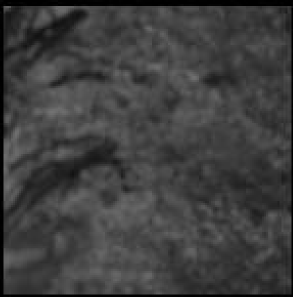
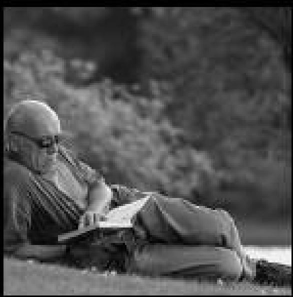







Green Living Spaces Plan

Appendix 2: **Multiple Challenge Map for Birmingham**

September 2013

Multiple Challenge Map for Birmingham

Ecosystem Services Supply and Demand Maps

Oliver Hölzinger[a], Nick Tringham[b], Nick Grayson[b] and Richard Coles[c]

[a] Consultancy for Environmental Economics & Policy
[b] Birmingham City Council
[c] Birmingham Institute of Arts and Design, Birmingham City University

Contact:
Oliver Hölzinger
oliver.h@ceep-online.co.uk

Citation example:

Hölzinger, O., Tringham, N., Grayson, N., and Coles, R. 2013. *Multiple Challenge Map for Birmingham: Ecosystem Services Supply and Demand Maps.* Appendix 2 to Birmingham's Green Living Spaces Plan 2013, Birmingham City Council, Birmingham.

Project partners:

I. Acknowledgements

The authors are very grateful to the many organisations and individuals that provided their valuable contributions and comments. In particular, we would like to thank all steering group members, members of the different expert groups as well as participants of the weighting exercise (all listed in Section 9.3). We would also like to thank the Environment Agency and Natural England for funding this project.

II. Contents

III. List of Figures and Maps

FIGURES

MAPS

1. Executive Summary

Appendix 1 of the Green Living Spaces for Birmingham Plan 2013 provided a comprehensive ecosystem services assessment of the city utilising the same scientific methodologies as contained in the National Ecosystem Assessment; making Birmingham the first UK City to achieve this.

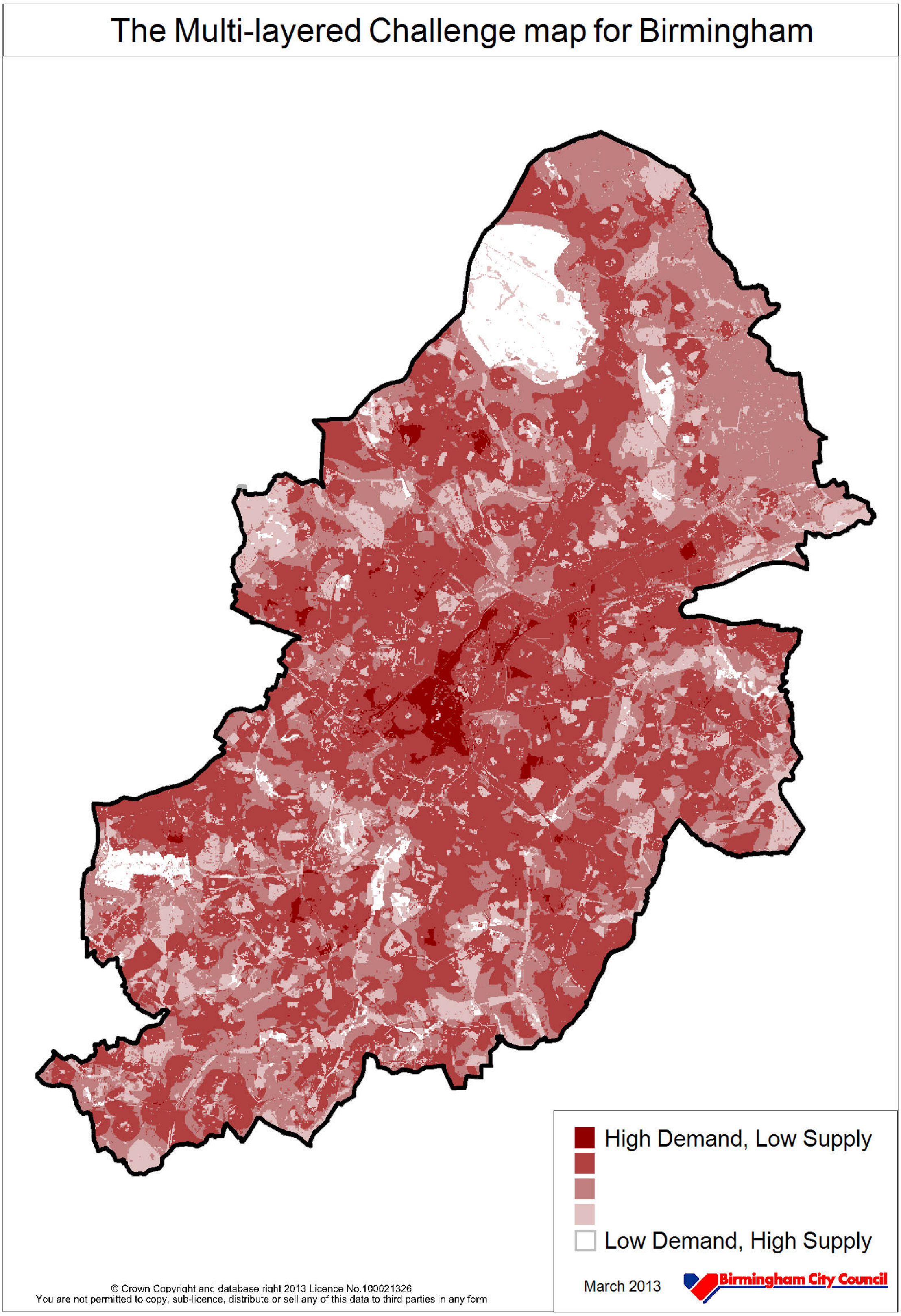
This Appendix 2 takes that work a stage further, and provides a global first.

This report is Appendix 2 of Green Living Spaces for Birmingham Plan 2013. The purpose of the project was to evaluate the supply of; and demand for important ecosystem services at the city scale. Ecosystem services are *"the benefits people obtain from ecosystems"*.[1] For the purpose of this investigation, only those ecosystem services have been mapped where the potential impact of local planning is considered to be the greatest. Ecosystem Services evaluated within this investigation include biodiversity, recreation, aesthetic values & sense of place, education, local climate regulation and flood risk regulation. Plans have been produced to serve decision-makers, planners, and other delivering organisations (1) to prioritise areas where the demand for ecosystem services can't be sufficiently satisfied (high demand and/or low supply), locally referred to as 'hotspots'; and (2) locations where ecosystem services exist which are providing a very high value of benefits across a wide range of ecosystem services (low demand and/or high supply).

The former indicate areas of Birmingham where a specific need for the future creation and/or improvement of green and blue infrastructure will be most effective to satisfy human needs. The latter indicates areas of Birmingham where existing green infrastructure is very valuable and may require specific protection/measures – short of formal designation, (if not already so protected). To produce the maps in this report, a new framework has been developed. Several data sources have been used and manipulated and many experts from local universities, agencies, and other relevant organisations have been consulted. The whole project can be seen as an innovative, but also experimental approach to inform decision-making. A detailed description how the maps can and can't be used is outlined in Chapter 7 of this report; and pages 26-29 of the Green Living Spaces Plan for Birmingham.

[1] Millennium Ecosystem Assessment 2005, V.

Map 1.1 **Multi-layered Challenge Map for Birmingham**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

As a general rule, the maps provided in this report should be considered as starting point for future investigation – not as comprehensive delivery or protection plan. The approach used in this study should be seen as a pragmatic approach. It uses methodologies and evidence that is available to date and can be implemented for decision-making purposes. Available scientific evidence has been accompanied by expert judgement to overcome the lack of data availability and sufficient indicators. The underlying habitat inventory data, for example, is incomplete and some habitats providing very valuable ecosystem services may not be covered by the maps at all.

One problem that can't be solved by this mapping exercise is the definition of the optimal land-use option and land-use management for single sites. The map indicates where a land-use change could be benefiting, but not which one is the most favourable. Such a decision is very context-specific and requires further case-by-case investigation as well as the involvement of the local community. The maps provided in this report can indicate where action should take place; but not which action in detail.

Decisions can't be based entirely on the maps provided in this report. Therefore, it is strongly recommended to read the corresponding chapters with care when using the maps. The maps in this report can't for example substitute any other monitoring and evaluation methods such as for example an Environmental Impact Assessment (EIA).

Acknowledging such limitations and caveats, the approach won't provide decision-makers with the perfect information; but with an information basis that can be seen as a significant improvement to the status quo. Future research will allow improvements and refinements of this experimental approach. It is recommended to subsequently update the approach and the maps to make use of advanced evidence; but also to acknowledge on-going land-use changes in the city. Further recommendations have been made throughout the report.

2. Introduction

This report is Appendix 2 of Birmingham's Green Living Places Plan 2013 which provides an evidence base for the Supplementary Planning Document 'Your Green and Healthy City'. The purpose of the project was to evaluate the supply of; and the demand for - important ecosystem services (ES) at the city scale. The different supply-demand maps have then been combined to provide an indicative multiple challenge map of Birmingham; which shows the spatial demand for additional green infrastructure and how to provide and manage ecosystem services in the most efficient way, going forward.

Ecosystem services can be defined as *"the benefits people obtain from ecosystems"*.[2] Examples are space for recreation, flood risk reduction or health benefits. For a more detailed introduction to the ecosystem services concept see Section 2.1 of Appendix 1 to the Birmingham's Green Living Places Plan 2013.

The main aims of the plans are to serve decision-makers and planners (1) to prioritise areas where the demand for ES can't be sufficiently satisfied, locally referred to as 'hotspots'; and (2) to identify areas which are providing a very high value of benefits across a wide range of ecosystem services. The former indicates in which areas of Birmingham a specific need for the creation and/or improvement of green infrastructure might be most effective. This allows for example to prioritise actions in scope of the Nature Improvement Area (NIA). The latter indicates where existing green infrastructure is very valuable and will therefore require specific protection/measures – short of formal designation.

It has to be stressed that decisions shouldn't be based entirely on the maps provided in this report. Several caveats and uncertainties as well as the degree of abstraction do not allow that. As mentioned before and further explained in Chapter 7, these maps are indicative and should be seen as starting point for further investigation. This should for example involve a visit of the locations identified by the map as well as the consultation of the local community. What the maps don't show, for example, is the quality of green infrastructure or the availability of opportunities to create new ecosystems.

[2] Ibid.

Academia as well as many policy agendas in the UK recommend and promote the ecosystem services concept and its implementation in decision-making and planning.[3] But tools and concepts applicable at the local scale where most of the planning decisions take place are rare.[4] Furthermore, the complex ecosystem services concept and its language are often not entirely understood by the potential users in a decision-making context.[5] Mapping ecosystem services has the potential to overcome these constrains because maps are easily accessible and tangible for a wider audience. Therefore it can be considered as a practicable approach to inform decisions 'on the ground'.

Most mapping exercises in the past have entirely focussed on the ecosystem function or potential rather than incorporating the demand side as well, even if this is of crucial importance.[6] Fisher, Turner and Morling (2009) provide a very tangible thought experiment to clarify this issue: Assuming there was an Earth-like planet with no humans, that planet would have a wide array of ecosystem structures, processes and functions, but because there is no human demand for that, there would be no ecosystem services.[7]

This investigation is driven by what is really demanded by decision-makers and relevant stakeholders to improve for example planning decisions; not by what can be best provided by academia. Therefore, stakeholders have been involved and consulted at all stages of this project. Applying a bottom-up approach may reveal one problem - decision-makers and practitioners may demand tools and information which academia can't provide to a sufficient degree and accuracy.[8] However, decisions affecting the environment won't wait for the perfect scientific evidence - they have to be made now. Therefore it seemed to be justifiable to use methodologies and proxies that are not based on perfect scientific evidence; but provide a real practicable decision-aid.

The approach used in this study should be seen as a pragmatic approach. It uses methodologies and evidence that is available to date and can be implemented for decision-making purposes; considering inherent time- and resource restrictions. Available scientific

[3] Defra 2007; HM Government 2011; UK NEA 2011b; DCLG 2012.
[4] Daily et al. 2009.
[5] Paetzold, Warren, and Maltby 2010; Fish 2011.
[6] Burkhard et al. 2012; Syrbe and Walz 2012; Fisher, Turner, and Morling 2009.
[7] Fisher, Turner, and Morling 2009.
[8] Burkhard et al. 2012.

evidence has been accompanied by expert judgement to overcome the lack of data availability and sufficient indicators. Recognising such caveats, the approach won't provide decision-makers with the perfect information; but with an information basis that can be seen as significant improvement to the status quo. Therefore, this approach should be interpreted as a stepping stone towards implementing the ecosystem services concept in decision-making. Future research will advance improvements and refinements of this experimental approach. Corresponding recommendations have been made throughout the report.

3. Methodology

3.1 Scope of the Project

The context specific decision-making purposes have been the driver for the selection of methodology, scope and scale of the investigation. In this study, the main aims are (1) the identification of areas in the city where the demand for ecosystem services can't be sufficiently satisfied locally referred to as 'hotspots'; and (2) the identification of locations where ecosystems demand specific protection to ensure a sustainable flow of ecosystem services over time. To satisfy these demands, priority has been given to those ecosystem services where the local management of ecosystems in Birmingham has the greatest impact on human welfare. This approach is consistent with the aim to provide best applicability and practicability for decision-making and planning purposes.

This investigation focuses on such services that can be locally managed, considering that the local planning system and local decision-makers have a limited influence on the management of ecosystems outside the city. Therefore only ecosystem services 'produced' within the boundaries of the City of Birmingham have been evaluated. Consequently, benefits to Birmingham's population as well as 'exported' services have been prioritised in case where ES flows don't only occur locally. Imported ES are not recognised within scope of this investigation. One example for predominantly imported ES in Birmingham is for example fresh water supply.

An opportunity for the future could be to investigate especially in imported ES and how the flow may be affected in the future. The concept of ecosystem service footprints might be applied to evaluate this effect.[9] This would reveal Birmingham's dependence on ecosystem services provided outside the city. Partnerships and instruments such as Payments for Ecosystem Services (PES) might be considered to influence such services.

The supply of; and demand for ecosystem services will change over time depended on the ES evaluated. Within scope of this investigation we only incorporated climate change as one main, and more importantly, independent driver in our assessment. Therefore a future

[9] Ibid.

climate scenario has been applied to provide best information for decision-makers how to plan green infrastructure to adapt to climate change and influence the local climate. For other services a *ceteris paribus* scenario has been assumed. The spatial distribution of a predicted growing population in Birmingham, for example, has not been implemented.

One option for the future would be to define scenarios to evaluate how ES change under different policy options. It is strongly recommended that this report should be updated in the future; in line with other areas of planning policy evidence bases; to consider for example changes in the extent and quality of green infrastructure, socio-economic changes, but also to incorporate new available evidence and GIS data. Selection of Ecosystem Services to Map

One of the first questions to answer was which ES shall be mapped; and why. Incorporating as many ES as possible into the assessment obviously provides a more complete and holistic picture. On the other hand the complexity of the model increases significantly with every added ES layer, especially when considering interactions and trade-offs between the different ES as well as the spatial and temporal distribution of ES flows and imported and exported ES. Another limitation is the availability of appropriate indicators.

To reduce the complexity of the model, the mapping of trade-offs has been avoided as far as possible. In general, only such ES have been evaluated within scope of this investigation which are considered to have the greatest impact on human wellbeing. One feasible step was to exclude such ES from the mapping exercise which can be considered to lower the total value of ecosystem services provision if the land-management would be optimised for that single ES. Furthermore, ES that have a very minor effect on human wellbeing have not been recognised. Such ES have been classified as 'secondary' ecosystem services. It has been agreed that local planning decisions in Birmingham should not predominantly depend on the provision of such services.

The classification has been judged by the steering group, considering available scientific evidence. The authors have undertaken a pre-selection of ecosystem services considered to be most important for the specific context of Birmingham. This selection is based on the individual experience as well as a literature review. The pre-selected ES and their potential benefits have been summarised for the steering group members with a focus on the specific context of Birmingham, potential trade-offs as well as the ability of such ES to be managed and influenced locally. A group discussion has revealed which ES shall be treated as 'primary' and 'secondary' ES.

In the context of Birmingham, for example, harvesting and woodfuel production have been classified as 'secondary' ecosystem services. Woodland that is optimised for intensive timber production usually provides lower cultural and regulating services. Another example is global climate regulation. The contribution of Birmingham's green infrastructure to mitigate climate change has been acknowledged, but in the urban context other services outweigh this service. Furthermore the spatial distribution of green infrastructure within the city has a comparatively low impact on this service. More important is the total area and the habitat selection; not the location. The total amount of carbon stored in vegetation and soils is important – not its location. Therefore it is not feasible to plan and manage the urban green infrastructure predominantly for global climate regulation purposes.

Thirteen ES have been considered as most important for this specific policy context and the purpose of this project. Out of that 13 ecosystem services, 7 have been classified as 'primary' ES and 6 as 'secondary' ES. The selection is based on a literature review, the ecosystem assessment for Birmingham's green infrastructure which has been undertaken in advance to this project[10], and the steering group and expert groups which have been set up for this project. Latter was of particular importance to incorporate local and context-specific knowledge. More detail about how and why ES have been selected can be found in Chapters 4 to 6.

Figure 3.1 Ecosystem Services Selected for this Investigation

[10] See Appendix 1 of Birmingham's Green Living Places Plan 2013.

Provisioning Services	***Raw Materials:*** *For example timber to construct furniture or woodfuel.**
	Food: Ecosystems provide the conditions for growing food or for fishing.*
	Biodiversity: Ecosystems provide everything that an individual plant or animal needs to survive.
Cultural Services	**Recreation:** Accessible greenspace offers an opportunity for recreation, sports, etc. which also influences physical health.
	Aesthetic Values & Sense of Place: People benefit from a view on beautiful landscapes which improves mental health.
	Education: Contact with nature is important to form ecological knowledge.
Regulating Services	***Global Climate Regulation:*** *Green infrastructure mitigates climate change by capturing and storing Carbon Dioxide.**
	Local Climate Regulation: Green Infrastructure mitigates the impacts of climate change and reduces the Urban Heat Island Effect (UHIE).**
	Flood Risk Mitigation: Ecosystems create buffers against natural hazards such as flooding events.
	Noise Regulation: *Dense vegetation can create a buffer against noise.**
	Water Quality Regulation: Micro-organisms and plants remove and decompose pollutants from water bodies.*
	Air Quality Regulation: Especially trees can significantly impact air quality.**

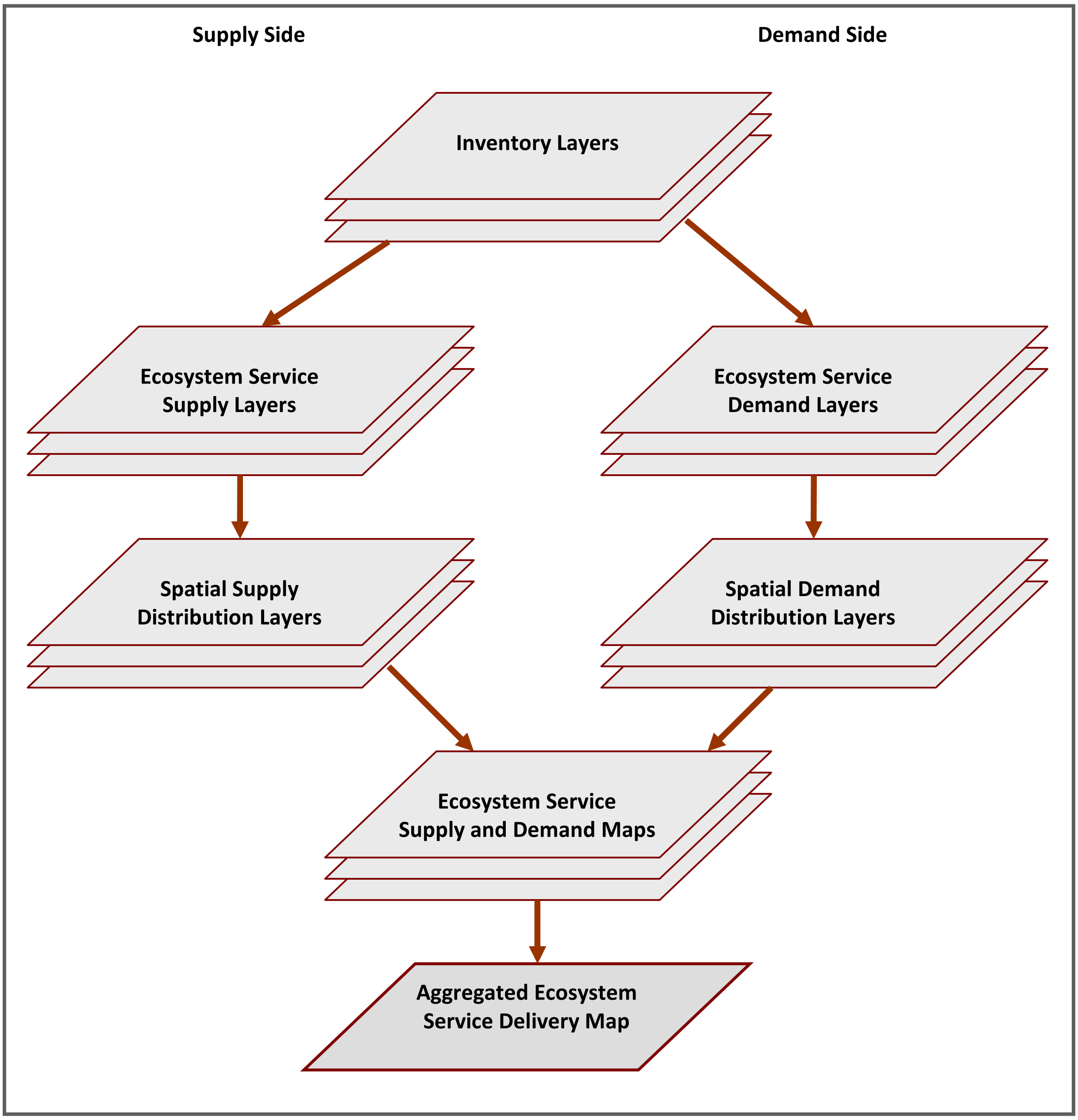
*) 'Secondary' Ecosystem Services.
**) The ecosystem services 'air quality regulation' and 'local climate regulation' been classified as primary ES but data limitations did not allow to map this service within scope of this assessment.

