such as Public Rights of Way, pavements and Sustrans routes.
- Publicly accessible areas such as country parks, CRoW access land, local nature reserves and accessible woodlands.
- Areas of green infrastructure marked as accessible, including parks, playgrounds, and other amenity greenspaces.

These areas were then scored for their perceived level of naturalness, with scores taken from the scientific literature. Naturalness was scored in a 300m radius around each point, representing the visitors experience within a short walk of each point.

The resulting map shows accessible areas, with high values representing areas where habitats have a higher perceived naturalness score. Scores are on a 1 to 100 scale, relative to values present within the study area. White space shows built areas or areas with no public access.

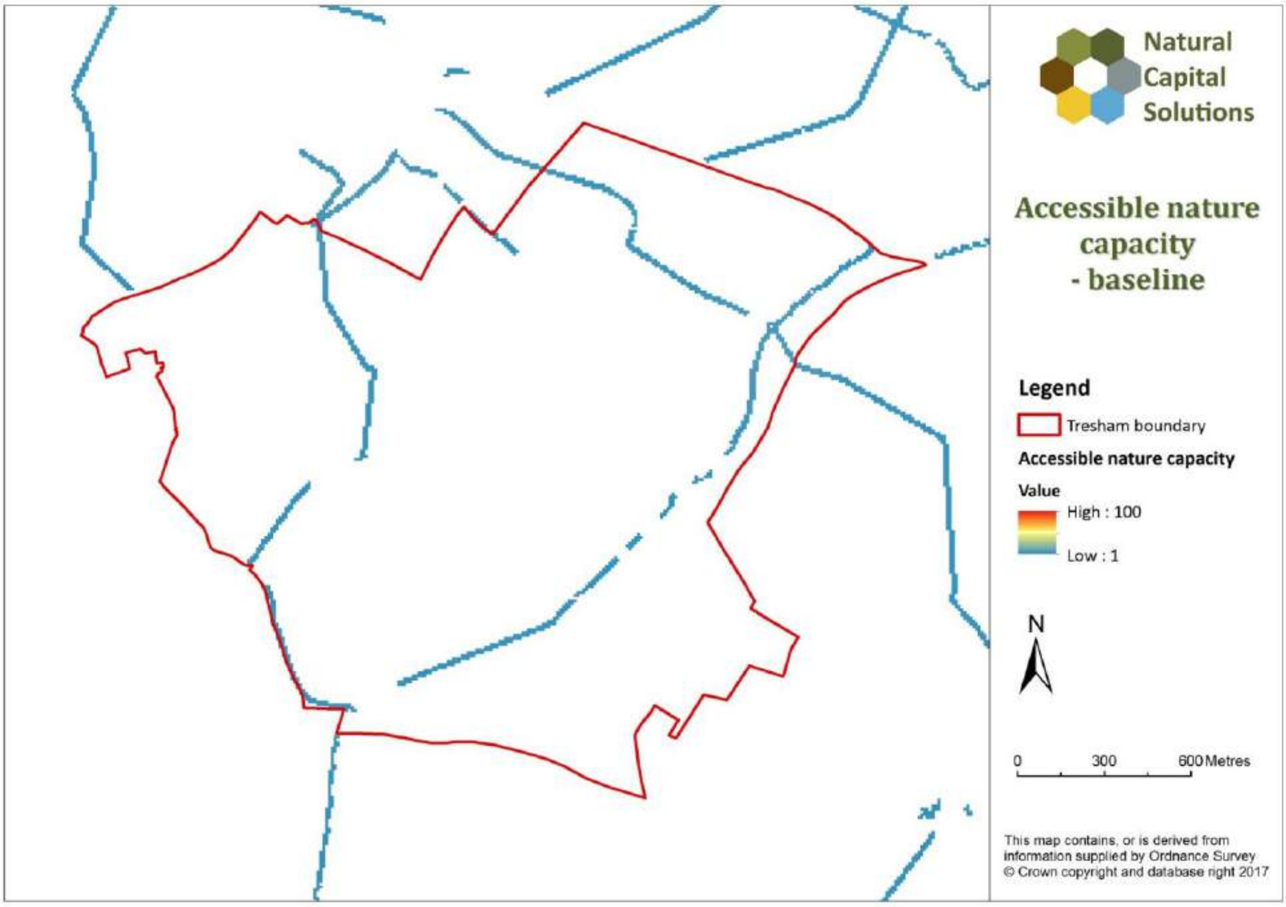
Larger continuous blocks of more natural habitat types will have higher scores than smaller isolated sites of the same habitat type. One consequence is that linear routes, such as footpaths, that pass through land with no other access will not score highly.

Results for Tresham

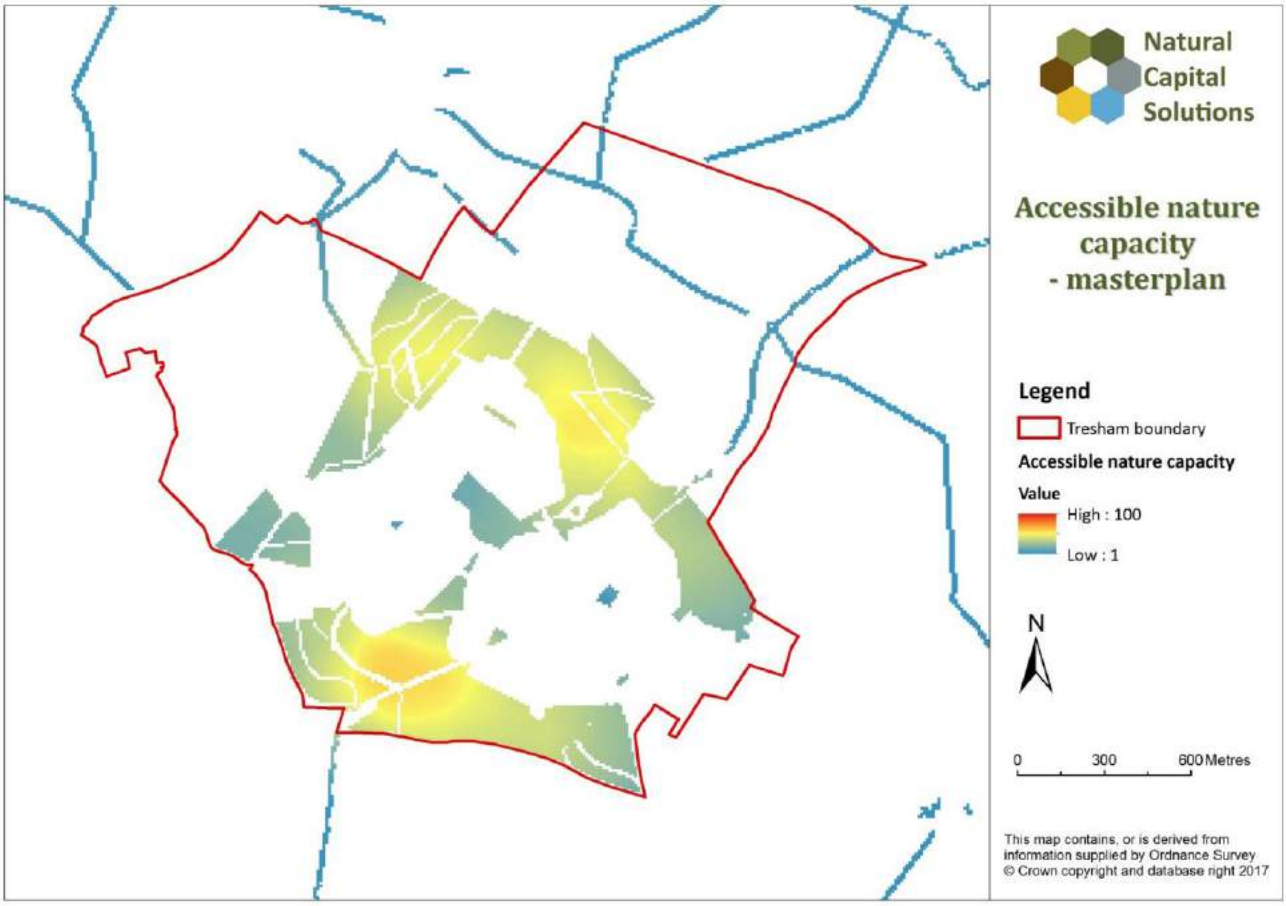
Under the current situation, there is no public access across the site, apart from along the footpath network, which appear as blue lines on Map 21. Hence the baseline score is extremely low. The proposed masterplan provides lots of accessible habitats, especially around the edge of the main built area, in the new woodland and parkland areas (Map 22). However, these are still relatively small blocks of habitat, hence these areas are mostly shown as green-yellow, indicating intermediate scores. Overall, accessible nature capacity is expected to increase dramatically from a very low base prior to development, although still remaining relatively low.

Baseline score = 0.1 **Masterplan score = 8.7** **Change = 8.6**

Map 21: Accessible nature capacity for the baseline condition at Tresham Garden Village



Map 22: Accessible nature capacity under the proposed masterplan at Tresham Garden Village



3.11 Accessible nature demand

What is it and why is it important?

This indicates where there is greatest demand for accessible nature, which is strongly related to where people live. Research, including large surveys such as the Monitor of Engagement with the Natural Environment (MENE), as well as surveys conducted as part of the Nene Valley NIA project, have shown that there is greatest demand for accessible greenspace close to people's homes, especially for sites within walking distance.

How is it measured?

This model maps sources of demand, taking no account of habitat, based on three indicators: population density (based on 2011 census data), health scores (from the Index of Multiple Deprivation), and distance to footpaths and access points. The three indicators are calculated at three different scales as demand is strongly related to distance. The Visitor Access Study of the Upper Nene Valley Gravel Pits SPA was used to determine appropriate distances. The distances chosen (and rationale) were: 800m (the median distance travelled by people walking to sites), 3.2 Km (median distance travelled by all visitors using all modes of transport), and 14 Km (90% of all visitors travelled less than this distance).

The three indicators were normalised from 0-1, then combined with equal weighting at each scale and then the three different scales of analysis were combined and projected on a 0 to 100 scale. High values (red) indicate areas (sources) that generate the greatest demand for accessible nature.

Results for Tresham

Demand for accessible nature is focussed around where people live, hence Corby provides the largest demand in the wider area. Under the current baseline there is only limited demand across the Tresham site and this is driven by a small amount of local demand from the village of Deenethorpe, together with some longer-distance demand from Weldon and Corby (Map 23). Creating a new village at Tresham will create significantly greater demand for accessible nature within the site boundary, especially local-scale, within a short walk of peoples' homes (Map 24). Overall, therefore, demand will increase substantially following development.

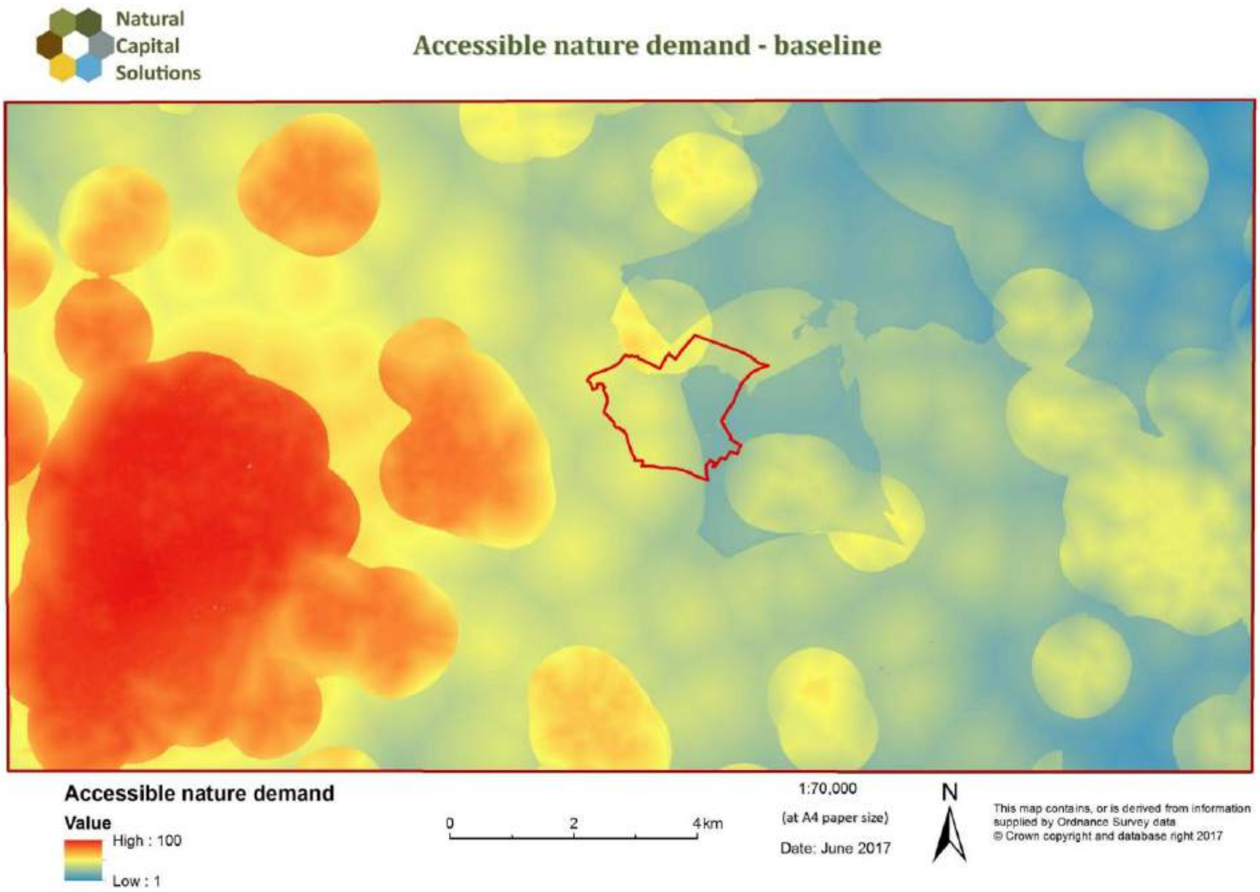
Baseline score = 34.4 **Masterplan score = 60.8** **Change = 26.4**

Balancing supply and demand for accessible nature

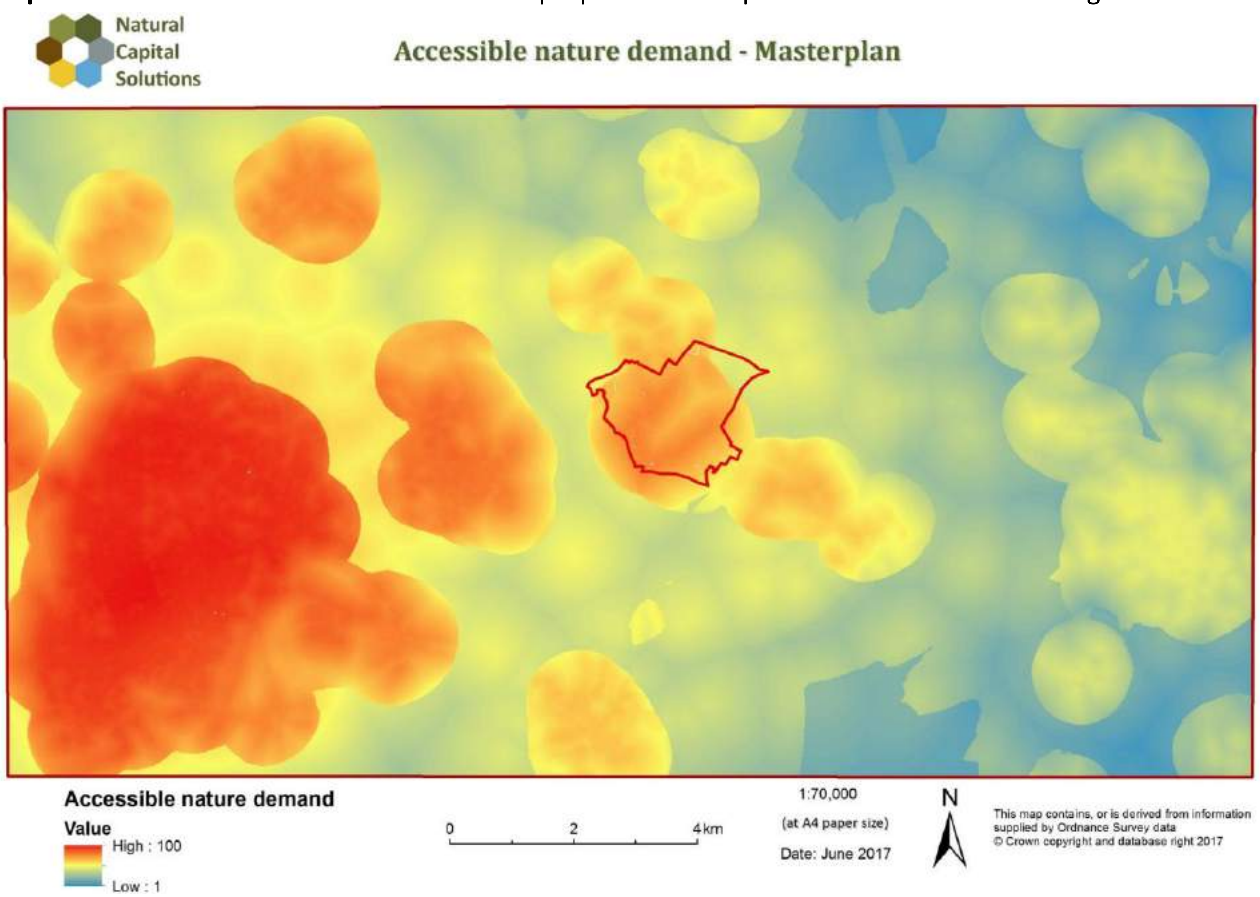
Numerous research has shown that people travel most frequently to greenspaces very close to their homes and Natural England recommend that everyone should have access to at least some greenspace within 300m (5 minutes walk) and larger sites within 2 km. Furthermore, surveys both in Northamptonshire and nationally have shown that the median distance that people will travel to visit even high quality greenspace is only 3.2 km. Any new housing area will create demand for accessible greenspace. It is therefore vitally important that this demand is met on-site.

There is now a vast amount of evidence showing the benefits of greenspace, particularly in built-up areas. Furthermore, research has shown that people gain greater well-being from visiting sites that they perceive to be more natural and richer in biodiversity. This shows that as well as providing access to greenspace on a new development such as Tresham, it is important that the greenspace is of a high quality and as natural as possible.

Map 23: Accessible nature demand for the baseline condition at Tresham Garden Village



Map 24: Accessible nature demand under the proposed masterplan at Tresham Garden Village



3.12 Agricultural production capacity

What is it and why is it important?

Agricultural production models the capacity of the land to produce food under current farming practices. Farming is the dominant land-use within the site prior to development and it is important that the impact on farming and rural livelihoods is taken into account when considering the impact of the development.

It should be noted that agricultural production is reliant upon a combination of the natural environment and human inputs, in the form of machinery and other manufactured inputs, labour and expertise. Hence a value for agricultural production capacity includes more than simply natural capital and does not attempt to disentangle natural from human inputs.

