Natural Capital Solutions

PEEL

Understanding natural capital in practice

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Executive summary

The ‘Understanding natural capital in practice’ project aimed to raise awareness of the natural capital concept, and how it can be applied to the Peel Group businesses. Following the launch of the Government’s 25-year environment plan, and the current refreshing of the National Planning Policy Framework, it is clear that natural capital is to become an important component in environmental policy and in the regulation of the development sector. The consequence is that developers will soon need to demonstrate that their projects deliver biodiversity and natural capital / environmental net gain. Peel was, therefore, keen primarily to understand how natural capital and ecosystem services assessment methods can be used to show whether their developments have achieved net gain. They were also interested in how such assessment methods can be used on their existing landbank. It was important to Peel to explore how to influence the national scale natural capital agenda, and to be able to influence it by standardising methodologies and setting best practice.

The natural environment underpins our well-being and economic prosperity, providing multiple benefits to society, yet is consistently undervalued in decision-making. Natural capital can be defined as *“..elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans*” (Natural Capital Committee 2014). These benefits include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities. There are three main steps to any natural capital assessment, (i) the creation of an asset register for a site, that describes the extent and type of habitats, (ii) the estimation of the level of ecosystem services provided by the natural capital (physical flows), and (iii) the monetary valuation of the benefits provided by the ecosystem services (monetary flows). Using natural capital assessments in the development sector can reveal the positive and negative impacts of the design of a build on the natural capital assets and ecosystem services provided by the site. Such an assessment can demonstrate whether a design will be able to deliver net gain in ecosystem services.

We developed and tested three natural capital assessment methods in three Peel case study sites. These represented a site with no current masterplan (Site 1), a site at the masterplanning phase (Site 2), and a site with a fully scoped proposal (Site 3). After the natural capital assets at all of the sites were identified, the baseline ecosystem services provision was estimated for all three sites using an expert estimation of the level of provision across a range of ecosystem services (qualitative method). The level of ecosystem service provision was then estimated for the masterplan of Sites 2 and 3. A more detailed and quantitative natural capital approach was taken at Site 2. Four ecosystem services were modelled non-spatially and the value of the benefits that are derived from the ecosystem services provided was estimated using monetary valuation. Six ecosystem services were also modelled spatially using the EcoServ-GIS mapping toolkit and an overall site score reported on a scale from 0-100. The demand for two ecosystem services was also mapped using this approach.

The qualitative assessment at Site 1 (a site with no current masterplan) showed it was dominated by arable agriculture, but with a significant area of broadleaved woodland,

some of which is a priority habitat for biodiversity. The woodland area scored the highest of the habitats present for ecosystem service provision, being important for provision of timber and wood fuel, and for regulating air quality, climate through carbon sequestration and flood regulation, and for cultural services such as recreation. The site delivered multiple benefits but with a low overall score. This could be enhanced through more woodland planting, better woodland management, planting of hedgerows and encouraging more sustainable farming practices.

The qualitative assessment at Site 3 (a fully scoped development proposal) showed a slight net gain in ecosystem services. The site consists of landscaped parkland and has large areas of woodland, surrounded largely by improved grassland used for grazing. The development of a golf course and residential area will replace this agricultural land, and an area of poor quality semi-improved grassland, with hard surfaces, but will significantly increase the area of good quality semi-improved and amenity grassland. With better management of woodland, timber and wood fuel production will increase, conservation meadows will create better quality habitats for pollination and biodiversity (a net gain in biodiversity has been demonstrated using the Defra metric independently of this project), and the improvement in public access to the site will increase recreation and health and well-being. These improvements can only very slightly outweigh the loss of the food production service, and the slight reduction in climate and flood regulation, water purification and aesthetic services. The build will also increase the demand for ecosystem services in the area, so the natural capital net gain needs to be greater. We recommend that planting more trees along roads and streets, and creating pockets of woodlands could increase the provision of a number of ecosystem services. Converting amenity grassland to more structured habitat and considering green roofs and walls would also contribute to increasing the net gain.

Site 2, a development in the masterplanning phase, is currently dominated by agricultural fields (improved grassland) and open parkland with few trees. Both the qualitative assessment at the site, and the quantitative assessment showed a net loss of ecosystem services under the proposed masterplan. The residential development will take up most of the agricultural area, which is low in the provision of ecosystem services, replacing it with hard surfaces, gardens and pockets of amenity grassland. There are also decreases in marshy grassland, semi-natural grassland and parkland. However, there is an increase (more than double) in woodland area in the masterplan. The quantitative assessment and mapping of ecosystem services shows increases in local climate regulation, timber production, and carbon sequestration as a result of this. Access to the site is likely to be improved in the masterplan, and this is reflected in an increase in the accessible nature service. Agricultural production, carbon storage capacity, local air quality, noise and water flow regulation all decrease with the changes in land cover. The increased area of woodland, and the patches of amenity grassland and gardens do provide benefits, but not to a level that is enough to offset the impact on services of the hard surfaces added to the site. Biodiversity was assessed qualitatively at this site, and a net loss is likely. Natural capital net gain could be increased at this site by creating and extending woodland where possible on site. The inclusion of trees on new streets and along roads, where the pollution sources are located, could be very beneficial. Pockets of woodland in communal spaces could also help to increase carbon sequestration, storage, air quality, noise regulation, local climate regulation, water flow regulation and timber production. Meadows instead of amenity grassland, the consideration of SuDS and other green infrastructures, and a focus on opening up access for recreation could also be easy wins to achieve natural capital net gain.

Piloting the three approaches showed the quantitative measurement of ecosystem services in combination with mapping to be the most robust and useful approach for assessing natural capital net gain. The combination of being able to measure even small changes in ecosystem service provision and demand, on a common scale across all services, as well as illustrating the spatial pattern on service provision across the site is very powerful. It allows an understanding of where service provision and demand is high, and where it is low, so that habitat and green infrastructure solutions can be targeted cost effectively to achieve the desired net gain. The qualitative approach is useful for a quick assessment of potential ecosystem service provision at sites where there are no current development aspirations. This will be good enough to make informed decisions about land management to enhance biodiversity and ecosystem services.

The outcomes of the workshop associated with this project (19th January 2018) has also informed this report. The participants were key individuals from across the Peel Group business. The workshop aimed to give participants a background in the natural capital concept and how it can be applied to the development sector, by demonstrating its use through the three case studies outlined above. Discussions and breakout activities highlighted some key issues and concerns about using the approach within the Peel business, and in the development sector more broadly. There was an acceptance that the natural capital agenda will influence regulation of the development sector. There were concerns that it might not improve the success of planning applications if local authorities were not up to speed with the application of the approach, and if they were using different measures of assessment from Peel. There was a good understanding of how changing land uses and the use of green infrastructure can increase ecosystem service provision at residential development sites to increase ecosystem service provision for achieving net gain. However, there were some concerns about the subjective nature of the qualitative approach to ecosystem service assessment, and how the approach in general could be applied in more urban settings, or in other parts of the Peel Group (e.g. airports and energy infrastructure). Participants saw the benefits of this approach being applied in Peel at the site level, but also at the business scale, where it could be used to assess the full value of Peel's assets, and allow strategic decision-making across its portfolio.

Our conclusions:

- The qualitative method is good enough for quick assessments of land holdings with no current plans for development.

- The quantitative estimation and mapping of ecosystem services is the best approach at sites with proposed development at the masterplanning stage, where a net gain in biodiversity and natural capital is required. This approach can place all ecosystem services (mapped and non-spatially modelled) and biodiversity (using the Defra metric) on a common indicative scale. It also allows adapted masterplans to be reassessed for net gain.

- Most of the information required for the quantitative method has already been gathered as part of the planning application process. However, closer working with the design team and other stakeholders is also required to implement innovative solutions that will increase ecosystem service provision.

- The quantitative natural capital assessment method may help shorten the planning process by creating evidence-based arguments to opposition. It may also make the developments more desirable places to live and work.

- The natural capital agenda is rapidly progressing, but there are no standard methods, or approaches established yet. Other organisations have not yet delivered a robust method that can assess natural capital and biodiversity net gain. This is a real opportunity for Peel to demonstrate and set best practice in this area.

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Introduction

The Peel 'Understanding natural capital in practice' project

Peel Land and Property Group commissioned Natural Capital Solutions to complete a project that would explore how natural capital approaches could be applied to their business. The Peel Group is an infrastructure, transport and real estate investor in the UK. It has an extensive land holdings portfolio. A proportion of the sites are managed but do not have plans for development in the short term. Peel wanted to understand how natural capital approaches could be applied to both the managed land holdings with no plans for development, as well as sites that are to be developed.

The specific aims of the project were to:

- Raise awareness and understanding of the approach amongst Peel employees
- Demonstrate what the approach can achieve for development appraisal, and how it can be used and integrated into Peel's existing processes
- Explore how to influence the national level natural capital agenda
- Set the agenda for standardisation of the natural capital approach in development projects
- Set best practice

It was important to establish that key individuals at Peel understand what the natural capital concept is, how it can be applied, and what are the advantages of taking this approach to development appraisal. Given the natural capital agenda in the UK (see section 2) it is important that Peel can be influential at the national level, and lead the way in standardising this approach and setting best practice in the development sector. Although the 25 Year Plan (HM Government 2018) emphasises that the focus is to be on biodiversity net gain initially, net gain in ecosystem service provision (natural capital net gain) will also be necessary in the near future. It is, therefore, sensible that tools are developed now that can integrate both biodiversity and natural capital net gain, so both concepts can be operationalised as soon as possible for maximum benefits. This ensures that Peel are prepared for new legislation and regulation as it arises.