Source: ***Referring to TEEB 2010 and UK NEA 2011.***

3.2 Framework

The initial literature review didn't reveal a fit-for-purpose framework for this project. Therefore a framework for mapping ecosystem services in Birmingham has been developed. This framework is summarised in Figure 3.2.

Figure 3.2 **Mapping Ecosystem Services Framework**



Source: ***Author***

Below, the different steps and layers are explained in more detail. Please note that in Chapter 4-6 the steps are explained for each specific ES that has been mapped in scope of this investigation.

Inventory layers

The first step of this mapping exercise was to find out which spatial data is available. Important layers for this investigation incorporate for example land cover classes, habitat types or population density. Layers have been selected depended on their ability to provide feasible indicators for the service supply and demand layers as well as the spatial distribution layers.

Ecosystem Service Supply Layers

For each ecosystem service a supply layer has been created, integrating the inventory layers, available scientific evidence as well as expert knowledge. It is clear that not all land-use options have the same capacity to provide the same bundle of ES to the same extend. The capacity depends for example on soil type, accessibility, biological quality, visual amenity etc. Maps assessing the supply of ecosystem services are usually not available to date. Indicators have been defined to 'translate' the available inventory layers into service supply layers. A weighting matrix has been developed to define the relative capacity of land cover classes to provide specific ecosystem services. Furthermore, the spatial distribution of supply of; and demand for ES had to be defined.

Ecosystem Service Demand Layers

As mentioned before, when mapping ES it is crucial to consider the supply side, but also the demand side. It is important to evaluate where potential beneficiaries are and if and how they utilise the supply. Because the ecosystem services concept follows an anthropocentric approach, population density is an important indicator. However, sometimes it is not most important where people live, but where they spent most of their time. Furthermore specific subsets of the population have been prioritised for some ecosystem services such as specific age groups for the ecosystem service 'education'. The indicator selection will be discussed in Section 3.4.

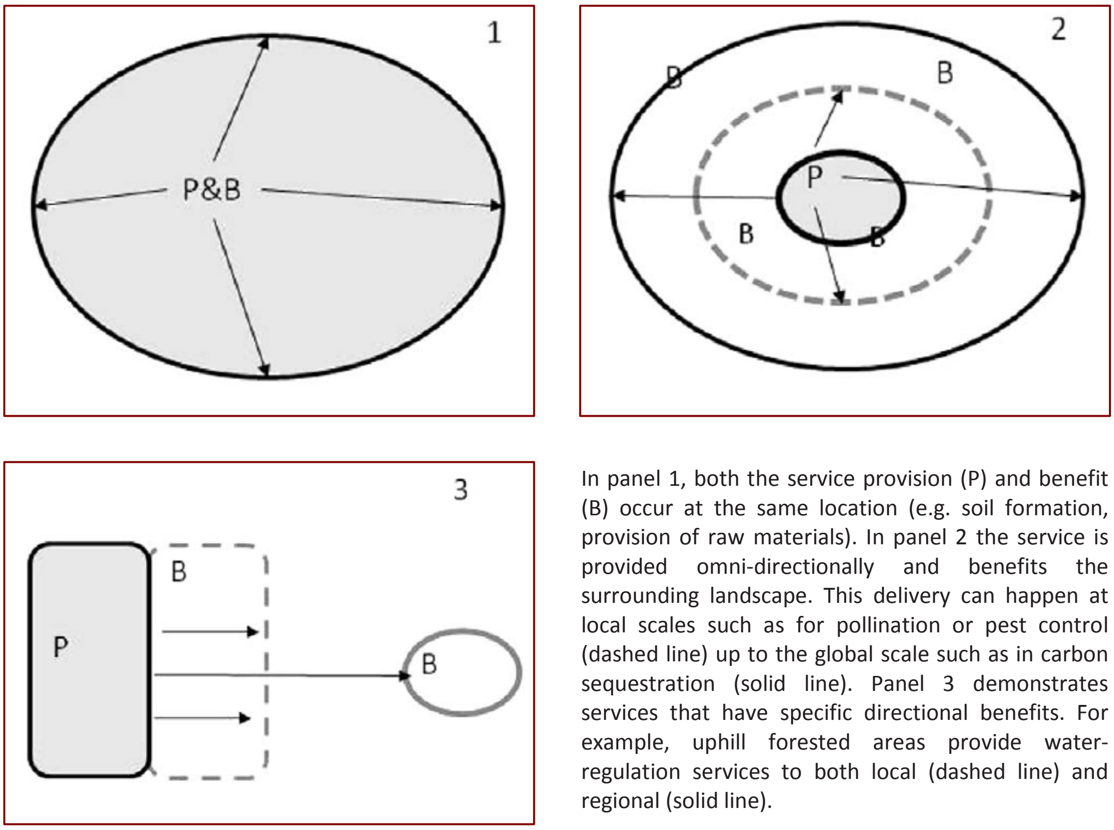
Spatial Supply & Demand Distribution Layers

The benefits ecosystem services provide are not necessarily realised at the same location where they are provided. Services spread through the landscape, for example influenced by wind or stream direction. One may also use the term service flow.[11] Fisher et al. (2009) distinguish between three spatial relationship categories:[12]

- **In situ** - where the services are provided and the benefits are realized in the same location.
- **Omni-directional** - where the services are provided in one location, but benefit the surrounding landscape without directional bias.
- **Directional** - where the service provision benefits a specific location due to the flow direction.

[11] Fisher et al. 2011.
[12] Fisher, Turner, and Morling 2009.

Fig 3.3 **Spatial Relationships Between Service Production Units and Service Benefit Units**



In panel 1, both the service provision (P) and benefit (B) occur at the same location (e.g. soil formation, provision of raw materials). In panel 2 the service is provided omni-directionally and benefits the surrounding landscape. This delivery can happen at local scales such as for pollination or pest control (dashed line) up to the global scale such as in carbon sequestration (solid line). Panel 3 demonstrates services that have specific directional benefits. For example, uphill forested areas provide water-regulation services to both local (dashed line) and regional (solid line).

Source: ***Adopted from Fisher et al. (2011), p. 601.***

When focussing on the ability to aid decision-making, the spatial distribution of ecosystem service demands should be integrated in such a model as well. Demand and (potential) benefit may occur at different locations. People may have a desire to access a public greenspace but the travel costs (and time) may be too high if the greenspace is far away from where they live.

Without knowing or developing feasible assumptions about the spatial distribution of ecosystem services supply and demand, it is hardly possible to derive practicable information for planning purposes. Therefore such aspects have been taken into account within this investigation, even if the available scientific evidence to identify and define accurate indicators is often lacking.[13] Considering such shortcomings, distribution layers could not have been defined for all ecosystem services.

[13] See Chapter 4-6

Ecosystem Service Supply and Demand Maps

After evaluating supply and demand of ES as well as the spatial distribution of flows, those layers have been combined for each ES assessed. The aim was to provide an indicative map that identifies areas of the city where the demand for ecosystem services can't be sufficiently satisfied and an underprovision with ES occurs. These maps can support decisions to prioritise areas related to a specific policy agenda – for example flood risk management. The map also indicates areas where actions regarding a specific ES may be most and least efficient.

However, as mentioned before, the maps are indicative and decisions can't entirely be based upon these maps. Shortcomings of the approach make a case by case evaluation and justification necessary. The approach doesn't for example take the quality of ecosystems into account.

Aggregated Ecosystem Services Supply and Demand Map

When optimising landscape management for human wellbeing, all important or significant ecosystem services should be taken into account. Therefore we combined all ES evaluated within scope of this study to a single map. This aggregated ecosystem services delivery map helps to (1) prioritise areas where the demand for ES can't be sufficiently satisfied locally referred to as 'hotspots'; and (2) identify locations which are providing a very high value across a wide range of benefits. The former indicates in which areas of Birmingham a specific need for the creation and/or improvement of green infrastructure will be needed, in the future. The latter indicates where existing green infrastructure is very valuable and will require specific protection/measures – short of formal designation. But it should be acknowledged that the map is indicative and should be interpreted as a starting point that identifies areas of Birmingham which demand further investigation 'on the ground'.

One problem that can't be solved by this mapping exercise is the definition of the optimal land-use option and land-use management for single sites. The map indicates where a land-use change could be benefiting but not which one is the most favourable. Such a decision is very context-specific and requires further case-by-case investigation as well as the involvement of the local community. The maps provided in this report can indicate where action should take place; but not which action in detail. The maps also don't incorporate (potential) management costs etc. This was outside the scope of this investigation. Cost-benefit analysis (CBA) or multi-criteria analysis (MCA) may for example be undertaken case by case to overcome this caveat and compare different management options.

One feasible next step is to evaluate areas of the city where an underprovision with ES has been identified and review if and where opportunities for the creation and improvements of ecosystems exist. This should also include costs for creation, management etc. plus related transaction costs. Consulting the local stakeholders is very important as well. This helps to incorporate local knowledge and demands into the decision-making process. It can also attract acceptance and in-kind contributions.

3.3 Indicator Selection, Weightings and Limitations

The data-availability of sufficient indicators for most ecosystem services is still lacking. This applies particularly for regulating and cultural services.[14] But especially latter ES are most important in cities like Birmingham. To define and evaluate sufficient robust indicators for each layer and each ES, a literature review has been conducted. To inform the steering group members a brief summary report has been prepared for each ES which set out the main influencing variables, the indicator and data availability, and opportunities to integrate such indicators into the model. For latter process often different options have been suggested how to define for example categories that can be assigned with weighting scores. However, the discussion process was generally open.

After an initial steering group meeting it has been decided to set up topic related expert groups for different (bundles of) ecosystem services that are related. Expert groups have been established for:

- Biodiversity
- Recreation, Aesthetic Values & Sense of Place, and Education
- Local Climate Regulation and Air Quality Regulation

[14] Layke 2009.

- Flood Risk Mitigation

The members of the expert groups were mainly selected from the steering group members along with experts from local universities, agencies, and third sector organisations. The members of the steering group as well as the different expert groups are recorded in Technical Appendix 9.3.

Summary reports for each ES have been presented to; and discussed with the expert groups. On topic-related workshops the experts have discussed and defined feasible indicators and variables for the different layers. Such variables are for example the distance to the site, the population density, or the size of a habitat. Then it has been discussed which influencing factors are most significant and how relevant indicators can be implemented in the model. Where appropriate, categories have been defined for the weighting exercise. Based on the expert workshop outcomes, the summary reports for each ES have been updated and experts have been given another opportunity to comment on that revised summary report. Remaining dissents have been solved via email or follow-up meetings with parts of the expert group.

One main outcome of these meetings was that the scientific evidence to date doesn't allow to define all variables and layers. Therefore it has been agreed to complement the available scientific evidence by expert judgement. This approach should be interpreted as 'second-best' approach. Steering group and expert group members felt that it would be better to base the relative weightings of different variables and ecosystem services on expert knowledge than waiting for robust evidence. It was the view that using expert knowledge and judgement in absence of proven scientific evidence would serve decision-making purposes better than not providing decision-makers and planners with relevant information about ecosystem services in Birmingham. However, the findings shall be taken with care and caveats shall be recognised when interpreting and using the maps.

To implement expert judgement in the model, excel-based weighting exercise questionnaires have been prepared for each of the 7 primary ecosystem services evaluated within scope of this investigation. Such questionnaires have been sent to the expert group members via email with the appeal to forward the questionnaire to colleagues and other experts. Within these questionnaires, the respondents have been asked to ascertain relative weighting scores to different scenarios and ecosystem services. The participants have been asked to ascertain a baseline score on a scale from 0 to 10 to different habitat types or land-use classes. Afterwards, they had to ascertain weighting score advances or penalties incorporating other influencing variables such as location of a site or environmental quality. Then the participants had the chance to review their ascertained scores which have been recalculated to a scale from 0 to 10 for the different scenarios. Additionally, the participants have been asked to ascertain weighting scores to compare the relative contribution of the selected ecosystem services to human wellbeing. This step was necessary to aggregate the different ecosystem service maps to one 'blueprint' for the city. Altogether 28 questionnaires have been replied. For more details about the questionnaires see Technical Appendix 9.1.

The stated weightings have then been aggregated and used to create the different ecosystem services layers. All weighting scores have been weighted equally. For more detail about how the weighting scores have been integrated into the ecosystem services maps see Technical Appendix 9.2 as well as Chapter 4-6.

This whole approach may for example be criticised because of the small sample size or the weighting exercise applied.[15] However, considering resource and time constrains the authors felt that this experimental approach including all shortcomings is justified to overcome the general lack of applicable data and scientific evidence to inform decision-making and planning. However, this experimental approach may be interpreted as matter of debate and has indeed room for improvement.

Bridging the gap between available scientific evidence and demands in a decision-making context reveals some major challenges. One major task is to handle the general lack of scientific evidence on the one hand, but provide a practicable decision-aid on the other. It demands to incorporate untested and imperfect evidence and also 'filling the gaps' by expert judgement rather than dismissing such uncertain aspects.

[15] See e.g. Koschke et al. 2012.

4. Provisioning Services

4.1 Timber & Woodfuel

The creation and/or management of green infrastructure in Birmingham optimised for timber or woodfuel production could reduce other services such as recreation and amenity significantly. Other ecosystem services are likely to outweigh the benefits of timber and woodfuel production in the city.

Because of this trade-off it has been decided by the steering group to treat the ecosystem services 'timber and woodfuel production' as 'secondary' ecosystem service. However, when trees and shrub have to be felled, for example because of health and safety issues, they may very well be used for timber or woodfuel production. The only implication of defining 'timber and woodfuel production' as secondary ecosystem service is that green infrastructure in Birmingham shouldn't be actively managed for these services.

4.2 Food

Local food production is considered as important ecosystem service in Birmingham with multiple benefits including health, recreation and education, as well as social and intergenerational cohesion. Even if people are not willing to participate in sporting activities, they may prefer less obvious exercise such as growing their own food, which involves both physical activity and the eating of fresh healthy food. The latter has significant importance for low-income groups who may otherwise have no access to healthy food, classed as 'living in food deserts', or unable to afford food to feed their family as evidenced by the rapid increase in food banks.

The active engagement with food growing also has educational benefits for both children and adults, respectively. It can engage patterns of healthier food consumption and the transfer of knowledge about sustainable food production and consumption between generations.

However, the pure existence or creation of allotments, community gardens and other sites of food production in the urban environment is often insufficient to actively engage people to grow their own food. Often additional efforts are required to get people involved with related projects such as the teaching of growing skills. Considering the limited statistical data available, the 'food' element couldn't be evaluated within scope of this project. To enable a detailed assessment of future (potential) demand throughout different socio-economic groups, as well as a more detailed monitoring of opportunities for local food production and related projects, community engagement will be necessary. Essentially a qualitative approach is required to obtain the necessary data. Evaluation questions include: how far/long are people willing to travel to grow their own food and how socio-economic variables such as multiple deprivation impact their willingness and ability to travel, their free time availability and if they possess growing skills.

5. Cultural Services

5.1 Biodiversity

Within this framework 'biodiversity' has been categorised as 'cultural service', however, in general it supports all final ecosystem services. Biodiversity in scope of this particular section has been evaluated referring to two aspects:

(1) The non-use value of species diversity: This service reflects the value people hold for the pure existence of specific species or the diversity of species in general, even if they don't use or experience them directly. Use-values are for example captured in the 'recreation' category.

(2) Infrastructure, insurance and resilience value of biodiversity: A 'healthy' ecosystem depends on some combinations of ecosystem structure and composition to provide its services sustainable. A higher biodiversity and complexity of species and habitats may provide an 'insurance' to ensure that such 'healthy' ecosystems remain, even if some species fail or get lost. It also may make ecosystems more resilient to 'external shocks'.[16]

Latter aspect is not directly impacting human wellbeing. It is supporting other ecosystem services and the ability of the ecosystem to provide other ES such as recreation, amenity, flood risk reduction etc. However, it was the view of the steering group that such values are of particular importance and should be evaluated directly.

Unfortunately the understanding, evidence and data availability for such aspects is very limited.[17] This implies that one has to work with more or less crude proxies and to reduce the complexity. It has been agreed by the expert group that there is scope to improve the methodology as well as the data baseline to improve indicators and methods to acknowledge the very high complexity of this topic. Opportunities would be to incorporate e.g. species records or habitat connectivity based on the migration distance for different (types of) species.

[16] Morling et al. 2010; Feld et al. 2010.
[17] Norris et al. 2011; Morling et al. 2010; Feld et al. 2010; Balmford and Bond 2005.

5.1.1 Ecosystem Service Supply Layer

Designation

The management of habitats has a significant impact on species-richness and biodiversity. Unfortunately the data availability about how habitats in Birmingham are managed is very limited. Therefore the designation has been used as a proxy. The management itself often depends on the designation of a site. Therefore a 'higher' designation is likely to positively impact biodiversity. But it should be stressed that single habitats without formal designation may be much better managed than those with formal designation. Accordingly the findings should be taken with care.

The expert group members have ascertained weighting scores for the following types of designation:

- Sites of Special Scientific Interest (SSSI)
- Site of Importance for Nature Conservation (SINC)
- Site of Local Importance for Nature Conservation (SLINC)
- No formal designation

Type of Habitat

Different types of ecosystems provide a habitat for different species. Some, such as broadleaved woodland, are (on average) species-richer. Other habitats such as amenity grassland are tendentially species-poorer. Based on the designation weighting scores penalties and advances have been ascertained for different habitat types.

The habitat types included are rivers, canals, lakes, ponds, (short) amenity grassland, grassland, heathland, fens, reedbeds, plantation on ancient woodland sites (broadleaved)[18], (other) broadleaved woodland, allotments, private gardens, green roofs and hedgerows. This selection is based on the habitat types occurring in Birmingham and the available GIS

[18] In the weighting exercise no separate category for Ancient Semi-natural Woodland (ASNW) has been created. The weighting score for 'plantation on acient woodland sites (PAWS)' has been applied for ASNW as well. Note that this may represent an underestimation.

data. In case where different types of habitats overlap the higher weighting score has been applied.

Please note that the habitat data has been collected from different sources and that the data is not always comprehensive and up to date. This caveat should be recognised when interpreting the maps. For the future it would be benefiting if all habitat data for Birmingham would be extended, improved, and managed and updated centralised by one department or organisation such as EcoRecord.

Size & connectivity

If the size of an ecosystem is bigger it tendentially can provide a habitat for more (diverse) species. The per-ha value increases overproportionally with increasing size of the ecosystem. This effect applies to a single habitat type, but also to the whole size of diverse adjoining or connected habitats. Within scope of this investigation only latter aspect could have been taken into account. Penalties/advances have been ascertained according to the total size of area where different types of habitats are adjoining or connected (e.g. by a wildlife corridor) for the following categories:

- Network area between 0 and 2 ha
- Network area between 2 and 10 ha
- Network area between 10 and 50 ha
- Network area between 50 and 200 ha
- Network area between 200 and 500 ha
- Network area 500+ ha

Amongst other, this factor is especially important in the long term considering drivers such as climate change.[19] Facing such changes of the local conditions many species need the ability to migrate. Rivers, canals and ponds are only considered in case they serve as wildlife

[19] Lawton et al. 2010.

corridor. A distance of 15m has been allowed between habitats. It has been assumed that if habitats were this close they are still connected.

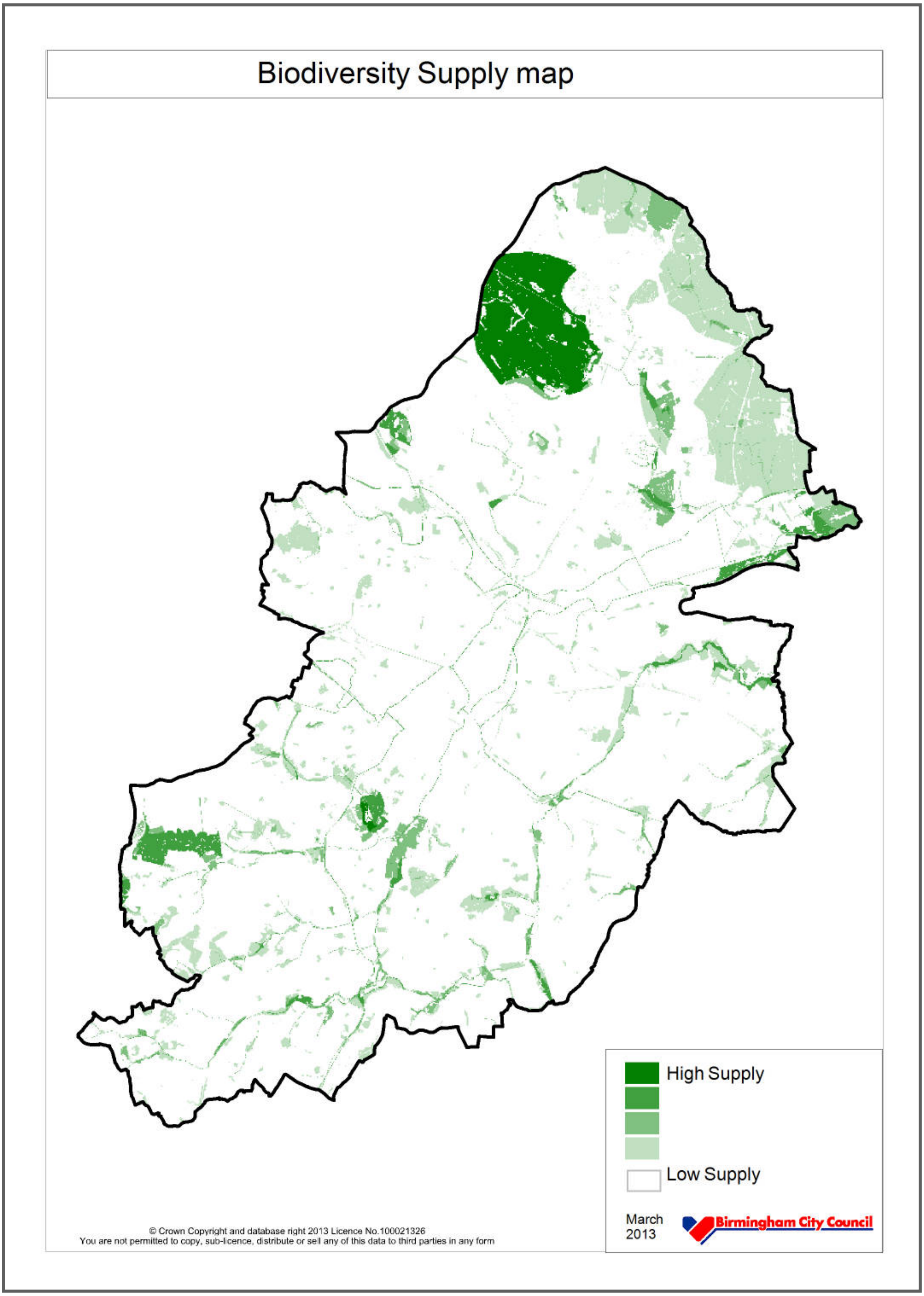
However, the map should be taken with care. Even small fragments of green infrastructure may still provide a high diversity of species when they are within close distance (but further away than 15m) to each other and built an ecological network. Habitats may also act as 'stepping stones' for species and/or genes to move between habitats.[20] Even single trees can be very species rich. Unfortunately the ability of species and genes to move between habitats is very species-specific. Some species such as birds can move far distances, others can only move small distances. Furthermore specific types of species demand specific types of habitat to move.[21] Such aspects couldn't have been included in this investigation.

