Green Living Spaces Plan

Appendix 1

September 2013

Appendix 1 of Birmingham's Green Living Places Plan 2013

Ecosystem Services Evaluation for Birmingham's Green Infrastructure

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Ecosystem Services Evaluation for Birmingham's Green Infrastructure

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II. Contents

III. List of Tables, Figures, Maps & Boxes

TABLES

FIGURES

MAPS

BOXES

1. Executive Summary

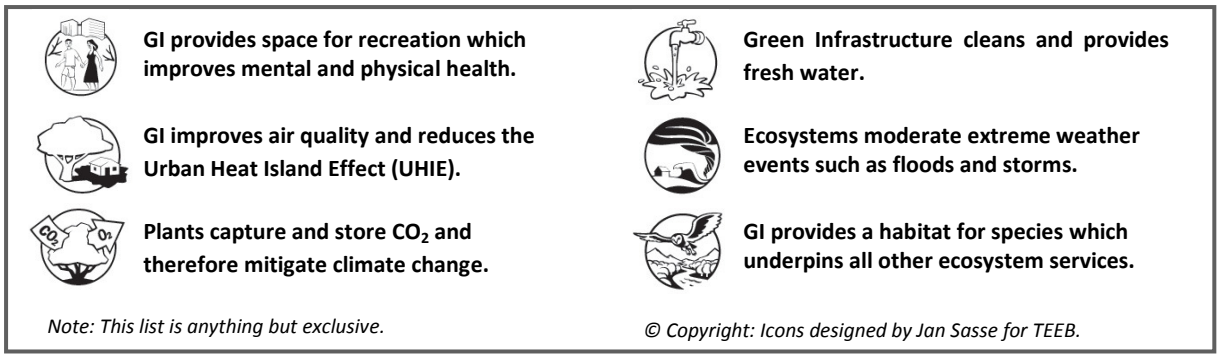
This report is appendix 1 of Birmingham's Green Living Places Plan. It is an assessment of the value of Birmingham's green infrastructure and focuses on the links between ecosystems and human wellbeing. As far as possible these benefits (ecosystem services) have been expressed in monetary terms. Examples for such ecosystem services are outlined in Figure 1.1 below.

It is very important to stress that in this context the monetary value reflects an advance to human wellbeing – it is not a price (tag) for the environment. The main aim of this investigation was to express the benefits people gain from ecosystems where no markets and prices exist. This report follows the recently published Natural Environment White Paper (NEWP) and the UK National Ecosystem Assessment (UK NEA) and is the first ecosystem assessment with this scope on a city scale in the UK and worldwide.[1]

> *"Taking the value of our natural services into account isn't an 'optional extra', it's part of good policy making."*[2]

Stating the best guess, ecosystem services provided by Birmingham's green infrastructure can be valued at £11.66m annually. Due to a lack of current proven scientific methods – certain significant types of city habitats such as amenity grassland and the streams and rivers have had to be omitted. Hence the values shown need to be understood as conservative estimates.

Figure 1.1 Examples for Ecosystem Services provided by Birmingham's Green Infrastructure



Source: ***Referring to TEEB 2010.***

[1] As far as the authors are aware.
[2] Defra 2010, 9.

Table 1.1 provides an overview of the ecosystem services that have been valued in monetary terms. It provides an annual value and a capitalised value for benefits provided within the next 50 years. However, as stated before services derived from unvalued habitats are still valuable but could not have a monetary value applied to them. A more detailed table including a sensitivity analysis can be found in Section 7.1. The values presented in this report are based on different methodologies including for example the avoided flood damage costs through water being held back by wetlands, peoples' willingness to pay to access greenspace for recreation or for protecting species and habitats.

Another aim of this investigation was to identify new research questions and feasible next steps that Birmingham City Council could undertake to develop and implement the ecosystem services approach as an aid to decision making. Key elements are the provision of a set of District Plans that would act as green infrastructure opportunity maps for each area of the city – which when pieced together would form a single multiple challenge map for the city. To undertake an "i-Tree Eco" assessment for Birmingham's urban forest. Significant improvements to the consistency and quality of ecological records including the central management of relevant datasets. Finally the development of a Natural Capital City Tool - a conceptual framework to incorporate ecosystem services in planning decisions – at the site scale. Birmingham wants to become a national pioneer for applying the ecosystem services approach as it sees this represents the most sustainable future for the city.

Table 1.1 Annual Value of Ecosystem Services provided by Birmingham's Green Infrastructure

Annual Values; 2011 Prices		Woodland	Heathland	Wetland	BAP Priority Grassland	Total
Provisioning Services	Water Supply			**£0.001m**		**£0.001m**
Cultural Services	Wild Species Diversity	**£0.25m**	**£0.19m**	**£0.10m**	**£0.03m**	**£0.56m**
	Recreation	**£1.42m**	**£0.65m**	**£0.10m**	**£0.10m**	**£10.05m**
	Aesthetic Values & Sense of Place	**£7.78m**				
	Cultural Heritage & Spiritual Values					
Regulating Services	Flood Regulation	**£0.76m**	**£0.10m**	**£0.10m**	**£0.01m**	**£0.98m**
	Storm Buffering					
	Water Quality Regulation			**£0.08m**		**£0.08m**
∑		**£10.20m**	**£0.94m**	**£0.38m**	**£0.14m**	**£11.66m**
Area of Habitat		**1,528 ha**	**310 ha**	**199 ha**	**70 ha**	**2,107 ha**
Average Value per Ha		**£6,678**	**£3,034**	**£1,904**	**£2,005**	**£5,536**

Notes: All values are 'best guess' estimates. Cells left blank can't be interpreted as 'no value', scientific evidence to date just doesn't allow to calculate a monetary value for these services. Not only because of that the real values may exceed the stated ones.

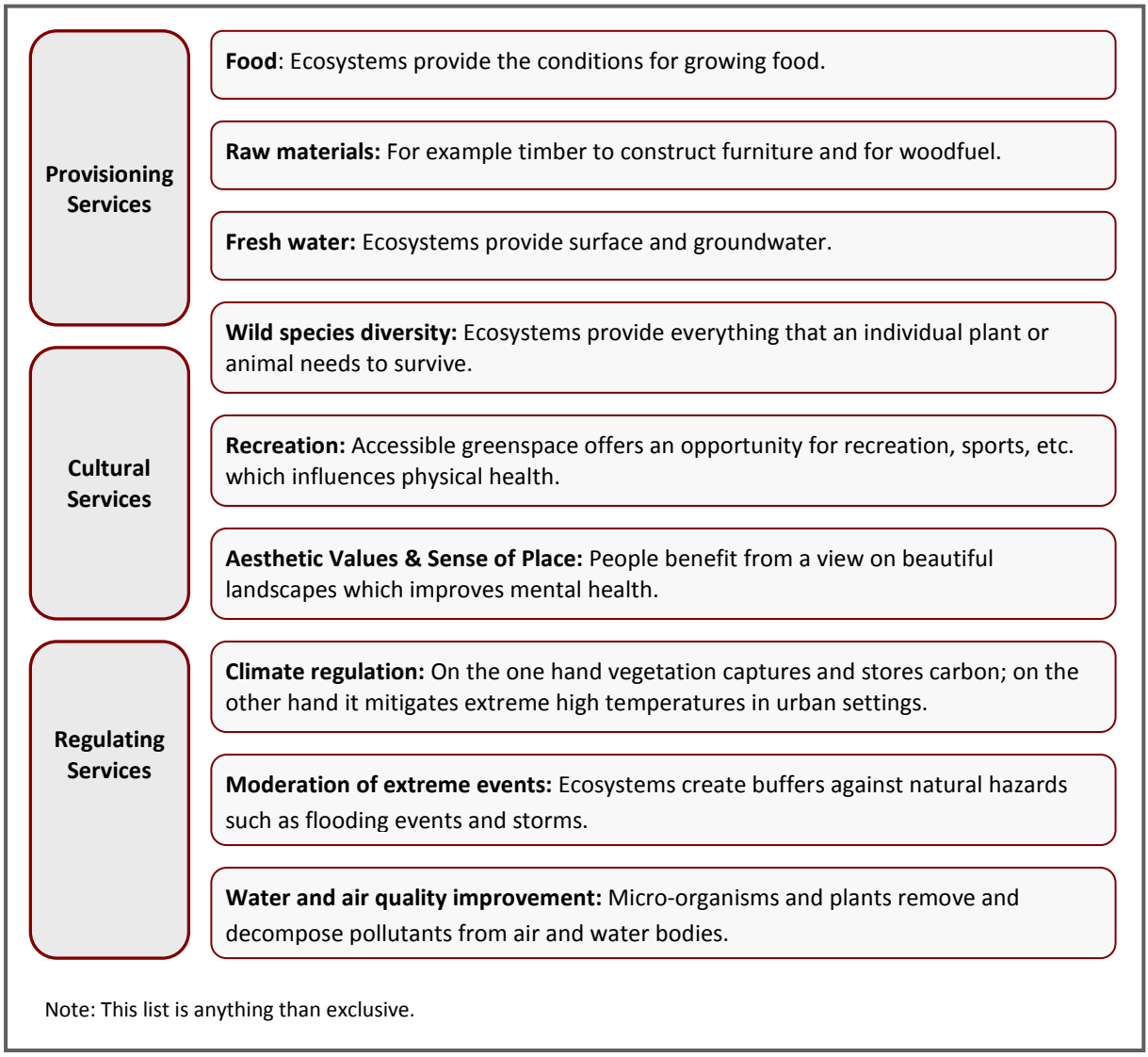
2. Introduction and Background

2.1 Objectives of this Survey

This report is appendix 1 of the Green Living Spaces Plan for Birmingham 2013 as such forms an evidence base to the emerging Supplementary Planning Document – 'Your Green and Healthy City' -2031. It is an assessment of the value of Birmingham's green infrastructure as defined in the Green Living Spaces Plan for Birmingham. The report focuses on how green infrastructure benefits human wellbeing. As far as possible these benefits have been expressed in monetary terms. In this context the monetary value reflects an advance to human wellbeing – it is not a price for the environment. Where the scientific evidence and data availability haven't allowed a monetary evaluation quantitative examples combined with a qualitative assessment has been provided.

This report follows the recently published Natural Environment White Paper (NEWP) and the UK National Ecosystem Assessment (UK NEA). The NEA was based on the founding principles established in the 2005 published Millennium Ecosystem Assessment (MA) which has been taken over and refined by The Economics of Ecosystems and Biodiversity (TEEB) in 2010. The framework and examples for ecosystem services are summarised in Figure 2.1 below. Additionally to this report a scientific paper will be published focussing on the research aspects and to promote the approach within the academic sphere.

Figure 2.1 **Examples for Ecosystem Services**



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

This study provides information about the magnitude of the economic value of the services provided by Birmingham's green infrastructure. The recent opinion expressed by the Department for Environment, Food and Rural Affairs (Defra) is that

> *"…the benefits the natural environment provides are not yet valued properly in policy and project appraisal across government."*[3]

This has been echoed in other publications such as The Economics of Ecosystems and Biodiversity (TEEB)[4], the Natural Environment White Paper[5] or the National Ecosystem

[3] Defra 2007, 2.
[4] TEEB 2010.

Assessment (UK NEA)[6] suggest that the ecosystem services approach will play a vital role in future environmental policy; in the UK and worldwide.

In the UK, natural habitats are under pressure. The current economic austerity coupled with the profound changes to public administration is unlikely to mitigate the pressure on the natural environment, especially within urban areas such as Birmingham where the stress on living landscapes is increasing. Development and climate change are the two main drivers. Many ecosystem services such as recreation, amenity or flood risk reduction are not marketable which leads to a general undervaluation of such services. Figure 2.1 provides a non-exclusive overview of important ecosystem services.[7] The aim of this research project is to make the value of such ecosystem services visible and tangible. This helps to promote better environmental decision making.

When developing and appraising spatial and city planning we have a comparatively good understanding about the benefits that 'grey infrastructure' provides to human wellbeing. Be it savings of x hours of travelling time each day in case of a motorway, the provision of properties for x people or an expected turnover of x for an industrial estate. All these benefits can be expressed quantitatively and in monetary terms because they are marketable.[8] Green infrastructure also provides a wide range of benefits to human wellbeing but beneficiaries don't have to reveal their real preferences for most of these goods and services through market prices. Environmental goods and services[9] are very often commonly used and non-exclusive. Usually nobody has to pay a fee to access a park or for experiencing the amenity of woodland. One can benefit from such services as a free-rider. This often results in the misjudgement that such ecosystem services are self-evident and without value. The high complexity of ecosystem interactions makes the value even more intangible and reinforces undervaluation.

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[5] HM Government 2011.
[6] UK NEA 2011b.
[7] The term 'ecosystem service' it not used entirely consistent within literature. We use the term consistent to the 'final ecosystem service' in the framework of the UK National Ecosystem Assessment (Ibid. Within this publication the term 'ecosystem service' has been used because of simplification and because it is more commonly used.
[8] It should be stressed, however, that such operating figures are usually based on more or less robust assumptions as well and therefore not certain. Presenting monetary figures often suggests a higher degree of certainty which is a misjudgement. Therefore it is important to review corresponding assumptions as well to make a deliberate judgement. This applies for marketable goods and services as does it for non-marketable ecosystem services.
[9] When referring to '(ecosystem) services' we include 'goods' as well within this publication.

> *"Because ecosystem services are largely outside the market and uncertain, they are too often ignored or undervalued…"*[10]

This undervaluation results in a general undersupply with ecosystems and ecosystem services and in the end to a decline of overall human wellbeing. This market failure should be compensated for by governmental institutions and regulations.[11] However, decisions - not only affecting the environment – have to cope with trade-offs and are very often based on cost-benefit deliberations. But in a case where the benefits of one (grey) policy option is comparatively clear and tangible and of the other (green) policy option is fairly uncertain and intangible - a justification of the first option is much easier and more defendable. The economic valuation of ecosystem services serves to mitigate this information bias and makes the services provided by the green infrastructure and ecosystems in general, more tangible.

As a supporting document of the Green Living Spaces Plan for Birmingham 2013 and the sustainable development policy 'Your Green and Healthy City' - Supplementary Planning Document (SPD) this report will provide decision makers, planners, but also other stakeholders with the most accurate ecosystem services evaluation for greenspace on a city-scale anywhere in the UK and maybe Europe and the World.[12] This evidence base helps to get a better understanding of the trade-offs inherent in decisions affecting greenspace and supports Birmingham's way into a sustainable future.

> *"The full value of goods such as health, educational success, family and community stability, and environmental assets cannot simply be inferred from market prices, but we should not neglect such important social impacts in policy making."*[13]

This report mainly serves as a resource to inform relevant people and organisations about the value that green infrastructure provides. Because many ecosystem services remain unvalued or undervalued in this report -this must be seen as just the starting point for the development of future policy-tools and planning decision-aids. Because there are still

[10] Costanza et al. 1997, 269.
[11] Ignoring that optimising human welfare is not always the main incentive for decision makers and bureaucrats (Hölzinger 2010.)
[12] As far as the authors are aware.
[13] HM Treasury 2003, 57.

significant gaps in the scientific evidence regarding the evaluation of ecosystem services and the available habitat data this study also reveals gaps and suggests research questions to overcome these shortcomings.

Throughout the report, recommendations for future actions are highlighted within text boxes. Further generic recommendations affecting the whole green infrastructure of Birmingham are contained in section 7.2. Also within section 7.2 there are a series of next steps and follow-up projects including how the planning system can be optimised to better consider the real value of green infrastructure and how the optimal amount of greenspace in Birmingham can be provided in the most efficient way.

2.2 The Methodological Approach and its Limitations

The scope of this research project is comparatively wide. Its aim was to calculate the Total Economic Value (TEV) of as many ecosystem services provided by as many broad habitats as possible within the City of Birmingham. In this context 'economic' does not equal 'financial'; rather it signals how the impacts on human wellbeing are measured and expressed in monetary terms – it is not a price-tag for the environment. The monetary value should be interpreted as a common denominator when comparing different policy-options influencing human welfare.

> *"In considering the task of valuing ecosystem services an important distinction needs to be drawn between the terms 'value' and 'price'. That they are not, in fact, equivalent is easy to demonstrate. Consider a walk in a local park. The market price of such recreation is likely to be zero as there are no entrance fees and anyone can simply walk in. However, the very fact that people do indeed spend their valuable time in parks shows that this is not a zero value good."*[14]

The available scientific evidence does not allow for the full calculation of monetary values for the total range of services – so the monetary assessment has been accompanied by a qualitative evaluation. Therefore monetary values shall generally be treated as the lower limit of the real value.[15] The time available to undertake this research has been very limited. With such limited time- and financial resources for this present study - no original primary valuation studies have been undertaken. Other findings were transferred applying the benefit transfer approach.[16] This approach allows us to transfer values from other valuation studies to our specific context of Birmingham's green infrastructure. Where possible adjustments regarding site-specific circumstances and socio-economic variables have been made to reduce the transfer-error. The application of this approach can be seen as a practicable and cost-effective way to implement the ecosystem services approach in decision making.[17]

[14] UK NEA 2011b, 1072.
[15] This effect is not implemented in the sensitivity analysis. Therefore the real value of ecosystem services may even exceed the upper boundary of the sensitivity analysis.
[16] Sometimes also referred as 'value transfer approach'.
[17] Defra 2007, 38.

Where possible the marginal value for a change of ecosystem services provision has been calculated and then applied for the whole area of green infrastructure in Birmingham. Even if the validity regarding decision making is limited it was the view of the authors that this is the best approach to match available scientific evidence and time limitations. The approach applied intentionally leads to an under- rather than over-estimation of ecosystem services values, which matches the principles of this research project. [18] The underlying assumption is that a marginal increase of green infrastructure would occur at a suitable place and a loss of green infrastructure would occur where it is likely to have the least negative impact. This means for example that a park would be established in an area where the provision of greenspace is deficient rather than where there is already an existing park.

The relevance of for example substitutional greenspace or the influence of the distance decay on the value of green infrastructure is still widely uncertain and strongly dependent on the ecosystem service being assessed. For climate change mitigation for example the marginal and total value of greenspace provision in Birmingham are almost equal.[19] On the other hand a 20 percent decline of accessible greenspace compared to a 10 percent decline would result in a disproportional decline of human well-being.[20] The two services have a different shape on the marginal value curve which relates to the extent of benefit provision – to local people. Climate change affects the global climate whilst recreational services usually occur locally which makes the influence of substitutional greenspace much stronger. Developing and implementing policy-tools incorporating the marginal value of ecosystem services provision on a spatial scale should be seen as the logical next step to implement the ecosystem services approach in decision-making.

In this report only valuation methods which comply with high scientific standards as well as the available evidence to date are applied. Nevertheless, the model implies some limitations. Related Willingness-To-Pay (WTP) techniques for example have their own imperfections such as the social desirability bias[21] or a potential inability of survey participants to perceive hypothetical markets and goods. However, questioning techniques are sufficiently advanced to gather resilient outcomes. Another limitation may occur from applying the value transfer

[18] UK NEA 2011b, 1076.
[19] Assuming that type, quality and extent of greenspace are equal.
[20] The first 10 percent decline reduces human wellbeing less than the second 10 percent (from -10% to -20%).
[21] The interviewees may like to make out that they value an ecosystem service more than they actually do

approach. Usually, the study area (the primary valuation studies) and the policy area (in this case the green infrastructure of Birmingham) are not entirely similar. Therefore, some socio-economic influencing variables such as income or population density as well as the context (availability of substitutes) need to be adjusted. Even if these adjustments are applied as thoroughly as possible, a benefit transfer error can never be ruled out. Some adjustments such as those for cultural differences are not practically possible. Further limitations are linked to general scientific uncertainties such as the future impacts of climate change. Further method-specific caveats are explained in the regarding chapters.