2. Background

What are natural capital and ecosystem services?

Natural capital can be 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 in turn 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.

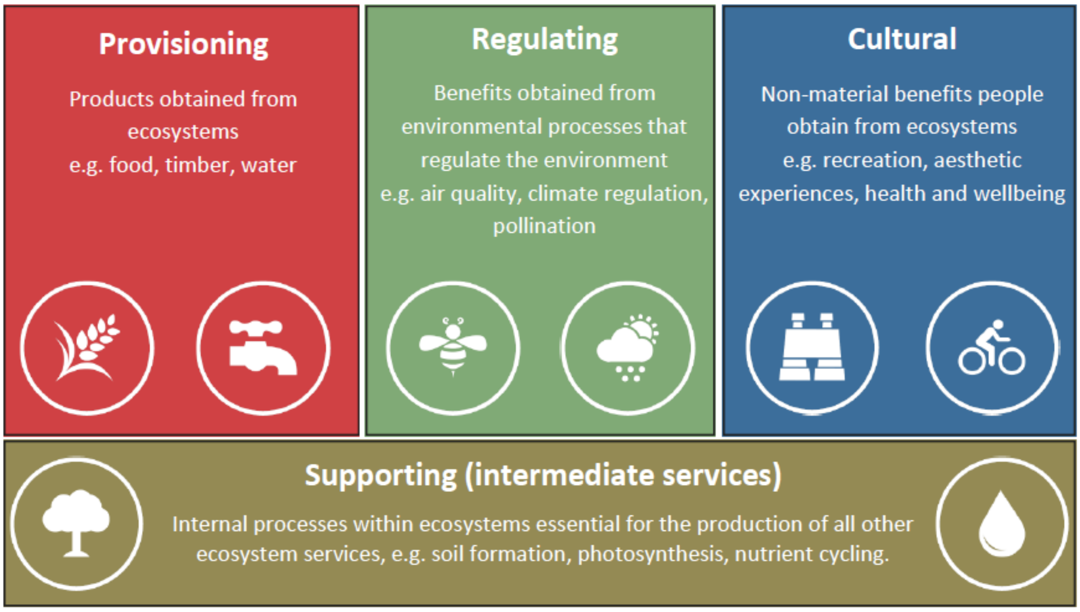


Figure 2.1 Broad classification of ecosystem services (based on MA (2005)).

Natural capital underpins our wellbeing and economic prosperity, providing multiple benefits to society, yet is consistently undervalued in decision-making. Much work is progressing on how to deliver natural capital approaches on the ground, and how to use it to inform and influence management and decision-making.

There are three main steps to any natural capital assessment. The first is to understand the extent, type and quality of natural capital assets. The creation of an **asset register** for a site, before and after planned development[1] if that is what is planned for the site, sets a baseline for further analyses. One of the most important steps is to recognise and quantify ecosystem service delivery (the **physical flow of services** derived from natural capital). These can also be examined before and after proposed 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. A last, and optional step, is to calculate the value of the benefits provided by the ecosystem services at the site, before and after development if desired (the **monetary flow of services** derived from natural capital). Economic valuation can be estimated in a number of units but it is common to use monetary valuation because it is a familiar, continuous unit of measurement and comparable. This requires further data on market values or other studies from which the value of benefits can be transferred.

[1] Asset registers can be compiled for a site after planned development using information on changes and additions in habitat from the masterplan.

The physical flow of some services still can't be measured well, and whether or not they can be applied depends on the context of the site being assessed, and the availability of data necessary to input into the ecosystem service model. Some services also remain difficult to value, particularly cultural services, flood alleviation and water quality. It is important to understand that this is an area of research at the cutting edge of science, it is still evolving, and approaches to measuring services, in particular, are constantly being updated with new knowledge. The application of natural capital approaches in practice across sectors, is also in its very early stages. As yet there is no single approach, or consistent methodology, that is being applied. The vocabularies around this approach are also evolving, and terms are used in different ways.

Biodiversity is the foundation for natural capital and performs important functions within ecosystems. It plays particularly important roles in relation to ecosystem services, although the complexities of the relationships between them are not fully understood. When considering ecosystem services, biodiversity is important in a number of ways: (i) as a factor that regulates the ecosystem processes that underpin ecosystem services, (ii) as a final ecosystem service that contributes directly to some benefits and their values, and (iii) it can itself be the benefit that has value. Biodiversity can therefore be presented as an ecosystem service or not. Here, we present it separately, as the foundation on which natural capital and ecosystem service provision depends, and to make biodiversity net gain distinct from natural capital net gain.

The natural capital agenda

The concept of natural capital is increasingly being recognised in the UK and globally, in both the public and private sectors. This is because it is a flexible approach that focuses on optimising the benefits from the natural environment, and can be used for ensuring land use and planning decision-making is evidence-based and transparent. The concept is a key policy objective of the UK Government through its Environment White Paper (2011). In this policy document the Government specifically stipulates that natural capital should be at the centre of economic thinking, and should be used sustainably. More recently this has been taken forward in 'A green future: Our 25-year plan to improve the environment' (HM Government 2018). Natural capital is central to this plan. We outline what this means specifically for the development sector below. The Government has shown its commitment to the natural capital concept through the creation of an independent advisory body the 'Natural Capital Committee'. They have helped develop the Government's approach to including natural capital in policy, and have been responsible for the Government delivering national natural capital accounts for a number of key habitats. Natural capital is also to be at the heart of the recently announced vision for a post-Brexit agricultural policy. Payments for ecosystem services (PES) are one mechanism by which farmers will be incentivised to change their behaviours.

Natural capital and the development sector

The Government is currently working with the Ministry for Housing, Communities and Local Government (MHCLG) to review the National Planning Policy Framework (2012). At the moment this policy states '*The planning system should contribute to and* *enhance the natural and local environment by […] recognising the wider benefits of ecosystem services*'.

The Government's 25-year plan (2018) proposes "*Embedding an 'environmental net gain' principle for development, including housing and infrastructure*", and promises to *"..expand the net gain approaches used for biodiversity to include wider natural capital benefits such as flood protection, recreation and improved water and air quality*". The plan makes no attempt to define 'environmental net gain', and does not expand on any approaches that could be put in place to do this.

The approach is also starting to be adopted at the regional and local scales. For example, the Greater Manchester Spatial Framework is working to a natural capital target. The Greater Manchester Urban Pioneer project is also piloting natural capital approaches.

The emergence of 'net gain'

The concepts of natural capital and biodiversity net gain are being used increasingly. Net gain has emerged, especially in relation to the development sector, referring to a situation where there is a gain in natural capital or biodiversity post development, compared with the pre-developed state. Previously developers have been working to 'no net loss' of biodiversity, i.e. that biodiversity should be the same post development as it was before it. However, following the 25 Year Environment Plan (HM Government 2018), it is now thought that no net loss is not sufficient due to increasing pressure on biodiversity, and that attempts should be made to enhance it where possible, both through on-site and off-setting methods. It has also placed an emphasis on natural capital, outlining how the benefits provided by natural capital also need to be enhanced post development.

Good practice principles for biodiversity net gain in development have been outlined by CIEEM, CIRIA, IEMA (2016). A document that takes this further is due out this spring. The Defra biodiversity metric, that was devised for use in off-setting (Defra 2012), is increasingly being used to demonstrate biodiversity net gain. There are some issues with this metric. For example, it deals well with natural habitats but not green infrastructure interventions (e.g. green roofs and walls), which limits its use in urban systems. There is an on-going consultation by Defra and Natural England on how to improve the biodiversity metric. Similar good practice guides do not exist for natural capital net gain, but metrics and tools are beginning to emerge. The Natural Capital Planning Tool has just been launched (http://ncptool.com), a project supported by RICS. This is a spreadsheet tool that allows planners to start thinking about ecosystem services and how development plans might impact on this. It is an indicative assessment tool that is not based on quantitative models of ecosystem service provision. A recent case study by Balfour Beatty (http://naturalcapitalcoalition.org/the-natural-capital-benefits-of-delivering-biodiversity-net-gain/) attempts to demonstrate the natural capital benefits of delivering biodiversity net gain. However, including natural capital within the biodiversity net gain concept may be a cause for confusion. The BRE (Building Research Establishment) and the BSI (British Standards Institution) are also developing their approaches to incorporating natural capital and ecosystem services into building standards.

However, to date there is only one example that we know of (Tresham Garden Village) that has applied a quantitative spatial natural capital approach to a site that is to be developed, to assess whether the development will meet net gain in biodiversity and ecosystem services provision. The reason there are not yet more examples is that there remains a big gap between policy and practice in applying the natural capital concept. There exists little knowledge of, and expertise in, the methodologies required to apply it in practice.

The natural capital approach can be applied in the development sector in two ways. The first is at the business scale to understand the value of the natural capital assets across the business, to enable strategic decisions to be made in managing those assets for net gain. The second is at the individual development scale, as an assessment of the impact of the design on natural capital and ecosystem service provision. The latter is the focus of this project.

Developments have impacts on natural capital and its ability to provide ecosystem services. These impacts can be positive or negative. Natural capital assessment methods can reveal these impacts on ecosystem services and their direction of change, to provide an appraisal of the design of a development. This process allows options for cost-effective interventions to be identified that can increase the provision of ecosystem services and deliver net gain. Changes to plans that do not deliver net gain can be altered and the design re-appraised using the same techniques. It is important to note that natural capital approaches are concerned with the benefits derived from the natural environment component of a build, which are impacted and delivered by the development. It does **not** assess the impact on the environment of the grey infrastructure and technology within a development, by measuring the consumption of water or the emissions of carbon.

