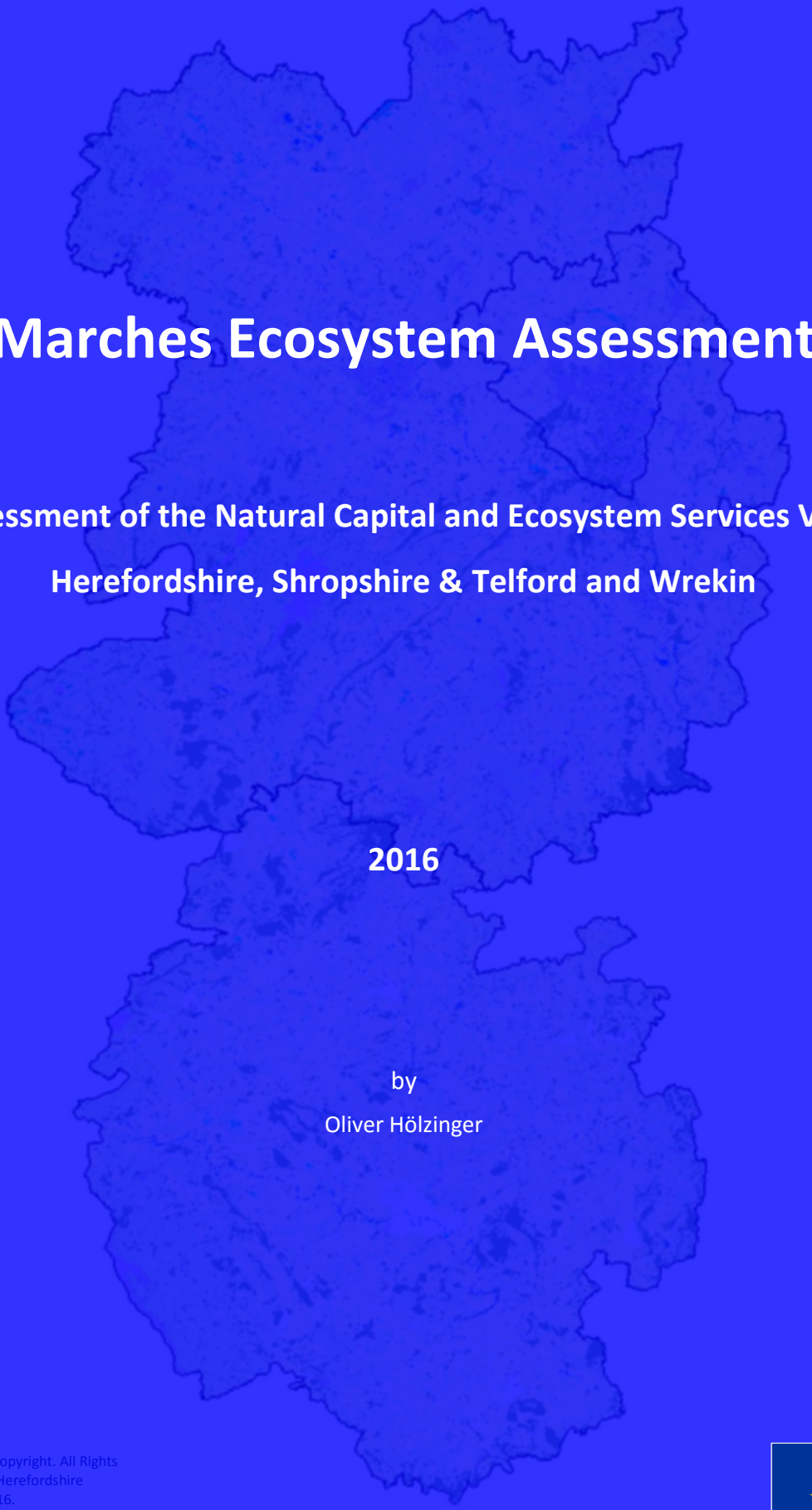

Marches Ecosystem Assessment

An Assessment of the Natural Capital and Ecosystem Services Value in Herefordshire, Shropshire & Telford and Wrekin

2016

by

Oliver Hölzinger

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An Assessment of the Natural Capital and Ecosystem Services Value in Herefordshire, Shropshire & Telford and Wrekin

June 2016

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I. Executive Summary

Aim of the project was to establish a robust and evidence-based Ecosystem Assessment for The Marches covering the geographical areas of Herefordshire, Shropshire and Telford and Wrekin. This is an assessment of the value of Natural Capital and ecosystem services. Natural Capital is the stock of natural ecosystems that yields a flow of valuable ecosystem services into the future.[1] Ecosystem services are the benefits people obtain from ecosystems such as food, timber, aesthetic and recreational opportunities including related health benefits, climate, water quality and flood regulation, and many more. Basically it is an assessment of what nature does for us humans.[2]

Ecosystems and their services have been degraded and declined in recent decades. To slow or halt further Natural Capital loss it is important to better acknowledge the real value of such services in policy and decision-making. Here, only 'external' values of ecosystem services that usually do not have a market price were included because these are the values that are still commonly ignored, undervalued and taken for granted in decisions affecting them such as in planning. Services that do have a market price such as food and timber were not included within the assessment scope.

The calculations resulted in a total Natural Capital value of £14.8 billion, stating the central estimate. This value is made up of the estimated stock value of carbon stored in ecosystems and corresponding soils (£7.2b) and the capitalised value of ecosystem services flows over 25 years (£7.5). The annual flow of ecosystem services was valued at £358.1 million. The findings, including a break-down for Herefordshire, Shropshire and Telford and Wrekin, are summarised in Table I.1 and Table I.2 below. For more detailed findings see Chapter 6.

[1] Costanza 2008.
[2] Millennium Ecosystem Assessment 2005.

Table I.1 Capitalised Baseline Value of Assessed Ecosystem Services in The Marches

	Assessment Area	Herefordshire			Shropshire			Telford and Wrekin			TOTAL		
	Assessed Habitat Area	110,192 ha			171,878 ha			8,423 ha			290,494 ha		
Ecosystem Service		High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low
Provisioning Services	Wild Food	£106	**£31**	£8	£117	**£34**	£10	£12	**£3**	£1	£234	**£69**	£19
	Ornamental Resources & Non-food Products	£190	**£39**	£11	£208	**£42**	£12	£20	**£4**	£1	£419	**£85**	£24
	Water Supply	£0	**£0**	£0	£1	**£0**	£0	£0	**£0**	£0	£1	**£0**	£0
Cultural Services	Wild Species Diversity	£1,851	**£404**	£164	£3,241	**£647**	£262	£299	**£34**	£14	£5,391	**£1,085**	£440
	Recreation & Aesthetic Values	£464	**£259**	£111	£1,050	**£544**	£240	£495	**£282**	£129	£2,010	**£1,086**	£479
	Health	£1,364	**£852**	£451	£2,329	**£1,536**	£903	£1,074	**£700**	£403	£4,767	**£3,088**	£1,757
	Productivity	£182	**£118**	£67	£366	**£237**	£134	£156	**£101**	£57	£704	**£456**	£259
Regu-lating	Flood Regulation	£1,326	**£656**	£160	£1,849	**£915**	£223	£121	**£60**	£15	£3,296	**£1,631**	£397
	Water Quality Regulation	£4	**£2**	£1	£45	**£25**	£10	£5	**£3**	£1	£54	**£30**	£12
TOTAL		£5,488	**£2,362**	£972	£9,206	**£3,981**	£1,794	£2,182	**£1,188**	£620	£16,876	**£7,531**	£3,387

Notes:
All values are stated in million pounds (£m); 2015 prices.
The capitalised value represents the present value of ecosystem services provided over a time period of 25 years.
Where monetary values have been calculated this may only cover a proportion of the full value of the ecosystem service.

Legend:
Central Central estimate
High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

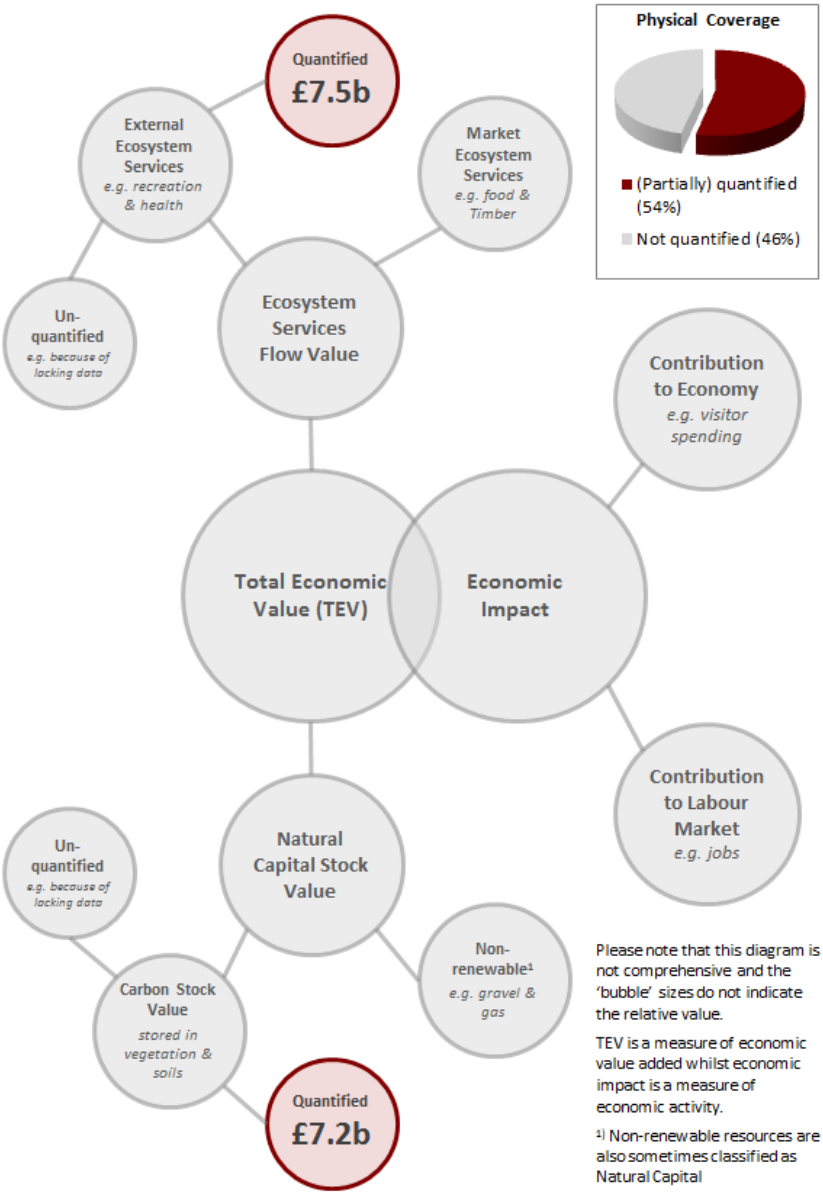
Table I.2 Carbon Stock Value in The Marches

		Assessed Area	Carbon Stock	**Stock Value**
Carbon	Herefordshire	110,192 ha	12,010,117 t	**£2,749m**
	Shropshire	171,815 ha	18,389,081 t	**£4,209m**
	Telford and Wrekin	8,423 ha	1,217,359 t	**£279m**
	Total Marches	290,431 ha	31,616,557 t	**£7,236m**

Source: ***Author calculations***

These figures should be interpreted as baseline value of 'non-market' ecosystem services in The Marches. Many ecosystem services could not be valued for example because of lacking or missing valuation evidence. It should also be acknowledged that often only an element of an ecosystem service could be valued which means that stated values often still understate the total value. Other elements of Natural Capital such as the value of geodiversity or non-renewables were also excluded. It is important that these values are not ignored. Figure I.1 below shows what is (and probably more important what is not) included within scope of this Marches Ecosystem Assessment.

Figure I.1 Assessment Scope

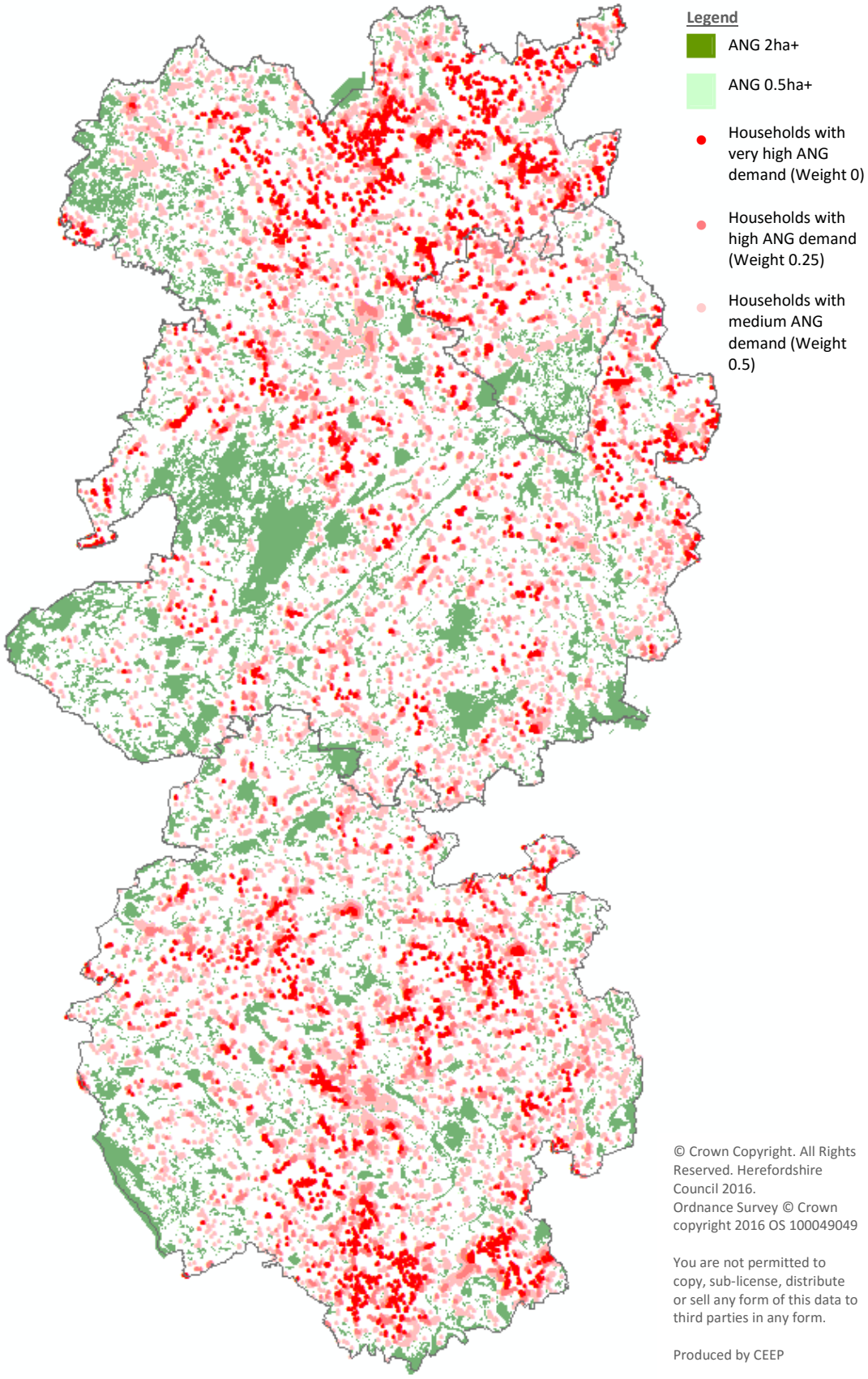


Source: ***Author***

An ANGSt+[3] assessment analysing the supply and demand for Accessible Natural Greenspace (ANG) in The Marches was also developed (see Chapter 5). Figure I.2 below identifies areas that are likely to benefit most from the creation of additional ANG (or providing access to existing so far inaccessible natural greenspace). In The Marches 195,509 households (63% of total) have access to ANG of at least 2 ha in size within 300m and therefore fulfil the ANGSt. About 4% of households (11,746) have no access to ANG of at least 2 ha within 900m nor do they have access to smaller ANG of between 0.5ha and 2ha within 600m.

[3] This is an advancement to Natural England's Accessible Natural Greenspace Standard (ANGSt).

Figure I.2 Demand for additional ANG: Marches ANGSt+



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Source: ***Based on GIS data provided by Shropshire County Council, SWT, HBRC and Natural England***

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1. Introduction and Background

1.1 Project Aims and Objectives

Aim of the project was to establish a robust and evidence-based Ecosystem Assessment for The Marches covering the geographical areas of Herefordshire, Shropshire and Telford and Wrekin. Specific project objectives included:

- The mapping and assessment of The Marches Natural Capital and ecosystem services,
- The economic quantification of those ecosystem services that do not have a market price and are therefore often undervalued and ignored,
- The monetary assessment of the health benefits of 'green exercise' within The Marches applying the WHO Health Economic Assessment Tool (HEAT), and
- An assessment of supply, demand and opportunity for accessible natural greenspace (ANGSt+) within The Marches.

The project also included the preparation of two audience-specific evidence summaries for health and business professionals which were published separately.

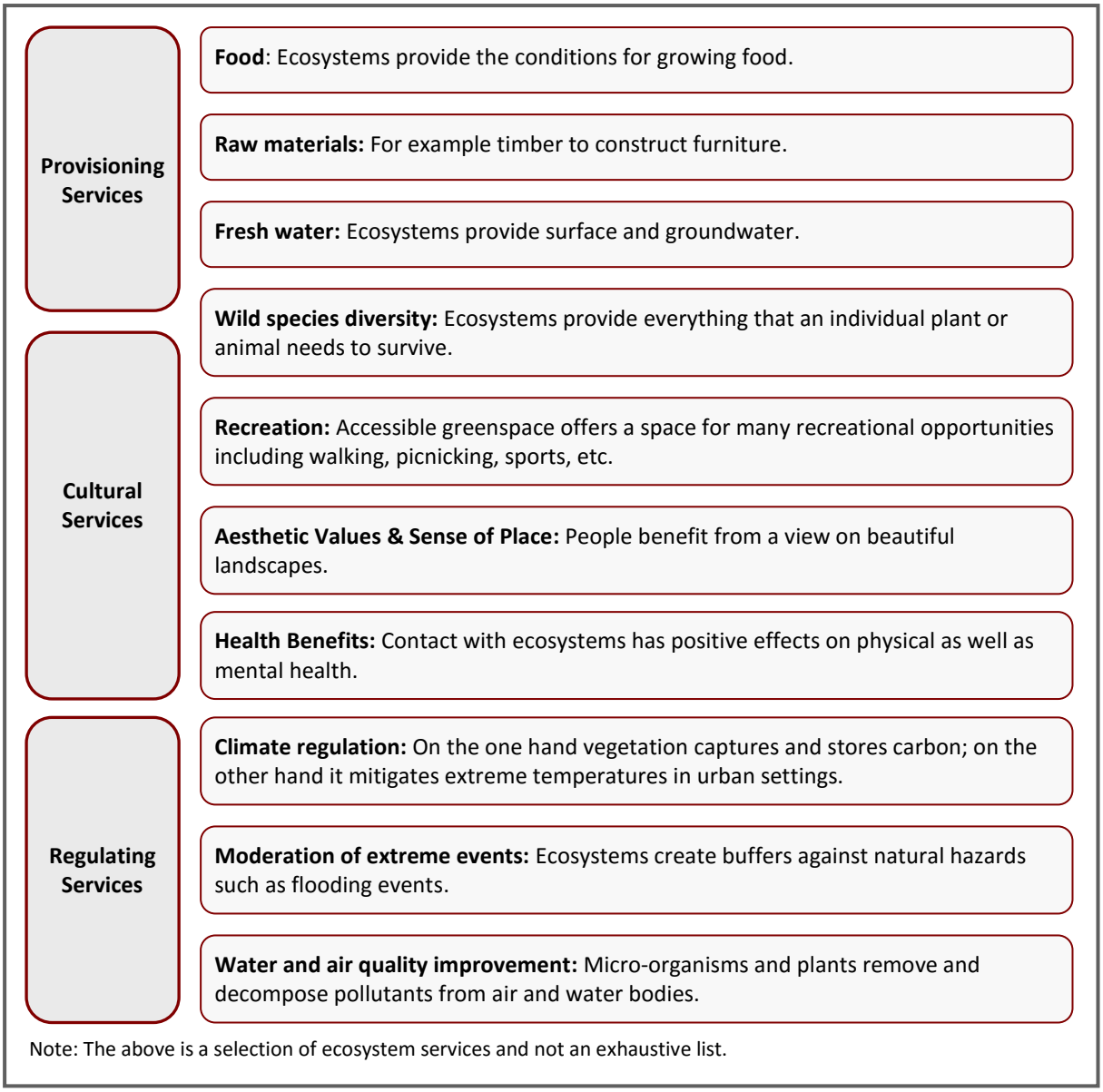
1.2 Introduction to Natural Capital, Ecosystem Services and Ecosystem Valuation

The natural environment surrounding us is not just a 'nice to have' but absolutely crucial for our human wellbeing and health. Ecosystems such as for example a water catchment, a forest or even a single tree provide us with many goods and services including food, timber, space for recreation, a pleasant amenity, water and air quality regulation functions, climate regulation benefits, and many more. These goods and services we gather or receive from nature are called ecosystem services. Ecosystem services are commonly defined as *"the benefits people obtain from ecosystems"*[4] and many ecosystem services in the UK are already in a degraded and/or declining status[5]. For more examples for ecosystem services

[4] Millennium Ecosystem Assessment 2005.
[5] UK NEA 2011b.

see Figure 1.1 below. The following Sections of this report outline the ecosystem services assessed within this report in greater detail.

Figure 1.1 Examples of Ecosystem Services



Source: ***TEEB, 2010 and UK NEA, 2011.***

The decline of Natural Capital means that we cannot keep on taking such ecosystem services for granted anymore – ecosystem services and Natural Capital which is *"the stock of natural ecosystems that yields a flow of valuable ecosystem goods or services into the future"*[6] needs to be actively managed to secure a sustainable service flow; and ultimately our own human wellbeing.

Ecosystem services do not present the value of ecosystems for their own sake (intrinsic value). Rather they reflect the benefits (and in some cases disbenefits) to human wellbeing and are therefore based on an anthropocentric approach. Choosing this approach should not be interpreted as undermining or neglecting intrinsic values of nature. The two concepts are not mutually exclusive but rather additive. However, the anthropocentric approach is the only practicable approach for quantification because *"non-anthropocentric value is, by definition, beyond any human knowledge."*[7] And we should note that the anthropocentric approach can also include existence or non-use values[8], option-use values[9] and bequest values[10].

It should also be acknowledged that ecosystem services are usually not solely based on ecological processes. Recreational benefits, for example, also depend on human inputs such as the landscape management) as well as for example the geodiversity shaping the landscape. Geodiversity and sub-soil assets including non-renewable resources such as gas and gravel are also included in some Natural Capital definitions.[11] There is not one universally accepted definition of Natural Capital. But because non-renewable resources usually have a market price they are not within scope of this assessment. However, sometimes, as for the recreation example above, such non-ecological benefits are indeed included in the ecosystem services value and should be recognised even if they are not explicitly assessed in the following chapters. It is clear that if there are changes to the geology and geodiversity in an area then this will also impact on ecosystem services. See also

[6] Costanza 2008.
[7] Defra 2007, 12.
[8] You might never be able to see a whale in nature, but you can nevertheless benefit from the pure existence of whales and have a preference for protecting them.
[9] You might never see a whale in nature, but you can benefit from the option to see whales in the future.
[10] You might never see a whale in nature, but you can benefit from the option of future generations being able to see whales.
[11] See for example Natural Capital Committee 2013.

Figure 1.6 for a clear definition of the assessment scope and how it relates to other elements of the environment that were not assessed. For more information about the value of geodiversity see for example the English Geodiversity Forum.[12]

For some ecosystem services such as food and timber it is comparatively easy to work out the value because they are traded on markets and therefore have a market price which indicates the value. But many ecosystem services do not have a market price. We do not have to pay trees (or those who planted them) for cleaning the air we breathe or an entrance fee for accessing a park, for example. If others provide these services we can benefit as 'free-rider' without paying. However, if no one pays for such ecosystem services there is also no incentive for others to provide such services in an unregulated market because they would not be paid for planting trees or managing a park. And because there is no payment there is also no market price which could indicate the value of such services.

But 'no price' does not mean 'no value'. This can be clarified using a simple example. The price for the air we breathe is zero but without air we would not be able to survive which means that clean air is clearly of high value to us.

> *"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."*[13]

Having no price or explicit quantified value for ecosystem services often results in the misjudgement that such ecosystem services are self-evident or without value. The high complexity of ecosystem interactions makes their value even more intangible and reinforces a tendency to neglect them.

[12] http://www.englishgeodiversityforum.org/
[13] UK NEA 2011b, 1072.

> *"Because ecosystem services are largely outside the market and uncertain, they are too often ignored or undervalued…"*[14]

This undervaluation commonly results in degradation of the ecosystems that provide these services, leading in turn to a progressive undersupply, and finally to a decline of overall human wellbeing.

In principle this 'market failure' leading to an undersupply with ecosystem services should be compensated for by governmental institutions and regulations. However, decisions – not only affecting the environment – have to cope with trade-offs and are very often based on cost-benefit deliberations generally related to more immediately marketable outcomes. In a case where the benefits of one 'grey' engineered policy option is comparatively clear and tangible and of the other 'green' policy option being less certain and tangible, a justification of the first option is much easier and more defendable.

> *"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."* (HM Treasury 2003, 57)

Economic valuation of ecosystem services serves to mitigate this information bias, and also makes the value of services provided by ecosystems more tangible for non-specialists which generates awareness for such benefits. This in turn supports more sustainable decision-making by better implementing formerly overlooked values into decision-making.

There are two main approaches to reveal the value of non-market ecosystem services. Sometimes the ecosystem value is contained within a market price (revealed preferences). This is for example the case for flood risk regulation. One can calculate the amount of water stored by a grassland patch in a flooding event. It can be modelled how much damage this amount of water would have caused e.g. to properties and infrastructure if that natural water storage capacity would not be available. These avoided damage costs reflect the value of the flood risk regulation service of the grassland patch. Another method to reveal the

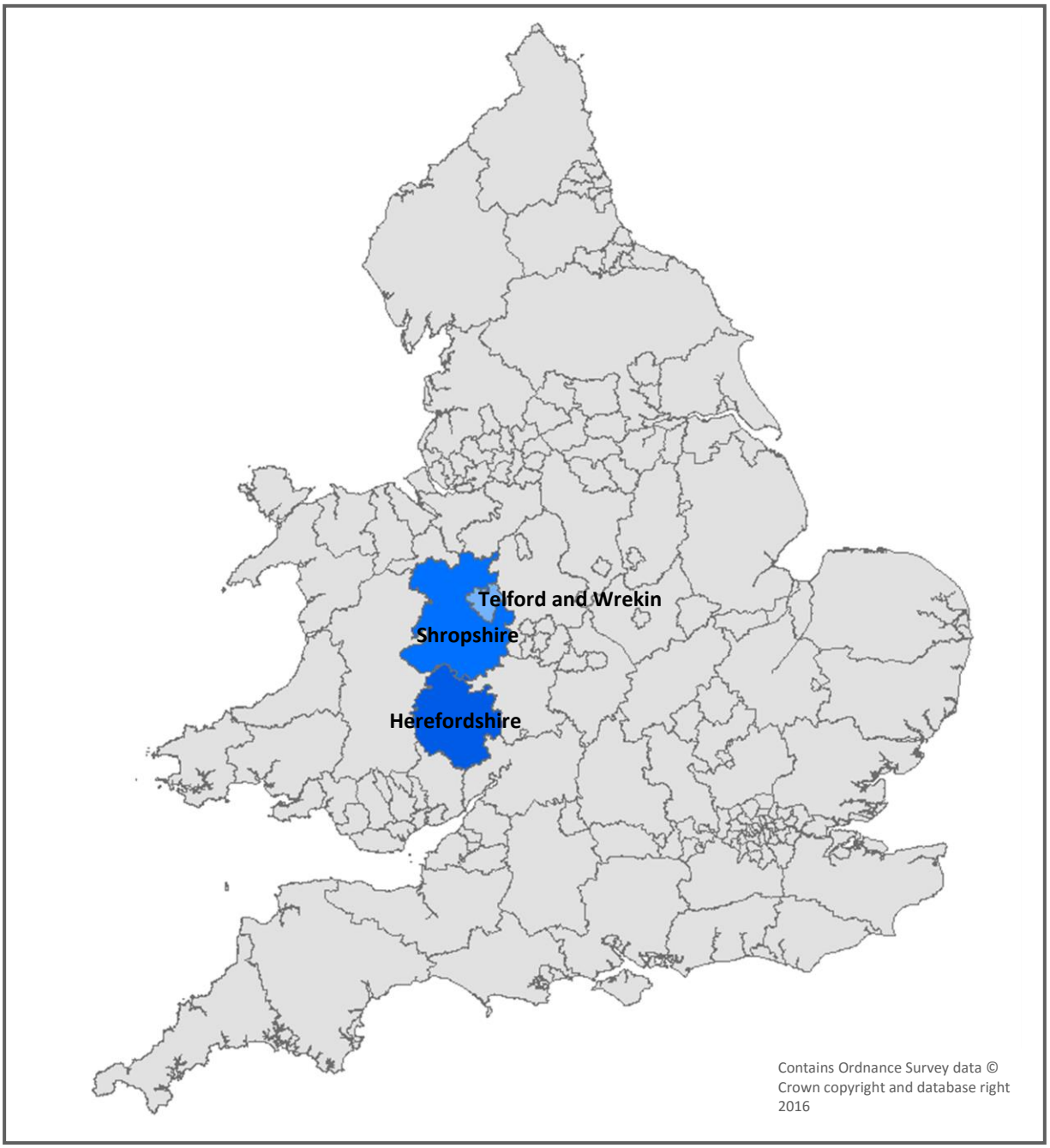
[14] Costanza et al. 1997, 269.

value of ecosystem services is by simply asking people what they would be willing to pay if there was a market (stated preferences). One can for example ask people what they would be willing to pay to access a park if there was an entrance fee. This is the kind of research this assessment is based on.

1.3 The Marches and its Natural Capital

The Marches is situated in the West Midlands Region of England, west from Birmingham, sharing a border with Wales. The Marches includes the Counties of Herefordshire and Shropshire as well as the Borough of Telford and Wrekin. The Marches covers an area of 5,676 km^2 and had a total population of about 669,000 in 2015. With a population density of 118 people per km^2 The Marches is one of the less populated areas of England.

Figure 1.2 **Where is The Marches?**



Source: ***Ordnance Survey***

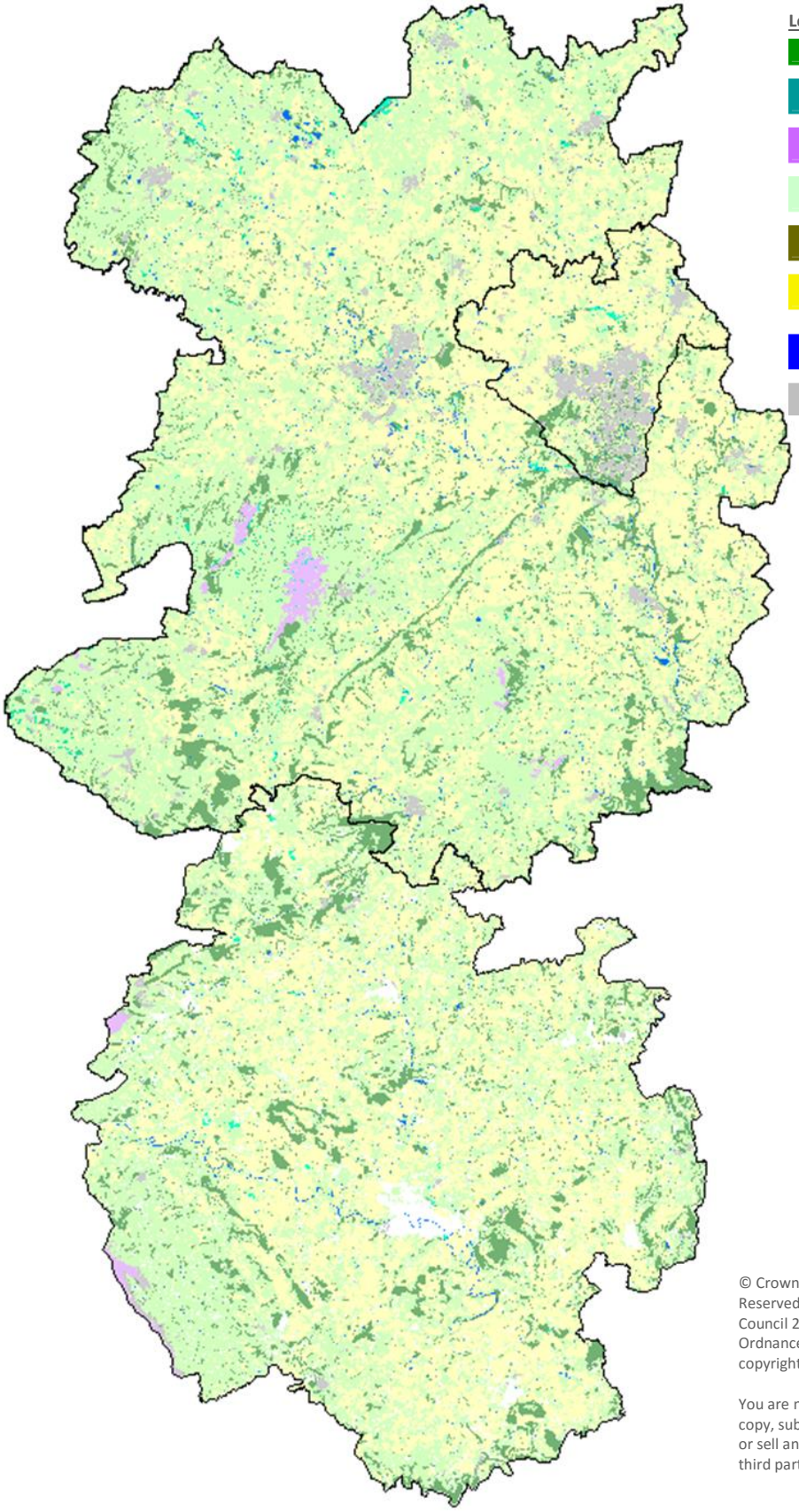
Spatial habitat information for The Marches has been obtained from Shropshire County Council, Herefordshire Biological Records Centre (HBRC) and Natural England. Much of the economic assessment is based on habitat information and considerable time has been invested to manipulate, interpret and categorise such data for the purpose of quantification. Geographical Information System (GIS) software was used to manipulate and combine different datasets. For valuation purposes a certain classification system needed to be

applied and after consultations with the project partners a suitable system was established and all habitat categories were 'translated' into a 'fit for valuation' framework. For valuation purposes it was also often necessary to distinguish between upland and lowland habitats. Where this information was not available in the layers then altitude maps were used to distinguish upland and lowland habitats.