To take these uncertainties and limitations into account within this investigation, a sensitivity analysis has been applied. Using sensitivity analysis every value is stated as a 'best guess'[22] with a range, following best practice recommendations.[23] It should also be noted that the values produced in this study are gross rather than net values. Neither alternative land-use options nor the costs of land management etc. have been considered.

A mistake often made when valuing ecosystem services is double counting. The risk is even higher when valuing such a wide range of services as well as different habitats as in the present survey covering the complete city of Birmingham. The ecosystem interactions as well as the relations between different services are characterised by high complexity. Therefore, considerable attention has been paid to this issue. In case of doubt - calculations are conservative to maintain validity. This principle has been applied to the valuation of all services.

Ecosystem services do not present the value of ecosystems for their own sake. Rather they reflect the benefits (and in some cases threats) to human wellbeing and therefore follows an anthropocentric approach. This is the only practicable approach because *"non-anthropocentric value is, by definition, beyond any human knowledge."*[24] But it should be kept in mind that the anthropocentric approach can involve for example existence values (non-use values)[25], option-use values[26] or bequest values[27] as a matter of course. However,

[22] If not stated otherwise values are always stated as 'best guess' per year within the study to hand.
[23] EFTEC 2010a, 35.
[24] Defra 2007, 12.
[25] You might never be able to see a whale in nature, but you can nevertheless benefit from the pure existence of whales.
[26] You might never see a whale in nature, but you can benefit from the ability to see whales in the future.

incorporating such values in an ecosystem assessment has been previously determined as ambivalent.[28] This will be considered within referring sections.

The values of ecosystem services are not only stated as annual values; they are also stated as capitalised value over 50 years. To calculate the 'net present value' of future benefit it is usual and reasonable to apply a discount rate. This discount rate is used to convert the benefits to present values and make them comparable. The UK Government recommends a discount rate of 3.5 percent for periods of up to 30 years. After 30 years this rate declines to 3.0 percent.[29] This discount rate has been applied within this investigation even if the authors view is that this rate is too high and its justification is outdated and not consistent with sustainable development.[30] The discount rate has been applied to ensure consistency and comparability with other publications. However, to provide a more realistic value a lower discount rate of 1.5 percent has been applied to all the 'best guess' values as well.[31] For the upper threshold a discount rate of 0 percent has been applied. For the lower threshold of the sensitivity analysis the discount rate recommended by HM Treasury has been applied.

It should be kept in mind that for capitalised values a *ceteris paribus* future has been implied. This assumption states that all variables are set constant over time. If variables change the capitalised value may change as well. Neither the assumed population growth in Birmingham nor the additional pressure caused by climate change has been considered in the capitalised value. Both can be expected to increase the values of ecosystem services over time. In a *ceteris paribus* scenario such influences are not considered.

[27] You might never see a whale in nature, but you can benefit from the ability of future generations to see whales in the future.
[28] UK NEA 2011b, 1185.
[29] HM Treasury 2003, 97.
[30] For a more extensive discussion of the discount rate recommended by HM Treasury; other discount rates and criticisms of the HM Treasury discount rate see for example Hölzinger 2011, 19; Stern 2006, 48; Perino et al. 2011, 22.
[31] Adopting recommendations of the German Federal Environment Agency 2008.

2.3 The Regional Context: Birmingham

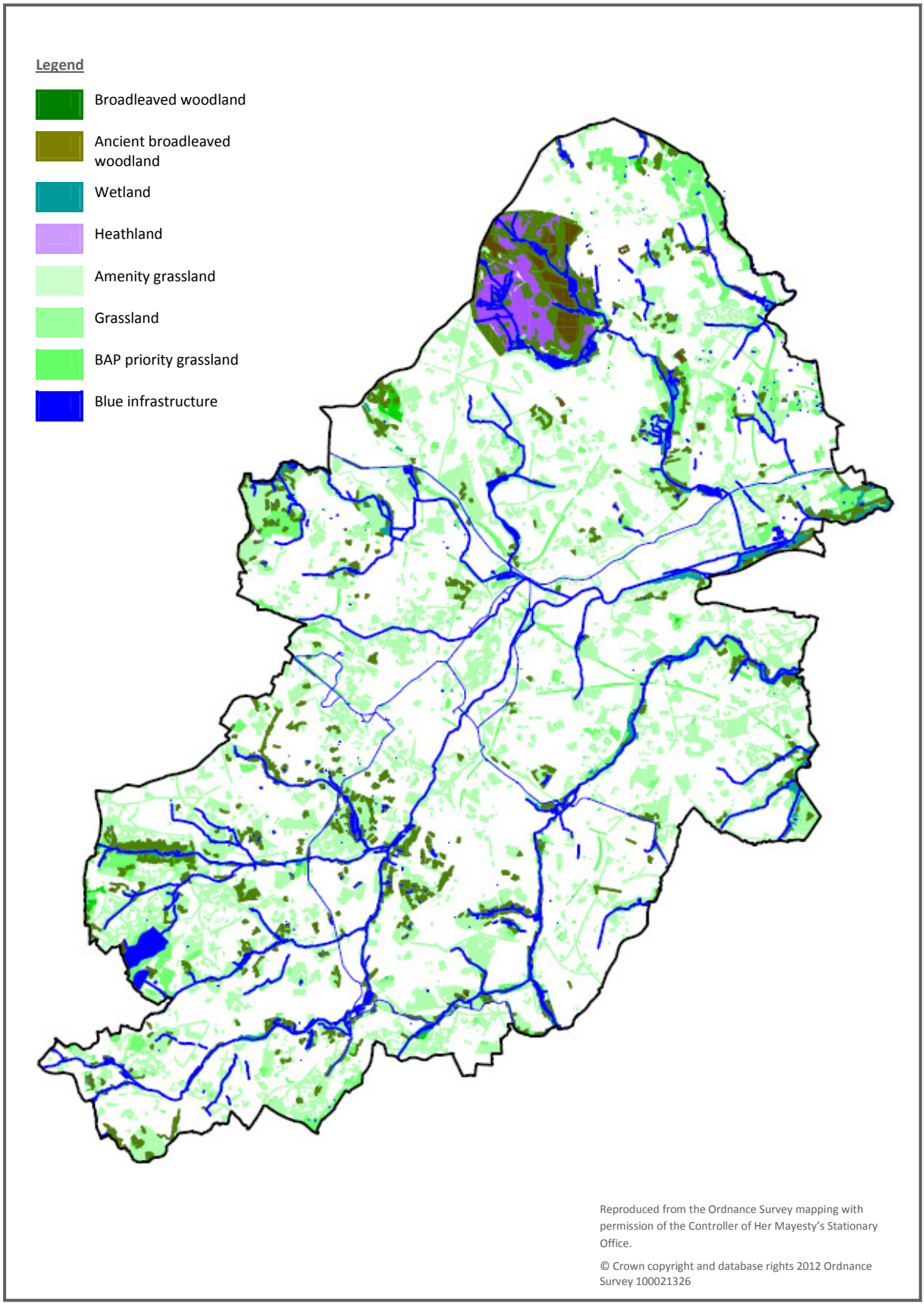
Outside London, within the UK, Birmingham is the city with the highest population. It is located in the centre of England. Birmingham covers an area of 26,779 hectares and has a population of more than 1 million. The area is highly urbanised with a population density of 3,739 people per km^2. [32]

In the past, Birmingham was characterised by an early and strong industrialisation with rapid growth rates. Even if the economy today is dominated by the service sector, the traces of the industrial revolution characterise broad areas of the city. One example would be the extent of the canal network and another is the quantity of factory buildings. Birmingham's green infrastructure is virtually unplanned due mainly to the pattern of historical land acquisition for open space purposes and philanthropic donations and gifts. Overall, Birmingham is characterised by a high degree of surface sealing and comparatively slight and fragmented areas of green space, except for Sutton Park in the north of Birmingham. Over the past years and decades, there has been a continuous loss of green infrastructure to development and increased urbanisation. Facing further growth of population (estimates suggest an increase of about 13 percent in Birmingham until 2030)[33] the pressure on green infrastructure is likely to increase.

The area of green infrastructure in Birmingham adds up to about 6,200 ha which equates to 23 percent of the total city area.[34] This doesn't include the 'blue infrastructure' including rivers, canals, lakes, ponds, and other water bodies. Additionally not all parts and types of green infrastructure are recorded in Birmingham. Map 2.1 provides an overview. This investigation only incorporates the green infrastructure within the city boundaries of Birmingham. Birmingham City Council also manages some parks outside the city boundary such as Lickey Hills Country Park in Bromsgrove. However, such parks are not part of this investigation.

[32] 2009 Resident Population Estimates by the Office of National Statistics
[33] 2006-based Subnational population projections by the Office of National Statistics
[34] This figure is based on incomplete and records and the total amount might exceed the mapped amount of greenspace.

Map 2.1 **Birmingham's Green and Blue Infrastructure**

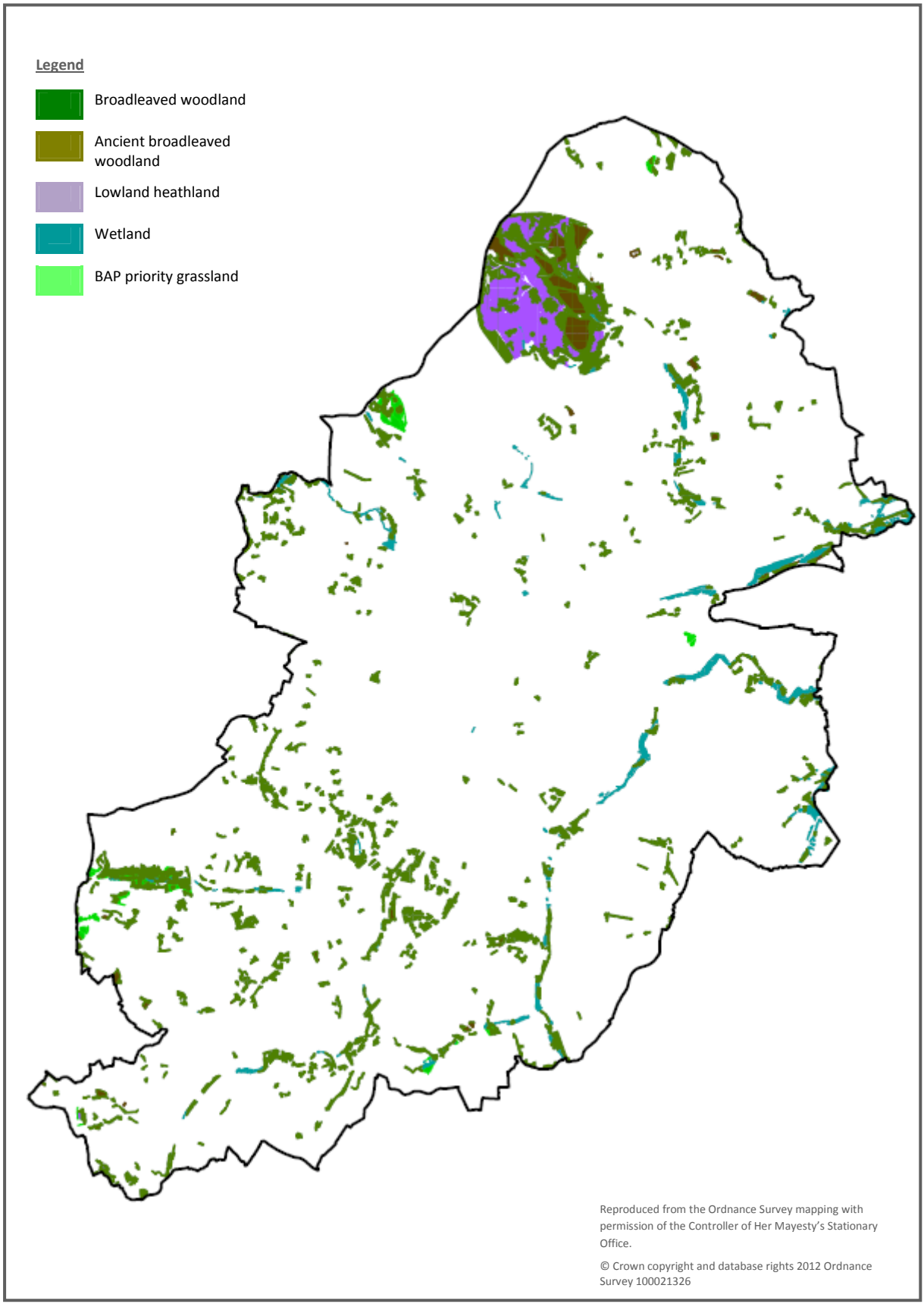


Source: ***GIS data provided by EcoRecord, Birmingham City Council and Forestry Commission.***

A major amount of 4,150 ha of greenspace can be classified as (amenity) grassland. Unfortunately the available scientific evidence to date doesn't allow us to estimate a robust value for ecosystem services provided by this habitat class. Within this investigation only 70 ha of BAP[35] priority grassland could have been evaluated. The habitat area that has actually been evaluated within this research project can be seen in Map 2.2.

[35] Biodiversity Action Plan

Map 2.2 **Habitats Evaluated within this Investigation**



Source: ***GIS data provided by EcoRecord, Birmingham City Council and Forestry Commission.***

By comparing these two maps one can see that only a fraction of the total green infrastructure in Birmingham could have been evaluated. This investigation only incorporates 2,100 ha of 'high quality' habitats of which broadleaved woodland represents the majority. 'High quality' in this context refers to biodiversity rather than other services. It is still possible that the average per hectare value of ecosystem services provided by (amenity) grassland exceeds the value of other habitat types – especially considering services such as recreation. The only reason why the ecosystem services of (amenity) grassland haven't been evaluated within this report is that the available scientific evidence to date doesn't allow for the evaluation of the ecosystem services provided by this habitat type in quantitative and monetary terms. It has to be stressed again, however, that this can't be interpreted as if there is no or low value of such (amenity) grassland. The problem is that to date we don't have the right measures and tools to evaluate such values and express them quantitatively.

Another limitation of this research is that sufficient robust data is not available for all types of habitat. We know, for example that arable margins, hedgerows and other important habitat types exist in Birmingham and that they have a considerable value in terms of ecosystem services. Here the limitation is that such habitats haven't been mapped accurately enough in Birmingham rather than the lack of scientific evidence to evaluate the ecosystem services provided by such habitats. An overview of greenspace evaluated in this report divided by habitat class can be reviewed in Table 2.1.

Box 2.1 Green Infrastructure Recording and (Amenity) Grassland Research

To improve the ecosystem services assessment of Birmingham's green infrastructure the habitat records have to be improved and all datasets should to be collected and managed by a central organisation such as EcoRecord. In terms of capturing, storing, evaluating and analysing data for Birmingham's GI, EcoRecord is the most important resource. However, for it to do this there is a requirement for continued survey and evaluation and access to new data sets to update and inform the process. Additional resources would be necessary to enable EcoRecord to satisfy these demands. This includes for example the interpretation of habitats or the assessment of BAP priority habitats such as hedgerows and arable margins for which no robust records exist. Additionally a similar ecosystem assessment for Birmingham's blue infrastructure is recommended as it is crucial for Birmingham's ecological network and ecosystem functioning. Primary research is recommended to overcome broad research gaps related to ecosystem services provided by (amenity) grassland which represents the vast majority of greenspace in Birmingham and other urban areas.

Table 2.1 Area of Habitats Evaluated

Broad habitat type *Subset*	**Area**	**Area in % of total green infrastructure** *(excl. blue infrastructure)*
Broadleaved woodland	1,528.2 ha	24.7 %
Ancient woodland	*187.2 ha*	*3.0 %*
Wetland	199.2 ha	3.2 %
Floodplain grazing marsh	*190.3 ha*	*3.1 %*
Fens	*7.6 ha*	*0.1 %*
Reedbeds	*1.3 ha*	*0.0 %*
Lowland Heathland	310.3ha	5.0 %
BAP priority grassland	69.6 ha	1.1 %
*Lowland meadows**	*63.2 ha*	*1.0 %*
Lowland dry acid grassland	*5.9 ha*	*0.1 %*
Purple moor-grass and rush pasture	*0.4 ha*	*0.0 %*
*) Excluding lowland meadows that is also classified as floodplain grazing marsh to avoid doublecounting.		

Source: ***EcoRecord, Birmingham City Council and Forestry Commission.***

To use the most accurate baseline habitat information GIS data provided by EcoRecord (the biological record centre for Birmingham and the Black Country) has been combined with latest GIS layers of the National Forest Inventory provided by the Forestry Commission and datasets held by Birmingham City Council. Following our 'conservative estimate' principle areas 'likely to be forests' have been excluded. In cases where habitat types fall into two classes the class with the better valuation data has been chosen to avoid overlaps. This schedule is not definitive. However, it is likely to be the best estimation to date. Not included in this table are other important BAP priority habitats such as hedgerows or arable margins. At the time of this investigation reliable datasets for these habitats were not available. This, together with the exclusion of grassland and the blue infrastructure are other reasons why the valued ecosystem services represents a lower limit for the total benefits provided by Birmingham's green infrastructure.

3. Provisioning Services

3.1 Water Supply

The ecosystem service 'water supply' refers to the provision of fresh water and groundwater for private consumption, agriculture, aquaculture, industry or energy rather than flood- or water quality regulation which are evaluated in separate sections of this publication. Apart from the fact that fresh water has an *in situ* value; it also supports many other services such as biodiversity.[36] So although water bodies such as rivers or canals haven't been covered within this investigation, in terms of their inherent value, they are very significant for additional benefits that can be attributed to them.

Green infrastructure such as wetland only plays a minor role by capturing water when the water level is higher and partially releasing it when the water level is lower. This helps to reduce variations in water flows and levels.[37] Water for supply is managed through Water Company water resource plans. Water for Birmingham largely comes from Wales and there is a major grid which allows water to be moved around the country. Furthermore in most parts of the UK the availability of freshwater is not a current problem. Baring this in mind it is not surprising that £817 is the annual value for water supply provided by Birmingham's wetlands, which is minor when compared to other services. This value is likely to increase in the future because water availability for immediate abstraction may be reduced by 10 percent by 2060. This may affect the sufficient provision of water to constant costs.[38]

3.2 Wild Species Diversity

The term 'biodiversity' generally describes diversity of life on earth. Therefore biodiversity underpins all other ecosystem services as most of them (at least partially) depend on living organisms.[39] This category used here relates especially to a high diversity of species and their related additional benefits. As suggested by the overview of ecosystem services 'wild species diversity' in this specific context can be partially considered as a provisioning service- and partially as a cultural service.

[36] UK NEA 2011b, 1088.
[37] Ibid., 1089.
[38] Ibid.
[39] Norris et al. 2011, 64.

"…this evidence shows that, in general terms, the level and stability of ecosystem services tend to improve with increasing biodiversity."[40]

The quantification of biodiversity services is often inadequate due to limited data and scientific evidence.[41] Furthermore some valuation approaches are considered controversial.[42] One example is pollination. On the one hand we have evidence that pollinators are declining. On the other hand we don't know how this loss influences pollination services; especially in agriculture.[43]

Nevertheless some authors calculate values for 'wild species diversity' and often refer to 'biodiversity' or 'habitat for species'. When they do so, they often refer to the occurrence of charismatic species. This usually reflects a non-use value of preferences for the pure existence of a species without using (watching/experiencing) it. This approach requires true altruism and its quantification is therefore considered controversial. Additionally it often overlaps with use-values occur.[44] Human preferences for the pure existence and survival of species can also be explained by option values[45] or bequest values[46]. Some authors calculate values explicitly for 'biodiversity' or 'wild species diversity'. Therefore we adopt this category but findings should be interpreted with care. The values refer (partially) to other (bundles of) services such as aesthetic appreciation. Within this exercise we tried to rule out overlaps as far as possible but it won't be feasible to add other benefits in the future without reflecting potential overlaps with the values below again.