4.15.2 How is it measured?

A model was created that estimates the gross margin of agricultural production for each parcel of land:

1. Crop areas were obtained from Rob Wilkinson, representing the Brudenell Estate, for each separate land holding (there were four land holdings within the Tresham Garden Village site boundary).
2. Information on the financial performance of farm businesses in England was obtained from Defra's Farm Business Survey. The average gross margin over the last five years was calculated for each crop and livestock type. This takes into account yields (for crops) and farm gate prices, to give gross output, and subtracts typical variable costs (e.g. fertilizers, seeds, sprays, husbandry, feed and forage costs) to give gross margins.
3. The average gross margin per hectare was calculated for each of the four holdings by multiplying the crop area by the relevant gross margin for each crop type in turn, and then averaging across the holding.
4. In GIS, all parcels of land within a land holding were assigned the average value for that holding. To maintain compatibility with the other maps, the scores were then normalised on a 0 to 100 scale relative to values present within the study area.
5. Under the masterplans, all parcels remaining as arable land were assumed to maintain the same gross margin as before development. For new areas of grazing, gross margin was calculated based on typical gross margin per head (from the Farm Business Survey), multiplied by the stocking density (assumed to be 1.5 livestock units per hectare for improved grassland, and 1 unit per ha for semi-natural grassland).

Note that this does not take into account fixed costs such as buildings and machinery. However, gross margin is the usual way in which agricultural outputs are reported in government statistics and in the scientific literature.

Results for Tresham

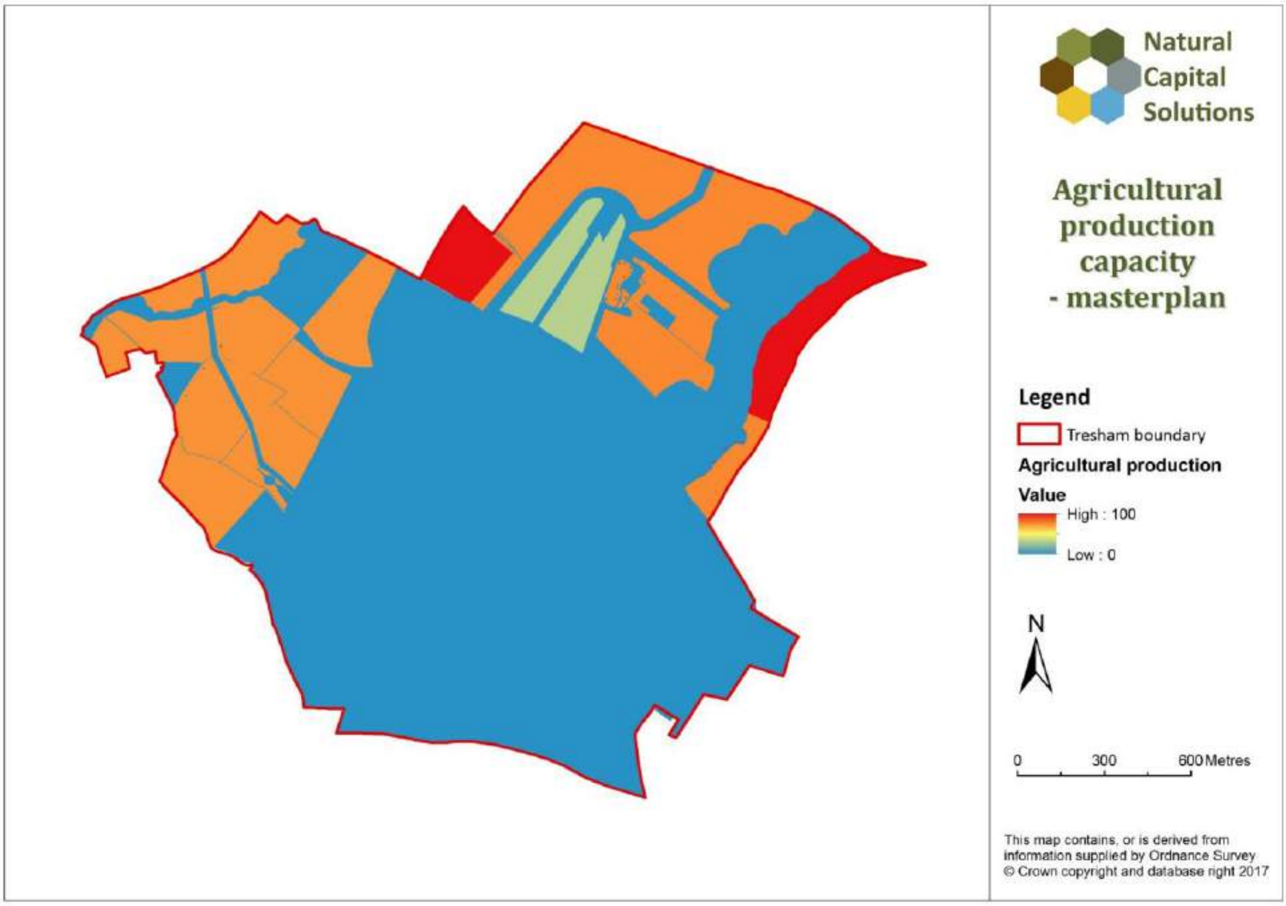
All the agricultural land within the study area boundary is currently under arable use, although one of the holdings has livestock immediately adjacent to the study area. A variety of crops are grown, with winter wheat (42% of the land area), winter oilseed rape (18%), winter barley (14%), spring wheat (9%), field beans (8%), oats (4%), sugar beet (3%) and maize (2%) being grown in 2016-17.

Under the masterplan (Map 26), agricultural output would decrease significantly, as many of the agricultural fields are built on or converted to other land uses. It is assumed that beef cattle will be grazed on the area of improved grassland to either side of the runway to the north of the main built zone, with a gross margin of around £306 per ha. No grazing is assumed to take place on the parkland areas, species rich meadow, or marshy grassland, but low intensity grazing would certainly be possible in these habitats, and if so, overall agricultural production would be a little higher than stated here. Overall, the agricultural production capacity of the site will decline by more than half.

Baseline score = 51.4 **Masterplan score = 23.4** **Change = -28.0**

Map 25: Agricultural production capacity for the baseline condition at Tresham Garden Village

Map 26: Agricultural production capacity under the proposed masterplan at Tresham Garden Village



3.13 Timber capacity

What is it and why is it important?

Timber capacity is simply a measure of the average value of the timber that could be extracted from each area of land per annum. Forestry remains an important component of the rural economy and many areas of woodland are still valued primarily on their timber value, hence it is important to capture this. It is also expected that at least some of the new woodland plantings will provide a commercial timber crop.

How is it measured?

information on the species mix and yield class for each compartment of new woodland, along with information on the existing areas of woodland, was obtained from The Deenethorpe Airfield Woodland Creation Plan (2016). This was used to determine the average yield of timber (m^3) per hectare per year for each different compartment.

This benefit was converted into a monetary value by multiplying the annual volume of timber by the unit value of timber (£ per m^3). The price for broadleaved timber ranges from £15 for woodfuel up to £250 per m^3 standing for high quality timber. It was assumed that most of the wood produced at Tresham will be used for woodfuel, so a conservative estimate was made using the lower price. The price for softwood was taken from the Forestry Commissions Coniferous Standing Sales Price Index 2016, with a mean price of £18.36 per m^3.

The annual average value of timber per hectare for each compartment was then mapped in GIS and, to maintain compatibility with the other ecosystem services maps, the scores were scaled on a 0 to 100 scale, relative to values present within the mapped area.

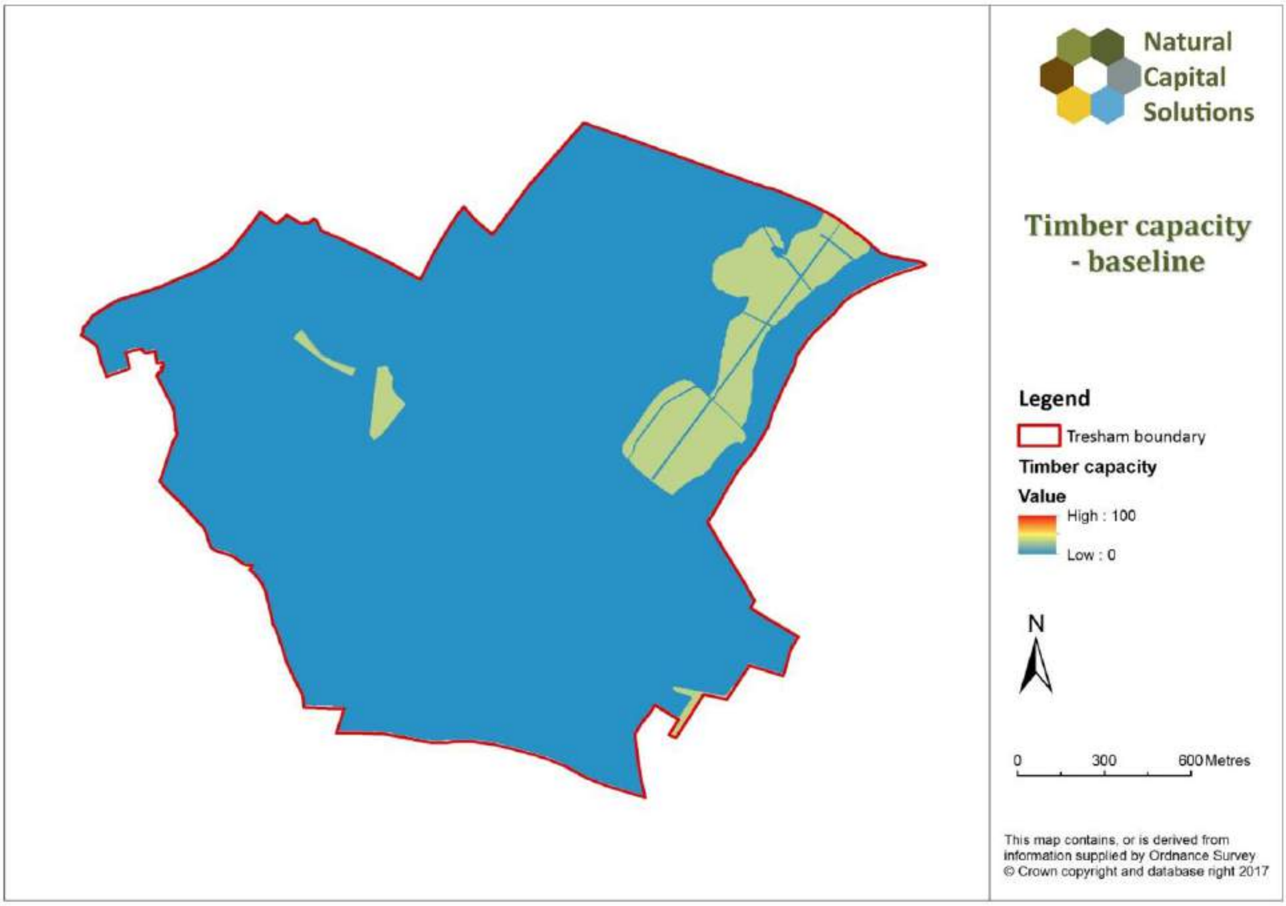
Results for Tresham

The existing areas of woodland around Tresham (Map 27) could provide an annual output of about £90 per hectare, if they were harvested for woodfuel. **Note however that this is the output and not the gross or net margin, so does not take into account harvesting, labour or other costs.** Under the proposed masterplan (Map 28), the potential timber output would increase significantly. Most of the new plantings are going to be broadleaved mixes, which would have a potential output of around £90-110 per annum if harvested for firewood. This could be considerably higher if harvested for high quality timber. One compartment is due to be planted as a productive conifer compartment (predominantly Douglas Fir), which would be expected to produce an output of around £269 per ha, with a further compartment of mixed woodland, with an expected output of £179 per ha per year.

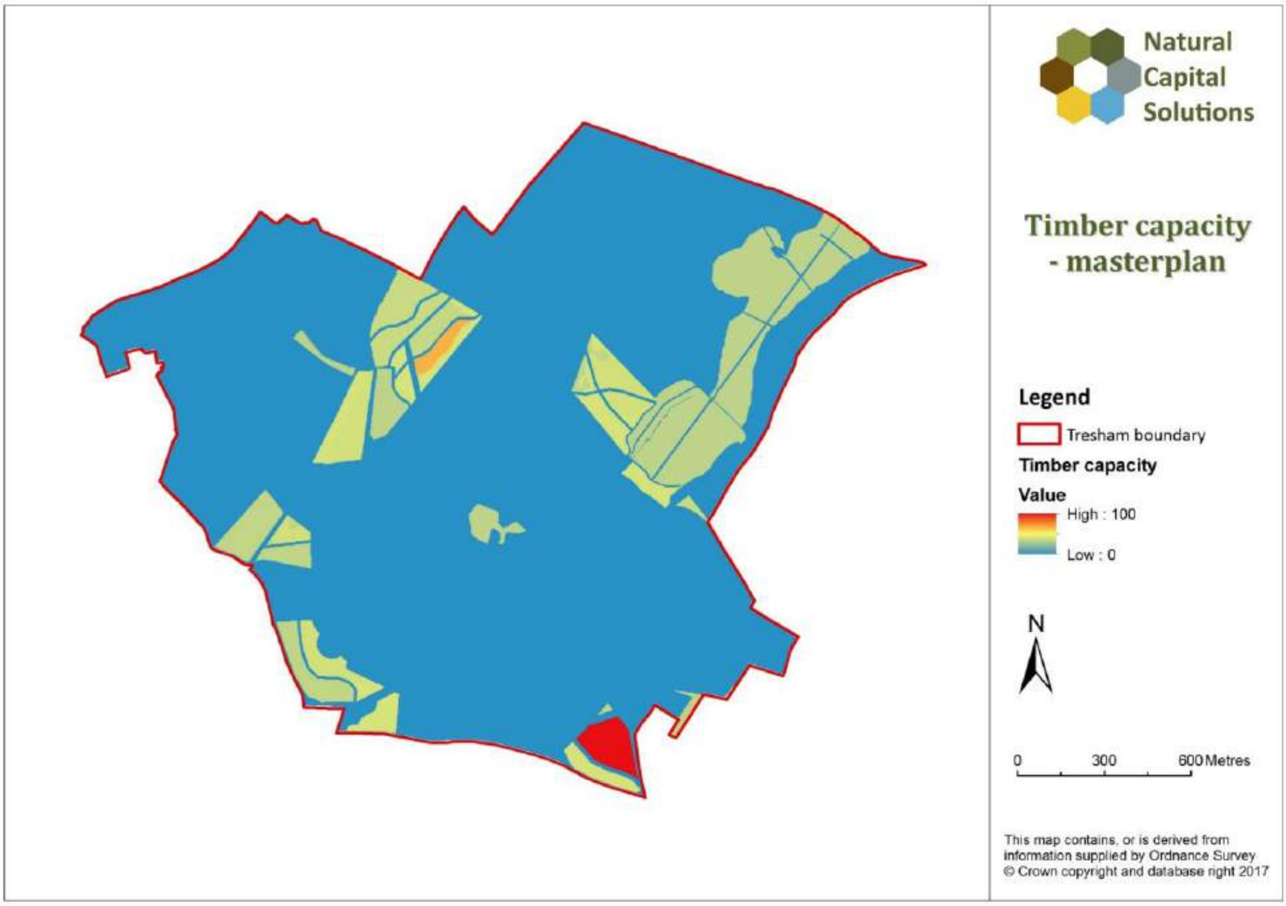
Overall, the timber capacity of the site will almost triple, although it remains relatively low compared to if the site was entirely managed as a commercial forestry enterprise.

Baseline score = 2.4 **Masterplan score = 6.3** **Change = 3.9**

Map 27: Timber production capacity for the baseline condition at Tresham Garden Village



Map 28: Timber production capacity under the proposed masterplan at Tresham Garden Village



3.14 Biodiversity capacity

What is it and why is it important?

Biodiversity capacity provides a measure of the quality of the habitats present at the site. It is based on habitats rather than species, as very few species records exist for areas of the wider countryside, such as Tresham, outside of nature reserves. Habitat can be assessed much more easily and gives an indication of overall quality for biodiversity. It also forms the basis of the Defra biodiversity metric, now being used frequently in assessments to determine ecological impact, including biodiversity net gain and offsetting.

Having habitats that support rich biodiversity is important in its own right, but also as biodiversity fundamentally underpins many of the ecosystem services from which we gain benefit. There is increasing evidence that areas richer in biodiversity support higher levels of ecosystem service provision for a whole range of services.

How is it measured?

The measure that has been developed is based on the Defra biodiversity metric. For the baseline situation, all habitats are scored by multiplying together two factors:

- **Habitat distinctiveness** – is scored as low (2), medium (4) or high (6). Distinctiveness includes parameters such as species richness, diversity, rarity and the degree to which a habitat supports species rarely found in other habitats. In general, intensive agricultural habitats are scored as low, semi-natural habitats score medium, and priority habitats score high.
- **Habitat condition** – is scored as poor (1), moderate (2) or good (3) and is based on standard condition assessment criteria applied to the specific habitat at the site.

For the situation under the proposed masterplan, two different maps have been produced. The first (Score 1, Map 30) simply uses the two categories above, with the scores based on the habits being planned. Thus, this score assumes that each new habitat is properly established and has been created successfully. This fits with the other ecosystem services maps, which all assume that any new habitats are fully and successfully established.

The second version of the metric (Score 2, Map 31) fully applies the Defra biodiversity metric be considering two additional constraints. Here, an initial score is calculated as above, based on the intended habitat, but this is then downweighted by dividing by the two additional factors:

- **Difficulty of creation / restoration** – a standard score given to each habitat type, scored as low (1), medium (1.5), high (3) and very high (10).
- **Years to target condition** – a sliding scale from 5 years (1.2) up to a maximum of over 30 years (3) is applied based on the length of time it takes to establish each new habitat in the target condition.

The final score for each parcel of land was then mapped in GIS and, to maintain compatibility with the other ecosystem services maps, the scores were scaled on a 0 to 100 scale, relative to values present within the mapped area.