5.1.2 Spatial Supply Distribution Layer

Non-use values for biodiversity are not spatially explicit. There is no theory why the non-use value people hold for wild species diversity would decrease with distance.[22] The same applies for the insurance and resilience values of biodiversity. The infrastructure value may be spatially explicit to some degree but simplifying this aspect hasn't been evaluated within scope of this investigation. Therefore the 'spatial supply distribution layer' equals the 'ecosystem service supply layer'. Map 5.1 shows the biodiversity spatial supply distribution layer. The colour shapes are based on the aggregated expert weighting scores. A darker green colour shape indicates that the biodiversity value of that area is high. However, as mentioned before, because of limited monitoring and data availability as well as limitations of the approach applied, the map should be taken with care and a bright shape doesn't necessarily mean that the area provides no or only minor biodiversity benefits.

[20] Ibid.
[21] Ibid.
[22] Brander et al. 2008.

Map 5.1 **Biodiversity Spatial Supply Distribution Layer**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

5.1.3 Ecosystem Service Demand Layer

Because the ecosystem services concept applies an anthropocentric approach the beneficiaries are humans. The benefits are gained indirectly and without use. This means that there is no relation between the location of people (beneficiaries) and the location of the green and blue infrastructure.

5.1.4 Spatial Demand Distribution Layer

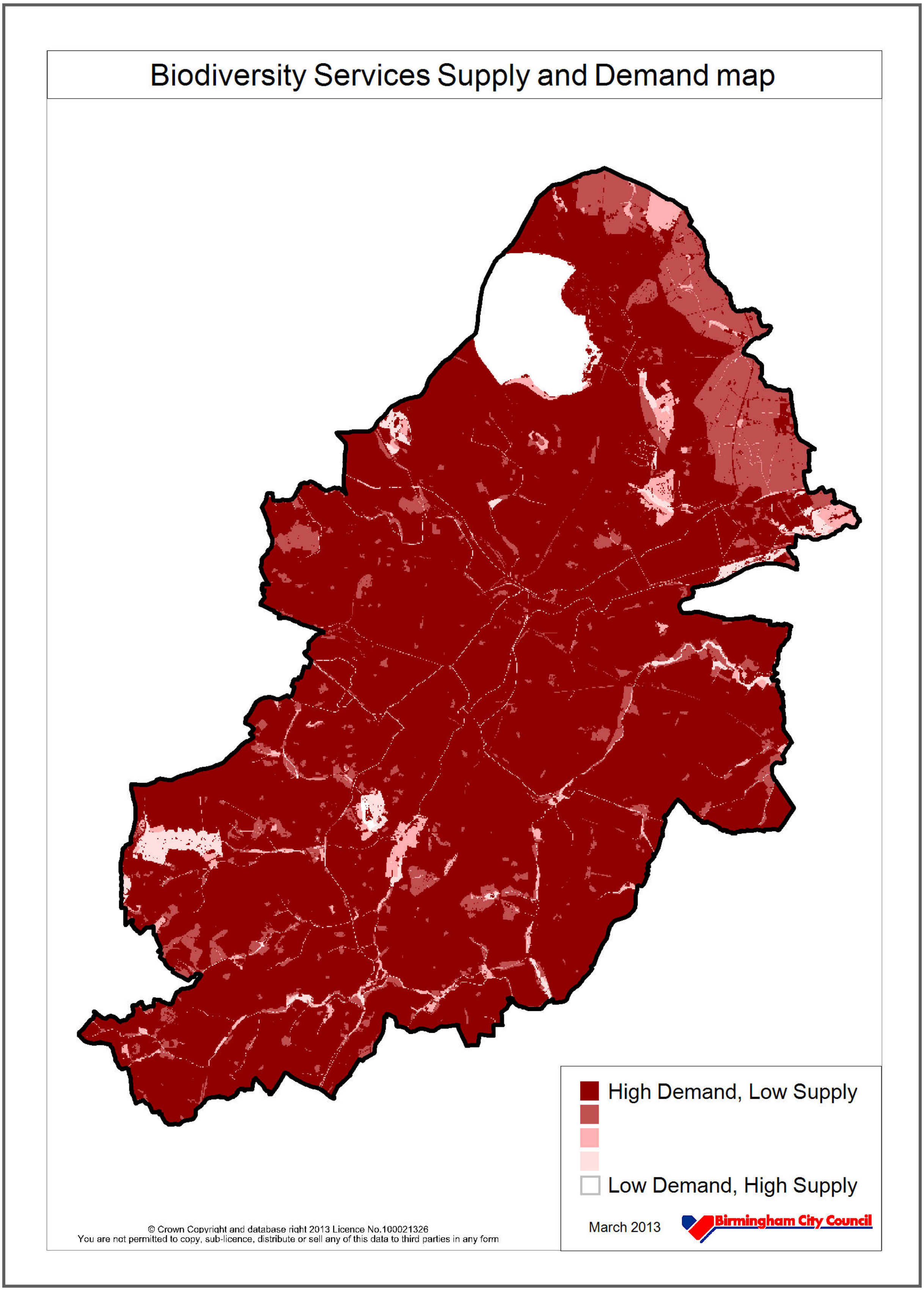
In general the creation of new green infrastructure would provide higher biodiversity values, for example if it connects other habitats or if it's an extension to or creates a 'green buffer' around existing habitats. However, such an evaluation is very location specific and depends on the case-by-case condition and circumstances. Simplifying it has been assumed that the demand is equally high everywhere in the city. In the future this approach may be developed and refined by for example defining buffer zones around existing high valuable ecosystems or by defining areas that would best connect existing greenspaces.

5.1.5 Ecosystem Service Supply and Demand Map

The combined supply and demand map has been produced by overlaying the 'spatial supply distribution layer' with the 'spatial demand distribution layer.[23] By adding up the weighting scores for the demand (0 to 10) and the constant weighting score for the demand (-10) a delivery map has been developed which can be seen in Map 5.2 below. This map indicates in which areas of the city the creation or improvement of ecosystems may provide the highest benefits to human wellbeing. Chapter 7 lines out how this map can serve decision-making and planning in the city.

[23] As mentioned before for the 'spatial demand distribution layer' a constant weighting score for the whole city has been assumed. Therefore the weighting score of -10 has been allpied for the whole area.

Map 5.2 Biodiversity Supply and Demand Map



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

5.2 Recreation

The Accessible Natural Greenspace Standard (ANGSt) developed by English Nature (now Natural England) in the 1990s provides appropriate criteria and indicators for mapping purposes. The development[24] and review[25] of this standard has been based on best available scientific evidence.

5.2.1 Ecosystem Service Supply Layer

Accessibility

It is clear that the open access to green infrastructure is necessary to gain recreational benefits. Inventory layers included are:

- Country parks
- Parks
- Public open space
- Private open space

Indeed, a private garden also provides such benefits. However, the number of potential beneficiaries is usually very limited. Other facilities such as golf courses also provide recreational benefits, but usually not on a regularly day-by-day basis. For the purpose of simplification, but also because of limited data availability to develop and apply alternative approaches, only green infrastructure that is accessible on a day-by-day basis has been assigned with a recreational value within scope of this investigation.

A potential improvement for future investigations could be to include factors such as accessibility for disabled people or the associated infrastructure (access points, paths, availability of public toilets etc.).

[24] Harrison et al. 1995.
[25] Handley et al. 2003.

Diversity of habitats

The expert group agreed that the diversity of different types of habitats is the better indicator for the capacity of a site to provide recreational benefits than the actual types of habitat. Different weighting scores have been ascertained to different numbers of habitats located on one site. The following categories have been used:

- Sites containing 1-2 different habitat types
- Sites containing 3-4 different habitat types
- Sites containing 5-6 different habitat types
- Sites containing 7-8 different habitat types
- Sites containing 9+ different habitat types

Size

The minimum greenspace size of 2 ha recommended by the ANGSt standard is not very good justified by scientific evidence. Especially in a highly urbanised area such as broad parts of Birmingham, smaller areas of accessible greenspace can still be very important for recreational purposes.[26] The 2 ha recommendation by the ANGSt is more related to biodiversity benefits or an 'operational goal' rather than recreational benefits.[27]

It is feasible that a certain minimum size of greenspace is necessary to provide recreational benefits. If located in a densely populated area with many potential users, the recreational per hectare value of a greenspace may rise with increased size (exceeding the minimum size). The reason is that recreational benefits may be reduced if the site is 'over-used'. But from a certain size, the marginal recreational value per hectare will decline with increased size.[28] The number of users, for example, won't increase proportionally to the size of the greenspace after a certain size has been transcended.

[26] Ibid.
[27] Ibid.
[28] Bateman et al. 2011.

This example shows that the relation between size and value can be very complex which makes the definition of proxies or an optimal size of accessible greenspace difficult. Because it would exceed the scope of this project to take this effect into account, the size of a greenspace site has not been included in the model. Therefore the findings should be taken with some care.

<u>Quality</u>

The quality of accessible greenspace can have a significant impact on the ability to provide recreational benefits. This doesn't only depend on the visual amenity and management of such places; it also depends on factors such as people's perception of security. The value of recreational services also often correlates positively with the species-richness or biodiversity which in turn increases with size of a habitat and vegetation density.[29] However, the experience of a natural landscape is usually not the main reason to visit for example a park, even if it's recognised to be an important factor.[30]

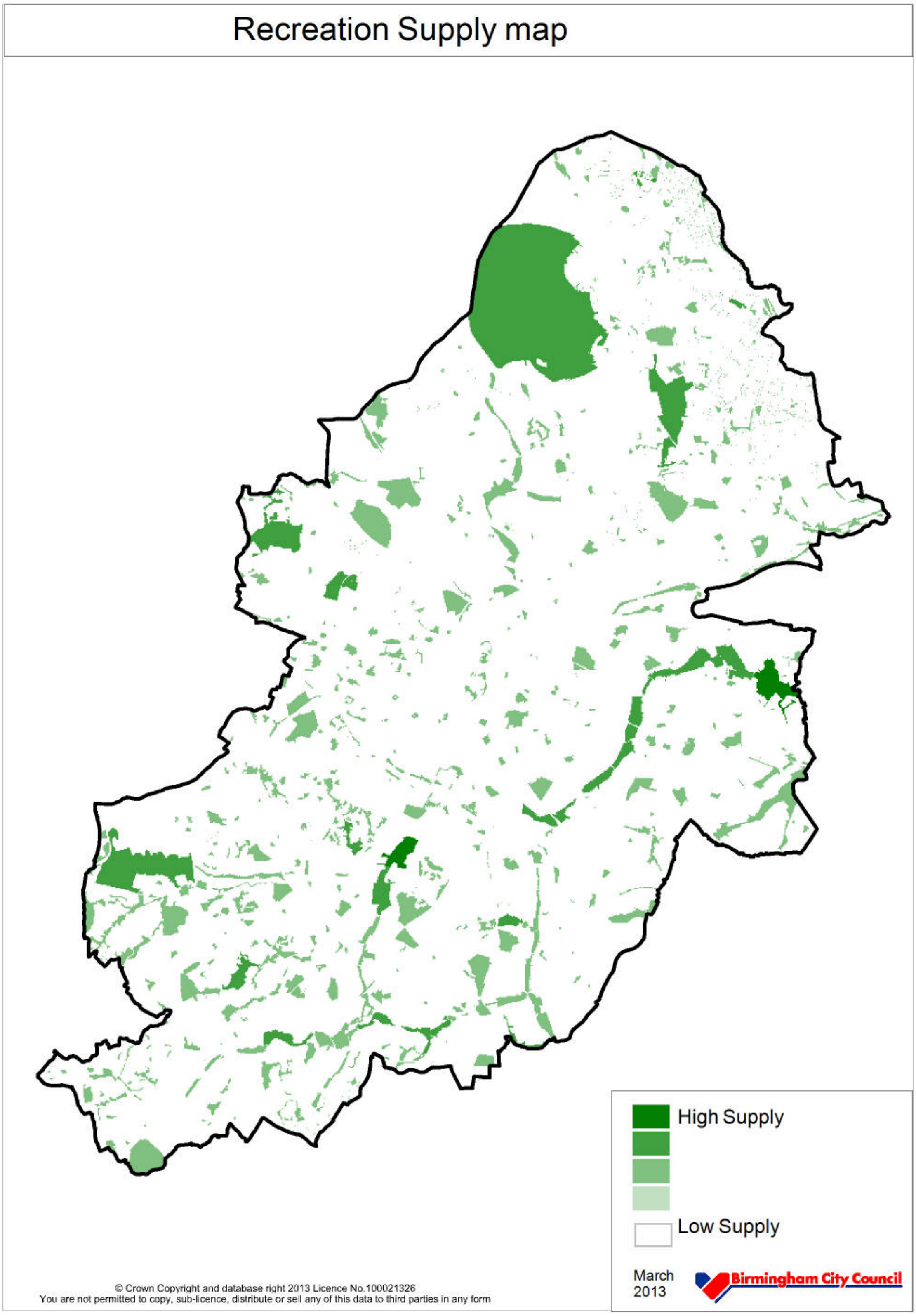
The best available indicator to account for greenspace quality in Birmingham is the Green Flag Award. This benchmark seems to be the best indicator to reflect the quality of a site for recreational purposes. Therefore an advance has been ascertained in case a site has been awarded a Green Flag Award.

5.2.2 Spatial Supply Distribution Layer

As mentioned before, greenspace has to be accessible to be able to benefit from recreational services. The benefits are realized at the same location as they occur; for example in a park or woodland. Consequently, the ecosystem service supply layer equals the spatial supply distribution layer. Map 5.3 below indicates which places in Birmingham may provide the highest recreational benefits.

[29] Harrison et al. 1995.
[30] Handley et al. 2003.

Map 5.3 Recreation Spatial Supply Distribution Layer



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

5.2.3 Ecosystem Service Demand Layer

Population density

A significant indicator for the demand of outdoor recreation is the amount of potential beneficiaries. This has been recognised, but not implemented in the ANGSt. It is a general criticism of comparable standards that the demand side is neglected.[31] The population density around greenspaces has a substantial impact on the marginal value of recreational services provided by such sites.[32]

As a matter of course the demand, as defined for purpose of this investigation, does not only occur around greenspaces, but also in other areas. Therefore the population density inventory layer has been used as indicator for the demand layer. Weighting scores have been ascertained to different levels of population density to estimate the relative weighting of the demand for outdoor recreation. It has been assumed that the demand increases proportionally with the population density on a scale from 0 people per ha to 250+ people per ha.[33] It is arguable that places where people spent much time (but not live) should be taken into account as well. However, such an assessment was outside scope of this investigation because referring data was not available. In the future footfall maps may improve the evaluation of the demand for outdoor recreation.

5.2.4 Spatial Demand Distribution Layer

Distance

For recreational demands (potential) benefits occur at different locations. Most people, especially in urban areas, don't live on the doorstep to accessible greenspace. They have to travel a certain distance to access it and benefit from it. However, with increasing distance the opportunity costs to access the greenspace rise.[34] Individuals may have a desire to access a public greenspace but the travel costs (including costs of time) may be too high if the greenspace is far away from where they live.

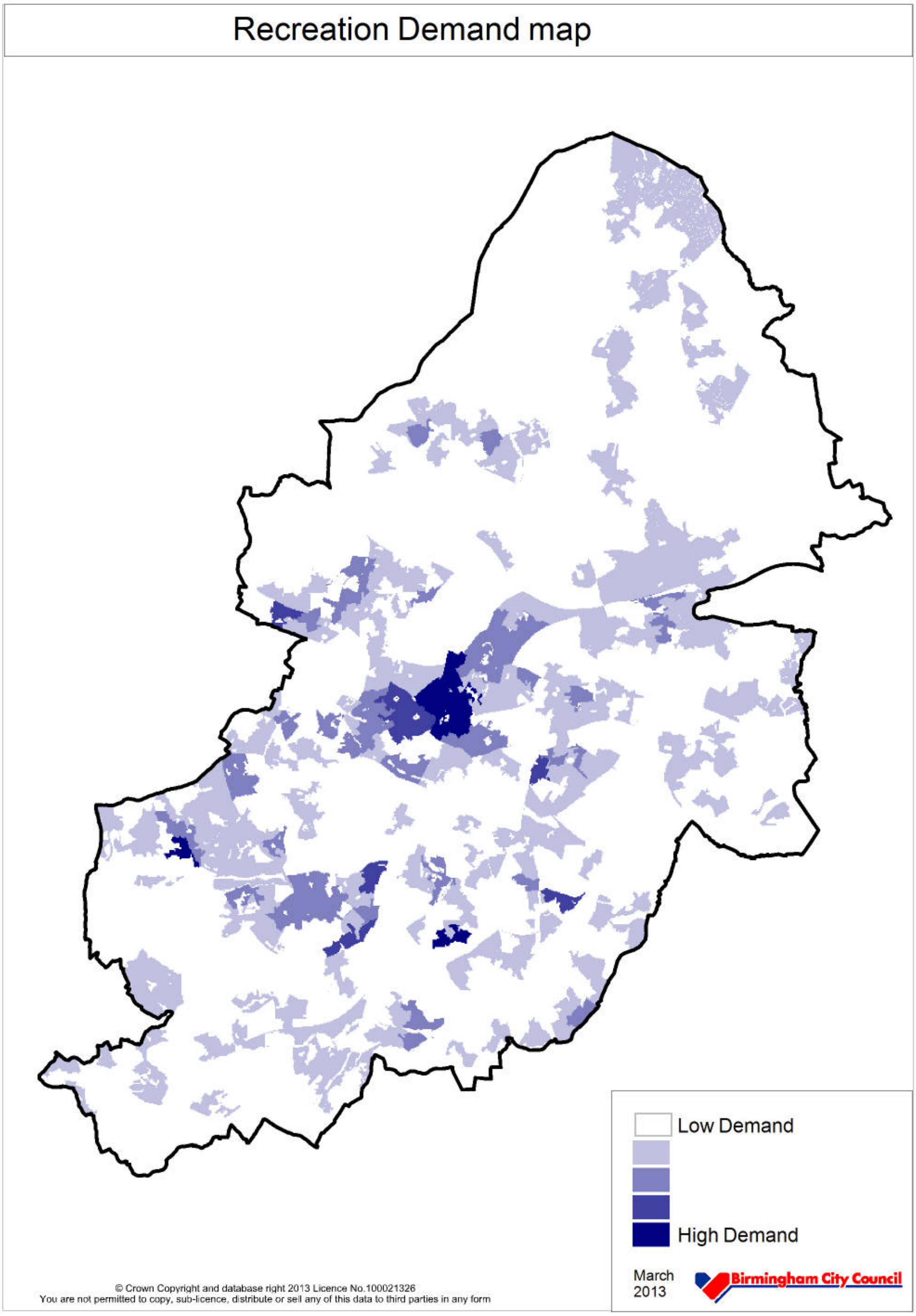
[31] Ibid.
[32] Bateman et al. 2011.
[33] The actual population density per ha on a ward scale goes up to 425 people per ha but only in one ward. Because this is an extreme exception a 0-250 scale has been applied.
[34] Bateman et al. 2006.

Because the vast majority of urban greenspace users reach such greenspaces on foot, it is of particular importance to provide natural greenspace within short distance from its potential beneficiaries.[35] Cole and Bussey (2000) found out that visits to woodlands decline significantly when the site is further than 5 minutes' walk (about 100 – 400m) away.[36] The ANGSt model suggests a straight line distance to accessible greenspace of 300m as a proxy, recognising the slightly longer actual walking distance to access the nearest accessible greenspace.[37] This indicator doesn't account for the increased mobility during the past 60 years to access environmental settings further away.[38]

For mapping purposes this effect hasn't been taken into account. It has been assumed that the spatial demand layer equals the spatial demand distribution layer. Therefore the population density is the main indicator for the demand for accessible greenspace. Please note that Map 5.4 below shows the relative population density in the city to identify areas where the demand is highest. However, white areas may still have a high demand – just not as high as blue areas.

[35] Handley et al. 2003.
[36] Coles and Bussey 2000.
[37] Handley et al. 2003.
[38] Church et al. 2011.