Hanley et al. (2002) values the non-use benefits of UK woodland as habitat for species. He revealed human preferences for the existence of woodland as habitat for species and biodiversity in general.[47] This study is considered to be appropriate for a benefit transfer even though the sample size was comparatively small and not representative for the whole population in the United Kingdom.[48] They valued the WTP for woodland habitats with

[40] Ibid.
[41] Ibid., 65.
[42] UK NEA 2011b, 1186.
[43] Norris et al. 2011, 68.
[44] UK NEA 2011b, 1186.
[45] You might never see a whale in nature, but you can benefit from the ability to see whales in the future.
[46] You might never see a whale in nature, but you can benefit from the ability of coming generations to see whales in the future.
[47] See section 1.4 for more details.
[48] Willis et al. 2003, 15.

different attributes, expressed by focus groups. This study was also applied to value the social and environmental benefits provided by woodland in Great Britain as a whole.[49]

To transfer the available statistics to the categories defined by Hanley et al. (2002), some assumptions are necessary. Ancient woodland in Birmingham fits well in the category of ancient semi-natural woodland (ASNW). The reason is that planted ancient woodland sites (PAWS) in Birmingham are replanted with native broadleaves to the greatest extent. Therefore the characteristics are comparable.

The mean WTP to protect and regenerate an area of 12,000 ha of lowland ancient semi-natural broadleaved woodland was £1.13 per household (in 2002 prices).[50] With inflation adjusted to 2011 price levels this results in £1.42 per household. Because this is a non-use value, the benefits are basically not restricted to local residents.

> *"There is no reason within standard economic theory why non-use values would also decrease with distance."*[51]

However, as mentioned before, non-use values are controversial and may contain use values as well which are distance related. As a compromise we assumed that only residents in the West Midlands benefit from woodland in Birmingham as 'habitat for species'. Multiplying the WTP by the number of households in the West Midlands (1.7m) and breaking the result down to the regional area of PAWS, an annual value of £39,000 for 187 ha has been calculated. However, for the upper limit of the sensitivity analysis all UK households have been taken into account.

The valuation of the 'usual' broadleaved woodland areas is more difficult because the focus group participants were asked explicitly for their WTP for an increase of woodland. However, the assumption is permissible that keeping established woodland is worth the equivalent of, or more than planting new woodland. If the amount of woodland and therefore the habitat for species declines, the marginal value increases. Furthermore, the species diversity in established woodlands is generally higher than in new planted woodlands. Following these arguments the valuation of broadleaved woodland in Birmingham, applying the values for an

[49] Willis et al. 2003.
[50] Hanley et al. 2002, 18.
[51] Brander et al. 2008, 18.

expansion of woodland, seems to be justifiable. The WTP for 12,000 ha broadleaved woodland is £1.05 (2002 prices). Adopting the calculation for PAWS above, the annual value of broadleaved woodland in Birmingham adds up to £207,000, representing the best guess. This results in a total annual value of woodland in Birmingham as habitat for species (wild species diversity) of £246,000.

Because these are passive- or non-use values, people often have problems in expressing their own preferences. On the one hand the topic is very abstract and hard to grasp. On the other, the WTP for this form of ecosystem service is a very small fraction of income which leads to a comparatively wide variation of expressed values. Furthermore, the form of moderation of focus groups and the information provided about the habitats can have a strong influence on the expressed WTP. Additionally, the comparatively small sample size and other caveats discussed above makes the application of a wide range of 80% reasonable for the sensitivity analysis. This results in a range from £49,000 up to £5.1m, annually.

The high importance of wetland as habitat for wild species can be expressed through the fact that all three habitat types captured within this investigation are categorized as BAP habitats of principal importance.[52]

> *"The degradation and loss of wetlands is more rapid than that for other ecosystems. Similarly, the status of both freshwater and, to a lesser extent, coastal species is deteriorating faster than that of species in other ecosystems."*[53]

One example is the especially high diversity in plant and invertebrate species within floodplain grazing marsh.[54] Following the calculations in Section 9.1 wetland in Birmingham as habitat for wild species can be valued at £95,000 annually. Within the scope of this study non-use values couldn't have been valued. Therefore the values calculated for wild species diversity can be interpreted as conservative estimate. Furthermore overlaps with aesthetic appreciation or recreation can't be completely ruled out.

[52] See section 4.1
[53] McInnes 2007, 8.
[54] B&BC LBAP Review Group 2010, 12.

For heathland and BAP priority grasslands the data values provided by Christie et al. (2011) have been applied. For calculations see Appendix 9.2. In absence of alternatives the assumption has been made that this ecosystem service directly relates to the area of habitat. Table 2.2 summarises the calculation.[55]

Table 2.2 **'Wild species diversity' benefits provided by heathland and BAP priority grassland**

	Heathland	BAP Priority Grassland
Area of Habitat	310 ha	70 ha
Annual WTP per ha for 'charismatic species' (2011 prices)	£486.59	£320.07-£356.47
Annual WTP per ha for 'non-charismatic species' (2011 prices)	£126.09	£30.11-£109.83
Annual value	**£190,000**	**£30,000**

Source: ***Christie et al. 2011 & own calculations***

Box 2.2 **Primary Research Regarding Wild Species Diversity**

To improve ecosystem services assessments in the future additional primary research is necessary. This should focus on the risk assessment of loosing native species diversity and the influence of invasive species. One question to answer is to what extent the ecosystem can cope with the decline of wild species diversity and which species are 'system-relevant'.

[55] Because of data availability issues the value for 'charismatic species' of dry acid grassland couldn't have been calculated. However, the effect on the sum is minor.

4. Cultural Services

4.1 Recreation

Recreation is part of general leisure and not always easily definable from education or aesthetic appreciation. It usually refers to doing things and interacting with others.[56] Ecosystems provide the settings for a wide range of human activities including walking, running, cycling but also climbing or horse riding. It also provides space for example for picnicking or observing nature. Because of the physical activity there are also overlaps with health benefits.

Recreational services have a high value, especially in the urban environment as many people can benefit from it and substitutional greenspaces are rare. Recreation as an ecosystem service raises individual wellbeing and is therefore a value in itself. Additionally, an increase of accessible green infrastructure close to homes is increasingly being shown to improve people's health by providing space for physical activity.[57] There are strong links between recreation and health benefits (see Section 4.5). However, referring to the Woodland Trust, in Birmingham only 9 percent of the population has access to a woodland site of at least 2ha within 500m from home.[58]

To value the recreational benefits from woodland in Birmingham, a benefit transfer of the findings of Scarpa, R. (2003) has been applied. This data is based on a primary contingent valuation study undertaken in 2002.[59] This data and the sample size have been extended by incorporating datasets of a broader contingent valuation study carried out in 1992. Visitors of woodland sites were asked how much they were willing to pay, if there were to be a charge for access.[60] The results show that the willingness to pay (WTP) for a visit differs by travelled distance to the site. The inflation adjusted WTP (price level 2010) to local woodland sites (within 5 miles from home) is £1.13 per visit.[61]

[56] Church et al. 2011, 657.
[57] Coombes, Jones, and Hillsdon 2010.
[58] Woodland Trust Appendix I.
[59] Scarpa 2003, 16.
[60] An open-ended questionnaire has been used and protest bids have been excluded.
[61] Scarpa 2003, 16.

To estimate the number of visits to woodland sites in Birmingham the 'Monitor of Engagement with the Natural Environment' (MENE) data has been used.[62] For the purposes of this report statistics have been available for the survey periods 2009/10 and 2010/11. The average number of annual visits to woodland undertaken by Birmingham residents has been estimated to be 1.26 million. Another assumption made has been the implied number of visits by local residents is a reasonable indication of visits to local woodland sites. Because the vast amount of visits to woodland is within a travelled distance below 5 miles, this assumption is reasonable.[63]

The total value of the recreational benefits provided by woodland in Birmingham can be calculated by multiplying the average annual visits with the mean WTP per visit. This results in an annual value of £1.42 million. In general this value is likely to represent an underestimation as the higher WTP for visits to woodland sites further away then 10 miles from home hasn't been applied.

To recognise uncertainties relating to the sample size, transfer errors and the general scientific uncertainties, a range of 40 percent has been applied for the sensitivity analysis, which leads to an annual value of between £0.85m and £1.98m. Considering the small amount of accessible woodland in Birmingham and the comparatively strong relationship between distance travelled and visits, the assumption is reasonable that creating access to more woodland would cause a significant increase of public welfare and therefore of the recreational value of woodland in Birmingham.

Wetland in Birmingham provides space for non-consumptive recreation like bird watching but also consumptive recreational activities such as fishing. However, the latter service is likely to have a negative effect in the total value of ecosystem services provided by wetland as it influences other services negatively;[64] but the summarised recreational services provided by wetlands has a positive value. In Birmingham the annual recreational value adds

[62] We would like to thank Stephen Herbert from Natural England for preparing the MENE data for Birmingham.
[63] Hölzinger 2011, 41.
[64] Brander et al. 2008.

up to £102,000.[65] However, it should be noted that this includes aesthetic appreciation as well. A distinction was not feasible in scope of this exercise.

As only a comparatively small proportion of wetland in Birmingham is accessible and both services are dependent on accessibility the value of wetland could be significantly increased if access to more sites were enabled. This also applies for wild species diversity. It is very likely that providing access to more wetland sites in Birmingham could add significant value to residents' wellbeing.

For heathland and lowland meadows the data provided by Christie et al. (2011) has been used to calculate the ecosystem values (see appendix 9.2). However, here the category used also includes aesthetic and spiritual benefits. Because for Birmingham there are no sufficient robust figures about the quality of habitats available we assume that it is the same proportion of habitat in favourable condition as in the UK average. Therefore no further adjustments regarding the quality are necessary.

Assuming a direct relation between area of habitat and value of cultural services would result in a crude undervaluation because especially cultural values are strongly related to the number of people who can locally benefit from such services. To take this factor into account the average value per hectare has been adjusted by the population density. In absence of alternatives the average value per hectare has been divided by the average population density per km^2 in the UK (255.6/km^2) and then multiplied by the average population density in Birmingham (3739/km^2). This approach can be judged as sufficient robust proxy.

Table 4.1 Cultural services provided by BAP priority habitats

	Heathland	Lowland meadows
Area of Habitat	310 ha	63 ha
Annual WTP per ha 'within own region' (2011 prices)	£133.91	£99.29
Population density UK (people/km^2)	255.6	255.6
Population density Birmingham (people/km^2)	3739.0	3739.0
Annual WTP per ha 'within own region' in Birmingham(2011 prices)	£1,958.92	£1,452.49
Annual WTP per ha 'outside own region' (2011 prices)	£128.30	£95.15
Annual value	**£648,000**	**£10,000**

Source: ***Christie et al. 2011 & own calculations***

[65] See section 9.1 for calculations

However, this approach has only been applied for the value 'within own region'. For the WTP stated for 'outside own region' it can be estimated that this value is more related to non-use values and therefore not related to the population density.[66] Therefore just the average value per hectare has been applied for the latter.[67] Because the degree of accuracy for assumptions made is comparatively low, a range of 85 percent has been applied for the sensitivity analysis.

Box 4.1 Recreational Values of (Amenity) Grassland and Parks

A significant gap in this investigation is that there is no primary research available that can be applied to value the recreational value provided by (amenity) grassland or parks in general. A transferable WTP estimate similar to the one applied for woodland would significantly improve ecosystem services assessments in the urban environment as most of such greenspace is (amenity) grassland. This research may be refined by accounting for specific features such as sport facilities and by incorporating the distance decay and the availability of substitutional greenspace. The latter information would significantly help decision making as it would enable the calculation of a sufficiently robust marginal value for additional (or lost) greenspace.

[66] Christie et al. 2011.

[67] Because of data availability issues for 'BAP priority grassland' only Lowland Meadows have been taken into account. However, this category covers more than 90 percent of the BAP priority grasslands.

4.2 Aesthetic Values & Sense of Place

The visual amenity of environmental landscapes is valuable and can have significant influences, e.g. on property prices. In environmental landscapes with trees, property values can increase by an average of 7%. This could also lead to an increase in council taxes.[68] Another study in Berlin, Germany, found that street trees can increase land values by up to 17%.[69] Research in the USA suggests that a view of woodland can also improve mental health by breaking down stress.[70] Ulrich (1984) found that the view of woodland from hospitals has a positive effect on recovery times.[71]

Within this investigation, the best applicable method to value the amenity benefits provided by woodland is to transfer the findings from Garrod (2002) who valued the Willingness-To-Pay for woodland views from home, applying a stated preferences method. This represents the best primary valuation study in the UK.[72] An additional advantage of this study is that overlaps with other benefits like recreation - have been avoided.[73]

Referring to these findings, the annual WTP per household for a view of urban fringe broadleaved woodland from home is estimated to be £336.97 in 2011 (inflation adjusted by £268.79 in 2002).[74] We adopt this value for the dominantly urban area of Birmingham in common with Edwards et al. (2009), who applied the same WTP to value the social contribution of forests in Scotland.[75] However, it should be noted that the sample size of completed questionnaires is comparative small and no socio-economic adjustment is possible because corresponding information is not available.[76] Nevertheless, the findings for peri-urban broadleaved woodland are estimated to be sufficiently robust.[77] In view of the lack of alternatives this valuation is adopted for the whole broadleaved woodland in Birmingham.

[68] Forest Research 2010, 19.
[69] Luther and Gruehn 2001, 23.
[70] Ulrich and Simons 1986.
[71] Ulrich 1984.
[72] Forest Research 2010, 22.
[73] Garrod 2002, 2.
[74] Ibid., 12.
[75] Edwards et al. 2009.
[76] Garrod 2002, 9 & 13.
[77] Forestry Commission 2010, 23.

The amenity value of woodland has been estimated by creating buffers around the urban woodland in Birmingham and then estimating the number of households within these buffer zones with a free view onto the woodland sites. Two buffers have been created – one with a 50m radius around woodland sites and one with a 100m radius. A close look at Map 4.1 reveals that the 50m buffer usually covers one row of households and the 100m buffer covers the second row. The map shows an example of woodland located in Cofton Park in the south of Birmingham.

Map 4.1 **Households with view on woodland**

Source: ***GIS data provided by Birmingham City Council and Forestry Commission.***

Ordnance Survey Address Point GIS data (residential only) has been overlaid against the buffer zones to count the number of households within each buffer zone.[78] Because it is not likely that all households within these buffer zones have a free view on the woodland only a proportion of the total households has been taken into account for the valuation. The free view from households onto woodland can be blocked or degraded by for example fences or other houses. Therefore the assumption states that 70 percent of households within the 50m buffer can have a free view onto the woodland site. For households within a distance between 50m and 100m from the woodland sites 30 percent have been taken into account for the valuation.

These are comparable conservative assumptions as for example Forest Research (2010) recommends applying the WTP for households within 300m from woodland sites.[79] Following this methodology it can be assumed that about 23,000 households have a free view onto woodland in Birmingham. The amenity value of woodland in Birmingham adds up to £7.78 million annually. Capitalised over 50 years this results in a value of £276.430 million.

[78] The authors thank Nick Tringham, GIS Manager at Birmingham City Council for preparing the data for this project.

[79] Forest Research 2010.

4.3 Education

Formatting ecological knowledge is a key element of the educational system and children benefit from this knowledge over their whole lifetime. Economically speaking, *"formation of ecological knowledge […] can be seen as an investment in human capital."*[80] A high level of ecological knowledge boosts average lifetime earnings. Furthermore it provides additional non-marketable benefits to human wellbeing. It is arguable that a good ecological education leads to more productive individual use of leisure by 'enjoying the nature'.[81] Referring to the increase in lifetime earnings Mourato et al. (2010) approximate that

> *"…the value of ecological knowledge embodied in this educational attainment at the end of the academic year 2009-10 [in the UK] was just over £2.1 billion."*[82]

Along with more theoretical environmental education in the classroom, for example by reading books, frequent interaction with the local environment is one key element of acquiring ecological knowledge.[83]

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 do not have the same relationship with nature as their counterparts living in the countryside. This applies especially for minority ethnic groups in urban contexts.[84]

Birmingham City Council has an outdoor education programme where schools and nurseries have the opportunity to visit Sutton Park, Lickey Hills Country Park, Woodgate Valley Country Park and Sheldon Country Park and attend ranger-led outdoor education activities. Unfortunately, research about the economic valuation of benefits or outdoor education is scarce. In England, Land Use Consultants (2002) made estimations about the economic value of benefits from woodland for education.[85] Based on these assumptions the educational benefits in the West Midlands are estimated to be about £2 million annually.[86] However, the assumptions made are very crude. More recently research has been undertaken within the

[80] Mourato et al. 2010, 31.
[81] Ibid.
[82] Ibid., 34.
[83] Ibid., 30.
[84] UK NEA 2011a, 34.
[85] Land Use Consultants 2002.
[86] ERM and Willis 2004, 26.

framework of the UK National Ecosystem Assessment.[87] Using a cost of investment approach[88] organised school visits to UK's Royal Society for the Protection of Birds (RSPB) reserves have been evaluated. Based on the travel costs approach[89] a value of between £16 and £26 has been calculated per trip and child.[90]

We adopt this approach to calculate the cost of investment of trips to Lickey Hills Country Park for outdoor education purposes. Unfortunately other educational trips couldn't have been valued within scope of this investigation. The value can be derived from the additional costs (including valuable time) to attend outdoor education activities. This includes direct resource costs for transport and ranger hire, but also the value of time spent travelling and waiting.[91] The time spent at the site is not included as the methodology only incorporates for the additional time spent to benefit from outdoor education. The alternative would be to spend the time in the classroom which would consume time as well. To calculate the educational benefits of green infrastructure all school and nursery trips to Lickey Hills Country Park in the years 2010/11 and 2011/12 have been evaluated.

Depending on distance between school/nursery and the park as well as the time of year schools can hire a coach for between £200 and £400 (return). Our calculation uses an average of £300 per trip. The charges to hire a ranger are between £125 (half day) and £200 (full day). However, not all schools and nurseries hire a ranger. Additional costs can occur for hiring a room to leave luggage or to hire outdoor equipment. In average the costs per trip for rangers, rooms and equipment add up to £48.

The value of time spent travelling and waiting can be subdivided in 'in-vehicle travel time' and 'excess time'. The latter covers the time spent waiting and walking to and from vehicles. The 'in-vehicle time' has been calculated using a GIS based AA route planner for each trip. On average the 'in-vehicle time' per trip (return) adds up to 51 minutes. It should be noted that this is a conservative estimate as it usually takes longer to travel at peak times. For the 'excess time' the assumption made by Mourato et al. (2010) of 15 to 22.5 minutes each way has been adopted. This results in an average 'excess time' of 37.5 minutes (return).

[87] UK NEA 2011a.
[88] This does not necessarily reflect the welfare benefits but can be estimated to reflect a baseline of that.
[89] This includes transport, time costs as well as entrance fees.
[90] Mourato et al. 2010, 42.
[91] Ibid., 41.

The value of time is based on the average cost to the government of students in education. An hourly value of £6.14 has been calculated, following assumptions and calculations made by Mourato et al. (2010).[92] These costs are based on costs per pupil per year of £5,360.[93] There are some caveats included in this assumption. On the one hand for an outdoor trip no class room, electricity, school equipment etc. is necessary. Furthermore average costs are calculated based on students in education but nursery schools are also included. The costs in these circumstances may be lower. On the other hand, however, more teachers and teaching assistants per pupil are necessary to supervise the students on an outdoor trip. Figures indicate that for trips to parks in Birmingham at least twice as many teachers have to attend compared to the number required for indoor education. Additionally, the assumption that teachers need more time to prepare and plan for outdoor education trips than for education in the classroom is reasonable. Considering all aspects the calculation applied in this report seems to be realistic. Table 4.2 below outlines the details of the site visits and the applicable costs and values.