3. Applying natural capital approaches to Peel case studies

Approach and rationale

The aim of this project was to develop a methodology that could be used by Peel to understand their natural capital assets at the development site scale. It needed to be flexible enough to be used across managed land holdings, that did not as yet have any development aspirations, sites that were in the masterplanning phase, and sites at which development plans had been fully scoped. In order for Peel to choose the approach that was most appropriate for their needs, we tested both a qualitative and quantitative approach. The case study sites and approaches are outlined below.

(i) Land holdings with no development planned

Site description	Site 1: a 232 ha area of arable farming and woodland land use.
Data available	No data on natural capital assets.
Approach used	Qualitative assessment of natural capital and ecosystem services at site baseline.

(iii) Fully scoped development proposal

Site description	Site 3: a 269 ha area of private parkland.
Data available	Phase 1 habitat survey of site baseline, geological and archaeological surveys, biodiversity net gain assessment, masterplan habitats, maps and assessment of residential and golf course developments, EIA documents etc.
Approach used	Qualitative assessment of natural capital and ecosystem services at site baseline and post development.

(ii) Masterplan stage

Site description	Site 2: a 268 ha area of proposed residential development.
Data available	Phase 1 habitat survey of site baseline, masterplan habitats and residential development (not complete).
Approach used	Qualitative assessment of natural capital and ecosystem services, and quantitative non-spatial and spatial natural capital and ecosystem services assessment, with mapping of ecosystem services at site baseline and post development.

For each of the three sites the first step was to assess the natural capital assets by establishing the habitat types present. A map of the baseline natural capital assets was produced for all sites, along with an asset register that outlined the area of each of the habitat types. The baseline ecosystem services provision was estimated for all three sites using an expert estimation of the level of provision across a range of ecosystem services (based on the Millennium Ecosystem Assessment categorisation of services (MA 2005)) provided by each habitat (Site 1) and across all habitats at the sites (Sites 2 and 3). The level of ecosystem service provision was then estimated for Site 3 and Site 2. A broad range of ecosystem services was used for the qualitative approach to highlight the range of ecosystem services that can be provided by these sites.

A more detailed and quantitative natural capital approach was taken at Site 2. Ecosystem services were modelled non-spatially (i.e. a single value for ecosystem service provision across the site). The value of the benefits that are derived from the ecosystem services provided was estimated using monetary valuation (see Technical Appendix section A). Ecosystem services were also modelled spatially using the EcoServ-GIS mapping toolkit (Technical Appendix section A), and an overall site score reported on a scale from 0-100. The demand for a sub-set of ecosystem services could also be mapped using this approach.

Table 3.1 Non-spatial and mapped ecosystem services modelled at Site 2.

Non-spatial	Spatially mapped
Carbon sequestration	Carbon storage
Timber production	Local climate regulation*
Air quality regulation (PM_{10} & SO_2)	Local air quality regulation*
Agricultural production	Noise regulation
GHG emissions	Water flow regulation
	Accessible nature

*demand was modelled for these services

In total the provision of 9 ecosystem services (air quality regulation and local air quality regulation are considered one service, GHG emissions are a disservice), and demand of two services were estimated in this pilot project. Noise regulation demand can also be mapped, however, we didn't include it, as it is very similar to air quality regulation demand. Water quality and pollination could not be modelled as additional data were not available.

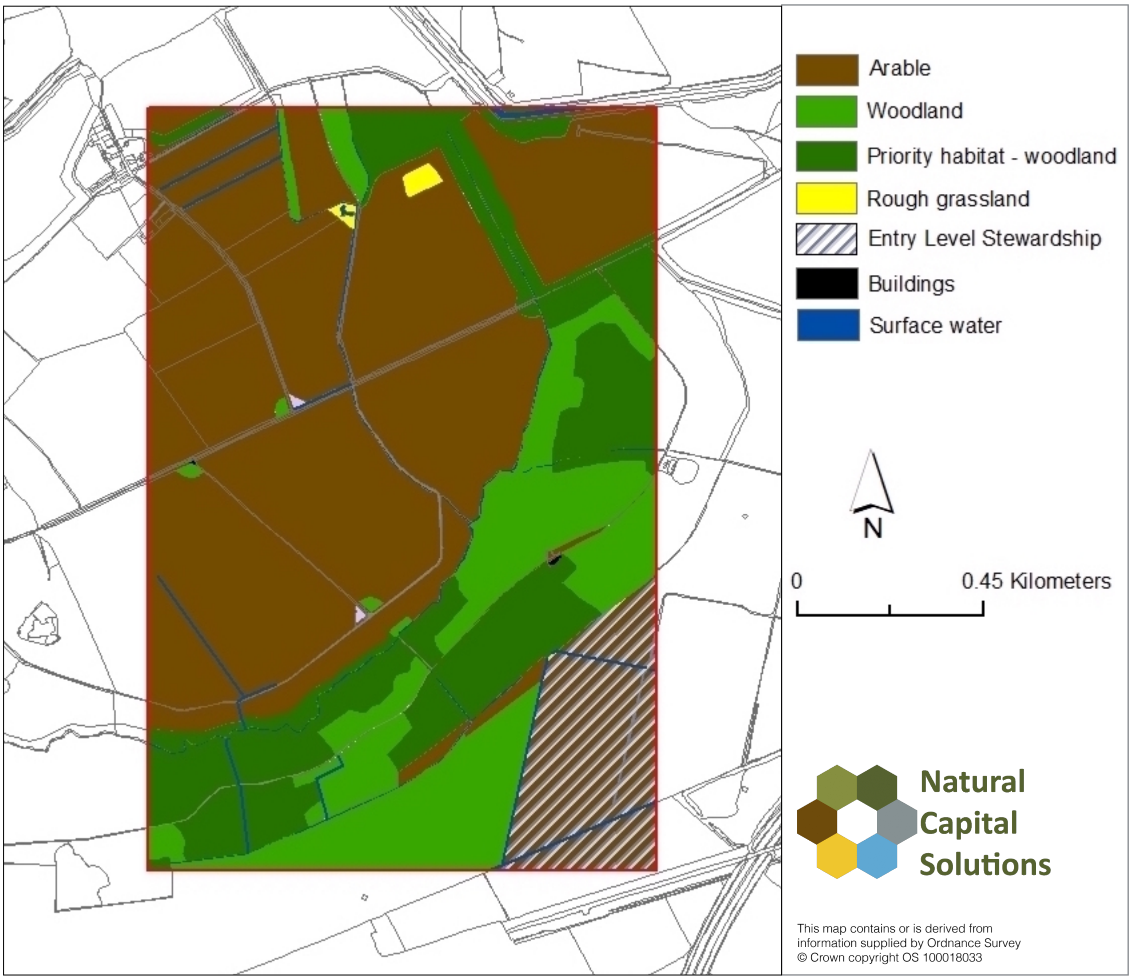
Biodiversity

Biodiversity net gain had already been assessed at the Site 3 based on the Defra biodiversity metric (Defra 2012)). Biodiversity net gain was not included in the assessment of Site 2. This was because it was assumed that this would automatically be included in the process of fully scoping the masterplan. However, we recommend that it is included within the overall natural capital assessment of a site in the future. It is possible to scale it from 1-100 so that it is directly comparable with the ecosystem service provision scores. See Technical Appendix section B for more details.

Case study results

Site 1

Natural capital assets
Site 1 is a 231 ha site managed by Peel, and there are no current plans to develop in the near future. The dominant land use (64%) is arable agriculture (Map 3.1, Table 3.2), with 13% of the arable area under Defra's Entry Level Stewardship scheme. Deciduous woodland covers most of the remaining area (35%), with 54% of this area considered as a priority habitat under section 41 of the Natural Environment and Rural Communities Act (2006). This means that this deciduous woodland area is of 'principal importance' for the conservation of biodiversity in England.



Map 3.1 Site 1 natural capital assets (habitats).

Table 3.2 Asset register for Site 1.

Habitat	Area (ha)	Proportion of site (%)
Arable Entry Level Stewardship	147.3 (19.8)	63.57 (8.55)
Woodland (mainly deciduous) Priority habitat (deciduous)	81.6 (44.0)	35.22 (18.99)
Rough grassland	0.7	0.30
Surface water	1.7	0.73
Total site	231.7	

Ecosystem services (physical flow account)

The expert estimation of ecosystem services showed the highest score for woodland habitats - 27.5 out of a possible 45 (Table 3.3). Woodlands are important for the provision of timber and wood fuel, and for regulating air quality, climate through carbon sequestration and flood regulation, and for cultural services such as recreation.

The area is also an important habitat for biodiversity. The rough grassland and freshwater habitats have a lower score than woodland, but are important for certain services (e.g. food provision, aesthetic value, water quality and regulation). Arable habitats score only 12.5 out of 45. This is low, as such habitats are managed to optimise the food provisioning service, and, depending on how this is managed, can be to the detriment of other ecosystem services. For example, frequent and deep ploughing can break up the structure of the soil and cause increased soil erosion, and reduce the capacity of the soil to retain water. The score across the whole site is 71 out of a possible 180 (Table 3.3).

Recommendations

Clearly the site already delivers multiple benefits, but there is a good deal of room for enhancement. Increasing the area of woodland would increase the provision of a number of ecosystem services. Better woodland management, planting hedgerows, increasing the area of land under Government stewardship schemes or setting up 'Payments for Ecosystem Services' (PES) schemes to incentivise farmer behaviour to more sustainable practices, and increasing access for recreation would all improve the scores.

Table 3.3 Estimated ecosystem service provision scores for Site 1: 0 - no delivery; 0.5 - some delivery but not significant, 1 - delivery, 2 -significant delivery, 3 - very significant delivery. The maximum score for each habitat is 45, and across the whole site is 180.