The interpretation and manipulation resulted in a baseline habitat/land-use map which probably represents the most accurate habitat inventory for The Marches at the time of publication of this report (see Figure 1.3). Land-use information was collected for 546,013 ha. This represents 96.3% of the total geographical area of The Marches of 566,727 ha.[15] However, it should be acknowledged that this map is not perfect and should be treated with some care as many habitats were not assessed recently and/or assessments were based on aerial photography interpretation rather than field surveys. The base map represents a snapshot in time and one recommendation of this report is to improve the accuracy and cover of habitat data in the future.

[15] Habitat information for some areas mainly Herefordshire (presumably mainly urban) was not available.

Figure 1.3 The Marches Habitat Map



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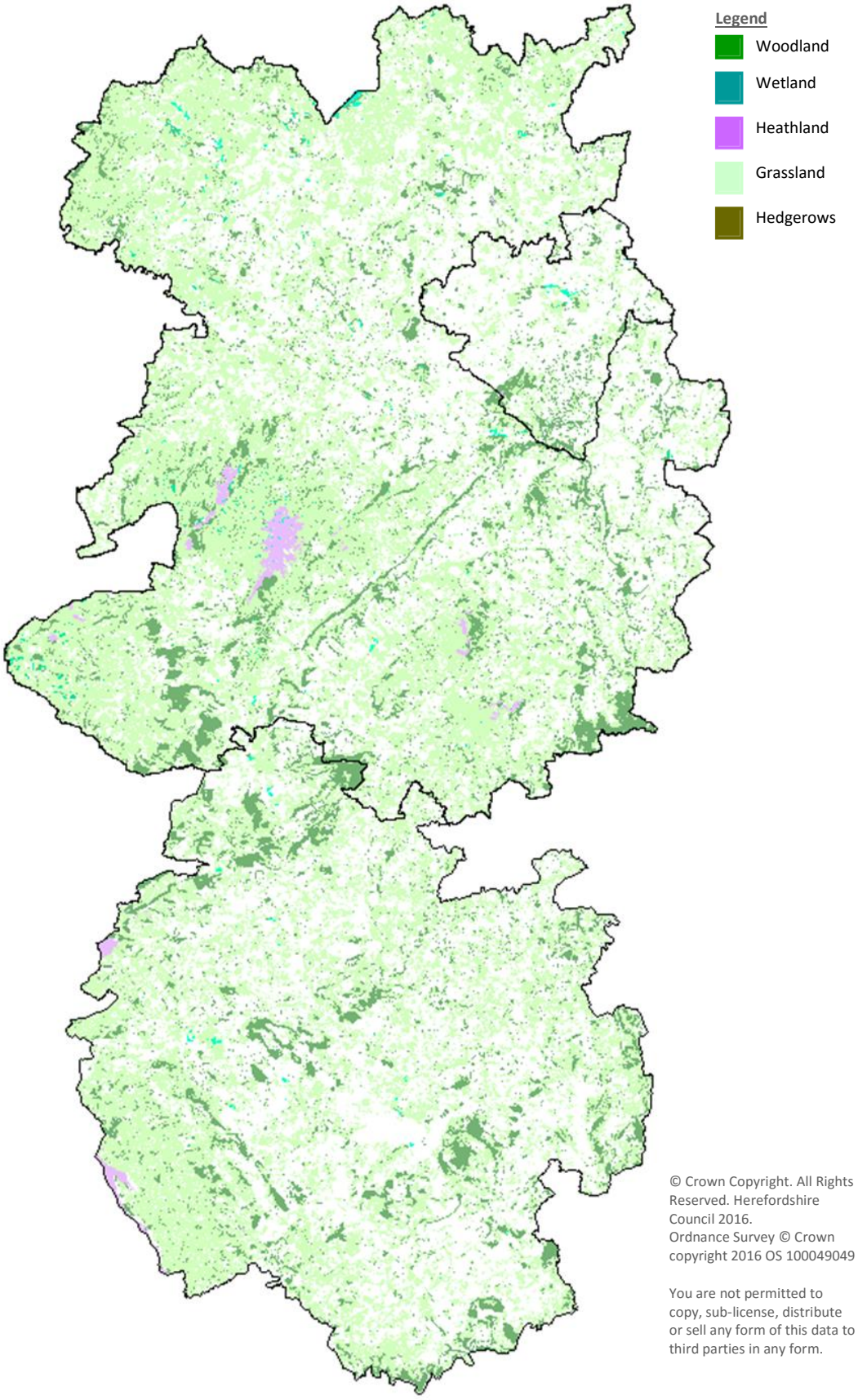
Source: ***Based on GIS data provided by Shropshire County Council, HBRC and Natural England***

The scope of this Ecosystem Assessment is limited to non-market ecosystem services which are not traded on markets and therefore do not have a market price (see Section 1.1 and Section 1.5 for more information). Therefore 231,109 ha of agricultural and horticultural land were excluded from the assessment scope because they mainly relate to food provision which is a market ecosystem service. Further land-use types that were excluded are (1) 3,047 ha of unspecified/unidentified grassland, (2) 3,804 ha of standing and running water, and (3) 16,883 ha of other habitats including bracken, bare ground, rock, build-up areas and gardens. These land-use types were excluded from the assessment scope either because the value of ecosystem services they perform are expected to be marginal (e.g. rock) or because valuation evidence available at the time of the assessment did not allow monetary quantification of these services (e.g. standing and running water). However, some of the benefits provided by such habitats were assessed qualitatively in the following Chapters. The habitats included in the assessment scope add up to 290,494 ha which covers 51.3% of the total geographical area of The Marches. This is one reason why the quantitative findings of this assessment should be interpreted as baseline of the real value. Figure 1.4 below shows all habitats included within scope of the Marches Ecosystem Assessment. Table 1.1 provides more detail about the habitats included in this assessment.

Figure 1.4 The Marches Habitat Map: Assessment Scope



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Source: ***Based on GIS data provided by Shropshire County Council, HBRC and Natural England***

Table 1.1 Habitats Included within Scope of the Marches Ecosystem Assessment

Woodland	**56,344.0 ha**
Broadleaved	28,458.5 ha
Ancient Semi-Natural Woodland	6,777.4 ha
Other	21,681.1 ha
Coniferous	10,321.2 ha
Mixed	16,332.0 ha
Recently felled	122.5 ha
Scrub	1,109.9 ha
Wetland	**1,902.9 ha**
Inland Marsh	1,612.3 ha
Floodplain Grazing Marsh	452.3 ha
Purple Moor-grass & Rush Pasture	858.0 ha
Fen	46.9 ha
Reedbed	9.9 ha
Swamp	138.0 ha
Other	107.2 ha
Peatbog	290.6 ha
Blanket Bog	2.4 ha
Lowland Raised Bog	192.7 ha
Fen	78.8 ha
Other	16.8 ha
Heathland	**3,819.6 ha**
Grassland	**228,364.1 ha**
Acid	9,108.8 ha
Calcareous	172.7 ha
Improved	187,466.8 ha
Neutral	31,615.8 ha
Hedgerows	**63.0 ha**
TOTAL	**290,493.5 ha**

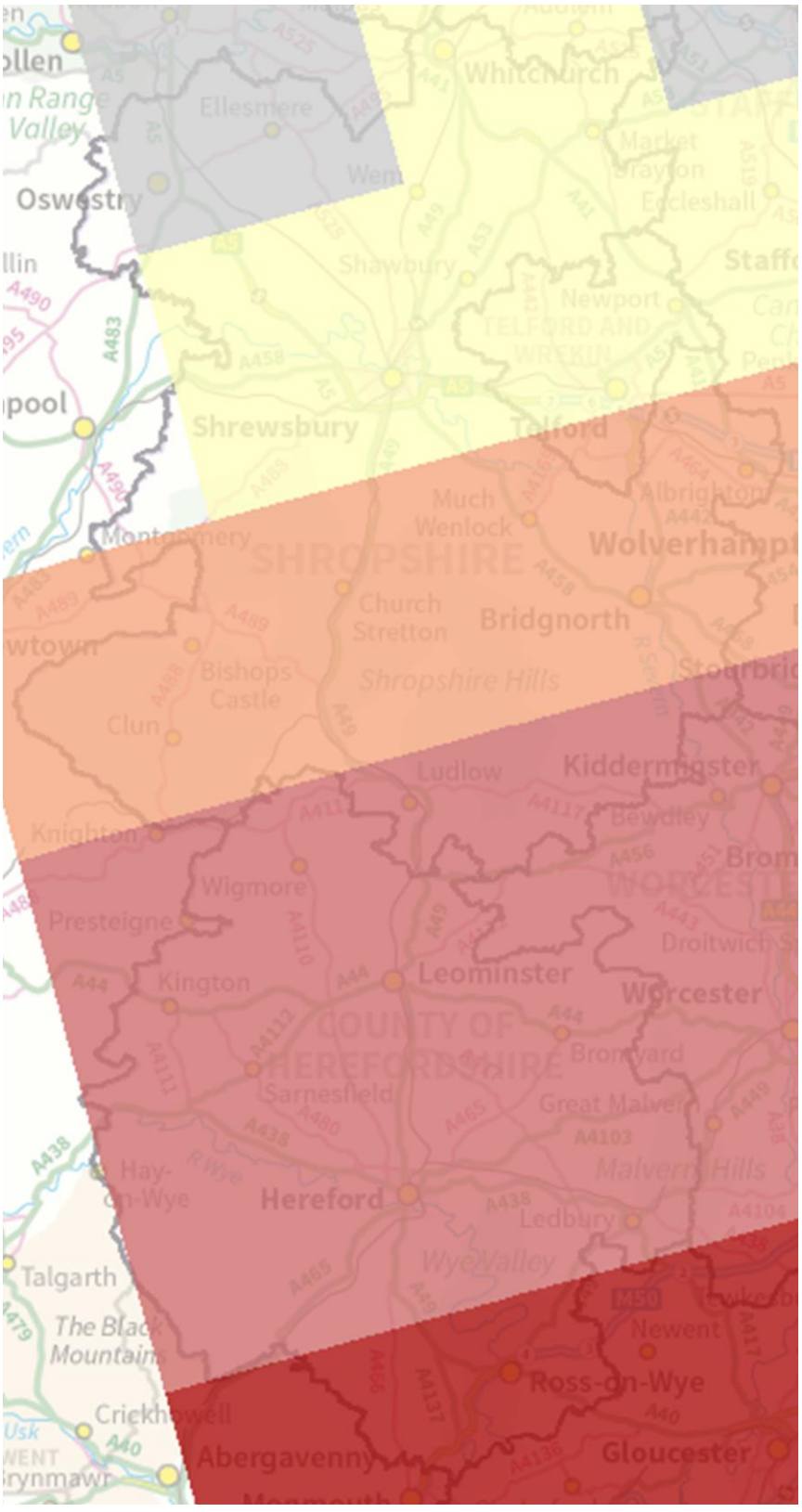
Source: ***Author calculations based on data provided by Shropshire County Council, HBRC and Natural England***

1.4 Drivers of Change

One significant driver of Natural Capital change is climate change. Even if we were to stop worldwide greenhouse gas emissions right now, a certain amount of warming is unavoidable and has already begun. Global average surface temperatures are already about 0.5 °C higher than in the 1960's to 1980's.[16] By the end of the Century (2081-2010) the global average surface temperature is likely to rise by between 0.3 °C and 4.8 °C; depending on the emission scenario (compared to 1986-2005).[17] This means that we need to adapt to some degree of climate change regardless of worldwide mitigation efforts. Figure 1.5 below shows the expected change to summer maximum temperatures in The Marches in the 2050s compared to the baseline period 1961–1990.

[16] Brohan et al. 2006.
[17] IPCC 2014.

Figure 1.5 Change of Summer Maximum Temperatures by 2050's



Source: ***Climatejust.org.uk***

One can see that the temperature rise is projected to be stronger in the south of The Marches. Under the medium emission scenario (central estimate) average summer maximum temperatures are projected to rise between 3.0% (north) and 3.8% (south) by the 2050's.[18] Under the high emission scenario (high estimate) summer temperatures may rise by between 6.0% (north) and 7.5% (south).

The UK Climate Change Risk Assessment (2012) published by Defra projects that climate change poses many risks to the United Kingdom; but also some opportunities. Opportunities of a changing climate include declines in winter mortality rates and increased wheat yields due to warmer temperatures. However, identified risks outnumber the opportunities by far and are for example related to (1) the increasing risk and intensity of flooding events, (2) increased summer mortality due to higher temperatures and ozone, (3) potential water deficits and water quality issues during summers, and (4) changes to species migration patterns where biodiversity can be lost when species cannot migrate tracking the changing climate.[19]

All these effects can either (1) be mitigated through adapted Natural Capital management for example by restoring wetlands to regulate flooding risks (see Section 4.3) or by creating more green infrastructure in cities to reduce the Urban Heat Island Effect (see Section 4.2) and/or (2) have a direct impact on ecosystem services for example by causing further biodiversity decline which in turn can have negative impacts on many other ecosystem services (see Section 3.7) and finally people's wellbeing. This shows that Natural Capital management becomes even more important over time considering greater climate pressures (e.g. biodiversity loss) on ecosystems as well as greater demand for the ecosystem services they perform due to the effects of climate change (e.g. flood risk regulation). This means that we do not just have to adapt our Natural Capital to climate change but we also have to adapt society to climate change; for example by better protecting and enhancing Natural Capital.

Another significant driver of change is population growth. The Marches population is projected to grow by 8% from 668,800 in 2015 to 720,200 in 2035. This is below the English

[18] HR Wallingford et al. 2012.
[19] Ibid.

average of 13% within the same time period but it will still require creating new housing opportunities and related infrastructure for about 51,400 new residents by 2035. In Shropshire, for example, 18,000 new houses need to be developed by 2026.

Table 1.2 Population Projections

	Projected Population		*Change 2015-2035*	
	2015	2035	*Total*	*%*
Herefordshire	187,700	205,600	*+17,900*	*+10%*
Shropshire	311,500	334,700	*+23,200*	*+7%*
Telford and Wrekin	169,600	179,900	*+10,300*	*+6%*
Total Marches	668,800	720,200	*+51,400*	*+8%*

Source: ***ONS 2012 based Subnational Population Projections***

Population growth is associated with many opportunities and advantages but development can also have negative impacts on the environment, the economy and people's wellbeing. The land-use changes that come with development, for example when development is 'creeping' into greenbelts, can put significant additional pressure on Natural Capital and the ecosystem services it performs including their associated health and wellbeing benefits. This means that the provision of ecosystem services including their wider benefits to people's wellbeing cannot be taken for granted and needs to be actively planned, managed and protected. HM Government's Natural Environment White Paper states that *"Planning has a key role in securing a sustainable future. However, the current system […] is failing to achieve the kind of integrated and informed decision-making that is needed to support sustainable land use".*[20] New tools such as the Natural Capital Planning Tool (NCPT) are being developed to better manage the impact of planning and development on Natural Capital (see Section 7 for further information).

1.5 Methodological Approach and Limitations

Aim of the project was to establish a robust and evidence-based Ecosystem Assessment for The Marches with a focus on quantifying the value[21] of as many non-market ecosystem services as possible; excluding services like timber and food provision because such products already have a market price indicating their value. The monetary value has been assessed for

[20] HM Government 2011.
[21] Total Economic Value (TEV)

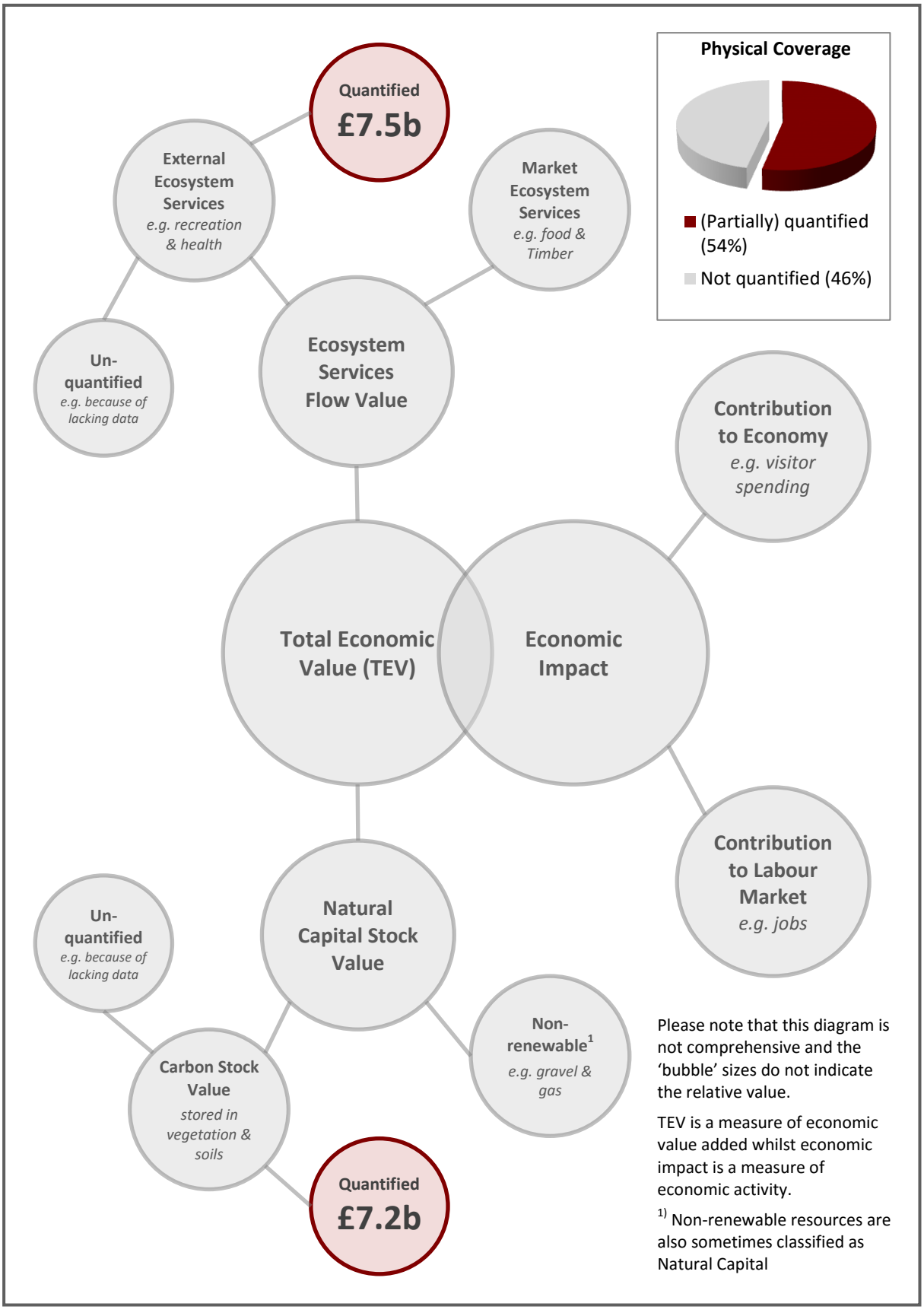
The Marches as a whole (see Section 6.1 for results) as well as for Herefordshire (Section 6.2), Shropshire (Section 6.3) and Telford and Wrekin (Section 6.4), each.

The available scientific evidence at the time of this assessment did not allow for the full calculation of monetary values for the total range of services. And even if values were calculated for an ecosystem service they often only cover an element of the ecosystem services value. The health value (see Section 3.4), for example, is only based on the impact of physical exercise on mortality which is only an element of the overall health benefits of Natural Capital. Therefore, the monetary assessment has been accompanied by a qualitative evaluation. Monetary values presented in this report should generally be treated as a baseline of the total or real value of non-market ecosystem services in The Marches.[22] Figure 1.6 clarifies what is (and probably more important what is not) included in this Ecosystem Assessment.

The Total Economic Value (TEV) is a measure of the net value Natural Capital provides to society. The Economic Impact on the other hand is a measure of economic activity such as for example Gross Development Product (GDP). The pay for a job to manage a greenspace, for example, is contributing positively to economic activity but in a TEV framework it is a cost factor because this pay is required to provide the economic value assuming that without that management the greenspace would not perform ecosystem services to the extent it does with management. Therefore jobs are reducing the net TEV whilst increasing economic impact. Also, economic impact is not necessarily contributing positively to society. If an asset would be destroyed and rebuild exactly as it was then this would only contribute to economic activity but wouldn't add economic value.

[22] This effect is not implemented in the sensitivity analysis. Therefore the real value of ecosystem services may even exceed the upper threshold of the sensitivity analysis.

Figure 1.6 Assessment Scope



Source: ***Author***

To quantify ecosystem services values in monetary terms the so called benefit transfer approach[23] has been applied. Valuation findings of studies carried out elsewhere were transferred to the assessment area (The Marches) applying suitable precautions and assumptions. This approach allowed transferring values from primary valuation studies to our specific context of The Marches. Where possible, adjustments regarding site-specific circumstances and socio-economic variables such as population density have been made to minimise potential transfer-errors. Carrying out original primary valuation studies was beyond the scope of this study as such studies demand extensive resources and lengthy timescales. The application of the benefit transfer approach can be seen as a practicable and cost-effective way for implementing the Ecosystem Approach in decision-making.[24] For further information about the benefit-transfer approach and how scientists calculate values for non-market ecosystem services see for example Defra's 'Introductory Guide to Valuing Ecosystem Services'.[25]

For this project only valuation methods and studies which comply with high scientific standards were chosen. Nevertheless, the model contains some limitations. For example, related Willingness-To-Pay (WTP) techniques applied in primary valuation studies have their own imperfections such as the social desirability bias[26] or a potential inability of survey participants to perceive hypothetical markets and goods. Another limitation may occur from applying the benefit transfer approach. Usually, the study area (where primary valuation studies are prepared) and the policy area (in this case The Marches) are not entirely similar. Therefore, adjustments are needed for some socio-economic influencing variables such as income or population density as well as local context (such as the availability of substitute habitats and services). But even if these adjustments were applied as carefully as possible, a benefit transfer error can never be ruled out. Further limitations are linked to general scientific uncertainties such as the future impacts of climate change (see also Section 1.4). For these reasons, calculated values should be regarded as essentially indicative of the magnitude of the service, so the lack of a definitive value is not necessarily problematic.

[23] Sometimes also referred as 'value transfer approach'.
[24] Defra 2007.
[25] Ibid.
[26] The interviewees may like to make out that they value an ecosystem service more than they actually do

Method-specific caveats are explained in more detail where relevant in the following Chapters and Appendices.

To take uncertainties into account within this investigation, a sensitivity analysis has been applied. Using sensitivity analysis, every value is stated as a 'central estimate'[27] with a range, following best practice recommendations.[28] 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 where different benefits arising from the same service are counted twice for the assessment of its value. The risk is even higher when valuing such a wide range of services as well as different habitats as in the present study. The ecosystem interactions as well as the relations between different services are characterised by high complexity. Therefore, particular attention has been paid to this issue. In case of doubt, calculations are conservative to maintain validity. This principle has been applied across this study.

The ecosystem services values assessed within scope of this project are not only stated as annual values; they are also stated as capitalised value over 25 years. To calculate the 'net present value' of future benefit it is common to apply a discount rate. This discount rate is used to convert future benefits (and costs) to present values which make them comparable across time. For the purpose of this investigation, a discount rate of 1.5% has been applied to calculate the net present value of future benefits.

Applying this discount rate was suggested in the Ecosystem Assessment Guidance[29] which was published as part of the National Ecosystem Assessment Follow-On (NEAFO)[30], even if it is not consistent with the discount rate recommended by the HM Treasury.[31] However, the German Federal Environmental Agency also recommends applying a discount rate of 1.5% for long-term assessments.[32] HM Treasury recommends a discount rate of 3.5% for periods

[27] If not stated otherwise values are generally stated as 'central estimate'.
[28] EFTEC 2010.
[29] Hölzinger 2014b.
[30] Scott et al. 2014.
[31] See for example HM Treasury 2003.
[32] See also German Federal Environment Agency 2008.

of up to 30 years.[33] HM Treasury argues for the use of the real interest rate for long term low risk investments.

> *"For individuals, time preference can be measured by the real interest rate on money lent or borrowed. Amongst other investments, people invest at fixed, low risk rates, hoping to receive more in the future (net of tax) to compensate for the deferral of consumption now. These real rates of return give some indication of their individual pure time preference rate."*[34]

With the phrase *"hoping to receive"* they appreciate that there is still a risk surcharge involved. Another crucial point is that especially long term cross-generational valuations always imply political value judgements.[35]

> *"Society as a whole, also prefers to receive goods and services sooner rather than later, and to defer costs to future generations."*[36]

With this sentence, the authors of the HM Treasury Green Book implicitly imply that *"to defer costs to future generations"* is a law of nature or at least socially deliberate and/or accepted. However, future generations may have a different view. Also, in the context of the overall accepted concept of sustainable development and assuming that a government is not less responsible for future generations than for the current, even if future generations are not able to participate in decision-making (e.g. elections), this Treasury approach may not be the best choice for Natural Capital as it often performs ecosystem services over a long time covering more than one generation.[37]

These factors determine that a long-term discounting approach is most ecologically relevant, equitable across generations and is also a well-supported approach. Hence, the discount rate of 1.5% has been applied for the 'central estimate' of capitalised values. The discount rate of 3.5% recommended by HM Treasury has been applied to the lower threshold of the

[33] HM Treasury 2003, 97.
[34] Ibid., 26.
[35] German Federal Environment Agency 2008.
[36] HM Treasury 2003, 26.
[37] 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 Stern 2006; Perino et al. 2011.

sensitivity analysis. However, to ensure transparency and comparability with other related publications within the UK, the 'central estimate' values have also been stated applying the discount rate recommended by HM Treasury. For the upper threshold of the sensitivity analysis a discount rate of 0% has been applied, also adopting the recommendations of NEAFO Ecosystem Assessment Guidance.[38]

It should be noted that for capitalised values a *ceteris paribus* future (everything else remains equal) has been assumed. This means that all variables such as population or impacts of climate change were set constant over time. Both, population growth and climate change impacts can be expected to increase the values of ecosystem services over time due to resource scarcity considerations. This is another reason why the findings of this assessment should be interpreted as the baseline of the real ecosystem services value. Further information about how findings should be read and interpreted is outlined in Chapter 6.

Each assessed ecosystem services is outlined in the following Sections. The structure is based on the widely accepted ecosystem services framework of provisioning services (Chapter 2), cultural services (Chapter 3) and regulating services (Chapter 4). Supporting services were not assessed individually because they represent an intermediate stage towards producing final ecosystem services which directly benefit people. Quantifying supporting services would result in double-counting and therefore overestimating the total value.

[38] Hölzinger 2014b.

2. Provisioning Services

2.1 Wild Food

The ecosystem service 'wild food' refers to non-commercial food harvested from nature such as deer and goose hunting, collecting mushrooms or the collection of bilberries which is for example considerable on The Stiperstones. Therefore wild food can be distinguished from agriculture and other commercial food production which are not included in this assessment because they usually have a market price. This ecosystem service value is not restricted to the value of the harvested products themselves; but also includes the value of the process of gathering or hunting, including for example the sense of wellbeing and community.

The annual value of wild food harvested from different habitat types of The Marches ads up to £3.3 million, stating the central estimate.[39] This is not much when compared to other assessed ecosystem services but still considerable. Capitalised over 25 years this results in a value of £68.7 million. Methods, calculations and a break-down for Herefordshire, Shropshire and Telford and Wrekin can be reviewed in Appendix A.

[39] If not stated otherwise all values in this report are stated for the central estimate

Table 2.1 **Wild Food Provision: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£3.602	**£1.260**	£0.378	£90.053	**£26.502**	£21.497	£6.449
Low land ASNW	£1.094	**£0.383**	£0.115	£27.356	**£8.051**	£6.530	£1.959
Low land Mixed Woodland	£2.644	**£0.925**	£0.277	£66.092	**£19.451**	£15.777	£4.733
Upland Broadleaved Woodland & Scrub	£0.176	**£0.062**	£0.018	£4.395	**£1.293**	£1.049	£0.315
Upland ASNW	£0.029	**£0.010**	£0.003	£0.730	**£0.215**	£0.174	£0.052
Upland Mixed Woodland	£0.064	**£0.022**	£0.007	£1.590	**£0.468**	£0.379	£0.114
TOTAL Woodland	£7.609	**£2.662**	£0.799	£190.216	**£55.980**	£45.407	£13.622
Low land Dry Acid Grassland	£0.006	**£0.001**	£0.001	£0.156	**£0.024**	£0.020	£0.010
Low land Meadow s	£0.069	**£0.024**	£0.012	£1.727	**£0.499**	£0.405	£0.202
TOTAL Grassland	£1.496	**£0.511**	£0.255	£37.406	**£10.746**	£8.717	£4.358
Low land Heathland	£0.012	**£0.004**	£0.002	£0.310	**£0.090**	£0.073	£0.036
Upland Heathland	£0.031	**£0.011**	£0.005	£0.774	**£0.226**	£0.184	£0.092
TOTAL Heathland	£0.043	**£0.015**	£0.008	£1.084	**£0.316**	£0.256	£0.128
Inland Marsh	£0.191	**£0.068**	£0.034	£4.774	**£1.427**	£1.157	£0.579
Floodplain Grazing Marsh	£0.024	**£0.008**	£0.004	£0.601	**£0.173**	£0.140	£0.070
Purple Moor-grass & Rush Pasture	£0.155	**£0.055**	£0.028	£3.872	**£1.167**	£0.946	£0.473
Fen	£0.011	**£0.004**	£0.002	£0.273	**£0.078**	£0.064	£0.032
Reedbed	£0.001	**£0.000**	£0.000	£0.029	**£0.009**	£0.007	£0.003
Peatbog	£0.018	**£0.006**	£0.003	£0.461	**£0.133**	£0.108	£0.054
Blanket Bog	£0.000	**£0.000**	£0.000	£0.002	**£0.001**	£0.000	£0.000
Fen	£0.018	**£0.006**	£0.003	£0.459	**£0.132**	£0.107	£0.054
TOTAL Wetland	£0.209	**£0.074**	£0.037	£5.235	**£1.560**	£1.265	£0.632
TOTAL Hedgerow s	£0.018	**£0.006**	£0.003	£0.457	**£0.134**	£0.108	£0.054
TOTAL	£9.376	**£3.268**	£1.102	£234.399	**£68.735**	£55.753	£18.795

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

2.2 Ornamental Resources & Non-food Products

Natural Capital in The Marches also provides a range of ornamental resources and other non-food products for example used for decorative, artistic or educational purposes. This includes wild flowers and plants for garden and indoor decoration[40] as well as stones, minerals, pieces of wood and fossils collected from the countryside. The non-commercial collection of firewood is also included in this category.

As for wild food a primary valuation study by Christie et al. (2011) was used for calculating monetary values for ornamental resources and non-food products in The Marches. The annual value is just over £4.0 million which adds up to a capitalised value of £85.2 million

[40] The commercial production of flowers is not included in this section.

over 25 years. Further details and a break-down by assessment area can be found in Appendix A.