Table 4.2 **Organised Outdoor Education School Trips to Lickey Hills Country Park**

	Lickey Hills Country Park
Average no. of trips per year (2010/11 + 2011/12)	62.5
Av. no. of pupils	36.0
Av. no. of teachers	6.7
Av. time spent on site (minutes)	168.0
Av. time spent traveling (minutes)	51.3
Av. 'excess time' (minutes)	37.5
Av. travel- & excess time/trip (minutes)	88.8
Total travel- & excess time/trip (hours)	3330.0
Av. costs to government/hour/student	£5.88
Total costs of time	**£19,580.40**
Av. costs for traveling/trip	£300.00
Av. charges for rangers, equipment etc./trip	£48.00
Total costs for traveling & charges	**£21,750.00**
Total	**£41,330.40**

Source: ***Birmingham City Council; Mourato et al. 2010 & own assumptions***

Outdoor educational benefits provided by Lickey Hills Country Park are valued at £43,330 annually (£1.53m capitalised). It should be stressed that this is in general a baseline of the real value because only trips organised by Birmingham City Council have been valued. This

[92] Based on £5,360 per pupil per year (2010-11), Pupils attend school 190 days per year l and 24 hours per week. The costs have been adjusted to 2011 prices. Conservatively the 250% premium has not been applied.
[93] Department for Children, Schools and Families 2009.

doesn't include for example other organised and non-organised trips to Lickey Hills Country Park by children. It can be assumed that every visit to ecosystems benefits education somehow. Because this park is located outside the city boundaries and only a minor fraction of educational benefits has been evaluated educational benefits are not included in the summary table in Section 1 and 7.

4.4 Economy & Employment

Many studies suggest that a green environment has manifold positive influences on the economy. Within a case study in Northumberland, respondents reported that they shop about one hour longer in retail areas landscaped with greenery and trees than in areas without. About ¾ reported that they prefer this setting.[94]

> *"Study results suggest that higher price valuations are mediated by psychological inferences of district character and product quality. Thus, creating and stewarding an urban forest canopy may enhance revenues for businesses in retail districts that offer diverse products at varied prices."*[95]

A well developed green infrastructure also attracts inward investments. The environmental setting is estimated to play a significant role for companies regarding to their location decision. This also attracts and retains especially high-skilled employees. The boost to economic competitiveness can be seen as a key factor in Birmingham to guarantee economic growth. The attraction of high-skilled workers by improving green infrastructure should be seen as a great opportunity to change the socio-economic structure in the region. However, the scientific evidence does not allow a quantitative analysis of these effects.[96]

Another effect of a high-quality greenspace around workstations is increased productivity. A view on greenspace increases motivation and health which in turn decreases absent days. The importance of green aesthetic amenity at work can also be clarified by the fact that employees without a view on a green environment often hang up pictures of natural

[94] Rskensr 2003.
[95] Wolf 2003, 124.
[96] Regeneris 2009, 24.

scenes.[97] These findings show that the environment has a significant influence on the local economy, even if these effects are difficult to quantify.

Box 4.2 **Green Infrastructure and the Economy**

Authors and Steering Group members equally identified a very important research gap here. Future research is necessary to identify the links between the health benefits derived from greenspaces and any related wealth generated by associated economic development. Questions to be evaluated are how greenspace exactly influences consumer behaviour and how it affects productivity and behaviour at a place of work.

4.5 Health benefits

The links between environmental settings and human health were comparatively well researched in the past and positive relations have been observed. However, there still remain large research gaps which make the exact quantification and monetary valuation of such effects very difficult.[98]

> *""Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."*[99]

Health is not just the absence of diseases and infirmity; it is the state of human wellbeing.[100] Therefore almost all ecosystem services link to health benefits in one or another kind which makes it difficult to isolate health benefits from other benefits.

Adults in the West Midlands are assumed to be the least physically active in England.[101] 15.9% of adults in Birmingham compared to 16.3% nationally complete three or more sessions a week of 30 minutes of moderate physical activity.[102] Apart from the negative effects on human wellbeing and reduced life expectancy this causes significant expenses to

[97] Heerwagen and Orians 1986, 623.
[98] World Health Organization.
[99] Church et al. 2011, 662.
[100] World Health Organization 1948.
[101] APHO 2010, 1.
[102] Sport England 2011.

the healthcare system and therefore society. The annual costs of physical inactivity in England are estimated to be about £13 billion (inflation adjusted).[103]

In Birmingham it is estimated that physical inactivity costs the NHS around £15.4 million per year in 2012. When incorporating additional costs to the city through sickness absence and early death this cost rises to approximately £71 million per year. These figures represent conservative estimates for the costs of inactivity based upon available published data and they exclude the cost implications of other diseases and health problems influenced by physical activity, such as osteoporosis and falls – which affect many older people.[104]

Accessible greenspace close to home is estimated to improve people's health by providing space for physical activity such as jogging.[105] The Department of Health suggests that increased accessible open spaces could reduce healthcare costs in the UK by more than £2 billion annually, even if this figure cannot be taken as valid estimate.[106]

Street trees can also encourage people to walk or cycle to work more often.[107] This in turn helps prevent the onset of diseases such as obesity, diabetes, heart diseases and strokes. In Birmingham, indicators of even those diseases are significantly worse than the England average.[108]

Table 4.3 Health Indicators for Birmingham and England

	England	Birmingham
Adult Obesity (2006-08)	24.2 %	26.2 %
People diagnosed with diabetes (2009/10)	5.4 %	6.6 %
Early deaths: heart disease & stroke (2007-09)	70.5 per 100,000 population under 75	91.5 per 100,000 population under 75

Source: ***APHO Health Profiles 2011***

Several studies have proven that regular park users are healthier than their counterparts. This applies for a range of measures such as diastolic and systolic blood pressure, depression

[103] Department of Health 2004, 9.
[104] Department of Health 2009.
[105] Coombes, Jones, and Hillsdon 2010.
[106] pers comm., Mallika Ishwaran, Defra, 2011, cited in UK NEA 2011b, 1104.
[107] van den Berg, Koole, and van der Wulp 2003.
[108] Department of Health 2011.

score and perception of general health.[109] Large scale studies undertaken in the Netherlands, Sweden and Japan have also provided a body of evidence that the availability of accessible local greenspace and human health are directly related.[110]

Green infrastructure does not only have a positive effect on physical health, it also has restorative effects and contributes to mental health.[111] One of the key findings of the Birmingham Joint Strategic Needs Assessment for Mental Health was that there has been a steady increase in the rates of admissions for mental health conditions due to substance use/misuse, and minor stress related emotional difficulties.

Research carried out in the USA suggests that a view of woodland can improve mental health by breaking down stress.[112] A recently published study carried out in the UK found that a view of grassland from home has a positive influence on emotional wellbeing.[113] Ulrich (1984) also found that the view of woodland from hospitals can reduce recovery times.[114] Evidence also indicates that habitats with high biodiversity, especially within an urban environment, may encourage greater use.[115]

Research carried out in New York suggests that a high tree density per square kilometre significantly reduces asthma prevalence in very young children.[116] Greenspace and especially trees are cleaning the air and therefore reducing related illnesses such as respiratory ailments, heart disease and cancer (see Section 5.5 for more information). About ¾ of the adults agree that green spaces are important for health.[117]

A healthier population does not only reduce healthcare costs or increases public wellbeing. It also increases economic productivity for example by reduced sickness absences. However, as mentioned before, the exact causal connection between the provision of greenspace and healthcare costs is still uncertain.

[109] Ho et al. 2003.
[110] Vries et al. 2003.; Grahn and Stigsdotter 2003.; Takano, Nakamura, and Watanabe 2002.
[111] Kaplan 1995.
[112] Ulrich and Simons 1986.
[113] Mourato et al. 2010, 71.
[114] Ulrich 1984.
[115] UK NEA 2011b, 1154.
[116] Lovasi et al. 2008, 647.
[117] Kuppuswamy 2009, 64.

> *"Casual relationships can be hard to identify, partly because—as is the case in many epidemiological studies—directionality is unclear. Existing health can affect an individual's use of greenspace or choice of residence near a particular environmental setting, and vice versa."*[118]

It is also hard to measure whether for example outdoor exercise is directly related to the greenspace and also additional. If the greenspace wouldn't be accessible it would still be possible that the exercise would have occurred in a sports hall.[119] This is one reason why a robust monetary valuation is not possible at the moment.[120]

Mourato et al. stresses these limitations but provides some tentative values for health benefits related to contact with nature. A one percent increase of broadleaved or mixed woodland within 1 km from home could be valued at between £8 and £12 per person per year. The monthly or more frequent use of non-countryside greenspace may be valued at between £112 and £377 annually per person.[121] However, these values are not robust enough to be implemented in this report.

Box 4.3 **Health Related Research and i-Tree Assessment**

The problems making the causal connection between health and greenspace have been outlined above. But because greenspace seems to be very relevant to improve human health additional research efforts are necessary to evaluate such links. The provision of greenspace may be very effective in reducing healthcare costs. One feasible next step would be to undertake an i-Tree assessment for Birmingham which would reveal the contribution of trees to air quality and the reduction of related healthcare costs. The i-Tree tool has been developed in the United States and helps to calculate a monetary value of the air pollution control, the carbon stock as well as the annual carbon uptake of an urban forest.

[118] Church et al. 2011, 663.
[119] CJC Consulting, Willis, and Osman 2005, 22.
[120] See also Mourato et al. 2010.
[121] UK NEA 2011b, 1105.

5. Regulating Services

5.1 Global Climate Regulation (Climate Change Mitigation)

Green infrastructure plays an important role in mitigating climate change and its negative influences by sequestrating and storing carbon. Trees as well as green plants in general use photosynthesis to take up carbon dioxide from the atmosphere and act as a net carbon sink. A broad amount of carbon is captured in corresponding soils.[122] The Forestry Commission estimates that UK woodland could contribute an emission abatement equivalent to 10 percent of the total UK greenhouse gas inventory in 2050. A requirement is the replanting of 4 percent of the land cover.[123] However, this potential is more relevant to rural areas than to urban areas like Birmingham.

There are some reasons why we haven't evaluated this ecosystem service quantitatively and in monetary terms within this investigation. After a certain time woodland and other habitat types don't capture additional carbon anymore. They still take up carbon from the atmosphere but on the other hand carbon is released for example when trees die or when they are felled because of health and safety issues. Therefore mature habitats reach a long-term equilibrium.[124] It would still be possible to evaluate and value the carbon taken up by newly created habitats and avoided carbon emissions related to the usage of timber for energy production. Here the Social Costs of Carbon (SCC) could be applied for a monetary evaluation. However, this exercise exceeded the scope of this investigation and is planned as a follow-up project. Another reason for not capturing this ecosystem service within this evaluation is that this report focuses on flows rather than stocks. It would be possible to evaluate the actual stock of carbon but it wouldn't fit into the conceptual framework of this investigation as it states on annual flows of ecosystem services.

[122] Read et al. 2009, xii.
[123] Ibid., ix.
[124] Broadmeadow and Matthews 2003, 3.

Box 5.1 **Long Term Evaluation of Carbon Stocks and Flows**

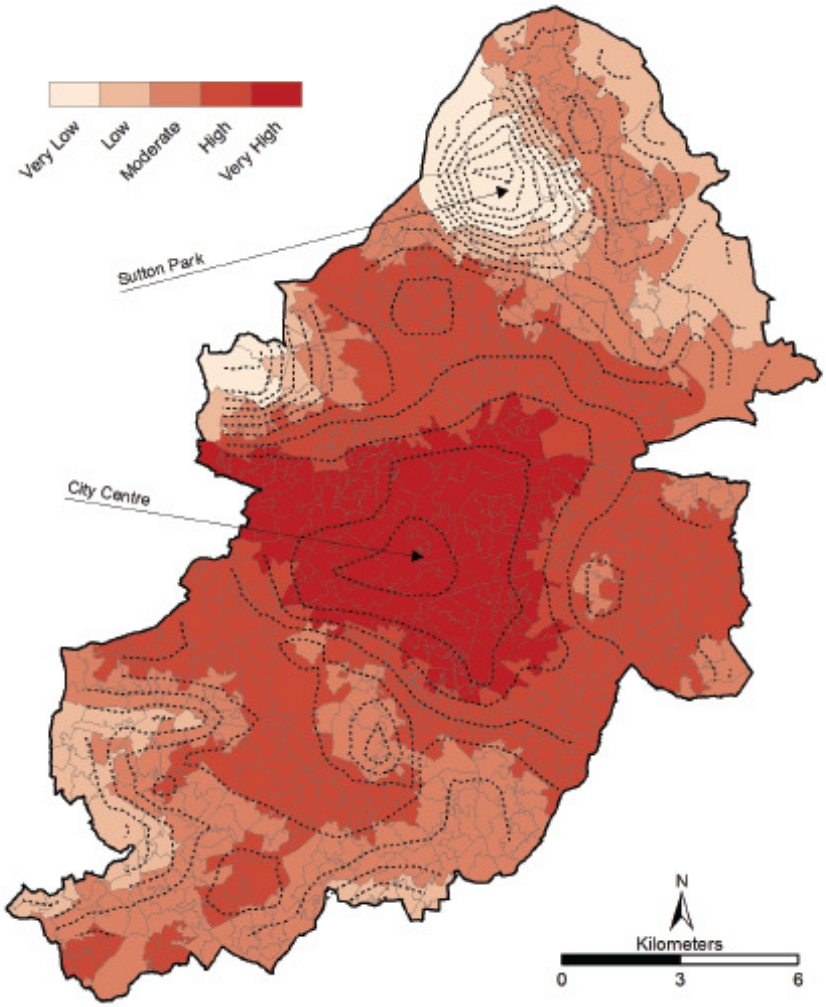
Research is necessary to estimate the carbon stocks and flows over a long time horizon. Just accounting for the annual carbon uptake leads to an over-estimation – especially in mature woodlands. In the short term it is recommended to undertake an i-Tree assessment to evaluate the carbon stock and uptake by the urban forest in Birmingham. A subset for new planted trees and woodland would provide figures for additional carbon taken up and its value. This could be accompanied by an evaluation of the carbon stock of other habitat types.

5.2 Local Climate Regulation (Climate Change Adaptation)

Green infrastructure in Birmingham has a significant influence on the local climate. Urban areas are usually several degrees warmer than their surroundings. This Urban Heat Island Effect (UHIE) is caused by the built environment 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 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.[125]

[125] Tomlinson 2009, 180.

Map 5.1 **UHI Magnitude for Birmingham During a Heatwave in 2006**



Birmingham UHI under heatwave conditions at LSOA level. 18th July 2006 from MODIS remotely sensed data. Shown with contour lines for validation.

Source: ***Adopted from Tomlinson et al. (2011), p. 7***

The importance of green infrastructure can be clarified by this difference. Tomlinson (2011) also found that a concentration of "very high" risk people live within areas of Birmingham with the highest UHIE. This circumstance should be considered by urban planners to reduce future vulnerability facing the increasing likelihood of warmer temperatures and more frequent extreme weather events such as heat waves causes by climate change. Especially the elderly population are thought to have a lower tolerance to extreme temperatures which can cause heat-related illnesses and deaths.[126]

[126] Tomlinson et al. 2011.

Green infrastructure and the urban forest in particular have a significant cooling effect on the local climate. The temperature around vegetation is reduced by evapotranspiration. Furthermore, trees and shrubs provide shading and protection from heat and UV radiation.[127] Research carried out in Manchester suggests that a 10 percent increase of green infrastructure in areas with the least greenery would reduce the UHIE by between 2.2 and 2.5 percent.[128] Other studies validate this effect.[129] Therefore green infrastructure has the potential to play a vital role in helping Birmingham to adapt to climate change.

Another positive effect on the local climate is the potential for reducing energy costs. 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 speed which results in lower heating costs. Kuppuswamy (2009) estimates that street trees provide a cooling effect of between 2% and 7%.[130] Research indicates that a medium-porosity green shelterbelt could reduce heating costs by about 4.5% for a typical two-story cellular office space in Scotland.[131] This in turn reduces carbon emissions and in the end mitigates climate change. Reducing the urban island heating effect also helps in reducing air pollution.[132] However, the maximum expression of this effect is closely related to the local settings and the location of the trees and shrubs. Unfortunately the economic valuation of the effect on the local climate in Birmingham was not possible within scope of this project. The scientific evidence to date is not robust enough to value this effect in monetary terms. [133]

Box 5.2 Green Infrastructure Creation to Adapt Birmingham to Climate Change

In future planning it is highly recommended that greenspace should be (re)created in the most built-up areas of Birmingham to mitigate the worst effects of climate change. Existing greenspace in such areas should gain particular protection. Considering the lack of opportunities to create additional greenspace alternatives such as green roofs and green walls should be considered as well.

[127] Forest Research 2010, 86.
[128] Gill et al. 2007, 122.
[129] Forest Research 2010, 87.
[130] Kuppuswamy 2009, 66.
[131] Wang et al. 8.
[132] Beckett, Freer-Smith, and Taylor 1998.
[133] Forest Research 2010, 90.

5.3 Flood Regulation

Green Infrastructure can help to mitigate extreme weather events and the risk of flooding in particular. The costs to UK insurers, caused by the 2007 flooding, are expected to be around £3 billion.[134] If no additional action is taken, the costs caused by urban flooding in the UK could increase to between £1 billion and £10 billion annually.[135] Extreme scenarios predict costs of £20 billion by 2060.[136] The risk of flooding to urban and rural areas is not new, but the increase in use of impermeable surfaces and more extreme events as a result of climate change is increasing the regularity and severity of these events.

Within the last twelve years Birmingham has faced eight large scale flooding events.[137] Along the River Tame alone, there are 3,100 properties at risk from flooding in Birmingham. Through climate change impacts this amount could rise to 5,400 in the future.[138] In Birmingham properties are not only at risk of flooding from rivers, times of high rainfall can also cause significant damage. Surface sealing in urban areas does not allow water to be absorbed by soil and the sewer system can overflow. This water can cause damage to properties and also worsens water quality in rivers as pollutants will be washed out from the sewer system and dumped into rivers and other water bodies, park pools in particular. The pollution load in this runoff can impact negatively on the ecology of these urban rivers which can negatively influence health.

The creation of green infrastructure can reduce the volume of water run-off through infiltration and absorption, as well as evapotranspiration.[139]

> *"For every 5% of tree cover area added to a community, run-off is reduced by approximately 2%."*[140]

In the UK, by the 2080s, between £22 billion and £75 billion of new investments in engineering might be needed to ensure protection from higher flood risks caused by climate

[134] Pitt 2007, 64.
[135] Evans et al. 2004.
[136] UK NEA 2011b, 1069.
[137] Overview & Scrutiny 2010, 15.
[138] EA 2009, 3.
[139] GIVaN 2011, 27.
[140] Coder 1996, 4.

change.[141] A share of these 'grey' infrastructure investments might be avoidable through the incorporation of Sustainable Urban Drainage Systems (SUDS) into an area of green space. Often, this might be the most cost-efficient alternative even if we do not account for additional benefits such as recreation, amenity etc. There are good practice examples available around the world where SUDS have been successfully retrofitted in the urban environment to reduce the risk of flooding.[142] New Hall Valley Country Park in Sutton Coldfield, Birmingham was the first use of a SUDS system in England.

Within scope of this project the effect could only have been valued for wetland habitats in Birmingham. The prevention from and reduction of damage costs caused by flooding is certainly one of the main services provided by wetland.[143] This habitat plays a very important role mitigating flooding damage (costs) as it can store much flood water during a flooding event and retains and releases it gradually. This is especially so in the highly urbanised area of Birmingham where floodplains are rare and the potential damage is great.

Flood protection services provided by Birmingham's wetlands can be monetised as about £100,000 annually, stating the best guess.[144] These values are mainly based on replacement costs (avoided damage costs).[145] However it should be noted that flood risk reduction services are very site-specific and should be valued case-by-case.[146] A more precise valuation is an assignment worthy of future policy appraisals. This could help to apply the best flood risk reduction management options. The creation of new wetlands is one discussed option to mitigate the flood risk from River Tame.[147]

As flood events are likely to increase in number and extent in the future the capitalised value of £3.6m is likely to represent a crude underestimation as it is calculated based on a *ceteris paribus* assumption. To take these caveats into account a range of 60 percent has been applied for the sensitivity analysis.