Ecosystem service category	Ecosystem services	Arable	Woodland	Rough grassland	Fresh water
Provisioning	Food: crop and livestock production	3	1	2	1
	Fibre: timber	0	2	0	0
	Fuel: wood / wood fuel	0	2	0	0
Regulating	Air quality regulation	0.5	2	1	0
	Climate regulation (carbon)	1	2	1	1
	Flood regulation	0.5	2	1	2
	Water purification (including erosion control)	0.5	0.5	1	2
	Pollination	1	1	1	0
	Noise regulation	0	1	0	0
Cultural	Aesthetic	2	2	2	2
	Recreation	1	3	1	1
	Health and well-being	1	2	1	2
	Education	1	2	1	2
Supporting	Biodiversity	0.5	3	2	3
	Soil formation and nutrient cycling	0.5	2	1	0
Total score	**Whole site: 71** **Per habitat:**	**12.5**	**27.5**	**15**	**16**

Site 3

Background
Site 3 (269 ha) is a 19th century landscaped park, with plantation woodland, and is a Grade II Listed Registered Park and Garden of Special Historic Interest. It is recorded on the Natural England Parkland BAP Priority Inventory and all woodlands in the site are identified as Sites of Biological Importance (a county level designation). It also contains grazing pasture (cattle and horses). It is of cultural and archaeological importance. It has one public right of way extending in to the western extent of the park. There is a local nature reserve (0.65 ha) on the southern edge (see Map 3.2). A stream flows through the centre of the proposed development site from the north-west to the south-west. Along its course it passes through two artificial lakes. Collectively, these three water bodies are designated as a Main River and as a Water Framework Directive water body. The area is in the Environment Agency's Flood Zone 1, which means it is at low risk of fluvial flooding (<1 in 1000 risk, 0.1% per annum).

The plan is to develop an eighteen-hole golf course, with a 142-bed hotel at the centre of the site (with 150 car parking spaces). There will be a golf clubhouse, grounds maintenance buildings, and associated on-site roads and circulation routes. North of the main road there will be a golf academy with a practice course, covered driving rage, adventure golf course, clubhouse, car (150 spaces) and buggy parking. Residential development is planned on the periphery of the golf course to the west, north-east and south-east. This will include 1036 houses/apartments, taking up an area of 56 ha.

Certain features of the area are to be restored. For example, a dam, along with historic buildings and features will be restored. The woodlands will be brought back into active management, with the removal of invasive species, and the planting of new parkland trees. Ponds have been retained and clustered for the protection of biodiversity. The Surface Water Drainage Strategy ensures there is no increase in the risk of flooding from the development (up to 1 in 100-year probability rainfall event with a 40% allowance for climate change), and Sustainable Drainage Systems (SuDS) will be used. Public access will be increased, with pedestrian access from the main road, a series of public footpaths around residential areas and re-routing, upgrading and additions made to the public right of way network including the creation of a new 'community trail'. A community informal open space will be created in the southern area of the site.

Much of the site, with the exception of the woodland areas, will be cleared to make way for the golf-course and residential areas . The golf and built environment will include conservation grassland areas. The construction is in 2 stages, with most of the site being cleared and developed initially, but with the area west of the golf academy and the south-west residential area being developed during a later phase. As a result, an assessment of the ecosystem services provision of the natural capital baseline is made in 2040 when all development works will be complete.

Natural capital assets
The dominant habitat in the baseline site is improved grassland or pasture (Table 3.4) which covers an area of 129 ha (46% of the site), there are some small fields of arable agriculture within this (8.7ha). There is a significant area of woodland (75.5 ha, 27% of the site), which includes an area of ancient woodland in the south of the site (Map 3.2).

There are 39.5 ha (14% of the site) of semi-improved grassland, the vast majority of it is poor quality. The good quality areas are likely to be the pockets of purple moor grass and rush pastures (see Map 3.2). An area of 4 ha is dense scrub, with hedges a significant feature at the site covering a length of 2908 metres (Table 3.4). Existing buildings and hardstanding cover an area of 6 ha. Other habitats such as freshwater, mire swamp, and amenity grassland, also feature but to a much lesser extent.

In the masterplan site the area of woodland will increase slightly by 2.9ha. The most significant change is the complete loss of improved grassland, poor quality semi-improved grassland and arable habitats (Table 3.4). This will be replaced by a 30 times increase in good quality semi-improved grassland (57.1), but also a very significant increase in amenity grassland (from a baseline of 0.6 to 87.1 ha). The area of freshwater at the site increases slightly. There is a decrease in the length of hedgerows (225 metres). An area of 25 ha will be occupied by buildings after development, which increases the area of hard surfaces by 19 ha (Table 3.4).

Map 3.2 Site 3 baseline natural capital assets (habitats).

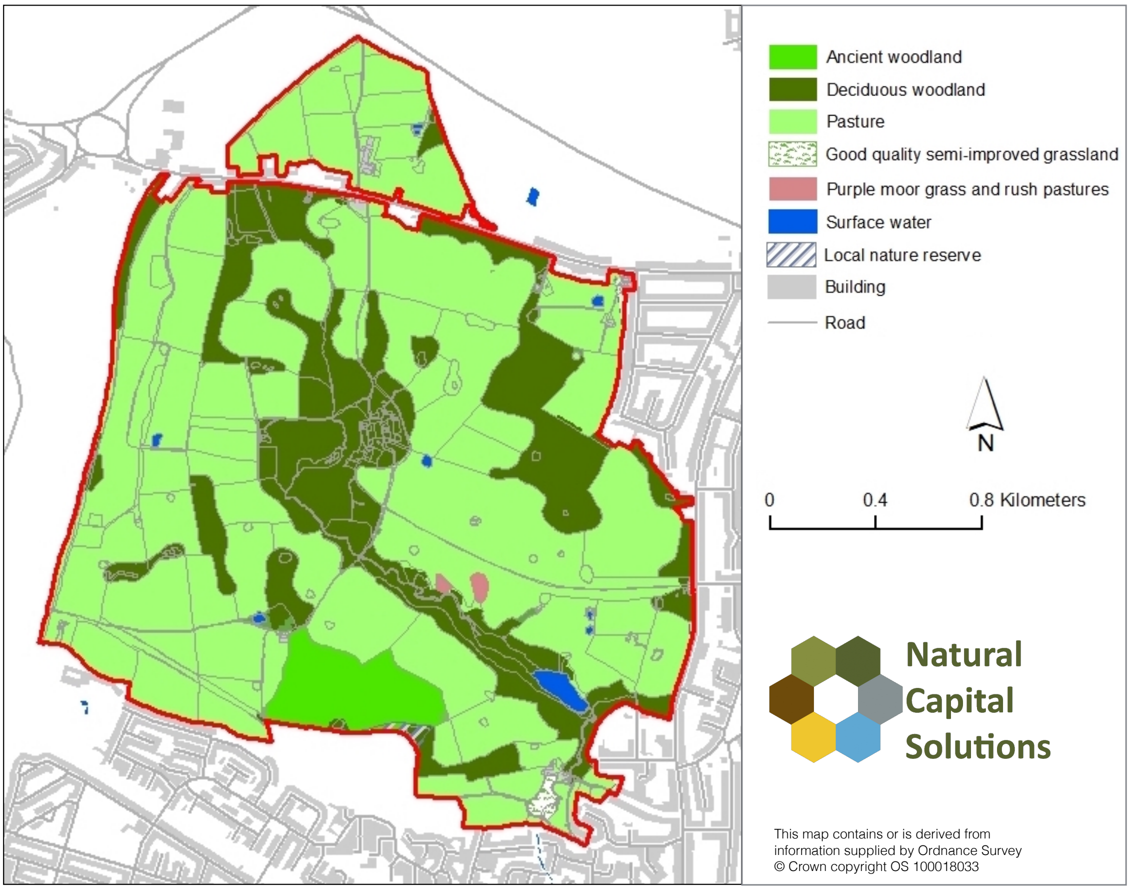


Table 3.4 Asset register for Site 3 baseline and masterplan 2040 site.

Habitat	Baseline ha	Masterplan 2040 ha	Habitat gain / loss ha
Semi-natural broadleaved woodland (deciduous)	75.5	78.34	2.9
Dense scrub	4.0	0.9	- 3.1
Semi-improved grassland	1.9	57.1	55.2
Improved grassland (pasture)	129.1	0	- 129.1
Poor semi-improved grassland	37.6	0	- 37.6
Freshwater	4.2	7.7	3.5
Mire / swamp	0.7	0.1	-0.6
Arable	8.7	0	- 8.7
Amenity grassland	0.6	87.1	86.6
Buildings and hard standing	6.0	10.9	4.9
Residential development	0	19.8	19.8
Bunkers and grasscrete	0	7.8	7.8
Bare ground	0.74	0	- 0.7
Total site	**279**	**279**	-
Hedgerows	2908m	2683	- 225

Ecosystem services (physical flow account)

There is an overall slight net gain in ecosystem services from baseline to masterplan at Site 3 (Table 3.5). Due to the management of the woodland there is likely to be a small increase in timber and wood fuel production. The conservation meadows and overall increase in semi-improved grassland will create better quality habitats to enable and increase the pollination service, and in general it is better for biodiversity than improved grassland and poor-quality semi-improved grassland (net gain in biodiversity has already been demonstrated independently for this masterplan). Due to consideration of public access to the currently private site, the improvement and addition of public rights of way, and the provision of community green spaces, the recreation and health and well-being services are thought to increase. The food production service will obviously decline at the site due to the complete loss of the improved grassland and arable. Climate regulation (carbon sequestration and storage), flood regulation, water purification and aesthetic services are likely to be very slightly reduced. This is due to the inevitable overall increase of hard surfaces at the site under the masterplan scenario. These could in reality go either way, and this qualitative estimation approach is not sensitive enough to pick up slight changes like this. However, the modelling approach used in the Site 2 case study would be effective in demonstrating the direction and magnitude of change.