Table 2.2 **Ornamental Resources & Non-Food Products: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£6.202	**£1.500**	£0.450	£155.042	**£31.552**	£25.593	£7.678
Low land ASNW	£1.884	**£0.456**	£0.137	£47.098	**£9.585**	£7.774	£2.332
Low land Mixed Woodland	£4.552	**£1.101**	£0.330	£113.788	**£23.156**	£18.783	£5.635
Upland Broadleaved Woodland & Scrub	£0.303	**£0.073**	£0.022	£7.567	**£1.540**	£1.249	£0.375
Upland ASNW	£0.050	**£0.012**	£0.004	£1.257	**£0.256**	£0.207	£0.062
Upland Mixed Woodland	£0.109	**£0.026**	£0.008	£2.737	**£0.557**	£0.452	£0.136
TOTAL Woodland	£13.100	**£3.169**	£0.951	£327.489	**£66.645**	£54.058	£16.217
Low land Calcareous Grassland	£0.009	**£0.002**	£0.001	£0.226	**£0.046**	£0.038	£0.019
Low land Dry Acid Grassland	£0.015	**£0.002**	£0.001	£0.366	**£0.037**	£0.030	£0.015
Low land Meadow s	£0.153	**£0.037**	£0.019	£3.834	**£0.785**	£0.637	£0.318
TOTAL Grassland	£3.334	**£0.806**	£0.403	£83.341	**£16.948**	£13.747	£6.874
Low land Heathland	£0.013	**£0.003**	£0.002	£0.333	**£0.067**	£0.054	£0.027
Upland Heathland	£0.113	**£0.028**	£0.014	£2.828	**£0.582**	£0.472	£0.236
TOTAL Heathland	£0.126	**£0.031**	£0.015	£3.162	**£0.649**	£0.526	£0.263
Inland Marsh	£0.162	**£0.039**	£0.019	£4.056	**£0.813**	£0.660	£0.330
Purple Moor-grass & Rush Pasture	£0.154	**£0.037**	£0.018	£3.858	**£0.772**	£0.626	£0.313
Fen	£0.006	**£0.001**	£0.001	£0.149	**£0.031**	£0.025	£0.013
Reedbed	£0.002	**£0.000**	£0.000	£0.048	**£0.010**	£0.008	£0.004
Peatbog	£0.010	**£0.002**	£0.001	£0.252	**£0.052**	£0.043	£0.021
Blanket Bog	£0.000	**£0.000**	£0.000	£0.001	**£0.000**	£0.000	£0.000
Fen	£0.010	**£0.002**	£0.001	£0.251	**£0.052**	£0.042	£0.021
TOTAL Wetland	£0.172	**£0.041**	£0.021	£4.308	**£0.866**	£0.702	£0.351
TOTAL Hedgerow s	£0.010	**£0.003**	£0.001	£0.260	**£0.054**	£0.043	£0.022
TOTAL	£16.742	**£4.049**	£1.391	£418.559	**£85.162**	£69.077	£23.727

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

2.3 Water Supply

The ecosystem service 'water supply' refers to the provision of fresh water and groundwater that is directly consumed by people, for example through private consumption, agriculture, aquaculture, industry or energy production. The regulating services of flood risk and water quality regulation are separately assessed in Chapter 4. In England and Wales, the amount of water abstracted for public water supply declined from more than 17 billion litres per day in 1990 to less than 15 billion litres per day in 2009.[41] This decline occurred despite the population growing over the same period. The decline can be explained by more efficient

[41] Edwards-Jones et al. 2011.

use of water and a reduced demand by industry. Another factor is that the leakage rate in the public supply network has declined from 23% in the late 1990s to 16% in 2009.[42]

This service could only be valued for wetlands in The Marches. Rivers and other elements of the 'blue infrastructure' have not been evaluated in monetary terms within this investigation. Despite the importance of blue infrastructure for the provision, storage and distribution of water, data is lacking or unsuitable for robust economic quantification.

With an annual value of about £14,500 annually, this contribution of wetlands to the provision of fresh water in The Marches is very small if compared to other ecosystem services. However, this value is likely to increase in the future because of climate change impacts (see Section 1.4). This climate change impact has not been considered when calculating the capitalised value of £305,500 over 25 years. This value is based on a benefit transfer from Brander et al. (2008). For more details about calculations see Appendix B.

Table 2.3 **Water Supply: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Wetland	£0.025	**£0.015**	£0.004	£0.617	**£0.305**	£0.248	£0.074

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

[42] Ibid.

3. Cultural Services

3.1 Recreation

The cultural ecosystem service 'recreation' is part of general leisure, and is not always easily distinguished from other services such as education or aesthetic appreciation. It usually refers to doing things and interacting with others.[43] Accessible greenspace provide the settings for a wide range of human activities including walking, running, cycling, climbing and horse riding. It also provides space, for example, for picnicking or observing nature, including bird watching, and for informal relaxation. Recreational activities raise individual wellbeing and are therefore a value in itself.[44] But there are also strong links between recreation and health benefits (see Section 3.4).

The Marches tourism offers are largely based on heritage and countryside and therefore Natural Capital dependent. 'Hotspots' for countryside visits and rural activities can for example be found within the 'golden triangle' of Shrewsbury, Ironbridge Gorge World Heritage Site and Ludlow. Other popular visitor destinations include the three Areas of Outstanding Natural Beauty (AONBs) that are found within the Marches – The Shropshire Hills AONB, The Malverns AONB and The Wye Valley AONB.[45]

To calculate the value of recreational benefits by woodland in The Marches a benefit transfer of the findings of Scarpa (2003) has been applied. In that study visitors of woodland sites were asked how much they were willing to pay if there was to be a charge for accessing woodland sites. To estimate the number of visits to woodland sites in The Marches, findings of the 'Monitor of Engagement with the Natural Environment' (MENE) survey by Natural England were used which revealed an average annual visitor count to woodland in The Marches of 12.1 million. The total value of woodland recreation in The Marches has been calculated by multiplying the average annual visitor count by the mean WTP per visit. This results in an annual recreational value of woodlands of £14.6 million. For more details about the methods, assumptions and calculations see Appendix C.

[43] Church et al. 2011.
[44] See e.g. UK NEA 2011b.
[45] The Marches LEP 2015.

Table 3.1 Woodland Recreation: Marches

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£19.593	**£14.581**	£9.569	£489.823	**£306.639**	£248.724	£163.225

Legend:

Central **Central Estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Scarpa (2003) and MENE data provided by Natural England.***

Wetlands in The Marches also provide space for recreational activities such as bird watching. Because the applied benefit transfer function only allowed valuation of cultural services (mainly recreation and aesthetic appreciation) together, a break-down for recreation alone was not possible. Therefore these cultural values provided by wetland sites have been assessed together resulting in an annual value of £319,000. Detailed findings for The Marches as a whole are summarised in Table 3.2 below. For methods, calculations and a break-down by assessment area see Appendix B.

Table 3.2 Wetland Recreation & Aesthetic Values: Marches

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.428	**£0.285**	£0.143	£10.704	**£6.003**	£4.869	£2.435
Floodplain Grazing Marsh	£0.119	**£0.079**	£0.040	£2.976	**£1.669**	£1.354	£0.677
Purple Moor-grass & Rush Pasture	£0.169	**£0.112**	£0.056	£4.218	**£2.366**	£1.919	£0.959
Fen	£0.022	**£0.015**	£0.007	£0.556	**£0.312**	£0.253	£0.126
Reedbed	£0.004	**£0.002**	£0.001	£0.088	**£0.049**	£0.040	£0.020
Swamp	£0.026	**£0.017**	£0.009	£0.651	**£0.365**	£0.296	£0.148
Other	£0.089	**£0.059**	£0.030	£2.215	**£1.242**	£1.008	£0.504
Peatbog	£0.051	**£0.034**	£0.017	£1.269	**£0.712**	£0.577	£0.289
Blanket Bog	£0.000	**£0.000**	£0.000	£0.011	**£0.006**	£0.005	£0.002
Lowland Raised Bog	£0.036	**£0.024**	£0.012	£0.893	**£0.501**	£0.406	£0.203
Fen	£0.015	**£0.010**	£0.005	£0.365	**£0.205**	£0.166	£0.083
TOTAL Wetland	£0.479	**£0.319**	£0.160	£11.973	**£6.715**	£5.446	£2.723

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008.***

For grassland, heathland and hedgerows values could also only be calculated for cultural services (recreation, aesthetic appreciation, education and spiritual values) as a whole because Christie et al. (2011) did not provide a breakdown by ecosystem service. Therefore the figures below represent the value of all cultural services rather than just recreation. In

The Marches, cultural services provided by grassland, heathland and hedgerows[46] total £21.2 million annually or £446.3 million capitalised, stating the central estimate. For methods, assumptions and calculations as well as a break-down for each assessed area see Appendix A.

Table 3.3 **Grassland, Heathland and Hedgerows Cultural Services: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£24.059	**£16.039**	£8.020	£601.479	**£337.316**	£273.607	£136.803
Lowland Calcareous Grassland	£0.022	**£0.015**	£0.007	£0.562	**£0.315**	£0.256	£0.128
Lowland Meadows	£0.314	**£0.209**	£0.105	£7.851	**£4.403**	£3.571	£1.786
Upland Calcareous Grassland	£0.001	**£0.000**	£0.000	£0.016	**£0.009**	£0.007	£0.004
TOTAL Grassland	£30.767	**£20.511**	£10.256	£769.176	**£431.362**	£349.890	£174.945
Lowland Heathland	£0.130	**£0.087**	£0.043	£3.248	**£1.821**	£1.477	£0.739
Upland Heathland	£0.908	**£0.605**	£0.303	£22.706	**£12.734**	£10.329	£5.164
TOTAL Heathland	£1.038	**£0.692**	£0.346	£25.953	**£14.555**	£11.806	£5.903
TOTAL Hedgerows	£0.026	**£0.017**	£0.009	£0.644	**£0.361**	£0.293	£0.146
TOTAL	£31.831	**£21.221**	£10.610	£795.773	**£446.278**	£361.989	£180.995

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

3.2 Aesthetic Appreciation

The visual amenity and aesthetic appreciation of environmental landscapes can have a significant influence on human wellbeing.[47] A large body of evidence demonstrates that people prefer to live in areas with high quality environmental landscapes and many studies suggest that such green landscapes increase for example property prices and land values.[48] One UK study suggests that in environmental landscapes with trees, property values can increase by an average of 7%. This could also lead to an increase in council taxes and therefore support of public services.[49] A study in Berlin, Germany, found that street trees can increase land values by up to 17%.[50] More recently, a contingent valuation study conducted on Whitworth Street in Manchester showed that people are willing to pay a

[46] Please note that habitat information about hedgerow extent was only available for Shropshire which is why the service could not be valued for Herefordshire and Telford and Wrekin.
[47] Church et al. 2011.
[48] See e.g. Saraev 2012 for an overview.
[49] Forest Research 2010.
[50] Luther and Gruehn 2001.

premium to the council tax of £2.33 per person per month for large street trees and grassed areas along the street. 61% of respondents preferred this option over the status quo with no trees or other options with smaller trees and/or no grassed areas.[51]

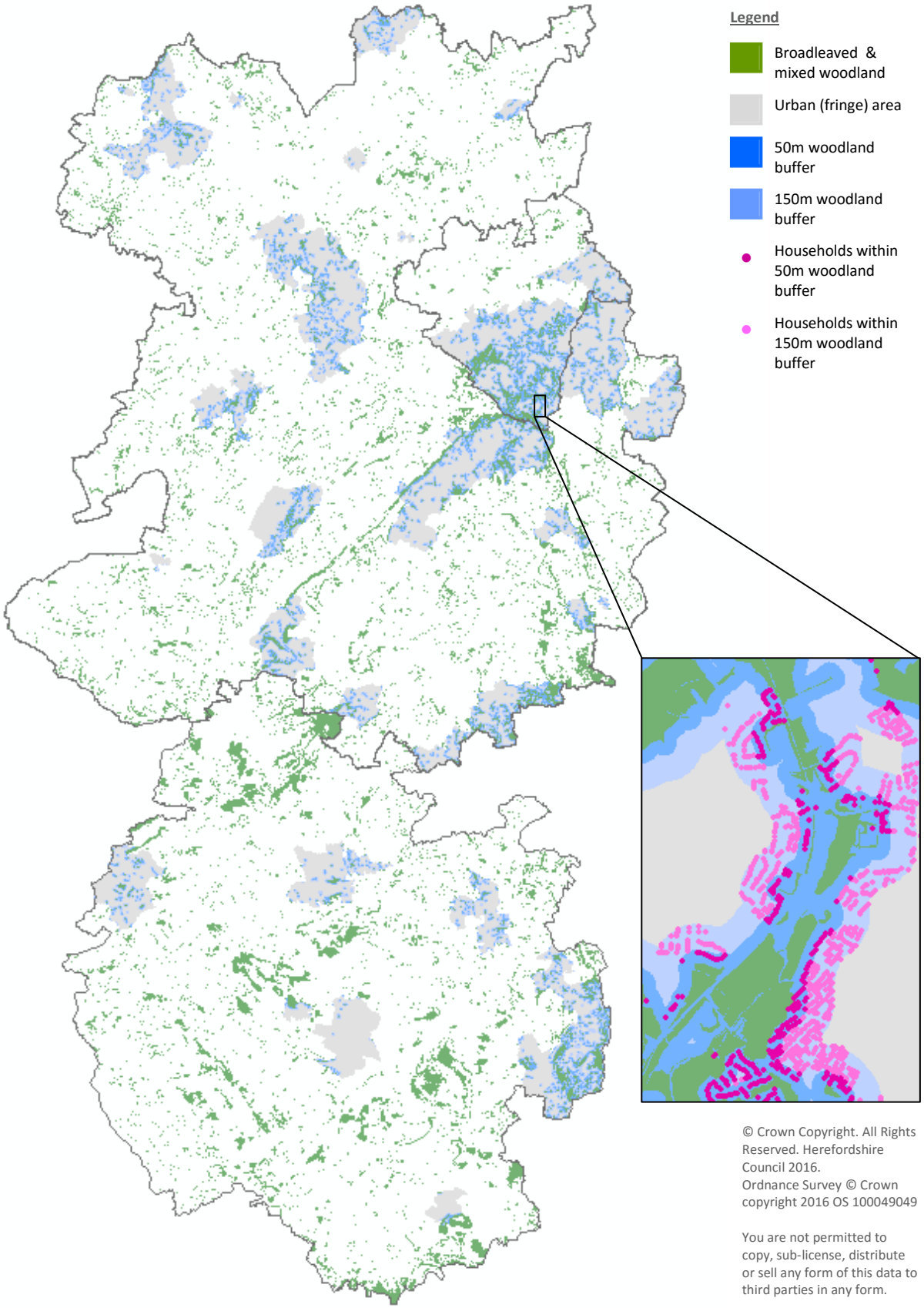
Research from the United States suggests that the view of woodland can improve mental health by breaking down stress.[52] Ulrich (1984) also found that the view of woodland from hospitals has a positive effect on recovery times.[53] For more information about health-related benefits of Natural Capital see Section 3.4.

Within the scope of this investigation, a valuation study by Garrod (2002) who valued the Willingness-To-Pay (WTP) for woodland views from home has been applied for a benefit transfer. Garrod (2002) calculated an annual WTP per household for a view of urban fringe broadleaved woodland of £360.64 (2015 prices).[54] Robust WTP estimates were obtained only for urban fringe broadleaved forests.[55] This means that this service could not be assessed for households with free view on woodland in the countryside.

GIS software was used to identify households within urban(fringe) areas of The Marches. Households within a 50m and 150m buffer around broadleaved and mixed[56] woodland sites were counted to identify how many households can benefit from woodland aesthetics. Figure 3.1 shows the urban (fringe) layers as well as the woodland buffers and benefiting households within such areas.

[51] Mell et al. 2012.
[52] Ulrich and Simons 1986.
[53] Ulrich 1984.
[54] Garrod 2002.
[55] Ibid.
[56] The same WTP as for broadleaved woodland has also been applied to mixed woodland.

Figure 3.1 Urban(fringe) Households with Woodland View



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Source: ***Based on GIS data provided by Shropshire County Council, HBRC and Natural England***

Altogether 22,561 households were counted within a 50m woodland buffer and an additional 52,207 within a 150m buffer. However, it is not reasonable to assume that all households within these buffers have unimpeded views of the woodland sites. Especially in the urban(fringe) environment, the view from households onto woodland can for example be blocked or degraded by fences or other houses. Therefore, only a proportion of the total number of households within these buffers has been taken into account for the valuation exercise. The assumption underlies that 75% of urban(fringe) households within the 50m buffer and 50% within the 51-150m buffer have an unimpeded view on broadleaved/mixed woodland. This is a very conservative assumptions when compared to Forest Research's recommendation for applying the WTP for all households within 300m of woodland sites.[57]

Based on these assumptions it was estimated that approximately 43,000 urban(fringe) households within The Marches have a free view on broadleaved and mixed woodland and can therefore benefit from their aesthetic value. Applying the WTP from Garrod (2002) the aesthetic value has been valued at £15.5 million annually or £326.3 million capitalised over 25 years. For a breakdown by assessment area as well as calculations, assumptions and methods see Appendix D.

Table 3.4 **Aesthetic Values of Broadleaved & Mixed Woodland: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£23.274	**£15.516**	£7.758	£581.861	**£326.314**	£264.683	£132.341

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Scarpa (2003).***

These figures only represent a fraction of the total aesthetic value of woodland in The Marches as only broadleaved and mixed woodland in an urban(fringe) setting has been assessed. Coniferous woodland, broadleaved/mixed woodland in rural settings and other features like park trees also provide aesthetic benefits but could not be assessed in monetary terms because of a lack of valuation evidence.

[57] Forest Research 2010.

For park trees in Islington (Highbury Fields) and Liverpool (Sefton Park), for example, an average capitalised value per single tree of £77,787 and £12,825, respectively, was calculated. Some mature plane trees were valued at £350,000.[58] The structural value of the tree resource in the Belle Vue area of Shrewsbury alone was estimated to be £44 million.[59] Unfortunately these findings were not suitable for a benefit transfer. Therefore this calculation should be interpreted as incomplete and baseline of the real aesthetic value of woodland in The Matches. The aesthetic value of other habitats such as wetlands and grasslands has partially been captured in the combined cultural values (see Section 3.1).

3.3 Spiritual Services

Ecosystems provide places and settings for spiritual enrichment, reflection and fulfilment. This includes spiritual values, moderated strongly by the highly heterogeneous beliefs and values of people experiencing these places and settings, which may include religious values as well as spiritual experiences. Such religious and spiritual values can also contribute to, and generally overlap with, other cultural benefits such as recreation and aesthetics.[60]

The Millennium Ecosystem Assessment (2005) found that spiritual services are of significant importance for many local communities around the world. This applies for indigenous communities, but also for communities in developing and industrialised countries.[61] Spiritual values act as a strong incentive for ecosystem conservation in many countries such as Peru, Costa Rica and India.[62] According to the UK NEA (2011), the importance of ecosystems in religious terms in the UK has almost certainly increased within the past 70 or so years.[63] One reason might be a shift from church religiosity to holistic spirituality.[64] People benefit from spirituality in many places, not just in churches. Such spiritual benefits are often perceived in natural settings, though may also flow from managed 'green' and 'blue' environments.

[58] CABE Space 2009.
[59] Shropshire Council 2015.
[60] Church et al. 2011.
[61] Millennium Ecosystem Assessment 2005.
[62] Ibid.
[63] Church et al. 2011.
[64] Heelas et al. 2005.

There is no doubt that Natural Capital in The Marches provides important and valuable spiritual and religious services for many people, and that they are likely to do so on a highly heterogeneous basis reflecting such variables as race, creed, gender, age, health, etc. However, such values are often intangible and therefore very hard to quantify. An initial literature review undertaken by Cooper (2009) revealed that almost half of the published papers and reports on ecosystem services (63 out of 138) make reference to spiritual services. However the overall view formed by this review was that spiritual services would be hard and therefore unreliable to quantify; none of the publications reviewed try to calculate a monetary value for spiritual ecosystem services.[65]

Therefore not attempt was made here to quantify spiritual or religious services, though it is important to record that they should not be overlooked in decision-making. Spiritual and other related values are extremely heterogeneous in nature and may be of great importance to different social groups.

3.4 Health benefits

Human health is a classical cross-cutting ecosystem service and is basically influenced by all ecosystem services as all ecosystem services have an impact on human wellbeing. The World Health Organization defines health as follows:

> *""Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."*[66]

This definition of health has also been adopted within the UK NEA.[67] Therefore all ecosystem services are linked to health benefits in one way or another. Large scale studies undertaken in the Netherlands, Sweden and Japan have provided a body of evidence suggesting that the availability of accessible local greenspace and human health are directly related.[68] About three out of four UK adults agree that green spaces are important for their general health.[69]

[65] Cooper 2009.
[66] World Health Organization 1948, 1.
[67] Church et al. 2011.
[68] Vries et al. 2003.; Grahn and Stigsdotter 2003.; Takano, Nakamura, and Watanabe 2002.
[69] Kuppuswamy 2009.

Ecosystems cannot only encourage physical activity by providing opportunities for 'green' exercise; they can also reduce illnesses caused by air pollution. Research carried out in New York suggests that a high tree density per square kilometre significantly reduces asthma prevalence in very young children.[70] Greenspace and especially trees contribute to the purification of the air, therefore reducing the risk of related illnesses such as respiratory ailments, heart disease and cancer. A case study modelling the mitigation effects of particulate (PM_{10}) pollution in East London estimates that an increase of grassland and tree cover could avert two PM_{10}-related deaths and two hospital admissions annually in a 10 km^2 area.[71] See also Section 4.5 for more information about air quality regulation benefits.

Sport England's Active People Survey[72] revealed that in 2013 more adults (16+) in Shropshire and Herefordshire were physically active than the year before and also the English average. In Telford and Wrekin, however, with less than half of the adult population, 16.1% less people than the English average were physically active in 2013. This is also a decline of 2.2% when compared to 2012.

Table 3.5 Proportion of Physically Active Adults in The Marches

Area	*2012*	*2013*
Herefordshire	56.4%	60.4%
Shropshire	57.1%	60.6%
Telford and Wrekin	51.1%	48.9%
West Midlands Region	51.0%	53.9%
England	54.9%	56.0%

Source: ***Sports England Active People Survey***

Overall the statistics show that more than 50% of adults in Telford and Wrekin and almost 40% in Herefordshire and Shropshire are not regularly physically active. Apart from the negative effects on human wellbeing and reduced life expectancy, physical inactivity also causes significant expenses to the healthcare system and therefore society. The annual costs of physical inactivity to the NHS are estimated to be between £1 billion and £1.8 billion. These figures represent conservative estimates for the costs of inactivity based upon available published data. They exclude for example the cost implications of diseases and

[70] Lovasi et al. 2008.
[71] Tiwary et al. 2009.
[72] http://activepeople.sportengland.org/

health problems influenced by physical activity, such as osteoporosis and falls which affect many older people.[73]

An increase in accessible greenspace close to where people live is increasingly being recognised to improve people's health by providing space for physical activity.[74] Street trees can also encourage people to walk or cycle to work more often.[75] This in turn helps prevent the onset of diseases such as obesity, diabetes, heart diseases and strokes. 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 score and perception of general health.[76] The Department of Health suggests that increasing accessible open spaces could reduce healthcare costs in the UK by more than £2 billion annually.[77] Evidence also indicates that habitats with high biodiversity, especially within an urban environment, may encourage greater use.[78] The ANGSt+ analysis can help to identify areas in The Marches where the additional provision of accessible greenspace could have the greatest positive effect (see Chapter 5).

Ecosystems also have restorative effects and thereby contribute to mental health.[79] A recently published study carried out in the UK found that a view of grassland from home has a positive influence on emotional wellbeing.[80] There are numerous case studies supporting this view. See for example Saraev (2012) for an overview.[81]

A healthier population not only reduces healthcare costs and increases public wellbeing, it also increases economic productivity for example by reduced sickness absences (see Section 3.6). However, even if the links between environmental settings and human health were comparatively well researched in the past and positive relations have been observed, the exact causal relationship between the provision of greenspace and human health is still uncertain.

[73] Department of Health 2009.
[74] Coombes, Jones, and Hillsdon 2010.
[75] van den Berg, Koole, and van der Wulp 2003.
[76] Ho et al. 2003.
[77] pers comm., Mallika Ishwaran, Defra, 2011, cited in UK NEA 2011b, 1104.
[78] UK NEA 2011b.
[79] Kaplan 1995.
[80] Mourato et al. 2010.
[81] Saraev 2012.

> *"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."*[82]

Health and the existence of greenspace close to home could also be a dependent variable of education and/or income. It is arguable that people living in green areas are healthier because of the available greenspace close to home. However, one could also argue that people with higher education live healthier lifestyles in general and can more readily afford properties within green areas as they usually have a higher income. Further research is necessary to better establish such causal links.

Within scope of this assessment only the effect of 'green' physical activity on mortality rates could be valued in monetary terms. To estimate the health benefit of activities undertaken in greenspaces in The Marches the Health Economic Assessment Tool (HEAT) developed by the World Health Organisation (WHO) has been used.[83] The tool was designed to assess the value of reduced mortality from walking and cycling and is based on several health and economic studies and was informed by an international expert panel.[84]

To inform the HEAT, Natural England's 'Monitoring the Engagement with the Natural Environment (MENE)[85] survey data as well as statistics provided as part of Sports England's Active People Survey 9 (2014/15) was assessed. The analysis revealed that annually an estimated 1.05 million cycling trips and 28.47 million walking trips were made in or to environmental settings in The Marches over the past few years. It was assumed that 100% of cycling and 67% of walking trips (18.97 million) were at the required intensity level to be suitable for a HEAT analysis.

The HEAT results suggest that the observed amount of 'green' walking and cycling prevents 68 deaths in The Marches every year. The benefit of mortality reduction due to walking and cycling was valued at £206.9 million. However, it can be questioned if all cycling/walking is a

[82] Church et al. 2011, 663.
[83] 2014 version.
[84] WHO 2014.
[85] https://www.gov.uk/government/collections/monitor-of-engagement-with-the-natural-environment-survey-purpose-and-results

direct result of the existence of greenspace. It could for example be that in case where a local park would not exist, at least a proportion of potential cyclists and walkers would still have similar activity levels because they may cycle/walk on the street or exercise in a gym. For the purpose of this assessment the assumption was made that two-third of 'green' cycling and walking (including related health benefit) is a direct result of the existence of green infrastructure in The Marches which would not occur otherwise in a different setting.

Based on these assumptions it was estimated that the existence of green infrastructure in The Marches prevents about 46 deaths annually. The health benefit of reduced mortality due to 'green' exercise (walking and cycling only) was valued at nearly £147 million annually. This results in a capitalised value of almost £3.1 billion over the next 25 years. For a more detailed outline of methods and calculations as well as a break-down of findings for Herefordshire, Shropshire and Telford and Wrekin see Appendix F.

Table 3.6 **Health Benefits from Walking & Cycling: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Walking	£176.870	**£137.977**	£99.085	£4,421.749	**£2,901.719**	£2,353.668	£1,690.223
Cycling	£13.813	**£8.875**	£3.938	£345.319	**£186.652**	£151.399	£67.174
TOTAL	£190.683	**£146.853**	£103.023	£4,767.068	**£3,088.371**	£2,505.067	£1,757.397

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on WHO (2014).***

3.5 Education

Gaining ecological knowledge is a key element of the educational system and children benefit from this knowledge over their whole lifetime. In economic terms, *"formation of ecological knowledge […] can be seen as an investment in human capital."*[86] A high level of ecological knowledge boosts average lifetime earnings. Furthermore it provides additional non-marketable benefits to human wellbeing. It is also arguable that a good ecological education can lead to more productive individual use of leisure time by better 'enjoying the

[86] Mourato et al. 2010, 31.

nature'.[87] 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."*[88]

Along with more theoretical environmental education in the classroom, frequent interaction with the local environment is one key element of acquiring ecological knowledge.[89]

The Marches Local Enterprise Partnership (LEP) identified Agri Technology and Environmental Technologies and Services as two key business sectors within The Marches.[90] Both sectors require a good knowledge and understanding of the environment and sustainability issues, which makes related education very important for local economic prosperity. Especially in more urban areas of The Marches, greenspace is capable of playing an even more important role in education. Children who have grown up in cities and 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.[91]

Unfortunately, research about the economic valuation of the benefits of outdoor education is scarce. In England, Land Use Consultants (2002) estimated the economic value of benefits from woodland for education.[92] The educational benefits in the West Midlands were estimated to be about £2 million annually.[93] However, the assumptions are very crude, so this valuation is highly uncertain. More recently, education-related research has been undertaken within the UK National Ecosystem Assessment.[94] Using a cost-of-investment approach[95] organised school visits to Royal Society for the Protection of Birds (RSPB) reserves have been evaluated. Based on the travel costs method[96], a value of between £16

[87] Ibid.
[88] Ibid., 34.
[89] Mourato et al. 2010.
[90] The Marches LEP 2014.
[91] UK NEA 2011a.
[92] Land Use Consultants 2002.
[93] ERM and Willis 2004.
[94] UK NEA 2011a.
[95] This does not necessarily reflect the welfare benefits but can be estimated to reflect a baseline of that.
[96] This includes transport, time costs as well as entrance fees.

and £26 has been calculated per trip and child.[97] But this study was not judged to be suitable for a benefit transfer. For some habitat types, however, the value of cultural services has been assessed in monetary terms which include educational benefits (see Section 3.1).

3.6 Economy & Employment (Productivity)

As for health benefits, economy and employment is a classical cross-cutting issue. Recreational services, for example, are also available to the workforce in The Marches and come with additional health benefits (see Section 3.1 and 3.4). The importance of outdoor education for the development of vital skills has already been highlighted (see Section 3.5). Businesses and employees also benefit from regulating services such as for example the reduced risk of businesses getting flooded (Section 4.3) or benefiting from clean air (Section 4.5) and lower water rates (Section 4.4).

But there are also more direct impacts of Natural Capital and many studies suggest that a green environment has a positive impacts on the economy. The Marches LEP Strategic Economic Plan (2014) highlights for example that The Marches represents an attractive investment area because of its high quality, attractive environment.[98] There is increasing evidence suggesting that a good quality natural environment is an important factor for attracting inward investment and also a highly skilled workforce.[99] The attraction of high-skilled workers by improving green infrastructure can be seen as an opportunity to adjust the socio-economic structure of regions like The Marches.[100]

Green infrastructure can also influence shopping behaviour. In a study in Northumberland respondents reported that they shop about one hour longer in retail areas landscaped with greenery and trees than in areas without such amenities. About three out of four customers reported that they prefer such settings.[101]

> *"Study results suggest that higher price valuations are mediated by psychological inferences of district character and product quality. Thus, creating and*

[97] Mourato et al. 2010.
[98] The Marches LEP 2014.
[99] Allin and Henneberry 2010; Mell et al. 2011; Keeley et al. 2013.
[100] Regeneris 2009.
[101] Rskensr 2003.

stewarding an urban forest canopy may enhance revenues for businesses in retail districts that offer diverse products at varied prices."[102]

Another effect of a high-quality greenspace around work settings is increased productivity. A view of greenspace increases motivation and health which in turn decreases the number of sickness absence. The importance of green aesthetic amenity at work is also demonstrated by the fact that employees without a view of a green environment from the office often hang up pictures of natural scenes.[103] These findings suggest that the environment has a significant influence on the local economy, even if these effects are difficult to quantify.

As part of the sustainability initiative 'Plan A' a green wall was created in the Simply Food store in Oswestry, Shropshire.[104] The main motivation was energy reduction but besides positive effects on air quality, biodiversity and noise pollution regulation this feature may well have positive effects on the consumer base.

Within scope of this assessment, only the effect of improved health due to green exercise on work productivity was assessed. To calculate the value the number of regular (at least once a week) walkers and cyclists has been used and the proportion in work has been estimated. On average, regular physical exercise reduces sickness absence days from work by 5.23 days per active person per year. The benefit of the assessed 'green' exercise (walking and cycling only) on productivity has been valued at £21.7 million annually which results in a capitalised value of £455 million over 25 years. For methods, calculations and findings for each assessment area see Appendix F.

Table 3.7 **Productivity Benefits from 'Green' Exercise: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL	£28.159	**£21.661**	£15.163	£703.985	**£455.541**	£369.503	£258.652

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations.***

[102] Wolf 2003, 124.
[103] Heerwagen and Orians 1986.
[104] The Marches LEP 2015.

3.7 Wild Species Diversity (Biodiversity)

The term 'biodiversity' generally describes the diversity of life on earth, both between and within species. Biodiversity underpins all ecosystem services as all, at least partially, depend on living organisms and processes.[105]

> *"…evidence shows that, in general terms, the level and stability of ecosystem services tend to improve with increasing biodiversity."*[106]

Within the framework of this investigation, a slightly narrower distinction on the valuation of biodiversity has been made, relating it in particular to areas with a high diversity of species and related additional benefits. Therefore, the ecosystem services 'wild species diversity' in this specific context is largely defined as a cultural service.

To value the ecosystem service 'wild species diversity' for woodland habitats, findings from Hanley et al. (2002) were used for a benefit transfer (see Appendix E for methods, assumptions and calculations). A total annual value of Marches woodland as habitat for species of almost £10 million has been calculated. This results in a capitalised value of nearly £199 million over 25 years.

Table 3.8 **Woodland Wild Species Diversity Benefits: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£82.699	**£4.869**	£2.435	£2,067.464	**£102.400**	£83.060	£41.530
Low land ASNW	£33.770	**£1.988**	£0.994	£844.261	**£41.816**	£33.918	£16.959
Low land Coniferous Woodland	£11.762	**£0.693**	£0.346	£294.043	**£14.564**	£11.813	£5.907
Low land Mixed Woodland	£15.893	**£1.404**	£0.702	£397.314	**£29.518**	£23.943	£11.971
Upland Broadleaved Woodland & Scrub	£2.929	**£0.172**	£0.086	£73.222	**£3.627**	£2.942	£1.471
Upland ASNW	£0.718	**£0.042**	£0.021	£17.944	**£0.889**	£0.721	£0.360
Upland Conifer Woodland	£4.035	**£0.238**	£0.119	£100.887	**£4.997**	£4.053	£2.027
Upland Mixed Woodland	£0.608	**£0.036**	£0.018	£15.196	**£0.753**	£0.610	£0.305
TOTAL	£152.413	**£9.442**	£4.721	£3,810.330	**£198.562**	£161.059	£80.530

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Hanley et al. 2002***

[105] Norris et al. 2011, 64.
[106] Ibid.