[141] Pitt 2007, 32.
[142] Kazmierczak and Carter 2010.
[143] Birol et al. 2007.
[144] Please note that the benefit transfer approach has been applied. See section 9.1 for calculations.
[145] Brander et al. 2008, 33.
[146] Land Use Consultants and GHK Consulting 2009, 132.
[147] EA 2009, 11.

Apart from wetland other habitats contribute to flood risk reduction as well. For woodland, heathland and BAP priority grasslands the findings provided by Christie et al have been applied (see technical appendix 9.2). We assume that the contribution of BAP habitats to flood risk reduction is directly related to the amount of habitat area. This can be seen as a conservative assumption because the distance of habitats to properties under risk of flooding is important as well and the proportion of households under risk of flooding per km^2 in Birmingham is higher than in the UK average.

To calculate the flood regulation benefits provided by woodland, heathland and BAP priority grassland habitats the WTP estimate per ha (Table 5.1) has been adjusted to 2011 prices and then multiplied by the area of habitat. For the sensitivity analysis a range of 70 percent has been applied.

Table 5.1 **Flood regulation provided by Woodland, Heathland & BAP Priority Grassland**

	Woodland	Heathland	BAP Priority Grassland
Area of Habitat	1528 ha	310 ha	70 ha
Annual WTP per ha (2009 prices)	*£461.18*	*£309.56*	*£183.02-£358.62*
Annual WTP per ha (2011 prices)	£497.81	£334.15	£0.00-£387.10
Annual value	**£761,000**	**£104,000**	**£12,000**

Source: ***Christie et al. 2011 & own calculations***

5.4 Water Quality Regulation

Another significant benefit provided by green infrastructure and especially wetlands is the improvement of freshwater quality, in particular the retention, removal and transformation of nutrients, organic matter and sediment. Furthermore wetlands can capture pesticides such as TBT (tributyl tin) and other complex organic pollutants.[148] Wetland habitats fill rapidly during flooding events and slowly filter back the flooding water. However, their capacity is limited. During the past 30 years the UK has faced a significant loss of wetlands due to land-use change for agricultural use, pollution or drainage. The concentration of nitrates and phosphate has been rapidly increased within the same timescale. Intensive agriculture is one of the main drivers. Wetland recreation may be a cost-effective mechanism to deliver some of the water quality improvements required for compliance with the EU Water Framework Directive.

Within this investigation the annual water quality improvement benefits by Birmingham's wetlands have been valued at £81,000, stating the best guess.[149] Most primary valuation studies calculate this effect by taking avoided remediation costs of water purification by water suppliers into account. This doesn't include additional benefits to wild species diversity caused by a good water quality.

[148] EFTEC 2010a, 12.
[149] See section 9.1 for calculations.

5.5 Air Quality Regulation

Green infrastructure and especially trees 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.[150] The main sources for this pollution are vehicle exhausts and conventional power stations.

Even if Birmingham meets most 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 still fails to meets the objectives.[151] And even if objectives are met for most pollutants, this doesn't mean that this level of air pollution has no effect on health.

As for climate change mitigation the monetary value of this effect provided by woodland and the urban forest will be evaluated within the framework of a follow-up i-Tree assessment. This valuation is based on the ability of local trees to absorb pollutants, air pollution statistics and avoided healthcare costs. Therefore this value is directly linked to health benefits.

[150] McPherson, Nowak, and Rowan 1994, 63.
[151] Fallon 2010, 5.

6. Parks Subset

Birmingham City Council requires fees for specific activities on council-owned parks. They charge for events carried out by external partners for use of the space or annual fees for using the sport facilities in parks.[152] Related council income has only been made available for the financial year 2010/11 and is minor compared to other services.

Table 6.1 Council Income through Fees and Charges for Park Usage in 2010/11

Income source	Council income 2010/11
Fishing passes	£1,928
Car parking fees	£5,771
Pitch renting and annual sports passes	£77,238
Rents for external organisations to run events or take photographs	£36,207
Other	£2,144
Total	£123,287

Source: ***Birmingham City Council***

This figure neither represents a good estimate for the actual usage of parks and related facilities nor the benefit people gain from recreational park usage. One reason is that some fees and charges are withdrawn by external organisations and only a proportion of the fees and charges benefits the city council coffers. Furthermore the control of park facility usage is comparatively weak because of a lack of staff and many activities, including general recreation, are not charged for. Therefore the figure reflects a very strong underestimation of the real benefits provided by parks.

In contrast to woodland and wetland primary valuation studies for recreational values provided by parks are very scarce. Brander and Koetse (2011) have undertaken an extensive literature review to develop a meta-regression model for urban open space. Out of 38 international contingent valuation studies they identified 20 to be sufficient enough to be included in the meta-analysis. However, out of derived 73 separate value observations only

[152] Especially latter values account also for man-made features such as goals. However, in parks it is almost impossible to separate between man-made and natural features anyway. Methodically it is feasible not to separate between these features.

one was for parks.[153] The referring primary valuation study is for an urban park in Sydney, Australia and has been published in 1995.[154] The literature review for this publication also revealed primary valuation studies deriving the recreational benefits for parks in Israel[155] and Valencia, Spain.[156] However, none of these studies seems to be appropriate for a value transfer for parks in Birmingham. The main reasons vary from the low sample size of respondents to dissimilarity of policy- and study site to cultural differences. Brander and Koetse (2011) confirm especially the latter caveat:

> *"We also find important regional differences in preferences for open space, which suggests that the potential for transferring estimated values between regions may be limited."*[157]

Hedonic pricing studies for urban parks are more widely available, even for the UK.[158] However, such values are usually given in a percentage of property value increase that relates to the proximity of parks or general greenspace. Furthermore the approach doesn't allow a separation between recreational- and for example aesthetic benefits. Research undertaken in Aberdeen found that a property located close to a local park has an average premium of 9 percent compared to a property 450 metres away. At 10.1 percent the premium for properties close to larger city parks is even higher.[159] Hedonic pricing studies, however, are not easy to handle for a value transfer.[160] This would require advanced modelling and extensive data collection which wasn't within scope of this project.[161]

To estimate an appropriate robust value for ecosystem services provided by parks in Birmingham the proportional area of valued habitats has been evaluated. The assumption underlies that the average value per ha of habitat in parks is equivalent to the average value per ha of habitat in Birmingham as a whole. This approach provides a subset for the value of

[153] Brander and Koetse 2011.
[154] Lockwood and Tracy 1995.
[155] Fleischer and Tsur 2003.
[156] Sazsalazar and Rausell-Koster 2008.
[157] Brander and Koetse 2011.
[158] For an overview see for example Forest Research 2010, 19.
[159] Dunse, White, and Dehring 2007, 25.
[160] Forest Research 2010, 25.
[161] The authors are not aware of examples where hedonic pricing studies have been applied for a value transfer with such detail and scope like the project to hand.

habitats located in Birmingham City Council managed parks and country parks.[162] Table 6.2 provides am overview of habitat area in Parks.

Table 6.2 Area of Habitat within Parks

Broad habitat type *Subset*	**Area**
Broadleaved woodland	721.9 ha
Ancient woodland	*147.0 ha*
Wetland	49.8 ha
Floodplain grazing marsh	*44.0 ha*
Fens	*5.7 ha*
Reedbeds	*0.2 ha*
Lowland Heathland	309.5 ha
BAP priority grassland	28.7 ha
*Lowland meadows**	*28.7 ha*
Lowland dry acid grassland	*0.0 ha*
Purple moor-grass and rush pasture	*0.0 ha*
*) Excluding lowland meadows that is also classified as floodplain grazing marsh to avoid doublecounting.	

Source: ***EcoRecord, Birmingham City Council and Forestry Commission.***

Applying this approach the annual value of ecosystem services provided by selected habitats in parks adds up to almost £6 million. Table 6.3 provides an overview of the findings. A significant proportion (836.9 ha) of green infrastructure in parks is (amenity) grassland. However, as explained in Section 2.3 scientific evidence doesn't allow valuing this habitat type in monetary terms. Further primary valuation research would be necessary to evaluate this for parks so important type of greenspace. The findings are summarised below.

[162] Only parks located within the city boundaries of Birmingham have been evaluated.

Table 6.3 **Annual Values of Ecosystem Services Provided by Green Infrastructure in Parks**

Annual Values; 2011 Prices		Woodland	Heathland	Wetland	BAP Priority Grassland	Total
Provisioning Services	Water Supply			**£0.0002m**		**£0.0002m**
Cultural Services	Wild Species Diversity	**£0.12m**	**£0.19m**	**£0.02m**	**£0.01m**	**£0.34m**
	Recreation	**£0.67m**	**£0.65m**	**£0.03m**	**£0.04m**	**£5.06m**
	Aesthetic Values & Sense of Place	**£3.68m**				
	Cultural Heritage & Spiritual Values					
Regulating Services	Flood Regulation	**£0.36m**	**£0.10m**	**£0.03m**	**£0.005m**	**£0.49m**
	Storm Buffering					
	Water Quality Regulation			**£0.02m**		**£0.02m**
∑		**£4.82m**	**£0.94m**	**£0.09m**	**£0.06m**	**£5.91m**
Area of Habitat		**722 ha**	**310 ha**	**50 ha**	**70 ha**	**1,110 ha**
Average Value per Ha		**£6,678**	**£3,034**	**£1,904**	**£2,005**	**£5,328**

Notes: All values are 'best guess' estimates. Cells left blank can't be interpreted as 'no value', scientific evidence to date just doesn't allow to calculate a monetary value for these services. Not only because of that the real values may exceed the stated ones.

Source: ***Own calculations.***

Table 6.4 and 6.5 provide a more detailed picture including the sensitivity analysis. For all underlying assumptions see the following section as well as the sections relevant for each ecosystem services.

Table 6.4 **Annual Values of Ecosystem Services Provided by Green Infrastructure in Parks (Detailed)**

PARKS SUBSET		Woodland			Heathland			Wetland			BAP Priority Grassland			∑		
		Annual			Annual			Annual			Annual			Annual		
		High	BG	*Low*	*High*	**BG**	*Low*	*High*	**BG**	*Low*	*High*	BG	*Low*	*High*	**BG**	*Low*
Prov.	Water Supply							*£0,00*	**£0,00**	*£0,00*				*£0,000*	£0,000	*£0,000*
Cultural	Wild Species Diversity (Biodiversity)	*£2.43*	**£0.12**	*£0.02*	*£0.30*	**£0.19**	*£0.08*	*£0,02*	**£0,02**	*£0,01*	*£0.02*	**£0.01**	*£0.00*	*£2,77*	£0,34	*£0,11*
	Recreation	*£0.94*	**£0.67**	*£0.40*	*£1.20*	**£0.65**	*£0.10*	*£0,04*	**£0,03**	*£0,01*	*£0.07*	**£0.04**	*£0.01*	*£7,77*	£5,06	*£2,35*
	Aesthetic Values & Sense of Place	*£5.51*	**£3.68**	*£1.84*												
	Cultural Heritage & Spiritual Values															
Regul.	Flood Regulation	*£0.61*	**£0.36**	*£0.11*	*£0.18*	**£0.10**	*£0.03*	*£0,04*	**£0,03**	*£0,01*	*£0.01*	**£0.00**	*£0.00*	*£0,84*	£0,49	*£0,15*
	Storm Buffering															
	Water Quality Regulation							*£0,03*	**£0,02**	*£0,01*				*£0,03*	£0,02	*£0,01*
∑		*£9.49*	**£4.82**	*£2.37*	*£1.68*	**£0.94**	*£0.20*	*£0,14*	**£0,09**	*£0,04*	*£0.10*	**£0.06**	*£0.01*	*£11,40*	**£5,91**	*£2,62*
Ø/ha (£ for annual values)		*£13,142*	**£6,678**	*£3,284*	*£5,410*	**£3,034**	*£658*	*£2.730*	**£1.904**	*£745*	*£3,577*	**£2,005**	*£433*	*£10,274*	**£5.328**	*£2.364*
Area (ha)		722			310			50			29			1,110		

Notes:
If not stated otherwise all values are stated in £m; 2011 prices.

Legend:

BG	Best Guess
Low	Lower boundary of the sensitivity analysis
High	Higher boundary of the sensitivity analysis (even if the real value could still exceed this boundary)
Ø/ha	Average value per hectare
£m	Million pounds

For the underlying assumptions, limitations and valuation methods see the relevant sections.

Source: ***Own calculations.***

Table 6.5 Capitalised Values of Ecosystem Services Provided by Green Infrastructure in Parks

PARKS SUBSET		Woodland				Heathland				Wetland				BAP Priority Grassland				∑			
		Capitalised				Capitalised				Capitalised				Capitalised				Capitalised			
		High	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*
Prov.	Water Supply									*£0,01*	**£0,01**	£0,01	*£0,00*					*£0,01*	**£0,01**	£0,01	*£0,00*
Cultural	Wild Species Diversity (Biodiversity)	*£121.27*	**£4.13**	£2.85	*£0.57*	*£15.21*	**£6.75**	£4.66	*£1.86*	*£1,19*	**£0,84**	£0,58	*£0,17*	*£0.99*	**£0.44**	£0.30	*£0.12*	*£138.65*	**£12,17**	£8,39	*£2,73*
	Recreation	*£46.83*	**£23.77**	£16.39	*£9.83*	*£59.90*	**£23.01**	£15.86	*£2.38*	*£2,18*	**£0,91**	£0,63	*£0,19*	*£3.74*	**£1.44**	£0.99	*£0.15*	*£388.32*	**£179.69**	£123.90	*£57,57*
	Aesthetic Values & Sense of Place	*£275.67*	**£130.58**	£90.04	*£45.02*																
	Cultural Heritage & Spiritual Values																				
Regul.	Flood Regulation	*£30.54*	**£12.77**	£8.80	*£2.64*	*£8.81*	**£3.68**	£2.54	*£0.76*	*£2,00*	**£0,89**	£0,61	*£0,25*	*£0.41*	**£0.17**	£0.12	*£0.04*	*£41,77*	**£17,51**	£12,07	*£3,68*
	Storm Buffering																	*£0,00*	**£0,00**	£0,00	*£0,00*
	Water Quality Regulation									*£1,42*	**£0,72**	£0,50	*£0,30*					*£1,42*	**£0,72**	£0,50	*£0,30*
∑		*£474.31*	**£171.24**	£118.07	*£58.06*	*£83.92*	**£33.44**	£23.06	*£5.00*	*£6,80*	**£3,37**	£2,32	*£0,91*	*£5.14*	**£2.05**	£1.41	*£0.31*	*£570,18*	**£210.10**	£144.87	*£64,28*
Ø/ha (£ for annual; £m for capitalised)		*£0.66*	***£0.24***	*£0.16*	*£0.08*	*£0.27*	***£0.11***	*£0.07*	*£0.02*	*£0,14*	***£0,07***	*£0,05*	*£0,02*	*£0.18*	***£0.07***	*£0.05*	*£0.01*	*£0.52*	***£0.19***	*£0.13*	*£0.06*
Area (ha)		722				310				50				29				1,110			

Notes:
All values are stated in £m; 2011 prices.
The capitalised value represents the present value of ecosystem services provided over a time period of 50 years.
The capitalised value 'BG (HM Tr.)' Best Guess (HM Treasury) applies a higher discount rate recommended by HM Treasury and is stated for comparability purposes.

Legend:

BG	Best Guess
Low	Lower boundary of the sensitivity analysis
High	Higher boundary of the sensitivity analysis (even if the real value could still exceed this boundary)
Ø/ha	Average value per hectare
£m	Million pounds

For the underlying assumptions, limitations and valuation methods see the relevant sections.

Source: ***Own calculations.***

7. Conclusion and guidance

7.1 Key Findings and Interpretation

The main findings of this investigation are summarised in Table 7.1 and 7.2. The structure of the summary table is based on the conceptual framework of the National Ecosystem Assessment (NEA). Stating the best guess, the green infrastructure in Birmingham covered in this report can be valued at £11.66 million annually or £414.38 million capitalised over the next 50 years.[163] As mentioned previously, the scientific basis is very incomplete which leads to a likely undervaluation. Furthermore, most of the ecosystem services which have been given a value are still likely to be undervalued.

The summary table covers only ecosystem services that it has been possible to value for at least one habitat. However, the unvalued services are considered to provide benefits as well. These benefits are described qualitatively in the relevant chapters. All quantitative values are presented as best guess (BG) figures and stated in 2011 prices. This reflects the best scientific evidence available. Furthermore, a sensitivity analysis with a high and a low estimate has been applied. This range considers for example scientific uncertainties or possible value transfer errors. Therefore, values should be read as for example: 'recreational benefits provided by woodland in Birmingham are estimated to have an annual value of between £0.85m and £1.98m with a best guess of £1.42m.' Generally, where figures are quoted the specific valuation methods and assumptions should be stated as well. For more information see the relevant chapters.

Values are calculated as annual benefits and also as capitalised values. For both, a *ceteris paribus* scenario is implicit. This means that other influencing quantities such as population growth, extent of habitats etc. are assumed to be constant over time. The capitalised values reflect the total annual benefits over the next 50 years. Technological progress has been taken into account by applying a discount rate of 1.5% to the best guess value.[164] Average values per hectare are also presented. However, the value for one particular hectare may differ very strongly in relation to accessibility, population density, quality etc.

[163] For the findings of the parks subset see chapter 6.
[164] For the sensitivity analysis and the (only stated) HM Treasury value other discount rates are applied. For more information see section 1.4.

Table 7.1 **Annual Value of Ecosystem Services Provided by Birmingham's Green Infrastructure**

		Woodland			Heathland			Wetland			BAP Priority Grassland			∑		
		Annual			Annual			Annual			Annual			Annual		
		High	**BG**	*Low*	*High*	**BG**	*Low*	*High*	**BG**	*Low*	*High*	**BG**	*Low*	*High*	**BG**	*Low*
Prov.	Water Supply							*£0,00*	**£0,00**	*£0,00*				*£0,001*	**£0,001**	*£0,000*
Cultural	Wild Species Diversity (Biodiversity)	*£5.13*	**£0.25**	*£0.05*	*£0.30*	**£0.19**	*£0.08*	*£0,10*	**£0,10**	*£0,03*	*£0.05*	**£0.03**	*£0.01*	*£5,58*	**£0,56**	*£0,17*
Cultural	Recreation	*£1.98*	**£1.42**	*£0.85*	*£1.20*	**£0.65**	*£0.10*	*£0,17*	**£0,10**	*£0,03*	*£0.18*	**£0.10**	*£0.01*	*£15,21*	**£10,05**	*£4,88*
Cultural	Aesthetic Values & Sense of Place	*£11.67*	**£7.78**	*£3.89*												
Cultural	Cultural Heritage & Spiritual Values															
Regul.	Flood Regulation	*£1.29*	**£0.76**	*£0.23*	*£0.18*	**£0.10**	*£0.03*	*£0,16*	**£0,10**	*£0,04*	*£0.02*	**£0.01**	*£0.00*	*£1,65*	**£0,98**	*£0,30*
Regul.	Storm Buffering													*£0,00*	**£0,00**	*£0,00*
Regul.	Water Quality Regulation							*£0,11*	**£0,08**	*£0,05*				*£0,11*	**£0,08**	*£0,05*
∑		*£20.08*	**£10.20**	*£5.02*	*£1.68*	**£0.94**	*£0.20*	*£0,54*	**£0,38**	*£0,15*	*£0.25*	**£0.14**	*£0.03*	*£22,55*	**£11,66**	*£5,40*
Ø/ha (£ for annual; £m for capitalised)		*£13,142*	**£6,678**	*£3,284*	*£5,410*	**£3,034**	*£658*	*£2.730*	**£1.904**	*£745*	*£3,577*	**£2,005**	*£433*	*£10,703*	**£5.536**	*£2.563*
Area (ha)		1,528			310			199			70			2,107		

Notes:
If not stated otherwise all values are stated in £m; 2011 prices.