Results for Tresham

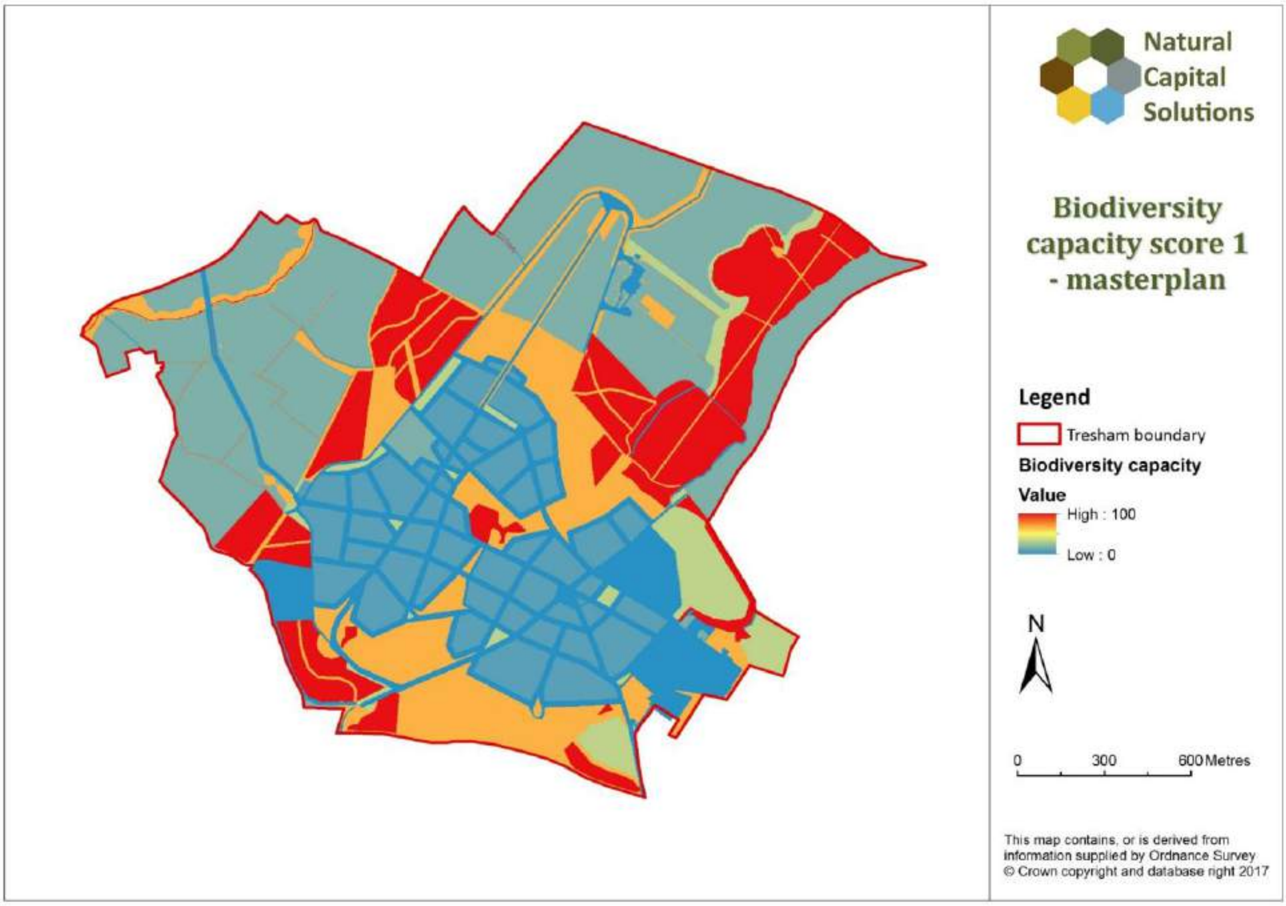
Langley Coppice provides the highest biodiversity capacity under the baseline conditions as it has high habitat distinctiveness, although it is only in moderate condition (Map 29). Some of the hedgerows also provide good quality habitat. The areas of semi-natural grassland are of moderate interest, with medium habitat distinctiveness, but most of the rest of the site has little capacity for biodiversity as it is dominated by arable with low habitat distinctiveness.

Under the simpler scoring option (Score 1, Map 30), that assumes that all new habitats have established successfully, the new broadleaved woodlands are expected to achieve a relatively high score. Planted woodlands of this type can only be classified as having medium distinctiveness, but they are expected to be managed to achieve good condition. The new parkland and semi-natural grasslands are expected to achieve medium distinctiveness and moderate condition. The infrastructure and buildings will reduce the biodiversity capacity in the core built area, but this is more than offset by the new habitats surrounding the built zone. This is reflected in the overall score, which increases under the proposed masterplan.
Under Score 2 (Map 31), which is a full implementation of the Defra biodiversity metric, to account for the time and difficulty required to establish new habitats, the new woodlands achieve a much lower score. This is because woodlands take a long time to establish properly and present a medium level of difficulty to achieve good condition. All of the new habitats score less than under Score A, but the grassland habitats are less penalised as they are so much quicker to establish. Applying the Defra metric, the overall biodiversity value is expected to fall very slightly compared to the baseline position.

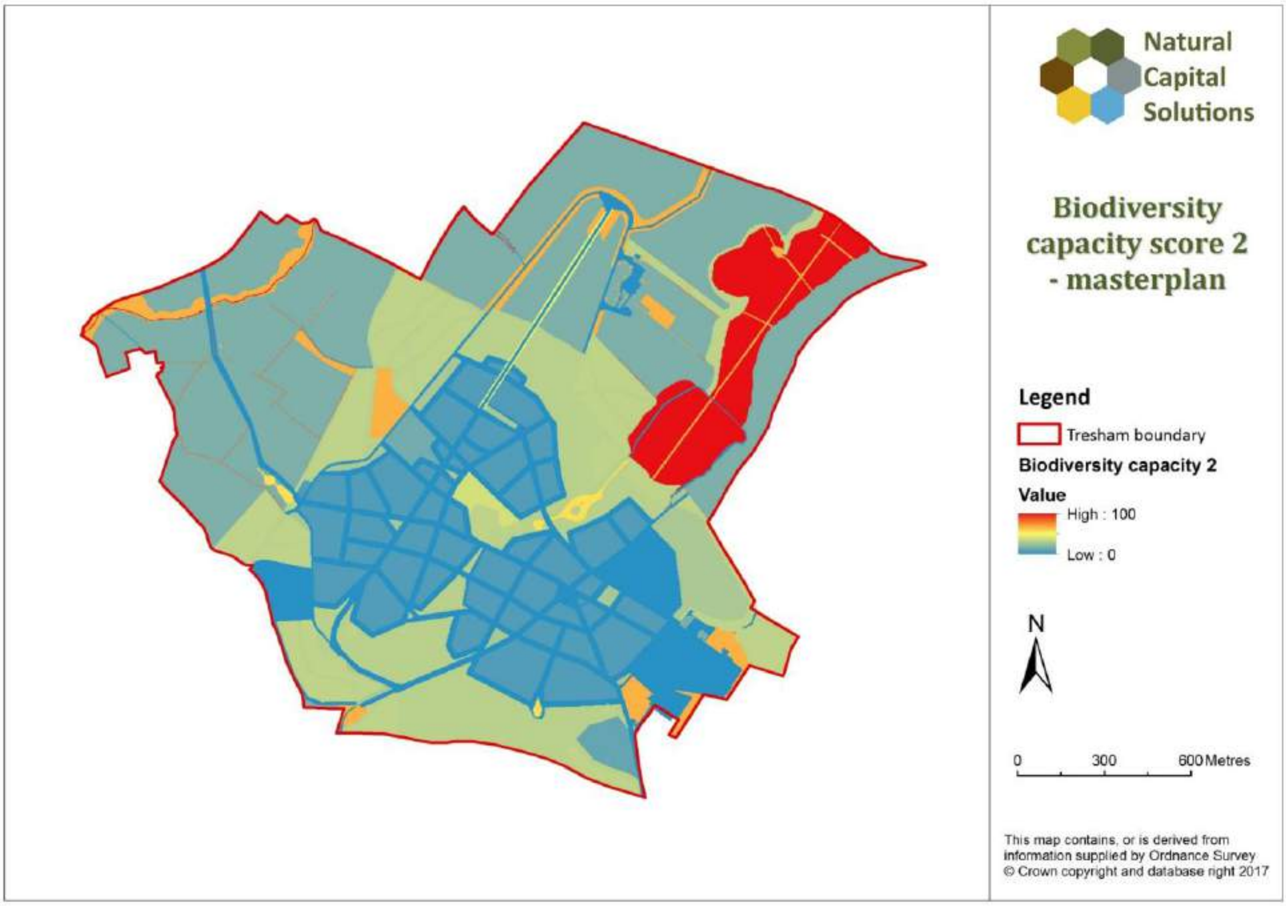
Baseline score = 26.8	**Masterplan score 1 = 35.4**	**Change = 8.6**
	Masterplan score 2 = 24.5	**Change = -2.3**

Map 29: Biodiversity capacity for the baseline (pre-development) condition at Tresham Garden Village

Map 30: Biodiversity capacity under the proposed masterplan at Tresham Garden Village using **Score 1**



Map 31: Biodiversity capacity under the proposed masterplan at Tresham Garden Village using **Score 2**



3.15 Overall results

The overall scores across the whole Tresham study area for each ecosystem service are shown in Table 2 and on Figures 3 and 4. Under the proposed masterplan, the capacity (supply) of most ecosystem services will increase, with the exception of water flow and biodiversity under Score 2, both of which will decrease by just a small amount, and agricultural production, which will decline by more than half. **Overall, the masterplan appears to have the potential to deliver net gain of ecosystem services**, although a number of simple measures could be taken to improve capacity further (see next section). The gain under the existing masterplan is driven almost entirely by the planting of new woodland around the edge of the core built zone. Woodland is particularly good at delivering a wide range of ecosystem services and in most cases, this new woodland will more than compensate for any loss of habitat to buildings and infrastructure. In addition, the majority of the site prior to development consists of arable farmland and improved grassland, which are habitats that supply few ecosystem services, apart from agricultural production, hence can be built on with little loss of services.

Table 2: Overall supply and demand for ecosystem services across the Tresham study area, under the baseline and proposed masterplan

Ecosystem service	Baseline	Masterplan	Change
Capacity			
Carbon storage	12.5	22.6	10.1
Carbon sequestration	5.5	10.8	5.3
Air purification	15.8	23.8	8.0
Noise regulation	14.7	19.4	4.7
Water flow	61.2	59.7	-1.5
Water quality	41.4	50.7	9.3
Pollination	91.1	95.4	4.3
Accessible nature	0.1	8.7	8.6
Agricultural production	51.4	23.4	-28.0
Timber production	2.4	6.3	3.9
Biodiversity Score 1	26.8	35.4	8.6
Biodiversity Score 2	26.8	24.5	-2.3
Demand			
Air purification	1.6	24.4	22.8
Noise regulation	0.8	11.0	10.2
Accessible nature	34.4	60.8	26.4

However, as well as increasing supply of ecosystem services, the new development will inevitably increase demand as well. In particular, demand for air purification, noise regulation and accessible nature was assessed, and demand for all three is expected to increase dramatically. Although the capacity for each of these ecosystem services is also expected to increase, the models do not allow a determination of whether the new supply fully meets the new demand. All new developments will create new demand, especially when being built away from existing towns, infrastructure and facilities, hence it is important that new capacity is created for these services that goes well beyond just replacing capacity lost due to the development. Location is also extremely important as air and noise pollution in particular, are highly localised, and so capacity to ameliorate these problems using natural capital should be located in the most appropriate places. See Section 6.1 for specific recommendations.

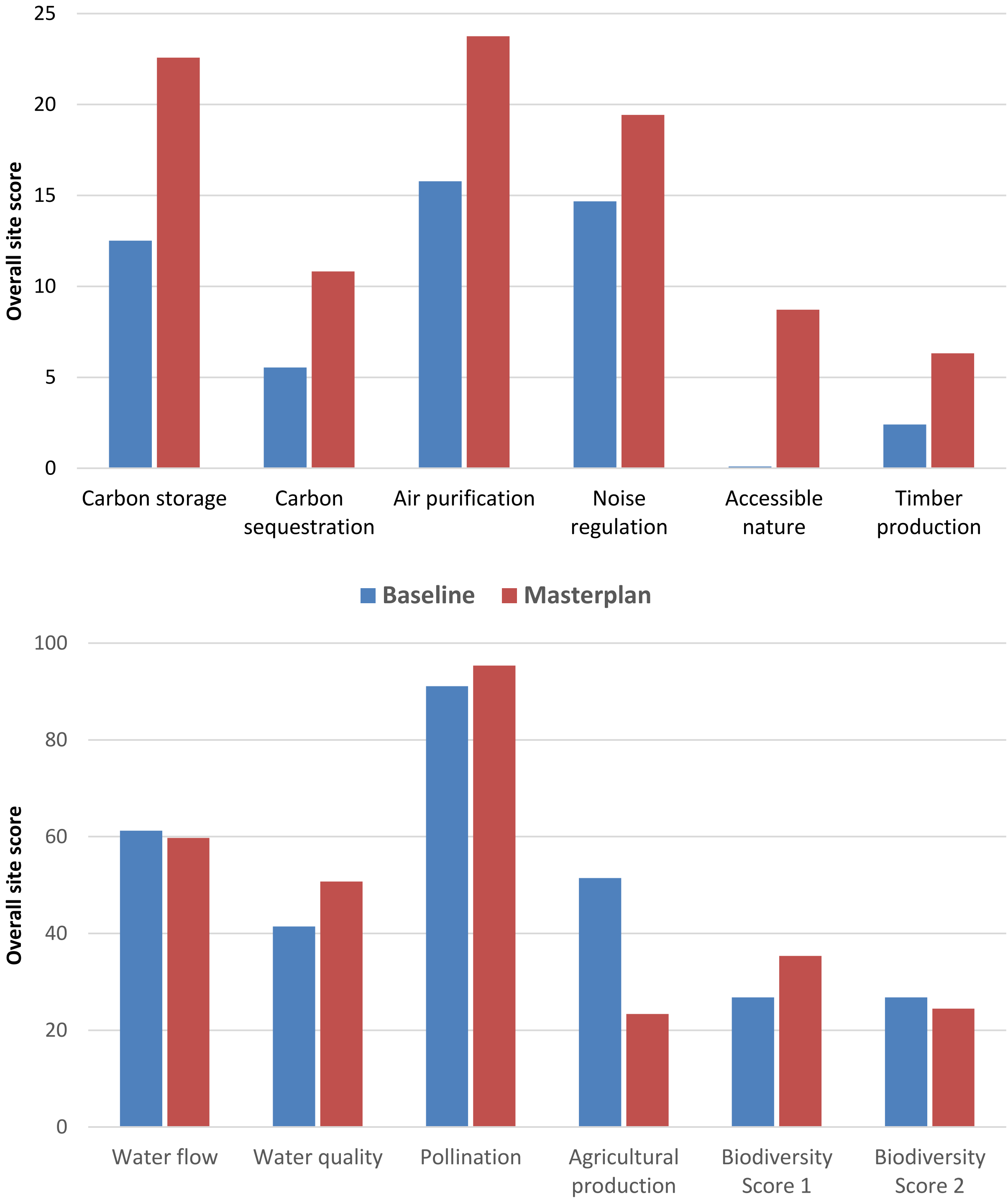


Figure 3: Overall **capacity** for ecosystem services delivery across the Tresham study area under the baseline and the proposed masterplan. **Note the different scales on the two graphs.**

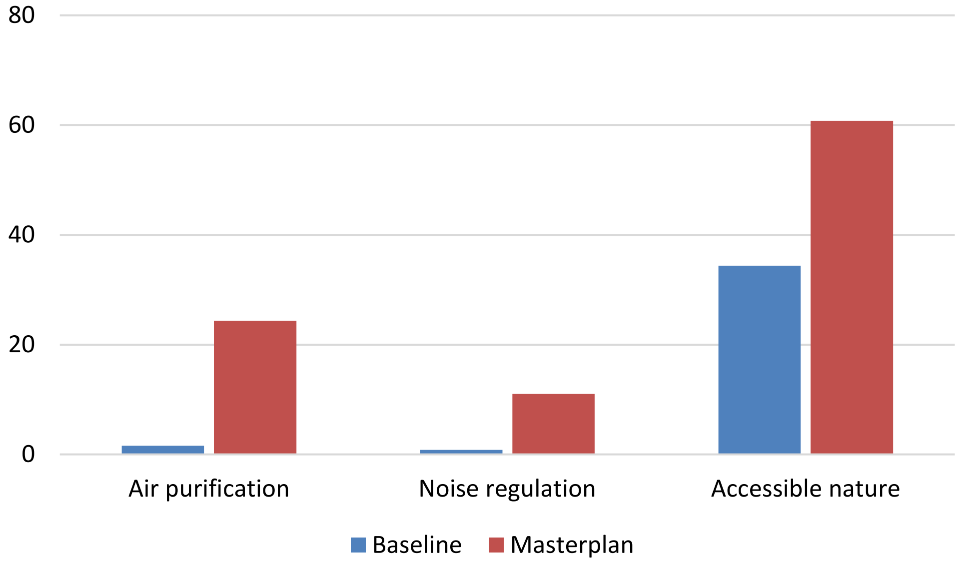


Figure 4: Overall **demand** for ecosystem services across the Tresham study area under the baseline and the proposed masterplan.

4. Stakeholder workshop to enhance design

One of the key aims of this project was to see if by adopting a natural capital and ecosystem services approach, it would be possible to engage stakeholders and enhance design, to deliver a greater range of ecosystem services. To that end, a workshop was held on 26th June 2017, hosted by East Northamptonshire Council in Thrapston. Workshop participants represented Northamptonshire County Council, East Northamptonshire Council, North Northamptonshire Joint Planning Unit, Natural England, Environment Agency, River Nene Regional Park, Northamptonshire Wildlife Trust, amongst others, as well as several representatives from the design team.

The workshop began with presentations on the evolution of the masterplan for Tresham, and an update on the ecological and green infrastructure elements of the proposed development. The ecosystem services project was then introduced, including reporting on some of the results from Section 3 of this report. Participants then took part in two workshop sessions.

4.1 Prioritising ecosystem services at Tresham

In the first workshop session, participants were asked to discuss and rate the importance of each ecosystem service in the context of Tresham Garden Village. They were asked to score each ecosystem service from 1 (very low importance) to 5 (very high importance) and also to highlight any others that they felt were important, and the key thinking behind their decisions.

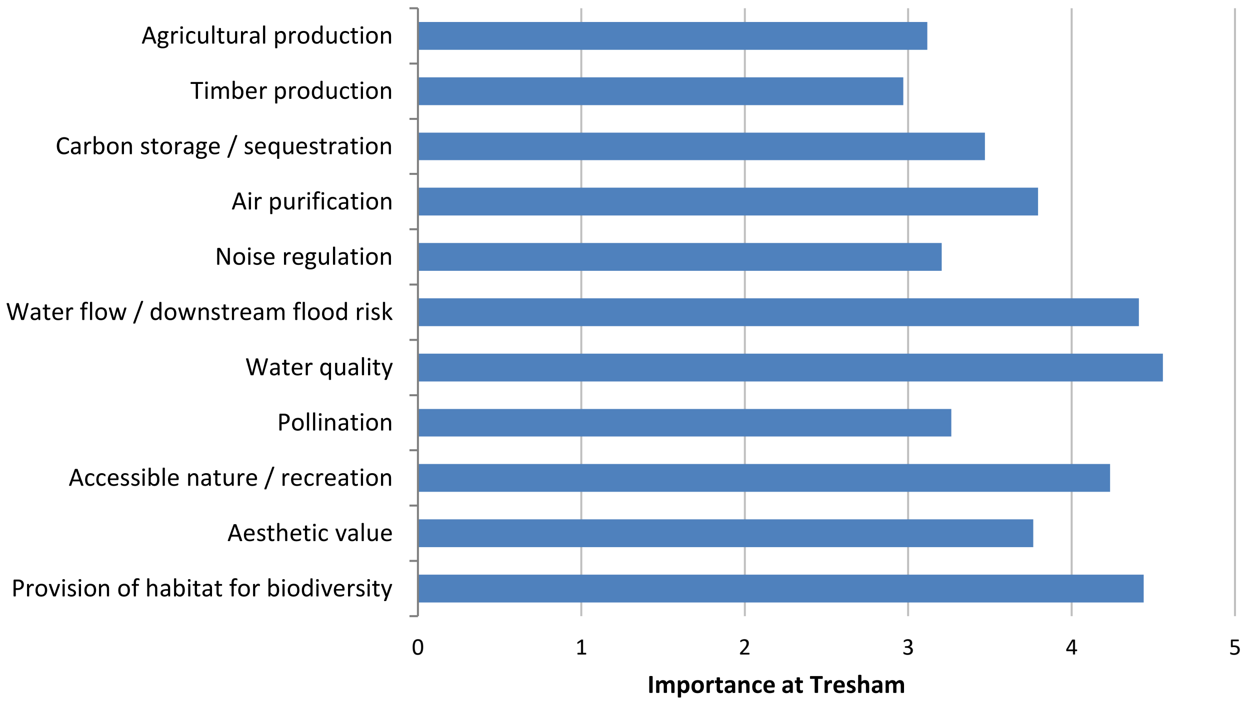


Figure 5: Importance of ecosystem services at Tresham Garden Village, according to workshop participants (n = 17). Scores ranged from 0 (very low importance) to 5 (very high importance).