Wetland habitats also have high biodiversity values and wetland species are under threat. Species diversity dependent on wetland habitats in many parts of the world are in continuing and accelerating decline.

> *"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."*[107]

To value wetland benefits the findings of Christie et al. (2011) were used for a benefit transfer. Wild species diversity values provided by wetlands in The Marches have been valued at £720,000 annually resulting in a capitalised value of just over £15 million. For methods and calculations see Appendix A.

Table 3.9 **Wetland Wild Species Diversity Benefits: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.934	**£0.623**	£0.311	£23.355	**£13.098**	£10.624	£5.312
Floodplain Grazing Marsh	£0.367	**£0.244**	£0.122	£9.164	**£5.139**	£4.169	£2.084
Purple Moor-grass & Rush Pasture	£0.537	**£0.358**	£0.179	£13.437	**£7.536**	£6.112	£3.056
Fen	£0.024	**£0.016**	£0.008	£0.602	**£0.338**	£0.274	£0.137
Reedbed	£0.006	**£0.004**	£0.002	£0.152	**£0.085**	£0.069	£0.035
TOTAL Wetland	£1.080	**£0.720**	£0.360	£27.008	**£15.146**	£12.286	£6.143

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011.***

For heathland, grassland and hedgerows, also the data provided by Christie et al. (2011) was used (for calculations see Appendix A). Together, the wild species diversity value of these habitats has been valued at £41.4 million annually. The high value of improved grassland is mainly related to the great extent of improved grassland in The Marches.

[107] McInnes 2007, 8.

Table 3.10 Grassland, Heathland and Hedgerows Wild Species Diversity: Marches

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£39.588	**£33.258**	£16.629	£1,247.162	**£699.422**	£567.321	£283.661
Lowland Calcareous Grassland	£0.022	**£0.015**	£0.008	£0.563	**£0.316**	£0.256	£0.128
Lowland Dry Acid Grassland	£0.248	**£0.091**	£0.046	£3.417	**£1.916**	£1.554	£0.777
Lowland Meadows	£3.549	**£0.738**	£0.369	£27.683	**£15.525**	£12.593	£6.296
Upland Calcareous Grassland	£0.002	**£0.001**	£0.001	£0.053	**£0.030**	£0.024	£0.012
Upland Hay Meadows	£0.000	**£0.000**	£0.000	£0.001	**£0.000**	£0.000	£0.000
TOTAL Grassland	£59.478	**£39.652**	£19.826	£1,486.959	**£833.902**	£676.402	£338.201
Lowland Heathland	£0.408	**£0.272**	£0.136	£10.197	**£5.719**	£4.638	£2.319
Upland Heathland	£2.214	**£1.476**	£0.738	£55.351	**£31.041**	£25.178	£12.589
TOTAL Heathland	£2.622	**£1.748**	£0.874	£65.548	**£36.760**	£29.817	£14.908
TOTAL Hedgerows	£0.046	**£0.030**	£0.015	£1.142	**£0.640**	£0.519	£0.260
TOTAL	£62.146	**£41.431**	£20.715	£1,553.648	**£871.303**	£706.739	£353.369

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

The total value of wild species diversity for all assessed habitats together adds up to £51.6 million annually or just over £1 billion capitalised.

4. Regulating Services

4.1 Global Climate Regulation (Climate Change Mitigation)

Since the pre-industrial era global Greenhouse Gas (GHG) emissions due to human activity have increased to a level unprecedented in at least the last 800,000 years. These anthropocentric GHG emissions are "extremely likely" to be the dominant cause for the observed global warming since the mid-20th century.[108]

> *"…the [Stern] Review estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more."*[109]

Ecosystems play an important role in mitigating climate change and its negative impacts by sequestering and storing carbon. The photosynthetic activities of trees and other vegetation sequester carbon dioxide from the atmosphere and therefore act as a net carbon sink, especially when carbon is stored into corresponding soils.[110] The Forestry Commission estimates that increased UK woodland stock could contribute an emission abatement equivalent to 10% of the total UK greenhouse gas inventory in 2050. This could be achieved by replanting an additional 4% of the UK land cover with woodland.[111]

The estimated actual woodland carbon stock in The Marches has been approximated by multiplying the average UK woodland carbon stock per ha by the area of woodland in The Marches of 57,021 ha. The carbon stock in Marches woodlands and corresponding soils was estimated to be in the region of 15.9 Mt which equals 58.1 Mt CO_2e. Multiplied by the actual price (2015 level) per tonne of CO_2e of £62.42, recommended by the UK Department of Energy & Climate Change (DECC), the value of carbon stored in Marches woodland and woodland soils was calculated at £3.6 billion.

[108] IPCC 2014.
[109] Stern 2006, vi.
[110] Read et al. 2009.
[111] Ibid.

Based on IPCC figures, wetlands in The Marches were estimated to have a carbon stock of 1.4 Mt valued at £329 million. However, this estimate may still significantly underestimate the carbon stock of some wetlands in The Marches such as in the Meres and Mosses. The IPCC estimate is only based on wetland and corresponding soils up to a 1m depth. Land-owners in the Meres and Mosses claim, however, that peat storing carbon in the Meres and Mosses is up to 14m deep in some areas.

The value of carbon stored in heathland and grassland habitats has been estimated using the findings of a review undertaken by Alonso et al. (2012). Calculations for 3,820 ha of heathland in The Marches resulted in a carbon stock of 344,000 t valued at £79 million. For 228,000 ha of assessed grassland habitats a carbon stock of 13.9 Mt valued at £3.2 billion has been calculated.

Aggregating the findings from above a total carbon stock in assessed habitats and corresponding soils of 31.6 Mt was calculated. This results in a total carbon value of £7.2 billion. It should be noted that this is a stock value; not to be confused with the (capitalised) flow value of other ecosystem services. Because the main framework of this investigation is based on calculating the annual flow of ecosystem services, the value of £7.2 billion has not been added to the main table of the monetary valuation within scope of this study as it does not match the conceptual framework. For more information about the methods, calculations, why stock and flow values cannot be easily added up, and how more accurate values could be generated see Appendix G. More details regarding the interpretation of the findings as well as summary tables for The Marches, but also for Herefordshire, Shropshire and Telford and Wrekin, are presented in Section 6.

Because of uncertainties and complexities in carbon calculations these figures should be treated as purely indicative. The complexity of calculating an accurate figure for carbon stocks and annual sequestration rates can be explained using the example of wetlands. The impact of wetlands on the climate is complex and the benefits of wetland concerning climate change mitigation still remain uncertain.[112] On the one hand, wetlands act as carbon sink. However, on the other, wetland micro-organisms emit other greenhouse gases, especially

[112] EFTEC 2007.

methane, which are highly dependent upon the characteristics of the wetland (redox, hydrology, pH, etc.). Within a comparatively short time horizon of 20 years, new created wetlands in northern latitudes are estimated to have net negative effects on climate change. This effect decreases over time and may lead to a balanced greenhouse gas effect over 100 years. After they have existed for 500 years, northern wetlands are estimated to reduce the net greenhouse gas warming potential.[113]

Large former wetland areas in England are still emitting carbon dioxide although they were drained many years ago to provide agricultural land.[114] Agriculture is also a major source of other important greenhouse gasses, and is believed to be one of the main causes of the observed increase in methane concentration in the atmosphere.[115] In 2011, UK agriculture accounted for 84% of total nitrous oxide emissions and 43% of total methane emissions in the UK. However, greenhouse gas emissions caused by agriculture are declining.[116]

4.2 Local Climate Regulation (Climate Change Adaptation)

As already outlined in Section 1.4, average summer maximum temperatures in The Marches are projected to rise between 3.0% and potentially 7.5% by the 2050's.[117] The effects of climate change in the UK have for example been identified to increase the risk and intensity of flooding events as well as summer mortality due to higher temperatures and ozone.[118]

Green vegetation has an influence on the local climate, and particularly so in more urbanised areas such as Telford, Shrewsbury and Hereford. Urban areas are usually warmer than their surroundings. This so called Urban Heat Island Effect (UHIE) is caused by the built environment retaining heat, which is released during the night, as well as the concentration of waste heat from warming and cooling. In the future, the UHIE will increasingly combine with global warming caused by climate change.

[113] Whiting and Chanton 2001; O'Gorman and Bann 2008.
[114] Natural England 2008.
[115] IPCC 2007.
[116] Defra et al. 2013.
[117] As compared to the baseline period 1961–1990.
[118] HR Wallingford et al. 2012.

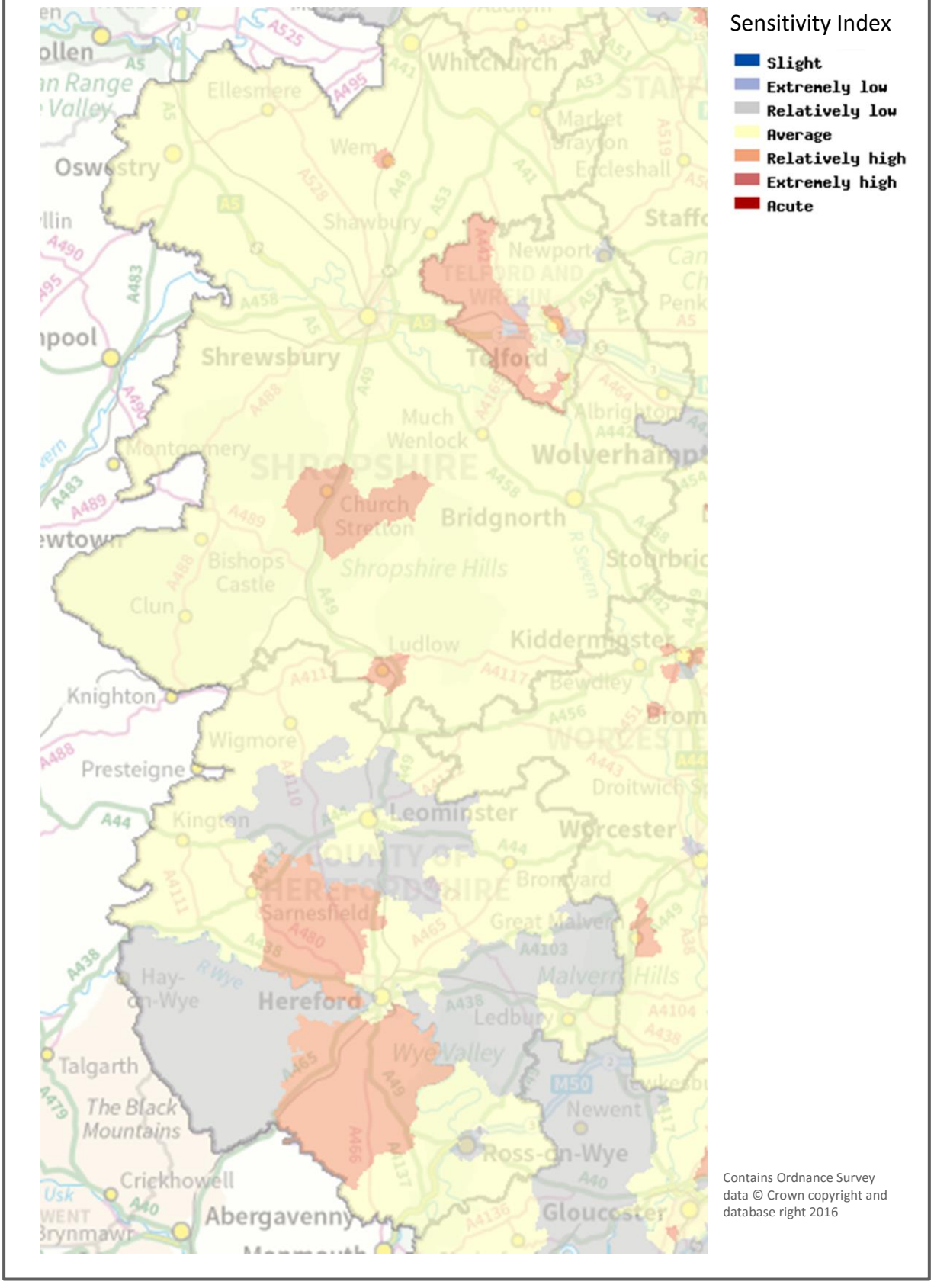
Green infrastructure and the urban forest in particular have a significant cooling effect on the local climate in cities and towns. The temperature around vegetation is reduced by evapotranspiration. Furthermore, trees and scrub provide shading and protection from heat and UV radiation.[119] Research carried out in Manchester suggests that a 10% increase of green infrastructure in areas with the least greenery would reduce the UHIE by between 2.2 and 2.5%.[120] In summer 2006 during a heatwave, the UHIE caused more than 4 degrees of additional warmth within the most built up area of Birmingham. Around Sutton Park, the largest park in Birmingham, the temperature was about 3 degrees lower.[121] Other studies validate these effects.[122] Therefore green infrastructure has the potential to play a vital role in helping urban areas to adapt to climate change. This is less of an issue in The Marches because of its comparatively low urbanisation and population density but should still be considered in larger towns to build resilience to the changing climate.

The elderly sector of the population and young children are thought to have a lower tolerance to extreme temperatures, and so excessive heat can be a significant contributory factor to exacerbating illnesses and contributing to increased mortality.[123] Land-use planners should bear this in mind when developing policies for creating urban areas that are more resilient to the effects of warmer temperatures and more frequent extreme weather events such as heat waves, which are a likely consequence of climate change.

Figure 4.1 below shows the socio-spatial vulnerability of The Marche's population to events like heatwaves at the neighbourhood (Middle Super Output Area) level. The sensitivity index is based on the proportion of the population being older (75+), young children (<5), and people in ill-health. One can see that The Marches is mainly within the English average with some areas having a relatively low/high sensitivity but no areas with extremely high or even acute sensitivity to heatwaves.

[119] Forest Research 2010.
[120] Gill et al. 2007.
[121] Tomlinson 2009.
[122] Forest Research 2010.
[123] Tomlinson et al. 2011.

Figure 4.1 Socio-spatial Vulnerability to Heatwaves



Source: ***Climatejust.org.uk***

There are also other effects of green vegetation on the local climate. Not only do trees provide shading, potentially reducing costs associated with air conditioning, but they can also act as shelter belts reducing wind speed which may result in lower heating costs. Kuppuswamy (2009) estimates that street trees provide a cooling effect of between 2% and 7% by providing building shade.[124] 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.[125] This in turn reduces carbon emissions, contributing to the mitigation of climate change. Reducing the UHIE also helps reducing air pollution.[126]

However, the maximum expression of such effects is closely related to local settings and the exact context and location of trees and scrub. Unfortunately, the economic valuation of these effects in The Marches was not possible within the scope of this investigation. The scientific evidence to date is not robust enough to value the effect of green infrastructure on the local climate in monetary terms.[127]

4.3 Flood Regulation

In the UK, soil cover has changed significantly due to human activity, especially within the past 50 years.[128] The increase in surface sealing, especially in urban areas but also in rural areas due to soil compaction and other land-use changes reducing the extent of vegetation with high infiltration capacities, has increased soil erosion as well as reducing the natural capacity of ecosystems to retain and store water. Reduced vegetation cover also generates faster water run-off rates which promotes flooding events.[129]

> *"The replacement of natural green spaces with concrete and impermeable pavements in urban areas reduces the effectiveness with which rainfall, snow melt and storm water are absorbed and returned to groundwater aquifers. […]*

[124] Kuppuswamy 2009.
[125] Wang et al. n.d.
[126] Beckett, Freer-Smith, and Taylor 1998.
[127] Forest Research 2010.
[128] Smith et al. 2011.
[129] Ibid.

This results in elevated levels of surface water run-off, which increases the likelihood of local flooding and sewers reaching overcapacity."[130]

Habitats and green vegetation can help to mitigate extreme weather events, and in particular the risk of flooding. Wetland and floodplain habitats fill rapidly during flooding events, at least to a point of saturation, and then slowly filter back retained water to buffer surface flows. The total costs to UK insurers of the 2007 flooding were estimated to be in the order of £3 billion.[131] If no additional flood risk management action is taken, the costs caused by urban flooding alone in the UK could increase to between £1 billion and £10 billion annually under the changing climate[132] with some extreme scenarios predicting annual costs arising from UK flooding of £20 billion by 2060.[133]

The risk of flooding to urban and rural areas is not a new concern, but the increase in use of impermeable surfaces, rural land-use changes, population rise and more extreme weather events as a likely result of climate change is increasing the frequency and intensity of flooding and the number of properties at risk. Such flooding events can cause damage to properties and risk to human lives, and also worsen water quality in rivers as soil is eroded and pollutants are washed out from sewerage and transport systems into rivers and other water bodies.

The creation of ecosystems such as wetlands can reduce the volume of water run-off. Wetlands are of particular importance for flood alleviation, contributing to suppressing flood generation, as well as damage and associated costs caused by flooding, due to their role in storing water during, and buffering flows after, flooding events.[134] To calculate the flood regulation service provided by wetlands in The Marches, the model of Brander et al. (2008) has been applied for a benefit transfer. Stating the central estimate, wetland habitats in The Marches provide flood risk regulation benefits worth £1.8 million annually or £37.4 million capitalised. See Appendix B for methods, calculations and a break-down for each assessment area.

[130] European Commission 2012, 22.
[131] Pitt 2007.
[132] Evans et al. 2004.
[133] UK NEA 2011b.
[134] Birol et al. 2007.

Table 4.1 **Flood Risk Regulation Benefits Provided by Wetlands: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£2.825	**£1.662**	£0.499	£70.625	**£34.947**	£28.347	£8.504
Floodplain Grazing Marsh	£0.691	**£0.406**	£0.122	£17.267	**£8.544**	£6.930	£2.079
Purple Moor-grass & Rush Pasture	£1.521	**£0.895**	£0.268	£38.019	**£18.813**	£15.260	£4.578
Fen	£0.094	**£0.056**	£0.017	£2.361	**£1.168**	£0.948	£0.284
Reedbed	£0.019	**£0.011**	£0.003	£0.485	**£0.240**	£0.195	£0.058
Swamp	£0.248	**£0.146**	£0.044	£6.196	**£3.066**	£2.487	£0.746
Other	£0.252	**£0.148**	£0.044	£6.298	**£3.116**	£2.528	£0.758
Peatbog	£0.198	**£0.117**	£0.035	£4.961	**£2.455**	£1.991	£0.597
Blanket Bog	£0.002	**£0.001**	£0.000	£0.043	**£0.021**	£0.017	£0.005
Lowland Raised Bog	£0.140	**£0.082**	£0.025	£3.490	**£1.727**	£1.401	£0.420
Fen	£0.057	**£0.034**	£0.010	£1.428	**£0.707**	£0.573	£0.172
TOTAL Wetland	£3.023	**£1.778**	£0.534	£75.586	**£37.402**	£30.338	£9.101

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008.***

These values are mainly based on replacement costs (avoided damage costs), applying a benefit transfer function.[135] However, it should be noted that flood risk regulation services are very site-specific and should be valued case-by-case.[136] Therefore a rather wide range of 70% has been applied for the sensitivity analysis. More precise valuation of the contribution of wetlands to flood risk management in The Marches would be a valuable policy contribution to help identify the best flood risk reduction management options, though this is beyond the scope of the present study.

Apart from wetlands, other habitats also contribute to flood risk regulation. For these habitats findings provided by Christie et al. (2011) have been applied to calculate a monetary value (see Appendix A; also for findings for each assessment area). The outcomes for The Marches are summarised in Table 4.2 below.

[135] Brander et al. 2008.
[136] Land Use Consultants and GHK Consulting 2009.

Table 4.2 **Flood Risk Regulation Services of Different Habitats: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£19.682	**£11.577**	£3.473	£492.038	**£243.477**	£197.491	£59.247
Low land ASNW	£5.979	**£3.517**	£1.055	£149.471	**£73.963**	£59.994	£17.998
Low land Mixed Woodland	£14.445	**£8.497**	£2.549	£361.116	**£178.692**	£144.942	£43.483
Upland Broadleaved Woodland & Scrub	£0.961	**£0.565**	£0.170	£24.014	**£11.883**	£9.639	£2.892
Upland ASNW	£0.160	**£0.094**	£0.028	£3.989	**£1.974**	£1.601	£0.480
Upland Mixed Woodland	£0.347	**£0.204**	£0.061	£8.686	**£4.298**	£3.486	£1.046
TOTAL Woodland	£41.573	**£24.454**	£7.336	£1,039.314	**£514.287**	£417.153	£125.146
Improved Grassland	£74.686	**£43.933**	£13.180	£1,867.159	**£923.932**	£749.428	£224.828
Low land Meadow s	£0.496	**£0.292**	£0.087	£12.395	**£6.133**	£4.975	£1.493
Other Neutral Grassland	£10.101	**£5.942**	£1.782	£252.519	**£124.955**	£101.355	£30.406
TOTAL Grassland	£85.283	**£50.166**	£15.050	£2,132.074	**£1,055.021**	£855.758	£256.727
Low land Heathland	£0.252	**£0.148**	£0.044	£6.303	**£3.119**	£2.530	£0.759
Upland Heathland	£1.702	**£1.001**	£0.300	£42.555	**£21.058**	£17.080	£5.124
TOTAL Heathland	£1.954	**£1.150**	£0.345	£48.858	**£24.176**	£19.610	£5.883
TOTAL Hedgerow s	£0.021	**£0.012**	£0.004	£0.527	**£0.261**	£0.211	£0.063
TOTAL	£128.831	**£75.783**	£22.735	£3,220.772	**£1,593.745**	£1,292.732	£387.820

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

All assessed habitats in The Marches (including wetlands) cumulatively provide flood risk regulation services valued at £77.6 million annually. However, since the projected future increase in number and magnitude of flooding events caused by climate change has not been taken into account, the calculated capitalised value of £1.6 billion is likely to be conservative.

By the 2080s, between £22 billion and £75 billion of new investments in engineering might be needed in the UK to ensure protection from higher flood risks caused by climate change.[137] A share of these 'grey' infrastructure investments might be avoidable through the creation of Sustainable Drainage Systems (SuDS) and the strategic protection or creation of vegetated areas such as woodland, grassland and wetland habitats. Often, this might represent a cost-efficient alternative even if assessed purely in terms of flood risk benefits. However, such 'green' flood regulation measures usually also come with a range of additional benefits such as recreation, biodiversity, etc.

[137] Pitt 2007.

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, and also where these additional benefits have been optimised.[138] A good local example is a planned £500,000 SuDS scheme at Ricoh's construction site in Telford where it is planned to create a series of pools and wetlands also to improve water quality. This SuDS creation shall mitigate the potential of a site shut down due to possible water pollution incidents and comes with a range of additional benefits for amenity and health, biodiversity, and carbon storage.[139]

However, in contrast to the USA, applied research into the role of trees and vegetation in water management is relatively scarce in the UK and Europe, despite government strategies as 'Making space for water'.[140] Because hydrological studies are very site-specific this represents a major research gap in the UK.[141]

4.4 Water Quality Regulation

Another significant benefit provided by ecosystems, especially wetlands, is the regulation of water quality. This occurs through processes such as the retention, removal and transformation of nutrients, organic matter and sediment, and bacterially-driven denitrification, nitrification and mineralisation, plant uptake and the trapping or filtering of particulates.[142] Furthermore, wetlands can capture pesticides and other complex organic pollutants.[143]

However, the UK's wetland resource, and hence its capacity to regulate water quality, has been in long-term decline. Since Roman times 90% of UK wetlands have been lost.[144] Former wetland habitats have often been drained to make the land usable for agricultural production.[145] The concentration of nitrates and phosphate in surface waters, on the other hand, has rapidly increased over the same timescale, with intensified agriculture being one of the major causes.

[138] Kazmierczak and Carter 2010.
[139] The Marches LEP 2015.
[140] Defra 2005.
[141] Saraev 2012.
[142] Maltby et al. 2011.
[143] EFTEC 2010.
[144] Maltby et al. 2011.
[145] Ibid.

All habitats have a role in the water cycle, and hence make a contribution to the regulation of water quality. However, in The Marches it was only possible to value the water quality regulation services of wetlands as relevant data for other habitat types was lacking or missing. Within the scope of this investigation, the benefits of wetlands in regulating water quality have been valued at £1.4 million annually, using the benefit transfer function provided by Brander et al. (2008). Capitalised over 25 years this results in a value of £30.3 million (see Appendix B for more details and also for a break down by assessment area). Most primary valuation studies included by Brander et al. (2008) calculated this effect by taking avoided remediation costs of water purification by water suppliers into account.

Table 4.3 **Water Quality Regulation Benefits Provided by Wetlands: Marches**

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£2.020	**£1.347**	£0.673	£50.497	**£28.319**	£22.971	£11.485
Floodplain Grazing Marsh	£0.494	**£0.329**	£0.165	£12.346	**£6.924**	£5.616	£2.808
Purple Moor-grass & Rush Pasture	£1.087	**£0.725**	£0.362	£27.184	**£15.245**	£12.366	£6.183
Fen	£0.068	**£0.045**	£0.023	£1.688	**£0.947**	£0.768	£0.384
Reedbed	£0.014	**£0.009**	£0.005	£0.347	**£0.194**	£0.158	£0.079
Swamp	£0.177	**£0.118**	£0.059	£4.430	**£2.484**	£2.015	£1.008
Other	£0.180	**£0.120**	£0.060	£4.503	**£2.525**	£2.048	£1.024
Peatbog	£0.142	**£0.095**	£0.047	£3.547	**£1.989**	£1.614	£0.807
Blanket Bog	£0.001	**£0.001**	£0.000	£0.031	**£0.017**	£0.014	£0.007
Lowland Raised Bog	£0.100	**£0.067**	£0.033	£2.496	**£1.400**	£1.135	£0.568
Fen	£0.041	**£0.027**	£0.014	£1.021	**£0.573**	£0.464	£0.232
TOTAL Wetland	£2.162	**£1.441**	£0.721	£54.044	**£30.309**	£24.584	£12.292

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008.***

A commonly cited example where ecosystem services were successfully managed to improve water quality is New York City. Instead of constructing a new water treatment plant, the city authority opted to develop a rural-urban partnership with land owners in the Catskills and Delaware area to improve farm management techniques in order to prevent run-off of wastewater and nutrients. This payment scheme has contributed towards securing a supply of good water quality in the watercourses from which New York City's water supply is drawn, saving the water consumers in the city between US$ 4.5 billion and US$ 7 billion in capital costs (which would have been necessary for the construction of a conventional water filtration plant) plus additional annual treatment costs of between US$ 300 million and US$

500 million.[146] New York City's water supply provides a good example of how economic instruments like Payments for Ecosystem Services (PES) can provide cost-effective solutions by optimising the supply chain cost-efficiently and also achieving multiple additional ecosystem services, rather than using engineering solutions at 'the end of the pipe' to address single-issue concerns.

In addition to justifying regulating and influencing farming practices in other ways, wetland habitat re-creation in The Marches may be a cost-effective mechanism to deliver some of the water quality improvements required for compliance with the EU Water Framework Directive as well as delivering a range of other linked benefits such as flood risk regulation and greenspace provision for recreation, biodiversity, etc.

4.5 Air Quality Regulation

Complex vegetation and particularly trees have a positive effect on the regulation of local air quality. This applies especially in towns where pollution emissions are comparatively high. The main sources for pollution are vehicle exhaust, industry and intensive agriculture.[147] Local authorities within The Marches have to cope with a range of air quality issues and there are 7 Air Quality Management Areas (AQMAs) declared in Herefordshire (2) and Shropshire (5) including, for example, Whitburn Street and Salop Street in Bridgnorth. All AQMAs were declared because of high concentrations of nitrogen dioxide (NO_2). There are no records of AQMAs in Telford and Wrekin.[148]

Trees and other vegetation absorb, through physical deposition as well as chemical reactions, deleterious pollution such as nitrogen dioxide; but also carbon monoxide (CO), sulphur dioxide (SO_x), ozone (0_3) and fine particulates (PM_{10}) which are responsible for major illnesses such as respiratory ailments, heart disease and cancer.[149] Research carried out in New York, for example, suggests that a high tree density significantly reduces asthma prevalence in very young children[150] On the other hand, it is possible that specific tree

[146] Perrot-Maître and Patsy 2001; Elliman and Berry 2007.
[147] van Oudenhoven et al. 2012.
[148] http://uk-air.defra.gov.uk/aqma/maps (accessed: 10/03/2016)
[149] McPherson, Nowak, and Rowan 1994.
[150] Lovasi et al. 2008.

species also have a negative impact on air quality by forming low level ozone and by liberating pollen which can reduce the net air pollution absorption benefits.[151]

The species selection as well as the location and management of trees and woodland have a significant impact on the ability to regulate air quality. In general, trees and vegetation can capture, for example, more fine dust if located close to the source of fine dust emissions.[152]

> *"...increasing deposition by the planting of vegetation in street canyons can reduce street-level concentrations in those canyons by as much as 40% for NO_2 and 60% for PM."*[153]

On the other hand, however, trees can also worsen local air quality, depending on their location. Trees directly located along frequently used streets such that there is a closed canopy 'roof' can trap pollutants because the polluted air from traffic exchanges slower. This can have a negative effect on local air quality along busy streets.[154] Therefore it can at times be appropriate to locate trees further away from the carriageway to gain the best outcomes.[155]

One can see that the ability of green vegetation and trees in regulating air quality is very context- and location-specific, requiring detailed knowledge about location and species structure if a robust assessment of this ecosystem service is to be achieved. Such information was not available for this investigation which is why a monetary quantification was not carried out. However, an i-Tree Eco assessment generalises outcomes and overcomes some of the data limitations for trees, albeit with uncertainties. Such an assessment would enable the calculation of a monetary value for air quality regulation (and also for example global climate regulation) services by trees and woodland in The Marches.

[151] Donovan 2003.
[152] van Oudenhoven et al. 2012.
[153] Pugh et al. 2012, 7692.
[154] Buccolieri et al. 2009.
[155] Woodland Trust 2012.

5. ANGSt+ Assessment

Natural England's Accessible Natural Greenspace Standard (ANGSt) is a framework for assessing the current level of accessible natural greenspace within a specific area as well as the population that can benefit from such accessible greenspace.[156] Here, the ANGSt has been advanced to an ANGSt+ with the aim to provide more detail about which areas are in greatest need of additional Accessible Natural Greenspace (ANG) to prioritise greenspace delivery on the ground. This Chapter summarises the ANGSt+ methods and findings. For more detail about the assessment see Appendix H.

For ANGSt, Natural England defines natural greenspace as *"places where human control and activities are not intensive so that a feeling of naturalness is allowed to predominate"*.[157] Relevant natural greenspace sites in The Marches were identified using GIS software. Spatial habitat information was provided by Shropshire County Council, Shropshire Wildlife Trust (SWT), Herefordshire Biological Records Centre (HBRC) and Natural England. This analysis resulted in a combined ANG layer for The Marches.

If available also ANG sites within a 1km buffer around The Marches were included because people in the Marches living close to the border may still benefit from ANG outside the Marches boundary. However, much information on ANG was only available for within The Marches which means that the identified demand for ANG close to the Marches boundary should be treated with some caution and it is recommended to individually assess ANG outside The Marches that may benefit people close to the border before action is taken.

ANGSt only considers sites of at least 2ha in size. However, it is arguable that also smaller sites can provide valuable recreational opportunities - especially in more densely populated urban areas with high demand for ANG. To take such considerations into account also smaller sites between 0.5ha and 2ha were considered for this ANGSt+ assessment. To acknowledge the higher recreational value of larger sites (for example because of the limited feel of privacy and because they are more likely to be overcrowded) a lower 'weight' has been applied to ANG sites <2ha.

[156] Natural England 2010.
[157] Ibid., 48.

Another modification made was that also sites further away from homes than 300m were considered because it is reasonable to assume that the recreational value does not fall to zero if a site is 301m away from home. Therefore also sites within 600m and 900m from home were part of the ANGSt+ assessment. However, the assumption underlies that such sites further away than 300m from homes have a reduced recreational value which is reflected by a lower weight. The following weighting matrix shows which weights were defined for ANGSt+.