Increasing net gain

When considering developments such as the one at Site 3, it is important to remember that the development will bring in more people to the area and, therefore, increase the demand for ecosystem services. This requires there to be a reasonably sized net gain, to compensate for this extra demand. Clearly this would be wise at Site 3, and there is more that could be done to increase ecosystem service provision at the site, whilst considering cost effectiveness and return on investment. For example, consideration could be given to planting more trees, and areas that are higher in air pollution around roads would be priority locations. This would increase carbon sequestration and storage, timber/wood fuel production, air pollution and noise regulation, water quality and flood alleviation services. Converting some amenity grassland areas to more structured habitat would help with flood alleviation, pollination and also increase biodiversity. Further consideration to the SuDS strategy and the inclusion of other green infrastructure, for example green roofs and walls, will also increase water quality and flood alleviation, air quality, climate regulation and pollination.

It is important to note that there were design changes at Site 3, arising through the planning process in 2017/18 during this study, which have not been integrated into this natural capital assessment. This includes additional woodland management and enhancement, which is likely to have a positive effect. In addition, there will be further opportunities to respond to the Site 3 findings in detailed design and delivery stages (e.g. street trees, gardens, landscaping, etc.).

Table 3.5 Estimated ecosystem service provision scores for Site 3: 0 - no delivery; 0.5 - some delivery but not significant, 1 - delivery, 2 -significant delivery, 3 - very significant delivery. The maximum score for the site at baseline or masterplan is 45.

Ecosystem service category	Ecosystem services	Baseline	Masterplan (2040)	Direction of change
Provisioning	Food: crop and livestock production	2	0	-2
	Fibre: timber	2	3	1
	Fuel: wood / wood fuel	2	3	1
Regulating	Air quality regulation	2	2	0
	Climate regulation (carbon)	3	2	-1
	Flood regulation	3	2	-1
	Water purification (including erosion control)	3	2	-1
	Pollination	1	2	1
	Noise regulation	2	2	0
Cultural	Aesthetic	2	1	-1
	Recreation	1	3	2
	Health and well-being	1	2	1
	Education	2	2	0
Supporting	Biodiversity	2	3	1
	Soil formation and nutrient cycling	2	2	0
	Total site score (max 45)	30	31	1

Site 2

Background

Site 2 is a 268 ha site consisting of agricultural fields and open parkland. The site is surrounded by residential areas. It is an area valued for its recreation services, for example, walking, fishing and bird watching. The proposed development at this site will create c. 3-4000 houses, building out from the residential areas on the outskirts of the site.

Natural capital assets

The most widespread habitat (58% of the site) in the Site 2 baseline is improved grassland, covering 156 ha. As a result of this there are very few trees in this site (up to 3 ha). Existing blue infrastructure covers 30 ha, surrounded by large patches of semi-natural grassland to the south-east and the north-west of the site (22ha). There are small pockets of marshy grassland in wet areas. Mowed grass (amenity) covers an area of 30 ha both in the north and south of the site. There are few houses and gardens in the site. The most significant change in natural capital assets from baseline to masterplan is the decrease in the area of improved grassland (117 ha). There are also decreases in marshy grassland, semi-natural grassland and trees/parkland. The numbers for these are small, but they are significant reductions in an already small area of habitat. However, there is an increase (more than double) in woodland area in the masterplan. There are also increases in amenity grassland and cultivated land. Obviously, due to this being a residential development, there is a significant increase in buildings (52 ha) and gardens (54 ha).

Table 3.6 Asset register for Site 2 baseline and masterplan.

Habitat	Baseline ha	Masterplan ha	Habitat gain / loss ha
Woodland, broadleaved	2	5	3
Trees / Parkland	1	0	- 1
Grassland, amenity	30	55	25
Grassland, improved	156	39	- 117
Grassland, marshy	7	3	- 4
Grassland, semi-natural	22	16	- 6
Uncertain agriculture (improved grass or arable)	6	2	- 4
Cultivated / disturbed land	0	2	2
Garden	3	57	54
Freshwater	30	36	6
Infrastructure	8	8	0
Built up areas	3	55	52
Total site	**268**	**268**	**-**

Ecosystem services (physical flow account)

Qualitative/expert estimation

The qualitative assessment of ecosystem services (Table 3.7) shows a net loss of ecosystem services at Site 2. There is a reduction in the food production ecosystem service due to the conversion of improved grassland. The loss of natural habitats along with a significant increase in hard surfaces associated with the development and infrastructure may result in a decrease in flood regulation, water purification services and aesthetic value of the site. However, there is likely to be a slight increase in timber /wood fuel production due to the increase in woodland cover in the masterplan. This may not be enough to make a difference to the rate of air pollution regulation, carbon sequestration and storage or noise regulation. Assuming that public access to the Site 2 will increase recreational opportunities (it has not been possible to establish this in this pilot project), health and well-being and educational value may increase. Although some semi-natural grassland will remain, the increases in amenity grassland and garden areas will not provide the same quality of habitat for biodiversity, but it may be enough to maintain the same pollination opportunities.

Table 3.7 Estimated ecosystem service provision scores for Site 2: 0 - no delivery; 0.5 - some delivery but not significant, 1 - delivery, 2 -significant delivery, 3 - very significant delivery. The maximum score for the site at baseline or masterplan is 45.

Ecosystem service category	Final services	Baseline	Masterplan	Direction of change
Provisioning	Food: crop and livestock production	2	1	- 1
	Fibre: timber	0.5	1	0.5
	Fuel: wood / wood fuel	0.5	1	0.5
Regulating	Air quality regulation	0.5	0.5	0
	Climate regulation (carbon)	1	1	0
	Flood regulation	2	1	- 1
	Water purification (including erosion control)	2	1	- 1
	Pollination	1	1	0
	Noise regulation	1	1	0
Cultural	Aesthetic	3	2	- 1
	Recreation	2	3	1
	Health and well-being	2	3	1
	Education	2	3	1
Supporting	Biodiversity	3	1	- 2
	Soil formation and nutrient cycling	2	1	- 1
	Total site score (max 45)	24.5	21.5	- 3

Non-spatial quantification and valuation

Four ecosystem services were quantified for the baseline and proposed masterplan (Table 3.8). Here, the differences between the two are presented in terms of physical values of ecosystem services, and the value of the flow of benefits from these services.

The masterplan habitats will take up an additional 16 tonnes of CO_2 and produce an extra 12.9 m^3 of timber per year, compared to the baseline situation, due to the increase in woodland at the site. Taken together, this small increase in physical flows of ecosystem services provides an increased annual value of £1,201 (2017 prices). The masterplan environment will have less capacity to absorb pollutants than the baseline site, a reduction of 0.29 tonnes per year of PM_{10} and 0.01 tonnes per year of SO_2. This means that the annual damage cost of the pollution avoided through the woodland asset will be reduced by £5,366 (2017 prices). The masterplan will reduce livestock farming productivity by 75%, a loss of £11,491 per year. However, there will be an associated decrease in GHG emissions (265.4 tonnes of CO_2), which is a saving of £16,720 (2017 prices) per year (note GHG emissions are a disservice and therefore have not been included in Table 3.8).

Table 3.8 Estimated service provision and the value of the benefits that flow from these services (£ 2017) from the natural capital assets of Site 2.

Ecosystem service	Baseline	Masterplan	Gain / loss
Carbon sequestration tCO2e/yr	21.20 (£1,336)	37.2 (£2,344)	+ 16 (£1,008)
Timber production m^3/yr	17.1 (£257)	30 (£450)	+ 12.9 (£193)
Air quality regulation tonnes/yr (trees and grass) PM_{10} SO_2	0.88 (£16,416) 0.03 (£59)	0.59 (£11,073) 0.02 (£36)	- 0.29 (- £5,343) - 0.01 (- £23)
Agricultural production Number of livestock	293 (£15,385)	74 (£3,894)	- 219 (- £11,491)

Spatial quantification (mapping)

The provision of six ecosystem services has been mapped, along with the demand for two (see Table 3.1), although we are not able to show them in this report due to their commercially-sensitive nature. Table 3.9 shows the baseline and masterplan provision and demand for each ecosystem service, with an indicative overall score of the level of provision (or demand) out of 100, which is an average across the whole site. The scores allow comparisons between the baseline and masterplan for each ecosystem service, but also allow the comparison of scores across ecosystem services within each site condition. Section A of the Technical Appendix outlines exactly what each service is and how it has been measured.

The score for carbon storage at the Site 2 baseline is not particularly high (Table 3.9). This may be due in part to a lack of trees in the area (woody vegetation is good at storing carbon), but also may be due to agricultural soils being less effective at storing carbon, and because the site contains large areas of freshwater. The score for carbon decreases in the masterplan. Although there are more trees in the area that are effective at storing carbon, the loss of semi-improved grassland and the replacement of the large agricultural area with buildings, reduces the overall capacity of the site for storing carbon.

Local climate regulation at both the baseline and masterplan are quite low (Table 3.9). This is largely due to the lack of trees at the site, as the model focuses on the cooling capacity of woodland, scrub and water. It is clear that the blue infrastructure is driving the capacity for climate regulation at the site. There is a slight increase in the service from baseline to masterplan. This is largely due to the patches of trees that will be planted as part of the development. The demand for this service is just over 5 times higher with the development, than at baseline conditions. High demand lies mainly in the residential areas on the periphery of the site at the baseline, but this changes with the addition of residential areas in the core of the site. The large number of houses to be developed increases the area of sealed surfaces that are particularly prone to urban heating. It brings in a large population of people who will require the regulation service, some of which may be in high risk age categories and therefore are in higher need of the climate regulation service.