Legend:

BG	Best Guess
Low	Lower boundary of the sensitivity analysis
High	Higher boundary of the sensitivity analysis (even if the real value could still exceed this boundary)
Ø/ha	Average value per hectare
£m	Million pounds

For the underlying assumptions, limitations and valuation methods see the relevant sections.

Source: ***Own calculations***

Table 7.2 Capitalised Value of Ecosystem Services Provided by Birmingham's Green Infrastructure

		Woodland				Heathland				Wetland				BAP Priority Grassland				∑			
		Capitalised				Capitalised				Capitalised				Capitalised				Capitalised			
		High	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*	*High*	**BG**	BG (HM Tr.)	*Low*
Prov.	Water Supply									*£0.06*	**£0.03**	£0.02	*£0.01*					*£0.06*	**£0.03**	£0.02	*£0.01*
Cultural	Wild Species Diversity (Biodiversity)	*£256.72*	**£8.74**	£6.03	*£1.21*	*£15.21*	**£6.75**	£4.66	*£1.86*	*£4.75*	**£3.38**	£2.33	*£0.70*	*£2.39*	**£1.06**	£0.73	*£0.29*	*£279.07*	**£19,93**	£13,75	*£4,06*
Cultural	Recreation	*£99.14*	**£50.31**	£34.69	*£20.82*																
Cultural	Aesthetic Values & Sense of Place	*£583.60*	**£276.43**	£190.61	*£95.30*	*£59.90*	**£23.01**	£15.86	*£2.38*	*£8,69*	**£3,63**	£2,51	*£0,75*	*£9.05*	**£3.48**	£2.40	*£0.36*	*£760.39*	**£356.86**	£246.06	*£119.61*
Cultural	Cultural Heritage & Spiritual Values																				
Regul.	Flood Regulation	*£64.66*	**£27.02**	£18.63	*£5.59*	*£8.81*	**£3.68**	£2.54	*£0.76*	*£8,00*	**£3,55**	£2,45	*£0,98*	*£1.00*	**£0.42**	£0.29	*£0.09*	*£82,48*	**£34,68**	£23,91	*£7,42*
Regul.	Storm Buffering																	*£0,00*	**£0,00**	£0,00	*£0,00*
Regul.	Water Quality Regulation									*£5,67*	**£2,88**	£1,99	*£1,19*					*£5,67*	**£2,88**	£1,99	*£1,19*
∑		*£1,004.12*	**£362.51**	£249.96	*£122.91*	*£83.92*	**£33.44**	£23.06	*£5.00*	*£27,18*	**£13,47**	£9,29	*£3,63*	*£12.44*	**£4.96**	£3.42	*£0.74*	*£1.127,67*	**£414.38**	£285.73	*£132.29*
Ø/ha (£ for annual; £m for capitalised)		*£0.66*	***£0.24***	*£0.16*	*£0.08*	*£0.27*	***£0.11***	*£0.07*	*£0.02*	*£0,14*	***£0,07***	*£0,05*	*£0,02*	*£0.18*	***£0.07***	*£0.05*	*£0.01*	*£0.54*	***£0.20***	*£0.14*	*£0.06*
Area (ha)		1,528				310				199				70				2,107			

Notes:
All values are stated in £m; 2011 prices.
The capitalised value represents the present value of ecosystem services provided over a time period of 50 years.
The capitalised value 'BG (HM Tr.)' Best Guess (HM Treasury) applies a higher discount rate recommended by HM Treasury and is stated for comparability purposes.

Legend:

BG	Best Guess
Low	Lower boundary of the sensitivity analysis
High	Higher boundary of the sensitivity analysis (even if the real value could still exceed this boundary)
Ø/ha	Average value per hectare
£m	Million pounds

For the underlying assumptions, limitations and valuation methods see the relevant sections.

Source: ***Own calculations***

It should be noted that it is possible to support estimates of the real values of some ecosystem services which are higher than the stated values. Sometimes, as for the moderation of extreme weather events, only elements of the total ecosystem service have been valued. In this case the real value may also exceed the high value presented in the sensitivity analysis.

It has to be emphasised again that the high average per-hectare values for woodland compared to wetland and heathland must not be interpreted in the way that woodland is necessarily worth more than the other habitats. Different approaches have been used and different ecosystem services have been valued. If all the possible ecosystem services could have been valued economically – then heathland might have an equivalent or higher value than woodland. The lower values for wetland relate to its poor accessibility together with the unvalued non-use benefits.

Based on questionnaire survey results, literature review and expert workshop assessments, Haines-Young and Potschin (2008) tried to compile a complete list of ecosystem services provided by different habitats. With 22, the highest number of services are provided by both broadleaved woodland and heathland.[165] For comparison, in this survey only 4 services are valued for woodland and 5 for heathland.[166] This is another argument why the values provided in this report should be interpreted as baseline of the real value of such habitats. Not to mention that a major extent of green infrastructure including (amenity) grassland and the blue infrastructure (rivers and streams) couldn't have been covered within this investigation at all. This is a task for the future, see recommendations for feasible next steps outlined in section 7.2 below.

[165] Haines-Young and Potschin 2008, 25.
[166] Even if some services might be pooled in the categories of this survey. Furthermore, especially some provision services are not occurring in Birmingham and the Black Country.

7.2 Identified Research Gaps, Recommendations and Conclusion

As mentioned earlier the aim of this research project was not only to evaluate the monetary value of the green infrastructure in Birmingham, but also to identify research gaps and feasible next steps to implement the 'ecosystem services approach' in decision making and planning. As Birmingham City Council has a duty to maximise the well-being of its inhabitants, the planning system could be improved to incorporate the real value of green infrastructure and acknowledge ecosystem services. This would enable better decision making based on local evidence. It should be stressed that this is no criticism of the established planning system – it's just a further development.

> *"Taking the value of our natural services into account isn't an 'optional extra', it's part of good policy making."*[167]

Research has developed new approaches that better account for environmental goods and services then has been possible in the past. Therefore future policy development should react to such new opportunities and implement the 'ecosystem services approach' in decision making.

Government has now put in place a number of initiatives which postulate incorporating the ecosystem services approach in decision making. This includes for example the Natural Environment White Paper (NEWP)[168] and the UK National Ecosystem Assessment (UK NEA)[169]. More locally, Birmingham and the Black Country have recently been assigned a Nature Improvement Area (NIA). Birmingham and the Black Country is the only urban NIA in the country. All these initiatives acknowledge the increasing importance of the ecosystem services approach and Birmingham can become a leader shaping and implementing this approach.

This investigation has revealed large research gaps and the monetary evaluation of ecosystem services only covers a comparatively small fraction of the overall value of green infrastructure. However, decisions have to be made now and can't wait for a perfect set of scientific evidences. Furthermore it is likely that science will never be able to quantify all

[167] Defra 2010, 9.
[168] HM Government 2011.
[169] UK NEA 2011b.

ecosystem services because of the high complexity of the ecosystem and all its interactions. It is very likely, that for example, the benefits ecosystems provide to culture, will never be entirely expressed in monetary terms. Therefore the monetary evaluation of ecosystem services always only aids the decision making process and does not substitute for it. Such a quantitative ecosystem assessment will always need to be read in line with the qualitative assessment as provided in this report. Otherwise, very important aspects that can't be quantified, would be missed, which again results in an undervaluation of services provided by green infrastructure.

The following recommendations are subdivided by timescale, but also by sector. We focus on actions that can be undertaken or initiated by Birmingham City Council and its partners (in particular Birmingham's Green Infrastructure and Adaptation Delivery Group and local academia) within a comparatively short time period. Additionally we summarise some research gaps that have to be directed to the academic sector, to improve ecosystem services assessments for decision making purposes in the future.

i-Tree & blue infrastructure assessment

In the short term the steering group recommends that Birmingham City Council should undertake an i-Tree assessment for its urban forest. The i-Tree tool has been developed in the United States and helps to calculate a monetary value of the air pollution control, the carbon stock as well as the annual carbon uptake of an urban forest. Additionally a structural value of the tree population will be provided. This would be a feasible next step and a valuable supplement to this current report. It could help to provide a wider scope on ecosystem services provision in Birmingham. Furthermore a similar ecosystem assessment for Birmingham's blue infrastructure could be considered as it represents a significant and important amount of Birmingham's environment.

Cost-benefit analysis

A cost-benefit analysis should be undertaken to justify (or not) the public expenditure on green infrastructure in the city. Such an analysis would compare the flow of ecosystem services and the public expenditure for managing Birmingham's green infrastructure. A benefit-cost ratio would provide the public benefits generated by every pound spent on green infrastructure.

Ecological records

A further recommendation is to improve the ecological records for the city's green infrastructure particularly with regards to achieving more comprehensive mapping of habitats in the city. Again, this shouldn't be misinterpreted as a criticism of the actual recordings. But even if the records of ecosystems in Birmingham are comparatively good there is still room for improvement. Every ecosystem assessment can only be as good as the ecological baseline data. If we don't know what's there and what its quality is, we can't know what its value is or how to protect it. Records for example of further BAP (Biodiversity Action Plan) priority habitats such as hedgerows would improve future ecosystem assessments and therefore decisions affecting green infrastructure.

EcoRecord has a significant role to play in terms of ecological data sets and looking at how other data sets might be used to add value and to interpret the natural environment. It plays a major role in capturing, storing, evaluating and analysing, and making data available to decision-makers and policy formers. From a biodiversity point of view, it is the main place where sites, habitats and species information is kept in one place. There are some important requirements for the value of this role to be maximised – one, resources are needed to maintain and improve investment in EcoRecord's capabilities; and two, resources are needed for continued ecological survey and evaluation, and access to other data sets.

Another improvement would be to develop and implement a more systematic and joined up approach to monitoring changes in greenspace provision. This would allow to evaluate the success of related activities.

Ecosystem services assessment for former developments

Another potential project that has been identified is applying the ecosystem services approach at past major developments within the city such as the Birmingham Battery site in Selly Oak, New Hall Valley and/or the Monyhull Hospital. This project would reveal (1) if and to what extent additional aspects and impacts on human well-being could be evaluated, (2) if decision makers involved in those former planning decisions feel that such additional information were helpful, and (3) if decisions may have been judged differently based on these new evidences. The same approach could then be applied to a proposed development project in the city such as Eastside or any Area Action Plan.

The Natural Capital City Tool

A medium-term task to implement the ecosystem services approach in spatial planning would be to develop a conceptual framework or tool that provides decision makers involved in planning decisions with ecosystem services related information prepared in the right format. This could for example be implemented as an addendum to environmental impact assessments (EIA's). The hypothesis is that the monetary valuation of ecosystem services would be very helpful and a powerful decision-aid in planning, especially if it follows a standardised structure and if it were combined with quantitative and qualitative analysis. If decision makers have to compare different aspects, beneficiaries, trade-offs, and complex cause and effect links of a decision, they have to reduce complexity somehow, either by ignoring or placing back the difficult, hard to grasp and uncertain arguments (such as complex ecosystem - human wellbeing relations) or by reducing their inherent complexity by quantification. The implementation of the ecosystem services approach (and where necessary valued ecosystem services) in planning decisions following consistent guidance could bring more structure and rationale to the decision making process and help to make better decisions. This could also reduce administration costs and the rate of subsequent disputes.

The application of the ecosystem services approach to improve planning decisions may have two other advantages. By following the structured methodology where information will be prepared following a fixed guideline it is not so easy to forget aspects and relevant stakeholder groups that aren't participating in the consultation process. Some ecosystem services are less obvious than others. In discussing a development proposal one might easily forget that the affected ecosystem has valuable effects on health, disease and pest control, noise level, air quality, spiritual values or education, to name just a few examples. It also makes stakeholders and their interests visible which are not participating in the consultation process. This applies for example for the population of the city 50 miles downstream which has to suffer from higher flood risk and worse water quality because locally a decision will be made that destroys significant areas of wetland. It also applies for people in most vulnerable places of the world who have to suffer the most from climate change because habitat destruction releases carbon to the atmosphere. Future generations are obviously excluded from participatory approaches as well.

Birmingham would be in a very good position to develop such a conceptual framework and achieve a pioneer position in sustainable planning. Such a conceptual framework could be developed as the Natural Capital City Tool and could become national industry standard.

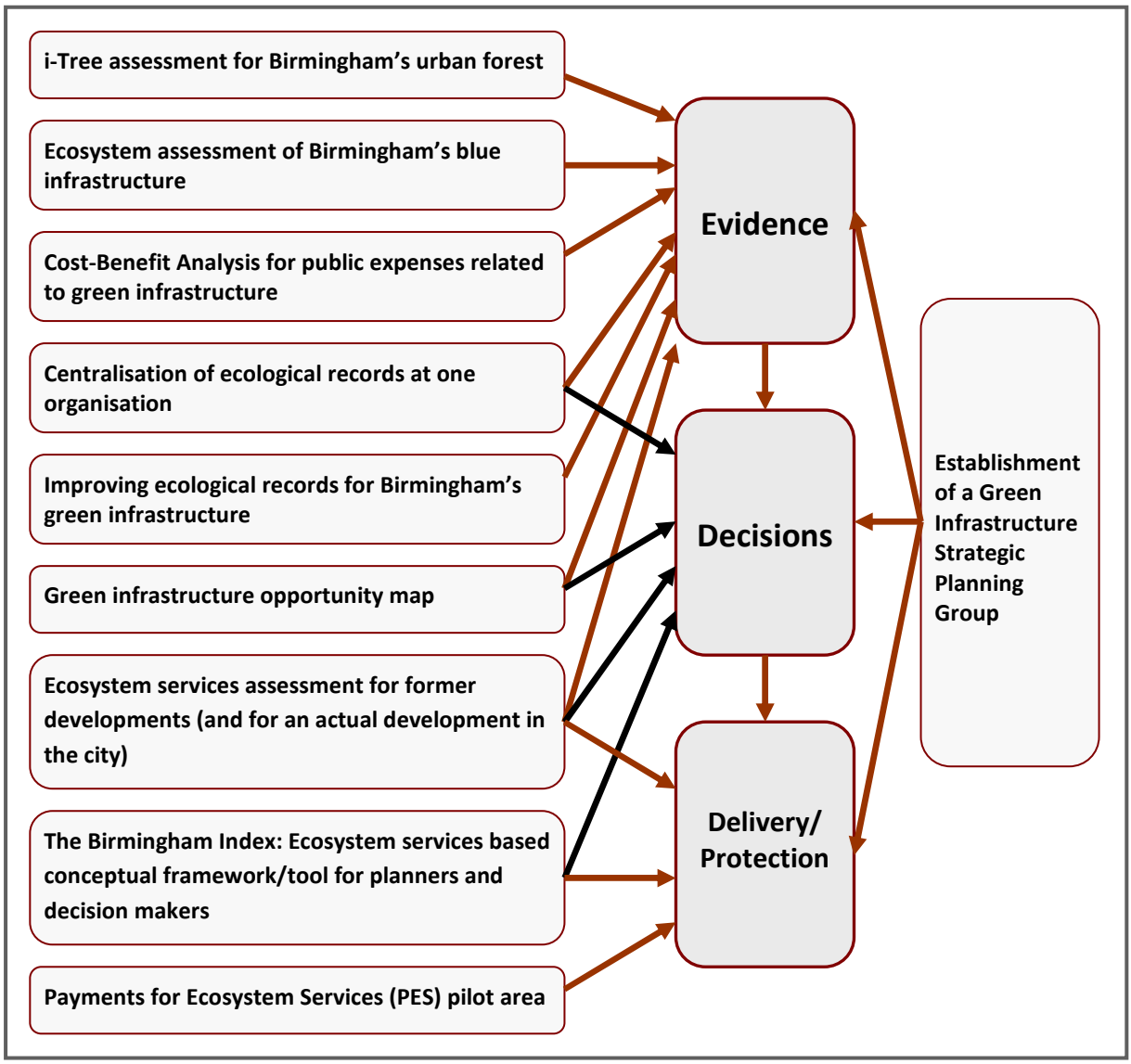
Green Infrastructure Strategic Planning Group and Payments for Ecosystem Services (PES)

All potential projects outlined above would provide a significant contribution to developing and implementing a more strategic approach to green infrastructure planning, focussing on multiple benefits and ecosystem services rather than a single agenda such as flood protection. To realise this it would be necessary to set up a new working group or extend the scope of an existing group such as the Green Infrastructure Adaptation Delivery Group (GIAD) involving all relevant organisations responsible for ecosystem services delivery. This also includes such organisations that are not legally responsible for green infrastructure delivery but still have a major interest in ecosystem services provision as they benefit from it. The steering group established for the purpose of this project could be seen as a good start.

Such a group could develop a strategic plan for green infrastructure development in Birmingham for the medium- and long term. It is very likely that such a strategic group or partnership would provide multiple ecosystem services most efficiently and that sub-optimisations could be reduced. The different agendas could be matched and commonly financed and delivered. This includes the projects recommended above but as a matter of course it would also include the concrete delivery of green infrastructure and ecosystem services 'on the ground'. A 'Payments for Ecosystem Services' (PES) scheme may be set up to finance projects proportionally to the benefits each organisation gains. Therefore Birmingham could become a PES pilot region with multiple buyers of ecosystem services in the future which hasn't been established in the UK so far.

All potential projects stated above could be undertaken or initialised by Birmingham City Council and its partners and would be realisable within one to three years. Figure 7.1 below summarises the different recommendations. By initialising and supporting such projects Birmingham City Council could put itself in a pioneer position for developing and implementing the ecosystem services approach in decision making. By doing so Birmingham would be model for other cities who could adopt the approach.

Figure 7.1 Recommendations for Birmingham City Council and its GIAD Partners



Source: ***Recommendations made by the authors and the steering group members.***

Recommendation for the Business Community of Birmingham

The completion of this report of an evaluation of the ecosystem services derived from the city's green infrastructure represents a first for the City of Birmingham, being the first UK city to complete such an undertaking.

With the creation of the City's Green Infrastructure and Adaptation Delivery (GIAD) Group which seeks to harness the synergies across 9 different disciplines, by sharing their evidence

bases, co-ordinating their policies and joint funding the delivery of projects – this group represents a substantial co-ordination of effort across the public sector of the city in it serious attempts to adapt to climate change. The work of the group is divided into 7 category headings that represent the 7 adopted principles of green infrastructure. The very nature of these principles are that they are embedded in and reinforce the ecosystem services approach.

It is the belief of the GIAD and the Steering Group responsible for this report, that though laudable – this plan for the city is only ever going to represent half of the total picture. What's missing is the complimentary half – that represents how business and the private sector could themselves contribute to this city vision. The Government's Ecosystem Market Task Force (EMTF) has been established as a national body, to explore the potential for businesses to recognise, adopt and gain from the emerging ecosystem services market. The EMTF are keen to support Birmingham in its ambitions to view the City as a single ecosystem and to develop a joint plan between the public and private sectors that will map how each can contribute to a sustainable and adapted future – utilising the ecosystem services approach.

Recommendations for the academic community

Apart from actions Birmingham City Council can undertake or initiate directly further actions by the academic sector would be necessary to improve the scientific evidence regarding ecosystem services and its implementation in decision making. Primary research is recommended to overcome broad research gaps related to ecosystem services for example provided by (amenity) grassland which represents the vast amount of greenspace in Birmingham and other urban areas. A transferable WTP estimate similar to the one applied for woodland would significantly improve ecosystem services assessments in the urban environment as most of such greenspace is (amenity) grassland. This research may be refined by accounting for specific features such as sport facilities. The latter would significantly help decision making as it would enable to the calculation of a sufficiently robust marginal value for additional (or lost) greenspace. Research is also necessary to estimate the carbon stocks and flows in vegetation and soils over a long time horizon. Just accounting for the annual carbon uptake leads to an overestimation – especially in mature woodlands.