All of the ecosystem services assessed were considered to be of at least moderate importance by workshop participants, although some services were considered more important than others (Figure 5). The ecosystem services considered to be of greatest importance were water quality, water flow (downstream flood risk), habitat for biodiversity, and accessible nature / recreation, each of which received an average score across the group of between 4 (high) and 5 (very high importance). The least important services at Tresham were judged to be timber production, agricultural production, noise regulation, and pollination, although these were still all rated as moderately important (scoring around 3).

Other factors that were considered to be important by some workshop participants were: land quality, wildlife abundance, soil quality/ sustainable use of soil, local climate (temperature) regulation, cultural heritage, and lighting (pollution & aesthetics). Of these, land quality and local climate regulation were the most frequently mentioned, both receiving three nominations.

Comments received generally reflected the importance of Tresham being an exemplary development, with aspiration to higher standards than normal. It was considered important to create a sustainable development that delivered across multiple ecosystem services and was well connected into the surrounding landscape. For example, footpaths and accessible natural spaces that encouraged people out into the surrounding countryside, and grazing that came onto site, with locally produced meat and fuelwood being sold in the village and carbon being offset in the adjacent woodlands. It was felt that providing accessible and connected nature in a rural village setting was important for fulfilling the “USP” of the site. The importance of managing the impacts of the development on the wider catchment, through water quality and flood risk considerations was also raised by several people.

4.2 Enhancing delivery of ecosystem services

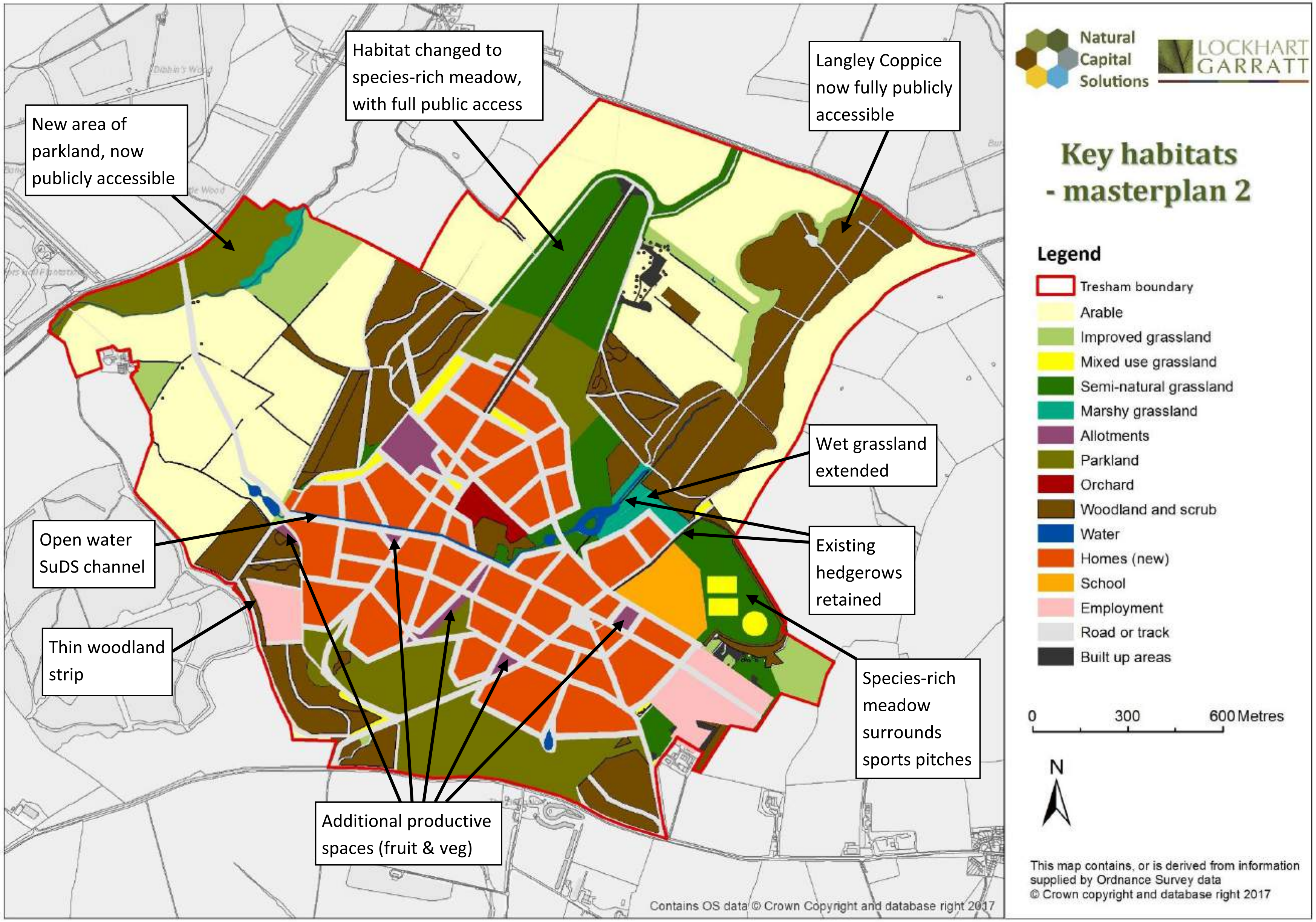
The main exercise at the workshop involved the participants making changes to the masterplan outline design to enhance the delivery of ecosystem services. Participants worked in three groups, with each group allocated a part of the core built area, plus the largely agricultural areas to the north and west (but still within the red-line boundary). They worked within the following constraints:

- The overall layout (e.g. street and block pattern) was retained, but field boundaries could be moved
- Participants were asked not to consider building features (e.g. green roofs) at this stage. This was because the masterplan at this stage did not go down to the level of individual built features. Land use changes and street features were included, including changes to management and public assess.
- For the currently agricultural areas, participants were asked to ensure that habitats retained an agricultural function (e.g. could be supported by agri-environment schemes).

Each group made a number of alterations to the original masterplan and the exercise generated lots of useful discussions. After the workshop, Lockhart Garrett collated all the changes, and worked with the Tresham design team to produce a single new version of the masterplan. This is shown as Map 32 on the next page, with key changes annotated on the map.

The original masterplan had been divided into zones to represent areas where different activities were considered to take priority. These were named the productive landscape (including the orchard, allotment and woodlands in the north and west of the built zone), species rich landscape (the semi-natural habitats, water features, and woodlands in the north-east), and recreational landscape (the sports area and parkland in the south). However, one theme that emerged from the workshop was that the different activities should not be segregated but should be mixed throughout the development.

Map 32: Key habitats present under the new adjusted masterplan (Masterplan 2) at Tresham Garden Village, with changes annotated.



A new GIS version of the masterplan (referred to as masterplan 2) was produced, with the area of each broad habitat type shown in Table 3. The largest increase has been in the amount of semi-natural grassland across the site, which has increased by 12.0 ha to 26.0 ha. This is an 86% increase compared to the original masterplan, and brings the total amount back to a similar area as under the baseline condition. The amount of parkland has also increased substantially (by 8.9 ha to 37.2 ha), primarily due to a new parkland area created by the entrance to the site by the A43. The largest declines have been in improved grassland (reduced by 9.9 ha), arable (7.4 ha) and mixed use grassland, which has reduced by 6.2 ha. The areas for fruit and vegetable growing and for water have both increased substantially, increasing by 75% and 30% respectively compared to the original masterplan.

Table 3: Area of broad habitat types across the Tresham study area under the baseline, original proposed masterplan and new masterplan (masterplan 2). The change from the original masterplan to the new masterplan is also shown.

Broad habitat type	Baseline (ha)	Masterplan (ha)	Masterplan 2 (ha)	Change from Masterplan 1 to 2 (ha)
Arable	248.1	105.7	**98.3**	-7.4
Improved grassland	36.4	23.7	**13.8**	-9.9
Mixed use (amenity) grassland	0.3	9.9	**3.7**	-6.2
Semi-natural grassland	28.0	14.0	**26.0**	12.0
Marshy grassland	1.2	2.5	**3.5**	0.9
Allotments	0.0	1.9	**3.4**	1.4
Orchard	0.0	1.5	**1.5**	0.0
Trees / Parkland	0.4	28.3	**37.2**	8.9
Scrub	3.8	1.2	**1.1**	-0.1
Broadleaved woodland	26.8	62.1	**62.5**	0.3
Coniferous woodland	0.0	2.6	**2.6**	0.0
Water	0.3	1.8	**2.4**	0.5
Built up areas	14.6	41.4	**41.0**	-0.3
Infrastructure	9.0	47.1	**46.7**	-0.3
Garden	0.0	25.9	**25.8**	-0.1
Hedgerows	1.4	0.9	**1.1**	0.2

5. Changes in ecosystem service delivery under the new masterplan

The final stage of the project consisted of taking the new designs produced through the stakeholder workshop, and assessing if this caused any changes in ecosystem service provision. To do this, the previous masterplan was edited and adjusted, based on the masterplan design collated by Lockhart Garrett and shown in Map 32 above. The ecosystem service models described in Section 3 were then all run again, relative to this new masterplan.

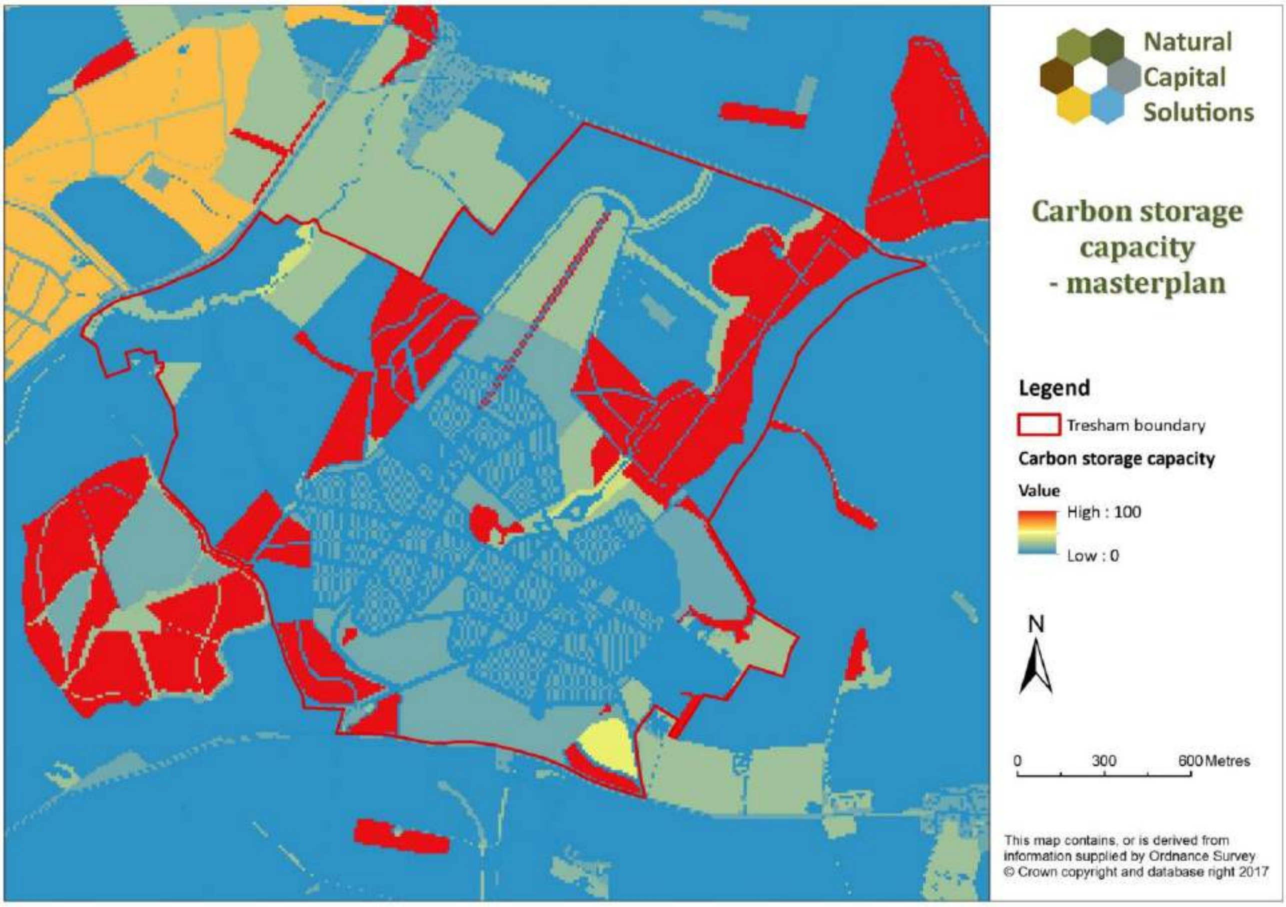
Overall, much of the area remained under the same land use and habitat as under the original masterplan, hence changes to ecosystem service provision was relatively small in most cases and with changes which are often not very obvious on the maps. Only the most relevant maps have been included here, to provide examples and to show the larger changes, with all remaining maps in Appendix 1.

The map for **carbon storage capacity** under the new masterplan (labelled as Masterplan 2) is shown overleaf (Map 34), along with the map for the original masterplan (Map 33), to illustrate the typical differences apparent in the maps. On first viewing, the maps appear very similar, but on closer inspection, differences are apparent where habitat changes have been suggested. In particular, the thin strip of new woodland on the south-west boundary now provides high capacity (shown in red), the new area of parkland to the far west of the site (by the A43) has increased capacity, as has the new area of species-rich meadow surrounding the sports pitches next to the school on the east side. The overall score for the whole site has increased from 22.6 to 23.0 under masterplan 2, a modest increase of 1.9% over the original masterplan and an 84% increase compared to the baseline pre-development situation.

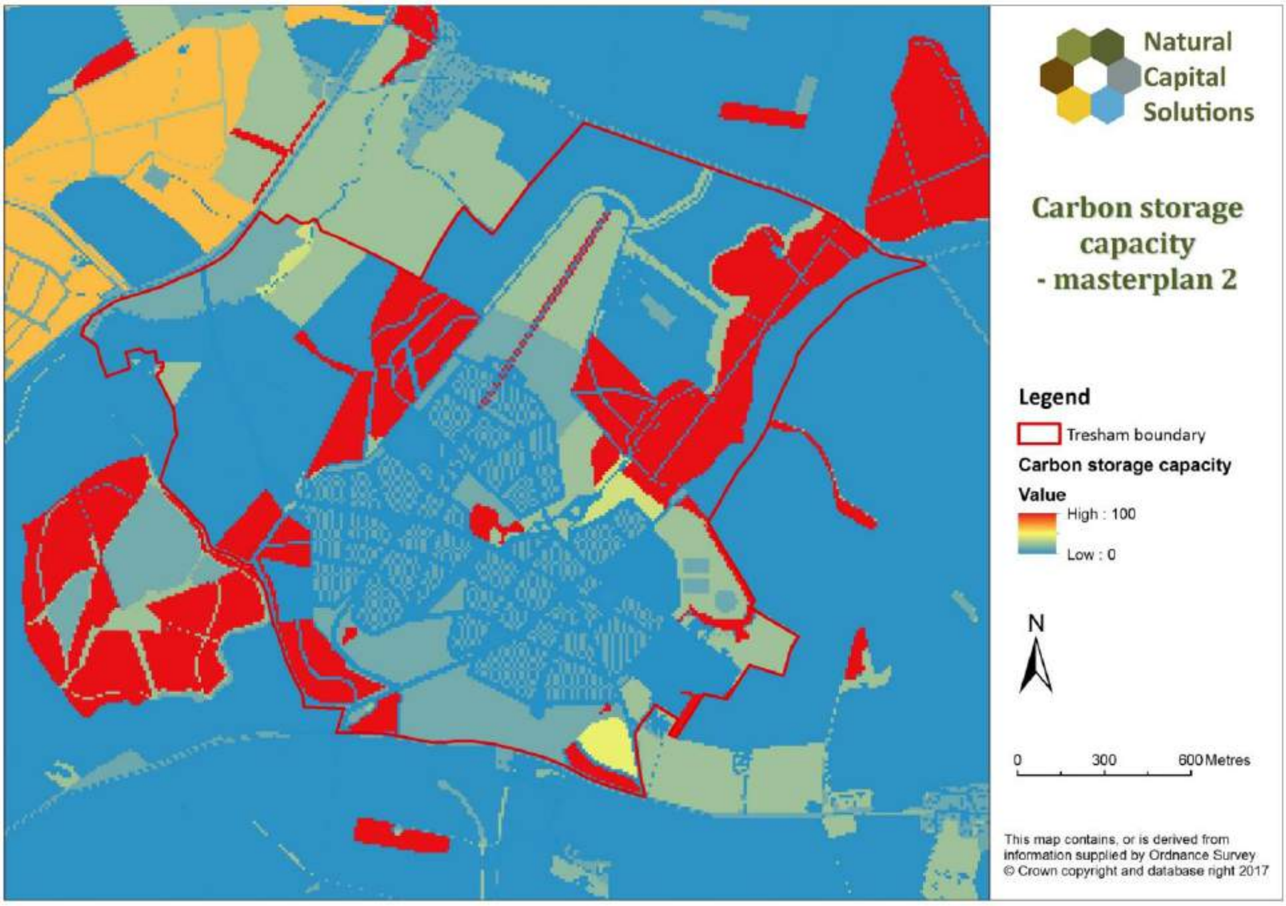
Accessible nature capacity represents the biggest change in ecosystem service provision and this is illustrated on the following page (Maps 35 and 36). Several additional areas have been made publicly accessible, the largest of which are Langley Coppice woodland, the new area of parkland by the A43 entrance, and the new area of species rich meadow which has been suggested to either side of the main runway to the north of the main built zone. The latter two are adjacent to existing area of accessible greenspace (those identified in the original masterplan), hence providing a much larger continuous area with public access. Larger areas of accessible greenspace are considered more valuable than smaller areas, hence much of this part of the map is now orange and the benefits have increased considerably. Overall, the score for accessible nature capacity increases form 0.1 under the baseline to 8.7 under the original masterplan and 15.7 under the new masterplan. This is an 80% increase from masterplan 1 to 2.