Local air quality regulation has similar scores to carbon storage, and these scores decrease slightly from baseline to masterplan conditions. It is clear that the increase in trees can promote patches of higher air quality regulation, however, it is the replacement of improved grassland habitat with sealed surfaces that drives the slight decrease in this service. The demand for this service will increase nearly 3-fold with the development (Table 3.9). The highest demand is mainly from the residential areas and roads (as a source of pollution) on the periphery of the site in the baseline, but the development brings an extra road through the middle of the site, an increase in built up areas (low capacity to regulate pollutants) and a higher local density of people, that will increase demand considerably.

Noise regulation decreases slightly from baseline to masterplan. These baseline scores are quite low and, as with air quality regulation, even though the planting of trees with the development will support a higher provision of this service in patches (woodlands are the most effective habitat at absorbing noise), overall they do not compensate for the increased area of sealed surfaces.

Water flow capacity shows quite high scores overall, showing that this site is effective at slowing run off and alleviating flood risk (Table 3.9). However, data also show that there is a decrease in the provision of this service with the development. Flat areas with permeable soils, and with woodland, are the best locations for slowing the flow of water. The masterplan introduces a higher proportion of sealed surfaces, which are smoother and promote higher run off. The new areas of trees do promote the capacity of this service, but not enough to compensate for the development.

The accessible nature service (extent of public access and perceived naturalness) increases from baseline to masterplan site (see Table 3.9). These scores are quite low as access is assumed to be limited in the baseline. This is likely to be an underestimate and public access is currently likely to be higher at the site. The development will bring the possibility of access to a broader area of the site, with community green spaces in and between residential areas.

Table 3.9 Summary of ecosystem services scores for the Site 2 baseline and proposed masterplan. See section A of the Technical Appendix for results in graph form.

Ecosystem services	Baseline	Masterplan	Change
Provision:			
Carbon storage	20.1	12.4	-7.7
Local climate regulation	11.4	12.7	1.3
Local air quality regulation	20.2	17.5	-2.7
Noise regulation	17.5	11.3	-6.2
Water flow regulation	66.1	52.9	-13.2
Accessible nature	1.6	5.9	4.3
Demand:			
Local climate regulation	7.4	38.2	30.8
Local air quality regulation	14.0	40.3	26.3

Overall there is a net loss in ecosystem services at Site 2 under the proposed masterplan. Four out of the six ecosystem services decline from baseline to masterplan. It is possible to add the additional non-spatial ecosystem services modelled (agricultural production, carbon sequestration and timber production) to this and score them on the same scale from 0-100. This would still show a net loss in ecosystem services with 5 services decreasing and 4 services increasing. We have not scored biodiversity within this framework, but it is possible to do so using the Defra metric and presenting it on the same scale as the ecosystem services. This metric has not been calculated, but it is likely that it will show a net loss in biodiversity at the site under the proposed masterplan.

Achieving net gain

To increase ecosystem services provision at Site 2 it is necessary to compensate for the loss of natural land covers. The most effective way to increase multiple services is by creating and extending woodland where possible on site. This option may be limited at this site, but the inclusion of trees along roads and streets, where pollution and noise sources are located and demand for the services are high, along with trees in communal green spaces would be very effective at increasing carbon sequestration, storage, air quality, noise regulation, local climate regulation, water flow regulation and timber production. It may even increase accessible nature scores. A further way of increasing the provision of services in the proposed masterplan is to limit the amount of amenity grassland and create more complex habitats (e.g. meadows). This increases water flow regulation, pollination and biodiversity. Optimising service provision can also be achieved through the use of Sustainable Drainage Systems (SuDS) and green infrastructures like green roofs. These are likely to influence water flow regulation, quality, air quality and local climate regulation and pollination.

It is important to note that the Site 2 masterplan that was tested was at an early stage and had not yet benefitted from any prior natural capital assessment or indeed any significant work on ecological and landscape impact mitigation. These are gradually being built into the masterplan as it is refined ahead of proposals being sought for planning. A further natural capital assessment would be appropriate to help shape and further refine the masterplan into a net gain position.

Advantages and limitations of the approaches

Three approaches to the assessment of natural capital and ecosystem services have been presented. The qualitative approach is subjective and depends on the knowledge of the 'expert' that is estimating the impacts of land use changes from baseline to masterplan. One expert's opinion may differ from another, so the ecosystem service scores may be different across experts. This is particularly an issue when the overall impacts of land use change leads to marginal/small changes in ecosystem service provision. This type of scoring is not nuanced enough to deal with these situations. The qualitative approach also does not account for differences in area of habitats at the site when scoring the level of service provision. This means that is does not highlight the relative levels of service provision. However, this is a quick method that is better suited to assessing the ecosystem service provision at a site, than to compare land use changes between a baseline and a development scenario.

The non-spatial approach used does not capture the whole range of services that flow from the natural capital assets across Site 2. It is also of limited value, as although it provides a biophysical value to service provision (i.e. tonnes of carbon), it gives just a single value for the whole site. It does not allow an understanding of how the provision or demand of services varies within a site.

The spatial modelling and mapping approach is the most robust and useful approach. It shows the spatial patterns in the provision and demand of services, allowing developers to understand where it is possible to change land uses to increase service provision, and where this is not necessary. Balanced with an understanding of the demands for services, this can lead to creating the most effective solutions to increasing natural capital net gain. The models also allow a broader range of services to be included in an assessment, and take a broader range of natural capital assets at a site into account. There are caveats associated with these models, and they are indicative (i.e. they indicate whether services are high or low, and the direction of change, but in most cases can't provide the biophysical units of services). See section A of the Technical Appendix for a full description of the models.

4. Peel natural capital workshop

Natural Capital Solutions organised and delivered a workshop at Peel Dome on the 19th January 2018. The participants were key individuals from across the Peel Group businesses. The aim of the workshop was to ensure the participants had a grounding in the natural capital concept, understood what is driving the natural capital agenda at the UK scale, and also how it is being applied to the development sector. The workshop was also used to deliver the results of the 'Understanding natural capital in practice' (UNCP) project, and importantly to allow the participants to input into the process of understanding how this concept could be integrated into the business of the Peel Group.

The workshop started with a presentation focused on defining natural capital and ecosystem services, and outlining the Government policies that are promoting the natural capital concept, and are likely to lead to new regulation in the development sector. A short question session afterwards generated some interesting discussion.

The following outlines the key points from the discussion:

- Participants were keen to know if and how local authorities were beginning to take on this concept, and how other companies were beginning to tackle applying it in practice.
- There was a general acceptance that the natural capital agenda is coming and Peel should decide how it can integrate the approach to meet new regulation.
- There was concern that there are differences in how local authorities are embracing (or not) the concept, and this could make the development process more difficult, or at least that Peel taking on the concept might not make much difference to a smooth planning process.

Following the discussion was a further presentation on the results of the UNCP project as outlined in the previous sections of this report. It included suggestions on easy wins for increasing ecosystem service provision to achieve natural capital net gain. This moved into the first of two breakout sessions.

Breakout session 1

The participants worked in four groups and were required to show how they would modify the habitats / land uses at a development site to increase the provision of ecosystem services. Each group had a map of Site 2 with tracing paper over the top, on which they had to mark their ideas for different habitats and green infrastructure. A graph of the ecosystem services provision and demand scores were also given to each group, so they could identify which services were a priority to increase. They were asked to consider the cost effectiveness of the interventions and how it might affect the overall return.

In general, the modifications to the site were quite different between the groups, certainly in their location within the site, but the use of habitat types was similar. The following outlines the key points from the activity:

- All groups increased tree cover along the roads, particularly the new primary access road through the proposed developments at the site. This would increase multiple services and be particularly efficient being placed at sites of highest pollution. One group created new woodland areas on the north-west and south of the site.

- Sustainable Drainage Systems in the residential areas was suggested by all of the groups, to reduce runoff and flood risk.
- Increasing access was seen as important for recreation, through footpaths and cycle provision around the site. There was even a suggestion of including a visitor and education centre, and water sports provision.
- There was a good deal of thought about increasing opportunities for biodiversity, increasing the nature reserve area and providing wildflower meadows to replace some areas of amenity grassland (which would bring with it additional benefits).
- An allotment area was suggested, to increase community cohesion and health and well-being.
- There was also a focus on sustainability, local recycling and renewable energy generation.

Breakout session 2

The groups were asked to discuss two questions that were designed to generate discussion that could feed into the conclusions of the UNCP project. The following questions were distributed among the groups and the key discussion outcomes are presented after each one.

(1) What do you believe are the practical challenges of making this approach standard practice for Peel? E.g. how can it be streamlined into existing processes, do current practices need to be adapted, how to think in natural capital terms?

- The weighting of ecosystem services against others at a site was perceived to be quite subjective, particularly in relation to the qualitative assessment.
- An ecosystem services expert would have to be an expert in many fields, which would be difficult in a planning inquiry.
- There was a question as to whether what Peel wants is a masterplan tool or guidance from this approach.

(2) Which natural capital approaches presented do you think are the most useful / appropriate and when?

- In the initial stages of planning it was suggested that the expert estimation (qualitative) approach would be the most useful.
- After this initial phase in the process to a final development proposal, quantification and mapping would be required.
- Towards the end of the process monetary valuation should be used, but there was some concern that this was subjective, and that there is a particular challenge with quantifying ecosystem services.