Another task is a risk assessment regarding the loss of native species diversity and the influence of invasive species. One question to answer is to what extent the ecosystem can cope with the decline of wild species diversity and which species are 'system-relevant'. Furthermore research is necessary to identify the links between the health benefits derived from greenspaces and a wealth created through economic development. Questions to be evaluated are how greenspace exactly influences consumer behaviour and how it affects productivity and behaviour at a place of work. Because greenspace seems to be very relevant to improve human health additional research efforts are necessary to evaluate the links between health and greenspace. The provision of greenspace may be very effective in reducing healthcare costs.

To improve the applicability of the ecosystem services approach for planning purposes it is also recommended to account for the distance decay and the availability of substitutional greenspace. People gain higher benefits from greenspace if it is created in an area where few greenspaces already exist rather than in an area which is already very green. On the one hand the value of especially recreational services increases when the greenspace is close to the beneficiaries. On the other hand the marginal value of recreational values declines when substitutional greenspace is available within a short distance from the valued greenspace. Furthermore we need to identify other robust measures that would enable the quality of green infrastructure because it has a significant influence – not only on the recreational value, to be accounted for. The scientific evidence to date only allows for the accounting of such influencing variables on a very limited basis.

This investigation has shown that the monetary and non-monetary valuation of ecosystems and ecosystem services provides sufficiently robust values that can aid the decision making process. However, it also revealed larger research gaps and necessary next steps to implement the ecosystem services approach in decision making. Birmingham City Council could play a major role in developing such approaches. Birmingham is in a very good position to take a national lead and set an example in applying the ecosystem services approach in decision making and therefore ensuring a sustainable future for the city. The next feasible steps to achieve this position have been outlined above.

8. List of Abbreviations

ANGSt	(Natural England's) Accessible Greenspace Standard
ASNW	Ancient Semi-Natural Woodland
BAP	Biodiversity Action Plan
BG	Best Guess
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
EFTEC	Economics for the Environment Consultancy
GIS	Geographic Information System
GI	Green Infrastructure
GIAD	(Birmingham's) Green Infrastructure and Adaptation and Delivery (Group)
m	Million (£)
MENE	Monitor of Engagement with the Natural Environment
MODIS	MODerate resolution Imaging Spectroradiometer
NEWP	Natural Environment White Paper
PAWS	Planted Ancient Woodland Sites
PES	Payments for Ecosystem Services
SCC	Social Costs of Carbon
SPD	Supplementary Planning Document
SSSI	Site of Specific Scientific Interest
SUDS	Sustainable Urban Drainage System
TBT	Tributyl tin
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UHI	Urban Heat Island
UHIE	Urban Heat Island Effect
UK NEA	UK National Ecosystem Assessment
WTA	Willingness-To-Accept
WTP	Willingness-To-Pay

9. References

APHO. 2010. West Midlands Health Profile 2010. Association of Public Health Observatories. Available from <http://www.apho.org.uk/resource/view.aspx?RID=95272>.

B&BC LBAP Review Group. 2010. Birmingham and the Black Country Biodiversity Action Plan. Birmingham and Black Country Biodiversity LBAP Review Group. Available from <http://www.bbcbap.org.uk/images/LBAP/bbcbapfinal2010.pdf>.

van den Berg, Agnes E., Sander L. Koole, and Nickie Y. van der Wulp. 2003. Environmental preference and restoration: (How) are they related? *Journal of Environmental Psychology* **23** (2): 135–146.

Birol, Ekin, Nick Hanley, Phoebe Koundouri, and Yiannis Kountouris. 2007. *The optimal management of wetlands: quantifying trade-offs between flood risks, recreation and biodiversity conservation*. Environmental Economy and Policy Research Working Paper. University of Cambridge, Department of Land Economics.

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.

Brander, Luke M., and Mark J. Koetse. 2011. The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management* **92** (10): 2763–2773.

Broadmeadow, Mark, and Robert Matthews. 2003. *Forests, Carbon and Climate Change: the UK Contribution*. Edinburgh: Forestry Commission.

Christie, Mike, Tony Hyde, Rob Cooper, Ioan Fazey, Peter Dennis, John Warren, Sergio Colombo, and Nick Hanley. 2011. *Economic Valuation of the Benefits of Ecosystem Services delivered by the UK Biodiversity Action Plan*. Report to Defra. London: Aberystwyth University.

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.

CJC Consulting, Ken Willis, and Liesl Osman. 2005. *Economic Benefits of Accessible Green Spaces for Physical and Mental Health: Scoping study*. Final report for the Forestry Commission. Oxford.

Coder, R. D. 1996. Identified Benefits of Community Trees and Forests. University of Georgia. Available from <http://www.coloradotrees.org/benefits/Identified%20Benefits%20of%20Community%20Trees.pdf>.

Costanza, Robert, Ralph d' Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* **387** (6630): 253–260.

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>.

Defra. 2010. What nature can do for you - A practical introduction to making the most of natural services, assets and resources in policy and decision making. Department of Environment, Food and Rural Affairs. Available from <http://www.defra.gov.uk/environment/policy/natural-environ/documents/nature-do-for-you.pdf>.

Department for Children, Schools and Families. 2009. Time Series: Revenue and Capital Funding per School Pupil 1997-98 to 2010-11. Available from <http://www.dcsf.gov.uk/rsgateway/DB/TIM/m002012/NSRStatsJuneGDP140809.pdf http>.

Department of Health. 2011. *APHO Health Profiles for Birmingham*.

Department of Health. 2004. *At least five a week - Evidence on the impact of physical activity and its relationship to health*. A report from the Chief Medical Officer. Department of Health, Physical Activity, Health Improvement and Prevention.

Department of Health. 2009. *Be active, be healthy: a plan for getting the nation moving*. Available from <http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_094358>.

Dunse, Neil, Michael White, and Carolyn Dehring. 2007. *Urban parks, open space and residential property values*. RICS Research paper series. London: RICS.

EA. 2009. *River Tame Flood Risk Management Strategy - Non Technical Summary*. Environmental Report. Environmental Agency. Available from <http://www.environment-agency.gov.uk/static/documents/Research/Tame_Strategy_non_technical_summary.pdf>.

Edwards, Dawid, Anna Elliot, Max Hislop, Suzanne Martin, Jake Morris, Liz O'Brien, Andrew Peace, Vadims Sarajews, Maud Serrand, and Gregory Valatin. 2009. *A valuation of the economic and social contribution of forestry for people in Scotland*. Forestry Commission Research Report. Edinburgh.: Forestry Commission Scotland. Available from <http://www.forestry.gov.uk/pdf/fcrp101.pdf/$FILE/fcrp101.pdf>.

EFTEC. 2010a. *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>.

EFTEC. 2010b. *Valuing Environmental Impacts: Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal. Case Study 3 – Valuing Environmental Benefits of a Flood Risk Management Scheme*. Report submitted to Department for Environment, Food and Rural Affairs. London: EFTEC. Available from <http://www.defra.gov.uk/environment/policy/natural-environ/using/valuation/documents/case-study3.pdf>.

ERM, and Kenneth Willis. 2004. *Woodland - its contribution to Sustainable Development and the Quality of Life*. Report prepared for the Woodland Trust. Environmental Resources Management. Available from <http://www.woodlandtrust.org.uk/SiteCollectionDocuments/pdf/policy-and-campaigns/woods-for-people/qol.pdf>.

Evans, E., R. Ashley, J. Hall, E. Penning-Rowsell, A. Saul, P. Savers, C. Thorne, and A. Watkinson. 2004. *Foresight. Future flooding. Scientific Summary. Volume I: Future risks and their drivers*. London: Office of Science and Technology. Available from <http://www.bis.gov.uk/assets/bispartners/foresight/docs/flood-and-coastal-defence/vol1chapter2.pdf>.

Fallon, Peter. 2010. *Air Quality Annual Report 2009 for Birmingham*. Birmingham: Birmingham City Council.

Fleischer, Aliza, and Yacov Tsur. 2003. Measuring the Recreational Value of Open Space. *Journal of Agricultural Economics* **54** (2): 269–283.

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>.

Forestry Commission. 2010. Forestry Statistics 2010: A compendium of statistics about woodland, forestry and primary wood processing in the United Kingdom. Forestry Commission. Available from <http://www.forestry.gov.uk/pdf/ForestryStatistics2010.pdf/$FILE/ForestryStatistics2010.pdf>.

Garrod, Guy. 2002. *Social and environmental benefits of forestry phase 2: landscape benefits*. Report to the Forestry Commission. Centre for Research in Environmental Appraisal & Management University of Newcastle. Available from <http://www.forestry.gov.uk/pdf/fclscaperep.pdf/$FILE/fclscaperep.pdf>.

German Federal Environment Agency. 2008. *Economic Valuation of Environmental Damage – Methodical Convention for Estimates of Environmental Externalities*. Dessau-Rosslau: German Federal Environment Agency.

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.

GIVaN. 2011. *Building Natural Value for Sustainable Economic Development – The Green Infrastructure Valuation Toolkit User Guide*. Available from

<http://www.greeninfrastructurenw.co.uk/resources/Green_Infrastructure_Valuation_Toolkit_UserGuide.pdf>.

Grahn, Patrik, and Ulrika A. Stigsdotter. 2003. Landscape planning and stress. *Urban Forestry & Urban Greening* **2** (1): 1–18.

Haines-Young, R., and M. Potschin. 2008. *England's Terrestrrial Ecosystem Services and the Rationale for an Ecosystem Approach*. Full Technical Report.

Hanley, Nick, Ken Willis, Neil Powe, and Maggie Anderson. 2002. *Valuing the Benefits of Biodiversity in Forests. Social & Environmental Benefits of Forestry Phase 2*. Report to the Forestry Commission. Edinburgh: Centre for Research in Environmental Appraisal and Management, University of Newcastle upon Tyne. Available from <http://www.cbd.int/doc/case-studies/inc/cs-inc-uk7-en.pdf>.

Heerwagen, Judith H., and Gordon H. Orians. 1986. Adaptations to Windowlessness. *Environment and Behavior* **18** (5): 623 –639.

HM Government. 2011. *The Natural Choice: securing the value of nature*. Available from <http://www.official-documents.gov.uk/document/cm80/8082/8082.pdf>. . Accessed17 June 2011.

HM Treasury. 2003. *The Green Book: appraisal and evaluation in central government*. TSO, London. Available from <http://www.hm-treasury.gov.uk/d/green_book_complete.pdf>.

Ho, Ching-Hua, Laura Payne, Elizabeth Orsega-Smith, and Geoffrey Godbey. 2003. *Parks, recreation and public health: parks and recreation improve the physical and mental health of our nation. (Research Update).: An article from: Parks & Recreation*. National Recreation and Park Association. Available from <http://findarticles.com/p/articles/mi_m1145/is_4_38/ai_100960607/pg_4/>.

Hölzinger, Oliver. 2010. *Institutionenökonomische Analyse des Politikversagens beim Klimaschutz: Warum dem Marktversagen 'Klimawandel' ein massives Politikversagen 'Klimaschutz' entgegensteht*. VDM Verlag Dr. Müller.

Hölzinger, Oliver. 2011. *The Value of Green Infrastructure in Birmingham and the Black Country - The Total Economic Value of Ecosystem Services provided by the Urban Green Infrastructure*. Birmingham: The Wildlife Trust for Birmingham and the Black Country. Available from <http://ceep-online.co.uk/joomla/index.php/projects-a-publications/75-the-economic-value-of-green-infrastructure-in-birmingham-and-the-black-country>.

Hulme, Mark, and Gavin Siriwardena. 2010. *Breeding Bird Diversity as a Function of Land Cover*. UK NEA Economic Analysis Report.

Kaplan, Stephen. 1995. The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology* **15** (3): 169–182.

Kazmierczak, Aleksandra, and Jeremy Carter. 2010. *Adaptation to climate change using green and blue infrastructure - A database of case studies*. Manchester: University of Manchester.

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

Land Use Consultants, and GHK Consulting. 2009. *Provision of Ecosystem Services Through the Environmental Stewardship Scheme*. Bristol. Available from <http://www.hedgelaying.ie/images/1253357089.pdf>.

Land Use Consultants. 2002. *South West Woodland and Forestry Strategic Economic Study*. Final Report Prepared for the South West Regional Development Agency and the Forestry Commission. Bristol. Available from <www.southwestlandscapes.org.uk/download.asp?DocId=53>.

Lockwood, Michael, and Kathy Tracy. 1995. Nonmarket Economic Valuation of an Urban Recreation Park. *Journal of Leisure Research* **27** (2). Available from <http://js.sagamorepub.com/jlr/article/view/867>.

Lovasi, Gina Schellenbaum, James W Quinn, Kathryn M Neckerman, Matthew S Perzanowski, and Andrew Rundle. 2008. Children living in areas with more street trees have lower asthma prevalence. *Journal of Epidemiology and Community Health*. Available from <http://jech.bmj.com/content/early/2008/05/01/jech.2007.071894.abstract>.

Luther, M., and D. Gruehn. 2001. Putting a price on urban green spaces. *Landscape Design*.

Maltby, Edward, Steve Ormerod, Mike Acreman, Martin Blackwell, Isabelle Durance, Mark Everard, Joe Morris, et al. 2011. UK National Ecosystem Assessment of Freshwaters – Openwaters, Wetlands and Floodplain. In *The UK National Ecosystem Assessment Technical Report*. Cambridge: UNEP-WCMC.

McInnes, Rob. 2007. *Integrating ecosystem services within a 50-year vision for wetlands*. WWT Report to the England Wetland Vision Partnership. Slimbridge. Available from <http://www.wetlandvision.org.uk/userfiles/File/Annex2_EcosystemServicesScopingReport.pdf>.

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>.

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.

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.

Perino, Grischa, Barnaby Andrews, Andreas Kontoleon, and Ian Bateman. 2011. *Urban Greenspace Amenity - Economic Assessment of Ecosystem Services provided by UK Urban Habitats*. Report to the Economics Team of the UK National Ecosystem Assessment. Norwich: University of East Anglia.

Pitt, Michael. 2007. *Learning Lessons from the 2007 floods*. Interim Report. Available from <http://www.coulthard.org.uk/hullfloods/Pitts_interim_flood_report_web.pdf>.

Read, D. J., P. H. Freer-Smith, J. I. L. Morison, Nick Hanley, C. C. West, and P. Snowdon. 2009. *Combating climate change - a role for UK forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change*. The synthesis report. Edinburgh: The Stationery Offi ce. Available from <http://www.tsoshop.co.uk/gempdf/Climate_Change_Synthesis_Report.pdf>.

Regeneris. 2009. *The Economic Contribution of the Mersey Forest's Objective One-Funded Investments*. Final Report. Available from <http://www.merseyforest.org.uk/files/Economic%20Contribution%20of%20The%20Mersey%20Forest%27s%20Objective%20One-Funded%20Investments.pdf>.

Rskensr. 2003. *Business Case for the Environment Research Study: Summary of Principle Findings*.

Sazsalazar, S., and P. Rausell-Koster. 2008. A Double-Hurdle model of urban green areas valuation: Dealing with zero responses. *Landscape and Urban Planning* **84** (3-4): 241–251.

Scarpa, Riccardo. 2003. *The Recreation Value of Woodlands - Social & Environmental Benefits of Forestry Phase 2*. Report to the Forestry Commission. Edinburgh: Centre for Research in Environmental Appraisal & Management University of Newcastle. Available from <http://www.forestry.gov.uk/pdf/nmbrecrep.pdf/$FILE/nmbrecrep.pdf>.

Sport England. 2011. *Active People Survey 5*. Available from <http://www.sportengland.org/research/active_people_survey/active_people_survey_51.aspx>.

Stern, Nicolas. 2006. *Stern Review on The Economics of Climate Change*. London: HM Treasury. Available from <http://webarchive.nationalarchives.gov.uk/+/http://www.hm-treasury.gov.uk/stern_review_report.htm>.

Takano, T, K Nakamura, and M Watanabe. 2002. Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces. *Journal of Epidemiology and Community Health* **56** (12): 913 –918.

TEEB. 2010. *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB*. Available from

<http://www.teebweb.org/LinkClick.aspx?fileticket=bYhDohL_TuM%3D&tabid=924&mid=1813>.

Tinch, Rob, Dugald Tinch, and Stephanie Hime. 2010. *Scoping study into the use of recreational surveys for economic valuation*. London: EFTEC.

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.

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>.

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. 1984. View through a window may influence recovery from surgery. *Science (New York, N.Y.)* **224** (4647): 420–421.

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.

Vries, Sjerp de, Robert A Verheij, Peter P Groenewegen, and Peter Spreeuwenberg. 2003. Natural environments -- healthy environments? An exploratory analysis of the relationship between greenspace and health. *Environment and Planning A* **35** (10): 1717 – 1731.

Wang, Fan, Theadore Hunt, Ya Liu, Wei Li, and Simon Bell. n.d. *Reducing Space Heating in Office Buildings Through Shelter Trees*. Edinburgh: The Research Centre for Inclusive Access to outdoor environments, Edinburgh College of Art. Available from <https://www.cibse.org/pdfs/8cwang.pdf>.

Willis, Kenneth, Guy Garrod, Riccardo Scarpa, Neil Powe, Andrew Lovett, Ian J. Bateman, Nick Hanley, and Douglas C. Macmillan. 2003. *Social & Environmental Benefits of Forestry Phase 2: The Social and Environmental Benefits of Forests in Great Britain*. Report to Forestry Commission. Edinburgh: Centre for Research in Environmental Appraisal & Management University of Newcastle. Available from <http://www.forestry.gov.uk/pdf/sebreport0703.pdf/$file/sebreport0703.pdf>.

Wolf, Kathleen. 2003. Social Aspects of Urban Forestry: Public Response to the Urban Forest in Inner-City Business Districts. *Journal of Arboriculture* **29** (3): 117–126.

Woodland Trust. n.d. *Space for People: Targeting action for woodland access*. Available from <http://www.woodlandtrust.org.uk/en/about-us/publications/Documents/space-for-people-new.pdf>.

World Health Organization. 1948. Preamble to the Constitution of the World Health Organization. New York, United States of America.

10. Technical Appendix

10.1 Calculation of Wetland Benefits

To value the benefits provided by the wetland in Birmingham a value transfer function based on the findings provided by Brander et al. (2008) who calculated on the base of a meta-analysis including 78 European studies has been applied.