Map 5.4 Recreation Spatial Demand Distribution Layer

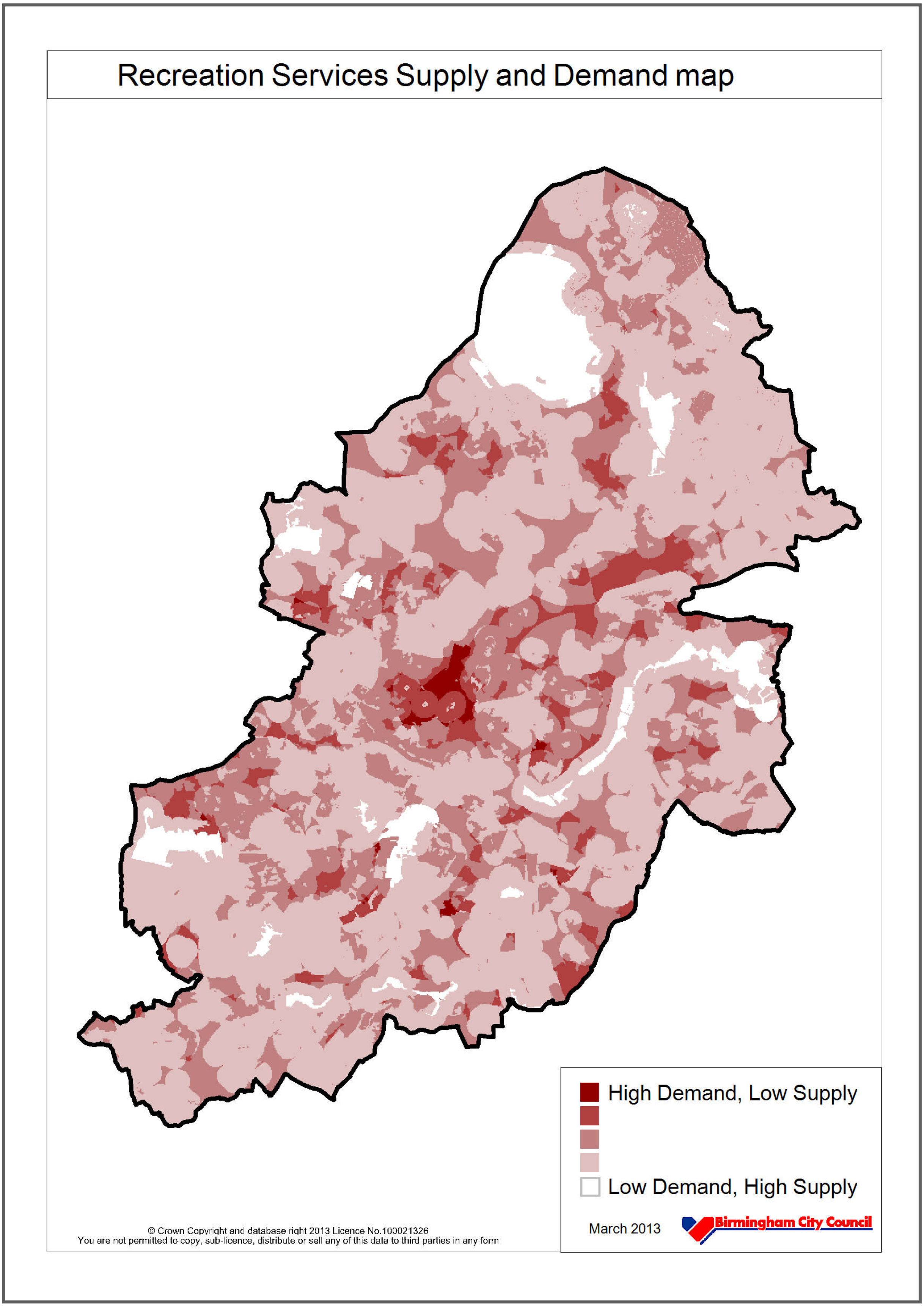


Source: ***Based on data provided by EcoRecord, Birmingham City Council, Forestry Commission, ONS, and the Environment Agency.***

5.2.5 Ecosystem Service Delivery Map

The negative weighting score of the demand distribution layer and the positive weighting score of the supply distribution layer have been combined to produce a map that indicates to which degree the demand can be satisfied. This map has to be taken with care as it doesn't take into account the link between size of a site and population density, available substitutes; or the effect of the greenspace on the population density. Furthermore the relation between supply and demand is only indicative. This evaluation doesn't allow saying that the demand for accessible greenspace in an area is satisfied or not. It only indicates that it is better satisfied in some areas than in others.

Map 5.5 Recreation Supply and Demand Map



Source: ***Based on data provided by EcoRecord, Birmingham City Council, Forestry Commission, ONS, and the Environment Agency.***

5.3 Aesthetic Values & Sense of Place

The visual amenity of environmental landscapes is valuable and can have a significant impact, e.g. on property prices. Research in the USA suggests that a view of woodland can also improve mental health by breaking down stress.[39]

5.3.1 Ecosystem Service Supply Layer

Quality

The quality of green and blue infrastructure has an effect on its visual amenity. In general, clean and well managed habitats are preferred. In case a habitat is very dirty, the amenity value can even turn negative. The only available indicator for quality is the Green Flag Award which has already been used for the recreation. This does not only relate to the visual amenity, but is the best indicator available. Weighting scores have been ascertained for green infrastructure with and without Green Flag Award. Furthermore, weighting scores have been ascertained for the blue infrastructure depending on the ecological status.

5.3.2 Spatial Supply Distribution Layer

Visibility

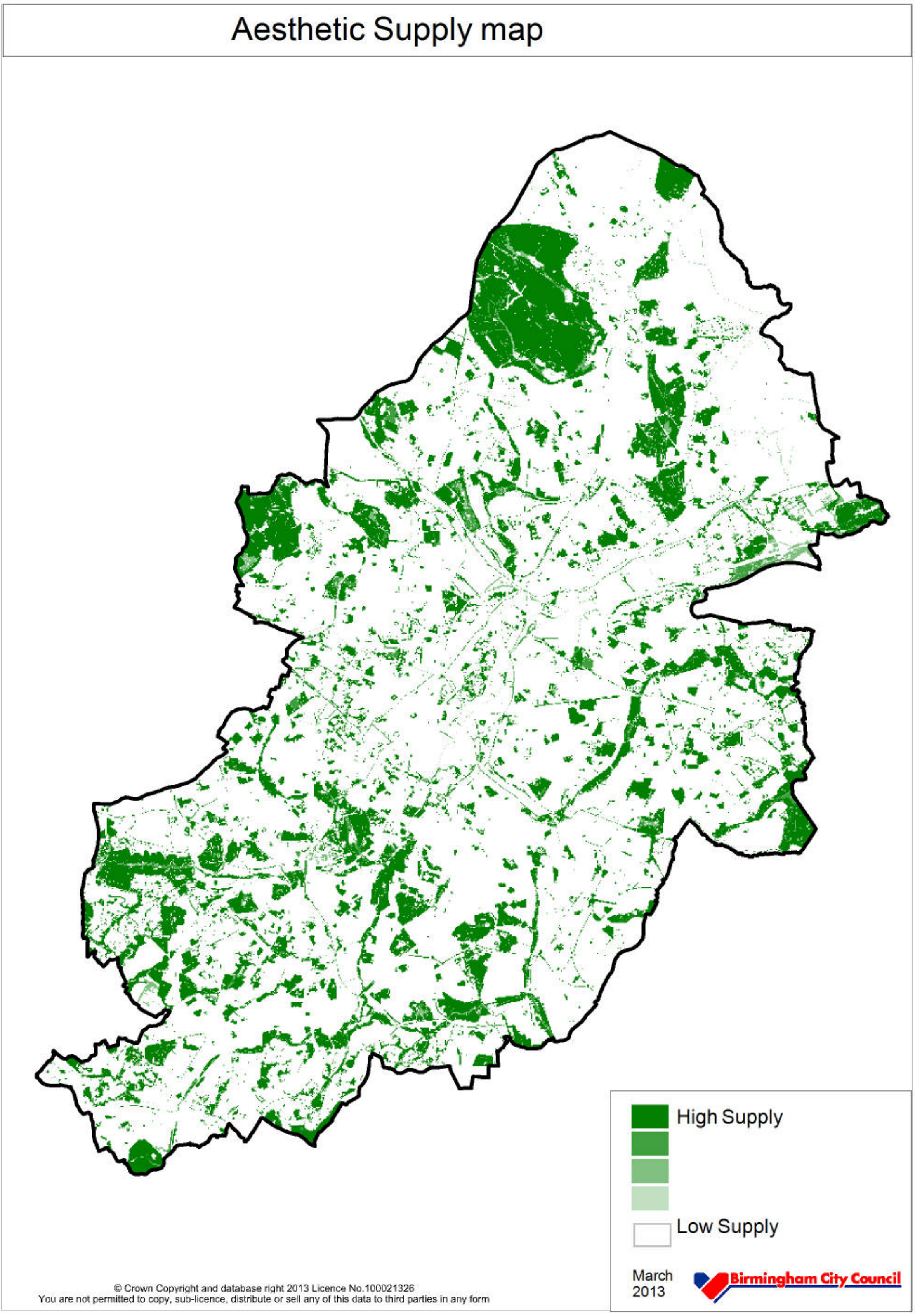
The best indicator for the amenity distribution is the visibility which is for example determined by its distance from a specific viewpoint. One important aspect for the demand is the visibility of green and blue infrastructure from home. The assumption underlies that habitats that are visible from home have a higher amenity value than others. A comprehensive viewshed analysis couldn’t have been undertaken within scope of this project. Simplifying buffers have been created around households in Birmingham.

Weighting scores have been ascertained to a buffer zone of 50m and a buffer zone from over 50m to 100m distance around households to indicate the likelihood of households to have a free view on a certain proportion of the green and blue infrastructure.

[39] Ulrich and Simons 1986.

Elements of the green and blue infrastructure within such buffers have been ascertained a weighting score advance. When parts of the green and blue infrastructure are visible from more than one household, the weighting scores haven't been added up. That doesn't take into account barriers or altitude differences. Therefore, the findings should be taken with care. Map 5.6 indicates the amenity and sense of place value of the green and blue infrastructure in Birmingham.

Map 5.6 **Aesthetic Values & Sense of Place Spatial Supply Distribution Layer**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

Please note that the type of habitat and vegetation also has an impact on the visual amenity of green infrastructure. People have higher preferences for the amenity of specific habitats and specific vegetation types (such as trees) are better visible than others. However, the expert group felt that this aspect shouldn't been taken into account within scope of this investigation.

5.3.3 Ecosystem Service Demand Layer

Population density

A significant factor is the amount of potential beneficiaries located around green and blue infrastructure. The more people are located around green and blue infrastructure the higher is the demand for the amenity and sense of place of it. As a matter of course, the demand, as defined for purpose of this investigation, does not only occur around greenspaces, but also in other areas. Therefore the population density inventory layer has been used as indicator for the demand layer. Weighting scores have been defined in relation to different levels of population density to estimate the relative weighting of the demand side.

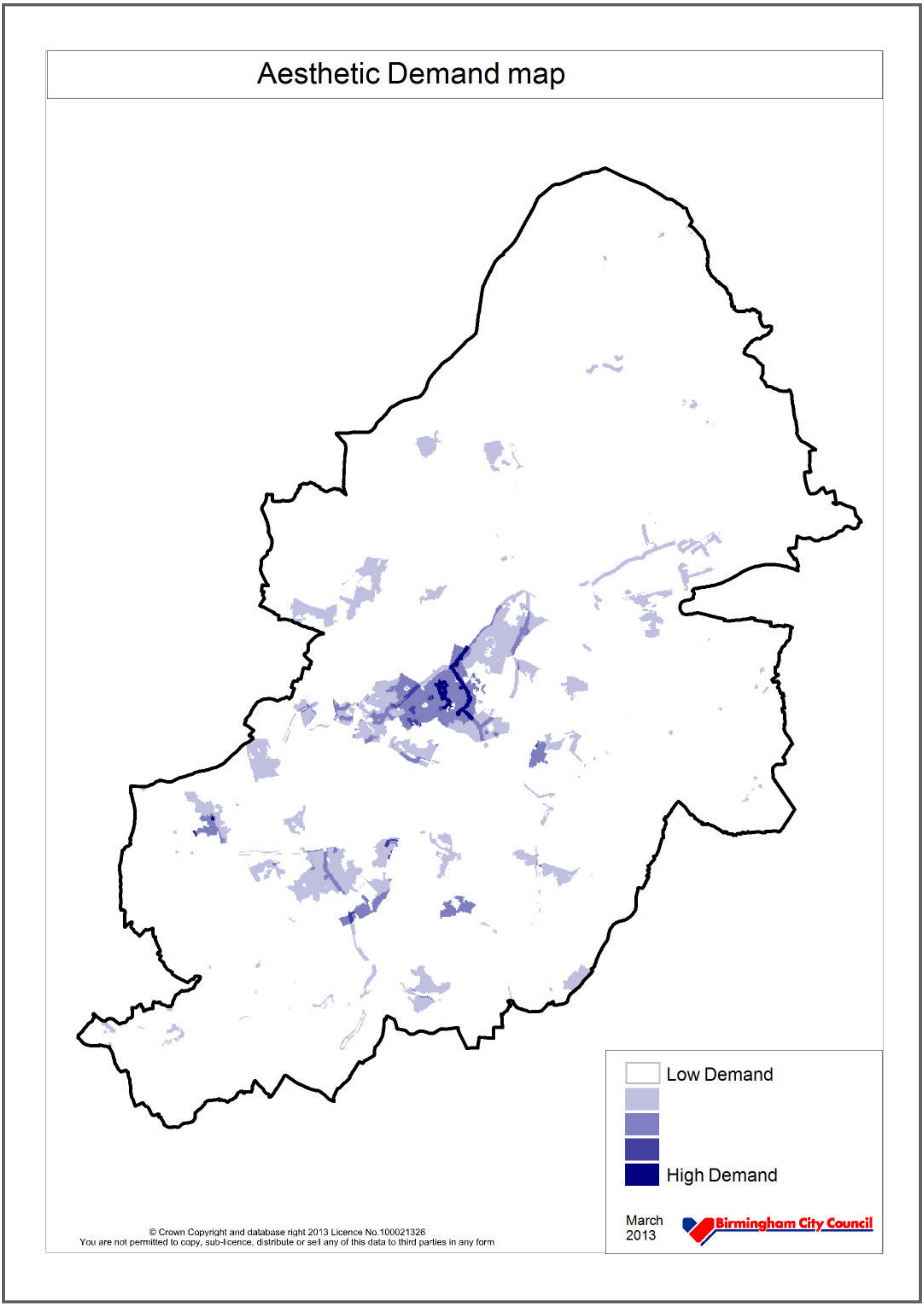
Green travel routes

Green and blue infrastructure around foot and cycle paths can increase the amenity and therefore the usage of such sustainable travel routes. This effect is linked to recreation, but a sustainable travel route and its benefits to health and wellbeing itself is not related to ecosystem services. It's often a tarred path. The additional benefit purely encouraged by the surrounding greenery and its amenity is an ecosystem service and therefore relevant for this investigation. To take this effect into account, a demand weighting score advance has been ascertained to areas within 50m around existing sustainable travel routes in Birmingham.

5.3.4 Spatial Demand Distribution Layer

As for recreation, people may travel a certain distance to experience the visual amenity of green infrastructure. However, it is very difficult to identify indicators to take this effect into account apart from the population density and the view from sustainable travel routes which have already been covered. Therefore it has been assumed that the 'spatial demand distribution layer' equals the 'ecosystem service demand layer'. Map 5.7 indicates the spatial demand distribution. However, the map may not be misinterpreted that there is no demand in white areas of the map. The map only indicates the relative demand for aesthetic values – not the absolute demand. The demand in white areas may still be significant.

Map 5.7 **Aesthetic Values & Sense of Place Spatial Demand Distribution Layer**

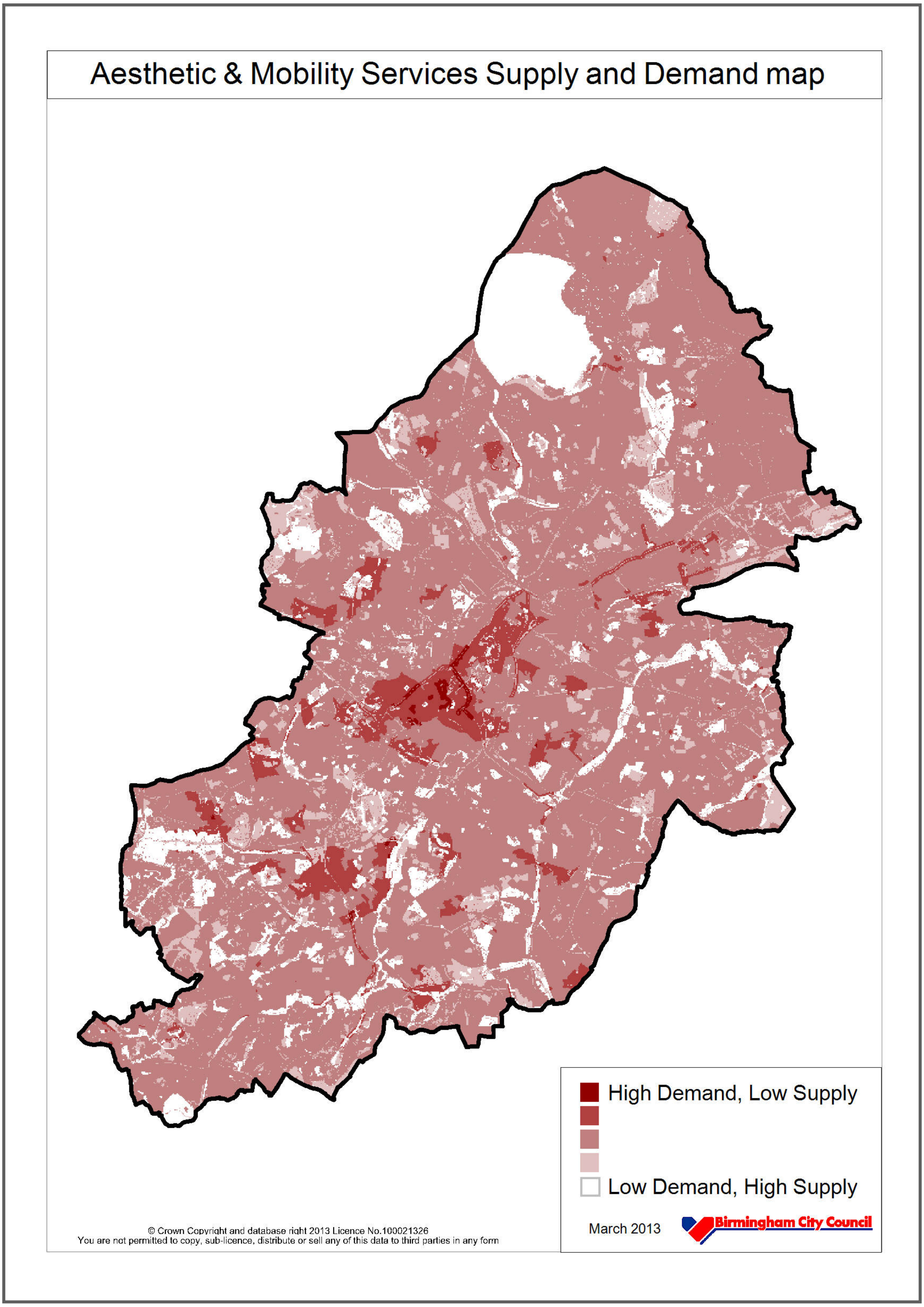


Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

5.3.5 Ecosystem Service Supply and Demand Map

For the combined supply and demand map, the negative weighting scores of the 'demand distribution layer' and the positive weighting scores from the 'supply distribution layers' have been combined. Map 5.8 indicates where improvements to the existing green and blue infrastructure and/or the creation of new ecosystems may be most benefiting.

Map 5.8 **Aesthetic Values & Sense of Place Supply and Demand Map**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

5.4 Education

Frequent interaction with the local environment is one key element of acquiring ecological knowledge.[40] Especially in urbanised areas, greenspace is capable of playing an even more important role in education. Children who have grown up in cities like Birmingham usually don't have the same connection with nature as their counterparts living in the countryside.[41]

Children in Birmingham have access to environmental/ecological education through a variety sources. Individual educational establishments make arrangements directly with local open spaces or via the Birmingham City Council Ranger Service. There are also a number of outdoor education establishments but more and more schools are creating forest school areas either on their own sites or in local public open spaces – developing the idea that environmental education takes place where you live and study and not on "special" sites. Many young people also gain ecological education experiences as part of out of school activities with youth organisations as for example Scouts, Woodcraft Folk and Duke of Edinburgh or John Muir Awards.

5.4.1 Ecosystem Service Supply Layer

<u>Accessibility</u>

As for 'recreation', accessibility to relevant sites is necessary to benefit from outdoor education. Because of limited data availability to develop and apply alternative approaches, only public accessible greenspace has been assigned with a recreational value within scope of this investigation. Unfortunately, data about outdoor education facilities on the school grounds were not available. Inventory layers to be included are:

- Country parks
- Parks
- Public open space
- Private open space

[40] Mourato et al. 2010.
[41] UK NEA 2011a.

Diversity of habitats

As for recreation, the expert group agreed that the diversity of different types of habitats is the better indicator for the capacity of a site to provide educational benefits than the actual types of habitat. This is feasible as the range of learning opportunities arises with number of different habitats. Different weighting scores have been ascertained to different numbers of habitats located on one site.

Quality

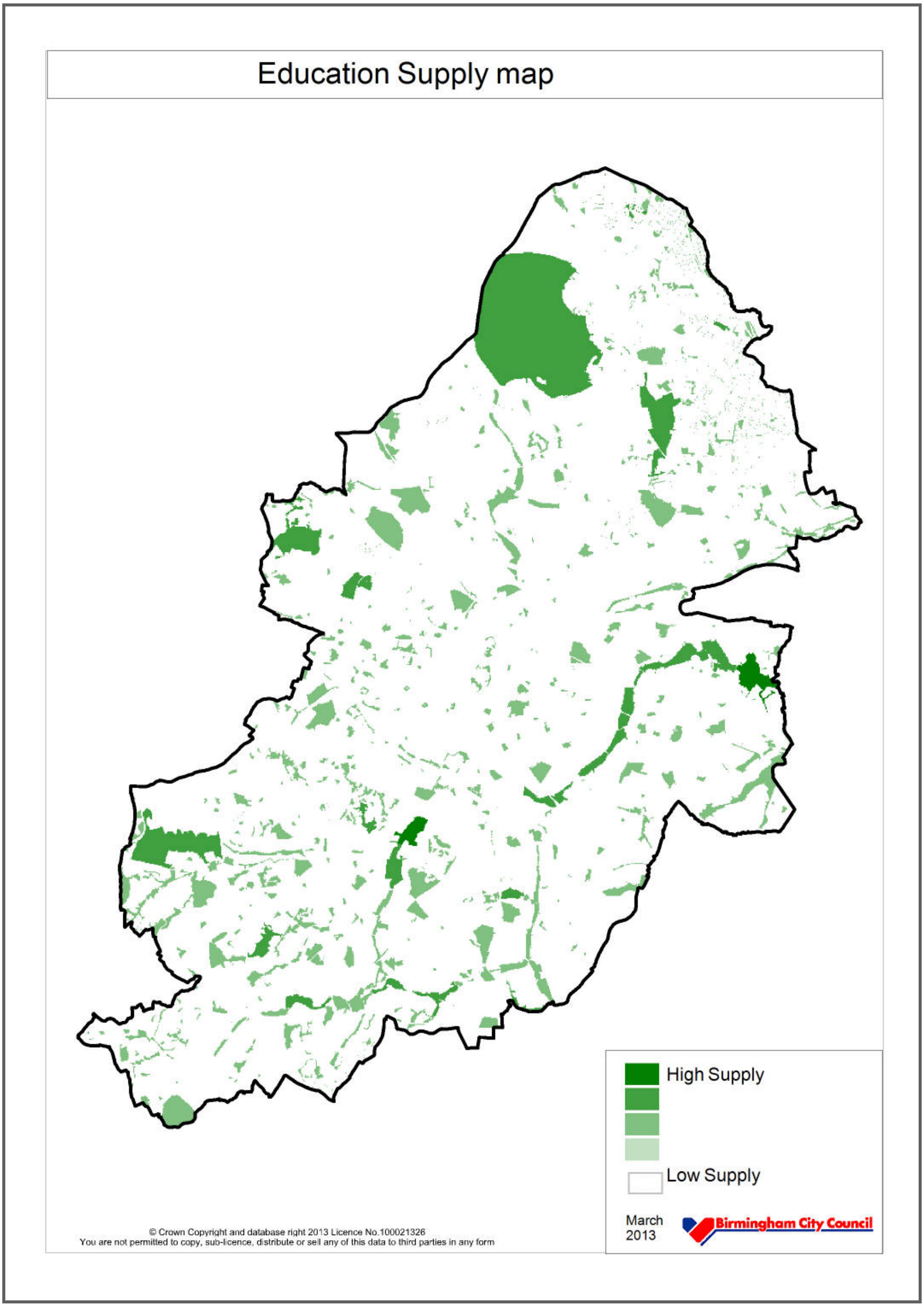
The quality of accessible greenspace can have a significant impact on the ability to provide educational benefits. This doesn't only depend on the visual amenity and management of such places; it also depends on factors such as peoples (perception of) security.