The final maps illustrated here (Maps 37 and 38) are for **biodiversity score 1**, which shows the second greatest increase from masterplan 1 to 2 of 8.2%, rising from a score of 35.4 to 38.2. Much of the new habitat suggested under the new masterplan, including the large areas of new parkland, and species rich meadows are expected to be of medium habitat distinctiveness and moderate condition (shown as orange on the map), and replaces low scoring habitats such as arable, improved grassland and amenity grassland. The new woodland strip, open water SuDS channel, and retained hedgerows will also all increase the biodiversity score, although these are small areas so their impact on the overall score is modest.

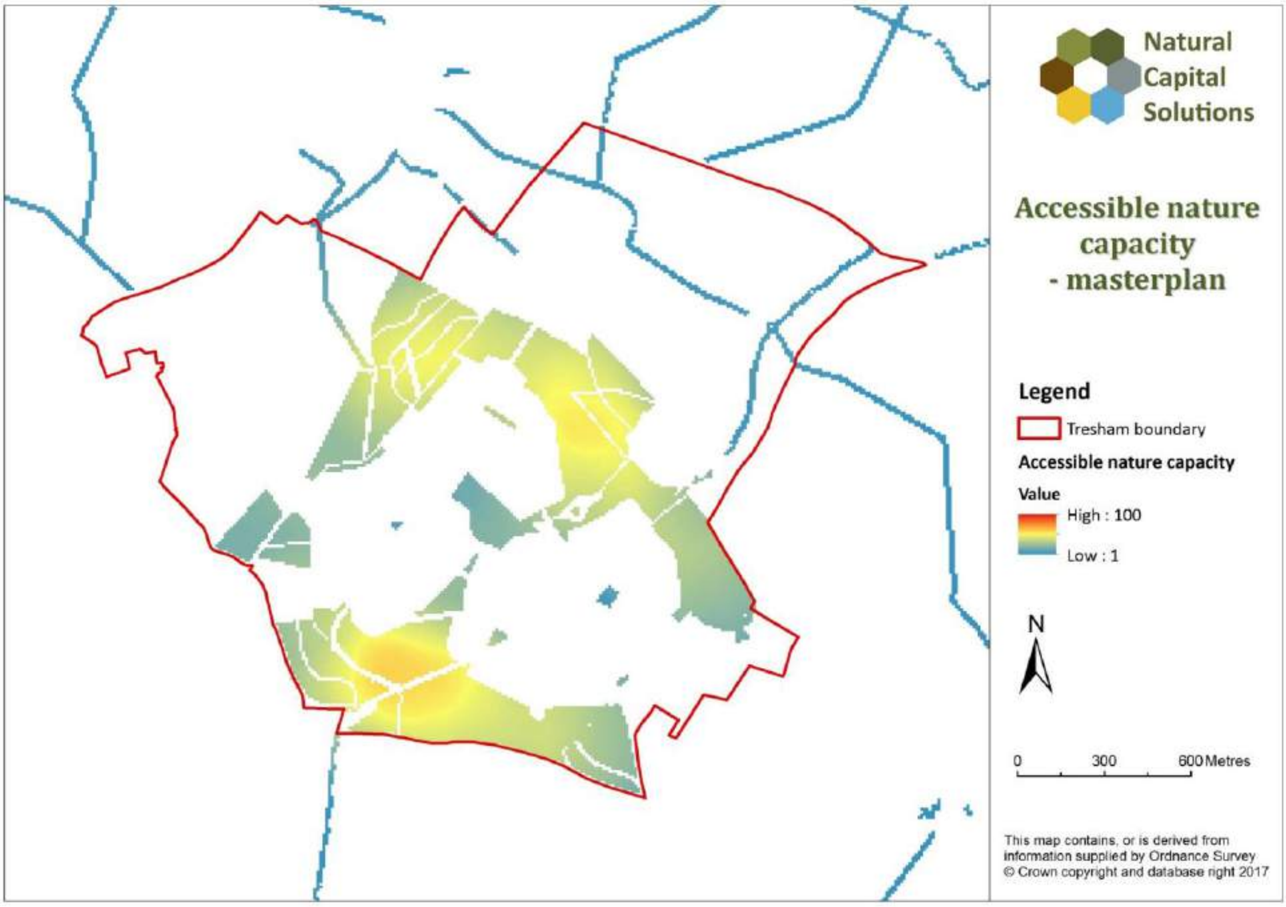
Map 33: Carbon storage capacity under the original masterplan at Tresham Garden Village



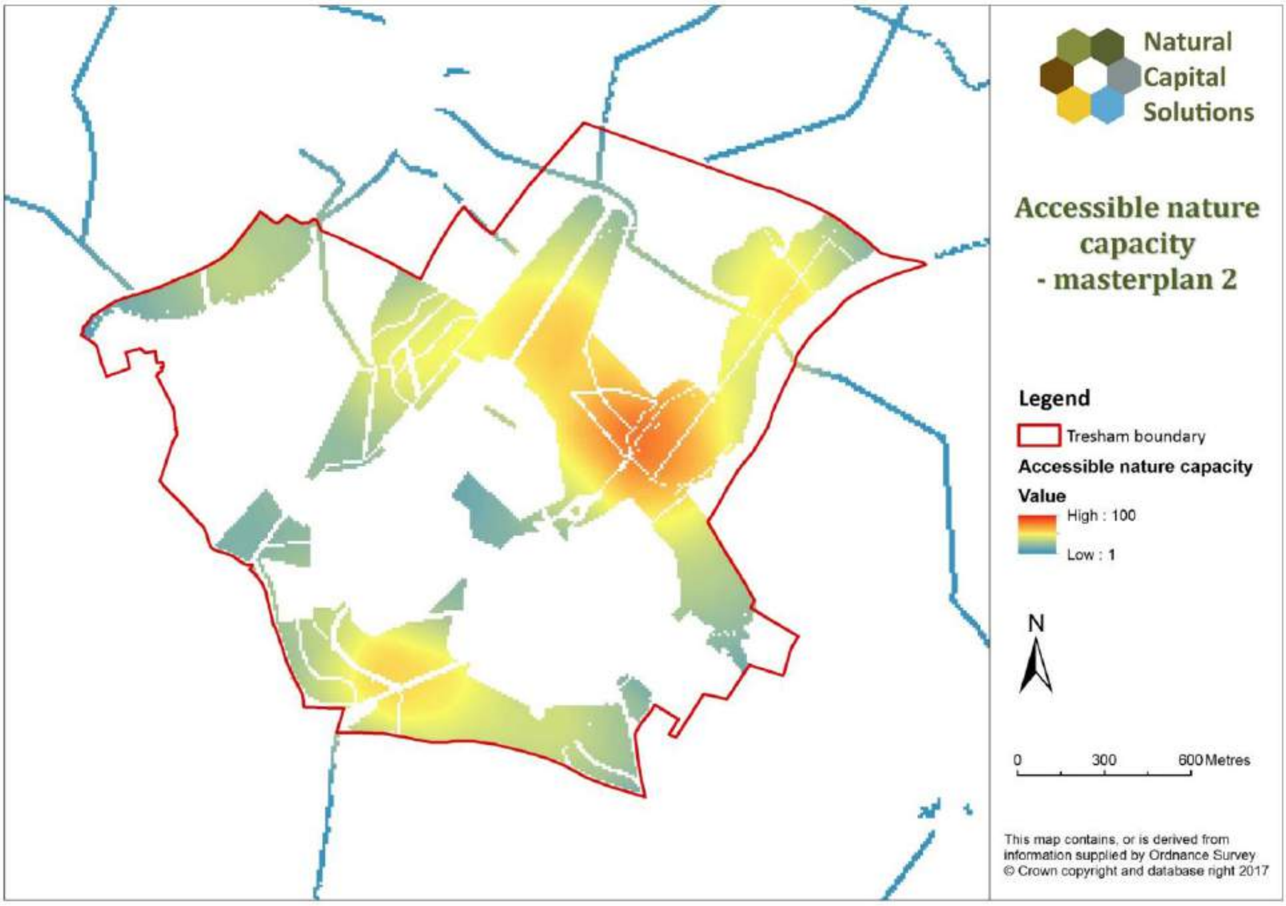
Map 34: Carbon storage capacity under the new masterplan (Masterplan 2) at Tresham Garden Village



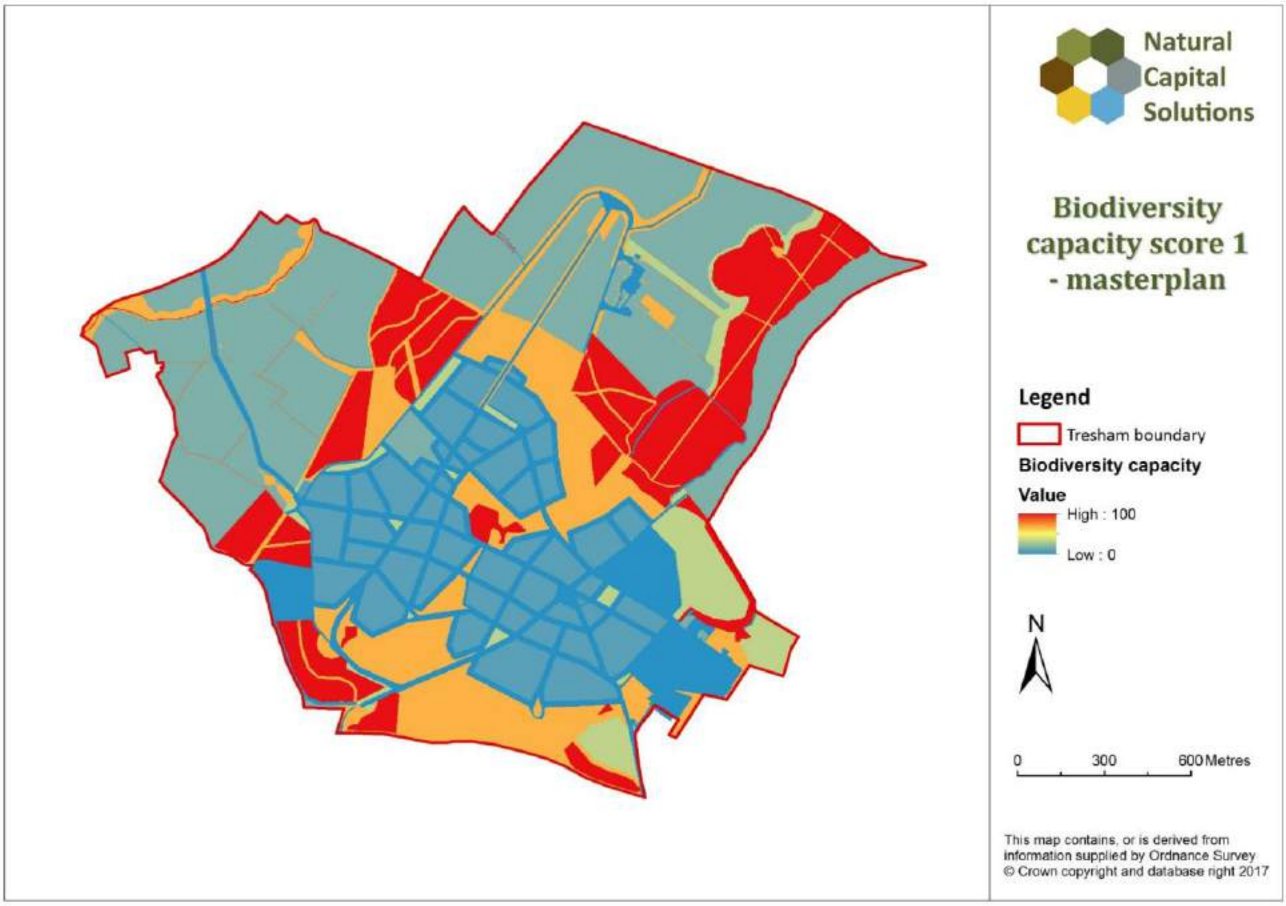
Map 35: Accessible nature capacity under the original masterplan at Tresham Garden Village



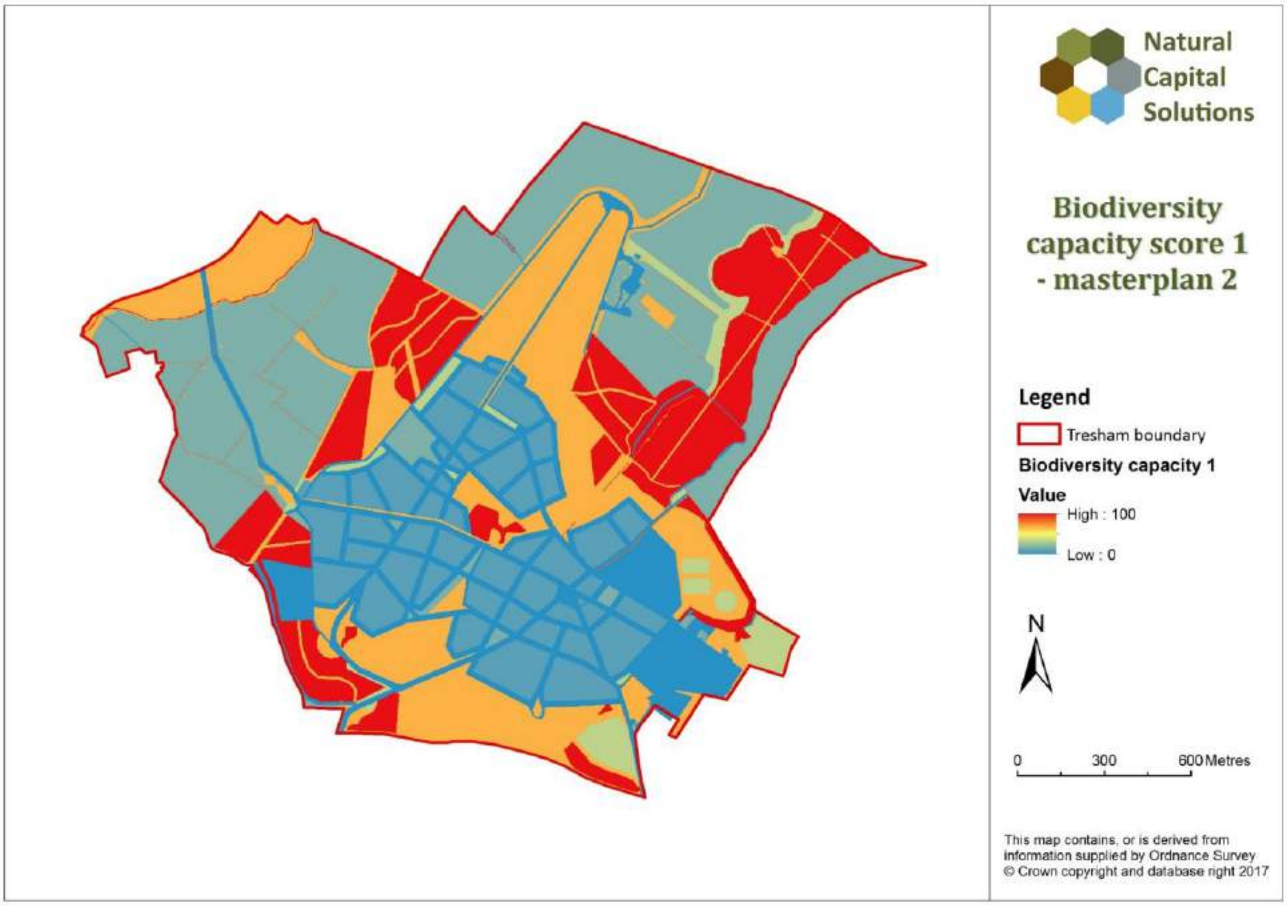
Map 36: Accessible nature capacity under the new masterplan (Masterplan 2) at Tresham Garden Village



Map 37: Biodiversity capacity under the original masterplan at Tresham Garden Village using Score 1



Map 38: Biodiversity capacity under the new masterplan at Tresham Garden Village using Score 1



5.1 Overall results

The overall scores across the whole site are shown in Table 4. This shows that the provision of all ecosystem services, apart from agricultural production, increase under the new masterplan (Masterplan 2) compared to the original masterplan. The increases are modest (apart from for accessible nature), with a median increase from the original masterplan to the new masterplan of 1.6%. This is perhaps not surprising given that land-use and habitats do not change over most of the area. It is encouraging that all ecosystem services (apart from agricultural production) respond in the same direction, so changing habitats to increase the provision of one ecosystem service is likely to increase the supply of all others.

Table 4: Overall supply of ecosystem services across the Tresham study area under the baseline, original proposed masterplan and new masterplan (Masterplan 2). The percentage change from the original masterplan to the new masterplan is also shown.

Ecosystem service	Baseline	Masterplan	Masterplan 2	% change from masterplan 1 to 2
Carbon storage	12.5	22.6	**23.0**	1.9
Carbon sequestration	5.5	10.8	**10.9**	0.3
Air purification	15.8	23.8	**24.6**	3.4
Noise regulation	14.7	19.4	**20.0**	3.1
Water flow	61.2	59.7	**59.8**	0.1
Water quality	41.4	50.7	**51.4**	1.3
Pollination	91.1	95.4	**95.9**	0.6
Accessible nature	0.1	8.7	**15.7**	80.3
Agricultural production	51.4	23.4	**21.5**	-7.8
Timber production	2.4	6.3	**6.3**	0.2
Biodiversity Score 1	26.8	35.4	**38.2**	8.2
Biodiversity Score 2	26.8	24.5	**25.3**	3.3

Accessible nature capacity shows by far the greatest increase. This is driven by increasing public access to greenspace, rather than increasing the naturalness of the habitats and shows that it is relatively easy to enhance the delivery of this ecosystem service. This is especially important given that accessible nature was judged by the stakeholders to be one of the most important ecosystem services to deliver at Tresham Garden Village, and evidence is continuing to mount over the significance of this service for peoples' health and wellbeing. In addition, where monetary valuations have been carried out, recreation and health benefits are usually found to be providing the greatest economic benefits of all ecosystem services, hence there is also a strong economic argument for providing accessible natural greenspace.

Figure 6 (overleaf) shows the overall score for each ecosystem service across the three scenarios (baseline, original masterplan and new masterplan) and once again highlights that the provision of almost all services increases, often quite significantly, from the baseline to the original masterplan, and increases a little more under the new masterplan.

Note that the scores above and the graphs below all show the capacity of the site to deliver the ecosystem services shown. The **demand** for services has not been shown as it will not change under the new masterplan. Demand is driven by population, road layout, amount of sealed surface, and various indices linked to population, none of which will be altered under the new masterplan. It would be possible to alter these factors, especially with more substantial changes to the masterplan, but that has not been tested here for the reasons outlined.