Table 5.1 ANGSt+ Weighting Matrix

Accessible Natural Greenspace Site Size	Distance From Home		
	Up to 300m	301m to 600m	601m to 900m
2ha+	1	0.5	0.25
0.5-2ha	0.5	0.25	0

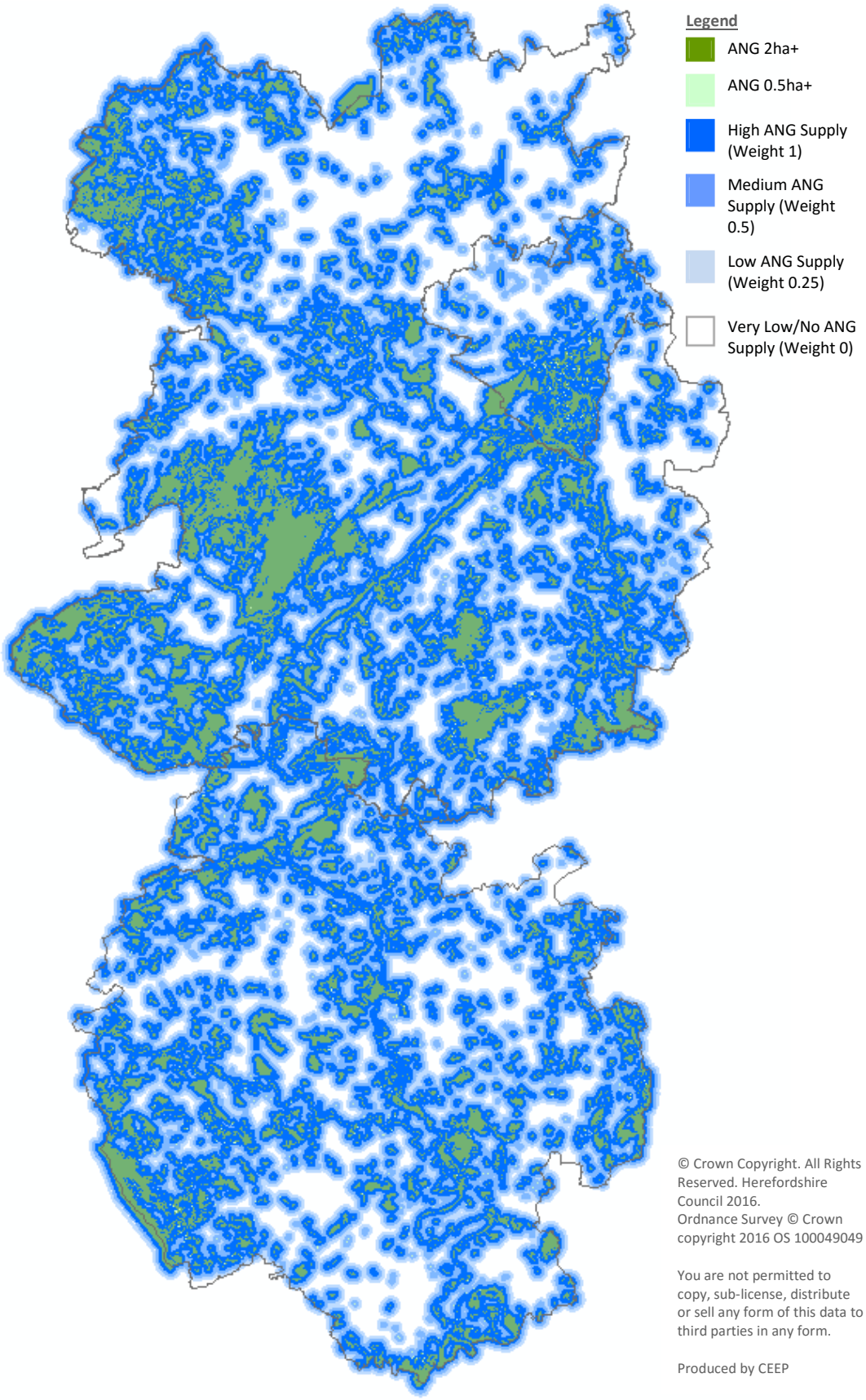
Source: ***Author***

The weights indicate the degree to which a household can benefit from ANG where a weight of 1 means high benefit and a weight of 0 means very low/no benefit. The assumption underlies that households within 300m from ANG of at least 2ha are covered and do not necessarily demand additional ANG opportunities. Households within 300m from ANG of 0.5-2ha are partially covered but would still benefit from additional ANG and so on.

The degree of people's demand for ANG can be assumed to be generally linked to the population density or number of households in an area. The more people living around an ANG the more people benefit from it. ANGSt+ explicitly considers the demand by counting the households with full, some and no access to ANG within reasonable walking distance; depending on the weight.

To visualise the supply of ANG different buffers were created and weighted based on to the weighting matrix. Figure 5.1 shows a map with the supply with ANG where white means very low/no supply with ANG and dark blue means high supply with ANG.

Figure 5.1 ANG Supply: Marches ANGSt+



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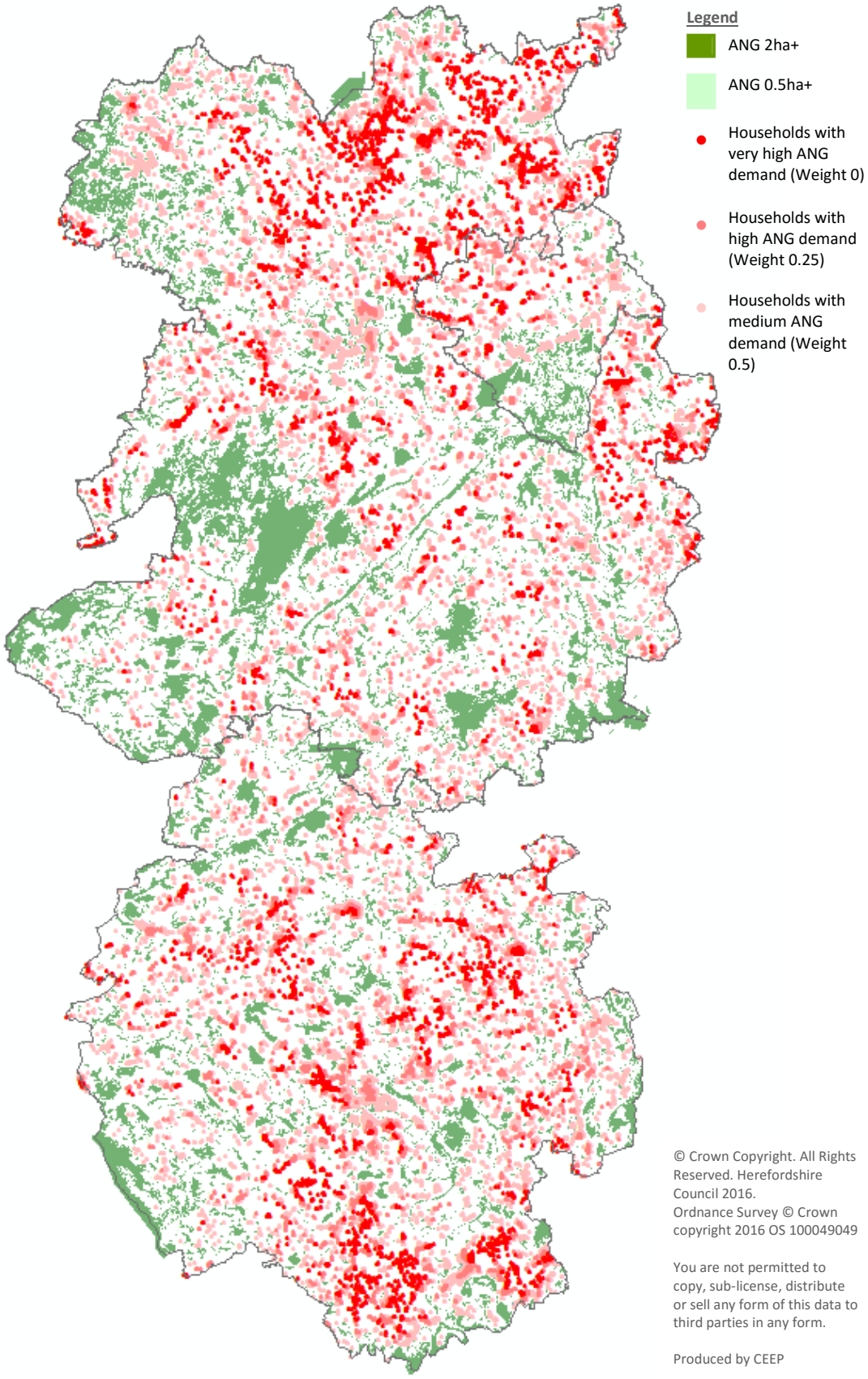
Produced by CEEP

Source: ***Based on GIS data provided by Shropshire County Council, SWT, HBRC and Natural England***

Figure 5.2 Demand for additional ANG: Marches ANGSt+



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Source: ***Based on GIS data provided by Shropshire County Council, SWT, HBRC and Natural England***

However, identifying the areas with least access to ANG was only the first step of this ANGSt+ assessment. The next step was to identify the demand for ANG. If there is an area with poor ANG supply but no one lives in that area then there is no need for ANG delivery (at least not for recreational purposes). The demand increases with the number of households with poor ANG supply (furthest away from ANG of reasonable size). Therefore another map has been produced for The Marches ANGSt+ displaying all households with demand for additional ANG. Figure 5.2 shows all households with demand for additional ANG applying a colour code where dark red means very high demand and light red means medium demand.

Figure 5.2 can be used to identify areas within The Marches that are likely to benefit most from the creation of additional ANG (or providing access to existing so far inaccessible natural greenspace). The ANGSt+ assessment provides a starting point for prioritising action. If an area has been identified for action then further investigations on the ground would be recommended to establish if the ANGSt+ map reflects the circumstances on the ground. It could be, for example, that there is an ANG site that has not been identified in the ANGSt+ assessment. This is particularly important in areas close to the boundary of The Marches as only few ANG sites outside have been included in the ANGSt+ assessment. It is also important to check if there is opportunity to create ANG locally and what the preferences of the local community are in this respect. The numbers of households with additional demand for ANG are outlined in Table 5.2. Please note that in a 'common' ANGSt assessment only households with a weight of 1 would meet the ANGSt criteria.

Table 5.2 **Number of Households within The Marches with Access to ANG**

Weight	Definition	Number of Households				Demand for new ANG
		Herefordshire	Shropshire	Telford and Wrekin	Total Marches	
1	Households within 300m from ANG of at least 2ha	44,134 (50%)	84,408 (58%)	66,967 (89%)	195,509 (63%)	Low
0.5	Households within 301m to 600m from ANG of at least 2ha and/or within 300m of ANG of between 0.5ha and 2ha	29,835 (34%)	43,433 (30%)	7,035 (9%)	80,303 (26%)	Medium
0.25	Households within 601m to 900m from ANG of at least 2ha and/or within 301m to 600m of ANG of between 0.5ha and 2ha	10,010 (11%)	10,435 (7%)	466 (0.6%)	20,911 (7%)	High
0	Households further away than 900m from ANG of at least 2ha and further away than 600m from ANG of between 0.5ha and 2ha	4,245 (5%)	7,133 (5%)	368 (0.5%)	11,746 (4%)	Very High

Source: ***Author calculations***

6. Results

6.1 Marches

Altogether, habitats covering 290.5 km^2 have been assessed within the scope of this Ecosystem Assessment for The Marches (Herefordshire, Shropshire and Telford and Wrekin). This constitutes more than 51% of the total geographical area. Stating the central estimate, the ecosystem services assessed within this investigation have been valued at £358.1 million annually. The sensitivity analysis results in a range from £198.6 million to £675.0 million per year. When capitalised over 25 years, those ecosystem services that could be assessed in The Marches have been valued at £7.5 billion (£3.4b - £16.8). The wide range of the sensitivity analysis for the capitalised value can be explained by the different discount rates (see Section 1.5). This capitalised flow value is in addition to the estimated value of the carbon stock in assessed vegetation and corresponding soils of £7.2 billion. If capitalised ecosystem services flow values and carbon stock values are added up then this results in a total value of £14.8 billion for Natural Capital and its 'external' services to society. The main findings of this investigation are summarised in Table 6.1 (annual flow values), Table 6.2 (capitalised flow values) and Table 6.3 (carbon stock value) below. All values are stated in million pounds (£m) and 2015 prices.

The calculated figures present the baseline of 'non-market' or 'external' ecosystem services only. Ecosystem services that have a market price such as commercial food and timber production were not included in the assessment scope and would add significantly to the calculated values. It also needs to be stressed that these are baseline figures as it has only been possible to value some ecosystem services. Data limitations prevented quantitative valuation of other ecosystem services. And even for those ecosystem services where a monetary value was calculated this often only captures an element of that ecosystem service. For health benefits, for example, only the effect of physical 'green' exercise on mortality has been quantified. The 'true' value is likely to be much higher and would for example also include the positive effects on mental health (see Section 3.4).

Table 6.1 Annual Baseline Value of Assessed Ecosystem Services in The Marches

Broad Habitat Type / Assessed Habitat Area		Woodland 56,344 ha			Grassland 228,364 ha			Wetland 1,903 ha			Heathland 3,820 ha			Hedgrows 63 ha			TOTAL 290,494 ha		
Ecosystem Service		High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low
Provisioning Services	Wild Food	£7.61	**£2.66**	£0.80	£1.50	**£0.51**	£0.26	£0.21	**£0.07**	£0.04	£0.04	**£0.02**	£0.01	£0.02	**£0.01**	£0.00	£9.38	**£3.27**	£1.10
	Ornamental Resources & Non-food Products	£13.10	**£3.17**	£0.95	£3.33	**£0.81**	£0.40	£0.17	**£0.04**	£0.02	£0.13	**£0.03**	£0.02	£0.01	**£0.00**	£0.00	£16.74	**£4.05**	£1.39
	Water Supply							£0.02	**£0.01**	£0.00							£0.02	**£0.01**	£0.00
Cultural Services	Wild Species Diversity	£152.41	**£9.44**	£4.72	£59.48	**£39.65**	£19.83	£1.08	**£0.72**	£0.36	£2.62	**£1.75**	£0.87	£0.05	**£0.03**	£0.02	£215.64	**£51.59**	£25.80
	Recreation	£19.59	**£14.58**	£9.57	£30.77	**£20.51**	£10.26	£5.69	**£0.32**	£0.16	£1.04	**£0.69**	£0.35	£0.03	**£0.02**	£0.01	£80.39	**£51.64**	£28.10
	Aesthetic Values & Sense of Place	£23.27	**£15.52**	£7.76															
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£190.68	**£146.85**	£103.02
	Productivity	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£28.16	**£21.66**	£15.16
Regu-lating	Flood Regulation	£41.57	**£24.45**	£7.34	£85.28	**£50.17**	£15.05	£3.02	**£1.78**	£0.53	£1.95	**£1.15**	£0.34	£0.02	**£0.01**	£0.00	£131.85	**£77.56**	£23.27
	Water Quality Regulation							£2.16	**£1.44**	£0.72							£2.16	**£1.44**	£0.72
TOTAL																	£675.03	**£358.08**	£198.56

Notes:

All values are stated in million pounds (£m); 2015 prices.

Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.

Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:

Central Central estimate

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

Table 6.2 Capitalised Baseline Value of Assessed Ecosystem Services in The Marches

	Broad Habitat Type	Woodland			Grassland			Wetland			Heathland			Hedgrows			TOTAL			
	Assessed Habitat Area	56,344 ha			228,364 ha			1,903 ha			3,820 ha			63 ha			290,494 ha			
	Ecosystem Service	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	HM Tr.	Low
Provisioning Services	Wild Food	£190	**£56**	£14	£37	**£11**	£4	£5	**£2**	£1	£1	**£0**	£0	£0	**£0**	£0	£234	**£69**	£56	£19
	Ornamental Resources & Non-food Products	£327	**£67**	£16	£83	**£17**	£7	£4	**£1**	£0	£3	**£1**	£0	£0	**£0**	£0	£419	**£85**	£69	£24
	Water Supply							£1	**£0**	£0							£1	**£0**	£0	£0
Cultural Services	Wild Species Diversity	£3,810	**£199**	£81	£1,487	**£834**	£338	£27	**£15**	£6	£66	**£37**	£15	£1	**£1**	£0	£5,391	**£1,085**	£880	£440
	Recreation	£490	**£307**	£163	£769	**£431**	£175	£142	**£7**	£3	£26	**£15**	£6	£1	**£0**	£0	£2,010	**£1,086**	£881	£479
	Aesthetic Values & Sense of Place	£582	**£326**	£132																
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£4,767	**£3,088**	£2,505	£1,757
	Productivity	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£704	**£456**	£370	£259
Regu-lating	Flood Regulation	£1,039	**£514**	£125	£2,132	**£1,055**	£257	£76	**£37**	£9	£49	**£24**	£6	£1	**£0**	£0	£3,296	**£1,631**	£1,323	£397
	Water Quality Regulation							£54	**£30**	£12							£54	**£30**	£25	£12
TOTAL																	£16,876	**£7,531**	£6,108	£3,387

Notes:
All values are stated in million pounds (£m); 2015 prices.
The capitalised value represents the present value of ecosystem services provided over a time period of 25 years.
Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.
Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:
Central Central estimate
High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr. This value is based on the higher discount rates recommended by HM Treasury and is stated for comparability purposes only.
Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

Table 6.3 **Carbon Stock Value in The Marches**

		Area	Carbon Stock	**Stock Value**
Carbon	Woodland	56,344 ha	15,855,771 t	**£3,629m**
	Grassland	228,364 ha	13,978,146 t	**£3,199m**
	Wetland	1,903 ha	1,438,879 t	**£329m**
	Heathland	3,820 ha	343,761 t	**£79m**
	TOTAL	290,431 ha	31,616,557 t	**£7,236m**

Source: ***Author calculations***

Table 6.1 and Table 6.2 only cover ecosystem services for which it has been possible to value at least one habitat. However, other ecosystem services such as local climate regulation (see Section 4.2) provide significant benefits as well, even if these services could not be quantified in monetary terms. Such benefits are described qualitatively in the relevant sections of this report and should not be neglected or ignored.

A sensitivity analysis with a high and a low estimate has been applied for flow values. This range considers, for example, scientific uncertainties or possible benefit transfer errors. However, the sensitivity analysis has only been applied for ecosystem services which could be quantified in monetary terms. Therefore, the real value of ecosystem services/habitats may still exceed the upper estimate of the sensitivity analysis.

The value of ecosystem services was calculated as both annual value and capitalised values. For both, a *ceteris paribus* scenario was implicit. This means that other influencing factors such as population growth, climate change, changes to the extent and quality of habitats etc. were assumed to be constant over time. However, both, climate change and population growth are likely to increase the demand for and therefore the value of ecosystem services (see Section 1.4).

It should also be acknowledged that different methods have been used to value ecosystem services for different habitat types and ecosystem services. Therefore one cannot confidently make a direct comparison between the values of different habitats or ecosystem services. Such limitations should always be acknowledged when making reference to figures and values presented in this publication. When figures are quoted, the specific valuation methods, assumptions and caveats should be stated as well. For more information see the relevant chapters in this report.

6.2 Herefordshire

The ecosystem services value has also been calculated for each authority within The Marches. Here, the main findings for Herefordshire are presented. The annual baseline 'non-market' flow value of ecosystem services in Herefordshire has been valued at £112.3 million, stating the central estimate. If capitalised over 25 years this results in a value of £2.4 billion. In addition, the stock value of carbon stored in vegetation and corresponding soils was valued at £2.7 billion. When capitalised flow value and carbon stock value are added this results in a total value of £5.1 billion.

More detailed findings are presented in the data tables below. The same remarks regarding limitations of the assessment and how findings should be interpreted as for Section 6.1 above also apply here and need to be acknowledged.

Table 6.4 **Carbon Stock Value in Herefordshire**

		Area	Carbon Stock	**Stock Value**
Carbon	Woodland	22,946 ha	6,568,783 t	**£1,503m**
	Grassland	86,189 ha	5,198,064 t	**£1,190m**
	Wetland	222 ha	168,186 t	**£38m**
	Heathland	834 ha	75,084 t	**£17m**
	TOTAL	110,192 ha	12,010,117 t	**£2,749m**

Source: ***Author calculations***

Table 6.5 Annual Baseline Value of Assessed Ecosystem Services in Herefordshire

	Broad Habitat Type	Woodland			Grassland			Wetland			Heathland			Hedgrows			TOTAL		
	Assessed Habitat Area	22,946 ha			86,189 ha			222 ha			834 ha			ha			110,192 ha		
Ecosystem Service		High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low
Provisioning Services	Wild Food	£3.52	**£1.23**	£0.37	£0.68	**£0.23**	£0.12	£0.02	**£0.01**	£0.00	£0.01	**£0.00**	£0.00	£0.00	**£0.00**	£0.00	£4.23	**£1.47**	£0.49
	Ornamental Resources & Non-food Products	£6.06	**£1.47**	£0.44	£1.52	**£0.37**	£0.18	£0.01	**£0.00**	£0.00	£0.03	**£0.01**	£0.00	£0.00	**£0.00**	£0.00	£7.62	**£1.84**	£0.63
	Water Supply							£0.00	**£0.00**	£0.00							£0.00	**£0.00**	£0.00
Cultural Services	Wild Species Diversity	£50.24	**£3.33**	£1.67	£23.09	**£15.39**	£7.70	£0.17	**£0.11**	£0.06	£0.55	**£0.37**	£0.18	£0.00	**£0.00**	£0.00	£74.05	**£19.20**	£9.60
	Recreation	£5.21	**£3.69**	£2.17	£11.59	**£7.73**	£3.86	£0.48	**£0.06**	£0.03	£0.22	**£0.14**	£0.07	£0.00	**£0.00**	£0.00	£18.56	**£12.33**	£6.49
	Aesthetic Values & Sense of Place	£1.07	**£0.71**	£0.36															
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£54.58	**£40.51**	£26.45
	Productivity	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£7.29	**£5.61**	£3.93
Regu-lating	Flood Regulation	£19.23	**£11.31**	£3.39	£33.18	**£19.52**	£5.85	£0.23	**£0.13**	£0.04	£0.42	**£0.25**	£0.07	£0.00	**£0.00**	£0.00	£53.05	**£31.21**	£9.36
	Water Quality Regulation							£0.16	**£0.11**	£0.05							£0.16	**£0.11**	£0.05
TOTAL																	£219.54	**£112.29**	£57.01

Notes:

All values are stated in million pounds (£m); 2015 prices.

Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.

Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:

Central Central estimate

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

Table 6.6 Capitalised Baseline Value of Assessed Ecosystem Services in Herefordshire

	Broad Habitat Type	Woodland			Grassland			Wetland			Heathland			Hedgrows			TOTAL			
	Assessed Habitat Area	22,946 ha			86,189 ha			222 ha			834 ha			ha			110,192 ha			
Ecosystem Service		High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	HM Tr.	Low
Provisioning Services	Wild Food	£88	**£26**	£6	£17	**£5**	£2	£0	**£0**	£0	£0	**£0**	£0	£0	**£0**	£0	£106	**£31**	£25	£8
	Ornamental Resources & Non-food Products	£151	**£31**	£8	£38	**£8**	£3	£0	**£0**	£0	£1	**£0**	£0	£0	**£0**	£0	£190	**£39**	£31	£11
	Water Supply							£0	**£0**	£0							£0	**£0**	£0	£0
Cultural Services	Wild Species Diversity	£1,256	**£70**	£28	£577	**£324**	£131	£4	**£2**	£1	£14	**£8**	£3	£0	**£0**	£0	£1,851	**£404**	£328	£164
	Recreation	£130	**£78**	£37	£290	**£162**	£66	£12	**£1**	£0	£5	**£3**	£1	£0	**£0**	£0	£464	**£259**	£210	£111
	Aesthetic Values & Sense of Place	£27	**£15**	£6																
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£1,364	**£852**	£691	£451
	Productivity	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£182	**£118**	£96	£67
Regu-lating	Flood Regulation	£481	**£238**	£58	£829	**£410**	£100	£6	**£3**	£1	£11	**£5**	£1	£0	**£0**	£0	£1,326	**£656**	£532	£160
	Water Quality Regulation							£4	**£2**	£1							£4	**£2**	£2	£1
TOTAL																	£5,488	**£2,362**	£1,916	£972

Notes:

All values are stated in million pounds (£m); 2015 prices.

The capitalised value represents the present value of ecosystem services provided over a time period of 25 years.

Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.

Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:

Central Central estimate

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. This value is based on the higher discount rates recommended by HM Treasury and is stated for comparability purposes only.

Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

6.3 Shropshire

This section covers the main findings for Shropshire. The annual baseline 'non-market' flow value of ecosystem services in Shropshire has been valued at £189.3 million, stating the central estimate. If capitalised over 25 years this results in a value of £4.0 billion. In addition, the stock value of carbon stored in vegetation and corresponding soils was valued at £4.2 billion. When capitalised flow value and carbon stock value are added this results in a total value of £8.2 billion.

More detailed findings are presented in the data tables below. The same remarks regarding limitations of the assessment and how findings should be interpreted as for Section 6.1 above also apply here and need to be acknowledged.

Table 6.7 **Carbon Stock Value in Shropshire**

		Area	Carbon Stock	**Stock Value**
Carbon	Woodland	30,513 ha	8,484,831 t	**£1,942m**
	Grassland	136,791 ha	8,456,203 t	**£1,935m**
	Wetland	1,564 ha	1,182,876 t	**£271m**
	Heathland	2,946 ha	265,171 t	**£61m**
	TOTAL	171,815 ha	18,389,081 t	**£4,209m**

Source: ***Author calculations***

Table 6.8 Annual Baseline Value of Assessed Ecosystem Services in Shropshire

	Broad Habitat Type	Woodland			Grassland			Wetland			Heathland			Hedgrows			TOTAL		
	Assessed Habitat Area	30,513 ha			136,791 ha			1,564 ha			2,946 ha			63 ha			171,878 ha		
Ecosystem Service		High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low
Provisioning Services	Wild Food	£3.65	**£1.28**	£0.38	£0.80	**£0.27**	£0.14	£0.18	**£0.07**	£0.03	£0.03	**£0.01**	£0.01	£0.02	**£0.01**	£0.00	£4.69	**£1.63**	£0.56
	Ornamental Resources & Non-food Products	£6.29	**£1.52**	£0.46	£1.78	**£0.43**	£0.21	£0.16	**£0.04**	£0.02	£0.10	**£0.02**	£0.01	£0.01	**£0.00**	£0.00	£8.33	**£2.01**	£0.70
	Water Supply							£0.02	**£0.01**	£0.00							£0.02	**£0.01**	£0.00
Cultural Services	Wild Species Diversity	£91.72	**£5.49**	£2.74	£34.95	**£23.30**	£11.65	£0.89	**£0.59**	£0.30	£2.03	**£1.36**	£0.68	£0.05	**£0.03**	£0.02	£129.65	**£30.77**	£15.39
	Recreation	£8.26	**£6.25**	£4.24	£17.51	**£11.67**	£5.84	£4.56	**£0.17**	£0.09	£0.80	**£0.53**	£0.27	£0.03	**£0.02**	£0.01	£42.01	**£25.88**	£14.06
	Aesthetic Values & Sense of Place	£10.86	**£7.24**	£3.62															
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£93.15	**£73.05**	£52.95
	Productivity	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£14.63	**£11.25**	£7.88
Regu-lating	Flood Regulation	£19.95	**£11.74**	£3.52	£49.99	**£29.41**	£8.82	£2.49	**£1.47**	£0.44	£1.51	**£0.89**	£0.27	£0.02	**£0.01**	£0.00	£73.97	**£43.51**	£13.05
	Water Quality Regulation							£1.78	**£1.19**	£0.59							£1.78	**£1.19**	£0.59
TOTAL																	£368.23	**£189.32**	£105.19

Notes:

All values are stated in million pounds (£m); 2015 prices.

Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.

Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:

Central Central estimate

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

Table 6.9 Capitalised Baseline Value of Assessed Ecosystem Services in Shropshire

Broad Habitat Type / Assessed Habitat Area		Woodland 30,513 ha			Grassland 136,791 ha			Wetland 1,564 ha			Heathland 2,946 ha			Hedgrows 63 ha			TOTAL 171,878 ha			
Ecosystem Service		High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	HM Tr.	Low
Provisioning Services	Wild Food	£91	**£27**	£7	£20	**£6**	£2	£5	**£1**	£1	£1	**£0**	£0	£0	**£0**	£0	£117	**£34**	£28	£10
	Ornamental Resources & Non-food Products	£157	**£32**	£8	£45	**£9**	£4	£4	**£1**	£0	£2	**£1**	£0	£0	**£0**	£0	£208	**£42**	£34	£12
	Water Supply							£1	**£0**	£0							£1	**£0**	£0	£0
Cultural Services	Wild Species Diversity	£2,293	**£115**	£47	£874	**£490**	£199	£22	**£12**	£5	£51	**£29**	£12	£1	**£1**	£0	£3,241	**£647**	£525	£262
	Recreation	£206	**£131**	£72	£438	**£245**	£100	£114	**£4**	£1	£20	**£11**	£5	£1	**£0**	£0	£1,050	**£544**	£442	£240
	Aesthetic Values & Sense of Place	£272	**£152**	£62																
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£2,329	**£1,536**	£1,246	£903
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£366	**£237**	£192	£134
Regu-lating	Flood Regulation	£499	**£247**	£60	£1,250	**£618**	£150	£62	**£31**	£8	£38	**£19**	£5	£1	**£0**	£0	£1,849	**£915**	£742	£223
	Water Quality Regulation							£45	**£25**	£10							£45	**£25**	£20	£10
TOTAL																	£9,206	**£3,981**	£3,229	£1,794

Notes:

All values are stated in million pounds (£m); 2015 prices.

The capitalised value represents the present value of ecosystem services provided over a time period of 25 years.

Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.

Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:

Central Central estimate

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. This value is based on the higher discount rates recommended by HM Treasury and is stated for comparability purposes only.

Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

6.4 Telford and Wrekin

In this section the main findings for Telford and Wrekin are presented. The annual baseline 'non-market' flow value of ecosystem services in Telford and Wrekin has been valued at £56.5 million, stating the central estimate. If capitalised over 25 years this results in a value of £1.2 billion. In addition, the stock value of carbon stored in vegetation and corresponding soils was valued at £279 million. When capitalised flow value and carbon stock value are added this results in a total value of £1.5 billion.

More detailed findings are presented in the data tables below. The same remarks regarding limitations of the assessment and how findings should be interpreted as for Section 6.1 above also apply here and need to be acknowledged.

Table 6.10 Carbon Stock Value in Telford and Wrekin

		Area	Carbon Stock	**Stock Value**
Carbon	Woodland	2,885 ha	802,157 t	**£184m**
	Grassland	5,384 ha	323,879 t	**£74m**
	Wetland	116 ha	87,817 t	**£20m**
	Heathland	39 ha	3,506 t	**£1m**
	TOTAL	8,423 ha	1,217,359 t	**£279m**

Source: ***Author calculations***

Table 6.11 **Annual Baseline Value of Assessed Ecosystem Services in Telford and Wrekin**

	Broad Habitat Type	Woodland			Grassland			Wetland			Heathland			Hedgrows			TOTAL		
	Assessed Habitat Area	2,885 ha			5,384 ha			116 ha			39 ha			ha			8,423 ha		
Ecosystem Service		High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low	High	**Central**	Low
Provisioning Services	Wild Food	£0.44	**£0.15**	£0.05	£0.01	**£0.01**	£0.00	£0.01	**£0.00**	£0.00	£0.00	**£0.00**	£0.00	£0.00	**£0.00**	£0.00	£0.46	**£0.16**	£0.05
	Ornamental Resources & Non-food Products	£0.75	**£0.18**	£0.05	£0.03	**£0.01**	£0.00	£0.01	**£0.00**	£0.00	£0.00	**£0.00**	£0.00	£0.00	**£0.00**	£0.00	£0.79	**£0.19**	£0.06
	Water Supply							£0.00	**£0.00**	£0.00							£0.00	**£0.00**	£0.00
Cultural Services	Wild Species Diversity	£10.45	**£0.62**	£0.31	£1.44	**£0.96**	£0.48	£0.02	**£0.02**	£0.01	£0.04	**£0.02**	£0.01	£0.00	**£0.00**	£0.00	£11.95	**£1.62**	£0.81
	Recreation	£6.13	**£4.64**	£3.15	£1.67	**£1.11**	£0.56	£0.65	**£0.09**	£0.04	£0.03	**£0.02**	£0.01	£0.00	**£0.00**	£0.00	£19.82	**£13.42**	£7.54
	Aesthetic Values & Sense of Place	£11.34	**£7.56**	£3.78															
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£42.95	**£33.29**	£23.62
	Productivity	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£6.24	**£4.80**	£3.36
Regu-lating	Flood Regulation	£2.39	**£1.41**	£0.42	£2.12	**£1.25**	£0.37	£0.30	**£0.18**	£0.05	£0.02	**£0.01**	£0.00	£0.00	**£0.00**	£0.00	£4.83	**£2.84**	£0.85
	Water Quality Regulation							£0.22	**£0.14**	£0.07							£0.22	**£0.14**	£0.07
TOTAL																	£87.26	**£56.47**	£36.37

Notes:

All values are stated in million pounds (£m); 2015 prices.

Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.

Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:

Central Central estimate

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

Table 6.12 Capitalised Baseline Value of Assessed Ecosystem Services in Telford and Wrekin

	Broad Habitat Type	Woodland			Grassland			Wetland			Heathland			Hedgrows			TOTAL			
	Assessed Habitat Area	2,885 ha			5,384 ha			116 ha			39 ha			ha			8,423 ha			
Ecosystem Service		High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	Low	High	Central	HM Tr.	Low
Provisioning Services	Wild Food	£11	**£3**	£1	£0	**£0**	£0	£0	**£0**	£0	£0	**£0**	£0	£0	**£0**	£0	£12	**£3**	£3	£1
	Ornamental Resources & Non-food Products	£19	**£4**	£1	£1	**£0**	£0	£0	**£0**	£0	£0	**£0**	£0	£0	**£0**	£0	£20	**£4**	£3	£1
	Water Supply							£0	**£0**	£0							£0	**£0**	£0	£0
Cultural Services	Wild Species Diversity	£261	**£13**	£5	£36	**£20**	£8	£1	**£0**	£0	£1	**£0**	£0	£0	**£0**	£0	£299	**£34**	£28	£14
	Recreation	£153	**£98**	£54	£42	**£23**	£10	£16	**£2**	£1	£1	**£0**	£0	£0	**£0**	£0	£495	**£282**	£229	£129
	Aesthetic Values & Sense of Place	£283	**£159**	£64																
	Health	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£1,074	**£700**	£568	£403
	Productivity	*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			*No breakdown available*			£156	**£101**	£82	£57
Regu-lating	Flood Regulation	£60	**£30**	£7	£53	**£26**	£6	£8	**£4**	£1	£1	**£0**	£0	£0	**£0**	£0	£121	**£60**	£49	£15
	Water Quality Regulation							£5	**£3**	£1							£5	**£3**	£2	£1
TOTAL																	£2,182	**£1,188**	£963	£620

Notes:

All values are stated in million pounds (£m); 2015 prices.