The best available indicator to account for quality is the Green Flag Award. This benchmark seems to be the best indicator to reflect the quality of a site for educational purposes. Therefore weighting score advances have been ascertained in case a site has been awarded a Green Flag.

5.4.2 Spatial Supply Distribution Layer

Green infrastructure has to be accessible to be able to benefit from educational benefits. The benefits are realized at the same location as they occur - for example in a park or woodland. Consequently, the 'ecosystem service supply layer' equals the 'spatial supply distribution layer'. Map 5.9 indicates where the green infrastructures with the highest educational values in Birmingham occur.

Map 5.9 **Education Spatial Supply Distribution Layer**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

5.4.3 Ecosystem Service Demand Layer

Population density of young people

Educational knowledge is not only provided by the formal educational system. There is evidence that basically every contact with nature formats ecological knowledge. Additional benefits of such contacts with nature are for example improved cognitive outcomes.[42] Accordingly, there is a general demand by children and young people for accessible greenspace, additionally to general recreation. A demand layer has been created for a subset of the population aged 18 or less. Weighting scores have been ascertained linear to the number of children per ha for the range between 0 and 40 children per ha.[43]

Educational facilities

One important way to improve children's ecological knowledge is within the formal educational system. Outdoor education represents an important share to develop ecological knowledge.[44] To take this factor into account, weighting scores have been ascertained to different types of educational facilities:

- Nursery Schools
- Primary Schools
- Secondary Schools
- Special Schools
- Further Education Establishments

It has been assumed that the demand for accessible greenspace is equally high around all such education establishments. The highest demand weighting score of -10 has been ascertained to the 300m buffer around education establishments. In the future this may be refined by for example incorporating the number of pupils of the different schools. If a school accommodates more children the demand for outdoor education facilities increases

[42] Church et al. 2011.

[43] In few cases the number of children per ha exceeds 40. In these cases the weighting score has been set to -10. Because there are no areas in Birmingham entirely without children calculated weighting scores of 0 have been changed to -1.

[44] Church et al. 2011.

as well because there are more (potential) beneficiaries. However, relevant data was not available by finalisation of this project.

5.4.4 Spatial Demand Distribution Layer

Distance from educational establishments

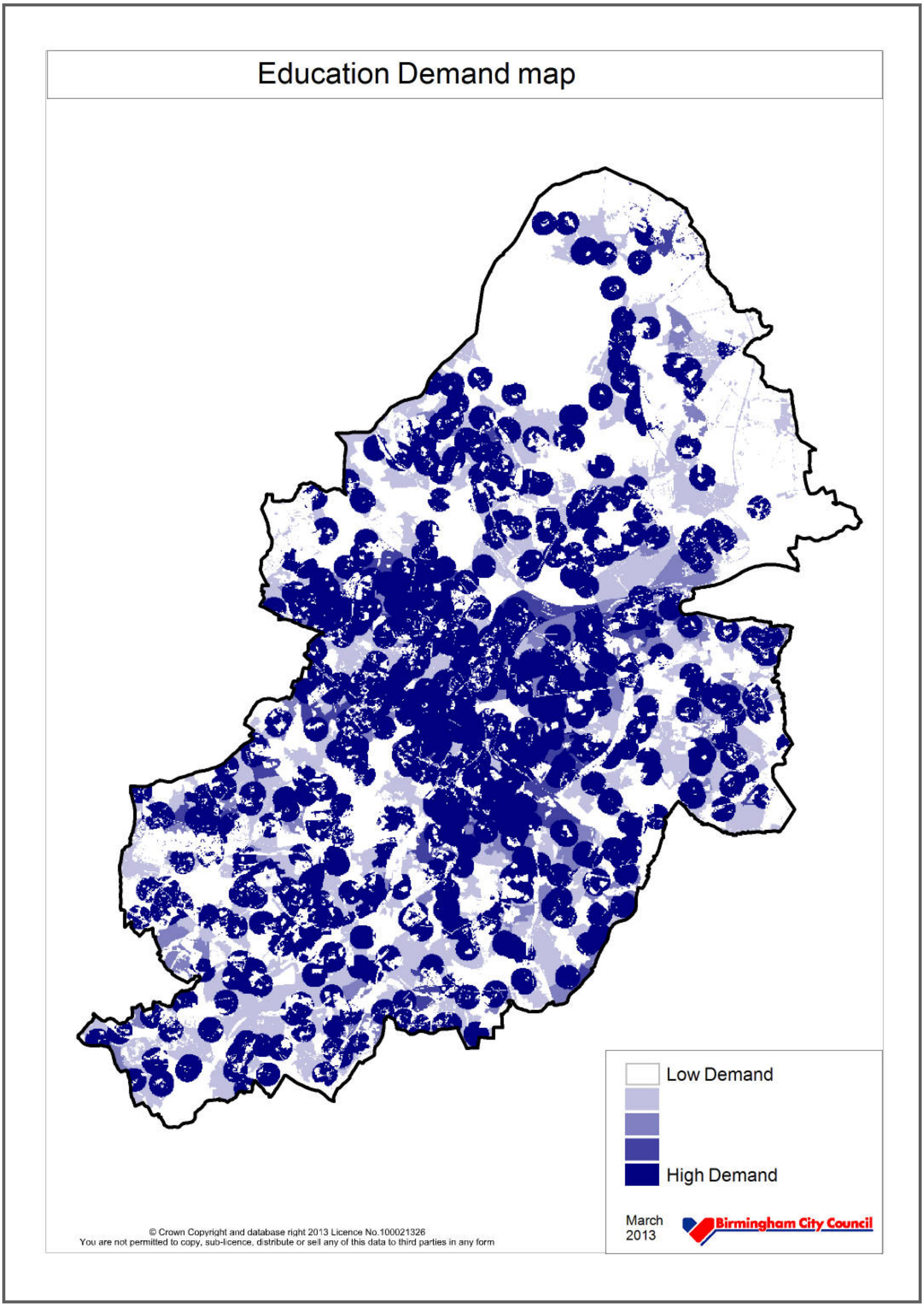
The assumption is feasible that accessible greenspace close to educational facilities can be used more frequently for formal outdoor education purposes than other greenspace sites. If a greenspace site is located within walking distance to a school, the transaction costs of for example planning a school trip and renting a bus etc. decline significantly. The travel time declines as well. The 300m buffer used for recreation has been adopted for educational establishments as well to take this factor into account.[45]

Distance from home

For 'general' outdoor education demands, (potential) benefits occur at different locations. Most children in Birmingham don't live on the doorstep to accessible greenspace. They have to travel a certain distance to access it and benefit from it. However, with increasing distance the opportunity costs to access the greenspace rise.[46] It is feasible to adopt the 300m buffer that has been applied for the 'spatial demand distribution layer' of recreation. Map 5.10 indicates the demand distribution for the ecosystem service 'education'.

[45] Educational facilities in Birmingham are only mapped as 'dots'. The closest building to such dots has been mapped and assumed to be the central building. The 300m buffer has been created around such building and not the whole educational facility site. This should be keept in mind when interpreting the findings.
[46] Bateman et al. 2006.

Map 5.10 **Education Spatial Demand Distribution Layer**

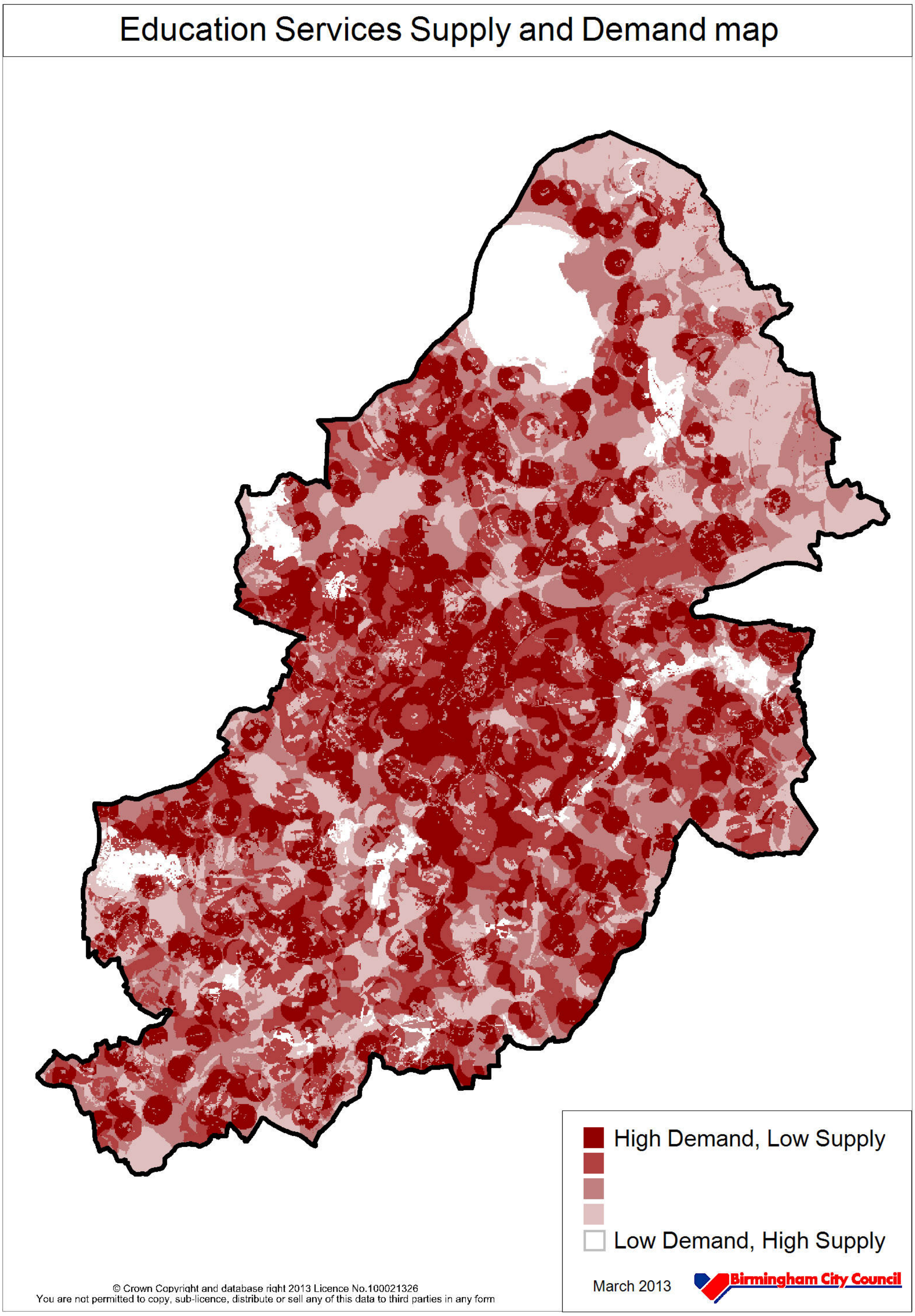


Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

5.4.5 Ecosystem Service Supply and Demand Map

As for recreation, the negative weighting scores of the demand distribution layer and the positive weighting scores of the supply distribution layer have been aggregated to produce a map that indicates to which degree the demand can be satisfied. Map 5.11 has to be taken with care as it doesn't take into account the link between size of a site and population density, available substitutes, and the effect of the greenspace on the population density. Furthermore the relation between supply and demand is only indicative. This evaluation doesn't allow saying that the demand for accessible greenspace in an area is satisfied or not. It only indicates that it is better satisfied in some areas than in others.

Map 5.11 Education Supply and Demand Map



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

6. Regulating Services

6.1 Global Climate Regulation

Global climate regulation has been classified as 'secondary' ecosystem service within scope of this evaluation. Main reason is that green infrastructure in Birmingham shouldn't predominantly be managed to provide a carbon sink. Of course all green infrastructure in Birmingham mitigates climate change somehow, but it was the view of the steering group that this should be seen as positive side-effect rather than a goal that should be actively intended.

6.2 Local Climate Regulation

The green and vegetated blue infrastructure has an influence on the local climate, even if this effect is limited. Urban areas are usually several degrees warmer than their surroundings. This Urban Heat Island Effect (UHIE) is caused by the massive use of materials retaining heat, which is released during the nights, as well as the concentration of waste heat from warming and cooling. In the future, the UHIE will combine with general global warming caused by climate change. In summer 2006 during a heatwave, for example, the UHIE caused more than 4 degrees of additional warmth within the central business district (most built up area) of Birmingham. Around Sutton Park the temperature was about 3 degrees lower.[47]

The temperature above and around vegetation is reduced by evapotranspiration. Furthermore, trees and shrubs provide shading and protection from heat and UV radiation.[48] Research in Manchester suggests that a 10% increase of green infrastructure in areas with the least greenery would reduce the UHIE by between 2.2% and 2.5%.[49] Other studies validate this effect.[50] Another positive effect on the local climate is the potential for reducing energy demands. On the one hand, trees provide shading which leads to reduced costs for air conditioning. On the other hand, trees can also act as a shelterbelt and reduce wind

[47] Tomlinson 2009.
[48] Forest Research 2010.
[49] Gill et al. 2007.
[50] Forest Research 2010.

speed which results in lower waste heat and heating costs. Kuppuswamy (2009) estimates that street trees provide a cooling effect of from 2% to 7%.[51] The blue infrastructure can also reduce the UHIE by acting as a heat sink.[52]

6.2.1 Ecosystem Service Supply Layer

Habitat type

Different vegetation types have different evapotranspiration rates and different abilities to provide shading. Grass has a comparable high evapotranspiration rate but climate change is likely to increase droughts which can dry out grass. In that case grass loses its evaporative cooling function and trees and water bodies become more important.[53] The expert group members have ascertained weighting scores to different types of habitat to estimate differences of the cooling effect. Considered habitat types include: Rivers, canals, lakes, ponds, (short) amenity grassland, grassland, heathland, fens, reedbeds, broadleaved woodland, allotments, private gardens, green roofs, and hedgerows.

6.2.2 Spatial Supply Distribution Layer

The cooling effect of green and blue infrastructure is not only impacting the temperature 'on site', it also affects the temperature of its surrounding. The cooler air is circulated by the wind flow and distributes throughout the city. Unfortunately, this effect couldn't have been evaluated within scope of this project. Therefore it has been assumed that the 'ecosystem service supply layer' equals the 'spatial supply distribution layer. Ecosystem Service Demand Layer

Population density of high risk groups

As the ecosystem services concept focuses on human wellbeing, the people in Birmingham are the (potential) beneficiaries of a reduced UHIE. Basically the demand is highest where people spent most of the time. Simplifying, the population density has been used, even if it doesn't take into account the places where people spent time working etc.

---

[51] Kuppuswamy 2009.
[52] Lundy and Wade 2011.
[53] Gill et al. 2007.

Some people benefit more from reduced temperatures than others. Especially the elderly population and young children are thought to have a lower tolerance to extreme temperatures which can cause heat-related illnesses and deaths.[54] Therefore the population density of young children (0-4) and elderly people (75+) is our main indicator for the demand. It can be assumed that especially for these age-groups the population density is closer related to the place where such people spent much of their time than for other groups because elderly people and young children are tendentially not as mobile as other age groups and spend much of their time at home. This may especially apply in time of extreme temperatures. Weighting scores have been ascertained linear to the density per ha of such risk groups.

<u>Temperature</u>

People living (or more accurate spending time) in areas of Birmingham with a higher UHI magnitude generally face a higher impact on comfort and health because average as well as extreme temperatures are higher. Tomlinson (2011) found that a concentration of "very high" risk people live within areas of Birmingham with the highest UHIE. Birmingham has been used as a case study to map the UHIE during a heatwave in 2006. Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data has been used to map the effect at a $1km^2$ resolution. Climate change is likely to intensify such events in quality and quantity.[55] Weighting scores have been defined by multiplying the population density of high risk people by the UHI magnitude and then recalculating the result to a 0 to -10 scale.

6.2.3 Spatial Demand Distribution Layer

The assumption underlies that the risk groups will tend to stay at home or within close distance to their homes most of the time during extreme weather events. Therefore it has been assumed that the 'spatial demand distribution layer' equals the 'ecosystem service demand layer'.

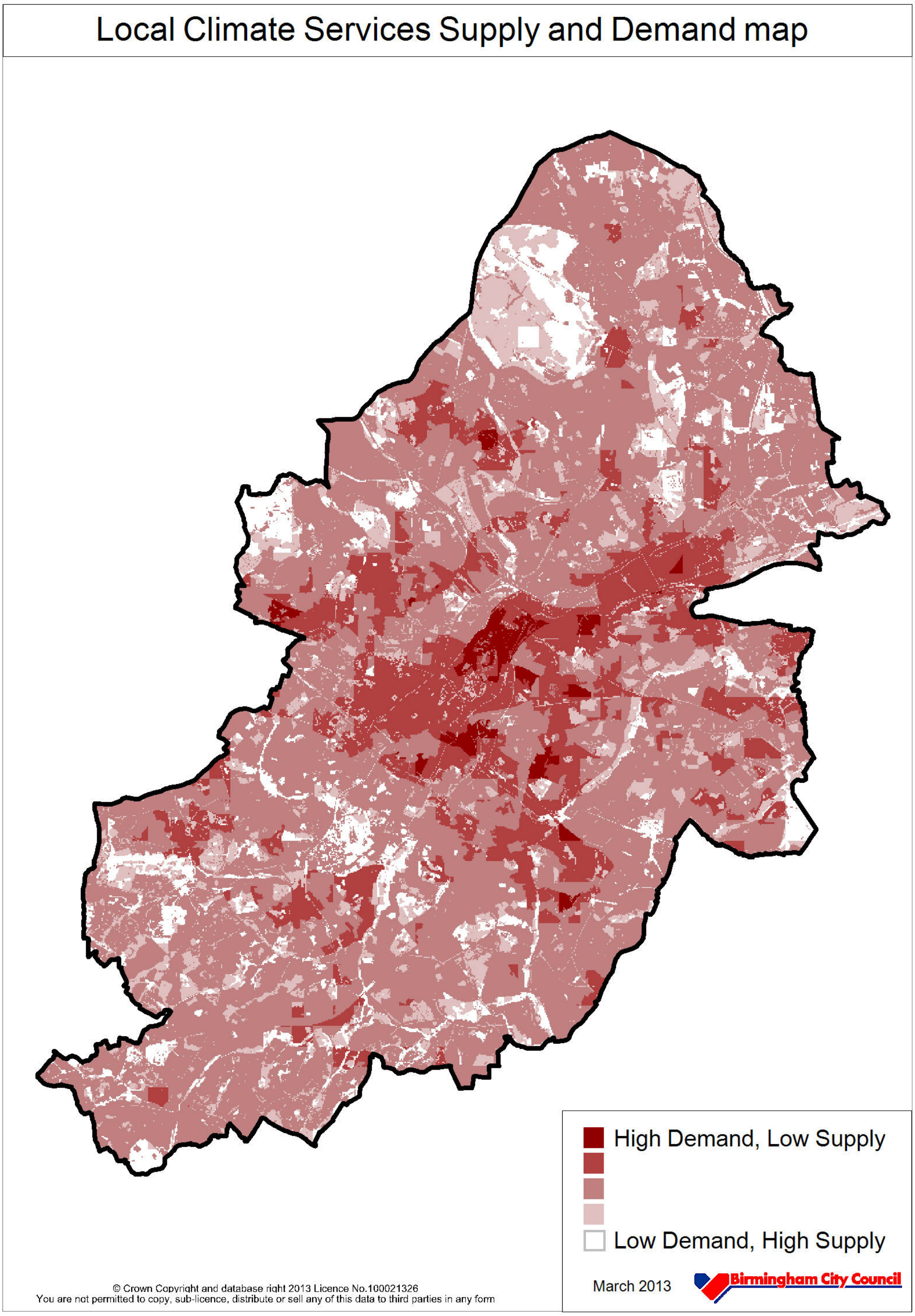
---

[54] Tomlinson et al. 2011; Tan 2008; Ballester et al. 1997; May et al. 2010.
[55] Confalonieri et al. 2007.

6.2.4 Ecosystem Service Supply and Demand Map

To produce the aggregated local climate supply and demand map, the positive weighting scores from the 'spatial supply distribution layer' and the negative scores from the 'spatial demand distribution layer' were added up. Map 6.3 indicates where in Birmingham the highest demand for the improvement of existing and creation of new ecosystems exists to provide local climate benefits to high risk groups.

Map 6.3 Local Climate Regulation Supply and Demand Map



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

6.3 Flood Risk Regulation[56]

Birmingham faces different types of flood risk. Heavy or prolonged rainfall as well as snow melt can cause fluvial flooding[57] when the watercourse cannot cope with the water draining from the surrounding land.[58]

Surface sealing in the city advances pluvial flooding where intense localised rainfall exceeds the drainage capacity of an area and can't enter the watercourse network or the sewer system. SuDS (Sustainable Drainage Systems) can mitigate this effect.[59] This is a local risk and depends e.g. on the height of an area in relation to its surrounding. Lower lying areas are tendentially at higher risk.

There is also a certain risk of groundwater flooding where the groundwater level rises above surface levels.[60] However, the effect of green infrastructure on this risk is very limited. Therefore this form of flooding is not part of this investigation. Another source of flooding is sewer flooding when the sewer system overflows or when it is blocked.[61] This can also have a significant negative effect on water quality when organic pollutant discharges from combined sewerage overflows.[62] Green infrastructure can prevent this type of flooding by capturing rainwater before it enters the sewer system.