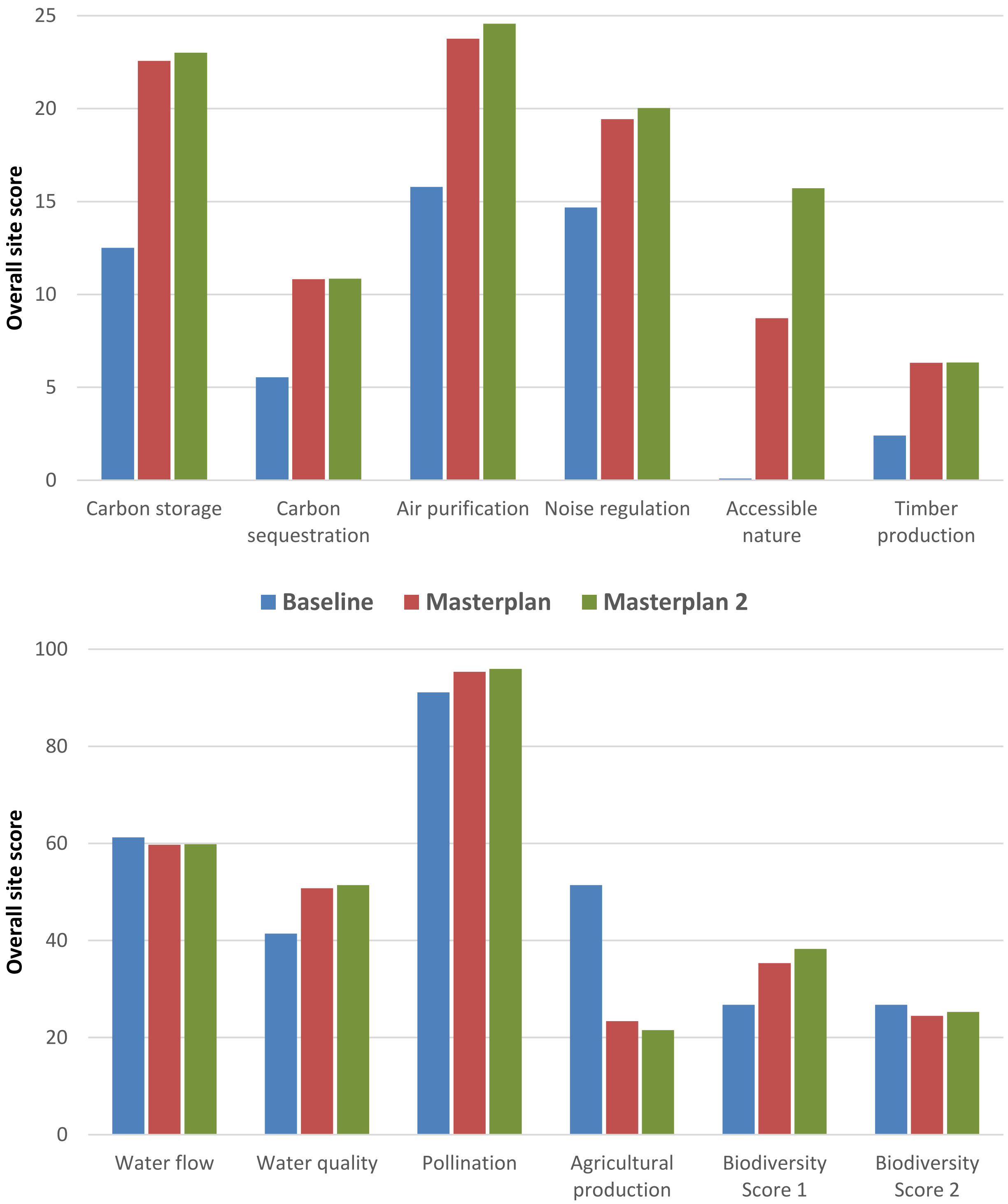


Figure 6: Overall capacity for ecosystem services delivery across the Tresham Garden Village study area under the baseline, original masterplan, and new masterplan (Masterplan 2). Note the different scales on the two graphs.

6. Conclusions and recommendations

This report has presented the results of an assessment of the potential impact of proposals for Tresham Garden Village on natural capital assets and the ecosystem services (the benefits) that flow from those assets. Taking such an approach has allowed a wide range of benefits to be considered, and provided an opportunity to enhance the overall benefits delivered by the development.

The site prior to development (the baseline) is dominated by arable farmland and as such is only providing very limited benefits. The greatest benefit from the land at present is agricultural production. However, the land is only classified as grade 3 agricultural land, hence of moderate quality and is not considered to be particularly productive. Note that when compared to the wider catchment, the Tresham area is likely to produce an agricultural gross margin that is 50-60% of the margin achieved in the areas with greatest output, around Peterborough. Only one part of the site is currently delivering a wide range of ecosystem services and that is Langley Coppice, an area of woodland at the edge of the proposed main village, but within the red line site boundary.

Under the proposed masterplan, the delivery of almost all ecosystem services is predicted to increase, with the exception of agricultural production, which declines by more than half, and water flow and biodiversity score 2, which both decline very slightly. Agricultural production falls sharply as more than half the arable fields are built on or converted to other land uses, and this is an inevitable consequence of the development. Water flow declines slightly due to the significant increase in sealed surfaces because of the new buildings and infrastructure, and this is not quite offset by the woodland plantings. However, the masterplan did not consider the design of individual built elements, and it is likely that this issue can be addressed through the installation of green roofs, permeable paving and other SuDS features. Biodiversity score 2 uses the official Defra biodiversity metric and declines slightly due to the way in which the metric is set up. New woodland does not score well under the metric as it is only possible to classify it as potentially achieving medium distinctiveness and the score is then significantly reduced due to the length of time it takes to establish new woodland. Restoration of existing habitats will achieve greater scores and should be considered by the Tresham development team (see next section for specific recommendations).

The increase in scores for all remaining ecosystem services is in large part due to the new woodland plantings adjacent to the main built zone. Large areas of accessible and interconnected greenspace are also particularly important for enhancing benefits.

As well as generally increasing the capacity of the natural environment to deliver benefits, the proposed development will also significantly increase demand for these services. This is an important point to consider and highlights that the site should not be simply maintaining capacity at baseline levels, but needs to increase capacity just to meet the increased demand. For example, air pollution levels will inevitably increase due to the development, hence more trees will need to be planted to help to ameliorate this increase. The location of trees in relation to pollution sources is also important, with trees adjacent to roads particularly important for air pollution regulation. It would also be interesting to determine if the new woodland plantings are able to offset the increased carbon emissions due to the new development.

The assessment of accessible nature has highlighted the importance of providing large areas of greenspace that are close to peoples' homes, and making these as natural as possible. Monetary valuation of ecosystem services in other studies has shown that the monetary value of recreation and health and wellbeing is extremely high and considerably more valuable than all other benefits. The use of access to nature, encouraging walking for health and other community and social prescribing for a whole range of ailments is starting to take off and its value is just starting to be realised.

The stakeholder workshop in July 2017 was successful at raising awareness of the natural capital and ecosystem services assessment approach being taken at Tresham, and engaging the stakeholders in the masterplan design process. The changes suggested by the stakeholders improved ecosystem services outcomes and should be incorporated into the final design. Furthermore, the priorities highlighted by the stakeholders, seem to fit quite well with the aims and ethos of the Tresham landowners. Namely that Tresham Garden Village should be an exemplar and sustainable site, delivering a range of ecosystem services, and be fully connected with the surrounding natural environment. Stakeholders considered all services to be of at least moderate importance, but water quality, water flow, habitat for biodiversity, and accessible nature were highlighted as the most important.

6.1 Designing Tresham Garden Village

The masterplan is already delivering a net increase in ecosystem services, but these benefits could be increased further. The suggestions made during the stakeholder workshop have increased delivery of all ecosystem services (with the exception of agricultural production) and should be incorporated in the final design. Additional recommendations arising from this assessment are:

- It is important to consider the specific location of elements such as trees in relation to demand. In particular, it would be highly beneficial to plant street trees on both sides of the main roads through the village. Street trees can deliver a wide range of benefits including air pollution removal, enhancing water quality, reducing runoff, providing shelter and shade, enhancing aesthetics, and a whole range of health and wellbeing benefits. The economic value of these benefits can be considerable and are usually much greater than the costs of planting and maintenance. Care should be taken, however, to plant the right types of tree in the right location and guidance is now available on factors such as ability to remove air pollution, carbon sequestration rate, ability to withstand urban conditions, biodiversity value, relative size, and so on, for different species. It is important that only native species are planted.
- Accessible nature is a particularly important service, highlighted as one of the most important by the stakeholders, and also providing the greatest economic benefits through increases to health and wellbeing, recreational expenditure and other benefits. It is also one of the easiest to enhance. Hence additional areas should be made publicly accessible, such as Langley Coppice, the area of grassland to either side of the runway to the north of the built zone, and the parkland by the entrance off the A43. It would also be sensible to enhance the paths and connections between different accessible areas.
- Water quality and flow were considered to be of primary importance by stakeholders and will need to be further addressed in the detailed design. Therefore, a full range of SuDS features should be further integrated into the design at the building level (e.g. green roofs, rain gardens, permeable paving etc.) and the entrance road from the A43 should be buffered by SuDS features.
- Langley Coppice should be restored as part of the woodland management works. At present it is not considered to be in good condition as it is dominated by a single species (overmature ash coppice), and heavily overgrazed by deer, meaning that there is little natural regeneration and poor ground flora. However, this is an ancient woodland site with high distinctiveness and would be relatively easy to restore to good condition. The Defra biodiversity metric (on which biodiversity score 2 in this report is based) shows a slight decline post development, but restoration of Langley Coppice would go some way towards achieving a net biodiversity gain for Tresham Garden Village. Public access should also be granted to Langley Coppice.

6.2 Natural capital and ecosystem services in the planning and development process

This project has demonstrated how a natural capital and ecosystem services approach can be applied to the planning and development process in regard to a major development. It has been useful at raising awareness and demonstrating the multiple benefits that can be achieved by fully considering the natural environment in development plans, engaging with stakeholders, highlighting how the masterplan design can be improved to enhance benefits, and ultimately, providing an assessment of the net impact of the development on the natural environment and the benefits that it provides.

Bringing an assessment of natural capital and ecosystem services into the planning and development process is currently a hot topic and is being explored in a number of different ways. At the moment, there is no single agreed method or process to follow and details are still being determined. However, it is clear that central government and local planning authorities are moving to embrace these approaches and it is highly likely that they will become standard practice over the next few years. Here, one such approach has been demonstrated, highlighting the kind of outputs that it will deliver. It is hoped that this type of approach will become a compulsory part of the planning process for many planning authorities. At the moment there is clear scope to influence exactly how an approach would be implemented in practice to deliver the most useful outcomes for all parties. Such an assessment as provided here could be formally incorporated into the planning application process either as part of the design and access statement, or as part of the environmental statement, or even as a stand-alone exercise.

An assessment can be carried out at a number of different stages of the planning process, with advantages and disadvantages at each stage. Broadly these can be divided into three major stages of the process:

1. It can be used at a very early stage in the development process, in **optioneering**, thus considering a number of different broad options for a site. The natural capital / ecosystem services approach is particularly good at highlighting broad benefits, synergies and trade-offs that would be achieved under different land-uses, and major differences in land-uses would result in significant changes in ecosystem service delivery. It can thus raise awareness of key issues at a site well before designs have been fixed. The main disadvantage of applying the approach at this stage is that in most locations there will be very little data or survey work undertaken on which to build the basemap and ecosystem services models. However, this is less of an issue in Northamptonshire and Peterborough, where we already have a basemap across the two areas (see the Appendix for more info on implications for accuracy).
2. An assessment can be performed on a draft or **outline masterplan**, before the design is finalised and a full planning application is submitted. This is more or less the stage at which the Tresham assessment was carried out. There are a number of advantages to an assessment at this stage: importantly there should still be scope to alter the design to enhance benefits in light of the assessment, it is possible to engage stakeholders with the process (as here), and there should normally be lots of baseline survey work on which to develop the basemap and models. Disadvantages can occur if there is actually very little opportunity to change the design, or alternatively if there is not enough detail in the design for a full assessment.
3. The final stage at which an assessment can be performed would be to accompany the **full planning application**, and hence will serve a different purpose. Here the assessment would presumably provide evidence in support of the application, showing overall predicted impact and the steps that have been taken to enhance ecosystem service delivery. The advantages are that it is likely that all necessary background data will have been collected, the assessment will provide useful evidence to demonstrate the multiple benefits and net impact of a proposal, and planning / development management officers

and elected members will be able to use this evidence in their decision making. The main disadvantage is that it will be too late to influence the design, so opportunities could be missed, and developers may consider it simply to be an exercise to be ticked-off, rather than as an aid to enhancing new developments.

Assessments can clearly be carried out at any of the three stages of the process outlined above, and the most appropriate is something that is still being explored, but will largely depend on the aims and objectives of the assessment. It should be noted, however, that the approach is most effective at assessing larger land-use changes and is less effective for building-scale changes

In addition to the uses outlined above, a natural capital / ecosystem services assessment can be applied in a number of other ways. It can be used in spatial planning, where an assessment of the current supply of, and demand for, ecosystem services across a wider area can provide valuable evidence to inform Local Plans, Green Infrastructure Delivery Plans and other spatial planning documents. A monetary valuation can be performed to demonstrate the benefits of the green infrastructure elements of a new development in economic terms, and these monetised benefits can also be compared to costs using a natural capital accounting framework. Finally, it can be used to engage with stakeholders, and to raise awareness of the importance and wider benefits of green infrastructure with developers and planners.

6.3 Next steps

The Tresham Garden Village development team are finalising a detailed masterplan document for consideration by the planning authorities, in advance of a full planning application. It is hoped that this masterplan has fully taken into consideration the suggestions made by the stakeholder workshop and the points that arose as a result of taking the ecosystem services approach described here.

Funding permitting, the next step for the project in relation to natural capital / ecosystem services would be to perform a monetary valuation of the costs and benefits of the green elements of the development. A natural capital accounting approach would be used to measure and value the natural capital assets of Tresham, based on the flow of ecosystem services and associated benefits from those assets, before and after the proposed development. By comparing these benefits against the construction and maintenance costs of the green infrastructure investments it will be possible to determine the return on investment.

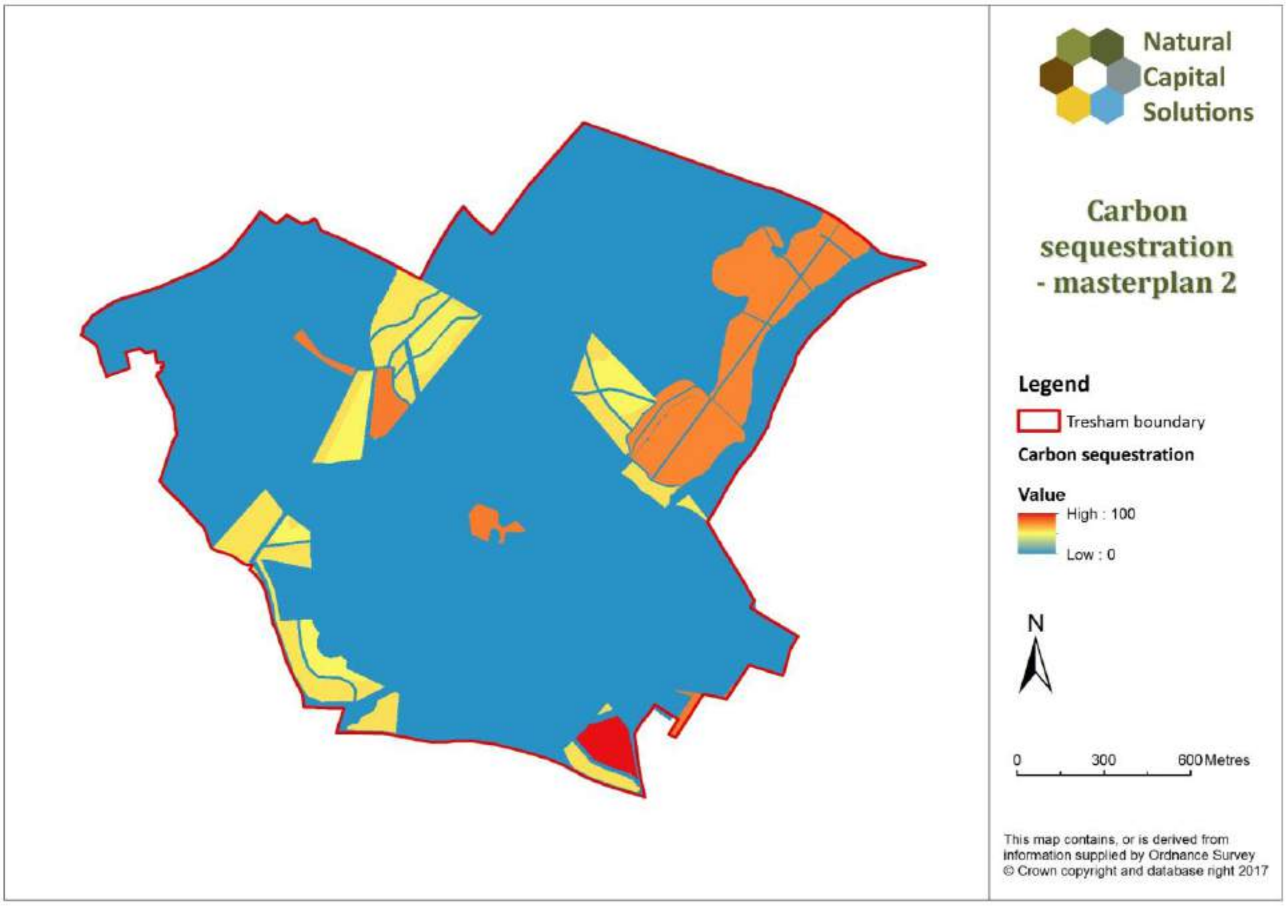
It would be highly worthwhile producing guidance for the planning and development sector, and the work described here is highly topical, with interest to others in the sector and elsewhere. There is little operational guidance on how to pursue this approach in practice and it would be beneficial to write a "how to" guide for a national audience, with Tresham as an exemplary case study. This would fit with the government's intention for the new garden villages to demonstrate innovative best practice. This would also be of benefit locally, providing guidance on how to fulfil the duties of the North Northamptonshire Joint Core Strategy to assess and enhance ecosystem services in new developments.

Finally, developing a mapping portal for North Northamptonshire JPU, or potentially for the whole of Northamptonshire, would provide a useful information portal for planners and developers. The mapping portal would contain the ecosystem service maps already produced under the Nene Valley NIA project, as well as opportunity maps currently being produced, enabling an initial baseline assessment to be carried out for any location, without further data collection or analysis. This can provide information on key benefits and opportunities already present at a site, help determine the best locations for new developments or areas that should not be built on, and provide an initial indication of the likely impact of new proposals.