The capitalised value represents the present value of ecosystem services provided over a time period of 25 years.

Blank cells do not mean 'no value', but that a monetary value could not have been calculated within scope of this assessment.

Where monetary values have been calculated this may only cover a proportion/element of the full value of the referring ecosystem service.

Legend:

Central Central estimate

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. This value is based on the higher discount rates recommended by HM Treasury and is stated for comparability purposes only.

Low Lower threshold of the sensitivity analysis

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

Source: ***Author calculations***

7. Conclusions & Recommendations

This Ecosystem Assessment shows just how important and valuable ecosystems and Natural Capital are for human wellbeing in The Marches. It cannot be stressed enough that the calculated value of £13.6 billion (capitalised flow and stock; central estimate) is still incomplete and therefore represents only a partial indication of the true value of ecosystem services in The Marches. All of the here calculated values are usually 'hidden' and often ignored because none of the assessed services are traded on markets and therefore do not have a market price – we all benefit as 'free riders' without paying for these services nature provides.

The Counties of Herefordshire and Shropshire as well as the Borough of Telford and Wrekin have a duty to maximise the wellbeing of their inhabitants. The findings of this study show that, in many cases, the protection, creation and improvement of ecosystems and Natural Capital can be seen as a cost-effective way of achieving this goal. This is particularly so when habitats and other natural assets are managed to optimise outcomes across multiple ecosystem services, contributing to overall cumulative public value. The government has now put in place a number of initiatives which promote the incorporation of ecosystem services values in decision-making. These include for example the Natural Environment White Paper (NEWP), the National Planning Policy Framework (NPPF) and the UK National Ecosystem Assessment (UK NEA).[158]

Implementing the true value of ecosystem services and natural assets in decision-making can help to mitigate the continuing loss of ecosystems and their beneficial services, thereby enhancing human wellbeing and security. This Ecosystem Assessment can be seen as an important first step towards a sustainable future for The Marches. However, further steps are necessary to make use of such values and information. I recommend the following measures to better implement and acknowledge ecosystem services values in decision-making in The Marches:

[158] HM Government 2011; UK NEA 2011b; DCLG 2012.

Ecosystem services mapping

The ANGSt+ assessment (see Chapter 5) provides a good indication for where the creation of new accessible green infrastructure would be most effective. I would recommend to also mapping further ecosystem services to also identify priority areas within The Marches for example for biodiversity, applying the principles of the Lawton Review.[159] This could build up on axiophytes biodiversity maps which were developed for Shropshire. Other services can also be mapped. Natural Capital/ecosystem services mapping approaches are still comparatively new and often experimental but meaningful maps can be created.

Planning

Planning and inherent land-use changes can have a significant impact on the provision of ecosystem services; especially when cumulative effects are assessed. The National Planning Policy Framework (NPPF) calls for better recognition of ecosystem services in planning decisions.[160] CEEP, together with the UK Business Council for Sustainable Development (UK BCSD), Birmingham City Council, the University of Birmingham, Birmingham City University and other partners, is developing a tool to assess the impact of planning and development on 10 different ecosystem services at the site/neighbourhood scale. The Natural Capital Planning Tool (NCPT) will be tested at a suitable site in The Marches. The wider implementation of the NCPT in planning would allow better assessment of ecosystem services impacts of planning and can be used to enable the planning system to ensure 'no net loss' or even a positive impact of planning on ecosystem services. This also offers opportunities for more holistic Ecosystem Services Offsetting (ESO) as opposed to rather controversial Biodiversity Offsetting schemes.

Collaboration and knowledge exchange

This Ecosystem Assessment has revealed that, due to the diversity of ecosystem services values and beneficiaries, organisations and sectors which are usually not engaged in nature conversation and environmental management may well share common goals. This particularly applies to institutions that may have formerly perceived 'nature' as a matter of

[159] Lawton et al. 2010.
[160] DCLG 2012.

pure altruistic conservation or cost factor, rather than a source of multiple values supporting the local economy, public health and quality of life. Better coordination, collaboration and mutual understanding of the multiple values of nature among these institutions may offer opportunities to achieve common goals by partnership working, sharing knowledge and resources and optimising the outcomes of projects on the ground, taking into account the full range of ecosystem services, and including objectives for these within projects and initiatives. This could for example lead to realising more 'green' problem solutions (e.g. Sustainable Drainage Systems) as opposed to 'grey' solutions' (e.g. flood walls) because the former usually come with a suit of additional benefits to society. This may also trigger opportunities for better Natural Capital management and investment by the private sector; especially when tools like Payments for Ecosystem Services (PES)[161] or Corporate Ecosystem Valuation (CEV)[162] are implemented.

Trend and scenario analysis

This Ecosystem Assessment provides advanced information about the state and value of ecosystem services in The Marches to date. However, robust information about trends and future changes in the provision of ecosystem services is lacking, and this information is important for consideration of vulnerabilities and future aspirations. A trend and scenario analysis could be undertaken in order to 'future-proof' the sustainable provision of ecosystem services. Such an analysis could for example use the framework of the UK National Ecosystem Assessment (2011). This would also allow to inform future green infrastructure strategies and Natural Capital investment plans.

[161] Smith et al. 2013.
[162] Hölzinger 2014a.

Figure 7.1 **Relative Importance of Broad Habitats in Delivering Ecosystem Services and Overall Direction of Change in Service Flow Since 1990 in the UK**

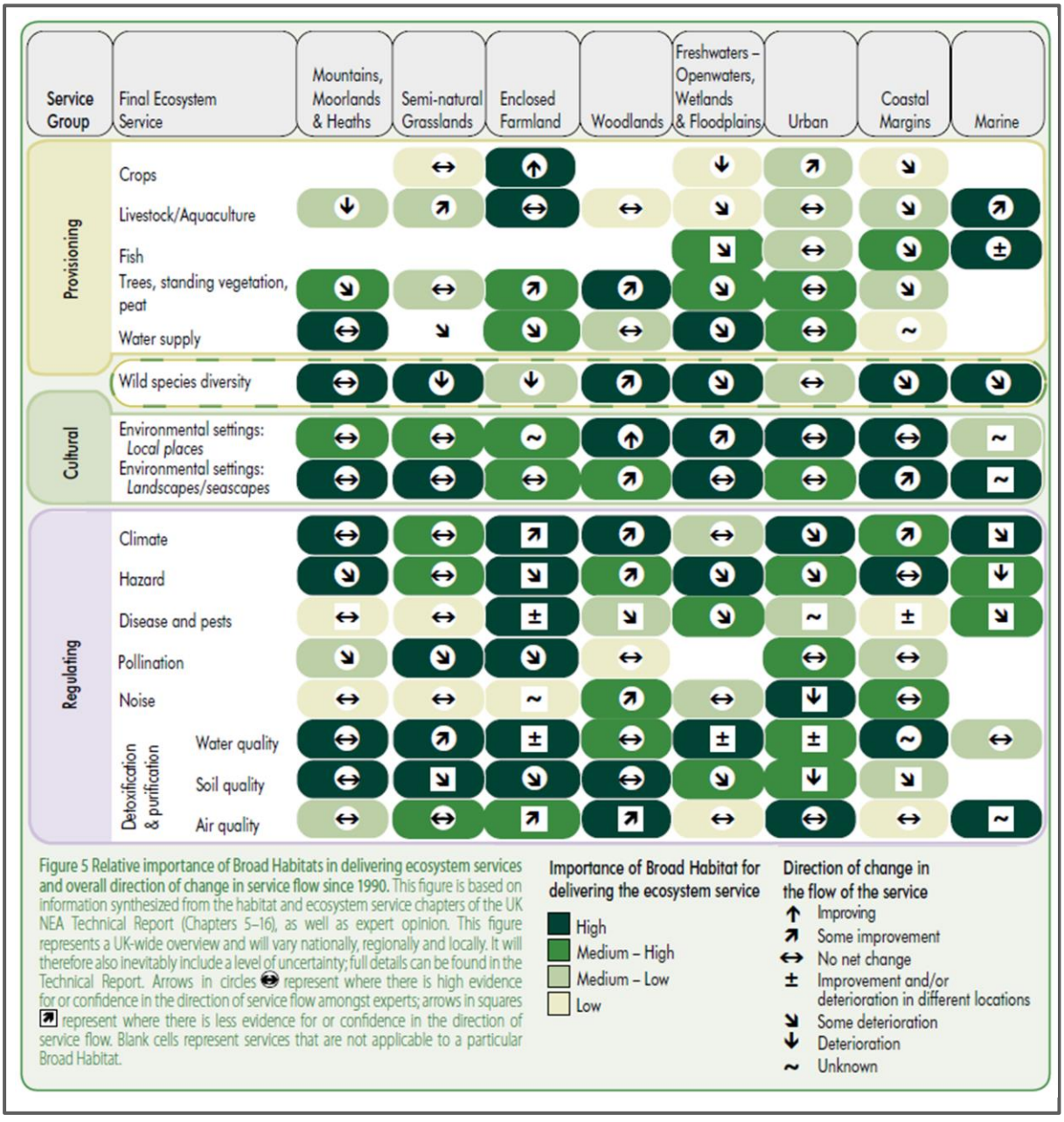

Figure 5 Relative importance of Broad Habitats in delivering ecosystem services and overall direction of change in service flow since 1990. This figure is based on information synthesized from the habitat and ecosystem service chapters of the UK NEA Technical Report (Chapters 5–16), as well as expert opinion. This figure represents a UK-wide overview and will vary nationally, regionally and locally. It will therefore also inevitably include a level of uncertainty; full details can be found in the Technical Report. Arrows in circles represent where there is high evidence for or confidence in the direction of service flow amongst experts; arrows in squares represent where there is less evidence for or confidence in the direction of service flow. Blank cells represent services that are not applicable to a particular Broad Habitat.

Source: ***Adopted from UK NEA 2011a, p. 11***

Additional valuation evidence

This Ecosystem Assessment still reveals some mayor gaps which are partially related to the scope definition and partially to a lack of valuation evidence and the quality of data and indicators. It would for example be possible to better assess the value of trees using the i-Tree Eco tool or collaborating with the Environment Agency to be able to assess data allowing to value the blue infrastructure. A future update of this Ecosystem Assessment

could incorporate such evidence and also new evidence subsequently created by the science community.

8. Abbreviations

ANG	Accessible Natural Greenspace
ANGSt	Accessible Natural Greenspace Standard
AQMA	Air Quality Management Area
ASNW	Ancient Semi-Natural Woodland
BAP	Biodiversity Action Plan
CO_2e	Carbon Dioxide Equivalent
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
EFTEC	Economics for the Environment Consultancy
GHG	Greenhouse Gas
GIS	Geographical Information System
HEAT	Health Economic Assessment Tool
m	Million (£)
MENE	Monitor of Engagement with the Natural Environment
Mt	Mega tonnes
NCPT	Natural Capital Planning Tool
NEWP	Natural Environment White Paper
ONS	Office for National Statistics
PES	Payments for Ecosystem Services
RSPB	Royal Society for the Protection of Birds
SuDS	Sustainable Drainage System
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UHIE	Urban Heat Island Effect
UK NEA	UK National Ecosystem Assessment
UK NEAFO	UK National Ecosystem Assessment Follow-On
WHO	World Health Organisation
WTP	Willingness-To-Pay

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Appendices

A. Methods & Calculations: Habitats of Principal Importance

To calculate ecosystem services provided by habitats of principal importance (formerly 'Biodiversity Action Plan (BAP) priority habitats') the findings of the study *"The Economic Valuation of the Ecosystem Service Benefits delivered by the UK Biodiversity Action Plan"*[163] have been recalculated for the purpose of this investigation. It should be noted that the list of habitats of principal importance has been revised after that study has been undertaken and therefore not all actual habitats of principal importance were included. On the other hand improved grassland which is not classified as habitats of principal importance was included.

The aim of that primary valuation study was to estimate the value of changes in biodiversity and associated ecosystem services which 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.

In the original primary valuation study values were calculated in two steps. The first step entailed a choice experiment to determine the values people place on ecosystem services delivered by UK BAP habitats. 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 reveals values associated with the different preferences or choices. The second step entailed a weighting matrix evaluating 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 with which they were most familiar across 19 UK BAP habitats. These results were then pooled. Experts were also asked to identify the proportion of ecosystem service values that were directly attributed to UK BAP conservation

[163] Christie et al. 2011.

activities. The primary outcome was the marginal change of ecosystem services provided by different UK BAP priority habitats in relation to different scenarios.[164]

Although the data warrants some caveats, it has been judged sufficiently robust to inform this investigation. The study results have been applied in cases where no other robust primary valuation data was available. For the purpose of this investigation the total ecosystem services value rather than the value of management/conversation interventions was needed. Therefore the values for a marginal change in conservation activities needed to be recalculated. Fortunately the available data allowed this step. Below I outline the calculation using the example of wild food provided by native woodland. The following paragraphs should be read in line with Christie et al. (2011).

In the first step, marginal change from scenario D (UK with BAP, but no further spending) to scenario A (full delivery of the UK BAP) has been calculated by adding the values from Table C30 and C31.[165] 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 the second step, the non-marginal WTP associated with scenario D has been calculated. The marginal value from above has been divided 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

In the next step the average value of the current level of ecosystem services provided by UK 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

[164] Ibid., 11.
[165] Tables with the 'C' refer to tables in Christie et al. (2011)

In a last step the average value per hectare was 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 for ecosystem services provided by habitats in The Marches have been derived from average UK values in Christie et al. (2011) rather than the values derived specifically 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 original study. However, just applying average per-hectare values is not always the best solution. Therefore additional assumptions have been made for each ecosystem service. Calculations and main assumptions are summarised below for each assessed ecosystem service.

Wild food

In Christie et al. (2011), 'wild food' is defined as *"non-rare food products that people might gather/hunt from nature"*.[166] Agricultural food production on farms and other commercial food production are not included. The ecosystem service 'wild food' mainly refers to the non-commercial use of food. Also included within this ecosystem service is a sense of wellbeing whilst gathering food from nature. This ecosystem service is not restricted to the value of the product; but also to the value of the process of gathering or hunting.

A direct link between the area of habitat and wild food provision has been assumed in the original study. For this Ecosystem Assessment only the WTP per ha 'within own region' has been applied for the central estimate. It is arguable that most wild food products provided by habitats in The Marches are extracted by residents within the West Midlands region rather than outside. This assumption is in line with the general purpose of providing a conservative value estimate. The total WTP (within and outside own region) has been applied for the high threshold of the sensitivity analysis only. The calculation for different habitats is summarised in the tables below for each assessment area. The aggregated

[166] Christie et al. 2011, 121.

findings for The Marches as a whole are presented in the main element of this report (as for all other calculations in these Appendices. Not surprisingly the value in the more urban area of Telford and Wrekin is much lower than in the less densely populated areas of Herefordshire and Shropshire which is mainly related to habitat extents.

Table A.1 Wild Food Provision: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£0.902	**£0.315**	£0.095	£22.541	**£6.634**	£5.381	£1.614
Low land ASNW	£0.430	**£0.150**	£0.045	£10.752	**£3.164**	£2.567	£0.770
Low land Mixed Woodland	£2.116	**£0.740**	£0.222	£52.900	**£15.568**	£12.628	£3.788
Upland Broadleaved Woodland & Scrub	£0.023	**£0.008**	£0.002	£0.572	**£0.168**	£0.136	£0.041
Upland ASNW	£0.007	**£0.002**	£0.001	£0.170	**£0.050**	£0.041	£0.012
Upland Mixed Woodland	£0.042	**£0.015**	£0.004	£1.043	**£0.307**	£0.249	£0.075
TOTAL Woodland	£3.519	**£1.231**	£0.369	£87.977	**£25.891**	£21.001	£6.300
Low land Dry Acid Grassland	£0.000	**£0.000**	£0.000	£0.008	**£0.001**	£0.001	£0.000
Low land Meadow s	£0.027	**£0.009**	£0.005	£0.671	**£0.194**	£0.157	£0.079
TOTAL Grassland	£0.683	**£0.235**	£0.117	£17.076	**£4.932**	£4.001	£2.000
Low land Heathland	£0.001	**£0.000**	£0.000	£0.022	**£0.006**	£0.005	£0.003
Upland Heathland	£0.007	**£0.003**	£0.001	£0.183	**£0.053**	£0.043	£0.022
TOTAL Heathland	£0.008	**£0.003**	£0.001	£0.205	**£0.060**	£0.049	£0.024
Inland Marsh	£0.018	**£0.006**	£0.003	£0.460	**£0.135**	£0.110	£0.055
Floodplain Grazing Marsh	£0.009	**£0.003**	£0.002	£0.221	**£0.064**	£0.052	£0.026
Purple Moor-grass & Rush Pasture	£0.009	**£0.003**	£0.002	£0.226	**£0.068**	£0.055	£0.028
Fen	£0.000	**£0.000**	£0.000	£0.012	**£0.004**	£0.003	£0.001
TOTAL Wetland	£0.018	**£0.006**	£0.003	£0.460	**£0.135**	£0.110	£0.055
TOTAL	£4.229	**£1.475**	£0.491	£105.717	**£31.019**	£25.160	£8.380

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.2 Wild Food Provision: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£2.369	**£0.829**	£0.249	£59.225	**£17.430**	£14.138	£4.241
Low land ASNW	£0.590	**£0.207**	£0.062	£14.759	**£4.343**	£3.523	£1.057
Low land Mixed Woodland	£0.497	**£0.174**	£0.052	£12.417	**£3.654**	£2.964	£0.889
Upland Broadleaved Woodland & Scrub	£0.153	**£0.053**	£0.016	£3.820	**£1.124**	£0.912	£0.274
Upland ASNW	£0.022	**£0.008**	£0.002	£0.560	**£0.165**	£0.134	£0.040
Upland Mixed Woodland	£0.020	**£0.007**	£0.002	£0.510	**£0.150**	£0.122	£0.037
TOTAL Woodland	£3.652	**£1.278**	£0.383	£91.291	**£26.867**	£21.792	£6.538
Low land Dry Acid Grassland	£0.006	**£0.001**	£0.001	£0.148	**£0.023**	£0.019	£0.009
Low land Meadow s	£0.041	**£0.014**	£0.007	£1.037	**£0.300**	£0.243	£0.122
TOTAL Grassland	£0.799	**£0.271**	£0.136	£19.966	**£5.709**	£4.631	£2.315
Low land Heathland	£0.011	**£0.004**	£0.002	£0.266	**£0.077**	£0.063	£0.031
Upland Heathland	£0.024	**£0.008**	£0.004	£0.589	**£0.172**	£0.140	£0.070
TOTAL Heathland	£0.034	**£0.012**	£0.006	£0.855	**£0.249**	£0.202	£0.101
Inland Marsh	£0.166	**£0.059**	£0.029	£4.140	**£1.240**	£1.006	£0.503
Floodplain Grazing Marsh	£0.015	**£0.005**	£0.003	£0.371	**£0.107**	£0.087	£0.043
Purple Moor-grass & Rush Pasture	£0.143	**£0.051**	£0.026	£3.570	**£1.076**	£0.873	£0.436
Fen	£0.007	**£0.002**	£0.001	£0.176	**£0.051**	£0.041	£0.021
Reedbed	£0.001	**£0.000**	£0.000	£0.023	**£0.007**	£0.006	£0.003
Peatbog	£0.018	**£0.006**	£0.003	£0.461	**£0.133**	£0.108	£0.054
Blanket Bog	£0.000	**£0.000**	£0.000	£0.002	**£0.001**	£0.000	£0.000
Fen	£0.018	**£0.006**	£0.003	£0.459	**£0.132**	£0.107	£0.054
TOTAL Wetland	£0.184	**£0.065**	£0.033	£4.601	**£1.373**	£1.114	£0.557
TOTAL Hedgerow s	£0.018	**£0.006**	£0.003	£0.457	**£0.134**	£0.108	£0.054
TOTAL	£4.687	**£1.632**	£0.561	£117.170	**£34.331**	£27.847	£9.565

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.3 Wild Food Provision: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£0.331	**£0.116**	£0.035	£8.287	**£2.439**	£1.978	£0.593
Low land ASNW	£0.074	**£0.026**	£0.008	£1.846	**£0.543**	£0.441	£0.132
Low land Mixed Woodland	£0.031	**£0.011**	£0.003	£0.775	**£0.228**	£0.185	£0.055
Upland Broadleaved Woodland & Scrub	£0.000	**£0.000**	£0.000	£0.003	**£0.001**	£0.001	£0.000
Upland Mixed Woodland	£0.001	**£0.001**	£0.000	£0.037	**£0.011**	£0.009	£0.003
TOTAL Woodland	£0.438	**£0.153**	£0.046	£10.948	**£3.222**	£2.613	£0.784
Low land Meadow s	£0.001	**£0.000**	£0.000	£0.019	**£0.006**	£0.004	£0.002
TOTAL Grassland	£0.015	**£0.005**	£0.003	£0.364	**£0.105**	£0.085	£0.043
Low land Heathland	£0.001	**£0.000**	£0.000	£0.022	**£0.006**	£0.005	£0.003
Upland Heathland	£0.000	**£0.000**	£0.000	£0.002	**£0.001**	£0.001	£0.000
TOTAL Heathland	£0.001	**£0.000**	£0.000	£0.024	**£0.007**	£0.006	£0.003
Inland Marsh	£0.007	**£0.002**	£0.001	£0.175	**£0.051**	£0.042	£0.021
Floodplain Grazing Marsh	£0.000	**£0.000**	£0.000	£0.009	**£0.003**	£0.002	£0.001
Purple Moor-grass & Rush Pasture	£0.003	**£0.001**	£0.001	£0.075	**£0.023**	£0.018	£0.009
Fen	£0.003	**£0.001**	£0.001	£0.085	**£0.024**	£0.020	£0.010
Reedbed	£0.000	**£0.000**	£0.000	£0.006	**£0.002**	£0.001	£0.001
TOTAL Wetland	£0.007	**£0.002**	£0.001	£0.175	**£0.051**	£0.042	£0.021
TOTAL	£0.460	**£0.161**	£0.050	£11.511	**£3.385**	£2.746	£0.850

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Ornamental resources and non-food products

As for wild food a direct link between the area of habitat and the provision of non-food products has been assumed in Christie et al. (2011). Again, only the WTP per ha 'within own region' has been applied for the central estimate. The total WTP (within and outside own region) has been applied for the high threshold of the sensitivity analysis. Below you can find a detailed break-down of findings for Herefordshire, Shropshire and Telford and Wrekin.

Table A.4 Ornamental Resources & Non-food Products: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£1.552	**£0.376**	£0.113	£38.808	**£7.898**	£6.406	£1.922
Low land ASNW	£0.740	**£0.179**	£0.054	£18.511	**£3.767**	£3.056	£0.917
Low land Mixed Woodland	£3.643	**£0.881**	£0.264	£91.076	**£18.534**	£15.034	£4.510
Upland Broadleaved Woodland & Scrub	£0.039	**£0.010**	£0.003	£0.984	**£0.200**	£0.162	£0.049
Upland ASNW	£0.012	**£0.003**	£0.001	£0.292	**£0.059**	£0.048	£0.014
Upland Mixed Woodland	£0.072	**£0.017**	£0.005	£1.796	**£0.365**	£0.296	£0.089
TOTAL Woodland	£6.059	**£1.466**	£0.440	£151.468	**£30.824**	£25.003	£7.501
Low land Calcareous Grassland	£0.003	**£0.001**	£0.000	£0.069	**£0.014**	£0.011	£0.006
Low land Dry Acid Grassland	£0.001	**£0.000**	£0.000	£0.018	**£0.002**	£0.002	£0.001
Low land Meadow s	£0.060	**£0.015**	£0.007	£1.489	**£0.305**	£0.247	£0.124
TOTAL Grassland	£1.519	**£0.370**	£0.185	£37.986	**£7.773**	£6.305	£3.152
Low land Heathland	£0.001	**£0.000**	£0.000	£0.024	**£0.005**	£0.004	£0.002
Upland Heathland	£0.027	**£0.007**	£0.003	£0.669	**£0.138**	£0.112	£0.056
TOTAL Heathland	£0.028	**£0.007**	£0.003	£0.692	**£0.142**	£0.115	£0.058
Inland Marsh	£0.009	**£0.002**	£0.001	£0.232	**£0.047**	£0.038	£0.019
Purple Moor-grass & Rush Pasture	£0.009	**£0.002**	£0.001	£0.225	**£0.045**	£0.037	£0.018
Fen	£0.000	**£0.000**	£0.000	£0.007	**£0.001**	£0.001	£0.001
TOTAL Wetland	£0.009	**£0.002**	£0.001	£0.232	**£0.047**	£0.038	£0.019
TOTAL	£7.615	**£1.844**	£0.629	£190.378	**£38.786**	£31.460	£10.730

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.5 Ornamental Resources & Non-food Products: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£4.079	**£0.987**	£0.296	£101.966	**£20.750**	£16.831	£5.049
Low land ASNW	£1.016	**£0.246**	£0.074	£25.409	**£5.171**	£4.194	£1.258
Low land Mixed Woodland	£0.855	**£0.207**	£0.062	£21.378	**£4.351**	£3.529	£1.059
Upland Broadleaved Woodland & Scrub	£0.263	**£0.064**	£0.019	£6.577	**£1.338**	£1.086	£0.326
Upland ASNW	£0.039	**£0.009**	£0.003	£0.965	**£0.196**	£0.159	£0.048
Upland Mixed Woodland	£0.035	**£0.008**	£0.003	£0.878	**£0.179**	£0.145	£0.043
TOTAL Woodland	£6.287	**£1.521**	£0.456	£157.173	**£31.985**	£25.944	£7.783
Low land Calcareous Grassland	£0.006	**£0.002**	£0.001	£0.157	**£0.032**	£0.026	£0.013
Low land Dry Acid Grassland	£0.014	**£0.002**	£0.001	£0.346	**£0.035**	£0.029	£0.014
Low land Meadow s	£0.092	**£0.022**	£0.011	£2.302	**£0.472**	£0.382	£0.191
TOTAL Grassland	£1.782	**£0.428**	£0.214	£44.546	**£9.010**	£7.308	£3.654
Low land Heathland	£0.011	**£0.003**	£0.001	£0.286	**£0.057**	£0.046	£0.023
Upland Heathland	£0.086	**£0.021**	£0.011	£2.152	**£0.443**	£0.359	£0.180
TOTAL Heathland	£0.098	**£0.024**	£0.012	£2.438	**£0.500**	£0.406	£0.203
Inland Marsh	£0.148	**£0.035**	£0.018	£3.693	**£0.740**	£0.600	£0.300
Purple Moor-grass & Rush Pasture	£0.142	**£0.034**	£0.017	£3.558	**£0.712**	£0.578	£0.289
Fen	£0.004	**£0.001**	£0.000	£0.096	**£0.020**	£0.016	£0.008
Reedbed	£0.002	**£0.000**	£0.000	£0.039	**£0.008**	£0.006	£0.003
Peatbog	£0.010	**£0.002**	£0.001	£0.252	**£0.052**	£0.043	£0.021
Fen	£0.010	**£0.002**	£0.001	£0.251	**£0.052**	£0.042	£0.021
TOTAL Wetland	£0.158	**£0.038**	£0.019	£3.945	**£0.793**	£0.643	£0.321
TOTAL Hedgerow s	£0.010	**£0.003**	£0.001	£0.260	**£0.054**	£0.043	£0.022
TOTAL	£8.334	**£2.013**	£0.703	£208.361	**£42.342**	£34.345	£11.984

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.6 Ornamental Resources & Non-food Products: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£0.571	**£0.138**	£0.041	£14.268	**£2.904**	£2.355	£0.707
Low land ASNW	£0.127	**£0.031**	£0.009	£3.178	**£0.647**	£0.525	£0.157
Low land Mixed Woodland	£0.053	**£0.013**	£0.004	£1.334	**£0.271**	£0.220	£0.066
Upland Broadleaved Woodland & Scrub	£0.000	**£0.000**	£0.000	£0.006	**£0.001**	£0.001	£0.000
Upland Mixed Woodland	£0.003	**£0.001**	£0.000	£0.063	**£0.013**	£0.010	£0.003
TOTAL Woodland	£0.754	**£0.182**	£0.055	£18.849	**£3.836**	£3.111	£0.933
Low land Dry Acid Grassland	£0.000	**£0.000**	£0.000	£0.002	**£0.000**	£0.000	£0.000
Low land Meadow s	£0.002	**£0.000**	£0.000	£0.042	**£0.009**	£0.007	£0.004
TOTAL Grassland	£0.032	**£0.008**	£0.004	£0.809	**£0.166**	£0.134	£0.067
Low land Heathland	£0.001	**£0.000**	£0.000	£0.024	**£0.005**	£0.004	£0.002
Upland Heathland	£0.000	**£0.000**	£0.000	£0.008	**£0.002**	£0.001	£0.001
TOTAL Heathland	£0.001	**£0.000**	£0.000	£0.032	**£0.006**	£0.005	£0.003
Inland Marsh	£0.005	**£0.001**	£0.001	£0.131	**£0.027**	£0.022	£0.011
Purple Moor-grass & Rush Pasture	£0.003	**£0.001**	£0.000	£0.075	**£0.015**	£0.012	£0.006
Fen	£0.002	**£0.000**	£0.000	£0.046	**£0.010**	£0.008	£0.004
Reedbed	£0.000	**£0.000**	£0.000	£0.010	**£0.002**	£0.002	£0.001
TOTAL Wetland	£0.005	**£0.001**	£0.001	£0.131	**£0.027**	£0.022	£0.011
TOTAL	£0.793	**£0.192**	£0.059	£19.820	**£4.034**	£3.272	£1.014

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Cultural Services

In the Christie et al. (2011) study the category 'sense of place' captures all cultural services such as aesthetic, spiritual, educational and recreational benefits. Wild species diversity which can also be categorised as 'cultural service' is not included. Here assuming a direct relation between area of habitat and value would bias outcomes because especially cultural values are strongly related to the number of people who can locally benefit from such services.[167] To take this factor into account the average value per hectare has been adjusted by 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 (256/km^2) and then multiplied by the average population density in Herefordshire (86/km2), Shropshire (97/km^2), and Telford and Wrekin (585/km^2), respectively. 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 population density. Therefore

[167] See also Church et al. 2011.

the average value per hectare has been applied for the latter. The assumption underlies that the proportion of BAP Priority Habitats in The Marches in favourable condition is similar to the UK average.

A range of 50% has been applied for the sensitivity analysis to account for uncertainties related to the applied assumptions, potential transfer errors, etc. Please note that habitat information about hedgerow extent was only available for Shropshire which is why the service could not be valued for Herefordshire and Telford and Wrekin. The findings for each assessment area are outlined below.

Table A.7 Cultural services provided by Grassland and Heathland: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£8.592	**£5.728**	£2.864	£214.799	**£120.462**	£97.710	£48.855
Low land Calcareous Grassland	£0.007	**£0.004**	£0.002	£0.167	**£0.094**	£0.076	£0.038
Low land Meadow s	£0.118	**£0.078**	£0.039	£2.940	**£1.649**	£1.338	£0.669
Upland Calcareous Grassland	£0.000	**£0.000**	£0.000	£0.005	**£0.003**	£0.002	£0.001
TOTAL Grassland	£11.588	**£7.726**	£3.863	£289.709	**£162.472**	£131.786	£65.893
Low land Heathland	£0.008	**£0.005**	£0.003	£0.203	**£0.114**	£0.092	£0.046
Upland Heathland	£0.208	**£0.139**	£0.069	£5.209	**£2.921**	£2.369	£1.185
TOTAL Heathland	£0.216	**£0.144**	£0.072	£5.412	**£3.035**	£2.462	£1.231
TOTAL	£11.805	**£7.870**	£3.935	£295.121	**£165.507**	£134.248	£67.124

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.8 Cultural services provided by Grassland, Heathland and Hedgerows: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£13.953	**£9.302**	£4.651	£348.817	**£195.621**	£158.674	£79.337
Low land Calcareous Grassland	£0.016	**£0.011**	£0.005	£0.395	**£0.221**	£0.180	£0.090
Low land Meadow s	£0.188	**£0.125**	£0.063	£4.704	**£2.638**	£2.140	£1.070
Upland Calcareous Grassland	£0.000	**£0.000**	£0.000	£0.010	**£0.006**	£0.005	£0.002
TOTAL Grassland	£17.506	**£11.671**	£5.835	£437.656	**£245.442**	£199.085	£99.543
Low land Heathland	£0.102	**£0.068**	£0.034	£2.540	**£1.425**	£1.156	£0.578
Upland Heathland	£0.694	**£0.463**	£0.231	£17.345	**£9.728**	£7.890	£3.945
TOTAL Heathland	£0.795	**£0.530**	£0.265	£19.886	**£11.152**	£9.046	£4.523
TOTAL Hedgerow s	£0.026	**£0.017**	£0.009	£0.644	**£0.361**	£0.293	£0.146
TOTAL	£18.327	**£12.218**	£6.109	£458.185	**£256.955**	£208.424	£104.212

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.9 Cultural services provided by Grassland and Heathland: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£1.515	**£1.010**	£0.505	£37.863	**£21.234**	£17.223	£8.612
Low land Meadow s	£0.008	**£0.006**	£0.003	£0.207	**£0.116**	£0.094	£0.047
TOTAL Grassland	£1.672	**£1.115**	£0.557	£41.811	**£23.448**	£19.019	£9.510
Low land Heathland	£0.020	**£0.013**	£0.007	£0.504	**£0.283**	£0.229	£0.115
Upland Heathland	£0.006	**£0.004**	£0.002	£0.152	**£0.085**	£0.069	£0.035
TOTAL Heathland	£0.026	**£0.017**	£0.009	£0.656	**£0.368**	£0.298	£0.149
TOTAL	£1.699	**£1.132**	£0.566	£42.467	**£23.816**	£19.318	£9.659

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Wild Species Diversity

The quantification of services flowing from wild species diversity is often inadequate due to limited data and scientific evidence.[168] Furthermore some valuation approaches are considered controversial.[169] 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) them.