6.3.1 Ecosystem Service Supply Layer

Interception Capacity

Green infrastructure can mitigate flooding events by capturing and storing water. It also allows water to evapotranspirate faster and to infiltrate into the soil. Furthermore, green infrastructure, depending on the vegetation type, reduces the water run-off. The interception capacity can be seen as the most important factor.[63] Different land-cover types

[56] Please note that in this context 'regulation' refers to the influence of ecosystems on processes rather than administrative regulation.
[57] In general canal breach is covered under this category as well, however, these are very rare events and therefore not evaluated within scope of this investigation.
[58] Overview & Scrutiny 2010.
[59] Ibid.
[60] Ibid.
[61] Ibid.
[62] Smith et al. 2011.
[63] Nedkov and Burkhard 2012.

have different abilities to store water.[64] This includes the habitat type, but also the soil type.[65] Green infrastructure allows the water to infiltrate into the soil. The benefit depends on the ability of the soil to allow this infiltration. However, corresponding soil data was not available to incorporate this factor. Furthermore, it wouldn't advance planning decisions because it is not feasible to replace vast amounts of soil to improve flood risk mitigation.

The blue infrastructure provides a storage and flow network for fluvial and surface water flows and does flatten peaks in the hydrograph as a result. It is essential to efficiently transport and store water through the city without flooding property. The expert group has ascertained weighting scores to different types of green and blue infrastructure to cover these aspects. The following habitat types have been evaluated: Rivers, canals, lakes, ponds, (short) amenity grassland, grassland, heathland, fens, reedbeds, broadleaved woodland, private gardens, green roofs, and hedgerows.

Location

In general, all greenspaces contribute to flood risk reduction. However, the contribution of green infrastructure to mitigate flooding events also depends on its location. If a habitat isn't located in a floodplain, it can't capture fluvial water coming from a river because the water won't reach the habitat. However, it may still contribute to mitigate pluvial flood risk.

To account for fluvial flood mitigation, weighting score advances have been allocated to green infrastructure located within flood zone 2 (0.1% likelihood of flooding each year) and flood zone 3 (1% likelihood of flooding each year). Birmingham City Council has also modelled the risk of pluvial flooding. This data is mainly based on area height and not as accurate as the data for fluvial flood risk but it represents the best data available. This assessment took into account the extent of flooding (over 10 cm or over 30 cm) and the likelihood of flooding (0.5% or 3.3% chance of flooding per year). Not included in the model is flooding that occurs from drainage systems of public sewers caused by catchment-wide rainfall events. Weighting scores have been adjusted for GI within the following areas:

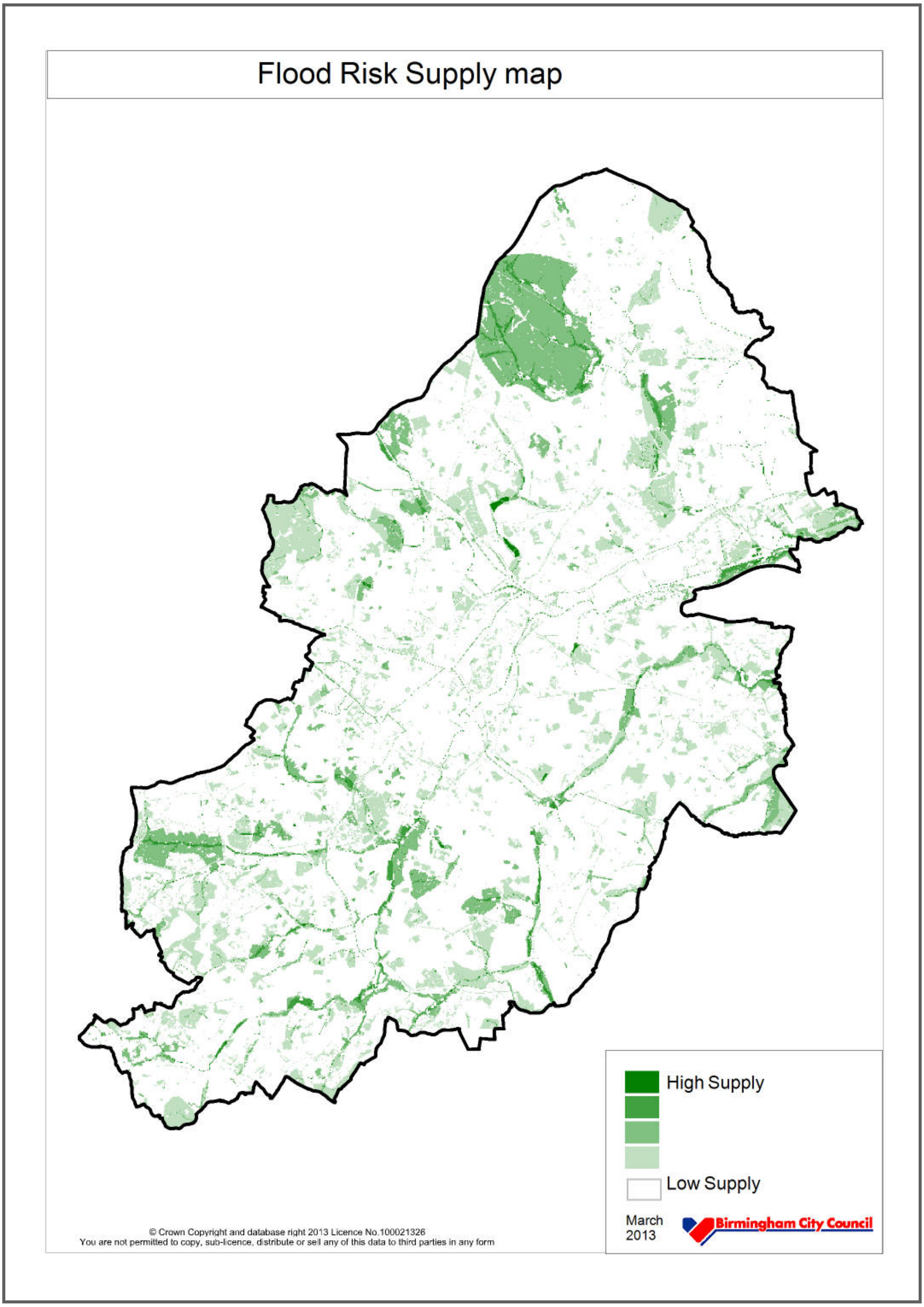
- >0.3m Flood Map for Surface Water (30 yr)

[64] Ibid.
[65] Collingwood Environmental Planning and GeoData Institute 2008.

- >0.1m Flood Map for Surface Water (30 yr)
- >0.3m Flood Map for Surface Water (200 yr)
- >0.1m Flood Map for Surface Water (200 yr)

A last category of 'other' location has been established where none of these applies to appreciate that even if GI is not located within a 'risk zone', it still reduces flood risk to some extent. It for example mitigates the water run-off to areas under flood risk. Map 6.4 indicates the relative contribution of the green and blue infrastructure in Birmingham to flood risk mitigation.

Map 6.4 **Flood Risk Regulation Supply Layer**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

6.3.2 Spatial Supply Distribution Layer

As mentioned before, the benefits of green infrastructure located in Birmingham to mitigate fluvial flood risk mainly occurs within the floodplain where it is located as well as floodplains downstream. There can also be an effect upstream, but this is spatially very limited. Unfortunately, limitations in data availability and scientific evidence didn't allow modelling the spatial distribution of this effect.

6.3.3 Ecosystem Service Demand Layer

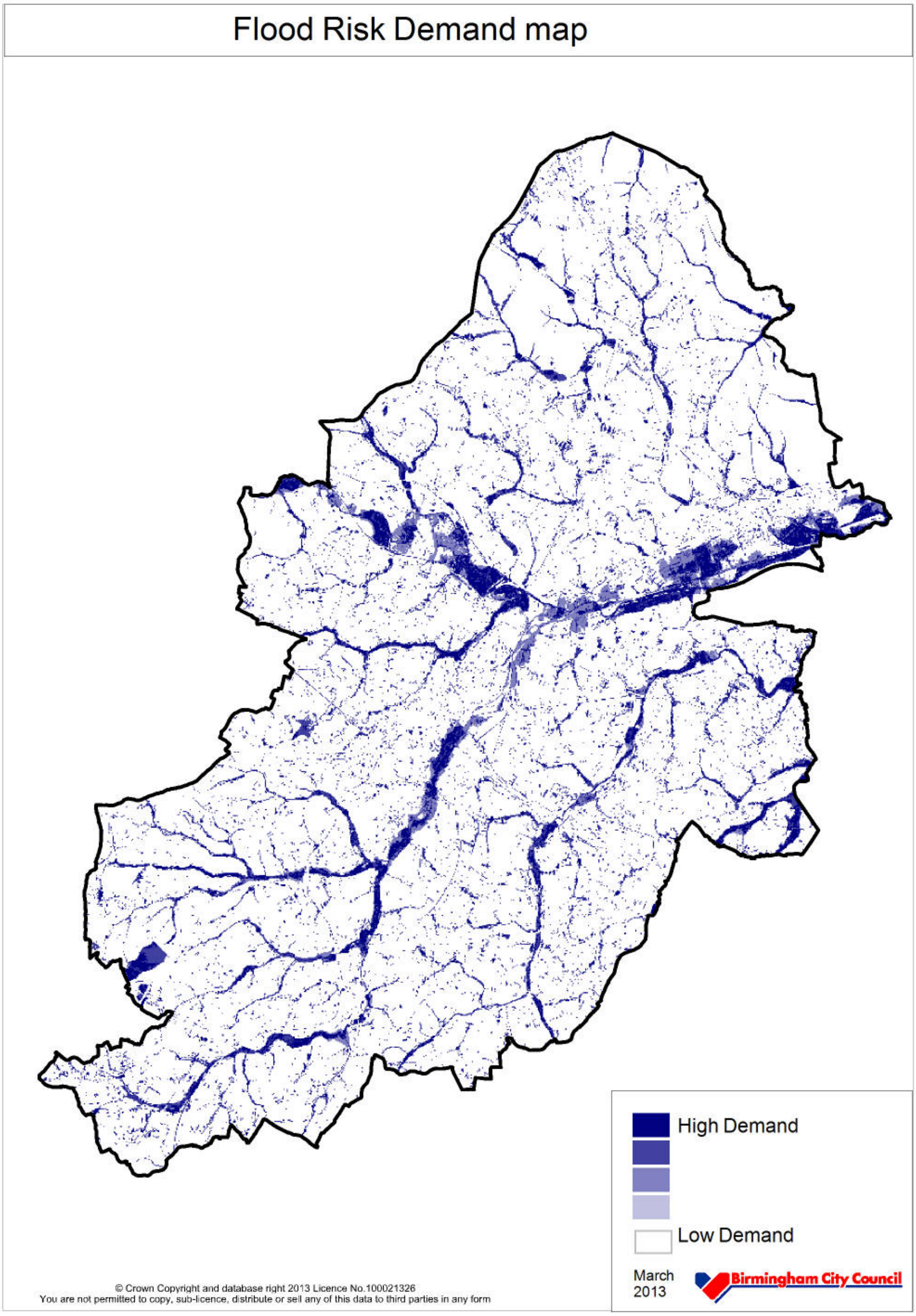
The ecosystem service 'flood risk mitigation' basically reduces the (risk of) damage to properties and other infrastructure (assuming that the potential damage to health and lives is either negligible or correlated to the potential damage costs to properties). Therefore, the demand depends on the potential damage costs to properties multiplied by the probability of occurrence. However, corresponding data about potential damage costs couldn't have been made available within scope of this project. It has been assumed that the location of green infrastructure is the dominant factor. As for the supply layer, it has been assumed that the different flood zones determine the demand for the creation of new and the improvement of existing green and blue infrastructure, respectively.

6.3.4 Spatial Demand Distribution Layer

As for the supply side, the demand distribution was too complex to model within scope of this investigation. It has been assumed that the 'ecosystem service demand layer' equals the 'spatial demand distribution layer'. It is not unfeasible to assume that the creation of new green and blue infrastructure or the improvement of such areas would be most benefiting where they contribute the most to flood risk reduction, even if the exact distribution of this effect can't be modelled. Therefore, the weighting scores that have been ascertained to the different flood zones have been adopted to map the demand as well.[66] Map 6.5 indicates where the demand for creation of; and improvements to green and blue infrastructure may be the highest for flood risk mitigation purposes.

[66] The positive weighting scores have been changed to negative weighting scores (e.g. 5 to -5).

Map 6.5 **Flood Risk Regulation Spatial Demand Distribution Layer**

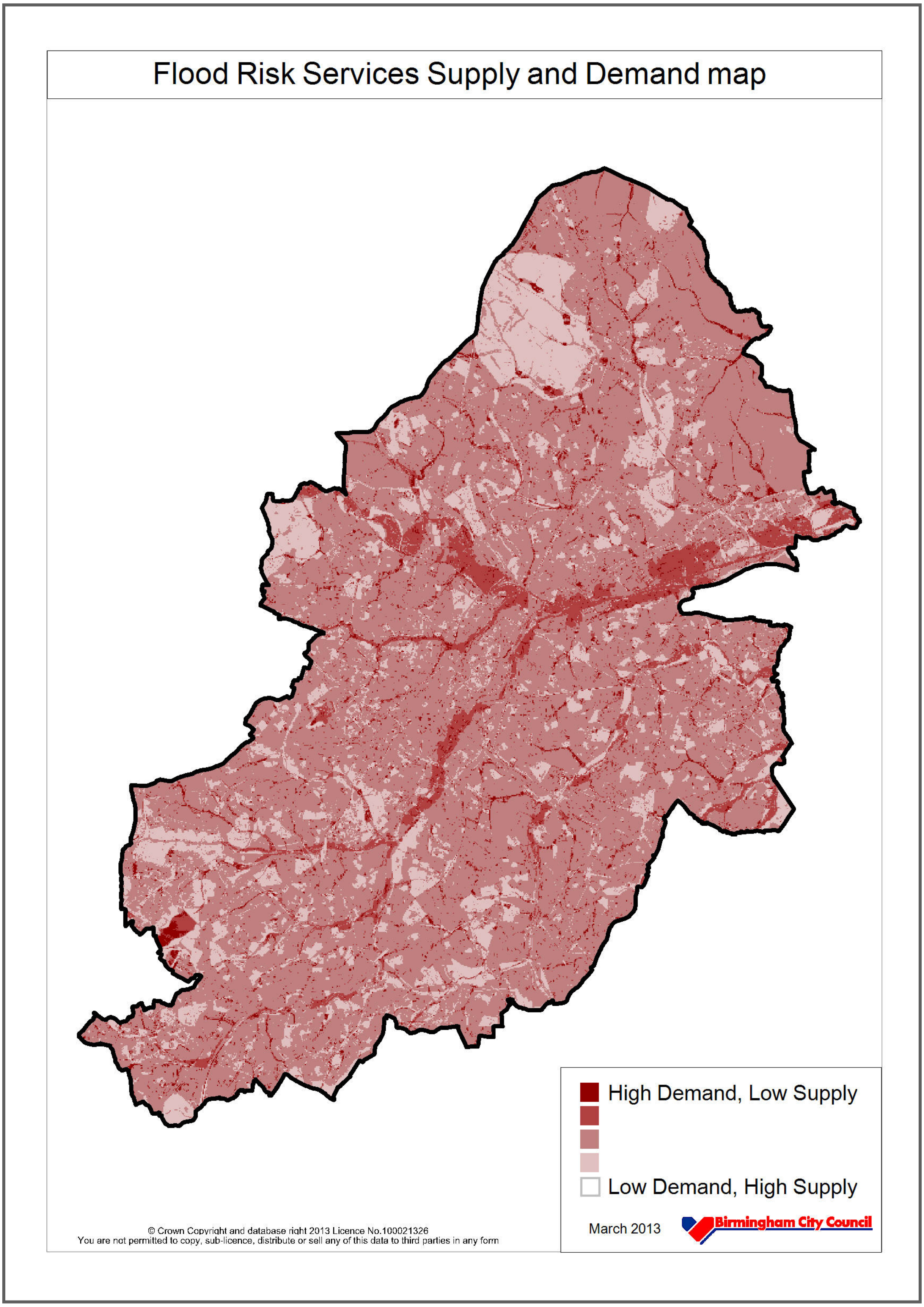


Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

6.3.5 Ecosystem Service Supply and Demand Map

To create the combined flood risk regulation supply and demand map, the positive weighting scores of the 'ecosystem service supply layer' and the negative weighting scores of the 'spatial demand distribution layer' have been added up. Map 6.6 below indicates where in Birmingham the creation or improvement of green and blue infrastructure may provide the highest benefits to the ecosystem service 'flood risk regulation'.

Map 6.6 **Flood Risk Regulation Supply and Demand Map**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

6.4 Water Quality Regulation[67]

When flooded, wetlands, but also other types of habitat, retain, remove and transform nutrients, organic matter and sediment. Furthermore, green infrastructure can capture pesticides such as TBT (tributyl tin) and other complex organic pollutants.[68] However, scientific uncertainties about the ability of terrestrial ecosystem to improve water quality remain.[69] Furthermore such effects on water quality by green infrastructure are very limited.

Many of water quality problems caused in Birmingham are about misconnections and combined sewer overflows. The vast amount of green infrastructure in Birmingham has a general effect on water quality by cleaning rain water and intercepting silt. It provides a general background pre-treatment of rainwater. The location of green infrastructure to provide this service is less important. Any form of vegetated cover can benefit water quality. As water passes through vegetation, pollutants can become fixed within the plant itself, rather than wash into rivers or the combined sewer system. In this case a certain amount of such pollutants won't enter the sewer system which reduces treatment costs.

Watercourses allow aeration of water and water bodies are usually vegetated and this kind of vegetation (reeds and aquatic plants) is often the best with regard to pollutant removal. Improvements to water quality caused by green and blue infrastructure reduce the remediation costs of water purification and have direct effects on for example biodiversity, aquatic recreation and food production (fish).

Because the spatial location of green infrastructure is less important for the provision of this ES and difficult to model, it has been classified as 'secondary ecosystem service'. Any additional GI benefits water quality, even if vegetation type and density affects the ability of an ecosystem to improve water quality. This should be considered when decisions about green infrastructure are due.

---

[67] Please note that in this context 'regulation' refers to the influence of ecosystems on processes rather than administrative regulation.
[68] EFTEC 2010.
[69] Smith et al. 2011.

6.5 Air Quality Regulation

Green infrastructure and especially trees can have a positive effect on the local air quality. In urban areas such as Birmingham where pollution emissions are comparatively high, the air pollution absorption by trees is even more important. They absorb, through deposition and chemical reactions, deleterious pollution such as carbon monoxide (CO), sulphur dioxide (SO_x), nitrogen dioxide (NO_2), ozone (0_3) and fine particulates (PM_{10}) which are responsible for major illnesses e.g. respiratory ailments, heart disease and cancer.[70] In a city like Birmingham local pollution sources like vehicle exhausts dominate.

> "...increasing deposition by the planting of vegetation in street canyons can reduce street-level concentrations in those canyons by as much as 40% for NO_2 and 60% for PM."[71]

On the other hand, however, trees can also worsen local air quality, depending on their location. Trees directly located along frequently used streets can trap pollutants because the polluted air exchanges slower. This can have a negative effect on the local air quality along such frequently used streets.[72] Therefore it can have an advance to allocate trees further away to gain the best outcomes.[73]

Another issue to consider is the tree species. Some trees have a greater impact on air quality than others with an advance to big evergreen broadleaved trees.[74] Furthermore different tree species have different effects on ozone levels.

> "Biogenic volatile organic compounds (BVOCs) emitted by trees can cause increases in ozone pollution, acting contrary to the pollution-scrubbing effect. Not all species emit BVOCs at the same rate, therefore selection of low BVOC emitting species where possible can decrease the risk of high-ozone episodes."[75]

[70] McPherson, Nowak, and Rowan 1994.
[71] Pugh et al. 2012, 7692.
[72] Buccolieri et al. 2009.
[73] Woodland Trust 2012.
[74] Ibid.
[75] Ibid., 4.

Even if Birmingham meets the air quality objectives identified in the National Air Quality Strategy, which was introduced through Part IV of the Environment Act 1995, the level of nitrogen dioxide at certain points within the city would still be above the objective levels, although it would meet the objective level by reason of there being no relevant exposure. However, even if objectives are met, this doesn't mean that the actual level of air pollution has no negative effect on health.

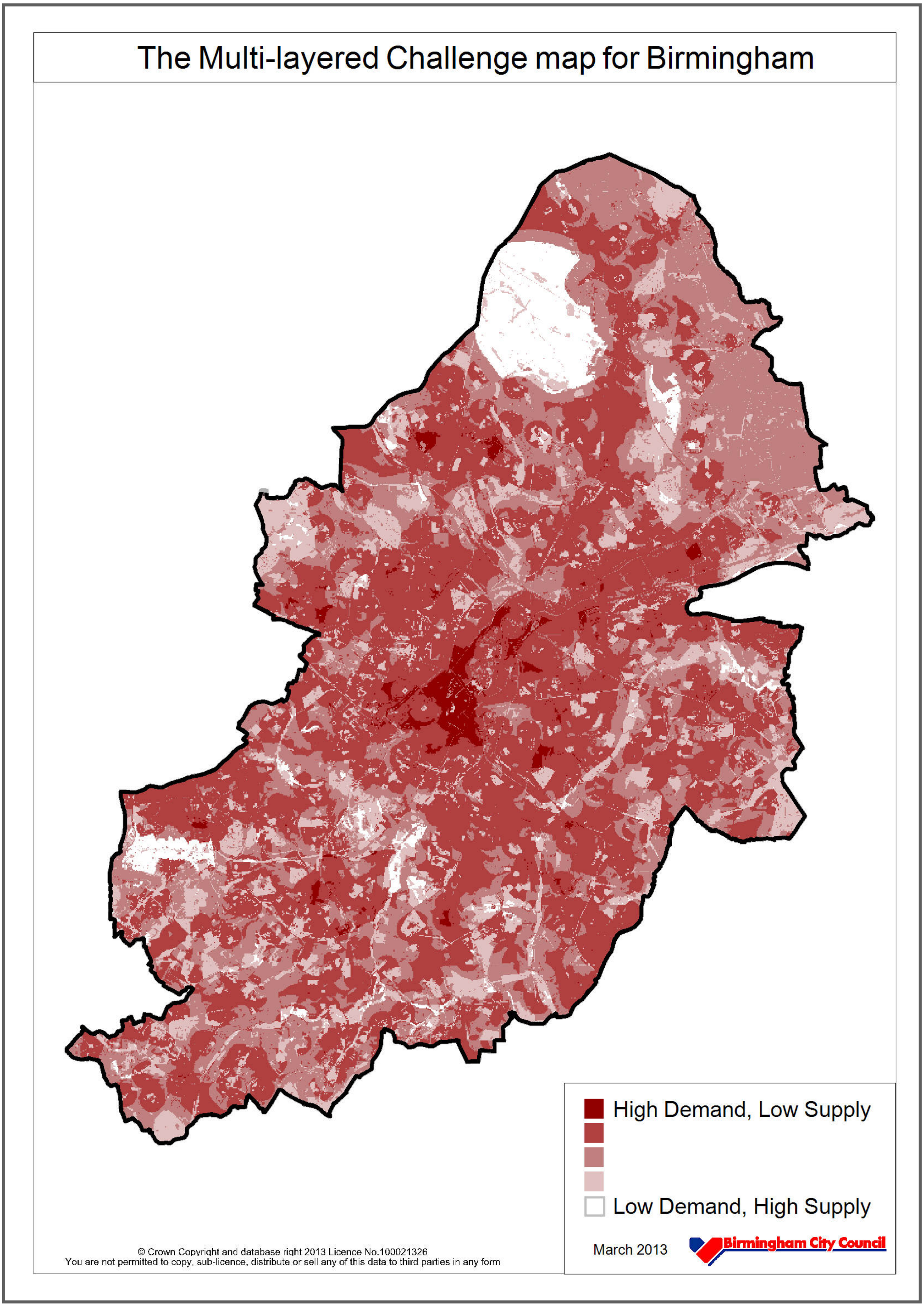
Air quality regulation has been identified as a 'primary' ecosystem service which should be assessed within scope of this mapping exercise. Unfortunately a lack of baseline data did not allow including this ecosystem service in the assessment. We recommend re-visiting the issue of air quality when updating maps and approaches in the future.