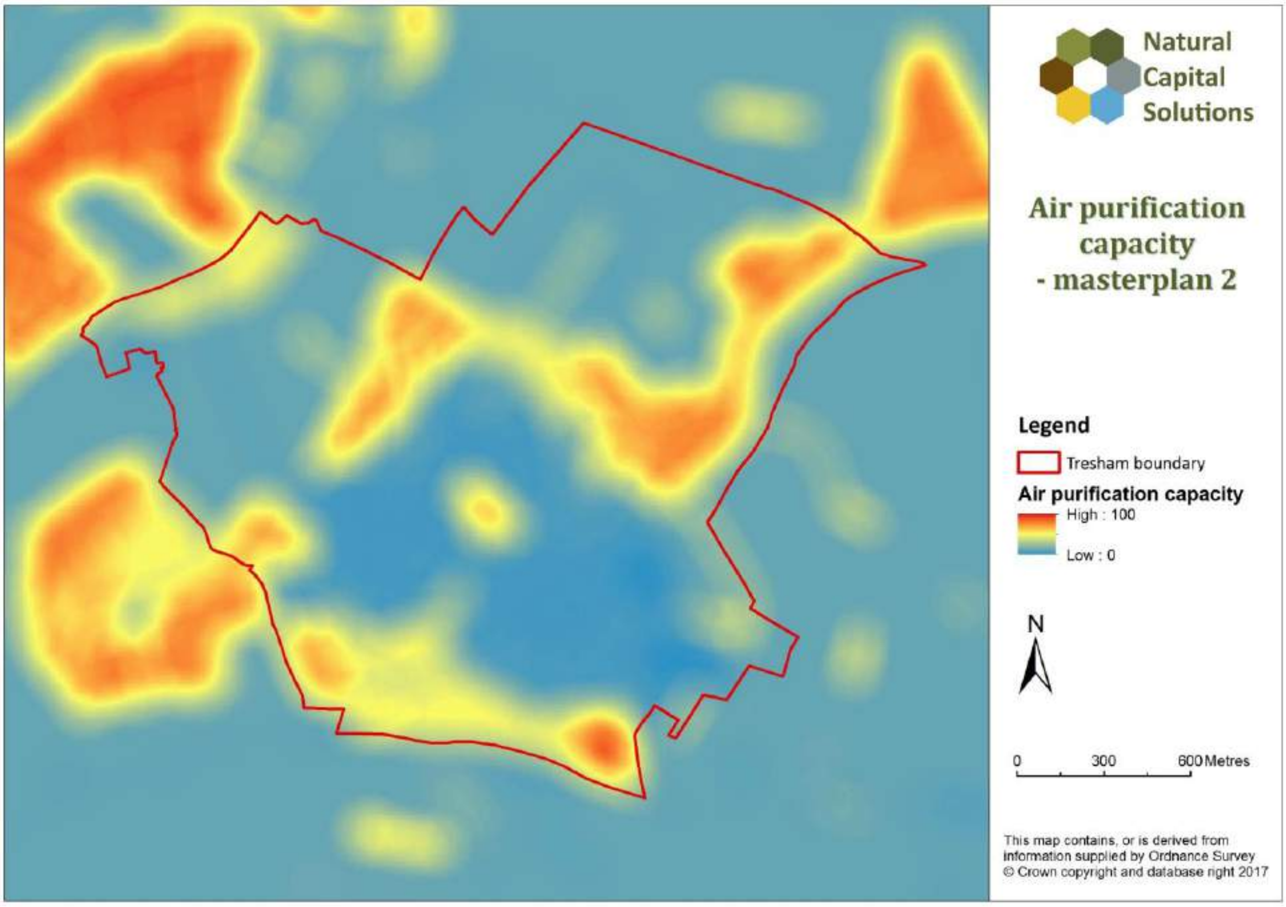
Appendix 1 – Remaining ecosystem services maps for Masterplan 2

Section 5 of this report describes the flow of ecosystem services from the updated masterplan (Masterplan 2). Changes compared to the original masterplan were highlighted and maps presented for carbon storage capacity, accessible nature capacity and biodiversity capacity using Score 1. Below, all the remaining ecosystem services maps are provided.

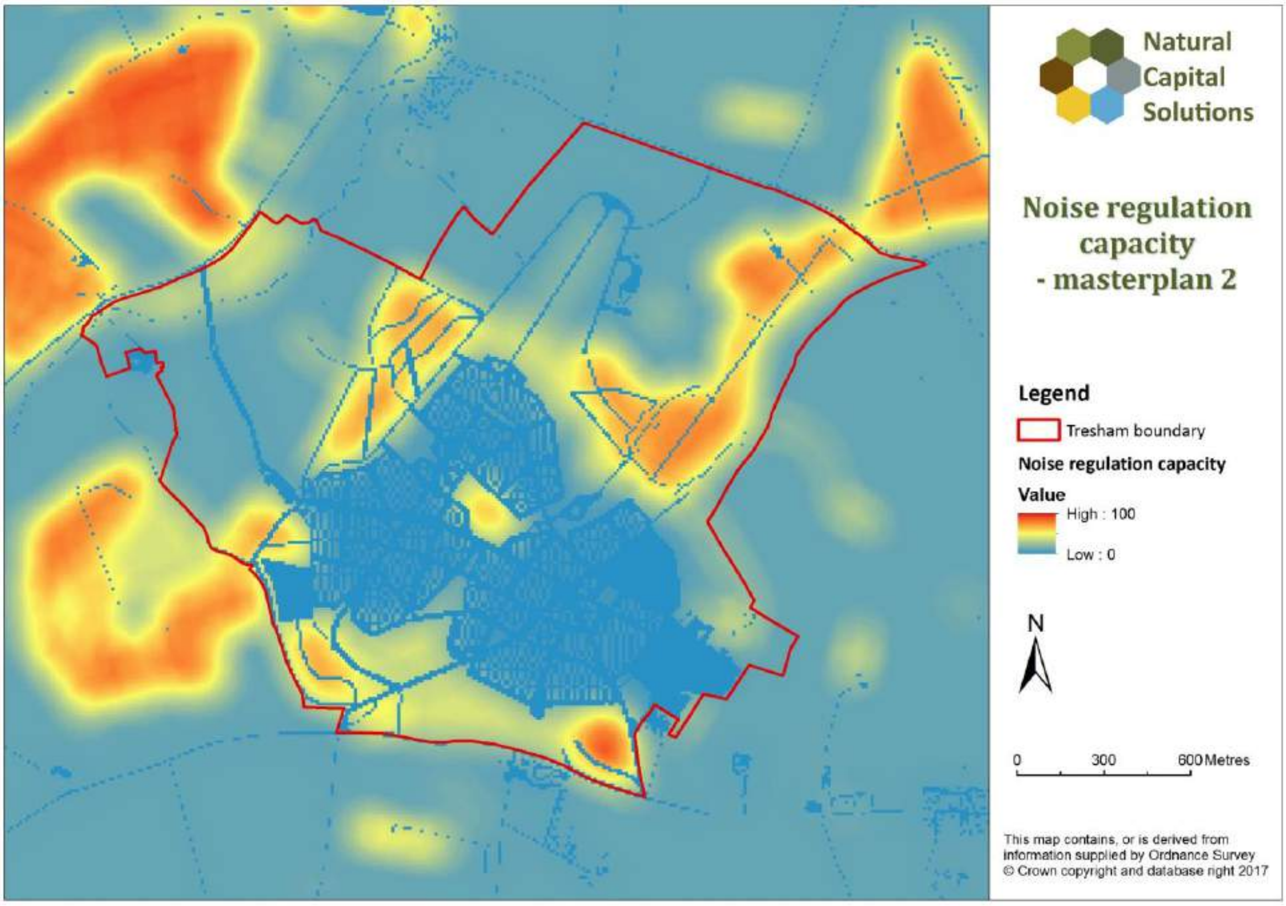
Map 39: Carbon sequestration capacity under the new masterplan at Tresham Garden Village



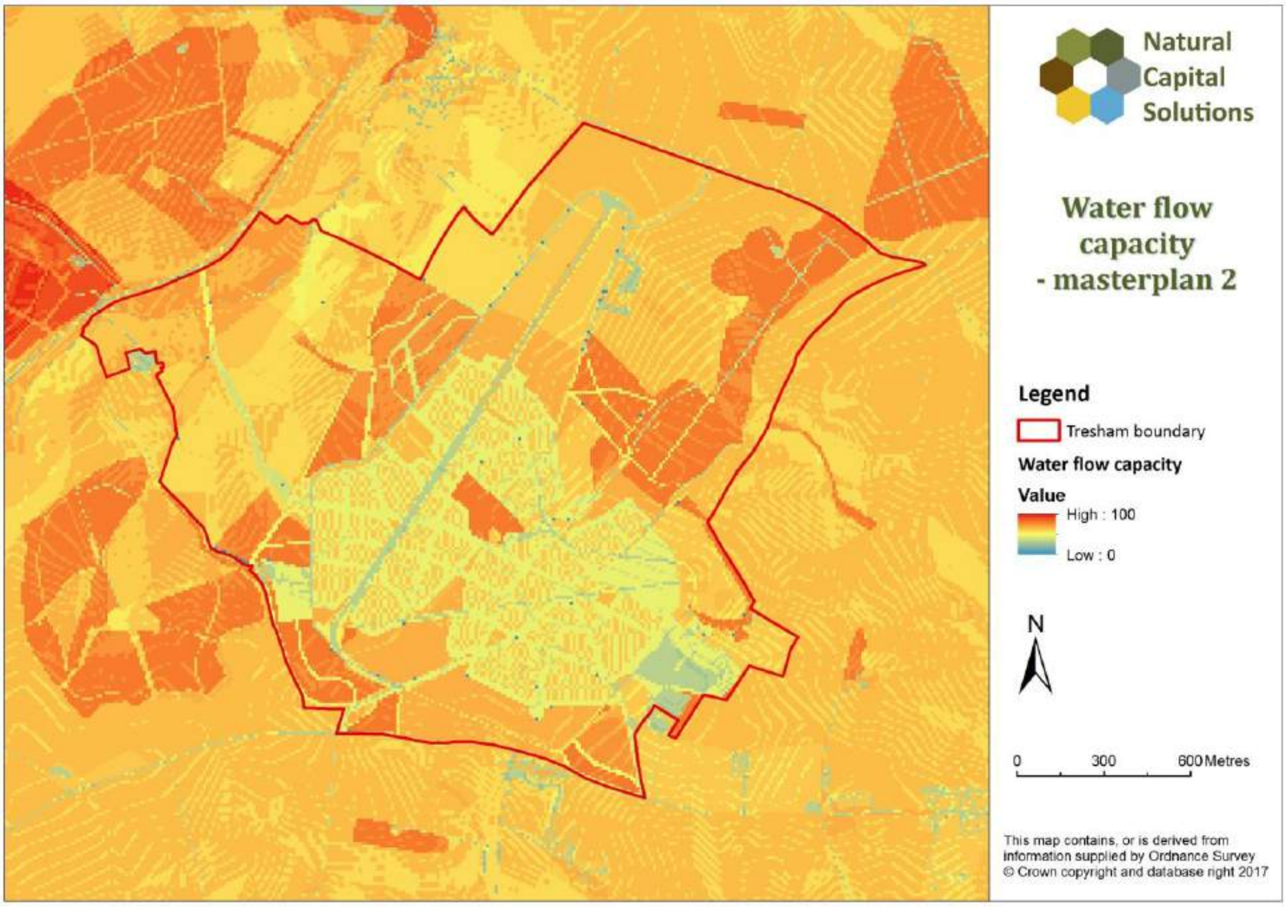
Map 40: Air purification capacity under the new masterplan at Tresham Garden Village



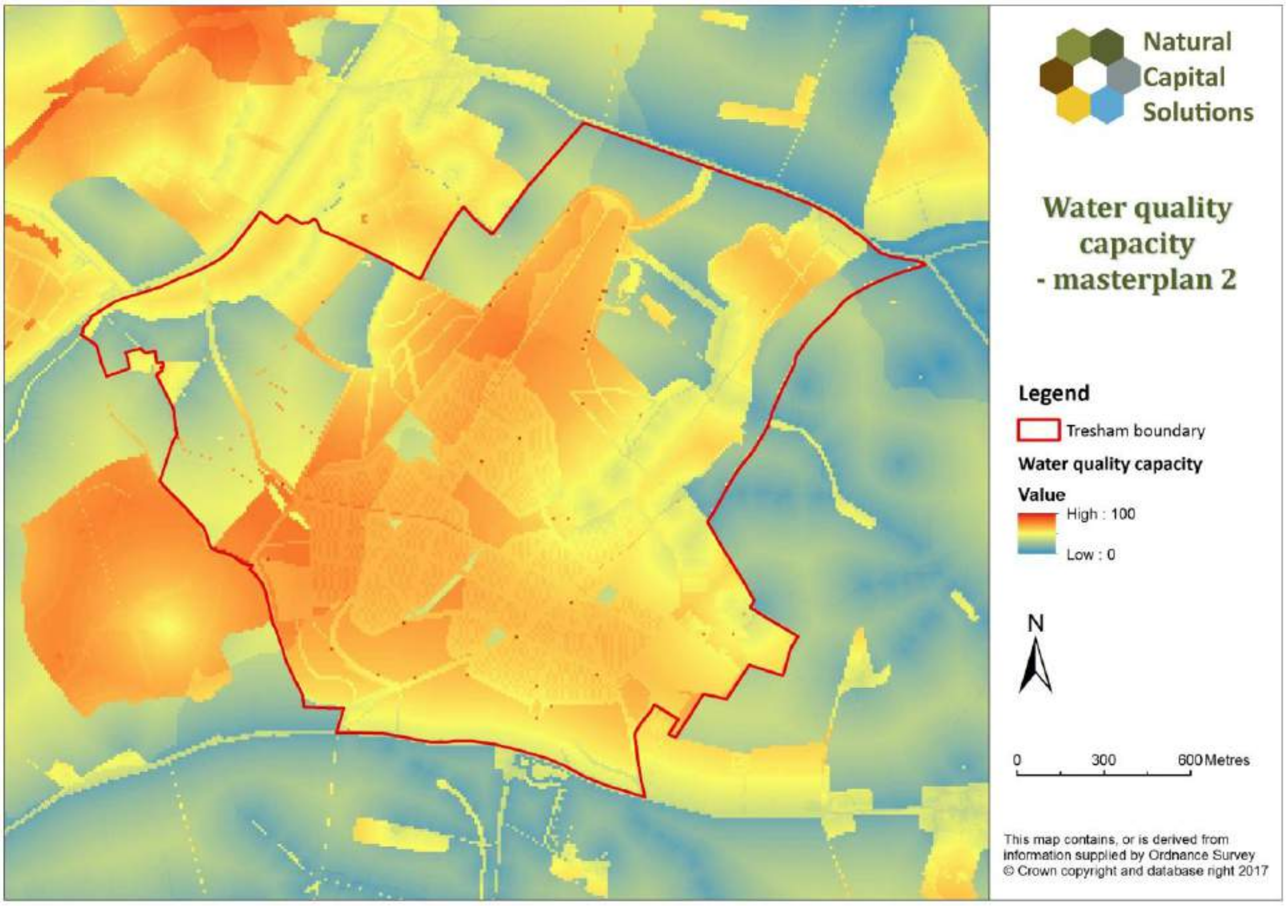
Map 41: Noise regulation capacity under the new masterplan at Tresham Garden Village



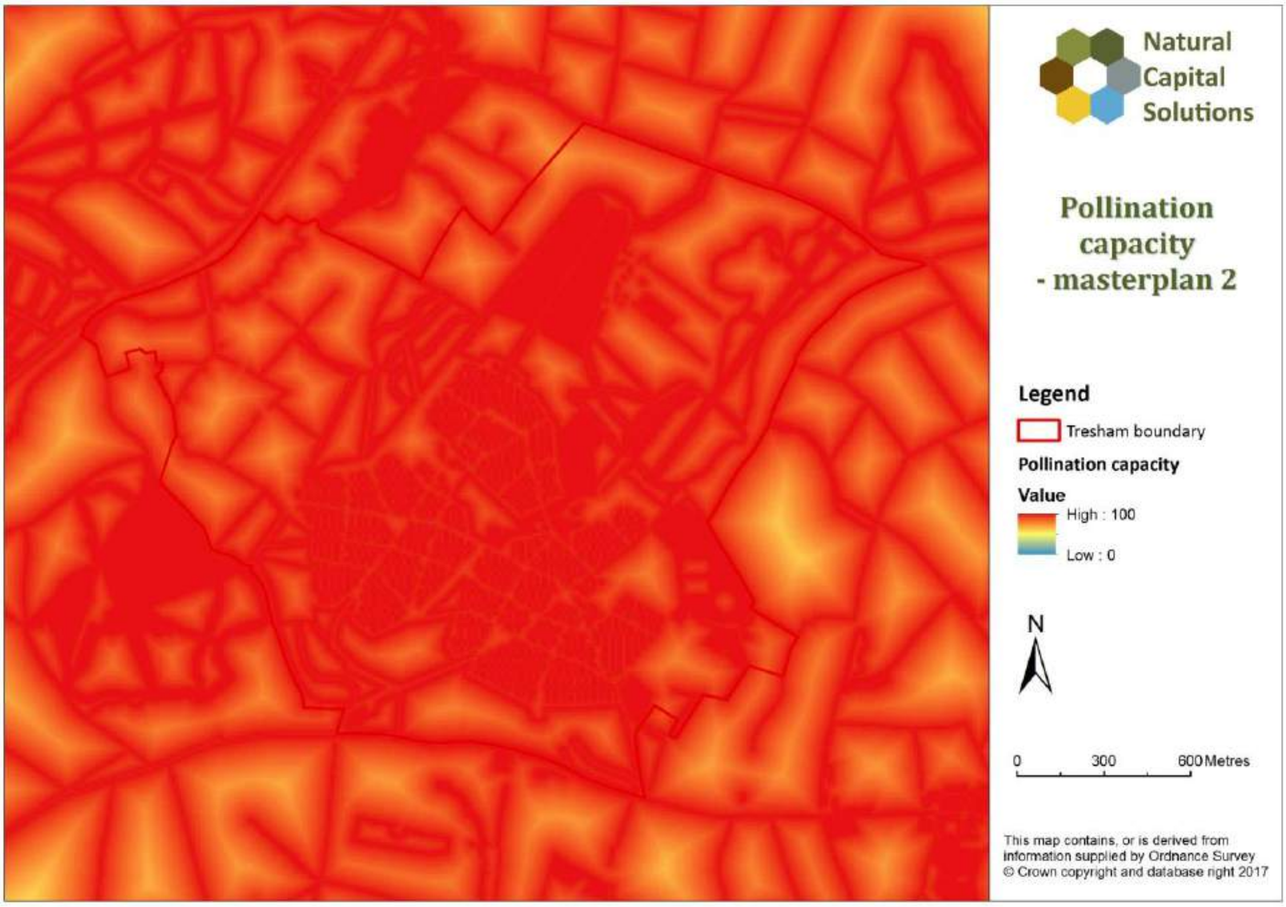
Map 42: Water flow capacity under the new masterplan at Tresham Garden Village