(3) If Peel takes this approach as standard, who else that the business relies on as part of the processes of planning and completing a development need to be influenced to ensure a successful implementation of the approach? E.g. local authorities, surveyors and others who make valuations?

- The following groups were thought to be important:

Customers of Peel – developers, occupiers and existing tenants.
Neighbours – stakeholders and community.
Policy- and decision-makers at the local, national and regional scale.
Consultants and designers – a combined design approach.
Regulatory bodies.

(4) How could the natural capital approach be applied in other areas of the Peel business? E.g. airports, renewable energy, recreation projects.

- The application of the approach to airports may not be necessary due to already tight regulations on noise and pollution, but also would be difficult given the safety guidelines in relation to vegetation and wildlife.
- There was a feeling that the EIA of energy infrastructure means the process of assessment and reporting is already in place for many ecosystem services (e.g. noise regulation etc.).
- This approach could work well for Peel's retained sites and property, particularly planning at local site level and involving stakeholders in workshops.

Breakout session 2 led into a broader discussion about the approach and what the next phase of the Peel natural capital project should focus on. The following outlines the key points from the discussion:

- If Peel do not take this approach they might be underestimating the value of their land.
- A natural capital approach would be important for strategic decisions across the portfolio.
- A linked-up methodology is required to take this approach in practice. There was uncertainty as to whether this approach should be just for understanding Peel's natural capital assets internally, or should be showcased as a methodology in Greater Manchester or UK.
- A need to see how the approach works in inner city / urban developments was identified, as it may show very different results to the approach applied to rural developments.
- The approach should be applied from the top-down to create a strategy for the management of Peel's natural capital assets (e.g. understanding how to off-set for net gain across the portfolio of sites) and from the bottom up to guide decisions at the development site scale.

5. Conclusions

Natural capital assessment and net gain methods at the development scale

Having completed the pilot project, Peel Land and Property Group and Natural Capital Solutions are considering the various lessons learnt and issues involved in implementation.

Three different approaches to assessing natural capital and ecosystem services have been tested in this pilot project to understand how natural capital approaches can be used in practice as part of Peel Group business. The qualitative method is good enough for quick assessments of land holdings with no current plans for development. The quantitative estimation and mapping of ecosystem services is the best approach at sites with proposed development at the masterplanning stage, where a net gain in biodiversity and natural capital is required. This approach can place all ecosystem services (mapped and non-spatially modelled) and biodiversity (using the Defra metric) on a common indicative scale. It also allows adapted masterplans to be reassessed for net gain.

Most of the information required for the quantitative method has already been gathered as part of the planning application process. However, closer working with the design team and other stakeholders is also required to implement innovative solutions that will increase ecosystem service provision. The quantitative natural capital assessment method may help shorten the planning process by creating evidence-based arguments to opposition. It may also make the developments more desirable places to live and work.

Integrating with policy and regulatory change

The application of natural capital to the development sector (and indeed in other sectors) is new and constantly developing. The Government has recently articulated a vision for environmental policy that is based on natural capital. This will stimulate change across a broad range of policies and regulation. Peel are early to recognise that regulatory change to include this approach is on the horizon, and that it makes sense to look forward to integrating biodiversity net gain and natural capital net gain now, as the regulation will come into place at some point making both mandatory. We have offered a way to measure biodiversity and natural capital net gain that is flexible enough to adapt to whatever policy and regulation emerges.

Technical Appendix

Section A

This section of the technical appendix outlines the methods used to quantify ecosystem services at Site 2.

Non-spatial ecosystem services models

Carbon sequestration

What it is 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 from the woodland areas at Site 2 was calculated following the UK Woodland Carbon Code methodology and look-up tables (Woodland Carbon Code 2012a, b). All trees at Site 2 were broadleaved and assumed to be a standard mix of birch, ash and sycamore. The average yield class was used for each species, as well as an average spacing between trees, and it was assumed the woodland was not thinned. The sequestration rates were averaged over a 100-year period (this being the time period after which they are harvested). The average annual sequestration rates were then multiplied by the area of each woodland type and added together to give the total sequestration estimate for woodland at the site. This was calculated for the baseline and masterplan scenario at Site 2.

Monetary valuation

Carbon is increasingly being given a monetary value and forms the basis of Payments for Ecosystem Services (PES) schemes such as the Woodland Carbon Code. Monetary flows were calculated using the Government's central non-traded carbon prices for 2017 (HM Treasury 2015).

Timber capacity

What is it and why is it important?
Timber capacity is simply a measure of the average value of the timber or wood fuel 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.

How is it measured?
The physical flow of timber production was estimated using the average yield classes of the woodland type present, as outlined for carbon sequestration. The physical flow of this service was calculated by multiplying the yield class by the area of each woodland type. This was calculated for the baseline and masterplan scenario at Site 2.

Monetary valuation
The monetary flows of timber production were calculated using the following formula: Unit value of timber (£/m^3) x Annual volume of timber (m^3/ year).

The price for broadleaved timber ranges from £15 to high quality timber reaching £250 per m^3 standing (ABC 2015). It is assumed that most of the wood produced in the urban area will be used for wood fuel, so a conservative estimate is made using the lower price inflated to 2017 prices.

Air pollution regulation

What is it and why is it important?
Vegetation can be effective at mitigating the effects of air pollution, primarily by intercepting particulates, especially PM_{10} (particulate matter 10 micrometres or less in diameter), but also by absorbing ozone, SO_2 and NO_x. Trees are much more effective than grass or low-lying vegetation, although effectiveness varies greatly depending on the species. The ability of the woodland and grassland habitats of the baseline and the masterplan to absorb two of these key pollutants, PM_{10} and sulphur dioxide SO_2, was quantified.

How is it measured?
The deposition rates for PM_{10} and SO_2 deciduous woodland and grassland were taken from Powe & Willis (2004). The average background pollution concentration in 2015 (most recent year available at the time of analyses) was calculated using Defra 1 x 1 km resolution maps clipped to the relevant local authority boundary using GIS software (Modelling of Ambient Air Quality (MAAQ) https://uk-air.defra.gov.uk/data/pcm-data). The surface area index of deciduous woodland and grassland in on-leaf and off-leaf periods was taken from Powe & Willis (2004). The proportion of dry days (rainfall <1mm) for Greater Manchester region was estimated using MET office data for East Scotland (http://www.metoffice.gov.uk/climate/uk/summaries/datasets). The proportion of on-leaf relative to off-leaf days was estimated at the UK level using the average number of bare leaf days for five of the most common broadleaf tree species (ash, beech, horse chestnut, oak, silver birch) in the UK using The Woodland Trust data averages tool (http://www.naturescalendar.org.uk/findings/dataaverages.htm). This was calculated for the baseline and the proposed masterplan at Site 2.

Monetary valuation
The air quality regulation service was valued using guidance from Defra that provides estimates of the damage costs per tonne of emissions across the UK (Defra 2015). These are social damage costs based on avoided mortality and morbidity. Therefore, it was assumed that the value of each tonne of absorbed pollutant by the woodland and

grassland assets was equal to the average damage cost of that pollutant. The PM_{10} damage cost estimate depends on the location (urban or rural) and source of pollution. Site 2 is considered rural, and the central damage costs per tonne was adjusted to 2017 prices. The central damage cost for SO_2 across all locations was used adjusted to 2017 prices.

Agricultural production capacity and GHG emissions forgone

What is it and why is it important?
Agricultural production models the capacity of the land to produce food under current farming practices. Livestock 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.

How is it measured?
This is an indicator of ecosystem services forgone, so we have quantified the physical and monetary flows that have been lost by converting agricultural land in the baseline to buildings in the masterplan, and calculated the GHG emissions that have not occurred as a result of this conversion. It has been assumed that agricultural land at the Site 2 would have been farmed with a crops / livestock mix typical of the wider county. The numbers of livestock for the area were obtained from Defra. This was then monetised by multiplying the crop area and livestock numbers by the average gross margin over the last five years for each crop and livestock type (from Defra's Farm Business Survey). Gross margin takes into account farm gate prices (gross output) and subtracts typical variable costs (e.g. fertilizers, seeds, sprays, husbandry, feed and forage costs), but does not take into account fixed costs such as buildings and machinery. The total agricultural production was divided by the farmed area of the region to derive an average production (gross margin) per hectare. This was then multiplied by the area of improved grassland at the baseline and proposed masterplan.

The GHG emissions forgone were calculated at the regional scale by multiplying crop and livestock data from Defra (as above) by emissions figures for each crop and livestock type in Bateman et al. (2013). Three types of agricultural emissions were assessed:

1. Emissions from typical farming practices (e.g. tillage, sowing, spraying, harvesting, and the production, storage and transportation of fertilizers and pesticides)
2. Emissions of N_2O from fertilizers
3. Emissions of N_2O and methane from livestock, caused by enteric fermentation and the production of manure

Total emissions (in tCO_2e) were summed for the region and divided by the grazed area to derive an average emission per hectare. This was then multiplied by the farmed area at Site 2 before and after development as above). The emissions forgone was monetised using the non-traded carbon price for 2017 (HM Treasury 2015).

Modelling and mapping ecosystem services at Site 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 is to create a habitat basemap for the current situation and a comparable map for the proposed masterplan.

The habitat basemap for Site 2 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. A phase 1 habitat survey of Site 2 was used as part of the basemapping process.

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. A design team had created an outline masterplan which was converted from CAD to be compatible with ArcGIS. This detailed additional habitats that were to be created, roads, and the residential areas (this did not include details of individual houses, gardens, pavements and streets). 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 4000 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 is 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.