7. Main Findings, Use of Data & Recommendations

The main goals of this exercise were (1) to identify areas in the city where the demand for ecosystem services can't be sufficiently satisfied and the creation/improvement of green and blue infrastructure might be most benefiting in the future, these areas referred to locally as 'hotspots'; (dark red colour shape in Map 7.1); and (2) to identify locations where ecosystems demand specific protection to ensure a sustainable flow of ecosystem services over time in such areas (bright colour shape in Map 7.1). All six single 'ecosystem service supply and demand maps' for each of the six 'primary' ecosystem services have been combined to create a 'multi-layered challenge map for Birmingham'. Map 7.1 shows this 'aggregated ecosystem service supply and demand map'.

The main aim of this map is to allow decision-makers and other organisations to prioritise areas of Birmingham to create and/or improve green infrastructure most effectively to benefit human wellbeing in the city. Emphasis has been given to the maximisation of multiple ecosystem services delivery. The darker red colour shape (high demand and/or low supply) of the 'aggregated ecosystem services supply and demand map' indicates in which parts of Birmingham action may be most benefiting, hence the local reference of 'hotspot'. However, limitations and caveats of the maps including limited data availability, limitations to the scientific evidence as well as methodical caveats of the approach applied limit the application of such maps. The 'aggregated ecosystem services supply and demand map' can be used to identify areas in the city where the creation of new ecosystems or the improvement of existing ecosystems may provide the highest additional benefits to human wellbeing, with a focus on the provision of multiple ecosystem services. However, this is just an indication. Such areas have to be examined in more detail 'on the ground' to allow a final judgement. It has to be reviewed, for example, if the areas provide opportunities to create and/or improve new/existing ecosystems. It has to be reviewed if the demand in specific areas that have been identified by the map is really as high as the maps indicate and if the creation/improvements would provide the intended additional benefits. A site visit is recommended to evaluate the local circumstances. Additionally, the local community and local knowledge should be consulted prior to decisions about the delivery of green infrastructure and management changes to existing ecosystem services.

Map 7.1 **Aggregated Ecosystem Service Supply and Demand Map**



Source: ***Based on GIS data provided by EcoRecord, Birmingham City Council, Forestry Commission, and the Environment Agency.***

Considering local circumstances and the preferences of the local community it also has to be decided which kind of ecosystems should be created/improved; and why. The 'aggregated ecosystem service supply and demand map' can't answer this question but the 'ecosystem services delivery maps' for specific ecosystem services may provide some information – e.g. which specific ecosystem services are demanded in that area. Additionally, the costs of habitat creation and management should be taken into account before action can take place. Involving local stakeholders in the decision-making process can also attract acceptance of such projects as well as in-kind contributions, e.g. by local friends groups.

Another main aim of this investigation was to identify ecosystem service 'hot spots' in Birmingham where the green and blue infrastructure is particularly valuable to human wellbeing. A brighter colour shape in Map 7.1 (low demand and/or high supply) indicates where such 'hot spots' may exist. But again, further investigation on the ground is necessary to allow a final judgement.

As a general rule, the maps provided in this report should be considered as starting point for future investigation – not as comprehensive delivery or protection plan. It is of crucial importance to state that the provided maps in this report can't substitute any other monitoring and evaluation methods such as for example an Environmental Impact Assessment (EIA) etc. The level of detail and accuracy of the maps explicitly don't allow such applications. The maps can't be used to justify any destruction of or development on existing greenspace in Birmingham. The maps provide an additional information sources but can't replace any other assessment and monitoring. When this report and its findings and maps are used to inform other reports or for example EIA's, all relevant caveats and limitations must be mentioned to as well.

Please note that future changes to the green and blue infrastructure; but also for example to population density and structure or any other indicator will impact on the validity of the maps presented in this report. Birmingham is changing fast and so the maps in this report will require updating in line with other planning policy evidence bases. This should include an update of the maps based on latest baseline data and indicators. An update study should also include a review of new scientific evidence and improved monitoring data. It has been stressed throughout the report that several limitations and caveats apply. By improving data sources and methodologies over time, such limitations can be reduced and more advanced outcomes can be created. A higher accuracy of the maps may also allow additional and advanced applications.

One feasible next step is to evaluate areas of the city where an underprovision with ES has been identified and review if and where opportunities for the creation and improvements of ecosystems exist. This may also include the costs for habitats creation, management, etc. Such an ecosystem service opportunity map is likely to provide valuable additional information to decide where the creation and improvement of ecosystems would be most efficient.

Another opportunity for the future could be to investigate especially in imported ecosystem services and how the flow the flow of such ES may change in the future. The concept of ecosystem service footprints might be applied to evaluate this effect.[76] This would reveal Birmingham's dependence on ecosystem services 'produced' outside the city. Partnerships and instruments such as Payments for Ecosystem Services (PES) might be considered to ensure the sustainable flow of such ecosystem services benefiting human wellbeing in the city.

Optimising the aggregated map for specific policy agendas or the responsibilities and priorities of single agencies and departments could also add additional value to the maps. In this case, a set of ES could be defined as 'prioritised' ES (from the point of view of that agency/department). This would prioritise areas of action for that delivery body. These prioritised areas can then again be ranked by incorporating all other ES in the model.

The whole project should be seen as the start of a progress rather than a one-off investigation. The report raises many research questions affecting several scientific disciplines. Birmingham could serve as case study to improve methods implementing the 'ecosystem services concept' into practical decision-making.

[76] Burkhard et al. 2012.

8. List of Abbreviations

AADT	Average Annual Daily Traffic
ANGSt	(Natural England's) Accessible Greenspace Standard
ASNW	Ancient Semi-Natural Woodland
BAP	Biodiversity Action Plan
BVOCs	Biogenic volatile organic compounds
CBA	Cost-Benefit Analysis
CO	Carbon monoxide
Defra	Department for Environment, Food and Rural Affairs
EIA	Environmental Impact Assessment
ES	Ecosystem Service
GIS	Geographic Information System
GI	Green Infrastructure
MCA	Multi-Criteria Analysis
MODIS	Moderate Resolution Imaging Spectroradiometer
NIA	Nature Improvement Area
NO_2	Nitrogen dioxide
0_3	Ozone
PES	Payments for Ecosystem Services
PM_{10}	Fine particulates
SINC	Site of Importance for Nature Conservation
SLINC	Site of Local Importance for Nature Conservation
SO_x	Sulphur dioxide
SSSI	Site of Specific Scientific Interest
SUDS	Sustainable Urban Drainage System
TBT	Tributyl tin
UHIE	Urban Heat Island Effect

9. References

Ballester, F., D. Corella, S. Pérez-Hoyos, M. Sáez, and A. Hervás. 1997. Mortality as a function of temperature. A study in Valencia, Spain, 1991-1993. *International Journal of Epidemiology* 26 (3): 551–561.

Balmford, Andrew, and William Bond. 2005. Trends in the state of nature and their implications for human well-being. *Ecology Letters* 8 (11): 1218–1234.

Bateman, Ian J., David Abson, Nicola Beaumont, Amii Darnell, Carlo Fezzi, Nick Hanley, Andreas Kontoleon, et al. 2011. UK National Ecosystem Assessment: Economic Valuation. In *The UK National Ecosystem Assessment Technical Report*. Cambridge: UNEP-WCMC.

Bateman, Ian J., Brett H. Day, Stavros Georgiou, and Iain Lake. 2006. The aggregation of environmental benefit values: Welfare measures, distance decay and total WTP. *Ecological Economics* 60 (2): 450–460.

Brander, L. M., A. Ghermandi, O. Kuik, A. Markandya, P. Nunes, M. Schaafsma, and A. Wagtendonk. 2008. Scaling up ecosystem services values - methodology, applicability and a case study.

Buccolieri, Riccardo, Christof Gromke, Silvana Di Sabatino, and Bodo Ruck. 2009. Aerodynamic effects of trees on pollutant concentration in street canyons. *Science of The Total Environment* 407 (19): 5247–5256.

Burkhard, Benjamin, Franziska Kroll, Stoyan Nedkov, and Felix Müller. 2012. Mapping ecosystem service supply, demand and budgets. *Ecological Indicators* 21 (0): 17–29.

Church, Andrew, Jacquelin Burgess, Neil Ravenscroft, William Bird, Kirsty Blackstock, Emily Brady, Michael Crang, et al. 2011. UK National Ecosystem Assessment of Cultural Services. In *The UK National Ecosystem Assessment Technical Report*. Cambridge: UNEP-WCMC.

Coles, R.W, and S.C Bussey. 2000. Urban forest landscapes in the UK — progressing the social agenda. *Landscape and Urban Planning* 52 (2–3): 181–188.

Collingwood Environmental Planning, and GeoData Institute. 2008. *Thames Gateway Ecosystem Services Assessment Using Green Grids and Decision Support Tools for Sustainability: Supporting the Development of a Strategy for the Kent Thameside Green Grid Using Ecosystem Services*. Strategic Study Report. London.

Confalonieri, Ulisses, Bettina Menne, Rais Akhtar, Kristie L. Ebi, Maria Hauengue, R. Sari Kovats, Boris Revich, and Alistair Woodward. 2007. Human health. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, 391–431. Cambridge: Cambridge University Press.

Daily, Gretchen C, Stephen Polasky, Joshua Goldstein, Peter M Kareiva, Harold A Mooney, Liba Pejchar, Taylor H Ricketts, James Salzman, and Robert Shallenberger. 2009. Ecosystem services in decision making: time to deliver. *Frontiers in Ecology and the Environment* 7 (1): 21–28.

DCLG. 2012. *National Planning Policy Framework*. London: Department for Communities and Local Government.

Defra. 2007. An introductory guide to valuing ecosystem services. Department of Environment, Food and Rural Affairs. Available from <http://www.defra.gov.uk/environment/policy/natural-environ/documents/eco-valuing.pdf>.

EFTEC. 2010. *Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects*. Handbook prepared for the Environment Agency for England and Wales. EFTEC. Available from <http://publications.environment-agency.gov.uk/pdf/GEHO0310BSFH-e-e.pdf>.

Feld, Christian, José Sousa, Pedro da Silva, and Terence Dawson. 2010. Indicators for biodiversity and ecosystem services: towards an improved framework for ecosystems assessment. *Biodiversity and Conservation* 19 (10): 2895–2919.

Fish, Rob D. 2011. Environmental Decision Making and an Ecosystems Approach: Some Challenges from the Perspective of Social Science. *Progress in Physical Geography* 35 (5): 671–680.

Fisher, Brendan, R. Kerry Turner, Neil D. Burgess, Ruth D. Swetnam, Jonathan Green, Rhys E. Green, George Kajembe, et al. 2011. Measuring, Modeling and Mapping Ecosystem Services in the Eastern Arc Mountains of Tanzania. *Progress in Physical Geography* 35 (5): 595–611.

Fisher, Brendan, R. Kerry Turner, and Paul Morling. 2009. Defining and classifying ecosystem services for decision making. *Ecological Economics* 68 (3): 643–653.

Forest Research. 2010. *Benefits of green infrastructure*. Report to Defra and Communities and Local Government. Farnham: Forest Research. Available from <http://www.forestresearch.gov.uk/pdf/urgp_benefits_of_green_infrastructure_main_report.pdf/$FILE/urgp_benefits_of_green_infrastructure_main_report.pdf>.

Gill, S. E., J. F. Handley, A. R. Ennos, and S. Pauleit. 2007. Adapting cities for climate change: the role of the green infrastructure. *Built Environment* 33: 115–133.

Handley, John, Stephan Pauleit, Paul Slinn, Alan Barber, Mark Baker, Carys Jones, and Sarah Lindley. 2003. *Accessible Natural Green Space Standards in Towns and Cities: A Review and Toolkit for their Implementation*. English Nature Research Reports. English Nature.

Harrison, Carolyn, Jacquelin Burgess, Allison Millward, and Gerald Dawe. 1995. *Accessible natural greenspace in towns and cities: A review of appropriate size and distance criteria*. English Nature Research Reports. English Nature.

HM Government. 2011. *The Natural Choice: securing the value of nature*. Available from <http://www.official-documents.gov.uk/document/cm80/8082/8082.pdf>.

Koschke, Lars, Christine Fürst, Susanne Frank, and Franz Makeschin. 2012. A multi-criteria approach for an integrated land-cover-based assessment of ecosystem services provision to support landscape planning. *Ecological Indicators* 21 (0): 54–66.

Kuppuswamy, Hemavathy. 2009. Improving health in cities using green infrastructure: A review. *FORUM Ejournal* 9: 63–76.

Lawton, John, Valerie Brown, Clive Elphick, Alastair Fitter, Jane Forshaw, Ross Haddow, Stephanie Hilborne, et al. 2010. *Making Space for Nature: A review of England's Wildlife Sites and Ecological Network*. Report to Defra.

Layke, Christian. 2009. *Measuring Nature's Benefits: A Preliminary Roadmap for Improving Ecosystem Service Indicators*. WRI Working Paper. Washington DC: World Resources Institute.

Lundy, L., and R. Wade. 2011. Integrating Sciences to Sustain Urban Ecosystem Services. *Progress in Physical Geography* 35 (5): 653–669.

May, Emily, Lorenza Baiardi, Edna Kara, Smriti Raichand, and Cyril Eshareturi. 2010. *Health Effects of Climate Change in the West Midlands*. Technical Report.

McPherson, E. G., Javid J. Nowak, and A. R. Rowan. 1994. *Chicago's urban forest ecosystem - results of the Chicago Urban Forest Climate Project*. General Technical Report. Radnor: U.S. Department of Agriculture. Available from <http://www.nrs.fs.fed.us/pubs/gtr/gtr_ne186.pdf>.

Millennium Ecosystem Assessment. 2005. *Ecosystems and human well-being*. Synthesis Report. Available from <http://www.maweb.org/documents/document.356.aspx.pdf>.

Morling, Paul, Emma Comerford, Ian Bateman, Nicola Beaumont, Katherine Bolt, Daan van Soest, and James Vause. 2010. *Economic Assessment of Biodiversity*. UK NEA Economic Analysis Report.

Mourato, Susana, Giles Atkinson, Murray Collins, Steve Gibbons, George MacKerron, and Guilherme Resende. 2010. *Economic Analysis of Cultural Services*. UK NEA Economic Analysis Report. London: London School of Economics and Political Science.

Nedkov, Stoyan, and Benjamin Burkhard. 2012. Flood regulating ecosystem services—Mapping supply and demand, in the Etropole municipality, Bulgaria. *Ecological Indicators* 21 (0): 67–79.

Norris, Ken, Mark Bailey, Sandra Baker, Richard Bradbury, David Chamberlain, Callan Duck, Martin Edwards, et al. 2011. Biodiversity in the Context of Ecosystem Services. In *The UK National Ecosystem Assessment Technical Report*. Cambridge: UNEP-WCMC.

Overview & Scrutiny. 2010. *Flood Risk Management and Response*. Report to Birmingham City Council.

Paetzold, Achim, Philip H. Warren, and Lorraine L. Maltby. 2010. A framework for assessing ecological quality based on ecosystem services. *Ecological Complexity* 7 (3): 273–281.

Pugh, Thomas A. M., A. Robert MacKenzie, J. Duncan Whyatt, and C. Nicholas Hewitt. 2012. Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons. *Environmental Science & Technology* 46 (14): 7692–7699.

Smith, Pete, Mike Ashmore, Helaina Black, Paul Burgess, Chris Evans, Rosemary Hails, Simon Potts, et al. 2011. UK National Ecosystem Assessment of Regulating Services. In *The UK National Ecosystem Assessment Technical Report*. Cambridge: UNEP-WCMC.

Syrbe, Ralf-Uwe, and Ulrich Walz. 2012. Spatial indicators for the assessment of ecosystem services: Providing, benefiting and connecting areas and landscape metrics. *Ecological Indicators* 21 (0): 80–88.

Tan, Jianguo. 2008. Commentary: People's vulnerability to heat wave. *International Journal of Epidemiology* 37 (2): 318–320.

Tomlinson, Charlie. 2009. *Climate Change and Heat Risk in Urban Areas: A Birmingham Case Study*. Birmingham: School of Engineering, University of Birmingham. Available from <http://www.universitas21.com/GRC/GRC2009/Tomlinson.pdf>.

Tomlinson, Charlie, Lee Chapman, John Thornes, and Christopher Baker. 2011. Including the urban heat island in spatial heat health risk assessment strategies: a case study for Birmingham, UK. *International Journal of Health Geographics* 10: 42.

UK NEA. 2011a. *UK National Ecosystem Assessment: Synthesis of the Key Findings*. Cambridge: UNEP-WCMC. Available from <http://archive.defra.gov.uk/environment/natural/documents/UKNEA_SynthesisReport.pdf>.

UK NEA. 2011b. *UK National Ecosystem Assessment: Technical Report*. Cambridge: UNEP-WCMC.

Ulrich, R. S., and R. F. Simons. 1986. Recovery from Stress During Exposure to Everyday Outdoor Environments. In *The cost of Not Knowing*. Barnes, R. et al.

Woodland Trust. 2012. *Urban Air Quality*. Lincolnshire: Woodland Trust.

10. Technical Appendix

10.1 Weighting Exercise

In this appendix, the weighting exercise questionnaire for the ecosystem service ‘biodiversity’ can be found. It is an interactive excel-spreadsheet. The weighting exercise questionnaires have been circulated via email with the following text:

Dear Expert Group Members and Supporters,

I wondered if you would like to undertake a weighting exercise evaluating the relative contribution of ecosystem services in Birmingham to human well-being. The excel-based questionnaires (attached) will take between 10 and 15 minutes to complete.

You receive this email because you are a member of the expert groups or because colleagues have nominated you for this exercise.

The aim of this project is to evaluate the relative contribution of different habitats, scenarios, and ecosystem services in Birmingham to human well-being. Based on this assessment maps will be published as part of Birmingham’s Green Infrastructure Strategy 2013-28. This ‘blueprint’ of Birmingham’s spatial distribution of the provision of; and demand for ecosystem services shall serve (1) to prioritise areas where the demand for ES can’t be sufficiently satisfied, and (2) to identify areas where ES ‘hotspots’ exist which are providing a very high value of benefits across a wide range of ecosystem services. The former indicates in which areas of Birmingham a specific need for the creation and/or improvement of green infrastructure will be most effective. This allows for example to prioritise actions in scope of the Nature Improvement Area (NIA). The latter indicated where existing green infrastructure is very valuable and will therefore require specific protection/measures – short of formal designation. Attached you can find a draft of the project report for more detailed information.

You can complete **up to 3** questionnaires for the following ecosystem services:

- Aesthetic values and sense of place
- Air quality regulation
- Biodiversity
- Education
- Flood risk mitigation
- Local climate regulation
- Recreation

In case you would like to participate please complete up to 3 of the excel-based questionnaires attached and send the file(s) back to oliver.hoelzinger@birmingham.gov.uk.

Please forward this email to colleagues who might be interested as well. It is very important for the success of this project that as many experts as possible participate in this exercise!

When opening the file you may be asked to activate macros (by setting the security level to a lower level). There is no danger in doing so but in case you don’t want to do that you don’t have to. It won’t impact the calculations but you won’t be able to navigate through the spreadsheets by double-clicking on the orange buttons. In that case please use the tabs to continue with the next step.

Final deadline to reply is Friday the 17th August 2012. However, an earlier reply would be appreciated!

Please rename the file to **'CCP for Birmingham - Flood Risk - *your name***' before you send it back.

Your participation in this project will be greatly appreciated!

Kind regards,

Oliver Hoelzinger

Researcher
Consultancy for Environmental Economics & Policy / University of Birmingham

The seven different weighting exercises have been attached to that email. Here the weighting exercise questionnaire for 'biodiversity' can be reviewed.

Start

Thank you very much for participating in this weighting exercise! It shouldn't take more than 10-15 minutes to complete the spreadsheet. The aim of this exercise is to ascertain weighting scores to the relative supply of different sites in Birmingham to provide biodiversity benefits. Please use only the white cells to make entries. There will be a drop-down menu.

Biodiversity in scope of this particular section has been evaluated referring to two aspects:

(1) The non-use value of wild species diversity: This service reflects the value people hold for the pure existence of specific species or the diversity of species in general, even if they don't use or experience them directly. Use-values are for example captured in the 'recreation' category. Scientific evidence suggests that people hold higher non-use values for charismatic species such as mammals, birds, amphibians, reptiles, butterflies, and moths.

(2) Infrastructure, insurance and resilience value of biodiversity: A 'healthy' ecosystem depends on some combinations of ecosystem structure and composition to provide its services sustainable. A higher biodiversity and complexity of species and habitats may provide an 'insurance' to ensure that such 'healthy' ecosystems remain, even if some species fail or get lost. It also may make ecosystems more resilient to 'external shocks'.

It is very important that you evaluate this ecosystem service 'biodiversity' isolated from other services such as 'amenity & sense of place' or 'recreation'. Such ecosystem services will be evaluated separately!

The exercise includes the following steps:

Step 1 - Personal data: Include your contact details. These details won't be published or linked to your entries.

Step 2 - Baseline scores: Ascertain baseline weighting scores to different types of habitats.

Step 3 - Adjusted scores: Ascertain weighting penalties/advances for variant scenarios.

Step 4 - Review: This allows you to review your scores and make final alterations.

Step 5 - Weighting of ES: Ascertain weighting scores for different ecosystem services to compare them.

Step 6 - Finish: This allows you to give feedback and to suggest further participants.