> *"A review of recent meta-analyses of wetland valuation concludes that Brander et al. (2008) provide the most appropriate benefit transfer function for the UK case."*[170]

The valuation techniques involved in the studies reviewed are hedonic pricing, the travel cost method, contingent valuation, choice experiments, market prices, net factor incomes, production functions, replacement costs as well as opportunity costs.[171] The applied meta-regression model was prepared to value wetland in Europe.[172]

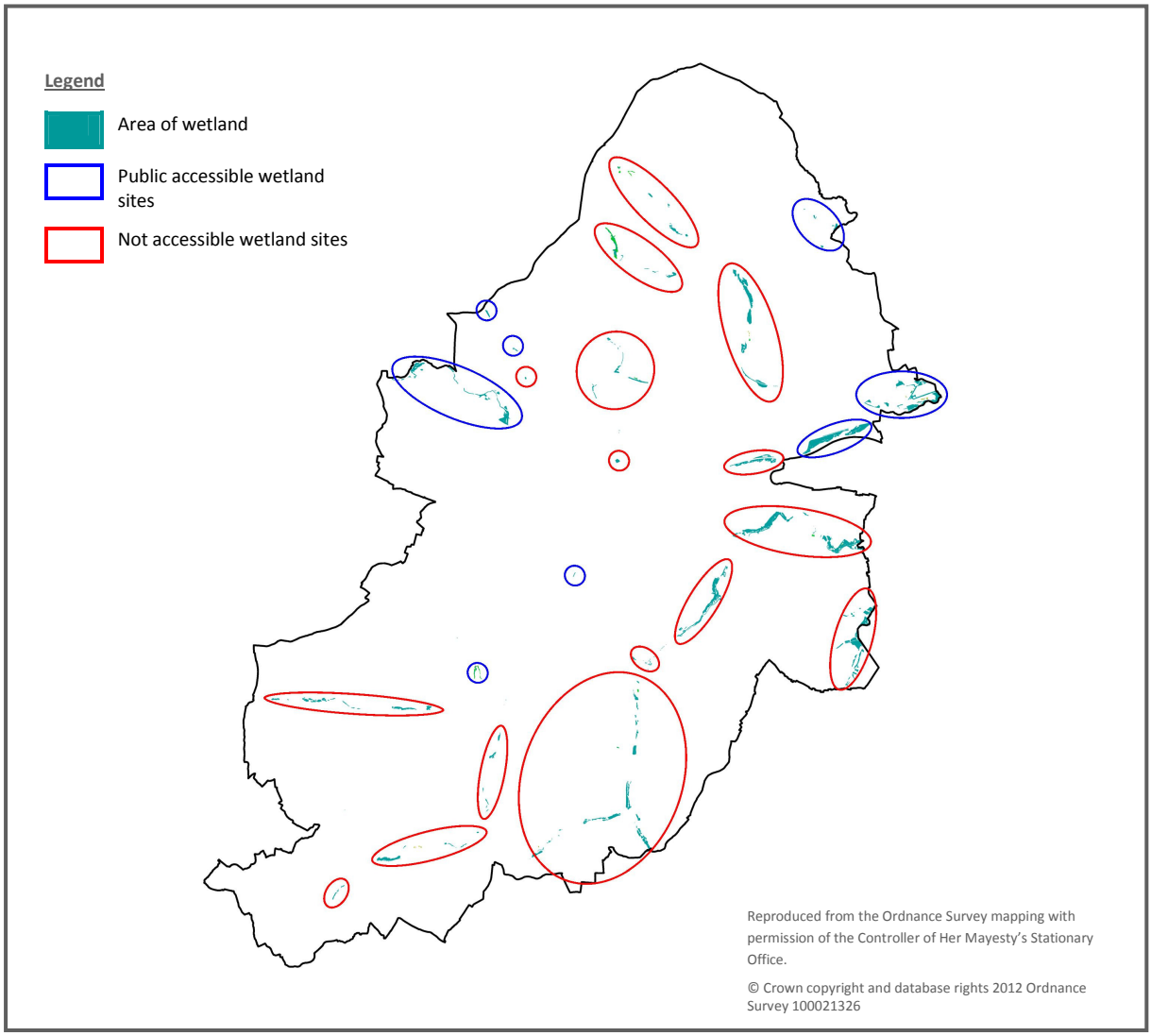
For the purpose of applying the value transfer function the whole area of wetland in Birmingham has been categorised as inland marsh. EFTEC for example applied that function before as well and categorised floodplain grazing marsh as inland marsh in their case study 'Valuing Environmental Benefits of a Flood Risk Management Scheme.'[173] The same function has also been applied to value services provided by wetland in the UK as part of the UK NEA.[174]

In Birmingham wetland habitats are highly fragmented. One practical problem was to estimate the size of the different wetland habitats. The size of a wetland has a significant influence on its value. To avoid over-estimation, polygons have been pooled within a close area, for example alongside a river. Map A1 below shows how the wetland sites were pooled. A map analysis regarding the connectivity between the sites results in 24 areas of wetland in this definition. The average wetland size per site is 8.3 ha.

[170] Hulme and Siriwardena 2010, 7.
[171] EFTEC 2010a, 125.
[172] Brander et al. 2008, 30.
[173] EFTEC 2010b.
[174] Maltby et al. 2011.

Another distinction has been made regarding the accessibility of sites. The underlying assumption is that ecosystem services such as recreation and aesthetic appreciation can only be experienced if the site is accessible. Because non-use values are explicitly excluded in the meta-analysis provided by Brander et al. (2008)[175] one has to imply that accessibility to the habitat is necessary to profit from the ecosystem service wild species diversity as well. Wetland sites which are predominantly located on public accessible land have been classified as accessible. Such eight sites provide significant higher values than non-accessible wetland sites.

Map A1 **Map Interpretation of Wetland Sites in Birmingham**



Source: ***GIS data provided by EcoRecord and Birmingham City Council***

[175] Brander et al. 2008, 33.

The Brander et al. (2008) value transfer function allows taking different socio-economic variables and context specific attributes into account. One variable is the population density. However, especially for access related ecosystem services (recreation, aesthetic appreciation and wild species diversity) the assumption has been made that the applied radius of 50 km^2 doesn't match the specific context of the highly urbanised area of Birmingham and would lead to a significant underestimation of the real value. Therefore, only for theses services the population density within a smaller area has been applied. Table A1 below outlines how the Brander et al. (2008) benefit transfer function has been applied as well as corresponding assumptions.

Table A1 Value Function and Corresponding Assumptions

Variable	Coefficient value	Value of explanatory variable	Comment
Constant a	-3.078	1	
Wetland type: Inland marsh	0.114	1	
Wetland size:	-0.297	*ln* 8.3	Average size of wetland sites
Flood risk reduction and storm buffering:	1.102	1	These services are occurring independently from accessibility of the site.
Water quality improvement:	0.893	1	
Surface and ground water supply:	0.009	1	
Biodiversity (wild species diversity):	0.917	0/1	These services only occur of the wetland site is accessible. Therefore the variable has only been applied for accessible sites. Note that recreational fishing has a negative influence on the total value.
Recreational fishing:	-0.288	0/1	
Non-consumptive recreation:	0.340	0/1	
Amenity and aesthetic services:	0.452	0/1	
GDP per capita (2003 US$):	0.468	*ln* 30,320	GDP is approximated from the West Midlands Unitarian level with €26,500 (NUTS 2 level, source: EuroStat). Converted to 2003 US$ using OECD purchasing power parity (PPP) exchange rates (factor 0.87) this results in US$30,320.
Population density per km^2 within 50 km:	0.579	*ln* 420 /*ln* 1,392	Simplifying the weighted average population density of 1,392 for the area of Birmingham as well as surrounding local government districts (Lichfield, North Warwickshire, Dudley, Sandwell, Solihull, Walsall, Bromsgrove and Wyre Forest) with a total area of 1761 km2 have been applied to calculate values for recreation, aesthetic appreciation and wild species diversity only. For all other services the population density of 420 for the West Midlands region (12998 km2) has been applied.
Wetland area within 50 km:	-0.023	*ln* 3,000	Considering the marginal influence on the result it has conservatively been allowed a generous wetland area of 3,000 ha within 50 km radius of each wetland site.

Source: ***Brander et al (2008) and own assumptions/calculations (see also comments within the table).***

Applying the value function for the different scenarios[176] the annual value of ecosystem services provided by wetland in Birmingham can be valued at £379,000. Please note that this is the totalised marginal value rather than the totalised average value. The marginal value describes a marginal loss (extend) of the total area of habitat. In this case it has been valued for a loss of ten percent of wetland. With £798,000 the total average annual value of wetland in Birmingham is much higher. However, there is no realistic policy scenario where all wetland in Birmingham would be destroyed. Therefore stating the marginal value is more sensible.

In the next step the amount attributable for each ecosystem service can be approximated. This step is not necessary but to maintain consistency within this survey it is important. By setting every variable standing for an ecosystem service to equal zero and viewing the difference in the sum, an estimation can be made of the attributable value for each benefit.[177] For the sensitivity analysis, uncertainties regarding the estimations taken, as well as the scientific evidence, have been considered. In general a range of 40 percent has been applied. In addition another 30 percent have been added for the services biodiversity, recreation and aesthetic appreciation. The wider range for latter services has been applied because the context-specific variables (population density) were changed in the value transfer function. As noted before in section 5.3 the uncertainties for flood risk reduction and storm buffering are generally higher because they are more context-specific. Regarding this circumstance a range of 60 percent has been applied for this ecosystem service. All findings are summarised in Table 7.1 and 7.2.

[176] With and without recreational-, aesthetic- and biodiversity benefits as well as with the higher and lower population density.
[177] The negative influence of recreational fishing has been distributed equally to recreation+amenity and biodiversity.

10.2 Calculation of Benefits Provided by BAP Priority Habitats

To calculate ecosystem services provided by BAP priority habitats findings of a study of *"The Economic Valuation of the Ecosystem Service Benefits delivered by the UK Biodiversity Action Plan"*[178] have been recalculated for the purpose of this investigation. The aim of that primary valuation research study was to estimate the value of changes in biodiversity and associated ecosystem services which will result directly from the delivery of the UK Biodiversity Action Plan (UK BAP). Specific objectives were to assess the marginal value of ecosystem services per habitat associated with the UK BAP and the marginal value of conservation activities associated with different scenarios.

The values have been calculated in two steps. In a first step a choice experiment has been conducted to determine the values people place on ecosystem services delivered the UK BAP. Choice experiments are surveys that present people with different policy scenarios, where scenarios are described in terms of different environmental characteristics and different 'prices'. Analysis of people's choices for these scenarios allow to understand the value associated with the different scenarios.

In a second step a weighting matrix has been produced that evaluates the proportion of ecosystem service provision related to habitat and ecosystem service (group). Experts were asked to identify the relative levels of ecosystems services delivered by the habitats they were most familiar with across 19 broad BAP habitats. These results were then pooled. Experts were also asked to identify the proportion of ecosystem services that were directly attributed to BAP conservation activities. Main outcome was the marginal change of ecosystem services provided by different BAP priority habitats in relation to different scenarios. [179]

Even if the data implies some caveats it has been judged sufficient robust enough to 'fill the gaps' within this investigation. The study results have been applied in cases where no other robust primary valuation data was available.

[178] Christie et al. 2011.
[179] Ibid., 11.

For purpose of this investigation the marginal change of ecosystem services related to land use changes was crucial. Therefore the values for a marginal change in conservation activities had to be recalculated. Fortunately the data allowed this step.

In a first step the marginal change from scenario D (UK with BAP, but no further spending) to scenario A (full delivery of the UK BAP)[180] have been calculated by adding the values from table C30[181] and C31. Below an example for the aggregate value of 'wild food' benefits provided by native woodland has been outlined to clarify the calculation.

£8.33m + £9.77m = £18.10m

In a next step the non-marginal WTP associated with scenario D has been calculated. The marginal value from above has been divide by the weighting score (Table C26) for 'additional service due to BAP' and then multiply by the 'services without BAP'.

£18.10m / 0.063 * 0.318 = £91.36m

Following that the average value of the current level of ecosystem services provided by BAP priority habitats has been calculated by adding up the WTP associated with scenario D and the marginal value for the current spent scenario (change from scenario D to C; Table C31).

£91.36m + £9.77m = £101.13m

In a last step the average value per hectare could have been calculated by dividing the total value by area of habitat from Table C56.

£101.13m / 1,059,180 = £95.48

This value reflects the annual value per hectare of ecosystem services provision (in this example 'wild food' provided by native woodland). The values have been summarised in table A2.

[180] Ibid., 33.
[181] Tables with the 'C' refer to tables in Christie et al. (2011)

Table A2 **Annual value per hectare of ecosystem services provision**

	Lowland dry acid grassland			Lowland meadows			Purple moor-grass and rush pastures			Lowland heathland		
	Within + outside own region	Within own region	Outside own region	Within + outside own region	Within own region	Outside own region	Within + outside own region	Within own region	Outside own region	Within + outside own region	Within own region	Outside own region
Marginal per ha (£ p.a.)												
Wild food	£1	£0	£1	£27	£14	£13	£104	£56	£48	£17	£9	£8
Non-food products	£3	£1	£2	£60	£22	£38	£104	£37	£67	£19	£7	£12
Climate regulation	£0	£0	£0	£113	£45	£69	£377	£146	£230	£208	£81	£127
Water regulation	£0	£0	£0	£171	£61	£110	£359	£126	£232	£310	£110	£200
Sense of place	N/A	N/A	N/A	£180	£92	£88	N/A	N/A	N/A	£243	£124	£119
Charismatic species	N/A	N/A	N/A	£330	£145	£186	£297	£129	£167	£451	£196	£255
Non-charismatic species	£28	£28	£0	£102	£102	£0	£65	£65	£0	£117	£117	£0

	Coastal and floodplain grazing marsh			Fens			Wet reedbeds			Native woodland		
	Within + outside own region	Within own region	Outside own region	Within + outside own region	Within own region	Outside own region	Within + outside own region	Within own region	Outside own region	Within + outside own region	Within own region	Outside own region
Marginal per ha (£ p.a.)												
Wild food	£31	£16	£15	£134	£69	£65	£67	£36	£31	£96	£50	£45
Non-food products	N/A	N/A	N/A	£73	£27	£46	£113	£42	£71	£165	£60	£105
Climate regulation	£329	£129	£200	£471	£187	£284	£572	£225	£347	£614	£240	£373
Water regulation	£571	£202	£369	£539	£193	£346	£627	£223	£404	£461	£164	£298
Sense of place	£206	£105	£101	N/A	N/A	N/A	£176	£90	£86	£265	£135	£130
Charismatic species	£375	£163	£212	£159	£70	£89	£293	£129	£165	£429	£187	£242
Non-charismatic species	£93	£93	£0	£137	£137	£0	£63	£63	£0	£115	£115	£0

Source: ***Christie et al. 2011 & own calculations***

The values for green infrastructure have been derived from the UK values rather than the values calculated for the West Midlands Region. Crucial for this decision was the bigger sample size for the choice experiment as well as the higher degree of accuracy of habitat data used in the main study. However, just applying average per-hectare values wouldn't match the specific circumstances of the urban green infrastructure. Therefore additional assumptions have been made for each ecosystem service (category).

Wild food

In Christie et al. (2011) 'wild food' is defined as *"non-rare food products that people might gather / hunt from nature"*.[182] Agricultural food production on farms is not included. A direct link between the provision of habitat and wild food provision has been assumed. However, this ecosystem service is more related to rural rather than urban areas. Even if some food products might be extracted from urban BAP habitats the proportion can be assumed to be minor. Therefore this service hasn't been evaluated within this investigation.

[182] Christie et al. 2011, 121.

Non-food products

In this section natural products such as timber for firewood and plants, fibre cones etc. for educational and artistic purposes are covered. However, as for wild food this applies predominantly for habitats on the countryside. Therefore it has been excluded from the valuation exercise as well to ensure sufficient conservative and robust figures.

Climate regulation

As mentioned earlier the climate regulation benefits provided by green infrastructure in Birmingham will be calculated within scope of a separate investigation including the i-Tree analysis.

Water regulation (flood regulation)

Within the Christie et al. (2011) study 'water regulation' describes flood risk reduction. Impacts on water quality or water provision are not covered within this category.[183] It is arguable that BAP habitats benefit flood risk reduction. We have explained this effect in section 5.3 for wetland habitats. However, apart from wetland other habitats contribute to flood risk reduction as well. We assume that the contribution of BAP habitats to flood risk reduction is directly related to the amount of habitat area. This can be seen as a conservative assumption because the distance of habitats to properties under risk of flooding is important as well and the proportion of households under risk of flooding per km^2 in Birmingham is higher than in the UK average.

To calculate the flood regulation benefits provided by woodland, heathland and BAP priority grassland habitats the WTP estimate per ha (Table A2) has been adjusted to 2011 prices and then multiplied by the area of habitat. For the sensitivity analysis a range of 70 percent has been applied.

[183] Ibid., 126.

Table A3 **Flood regulation benefits provided by BAP priority habitats**

	Woodland	Heathland	BAP Priority Grassland
Area of Habitat	1528 ha	310 ha	70 ha
Annual WTP per ha (2009 prices)	*£461.18*	*£309.56*	*£0.00-£358.62*
Annual WTP per ha (2011 prices)	£497.81	£334.15	£0.00-£387.10
Annual value	**£761,000**	**£104,000**	**£12,000**

Source: ***Christie et al. 2011 & own calculations***

Sense of place (cultural services)

In the Christie et al. investigation the category 'sense of place' captures all cultural services such as aesthetic, spiritual, educational and recreational benefits. However, we exclude 'educational benefits' in the definition of this investigation where only organised school and nursery trips are covered. The overlaps can be assumed to be minor. Because for Birmingham there are no robust figures about the quality of habitats available we assume that it is the same proportion of habitat in favourable condition as in the UK average. Therefore no further adjustments regarding the quality are necessary.

Here assuming a direct relation between area of habitat and value would result in a crude undervaluation because especially cultural values are strongly related to the number of people who can locally benefit from such services.[184] To take this factor into account the average value per hectare has been adjusted by the population density. In absence of alternatives the average value per hectare has been divided by the average population density per km^2 in the UK (255.6/km^2) and then multiplied by the average population density in Birmingham (3739/km^2). This approach can be judged as sufficient robust proxy. However, this approach has only been applied for the value 'within own region'. For the WTP stated for 'outside own region' it can be estimated that this value is more related to non-use values and therefore not related to the population density. Therefore just the average value per hectare has been applied for latter.[185] Because the degree accuracy of assumptions made is comparatively low a range of 85 percent has been applied for the sensitivity analysis.

[184] See also Church et al. 2011.

[185] Because of data availability issues for 'BAP priority grassland' only Lowland Meadows have been taken into account. However, this category covers more than 90 percent of the BAP priority grasslands.

Table A4 **Cultural services provided by BAP priority habitats**

	Woodland	Heathland	Lowland meadows
Area of Habitat	*Has been calculated separately*	310 ha	63 ha
Annual WTP per ha 'within own region' (2011 prices)		£133.91	£99.29
Population density UK (people/km^2)		255.6	255.6
Population density Birmingham (people/km^2)		3739.0	3739.0
Annual WTP per ha 'within own region' in Birmingham(2011 prices)		£1,958.92	£1,452.49
Annual WTP per ha 'outside own region' (2011 prices)		£128.30	£95.15
Annual value		**£648,000**	**£10,000**

Source: ***Christie et al. 2011 & own calculations***

Charismatic and non-charismatic species (wild species diversity)

Christie et al. made a distinction between 'charismatic species' and 'non-charismatic species'. Former include terrestrial mammals, birds, amphibians, reptiles, butterflies, and moths. Latter incorporate vascular plants, non-vascular plants, terrestrial invertebrates (excluding butterflies and moths), and fungi (including lichens).[186] Not surprisingly the WTP for 'charismatic species' is significant higher than for 'non-charismatic species'.

To keep consistency within this investigation the two categories have been combined as 'wild species diversity'. In absence of alternatives the assumption has been made that this ecosystem service directly relates to the area of habitat. Table A5 summarises the calculation.[187]

Table A5 **'Wild species diversity' benefits provided by 'other habitats'**

	Woodland	Heathland	BAP Priority Grassland
Area of Habitat	*Has been calculated separately*	310 ha	70 ha
Annual WTP per ha for 'charismatic species' (2011 prices)		£486.59	£320.07-£356.47
Annual WTP per ha for 'non-charismatic species' (2011 prices)		£126.09	£30.11-£109.83
Annual value		**£190,000**	**£30,000**

Source: ***Christie et al. 2011 & own calculations***

[186] Christie et al. 2011, 131.

[187] Because of data availability issues the value for 'charismatic species' of dry acid grassland couldn't have been calculated. However, the effect on the sum is minor.

All findings have also been outlined in the referring chapters of the main report as well as the summary tables.

10.3 Steering Group

The report to hand and the investigation as a whole has been supported by a Steering Group bringing together experts from academia and practitioners. The authors would like to take this opportunity to thank all members for their valuable contributions to the project. The members of the Steering Group and referring organisations are outlined below (in alphabetic order):

Jaqueline Ashdown	National Health Service
Sara Carvalho	EcoRecord
Rachel Curzon	Birmingham City University
Nicola Farrin	Birmingham City Council
Chris Parry	The Wildlife Trust for Birmingham and the Black Country
Amanda Patterson	Environment Agency
Kyle Stott	National Health Service
Tim Sunderland	Natural England
Emma Woolf	Friends of Cotteridge Park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