[168] Norris et al. 2011, 65.
[169] UK NEA 2011b, 1186.

This approach requires true altruism and its quantification is therefore considered controversial; assigning absolute values also raises theoretical problems. Additionally, overlaps with use-values can occur.[170] However, human preferences for the pure existence and survival of species can also be explained by option-use values[171] or bequest values[172].

Some authors calculate values explicitly for 'biodiversity' or 'wild species diversity'. Therefore, we adopt this category but findings should be interpreted with care. Within this exercise we tried to rule out overlaps with services like recreation and aesthetic appreciation as far as possible.

For quantifying wild species diversity in wetland habitats the findings from Christie et al. (2011) have been used. Christie et al. (2011) made a distinction between 'charismatic species' and 'non-charismatic species'. The former include terrestrial mammals, birds, amphibians, reptiles, butterflies, and moths. The latter incorporates vascular plants, non-vascular plants, terrestrial invertebrates (excluding butterflies and moths), and fungi (including lichens).[173] Not surprisingly the average 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. The findings for each assessment area are summarised below.

[170] Ibid.
[171] You might never see a whale in nature, but you can benefit from the ability to see whales in the future.
[172] You might never see a whale in nature, but you can benefit from the ability of coming generations to see whales in the future.
[173] Christie et al. 2011, 131.

Table A.10 Wetland Wild Species Diversity Benefits: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.167	**£0.112**	£0.056	£4.184	**£2.346**	£1.903	£0.952
Floodplain Grazing Marsh	£0.135	**£0.090**	£0.045	£3.371	**£1.891**	£1.534	£0.767
Purple Moor-grass & Rush Pasture	£0.031	**£0.021**	£0.010	£0.785	**£0.440**	£0.357	£0.179
Fen	£0.001	**£0.001**	£0.000	£0.027	**£0.015**	£0.012	£0.006
TOTAL Wetland	£0.167	**£0.112**	£0.056	£4.184	**£2.346**	£1.903	£0.952

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011.***

Table A.11 Wetland Wild Species Diversity Benefits: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.742	**£0.495**	£0.247	£18.556	**£10.406**	£8.441	£4.220
Floodplain Grazing Marsh	£0.226	**£0.151**	£0.075	£5.654	**£3.171**	£2.572	£1.286
Purple Moor-grass & Rush Pasture	£0.496	**£0.330**	£0.165	£12.392	**£6.950**	£5.637	£2.818
Fen	£0.016	**£0.010**	£0.005	£0.388	**£0.217**	£0.176	£0.088
Reedbed	£0.005	**£0.003**	£0.002	£0.122	**£0.069**	£0.056	£0.028
TOTAL Wetland	£0.888	**£0.592**	£0.296	£22.208	**£12.455**	£10.102	£5.051

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011.***

Table A.12 Wetland Wild Species Diversity Benefits: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.025	**£0.016**	£0.008	£0.616	**£0.345**	£0.280	£0.140
Floodplain Grazing Marsh	£0.006	**£0.004**	£0.002	£0.138	**£0.078**	£0.063	£0.031
Purple Moor-grass & Rush Pasture	£0.010	**£0.007**	£0.003	£0.260	**£0.146**	£0.118	£0.059
Fen	£0.007	**£0.005**	£0.002	£0.187	**£0.105**	£0.085	£0.043
Reedbed	£0.001	**£0.001**	£0.000	£0.030	**£0.017**	£0.014	£0.007
TOTAL Wetland	£0.025	**£0.016**	£0.008	£0.616	**£0.345**	£0.280	£0.140

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011.***

These values for wetland explicitly refer to the non-use values based on the findings of Christie et al. (2011). Not included are the use-values for biodiversity based on the findings

of Brander et al. (2008) (see Appendix B). Because such use-values are dependent on site-visits and physical interaction with the ecosystem, the latter values have been included in cultural services such as recreation (see Section 3.1). Because non-use values were explicitly excluded by Brander et al. (2008), it can be assumed that no overlaps between these two value domains exist.

For heathland, grassland and hedgerows, also the findings provided by Christie et al. (2011) were used applying similar assumptions as for wetland wild species diversity above. Together, the wild species diversity value of these habitats has been valued at £41.4 million annually. The findings are summarised below.

Table A.13 Grassland and Heathland Wild Species Diversity: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£8.592	**£12.594**	£6.297	£472.262	**£264.850**	£214.827	£107.414
Low land Calcareous Grassland	£0.007	**£0.005**	£0.002	£0.172	**£0.096**	£0.078	£0.039
Low land Dry Acid Grassland	£0.118	**£0.005**	£0.002	£0.170	**£0.095**	£0.077	£0.039
Low land Meadow s	£2.872	**£0.287**	£0.143	£10.752	**£6.030**	£4.891	£2.446
Upland Calcareous Grassland	£0.000	**£0.000**	£0.000	£0.018	**£0.010**	£0.008	£0.004
TOTAL Grassland	£23.088	**£15.392**	£7.696	£577.191	**£323.695**	£262.558	£131.279
Low land Heathland	£0.029	**£0.019**	£0.010	£0.724	**£0.406**	£0.329	£0.165
Upland Heathland	£0.523	**£0.349**	£0.174	£13.084	**£7.337**	£5.952	£2.976
TOTAL Heathland	£0.552	**£0.368**	£0.184	£13.807	**£7.743**	£6.281	£3.140
TOTAL	£23.640	**£15.760**	£7.880	£590.999	**£331.438**	£268.839	£134.420

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.14 Grassland, Heathland and Hedgerows Wild Species Diversity: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£29.651	**£19.768**	£9.884	£741.285	**£415.721**	£337.203	£168.602
Lowland Calcareous Grassland	£0.016	**£0.010**	£0.005	£0.392	**£0.220**	£0.178	£0.089
Lowland Dry Acid Grassland	£0.129	**£0.086**	£0.043	£3.229	**£1.811**	£1.469	£0.734
Lowland Meadows	£0.665	**£0.443**	£0.222	£16.626	**£9.324**	£7.563	£3.781
Upland Calcareous Grassland	£0.001	**£0.001**	£0.000	£0.035	**£0.020**	£0.016	£0.008
Upland Hay Meadows	£0.000	**£0.000**	£0.000	£0.001	**£0.000**	£0.000	£0.000
TOTAL Grassland	£34.954	**£23.303**	£11.651	£873.861	**£490.071**	£397.510	£198.755
Lowland Heathland	£0.350	**£0.233**	£0.117	£8.748	**£4.906**	£3.979	£1.990
Upland Heathland	£1.685	**£1.123**	£0.562	£42.113	**£23.618**	£19.157	£9.578
TOTAL Heathland	£2.034	**£1.356**	£0.678	£50.861	**£28.524**	£23.136	£11.568
TOTAL Hedgerows	£0.046	**£0.030**	£0.015	£1.142	**£0.640**	£0.519	£0.260
TOTAL	£37.035	**£24.690**	£12.345	£925.864	**£519.235**	£421.166	£210.583

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.15 Grassland and Heathland Wild Species Diversity: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Improved Grassland	£1.345	**£0.896**	£0.448	£33.615	**£18.851**	£15.291	£7.645
Lowland Calcareous Grassland	£0.000	**£0.000**	£0.000	£0.000	**£0.000**	£0.000	£0.000
Lowland Dry Acid Grassland	£0.001	**£0.000**	£0.000	£0.019	**£0.010**	£0.008	£0.004
Lowland Meadows	£0.012	**£0.008**	£0.004	£0.305	**£0.171**	£0.139	£0.069
TOTAL Grassland	£1.436	**£0.957**	£0.479	£35.906	**£20.137**	£16.333	£8.167
Lowland Heathland	£0.029	**£0.019**	£0.010	£0.725	**£0.407**	£0.330	£0.165
Upland Heathland	£0.006	**£0.004**	£0.002	£0.154	**£0.086**	£0.070	£0.035
TOTAL Heathland	£0.035	**£0.023**	£0.012	£0.879	**£0.493**	£0.400	£0.200
TOTAL	£1.471	**£0.981**	£0.490	£36.785	**£20.630**	£16.733	£8.367

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

It should be noted that because these are non-use values, people often have problems in expressing their own preferences.[174] Such values are abstract and sometimes hard to grasp for non-specialists. Also, the WTP for this form of ecosystem service is a very small fraction of income which often 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. The comparatively small

[174] See also Saraev 2012.

sample size and other caveats discussed above makes the application of a wide range of 50% reasonable for the sensitivity analysis.

Flood regulation

As for wild food, for example, a direct link between the area of habitat and the provision of flood risk regulation services has been assumed in Christie et al. (2011). Within the Christie et al. (2011) study 'water regulation' stands for the ecosystem service 'flood regulation' as defined in this investigation. The ecosystem services water quality regulation and water provision are not covered within this category.[175]

For the purpose of this calculation the WTP 'within own region' and 'outside own region' has been applied as also remote areas could benefit for example when water levels of upstream rivers are reduced. Flood risk regulation values were available for a range of habit types (see below). It should be noted that the value for lowland meadows has also been applied to other neutral grassland habitats as these are likely to perform similarly in terms of flood risk regulation benefits. Below you can find a detailed break-down of findings for each assessment area.

[175] Christie et al. 2011, 126.

Table A.16 Flood Risk Regulation Services of Different Habitats: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£4.926	**£2.898**	£0.869	£123.162	**£60.945**	£49.434	£14.830
Low land ASNW	£2.350	**£1.382**	£0.415	£58.746	**£29.069**	£23.579	£7.074
Low land Mixed Woodland	£11.562	**£6.801**	£2.040	£289.038	**£143.026**	£116.012	£34.804
Upland Broadleaved Woodland & Scrub	£0.125	**£0.074**	£0.022	£3.124	**£1.546**	£1.254	£0.376
Upland ASNW	£0.037	**£0.022**	£0.007	£0.927	**£0.459**	£0.372	£0.112
Upland Mixed Woodland	£0.228	**£0.134**	£0.040	£5.699	**£2.820**	£2.288	£0.686
TOTAL Woodland	£19.228	**£11.310**	£3.393	£480.696	**£237.864**	£192.939	£57.882
Improved Grassland	£28.281	**£16.636**	£4.991	£707.036	**£349.865**	£283.785	£85.136
Low land Meadow s	£0.193	**£0.113**	£0.034	£4.814	**£2.382**	£1.932	£0.580
Other Neutral Grassland	£4.702	**£2.766**	£0.830	£117.549	**£58.167**	£47.181	£14.154
TOTAL Grassland	£33.176	**£19.515**	£5.855	£829.400	**£410.414**	£332.899	£99.870
Low land Heathland	£0.018	**£0.011**	£0.003	£0.447	**£0.221**	£0.180	£0.054
Upland Heathland	£0.402	**£0.237**	£0.071	£10.059	**£4.978**	£4.037	£1.211
TOTAL Heathland	£0.420	**£0.247**	£0.074	£10.506	**£5.199**	£4.217	£1.265
TOTAL	£52.824	**£31.073**	£9.322	£1,320.602	**£653.477**	£530.054	£159.016

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.17 Flood Risk Regulation Services of Different Habitats: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£12.944	**£7.614**	£2.284	£323.597	**£160.126**	£129.883	£38.965
Low land ASNW	£3.226	**£1.897**	£0.569	£80.639	**£39.903**	£32.366	£9.710
Low land Mixed Woodland	£2.714	**£1.596**	£0.479	£67.845	**£33.572**	£27.231	£8.169
Upland Broadleaved Woodland & Scrub	£0.835	**£0.491**	£0.147	£20.873	**£10.328**	£8.378	£2.513
Upland ASNW	£0.122	**£0.072**	£0.022	£3.062	**£1.515**	£1.229	£0.369
Upland Mixed Woodland	£0.111	**£0.066**	£0.020	£2.786	**£1.379**	£1.118	£0.335
TOTAL Woodland	£19.952	**£11.736**	£3.521	£498.801	**£246.823**	£200.205	£60.062
Improved Grassland	£44.392	**£26.113**	£7.834	£1,109.798	**£549.165**	£445.443	£133.633
Low land Meadow s	£0.298	**£0.175**	£0.053	£7.444	**£3.684**	£2.988	£0.896
Other Neutral Grassland	£5.300	**£3.118**	£0.935	£132.498	**£65.564**	£53.181	£15.954
TOTAL Grassland	£49.990	**£29.406**	£8.822	£1,249.740	**£618.413**	£501.612	£150.484
Low land Heathland	£0.216	**£0.127**	£0.038	£5.407	**£2.676**	£2.170	£0.651
Upland Heathland	£1.295	**£0.762**	£0.229	£32.378	**£16.022**	£12.996	£3.899
TOTAL Heathland	£1.511	**£0.889**	£0.267	£37.785	**£18.697**	£15.166	£4.550
TOTAL Hedgerow s	£0.021	**£0.012**	£0.004	£0.527	**£0.261**	£0.211	£0.063
TOTAL	£71.474	**£42.044**	£12.613	£1,786.852	**£884.194**	£717.195	£215.158

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

Table A.18 Flood Risk Regulation Services of Different Habitats: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£1.811	**£1.065**	£0.320	£45.279	**£22.406**	£18.174	£5.452
Low land ASNW	£0.403	**£0.237**	£0.071	£10.087	**£4.991**	£4.049	£1.215
Low land Mixed Woodland	£0.169	**£0.100**	£0.030	£4.233	**£2.094**	£1.699	£0.510
Upland Broadleaved Woodland & Scrub	£0.001	**£0.000**	£0.000	£0.018	**£0.009**	£0.007	£0.002
Upland Mixed Woodland	£0.008	**£0.005**	£0.001	£0.201	**£0.099**	£0.080	£0.024
TOTAL Woodland	£2.393	**£1.407**	£0.422	£59.817	**£29.600**	£24.009	£7.203
Improved Grassland	£2.013	**£1.184**	£0.355	£50.325	**£24.903**	£20.199	£6.060
Low land Meadow s	£0.005	**£0.003**	£0.001	£0.137	**£0.068**	£0.055	£0.016
Other Neutral Grassland	£0.099	**£0.058**	£0.017	£2.472	**£1.223**	£0.992	£0.298
TOTAL Grassland	£2.117	**£1.246**	£0.374	£52.934	**£26.194**	£21.246	£6.374
Low land Heathland	£0.018	**£0.011**	£0.003	£0.448	**£0.222**	£0.180	£0.054
Upland Heathland	£0.005	**£0.003**	£0.001	£0.118	**£0.059**	£0.047	£0.014
TOTAL Heathland	£0.023	**£0.013**	£0.004	£0.567	**£0.280**	£0.227	£0.068
TOTAL	£4.533	**£2.666**	£0.800	£113.318	**£56.073**	£45.483	£13.645

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Christie et al. 2011***

B. Methods & Calculations: Wetland Benefits

To calculate the benefits provided by wetlands in The Marches a benefit transfer function created by Brander et al. (2008) has been used. They established a meta-analysis function including 78 European studies. It is acknowledged that this introduces uncertainties as it is based on a coarse assessment of a several services. However, more precise methods on a service-by-service basis are lacking. For this reason, the same value transfer function has also been applied for the UK National Ecosystem Assessment:

> *"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."*[176]

The valuation techniques involved in the studies included by Brander et al. (2008) 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.[177]

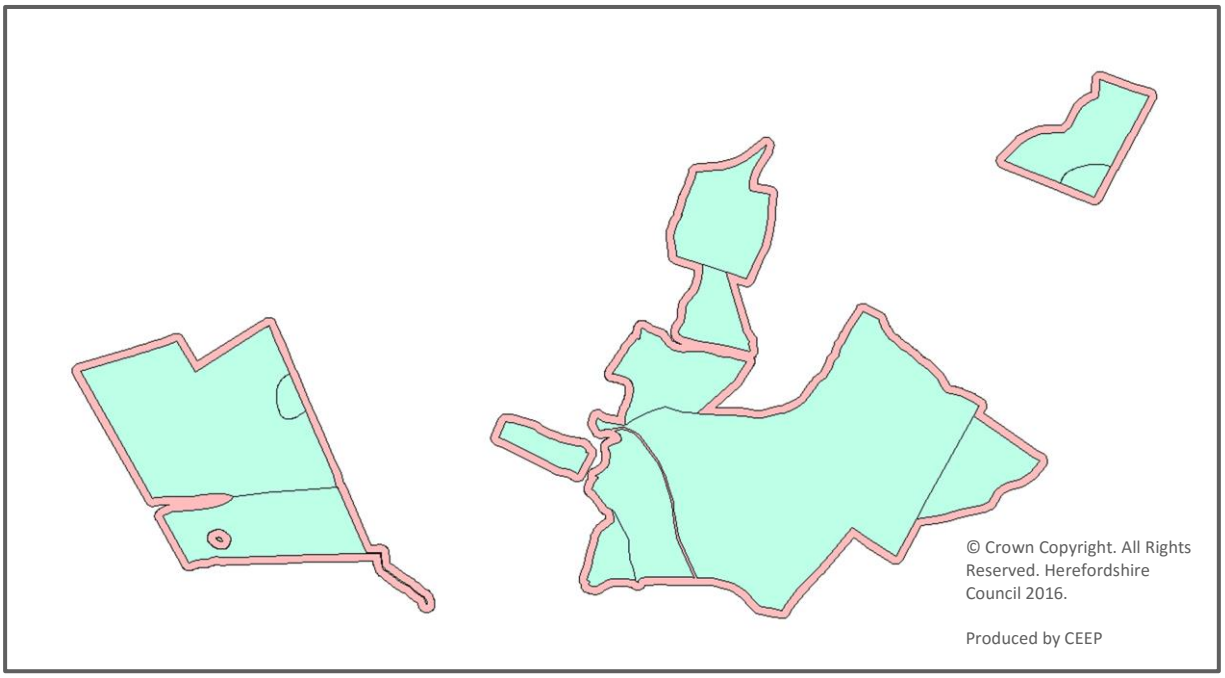
Wetland habitats in The Marches are highly fragmented. One practical problem was to estimate the number and average size of the different wetland habitats. It is likely that the primary valuation studies included in the Brander et al. (2008) meta-analysis have assessed larger wetland habitats rather than small and fragmented ones. The average size of a wetland site has a significant influence on the benefit transfer function. However, linearity cannot be assumed, with some wetland services, such as biodiversity, potentially served well by small habitat mosaics whilst others, such as carbon sequestration, are likely to increase in proportion to wetland size. Whilst these complexities are acknowledged, availability of data precluded more fine-scaled analysis.

Geographic Information System (GIS) software was used to determine the number and extent of wetland sites. To avoid overestimating the number of sites (and therefore the total value) identified wetland polygons within short proximity (20 metres distance) to each other

[176] Hulme and Siriwardena 2010, 7.
[177] EFTEC 2010, 125.

were combined and assessed as one wetland site. Below you can see a common example from the south-west of Herefordshire. If all wetland polygons (green) in Figure A.1 were accounted for as single sites then this would be 14 sites in the example below. Instead a 10m buffer (red) has been created around all wetland sites and all wetland polygons connected by this buffer were accounted for as one site. This approach resulted in 4 sites in the example below.

Figure A.1 **Wetland Site Assessment**



Source: ***Based on GIS data provided by HBRC***

Wetland benefits have been assessed separately for Herefordshire, Shropshire and Telford and Wrekin to increase accuracy for the single assessments. Here, I will explain the methods and calculation using the example of Herefordshire. The same methods and assumptions apply for Shropshire and Telford and Wrekin. Applying the approach outlined above 55 wetland sites were identified in Herefordshire with an average size of 4.1 ha.

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 publicly accessible. Because non-use values are explicitly

excluded in the meta-analysis provided by Brander et al. (2008)[178], one has to infer that accessibility to the habitat is necessary to benefit from the ecosystem service biodiversity as well. Therefore the Brander et al. (2008) biodiversity value has been added to the cultural services of recreation and aesthetic appreciation. The wetland layer was overlaid with a public access layer to determine accessibility. In Herefordshire 16 out of 55 wetland sites were identified as being accessible. This is a conservative estimate as other wetland sites may be accessible for example by informal agreements with landowners.

The Brander et al. (2008) value transfer function allows taking different socio-economic variables and context-specific attributes into account. Table A.19 below outlines how the Brander et al. (2008) benefit transfer function has been applied for Herefordshire. The underlying assumptions and variables are also explained in the comments section of this table.

[178] Brander et al. 2008, 33.

Table A.19 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	The function has also been applied for peatbog habitats. The assumptions were similar to the ones outlined below.
Wetland size:	-0.297	*ln* 4.1	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:	0.917	0/1	These services only occur if 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$):	0.468	*ln* 23,400	GDP is approximated from the Shropshire and Staffordshire level with €21,000 (in 2003, real prices, NUTS 2 level, source: Eurostat). Converted to 2003 US$ using OECD purchasing power parity (PPP) exchange rates. This resulted in US$24,028.
Population density per km^2 within 50 km:	0.579	*ln* 85	Simplifying the population density of 85/km^2 for Herefordshire and surrounding Local Authorities has been used.
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 author assumptions/calculations.***

Applying the benefit function for inland marsh and for peatbog, both for accessible as well as inaccessible sites, the annual value of the ecosystem services of flood regulation, water supply, water quality regulation as well as recreation, aesthetic appreciation and biodiversity provided by wetland in The Marches has been calculated. In the next step, the value attributable to each ecosystem service can be approximated. This step is not necessary but has been chosen to maintain consistency within this study. By setting every variable standing

for an ecosystem service to zero and viewing the difference in the sum, an estimate can be made of the attributable value for each ecosystem service.[179]

For the sensitivity analysis, uncertainties regarding the estimations taken as well as the scientific evidence have been considered. For the ecosystem services of water quality regulation, recreation, aesthetic appreciation and biodiversity, a range of 50% has been applied. Uncertainties for flood regulation and water supply are generally higher because they are more context-specific. Taking this circumstance into account, a range of 70% has been applied for this ecosystem service.

The findings for each assessed ecosystem service for Herefordshire, Shropshire and Telford and Wrekin can be reviewed in the Tables below. Note that also additional ecosystem services provided by wetland in The Marches have been calculated applying a different methodology. This includes the services wild food, non-food products as well as biodiversity (non-use element) (see Appendix A).

Herefordshire Findings

Table A.20 Wetland Flood Regulation: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.227	**£0.133**	£0.040	£5.672	**£2.807**	£2.277	£0.683
Floodplain Grazing Marsh	£0.170	**£0.100**	£0.030	£4.244	**£2.100**	£1.703	£0.511
Purple Moor-grass & Rush Pasture	£0.051	**£0.030**	£0.009	£1.278	**£0.633**	£0.513	£0.154
Fen	£0.002	**£0.001**	£0.000	£0.054	**£0.027**	£0.022	£0.006
Swamp	£0.004	**£0.002**	£0.001	£0.096	**£0.047**	£0.038	£0.012
Peatbog	£0.000	**£0.000**	£0.000	£0.001	**£0.001**	£0.000	£0.000
Lowland Raised Bog	£0.000	**£0.000**	£0.000	£0.001	**£0.001**	£0.000	£0.000
TOTAL Wetland	£0.227	**£0.133**	£0.040	£5.673	**£2.807**	£2.277	£0.683

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

[179] The negative influence of recreational fishing has been distributed equally to recreation, amenity and biodiversity.

Table A.21 Wetland Water Supply: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.002	**£0.001**	£0.000	£0.046	**£0.023**	£0.019	£0.006
Floodplain Grazing Marsh	£0.001	**£0.001**	£0.000	£0.035	**£0.017**	£0.014	£0.004
Purple Moor-grass & Rush Pasture	£0.000	**£0.000**	£0.000	£0.010	**£0.005**	£0.004	£0.001
Swamp	£0.000	**£0.000**	£0.000	£0.001	**£0.000**	£0.000	£0.000
Peatbog	£0.000	**£0.000**	£0.000	£0.000	**£0.000**	£0.000	£0.000
Lowland Raised Bog	£0.000	**£0.000**	£0.000	£0.000	**£0.000**	£0.000	£0.000
TOTAL Wetland	£0.002	**£0.001**	£0.000	£0.046	**£0.023**	£0.019	£0.006

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.22 Wetland Water Quality Regulation: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.162	**£0.108**	£0.054	£4.055	**£2.274**	£1.845	£0.922
Floodplain Grazing Marsh	£0.121	**£0.081**	£0.040	£3.035	**£1.702**	£1.380	£0.690
Purple Moor-grass & Rush Pasture	£0.037	**£0.024**	£0.012	£0.914	**£0.513**	£0.416	£0.208
Fen	£0.002	**£0.001**	£0.001	£0.038	**£0.022**	£0.017	£0.009
Swamp	£0.003	**£0.002**	£0.001	£0.068	**£0.038**	£0.031	£0.016
Peatbog	£0.000	**£0.000**	£0.000	£0.001	**£0.000**	£0.000	£0.000
Lowland Raised Bog	£0.000	**£0.000**	£0.000	£0.001	**£0.000**	£0.000	£0.000
TOTAL Wetland	£0.162	**£0.108**	£0.054	£4.056	**£2.275**	£1.845	£0.923

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.23 Wetland Recreation & Aesthetic Appreciation (incl. Biodiversity): Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.087	**£0.058**	£0.029	£2.185	**£1.225**	£0.994	£0.497
Floodplain Grazing Marsh	£0.065	**£0.044**	£0.022	£1.635	**£0.917**	£0.744	£0.372
Purple Moor-grass & Rush Pasture	£0.020	**£0.013**	£0.007	£0.492	**£0.276**	£0.224	£0.112
Fen	£0.001	**£0.001**	£0.000	£0.021	**£0.012**	£0.009	£0.005
Swamp	£0.001	**£0.001**	£0.000	£0.037	**£0.021**	£0.017	£0.008
Peatbog	£0.000	**£0.000**	£0.000	£0.000	**£0.000**	£0.000	£0.000
Lowland Raised Bog	£0.000	**£0.000**	£0.000	£0.000	**£0.000**	£0.000	£0.000
TOTAL Wetland	£0.087	**£0.058**	£0.029	£2.185	**£1.225**	£0.994	£0.497

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Shropshire Findings

Table A.24 Wetland Flood Regulation: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£2.296	**£1.351**	£0.405	£57.407	**£28.407**	£23.042	£6.913
Floodplain Grazing Marsh	£0.503	**£0.296**	£0.089	£12.579	**£6.224**	£5.049	£1.515
Purple Moor-grass & Rush Pasture	£1.426	**£0.839**	£0.252	£35.661	**£17.646**	£14.313	£4.294
Fen	£0.054	**£0.032**	£0.010	£1.360	**£0.673**	£0.546	£0.164
Reedbed	£0.014	**£0.008**	£0.003	£0.357	**£0.177**	£0.143	£0.043
Swamp	£0.237	**£0.140**	£0.042	£5.935	**£2.937**	£2.382	£0.715
Other	£0.061	**£0.036**	£0.011	£1.515	**£0.750**	£0.608	£0.182
Peatbog	£0.198	**£0.117**	£0.035	£4.960	**£2.454**	£1.991	£0.597
Blanket Bog	£0.002	**£0.001**	£0.000	£0.043	**£0.021**	£0.017	£0.005
Lowland Raised Bog	£0.140	**£0.082**	£0.025	£3.489	**£1.727**	£1.400	£0.420
Fen	£0.057	**£0.034**	£0.010	£1.428	**£0.707**	£0.573	£0.172
TOTAL Wetland	£2.495	**£1.467**	£0.440	£62.367	**£30.861**	£25.033	£7.510

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.25 Wetland Water Supply: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.019	**£0.011**	£0.003	£0.469	**£0.232**	£0.188	£0.056
Floodplain Grazing Marsh	£0.004	**£0.002**	£0.001	£0.103	**£0.051**	£0.041	£0.012
Purple Moor-grass & Rush Pasture	£0.012	**£0.007**	£0.002	£0.291	**£0.144**	£0.117	£0.035
Fen	£0.000	**£0.000**	£0.000	£0.011	**£0.005**	£0.004	£0.001
Reedbed	£0.000	**£0.000**	£0.000	£0.003	**£0.001**	£0.001	£0.000
Swamp	£0.002	**£0.001**	£0.000	£0.048	**£0.024**	£0.019	£0.006
Other	£0.000	**£0.000**	£0.000	£0.012	**£0.006**	£0.005	£0.001
Peatbog	£0.002	**£0.001**	£0.000	£0.041	**£0.020**	£0.016	£0.005
Blanket Bog	£0.000	**£0.000**	£0.000	£0.000	**£0.000**	£0.000	£0.000
Lowland Raised Bog	£0.001	**£0.001**	£0.000	£0.028	**£0.014**	£0.011	£0.003
Fen	£0.000	**£0.000**	£0.000	£0.012	**£0.006**	£0.005	£0.001
TOTAL Wetland	£0.020	**£0.012**	£0.004	£0.509	**£0.252**	£0.204	£0.061

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.26 Wetland Water Quality Regulation: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£1.642	**£1.095**	£0.547	£41.047	**£23.020**	£18.672	£9.336
Floodplain Grazing Marsh	£0.360	**£0.240**	£0.120	£8.994	**£5.044**	£4.091	£2.046
Purple Moor-grass & Rush Pasture	£1.020	**£0.680**	£0.340	£25.498	**£14.300**	£11.599	£5.799
Fen	£0.039	**£0.026**	£0.013	£0.973	**£0.545**	£0.442	£0.221
Reedbed	£0.010	**£0.007**	£0.003	£0.255	**£0.143**	£0.116	£0.058
Swamp	£0.170	**£0.113**	£0.057	£4.243	**£2.380**	£1.930	£0.965
Other	£0.043	**£0.029**	£0.014	£1.083	**£0.608**	£0.493	£0.246
Peatbog	£0.142	**£0.095**	£0.047	£3.546	**£1.989**	£1.613	£0.807
Blanket Bog	£0.001	**£0.001**	£0.000	£0.031	**£0.017**	£0.014	£0.007
Lowland Raised Bog	£0.100	**£0.067**	£0.033	£2.495	**£1.399**	£1.135	£0.567
Fen	£0.041	**£0.027**	£0.014	£1.021	**£0.573**	£0.464	£0.232
TOTAL Wetland	£1.784	**£1.189**	£0.595	£44.593	**£25.008**	£20.285	£10.143

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.27 Wetland Recreation & Aesthetic Appreciation (incl. Biodiversity): Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.210	**£0.140**	£0.070	£5.243	**£2.940**	£2.385	£1.192
Floodplain Grazing Marsh	£0.046	**£0.031**	£0.015	£1.149	**£0.644**	£0.523	£0.261
Purple Moor-grass & Rush Pasture	£0.130	**£0.087**	£0.043	£3.257	**£1.827**	£1.482	£0.741
Fen	£0.005	**£0.003**	£0.002	£0.124	**£0.070**	£0.057	£0.028
Reedbed	£0.001	**£0.001**	£0.000	£0.033	**£0.018**	£0.015	£0.007
Swamp	£0.022	**£0.014**	£0.007	£0.542	**£0.304**	£0.247	£0.123
Other	£0.006	**£0.004**	£0.002	£0.138	**£0.078**	£0.063	£0.031
Peatbog	£0.051	**£0.034**	£0.017	£1.269	**£0.711**	£0.577	£0.289
Blanket Bog	£0.000	**£0.000**	£0.000	£0.011	**£0.006**	£0.005	£0.002
Lowland Raised Bog	£0.036	**£0.024**	£0.012	£0.892	**£0.501**	£0.406	£0.203
Fen	£0.015	**£0.010**	£0.005	£0.365	**£0.205**	£0.166	£0.083
TOTAL Wetland	£0.260	**£0.174**	£0.087	£6.512	**£3.652**	£2.962	£1.481

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Telford and Wrekin Findings

Table A.28 Wetland Flood Regulation: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.302	**£0.178**	£0.053	£7.545	**£3.734**	£3.028	£0.909
Floodplain Grazing Marsh	£0.018	**£0.010**	£0.003	£0.444	**£0.220**	£0.178	£0.053
Purple Moor-grass & Rush Pasture	£0.043	**£0.025**	£0.008	£1.079	**£0.534**	£0.433	£0.130
Fen	£0.038	**£0.022**	£0.007	£0.947	**£0.469**	£0.380	£0.114
Reedbed	£0.005	**£0.003**	£0.001	£0.128	**£0.063**	£0.051	£0.015
Swamp	£0.007	**£0.004**	£0.001	£0.165	**£0.082**	£0.066	£0.020
Other	£0.191	**£0.113**	£0.034	£4.783	**£2.367**	£1.920	£0.576
TOTAL Wetland	£0.302	**£0.178**	£0.053	£7.545	**£3.734**	£3.028	£0.909

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.29 Wetland Water Supply: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.002	**£0.001**	£0.000	£0.062	**£0.030**	£0.025	£0.007
Floodplain Grazing Marsh	£0.000	**£0.000**	£0.000	£0.004	**£0.002**	£0.001	£0.000
Purple Moor-grass & Rush Pasture	£0.000	**£0.000**	£0.000	£0.009	**£0.004**	£0.004	£0.001
Fen	£0.000	**£0.000**	£0.000	£0.008	**£0.004**	£0.003	£0.001
Reedbed	£0.000	**£0.000**	£0.000	£0.001	**£0.001**	£0.000	£0.000
Swamp	£0.000	**£0.000**	£0.000	£0.001	**£0.001**	£0.001	£0.000
Other	£0.002	**£0.001**	£0.000	£0.039	**£0.019**	£0.016	£0.005
TOTAL Wetland	£0.002	**£0.001**	£0.000	£0.062	**£0.030**	£0.025	£0.007

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.30 Wetland Water Quality Regulation: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.216	**£0.144**	£0.072	£5.395	**£3.026**	£2.454	£1.227
Floodplain Grazing Marsh	£0.013	**£0.008**	£0.004	£0.317	**£0.178**	£0.144	£0.072
Purple Moor-grass & Rush Pasture	£0.031	**£0.021**	£0.010	£0.772	**£0.433**	£0.351	£0.176
Fen	£0.027	**£0.018**	£0.009	£0.677	**£0.380**	£0.308	£0.154
Reedbed	£0.004	**£0.002**	£0.001	£0.091	**£0.051**	£0.041	£0.021
Swamp	£0.005	**£0.003**	£0.002	£0.118	**£0.066**	£0.054	£0.027
Other	£0.137	**£0.091**	£0.046	£3.420	**£1.918**	£1.556	£0.778
TOTAL Wetland	£0.216	**£0.144**	£0.072	£5.395	**£3.026**	£2.454	£1.227

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Table A.31 Wetland Recreation & Aesthetic Appreciation (incl. Biod.): Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Inland Marsh	£0.131	**£0.087**	£0.044	£3.276	**£1.837**	£1.490	£0.745
Floodplain Grazing Marsh	£0.008	**£0.005**	£0.003	£0.193	**£0.108**	£0.088	£0.044
Purple Moor-grass & Rush Pasture	£0.019	**£0.012**	£0.006	£0.469	**£0.263**	£0.213	£0.107
Fen	£0.016	**£0.011**	£0.005	£0.411	**£0.231**	£0.187	£0.094
Reedbed	£0.002	**£0.001**	£0.001	£0.055	**£0.031**	£0.025	£0.013
Swamp	£0.003	**£0.002**	£0.001	£0.072	**£0.040**	£0.033	£0.016
Other	£0.083	**£0.055**	£0.028	£2.077	**£1.165**	£0.945	£0.472
TOTAL Wetland	£0.131	**£0.087**	£0.044	£3.276	**£1.837**	£1.490	£0.745

Legend:

Central **Central estimate**

High Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)

HM Tr. Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)

Low Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Brander et al. 2008***

Totals for The Marches for each assessed ecosystem service can be found in the corresponding sections of the main report.