To navigate through this worksheet you can double-click on the orange button below.

Step 1 - Personal Data

In case you can't open the next sheet by double-clicking on the orange button above please use the tabs below or activate cookies!

Please contact
oliver.hoelzinger@birmingham.gov.uk
in case you have any (technical) problems/questions undertaking this exercise.

Step 1 - Personal Data

Please note that your ascertained weighting scores won't be linked to your personal data.

Title:	
Name:	
Position:	
Institution:	
E-mail address:	

I agree that the final report states that I've undertaken this weighting exercise. Your personal entries won't be published! **Yes**

I'd like to receive a copy of the project outcomes and the final report. **Yes**

Please fill in all white fields before you proceed...

Step 2 - Baseline Scores

Please ascertain a weighting score reflecting the biodiversity value of the following types of habitat assuming that such habitats are designated as SSSIs (even if not all of these habitats are designated as SSSI in Birmingham...)

Please note that not the absolute, but the relative score is important. It is important to state how much more 'habitat A' contributes compared to 'habitat B'.

Tip: Select the habitat type which you think provides the highest biodiversity values and ascertain the maximum score (10). Than ascertain weighting scores to other habitat types relative to that 'reference designation'.

Rivers	☐	per ha
Canals	☐	per ha
Lakes	☐	per ha
Ponds	☐	per ha
(Short) Amenity Grassland	☐	per ha
Grassland	☐	per ha
Heathland	☐	per ha
Fens	☐	per ha
Reedbeds	☐	per ha
Plantation on Ancient Woodland Sites (Broadleaved)	☐	per ha
(Other) Broadleaved Woodland	☐	per ha
Mixed Woodland	☐	per ha
Allotments	☐	per ha
Brownfields	☐	per ha
Private Gardens	☐	per ha
Agricultural Farmland	☐	per ha
Green Roofs	☐	per ha

Green Walls		per ha
Hedgerows		per ha

Please fill in all white fields before you proceed...

Step 3 - Adjusted Scores

In the last step you've ascertained weighting scores for different habitat types assuming they're designated as SSSIs. Now indicate how the relative contribution would change if the site designation changes. To do so please select by how much percent the contribution would decline/increase.

Note that the relative score for habitats designated as SSSI is set to 100% because you've ascertained baseline scores in step 2 based on the assumption that they are designated as SSSI. When you ascertain for example 50% for an altering designation that means that the biodiversity value of habitats with that designation are halved.

Sites of Special Scientific Interest (SSSI)	100%
Site of Importance for Nature Conservation (SINC)	
Site of Local Importance for Nature Conservation (SLINC)	
No formal designation	

If the size of an ecosystem is bigger it tends to provide a habitat for more diverse species and the biodiversity value per hectare can increase. In general the per-ha value increases overproportionally with increasing size of the habitat or if habitats are connected - for example by a wildlife corridor. Please ascertain a weighting score advance/penalty for the per-ha value for habitats that are part of a network (of different habitat types).

Please note that this is still a per hectare value and not an absolute value for the total size. Rivers and canals are not included (except they serve as wildlife corridor).

Tip: Ascertain '100%' to the size of network you had in mind when ascertaining weighting scores in the last step. Then ascertain the relative per-ha weighting score advance/penalty for altering network sizes.

Network area between 0 and 2 ha	
Network area between 2 and 10 ha	
Network area between 10 and 50 ha	
Network area between 50 and 200 ha	
Network area between 200 and 500 ha	
Network area 500+ ha	

Please fill in all white fields before you proceed...

Please note that the entries below would have been calculated automatically.

Step 4 - Review

Below you can find your per-ha weighting scores. These scores have been adjusted considering your adjustments for altering scenarios.

Do not modify these scores! You'll have that opportunity further below.

		Network area between 0 and 2 ha	Network area between 2 and 10 ha	Network area between 10 and 50 ha	Network area between 50 and 200 ha	Network area between 200 and 500 ha	Network area 500+ ha	General score
Rivers	SSSI							0
	SINC							0
	SLINC							0
	No designation							0
Canals	SSSI							0
	SINC							0
	SLINC							0
	No designation							0
Lakes	SSSI	0	#####	#####	#####	#####	#####	
	SINC	0	#####	#####	#####	#####	#####	
	SLINC	0	#####	#####	#####	#####	#####	

	No designation	0	#####	#####	#####	#####	#####
Ponds	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
(Short) Amenity Grassland	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Grassland	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Heathland	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Fens	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Reedbeds	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Plantation on Ancient Woodland Sites (Broadleaved)	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
(Other) Broadleaved Woodland	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Mixed Woodland	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####

	No designation	0	#####	#####	#####	#####	#####
Allotments	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Brownfields	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Private Gardens	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Agricultural Farmland	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Green Roofs	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Green Walls	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####
Hedgerows	SSSI	0	#####	#####	#####	#####	#####
	SINC	0	#####	#####	#####	#####	#####
	SLINC	0	#####	#####	#####	#####	#####
	No designation	0	#####	#####	#####	#####	#####

The highest allowed weighting score is 10. Because your weighting score advances might have resulted in higher scores for specific scenarios the table above has been recalculated to a 0-10 scale.

Now you have the chance to review your weighting scores and make final adjustments. You may want to save the file before you proceed. Changed scores will be shown in red.

		Network area between 0 and 2 ha	Network area between 2 and 10 ha	Network area between 10 and 50 ha	Network area between 50 and 200 ha	Network area between 200 and 500 ha	Network area 500+ ha	General score
Rivers	SSSI							#####
	SINC							#####
	SLINC							#####
	No designation							#####
Canals	SSSI							#####
	SINC							#####
	SLINC							#####
	No designation							#####
Lakes	SSSI	#####	#####	#####	#####	#####	#####	
	SINC	#####	#####	#####	#####	#####	#####	
	SLINC	#####	#####	#####	#####	#####	#####	
	No designation	#####	#####	#####	#####	#####	#####	
Ponds	SSSI	#####	#####	#####	#####	#####	#####	
	SINC	#####	#####	#####	#####	#####	#####	
	SLINC	#####	#####	#####	#####	#####	#####	
	No designation	#####	#####	#####	#####	#####	#####	
(Short) Amenity Grassland	SSSI	#####	#####	#####	#####	#####	#####	
	SINC	#####	#####	#####	#####	#####	#####	
	SLINC	#####	#####	#####	#####	#####	#####	
	No designation	#####	#####	#####	#####	#####	#####	
Grassland	SSSI	#####	#####	#####	#####	#####	#####	
	SINC	#####	#####	#####	#####	#####	#####	
	SLINC	#####	#####	#####	#####	#####	#####	
	No designation	#####	#####	#####	#####	#####	#####	
Heathland	SSSI	#####	#####	#####	#####	#####	#####	
	SINC	#####	#####	#####	#####	#####	#####	
	SLINC	#####	#####	#####	#####	#####	#####	
	No designation	#####	#####	#####	#####	#####	#####	
Fens	SSSI	#####	#####	#####	#####	#####	#####	
	SINC	#####	#####	#####	#####	#####	#####	
	SLINC	#####	#####	#####	#####	#####	#####	

	No designation	#####	#####	#####	#####	#####	#####
Reedbeds	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Plantation on Ancient Woodland Sites (Broadleaved)	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
(Other) Broadleaved Woodland	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Mixed Woodland	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Allotments	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Brownfields	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Private Gardens	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Agricultural Farmland	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Green Roofs	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####

	No designation	#####	#####	#####	#####	#####	#####
Green Walls	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####
Hedgerows	SSSI	#####	#####	#####	#####	#####	#####
	SINC	#####	#####	#####	#####	#####	#####
	SLINC	#####	#####	#####	#####	#####	#####
	No designation	#####	#####	#####	#####	#####	#####

Please indicate how confident you feel with the weighting scores you've ascertained.

Confidence:

Please fill in all white fields before you proceed...

Step 5 - Weighting of ES

As mentioned before this exercise is part of a broader weighting exercise. To compare different benefits provided by green and blue infrastructure in Birmingham a relative weighting of different ecosystem services is necessary. The ecosystem service-specific weighting scores will be re-scaled based on the aggregated weighting scores below.

Please ascertain a weighting score reflecting the relative importance of different ecosystem services in Birmingham if you haven't done that as part of another weighting exercise already. Please indicate also if your work/research is focussed on one or more of the ecosystem services below.

Please note that again not the absolute, but the relative score is important. It is important to state how much more 'ecosystem service A' contributes compared to 'ecosystem service B'.

Tip: Select the ecosystem service which you think provides the highest benefits to human wellbeing and ascertain the maximum score (10). Than ascertain weighting scores to other ecosystem services relative to that 'reference ecosystem service'.

Have you already undertaken this step as part of another weighting exercise?

Biodiversity	☐	Is this your main area of work/research?	☐
Recreation	☐	Is this your main area of work/research?	☐
Aesthetic values & sense of place	☐	Is this your main area of work/research?	☐
Education	☐	Is this your main area of work/research?	☐
Local climate regulation	☐	Is this your main area of work/research?	☐
Flood risk mitigation	☐	Is this your main area of work/research?	☐
Air quality regulation	☐	Is this your main area of work/research?	☐

Please fill in all white fields before you proceed...

Step 6 - Finish

As part of this project further ecosystem services are evaluated. Please use the other excel files attached in case you would like to participate in other weighting exercises for the following ecosystem services as well.

Recreation
Aesthetic values & sense of place
Education
Local climate regulation
Flood risk mitigation
Air quality regulation

Please note that you can only undertake up to 3 weighting exercises!

For the success of this project it is very important that as many experts as possible participate to this weighting exercise. Please forward the email you received to collegues and/or other experts that might be interested in undertaking a weighting exercise as well. Alternatively you can propose experts below.

Title:		
Name:		*
Position:		
Institution:		*
E-mail address:		*
Expertise in:		*

*) Necessary fields

Title:		
Name:		*
Position:		
Institution:		*
E-mail address:		*
Expertise in:		*

*) Necessary fields

Title:		
Name:		*
Position:		
Institution:		*
E-mail address:		*
Expertise in:		*

*) Necessary fields

Below you can give us feedback or make comments about the approach.

Thank you very much for finishing this exercise!
Please don't forget to save and rename the file to:
'CCPfB - Biodiversity - *your name*'

Please send the completed file to:
oliver.hoelzinger@birmingham.gov.uk

10.2 Weighting Scores

Below you can find the aggregated weighting scores ascertained by the weighting score exercise participants. Please note that some demands are directly based on indicators such as population density or the location within a flood zone. For more detail see Chapter 4-6.

Aesthetic Values & Sense of Place

SUPPLY

	100m+ away from home	50-100m away from home	0-50m away from home
Green Infrastructure with Green Flag Award	**6**	**9**	**10**
Green Infrastructure without Green Flag Award	**5**	**7**	**8**
Average score for rivers and canals where no water quality data is available	**4**	**6**	**7**
Rivers with good ecological status	**6**	**9**	**10**
Rivers with moderate ecological status	**5**	**7**	**8**
Rivers with poor ecological status	**3**	**4**	**4**
Rivers with bad ecological status	**1**	**2**	**2**

DEMAND

Relative weighting advance of the demand for green and blue infrastructure within 50m around sustainable travel routes	**1.69**

This means that the demand is 69% higher around sustainable travel routes than the general demand.

Biodiversity

SUPPLY

		Network area between 0 and 2 ha	Network area between 2 and 10 ha	Network area between 10 and 50 ha	Network area between 50 and 200 ha	Network area between 200 and 500 ha	Network area 500+ ha	General score
Rivers	SSSI							**8**
	SINC							**7**
	SLINC							**6**
	No							**4**

	designation							
Canals	SSSI							7
	SINC							6
	SLINC							5
	No designation							4
Lakes	SSSI	4	7	8	9	10	10	
	SINC	3	6	7	7	8	8	
	SLINC	3	4	5	6	7	7	
	No designation	2	3	4	4	5	5	
Ponds	SSSI	4	6	8	9	9	10	
	SINC	3	5	6	7	8	8	
	SLINC	3	4	5	6	6	7	
	No designation	2	3	3	4	5	5	
(Short) Amenity Grassland	SSSI	1	2	2	3	3	3	
	SINC	1	1	2	2	2	3	
	SLINC	1	1	2	2	2	2	
	No designation	1	1	1	1	2	2	
Grassland	SSSI	4	6	8	8	9	9	
	SINC	3	5	6	7	7	8	
	SLINC	3	5	5	6	6	7	
	No designation	2	3	3	4	4	5	
Heathland	SSSI	4	6	8	9	9	10	
	SINC	3	5	6	7	8	8	
	SLINC	3	4	5	6	6	7	
	No designation	2	3	4	4	5	5	
Fens	SSSI	4	6	8	9	9	10	
	SINC	3	5	6	7	8	8	
	SLINC	3	4	5	6	7	7	
	No designation	2	3	4	4	5	5	
Reedbeds	SSSI	3	6	7	8	9	9	
	SINC	3	4	6	6	7	8	
	SLINC	3	4	5	5	6	6	
	No designation	2	2	3	4	4	4	
Plantation on Ancient Woodland Sites (Broadleaved)	SSSI	4	6	7	9	9	10	
	SINC	4	5	6	7	8	8	
	SLINC	3	4	5	6	7	7	
	No designation	2	3	4	4	5	5	
(Other) Broadleaved Woodland	SSSI	4	6	7	9	10	10	
	SINC	3	5	6	7	8	8	
	SLINC	3	4	5	6	6	7	

	No designation	2	3	3	4	5	5
Mixed Woodland	SSSI	4	5	6	7	8	8
	SINC	3	4	5	6	7	7
	SLINC	2	4	4	5	5	6
	No designation	2	2	3	3	4	4
Allotments	SSSI	3	5	6	7	7	7
	SINC	3	4	5	5	6	6
	SLINC	3	4	4	4	5	5
	No designation	2	2	3	3	3	4
Brownfields	SSSI	4	6	7	8	8	9
	SINC	4	5	6	6	7	8
	SLINC	3	4	5	6	6	6
	No designation	2	3	4	4	4	4
Private Gardens	SSSI	3	4	6	6	7	7
	SINC	3	4	4	5	6	5
	SLINC	2	3	4	4	5	5
	No designation	1	2	3	3	3	3
Agricultural Farmland	SSSI	3	4	5	5	6	6
	SINC	2	3	4	4	5	5
	SLINC	2	3	3	4	4	4
	No designation	1	2	2	2	3	3
Green Roofs	SSSI	2	4	4	5	6	6
	SINC	2	3	4	4	5	5
	SLINC	2	3	3	3	4	4
	No designation	1	2	2	3	3	3
Green Walls	SSSI	2	3	4	4	5	5
	SINC	2	3	3	3	4	4
	SLINC	2	2	3	3	3	4
	No designation	1	2	2	2	2	3
Hedgerows	SSSI	4	6	7	8	9	9
	SINC	4	5	6	7	7	8
	SLINC	3	4	5	6	6	6
	No designation	2	2	3	4	4	5

Flood Risk

SUPPLY

	Flood zone 3 (100 yr)	Flood zone 2 (1000 yr)	>0.3m Flood Map for Surface Water (30 yr)	>0.1m Flood Map for Surface Water (30 yr)	>0.3m Flood Map for Surface Water (200 yr)	>0.1m Flood Map for Surface Water (200 yr)	Other location
Rivers	8	5	9	10	8	9	7
Canals	5	4	6	7	6	6	5
Lakes	7	5	8	9	8	8	6
Ponds	7	5	8	9	7	8	6
(Short) Amenity Grassland	4	3	5	5	4	4	3
(Longer) Grassland	4	3	5	5	4	5	3
Heathland	4	3	5	5	5	5	3
Fens	6	3	6	7	6	6	5
Reedbeds	5	3	6	7	5	6	4
Broadleaved Woodland	6	4	7	7	6	6	5
Mixed Woodland	5	4	6	7	5	6	4
Allotments	4	2	4	5	4	4	3
Brownfields	3	2	4	4	3	4	3
Private Gardens	4	3	5	5	4	4	3
Agricultural Farmland	4	3	5	5	4	5	3
Green Roofs	4	2	4	5	4	5	3
Green Walls	3	2	4	4	4	4	2
Hedgerows	3	2	4	5	4	4	3

DEMAND

Flood zone 3 (100 yr)	8
Flood zone 2 (1000 yr)	5
>0.3m Flood Map for Surface Water (30 yr)	9
>0.1m Flood Map for Surface Water (30 yr)	10
>0.3m Flood Map for Surface Water (200 yr)	8
>0.1m Flood Map for Surface Water (200 yr)	8
Other location	6

Local Climate

SUPPLY

Rivers	**7**
Canals	**7**
Lakes	**7**
Ponds	**6**
(Short) Amenity Grassland	**6**
Grassland	**6**
Heathland	**6**
Fens	**5**
Reedbeds	**5**
Broadleaved Woodland	**10**
Mixed Woodland	**10**
Allotments	**7**
Brownfields	**3**
Private Gardens	**7**
Agricultural Farmland	**5**
Green Roofs	**6**
Green Walls	**5**
Hedgerows	**6**

Recreation

SUPPLY

	With Green Flag Award	Without Green Flag Award
Sites containing 9+ different habitat types	**10**	**8**
Sites containing 7-8 different habitat types	**9**	**7**
Sites containing 5-6 different habitat types	**8**	**7**
Sites containing 3-4 different habitat types	**7**	**5**
Sites containing 1-2 different habitat types	**5**	**4**

Education

SUPPLY

	With Green Flag Award	Without Green Flag Award
Sites containing 9+ different habitat types	**10**	**7**
Sites containing 7-8 different habitat types	**9**	**7**
Sites containing 5-6 different habitat types	**8**	**6**
Sites containing 3-4 different habitat types	**6**	**5**
Sites containing 1-2 different habitat types	**4**	**4**

10.3 Participants

Steering Group Members:

Andy Slater	EcoRecord
Antony Ratcliffe	Natural England
Chris Parry	Birmingham & Black Country Wildlife Trust
Dave Huges	Environment Agency
Emma Woolf	Birmingham Open Spaces Forum
Graham Lennard	Birmingham City Council
Hayley Pankhurst	Natural England
James Kitchen	Environment Agency
Jane Field	Environment Agency
Jeff Edwards	Natural England
Kyle Stott	National Health Service
Martin Eade	Birmingham City Council
Michael Hardman	Birmingham City University
Michelle Howard	National Health Service
Nicola Farrin	Birmingham City Council
Oliver Hoelzinger	University of Birmingham
Rachel Curzon	Birmingham City University
Richard Rees	Birmingham City Council
Rod Chapman	Birmingham City Council
Sara Cavalho	EcoRecord
Sarah Hepburn	Business Council for Sustainable Development UK
Simon Atkinson	Birmingham and the Black Country Wildlife Trust
William Groves	Environment Agency

Expert Group Members:

Biodiversity

Andy Crawford	Environment Agency
Andy Slater	EcoRecord
Chris Greziok	Environment Agency
Chris Parry	Birmingham & Black Country Wildlife Trust
Dan Van der Horst	University of Birmingham
Ian Trueman	University of Wolverhampton
Jon Sadler	University of Birmingham
Nick Grayson	Birmingham City Council
Nicola Farrin	Birmingham City Council
Richard Coles	Birmingham City University
Sara Cavalho	EcoRecord
Simon Atkinson	Birmingham & Black Country Wildlife Trust
Theresa Haddon	West Midlands Foodlinks

Recreation/Aesthetic Values & Sense of Place/Education

Emma Woolf	Birmingham Open Spaces Forum
Chris Parry	Birmingham & Black Country Wildlife Trust
Dan Van der Horst	University of Birmingham
Graham Lennard	Birmingham City Council
Jenny Colfer	Health Protection Agency
Jon Sadler	University of Birmingham
Lorraine Cookson	Birmingham City Council
Michelle Howard	National Health Service
Miles Tight	University of Birmingham
Nick Grayson	Birmingham City Council
Peter Lee	University of Birmingham
Richard Coles	Birmingham City University
Theresa Haddon	West Midlands Food Links
Verity Watson	University of Aberdeen

Local Climate Regulation/Air Quality Regulation

Andy Baker	National Health Service
Charles Story	Environment Agency
Dave Huges	Environment Agency
Jenny Colfer	Health Protection Agency
Juana-Maria Delgado	University of Birmingham
Kyle Stott	National Health Service
Lee Chapman	University of Birmingham

Mamoona Tahir	Health Protection Agency
Mark Wolstencroft	Birmingham City Council
Nick Grayson	Birmingham City Council
Paul Fisher	Health Protection Agency
Richard Coles	Birmingham City University
Richard Rees	Birmingham City Council
Rob MacKenzie	University of Birmingham
Ruth Meek	Environment Agency
Shawn Woodcock	Health Protection Agency
Xiaoming Cai	University of Birmingham

Flood Risk Mitigation

Dave Huges	Environment Agency
Chris Farmer	Environment Agency
Christopher Grzesiok	Environment Agency
Clive Wright	Birmingham City Council
Cynthia Carliell-Marquet	University of Birmingham
David Thrussell	Environment Agency
Fiona Keates	Environment Agency
Jane Field	Environment Agency
John Bridgeman	University of Birmingham
Keith Boyle	Environment Agency
Kerry Whitehouse	Birmingham City Council
Matt Ashworth	Environment Agency
Nick Grayson	Birmingham City Council
Pete Clarke	Environment Agency
Richard Coles	Birmingham City University
Rob Ellis	Environment Agency
Sara Cavalho	EcoRecord
Xiaonan Tang	University of Birmingham

Weighting Exercise Participants:

Andy Slater	EcoRecord
Antony Ratcliffe	Natural England
Chloe Bellamy	Durham Wildlife Trust
Chris Parry	Birmingham & Black Country Wildlife Trust
Christopher Boyko	Lancaster University
Cooper	Imagination Lancaster, Lancaster University
Dave Hughes	Environment Agency
Derrick Taylor	Birmingham City Council
Emma Woolf	Birmingham Open Spaces Forum
Iain Diack	Natural England
Ian Trueman	University of Wolverhampton
James Hale	University of Birmingham
Jeff Edwards	Natural England
Jenny Colfer	Health Protection Agency
Lee Chapman	University of Birmingham
Michael Hardman	Birmingham City University
Nick Grayson	Birmingham City Council
Nicola Farrin	Birmingham City Council
Paul Fisher	Health Protection Agency
Richard Rees	Birmingham City Council
Rob MacKenzie	University of Birmingham
Sara Carvalho	EcoRecord
Shawn Woodcock	Birmingham City Council
Stewart Clarke	Natural England
Theresa Haddon	West Midlands Food Links Ltd
Xiao NAN	University of Birmingham

MAKING BIRMINGHAM GREEN

Birmingham City Council