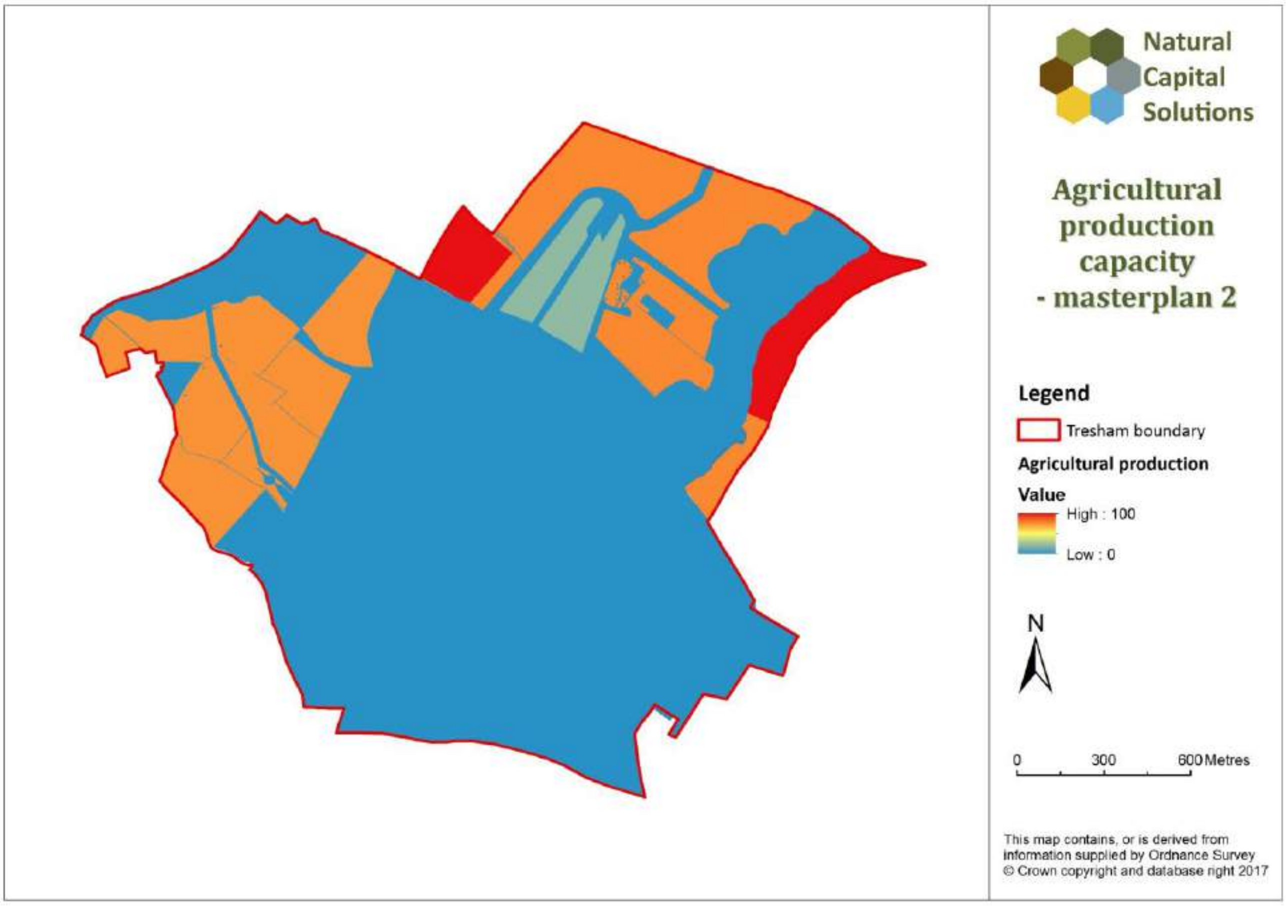
Map 43: Water quality capacity under the new masterplan at Tresham Garden Village



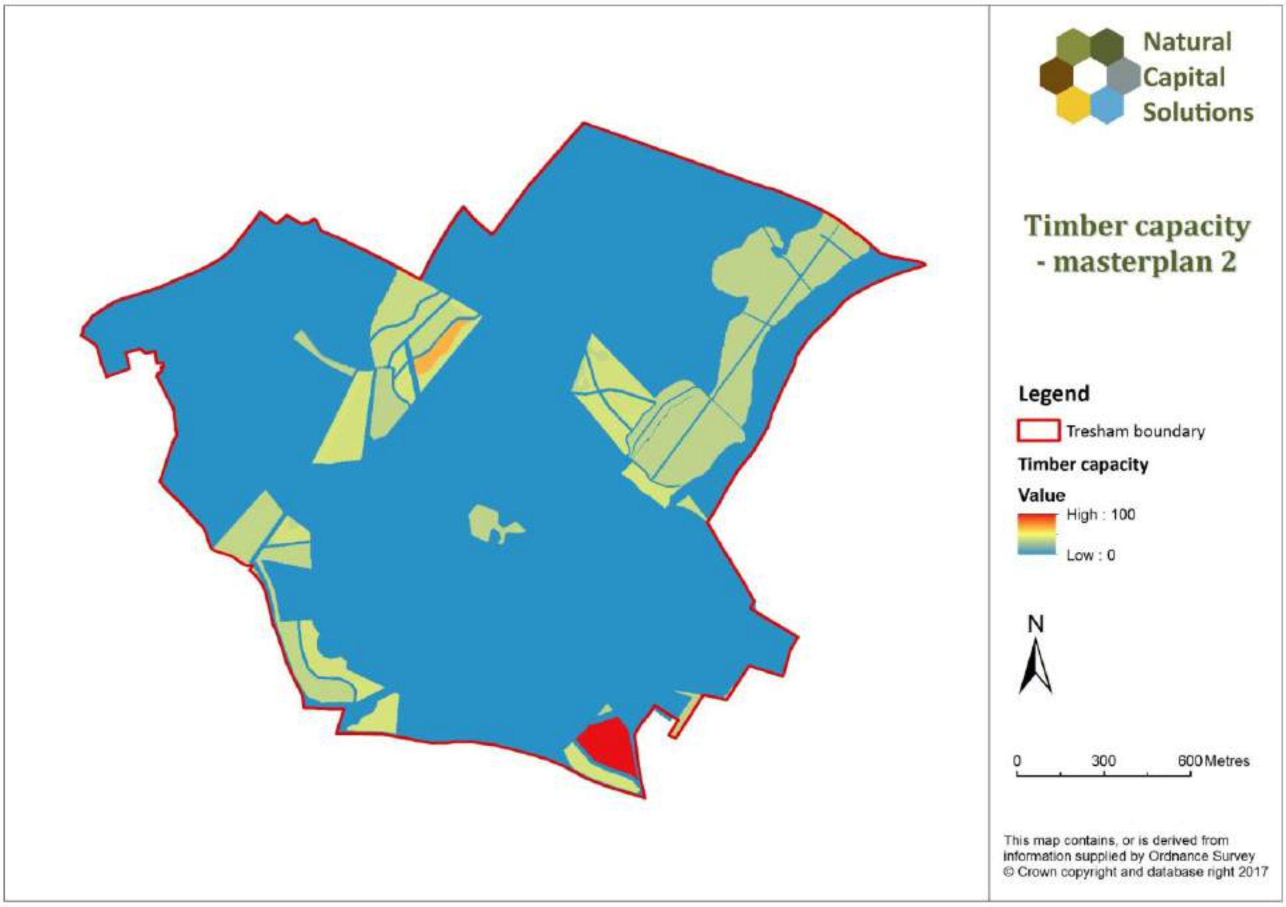
Map 44: Pollination capacity under the new masterplan at Tresham Garden Village



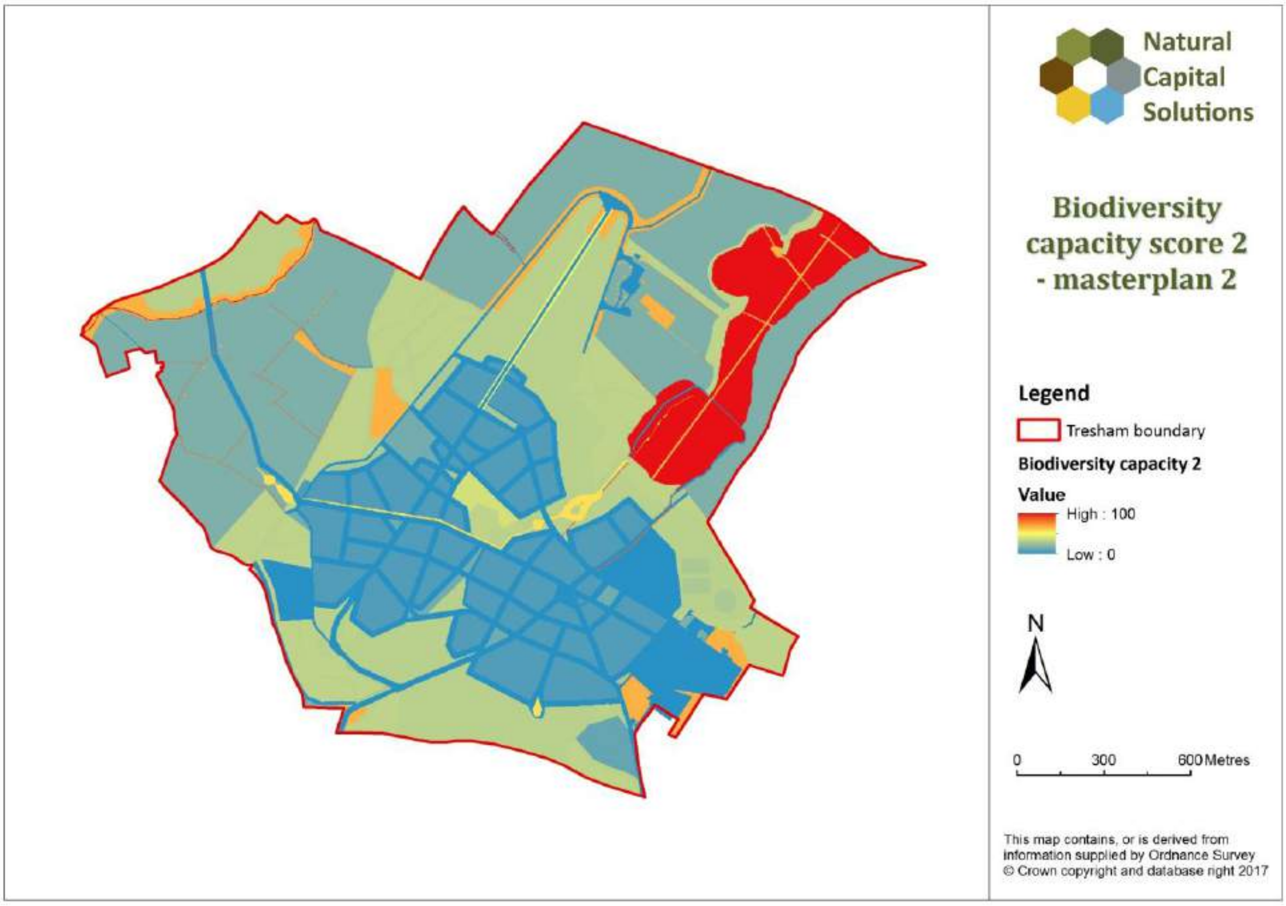
Map 45: Agricultural production capacity under the new masterplan at Tresham Garden Village



Map 46: Timber production capacity under the new masterplan at Tresham Garden Village



Map 47: Biodiversity capacity under the new masterplan at Tresham Garden Village using Score 2



Appendix 2 – Accuracy of the original basemap, without ground-truthing

As outlined in Section 2.2, a basemap was produced for the whole of Northamptonshire and Peterborough as part of the Nene Valley NIA project and a subsequent habitat opportunity mapping project. This was used as the primary basemap for this Tresham assessment (referred to as the uncorrected basemap), but was supplemented and updated based on a Phase 1 habitat survey carried out as part of the Tresham development process. An additional aim of this project was, therefore, to test the accuracy of the original uncorrected basemap and the impact that this would have on the ecosystem services results. Of key interest here, is to determine the difference in the results and hence if the uncorrected basemap could be used at other sites without additional ground-truthed survey data.

Accuracy of habitats

The map overleaf (Map 48) shows the key habitats based on the uncorrected basemap and should be compared to Map 1. Differences are clearly apparent, and these are focussed primarily around smaller and linear strips of habitat that aren't picked up in the uncorrected basemap. Running adjacent to most of the runways and perimeter road are linear strips of semi-natural grassland and improved grassland (Map 1), but these are not picked up in the uncorrected basemap (Map 48), which records all these areas as part of the adjacent fields, as arable farmland. The uncorrected basemap is based on Mastermap polygons and these do not divide fields unless there is a fence or boundary line, hence will never pick up features such as these. Similarly, Mastermap does not record field margins or hedgerows, and so these are also not shown in the uncorrected basemap.

The uncorrected basemap is fairly accurate at recording patches of woodland and scrub, although it will not record individual trees. It is also very good at determining roads, tracks and built-up areas. Most of the fields around Tresham have been correctly classified as arable, although a few fields have been miss-identified. A few small field are also classified as "uncertain agriculture" due to lack of information, whereas these can be fully classified using ground-truthed survey data.

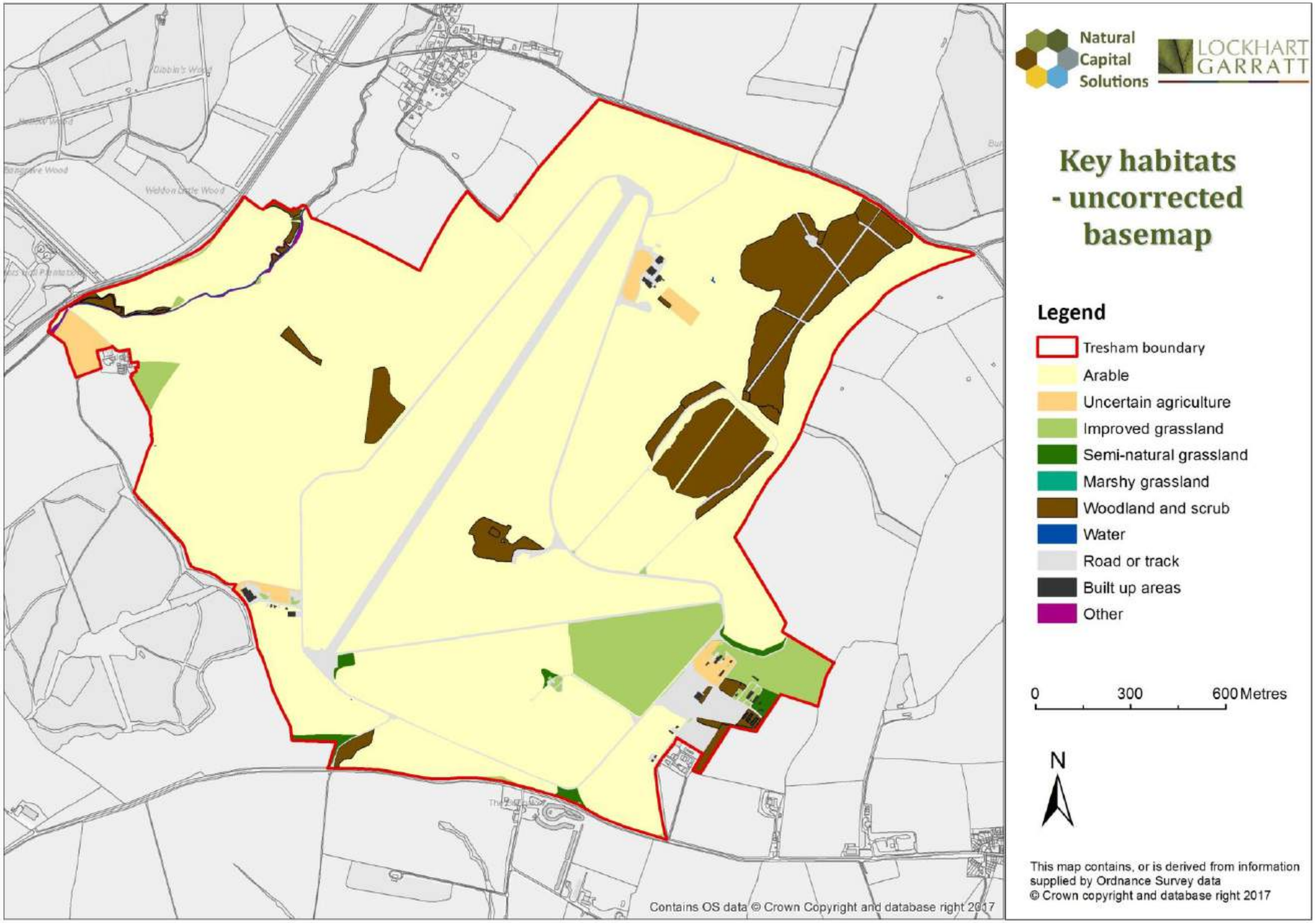
Overall, therefore, the uncorrected basemap is accurate at picking up the overall pattern of fields, infrastructure and so on, and can determine the typical dominant land-uses, but it does not pick up details within the landscape. The impact of this on the results of ecosystem service modelling is described next.

Impact on ecosystem services scores

Ecosystem services maps were produced for the Nene Valley NIA project, based on the uncorrected basemap, and these were clipped to the Tresham study area boundary and compared to the new ecosystem service maps produced as part of this Tresham Garden Village assessment. The overall scores for seven ecosystem services are shown in Table 5, alongside the scores calculated using the corrected baseline map. Scores have not been calculated for the remaining four services, as these were calculated specifically for this Tresham assessment and are not available for the wider area.

The scores for air purification capacity, noise regulation capacity and water flow capacity are all extremely similar, and with a score within 2.5%, of the more accurate baseline (ground-truthed) scores. Air purification and noise regulation scores are based primarily on woodland, and this is a habitat that is fairly accurately recorded in the uncorrected basemap. Water flow is to a large extent based on slope and runoff, which are only partly dependent on the basemap.

Map 48: Key habitats based on the uncorrected basemap at Tresham Garden Village



Water quality and pollination scores show a difference between the two habitat maps of 9 and 12% respectively. Pollination, in particular, is influenced by more detailed components of the landscape, especially hedgerows and field margins, hence is being under valued in the less detailed uncorrected basemap. Similarly, Water quality is worst in largely arable areas and the score based on the uncorrected map is not taking into account the field margins and strips of grassland that will improve this score.

The least accurate ecosystem services under the uncorrected basemap are carbon storage and accessible nature capacity, which are lower than the ground-truthed baseline by 20% and 37% respectively. For both of these services, arable farmland scores particularly poorly, whereas the smaller semi-natural habitats that were not being identified in the uncorrected basemap score well. However, although the percentage difference appears quite large, the difference between these scores and the score under the masterplans is far greater. For carbon storage, the scores under the original masterplan and Masterplan 2 are 22.6 and 23.0 respectively, and the scores for accessible nature are 8.7 and 15 (see Table 4). Hence, even if the uncorrected basemap had been used in the assessment, there would still have been a very significant increase in the ecosystem service scores post development.

Table 5: Supply of ecosystem services across the Tresham study area, showing the score achieved based on the uncorrected basemap compared to the ground-truthed baseline. The percentage difference is also shown.

Ecosystem service	Baseline	Uncorrected basemap	% difference
Carbon storage	12.5	**9.1**	-37.0
Air purification	15.8	**15.6**	-1.5
Noise regulation	14.7	**14.7**	0.0
Water flow	61.2	**62.7**	2.3
Water quality	41.4	**38.0**	-8.9
Pollination	91.1	**81.0**	-12.4
Accessible nature	0.12	**0.10**	-20.2

Conclusion

The uncorrected basemap does not pick up on more detailed elements of the landscape, especially field margins, hedgerows and linear strips of habitat, hence it presents are more simplified version of the landscape. However, it does identify the larger landscape elements including woodland, arable fields, built-up areas and infrastructure with a good level of accuracy. As a lot of the more detailed elements of the landscape tend to be higher quality semi-natural habitats, it means that the ecosystem service scores tend to be lower, although the impact varies depending upon how each ecosystem service score is calculated. But despite the differences in scores between the simplified landscapes depicted in the uncorrected basemap and the more complex landscapes in the ground-truthed baseline, the differences are much smaller than the change in scores that occur as a result of the proposed development.

It seems likely that this finding would occur elsewhere across Northamptonshire. It therefore seems viable to use the uncorrected basemap to carry out assessments where significant changes are predicted (such as major new developments) and for initial estimations of impact and optioneering. Using more accurate maps that have been updated based on ground-truthed surveys would be sensible when more accurate results are required, especially further along the development process, and when providing evidence for planning applications.