Ecosystem service models

Once a detailed habitat basemap was 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
- **Air quality regulation**
- Noise regulation
- Water flow
- Accessible nature
- **Local climate regulation**

For those services in bold the demand for that service could also be mapped. We only assessed two due to time constraints, but noise regulation demand mapping is based on similar data and models to air quality regulation, so would show a similar result. Accessible nature demand would have needed further data. Other additional services can be mapped e.g. pollination, water quality, but these were not mapped in this pilot project due to data, context and resource restrictions.

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 ecosystem services is mapped relative to the values present within the study area, on a scale from 0-100.

Carbon storage

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.

Air quality regulation

What is it and why is it important?

See the non-spatial ecosystem service models section above.

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.

Air quality regulation demand

What is it and how is it measured?
Air quality regulation 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 quality regulation 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 quality regulation (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.

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.

Local climate regulation provision

What is it and why is it important?
Land use can have a significant effect on local temperatures. Urban areas tend to be warmer than surrounding rural land due to a process known as the "urban heat island effect". This is caused by urban hard surfaces absorbing more heat, which is then released back into the environment, coupled with energy released by human activity such as lighting, heating, vehicles and industry. Climate change impacts are predicted to make the overheating of urban areas and urban buildings a major environmental, health and economic issue over the coming years. Natural vegetation, especially trees / woodland and rivers, are able to have a moderating effect on local climate, making nearby areas cooler in summer and warmer in winter. Local climate regulation capacity estimates the capacity of an ecosystem to cool the local environment and cause a reduction in urban heat maxima.

How is it measured?
EcoServ was used to model local climate regulation capacity. The model calculates the proportion of the landscape that is covered by woodland / scrub and water features within a 200m radius around each 10m by 10m cell across the study area. However, temperature regulating effects of woodland and water will also occur in nearby adjacent areas, with the distance of the effect dependent on the patch size of the natural area. To incorporate this effect, a buffer was applied around each woodland / water patch, with wider buffers modelled around larger natural sites.

Note that this model only includes woodland / scrub and water features. All greenspace is beneficial compared to artificial sealed surfaces, but there is no information available on the relative contribution of different types of natural surfaces to local climate regulation. We have therefore chosen to focus on the natural features with the most significant effects.

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 regulate temperatures, keeping them cool in the summer and warmer in the winter.

Local climate regulation demand

What is it and how is it measured?
Local climate regulation demand estimates societal and environmental need for ecosystems that can regulate local temperatures and reduce the effects of the urban heat island. Local climate regulation demand combines one indicator showing the location of areas suffering from the urban heat island effect (the proportion of sealed surfaces), with two indicators showing societal need for local climate abatement (population density, and proportion of the population in the highest risk age categories – defined as under 10 and over 65). Scores are on a 1 to 100 scale, relative to values present within the study area.

Water flow provision

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 study 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.

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 green spaces were mapped. These were determined from OS Open Greenspace data, and data sets on local nature reserves, accessible woodlands and others. Greenspaces that did not have full public access (e.g. golf courses, institutional grounds) were removed from further analysis. The retained 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.

Assessing ecosystem services under the proposed masterplan

For the purposes of this assessment, it was assumed that the Site 2 development 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* – Site 2 will consist of c.4000 new houses. Household occupancy, total population and age structure of the population, was estimated based on average figures for the whole of the local authority area, taken from the UK Census 2011.
- *Index of Multiple Deprivation (IMD)* – as above, IMD scores were estimated for Site 2 by calculating and applying the average scores across all IMD categories for the local authority area.
- *Roads* – a new layer showing all new roads within the development, and their classification, was created and merged with the existing roads layer.

Peel ecosystem service provision and demand graphs

In the main report we have presented the results of the natural capital and ecosystem services assessment for Site 2 in table form rather than maps, which are currently commercially-sensitive in nature. These can also be presented as graphs (Figures A1 & A2). These graphs nicely show the direction of change in provision and demand from baseline to the proposed masterplan, and also allow the comparison of the level of ecosystem service provision and demand at the site.

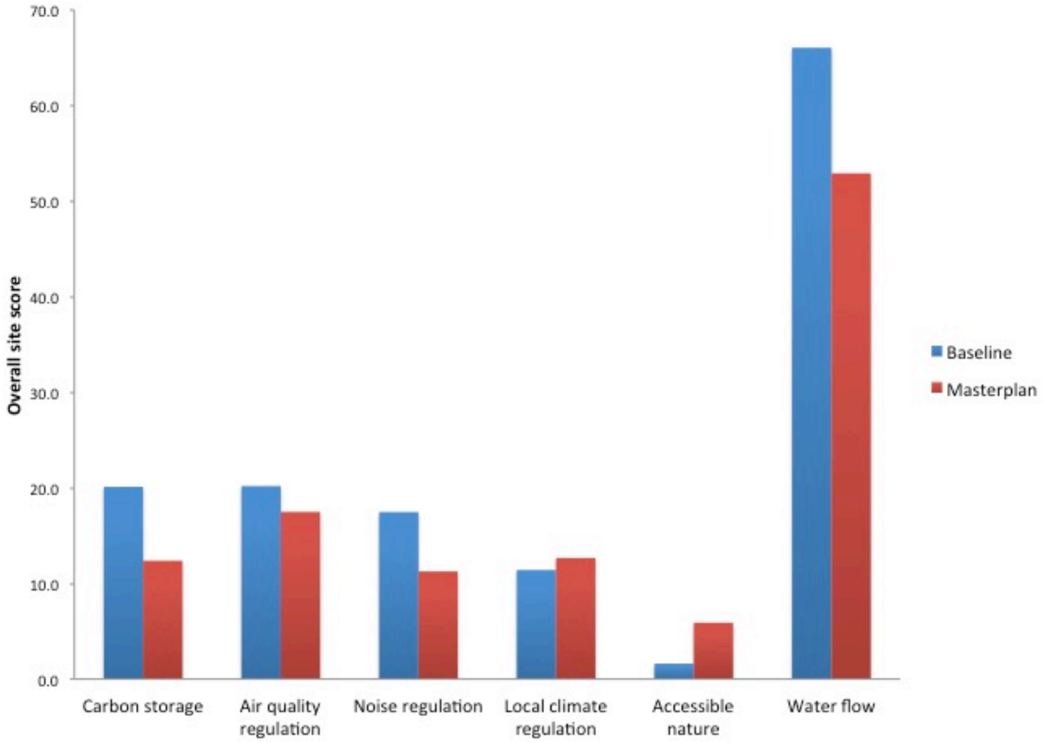


Figure A1 The provision of the six ecosystem services measured for the baseline and the proposed masterplan at Site 2.

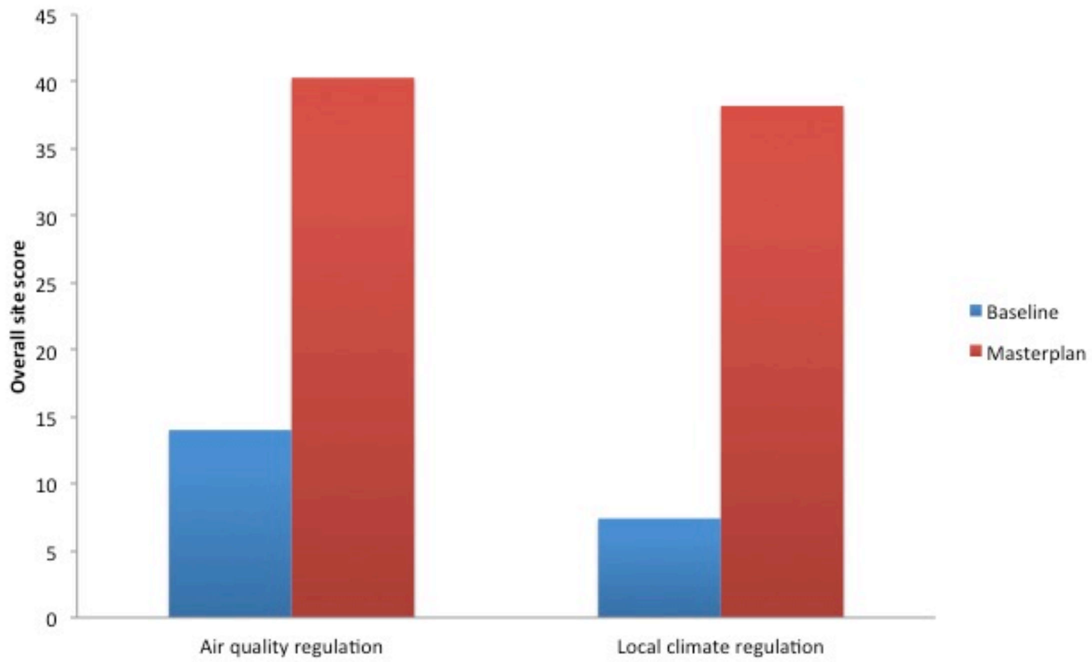


Figure A2 Air quality regulation and local climate regulation demand for the baseline and the proposed masterplan at Site 2.

Section B

Biodiversity net gain

We can use the Defra biodiversity metric to assess biodiversity net gain. This metric is now being used frequently in assessments to determine ecological impact, including biodiversity net gain and offsetting. Using this we are able to measure 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 outside of nature reserves. Habitat can be assessed much more easily and gives an indication of overall quality for biodiversity. 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.

For the baseline and the masterplan 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 can be produced. The first 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 fully applies the Defra biodiversity metric by 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 can then be mapped in GIS and, to maintain compatibility with the other ecosystem services maps, the scores can be scaled on a 0 to 100 scale, relative to values present within the mapped area.

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