C. Methods & Calculations: Woodland Recreation

To value the recreational benefits of woodland in The Marches a benefit transfer of the findings of Scarpa (2003) has been applied. The data of that study was based on a UK primary contingent valuation study undertaken in 2002.[180] Visitors of woodland sites were asked how much they were willing to pay if there was to be a charge for access to woodland sites.[181] The results show that the willingness to pay (WTP) for a visit differs by travelled distance to the site. The inflation adjusted WTP (2015 prices) to local woodland sites (within 10 miles from home) is £1.21 per visit.[182]

To estimate the number of visits to accessible woodland sites in The Marches, findings of the 'Monitor of Engagement with the Natural Environment' (MENE) survey by Natural England were used. For the purposes of this study, statistics for the survey periods 2009/10 through to 2013/14 have been analysed. Using data for more than one year had the advantage that the sample size was increased and inter-temporal variability (for example where attitudes may be shaped by weather) is smoothed. Within the 5 year period a total visitor count to woodland in The Marches of 46.4 million has been recorded. However, this figure only includes adult visits (16+ years). Visits by children under 16 were not regularly recorded as part of the MENE survey. Therefore we applied the MENE national child visit proportion of 0.3 children accompanying adults on visits to woodland. Multiplying the adult visits to woodland in The Marches by 1.3 results in a total visitor count to woodland of 60.4 million between 2009/10 and 2013/14 with an average annual visitor count of 12.1 million.

The total value of woodland recreation in The Marches has been calculated by multiplying the average annual visitor count by the mean WTP per visit. This results in an annual recreational value of woodland of £14.6 million. This value is deliberately conservative; excluding higher WTP values for visits to woodland sites further than 10 miles away from home as the sample size was too small to produce reliable results.

To recognise uncertainties relating to the potential transfer error and the general scientific uncertainties, a range of 20% has been applied for the sensitivity analysis. In addition 21%

[180] Scarpa 2003, 16.
[181] An open-ended questionnaire has been used and protest bids have been excluded.
[182] Scarpa 2003, 16.

for Herefordshire and 12% for Shropshire and Telford and Wrekin were added to the range to take standard derivations related to the survey sample size (rule of thumb) into account. The findings are summarised below.

Table A.32 Woodland Recreation: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£5.205	**£3.689**	£2.174	£130.129	**£77.590**	£62.936	£37.079

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Scarpa (2003) and MENE data provided by Natural England.***

Table A.33 Woodland Recreation: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£8.256	**£6.249**	£4.241	£206.399	**£131.412**	£106.592	£72.351

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Scarpa (2003) and MENE data provided by Natural England.***

Table A.34 Woodland Recreation: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£6.132	**£4.643**	£3.154	£153.294	**£97.637**	£79.196	£53.794

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Scarpa (2003) and MENE data provided by Natural England.***

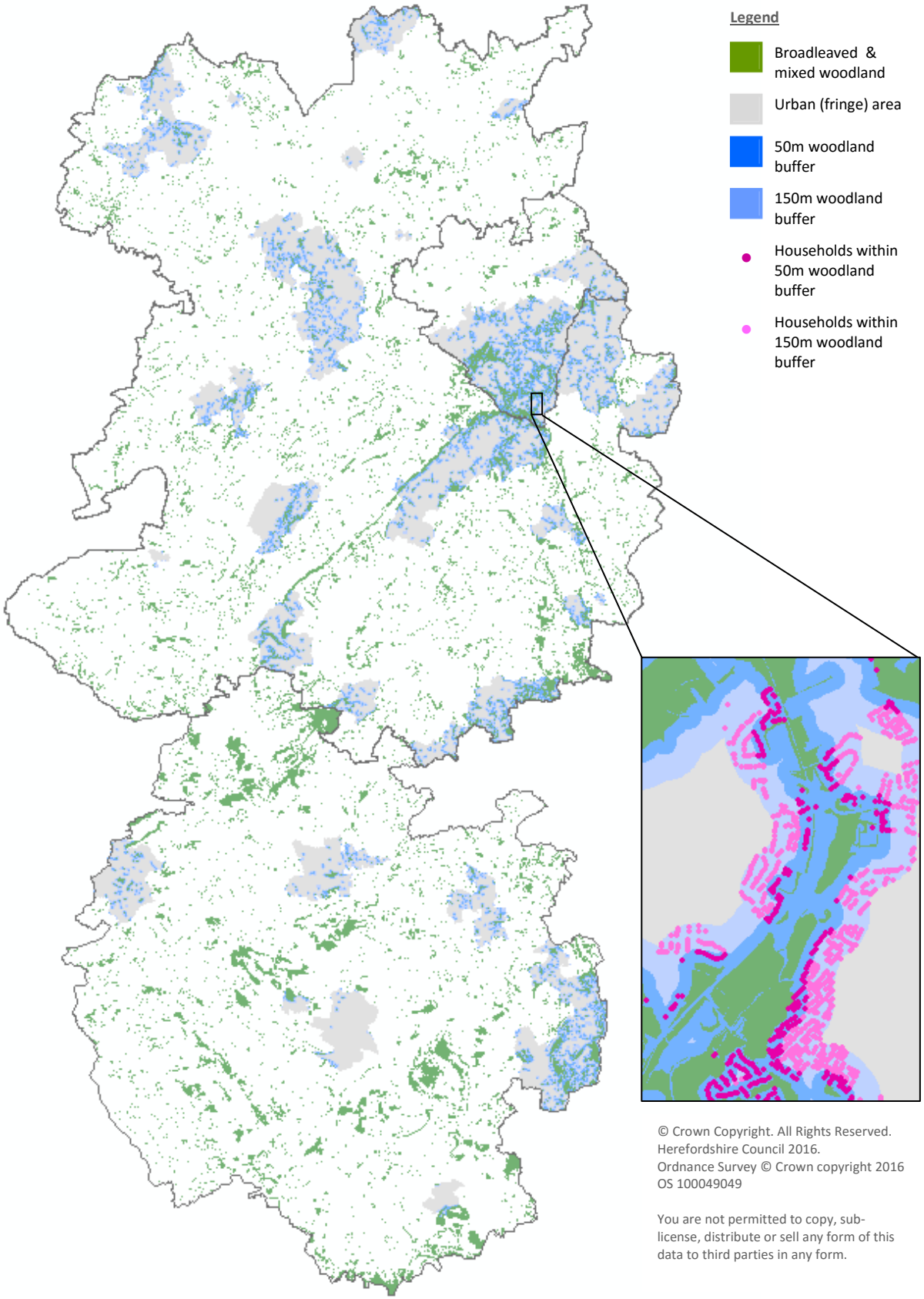
D. Methods & Calculations: Woodland Aesthetics

Within the scope of this investigation, findings from Garrod (2002) who valued the Willingness To Pay (WTP) for woodland views from home have been applied for a benefit transfer to The Marches. It is the most recent study of its kind available in the UK and represents the best primary valuation study for the UK context.[183] An additional advantage of this study is that overlaps and double-counts with other benefits such as recreation have been avoided.[184] The same primary valuation study has also been applied by Edwards et al. (2009) to value the social contribution of forests in Scotland.[185] Garrod (2002) calculated an annual WTP per household for a view of urban fringe broadleaved woodland of £360.64 (2015 prices).[186] Robust WTP estimates were obtained only for urban fringe broadleaved forests.[187] This means that this service could not be assessed for households with free view on woodland in the countryside.

To undertake this assessment for The Marches, an OS urban-rural land classification layer was used to identify urban(fringe) areas. Also 50m and 150m buffers were created around broadleaved and mixed[188] woodland sites using GIS software. These buffers were overlaid with the urban(fringe) layer to identify which buffers are located within urban(fringe) areas. Finally, an address layer (residential only) has been used to identify the number of households within each buffer. Figure A.2 shows the urban(fringe) layers as well as the woodland buffers and benefiting households within such areas.

[183] Forest Research 2010, 22.
[184] Garrod 2002, 2.
[185] Edwards et al. 2009.
[186] Garrod 2002, 12.
[187] Ibid., 20.
[188] The same WTP as for broadleaved woodland has also been applied to mixed woodland.

Figure A.2 Urban & Urban Fringe Households with Woodland View



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Source: ***Based on GIS data provided by Shropshire County Council, HBRC and Natural England***

Altogether 22,561 households were counted within the 50m buffer and an additional 52,207 within the 150m buffer. However, it is not reasonable to assume that all households within these buffers have unimpeded views of the woodland sites. For example, especially in the urban(fringe) environment, the view from households onto woodland can be blocked or degraded by, for example, fences or other houses. Therefore, only a proportion of the total number of households within these buffers has been taken into account for the valuation exercise. The assumption underlies that 75% of urban(fringe) households within the 50m buffer and 50% within a 51-150m buffer, respectively, have an unimpeded view on broadleaved/mixed woodland. This is a very conservative assumptions when compared to Forest Research's recommendation for applying the WTP for all households within 300m of woodland sites.[189]

Based on these assumptions it was estimated that approximately 43,000 urban(fringe) households within The Marches have a free view on broadleaved and mixed woodland and can therefore benefit from their aesthetic value. Applying the WTP from Garrod (2002) the aesthetic value has been valued with £15.5 million annually or £326.3 million capitalised over 25 years.

It should be noted that, with 211 completed questionnaires within Garrod (2002), the sample size of completed questionnaires was comparatively small and no socio-economic adjustment was possible because corresponding information was not available.[190] To take such limitations to the original study and potential transfer errors into account, a range of 50% has been applied for the sensitivity analysis.

Table A.35 Aesthetic Values of Broadleaved & Mixed Woodland: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£1.071	**£0.714**	£0.357	£26.781	**£15.019**	£12.182	£6.091

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Garrod (2002).***

[189] Forest Research 2010.
[190] Garrod 2002, 9 & 13.

Table A.36 Aesthetic Values of Broadleaved & Mixed Woodland: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£10.865	**£7.243**	£3.622	£271.620	**£152.327**	£123.557	£61.779

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Garrod (2002).***

Table A.37 Aesthetic Values of Broadleaved & Mixed Woodland: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL Woodland	£11.338	**£7.559**	£3.779	£283.460	**£158.968**	£128.943	£64.472

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Garrod (2002).***

These figures only represent a fraction of the total aesthetic value of woodland in The Marches as only broadleaved and mixed woodland in an urban(fringe) setting has been assessed. Coniferous woodland, broadleaved/mixed woodland in rural settings and other features like park trees also provide aesthetic benefits but could not be assessed in monetary terms because of a lack of valuation evidence. Therefore this calculation should be interpreted as incomplete and baseline of the real aesthetic value of woodland in the Matches.

E. Methods & Calculations: Woodland Wild Species Diversity

To value the ecosystem service 'wild species diversity' for woodland habitats, findings from Hanley et al. (2002) were used for a benefit transfer approach. Hanley et al. (2002) valued the non-use benefits of UK woodland as habitat for species. They revealed human preferences for the existence of woodland as habitat for species in general. The Willingness-To-Pay (WTP) method was used to elucidate values for woodland habitats with different attributes, expressed by focus groups.[191] This study is considered appropriate as a source for benefit transfer, even though the sample size was comparatively small and not representative of the whole population in the United Kingdom.[192] The study has also been used as a source for valuation of the social and environmental benefits provided by woodland in Great Britain as a whole.[193]

The mean WTP to protect and regenerate an area of 12,000 ha of lowland broadleaved Ancient Semi-Natural Woodland (ASNW) was expressed with £1.13 per household (2002 prices).[194] This equates to £1.52 per household in 2015 prices. Because this is a non-use value, the benefits are theoretically not restricted to local residents in The Marches.

> *"There is no reason within standard economic theory why non-use values would also decrease with distance."*[195]

However, as non-use values are controversial and may contain use value elements as well which are distance related. It is not clear at which level aggregation should stop.[196] Here, a conservative approach has been taken by assuming that only residents in the West Midlands benefit from woodland in The Marches as 'habitat for species'. Multiplying the WTP by the number of households in the West Midlands (2.4m) and breaking the result down to the regional area of lowland ASNW, an annual value of almost £2 million for 6,600 ha has been calculated. However, for the upper threshold of the sensitivity analysis, all UK households have been taken into account.

[191] Hanley et al. 2002.
[192] Willis et al. 2003, 15.
[193] Willis et al. 2003.
[194] Hanley et al. 2002, 18.
[195] Brander et al. 2008, 18.
[196] Saraev 2012, 25.

The valuation of other woodland habitats is more difficult because in the original valuation study the focus group participants were asked explicitly for their WTP for an increase of woodland.[197] However, there are confounding factors including: (1) woodland creation would entail loss of other habitat(s) set aside for tree planting, (2) if the amount of woodland and therefore the habitat for species declines, the marginal value increases, and (3) average species diversity in established woodlands is generally higher than in more recently planted woodlands. Following these arguments, the valuation of existing woodland in The Marches, applying the values for an increase of woodland, seems to be justifiable.

The WTP for 12,000 ha of lowland broadleaved woodland is £1.13 (2015 prices). Adopting the same methodology as for ASNW above, the annual value of lowland broadleaved woodland ads up to £4.9 million, stating the rather conservative central estimate. Applying similar calculations for conifers, mixed woodland and upland woodlands, a total annual value of woodland in The Marches as habitat for species of almost £10 million has been calculated. For the upper threshold of the sensitivity analysis, an annual value of £152 million has been calculated. The significant difference can be explained by the high range for the sensitivity analysis, but also because the value has been applied for all households in the UK and not just those in the West Midlands as for the central estimate. The findings are summarised for each assessment area below. For further caveats regarding biodiversity values see also Appendix A.

[197] Hanley et al. 2002.

Table A.38 Woodland Wild Species Diversity Benefits: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£20.746	**£1.221**	£0.611	£518.641	**£25.688**	£20.836	£10.418
Low land ASNW	£13.273	**£0.781**	£0.391	£331.814	**£16.435**	£13.331	£6.665
Low land Coniferous Woodland	£2.135	**£0.126**	£0.063	£53.380	**£2.644**	£2.145	£1.072
Low land Mixed Woodland	£12.722	**£1.124**	£0.562	£318.052	**£23.629**	£19.166	£9.583
Upland Broadleaved Woodland & Scrub	£0.381	**£0.022**	£0.011	£9.525	**£0.472**	£0.383	£0.191
Upland ASNW	£0.167	**£0.010**	£0.005	£4.170	**£0.207**	£0.168	£0.084
Upland Conifer Woodland	£0.417	**£0.025**	£0.012	£10.429	**£0.517**	£0.419	£0.209
Upland Mixed Woodland	£0.399	**£0.023**	£0.012	£9.971	**£0.494**	£0.401	£0.200
TOTAL	£50.239	**£3.333**	£1.666	£1,255.982	**£70.084**	£56.847	£28.424

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Hanley et al. 2002***

Table A.39 Woodland Wild Species Diversity Benefits: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£54.348	**£3.200**	£1.600	£1,358.705	**£67.296**	£54.585	£27.293
Low land ASNW	£18.219	**£1.073**	£0.536	£455.474	**£22.559**	£18.298	£9.149
Low land Coniferous Woodland	£9.275	**£0.546**	£0.273	£231.883	**£11.485**	£9.316	£4.658
Low land Mixed Woodland	£2.984	**£0.264**	£0.132	£74.607	**£5.543**	£4.496	£2.248
Upland Broadleaved Woodland & Scrub	£2.546	**£0.150**	£0.075	£63.643	**£3.152**	£2.557	£1.278
Upland ASNW	£0.551	**£0.032**	£0.016	£13.773	**£0.682**	£0.553	£0.277
Upland Conifer Woodland	£3.606	**£0.212**	£0.106	£90.146	**£4.465**	£3.622	£1.811
Upland Mixed Woodland	£0.195	**£0.011**	£0.006	£4.874	**£0.241**	£0.196	£0.098
TOTAL	£91.724	**£5.488**	£2.744	£2,293.105	**£115.423**	£93.623	£46.812

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Hanley et al. 2002***

Table A.40 Woodland Wild Species Diversity Benefits: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Low land Broadleaved Woodland & Scrub	£7.605	**£0.448**	£0.224	£190.117	**£9.416**	£7.638	£3.819
Low land ASNW	£2.279	**£0.134**	£0.067	£56.973	**£2.822**	£2.289	£1.144
Low land Coniferous Woodland	£0.351	**£0.021**	£0.010	£8.780	**£0.435**	£0.353	£0.176
Low land Mixed Woodland	£0.186	**£0.016**	£0.008	£4.655	**£0.346**	£0.280	£0.140
Upland Broadleaved Woodland & Scrub	£0.002	**£0.000**	£0.000	£0.055	**£0.003**	£0.002	£0.001
Upland Conifer Woodland	£0.012	**£0.001**	£0.000	£0.312	**£0.015**	£0.013	£0.006
Upland Mixed Woodland	£0.014	**£0.001**	£0.000	£0.351	**£0.017**	£0.014	£0.007
TOTAL	£10.450	**£0.621**	£0.310	£261.242	**£13.054**	£10.589	£5.294

Legend:

Central	**Central Estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on Hanley et al. 2002***

F. Methods & Calculations: Health & Productivity Benefits

Health benefits

Within scope of this assessment only the effect of 'green' physical activity on mortality rates could be valued in monetary terms. To estimate the health benefit of activities undertaken in or on the way to greenspaces in The Marches the Health Economic Assessment Tool (HEAT) developed by the World Health Organisation (WHO) has been used.[198] The tool was designed to assess the value of reduced mortality from walking and cycling and is based on several health and economic studies and informed by an international expert panel.[199]

To be able to apply the HEAT a range of indicators needed to be established and some assumptions to be made. The first step was to estimate the number of cycling/walking trips to greenspaces in The Marches. Natural England's 'Monitoring the Engagement with the Natural Environment (MENE)[200] survey data was analysed to estimate the number of walkers and cyclists in environmental settings. Whilst the visitor count for recreation also includes children the count used for the HEAT analysis is only based on adults as the tool was designed to assess health effects for adults only. The proportion of cycling and walking trips was estimating using a detailed analysis of the MENE survey. The MENE data allowed extracting the number of visits for a specific purpose; to a specific destination. The following MENE destination types were identified as being Natural Capital based:

- Woodland and Forest
- Farmland
- Mountain, Hill or Moorland
- River, Lake or Canal
- Country Park
- Another Open Space in the Countryside
- Park in Town or City
- Playing Field or Other Rec. Area

[198] 2014 version
[199] WHO 2014.
[200] https://www.gov.uk/government/collections/monitor-of-engagement-with-the-natural-environment-survey-purpose-and-results

- Another Open Space in Town or City

For each of these destination types the MENE survey revealed visitor counts for 'off-road cycling or mountain biking', 'road cycling', 'walking without a dog' and 'walking with a dog'. The former two have been aggregated to estimate the number of cycle trips in and to greenspaces whilst the latter two were aggregated to estimate the proportion of walking trips, respectively. Other activities such as running were not considered because the HEAT was designed to explicitly assess cycling and walking only.

The analysis revealed that annually an estimated 1.05 million cycling trips and 28.47 million walking trips were made in or to environmental settings in The Marches over the past few years. Also trips where only the destination was a greenspace were included assuming that the majority of these trips was motivated by the destination rather than the way towards it. This means that for example when someone was cycling on the road to go to a park then this exercise was assumed to be motivated by the park rather than the road meaning that the trip depends on Natural Capital. It should be noted that the sample size especially for cycling trips were very low which means that estimates should be treated with some care. Findings at Marches level are more certain than at sub-levels.

The necessary minimum intensity of cycling to have a measurable positive health effect is usually reached even at low cycling speed. Therefore the required intensity was assumed for all 1.05 million recorded cycling trips. For walking the HEAT model is based on studies involving individuals walking at a moderate speed of about 3 miles per hour.[201] However, it is unrealistic to assume that all walkers in green settings in The Marches reach this intensity level. For the purpose of this investigation the assumption was made that two-third of walkers walk at a speed of at least 3 miles per hour whilst one-third do not reach this intensity level. Therefore 18.97 million walking trips were included in the monetary assessment. That does not mean that lower intensity walking has no positive health effects but that this effect could not be assessed using the HEAT.

The HEAT also needed information about how many individuals undertake this amount of cycling and walking. Because the MENE survey gives very limited information about the

[201] WHO 2014.

number of people this has been estimated making use of Sports England's Active People Survey 9 (2014/15). The survey provides statistics at the national level about how many recreational cycling/walking trips each individual undertakes per week/year. Because the survey results are presented in categories (e.g. 'at least 3 trips per week' or 'at least 1 trip per month') the average number of cycle/walking trips per person per year has been approximated from the available data. It was estimated that the average recreational walker walks 145 times a year whilst the average cyclist cycles 77 times a year. Assuming that most cycling/walking trips are made by regular walkers/cyclists the number of walkers who undertake the number of recorded trips was estimated to be 130,809 whilst the number of cyclists undertaking the recorded cycling trips was estimated to be 13,605.

Another variable that needed to be estimated to be able to use the HEAT was the average walking/cycling duration. Here, I used the English average duration of recreational walking and cycling trips of 62 minutes and 82 minutes, respectively. This figure is also based on the Active People Survey 2014/15. The assumption underlies that these averages also apply for the population in Herefordshire, Shropshire and Telford and Wrekin.

Using this data the HEAT was run for all assessment areas; each time for walking and for cycling trips separately. The results suggest that this amount of walking and cycling prevents 68 deaths in The Marches every year. The value of reduced mortality rates due to walking and cycling is £206.9 million. However, it can be questioned if all cycling/walking is a direct result of the existence of greenspace. It could for example be that in case where a local park would not exist, at least a proportion of potential cyclists/walkers would still have similar activity levels because they may cycle/walk on the street or exercise in a gym. For the purpose of this assessment the assumption was made that two-third of cycling/walking (and related health benefit) is a direct result of the existence of greenspace in The Marches which would not occur otherwise in a different setting.

Applying the assumptions as outlined above it was estimated that the existence of green infrastructure in The Marches prevents about 46 deaths annually. For The Marches the health benefit of reduced mortality due to 'green' exercise (walking and cycling only) was valued at nearly £147 million annually. This results in a capitalised value of almost £3.1

billion over the next 25 years. The findings for Herefordshire, Shropshire and Telford and Wrekin are summarised below.

Table A.41 Health Benefits from Walking & Cycling: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Walking	£49.770	**£37.597**	£25.425	£1,244.241	**£790.687**	£641.349	£433.710
Cycling	£4.810	**£2.915**	£1.020	£120.258	**£61.311**	£49.731	£17.406
TOTAL	£54.580	**£40.513**	£26.445	£1,364.498	**£851.998**	£691.080	£451.115

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on WHO (2014).***

Table A.42 Health Benefits from Walking & Cycling: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Walking	£86.691	**£68.675**	£50.659	£2,167.286	**£1,444.270**	£1,171.489	£864.164
Cycling	£6.459	**£4.377**	£2.296	£161.476	**£92.057**	£74.670	£39.159
TOTAL	£93.150	**£73.053**	£52.955	£2,328.762	**£1,536.327**	£1,246.159	£903.323

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on WHO (2014).***

Table A.43 Health Benefits from Walking & Cycling: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
Walking	£40.409	**£31.705**	£23.000	£1,010.223	**£666.762**	£540.830	£392.350
Cycling	£2.543	**£1.583**	£0.622	£63.585	**£33.284**	£26.998	£10.609
TOTAL	£42.952	**£33.287**	£23.622	£1,073.808	**£700.046**	£567.828	£402.959

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations based on WHO (2014).***

Another assumption is that health benefits do not overlap with recreational benefits. It may be possible that when people were asked for their Willingness To Pay (WTP) to assess woodland, for example, that they included the ascertained health benefits into their consideration. This could result in double-counting of benefits when adding recreational and

health benefits up (see Chapter 6). However, such considerations would probably more relate to morbidity (which is not assessed by HEAT) rather than mortality risks. Furthermore other health benefits such as from lower intensity walking, other activities or 'green' exercise by children were not assessed here which means that it can be assumed that this is still a conservative health value estimate.

Productivity benefits

The activity-related health benefits outlined above also have the positive 'side-effect' of increased productivity because people being physically active also have fewer days of sickness absence from work. To work out the value of this effect the total estimated number of walkers (cyclists) walking (cycling) at least once per week of 107,168 for The Marches was the basis. Other activities were not included. In line with health benefits the assumption underlies that two-third of this walking (cycling) is a direct effect of the existence of accessible greenspace and would not occur without it.

The next step was to estimate the proportion of adults in working age (16-64 years). The proportion for Herefordshire (69.6%), Shropshire (70.0%) and Telford and Wrekin (78.1%) has been based on ONS statistics which were available for 2014. Of this figure, the employment rate has been estimated for each assessment area (H: 78.1%; S: 79.1%; T&W: 72.5%) using ONS local labour market indicator statistics. For The Marches as a whole, the number of employed people (regular 'green' walkers and cyclists only) benefiting from accessible greenspace was estimated to be 39,577.

The benefit was quantified by multiplying this figure by the estimated average daily wage (H: £100; S: £109; T&W: £100) and by the average number of sickness leave days due to physical inactivity (5.23 per year). This number of days is also used in the Physical Activity Return on Investment Tool developed by the National Institute for Health and Care Excellence (NICE) for similar assessments.[202] An annual average productivity benefit of the availability of accessible greenspace in The Marches of £21.7 million has been calculated. More detailed findings for each assessment area are summarised below.

[202] Mallender et al. 2013.

Table A.44 Productivity Benefits from 'Green' Exercise: Herefordshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL	£7.292	**£5.609**	£3.926	£182.302	**£117.965**	£95.685	£66.980

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations.***

Table A.45 Productivity Benefits from 'Green' Exercise: Shropshire

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL	£14.627	**£11.252**	£7.876	£365.679	**£236.627**	£191.935	£134.355

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations.***

Table A.46 Productivity Benefits from 'Green' Exercise: Telford and Wrekin

	Annual Value (£m)			Capitalised Value (£m)			
	High	***Central***	*Low*	*High*	***Central***	*HM Tr.*	*Low*
TOTAL	£6.240	**£4.800**	£3.360	£156.004	**£100.948**	£81.882	£57.318

Legend:

Central	**Central estimate**
High	Higher threshold of the sensitivity analysis (even if the real value could still exceed this threshold)
HM Tr.	Based on the higher discount rates recommended by HM Treasury (stated for comparability purposes)
Low	Lower threshold of the sensitivity analysis

Source: ***Author calculations.***

G. Methods & Calculations: Global Climate Regulation

To estimate the carbon stock in Woodland in the marches findings from Read et al. (2009) were used. The estimated total carbon stock in UK forests and corresponding soils in 2007 was approximately 790Mt (million tonnes), equivalent to 2,897 Mt CO_2e (carbon dioxide equivalent).[203] At that time, the estimated woodland area in the UK was 2.84 million hectares[204] which results in an average carbon stock in UK woodlands and corresponding soils of 278 t per ha.

The estimated carbon stock in The Marches has been approximated by multiplying the average UK carbon stock per ha by the area of woodland in The Marches of 57,021 ha. This is a rather crude estimate because it does not for example account for species and soil types, but it gives us a 'ballpark figure'. Applying the approach described above, the carbon stock in Marches woodlands and corresponding soils was estimated to be in the region of 15.9 Mt which equals 58.1 Mt CO_2e. Multiplied by the actual price (2015 level) per tonne of CO_2e of £62.42, recommended by the UK Department of Energy & Climate Change[205], the value of carbon stored in Marches woodland and woodland soils is in the region of £3.6 billion.

Globally, wetlands have one of the highest carbon stocks per ha. The Intergovernmental Panel on Climate Change (IPCC) estimates an average carbon stock in wetlands globally at more than 750 tonnes per ha.[206] When applied to the area of wetlands in The Marches, this results in a carbon stock of 1.4 Mt equivalent to 5.3 Mt CO_2e and valued at £329 million. However, this estimate may still significantly underestimate the carbon stock of some wetlands in The Marches such as in the Meres and Mosses. The IPCC estimate is only based on wetland and corresponding soils up to a 1m depth.[207] Land-owners in the Meres and Mosses claim, however, that peat storing carbon is up to 14m deep in some areas.

The value of carbon stored in heathland and grassland habitats has been estimated using the findings of a review undertaken by Alonso et al. (2012). They estimated that the average carbon stock in UK heathlands and corresponding soils is 90 tC per ha whilst the stock in

[203] Read et al. 2009, 7.
[204] Forestry Commission 2008.
[205] DECC 2009.
[206] Gorte 2009, 5.
[207] Gorte 2009.

grassland habitats varies from 60 tC per ha for improved grassland to 88 tC per ha for acid grassland.[208] Applying these estimates for 3,820 ha of heathland in The Marches results in a carbon stock of 344,000 t valued at £79 million. For 228,000 ha of assessed grassland habitats a carbon stock of 13.9 Mt valued at £3.2 billion has been calculated.

Aggregating the findings from above a total carbon stock in assessed habitats and corresponding soils of 31.6 Mt was calculated. This results in a total carbon value of £7.2 billion. It should be noted that this is a stock value; not to be confused with the (capitalised) flow value of ecosystem services. Because the main framework of this investigation is based on calculating the annual flow of ecosystem services, the value of £7.2 billion has not been added to the main table of the monetary valuation within scope of this study as it does not match the conceptual framework.

To calculate the annual value of the net carbon sequestration by for example woodland in The Marches, detailed information about the age structure of trees, species and soil structure, but also the amount and usage of felled trees (e.g. for energy production and furniture) including the substituted CO_2 emissions (e.g. from replaced fossil fuel usage for energy production) would have been necessary. It was not possible to gather such detailed information within the limited scope of this investigation. To get a better understanding of the value of carbon captured and stored in trees in The Marches an i-Tree Eco assessment could be undertaken.[209] The i-Tree tool has been developed in the United States and allows, for example, to estimate the carbon stock and sequestration by trees within a specific geographical area. A sample of the woodland, but also for example street, park and garden trees, would be measured and the species structure would be recorded. This would allow calculating more robust figures for carbon stock and actual carbon sequestration to be calculated.

However, even calculating the carbon sequestration rate would not result in the annual net value of the flow of the ecosystem service global climate regulation. After a certain time, woodland and other habitat types become saturated in their net capacity to capture additional carbon. They may still sequester carbon from the atmosphere but, on the other

[208] Alonso et al. 2012.
[209] http://www.itreetools.org/

hand, carbon dioxide and other greenhouse gases are also released for example when trees die or when they are felled to produce timber and wood fuel or because of health and safety issues. Therefore, mature habitats reach a long-term carbon stock equilibrium.[210]

More details regarding the interpretation of the findings as well as summary tables for The Marches, but also for Herefordshire, Shropshire and Telford and Wrekin, are presented in Section 6.

[210] Broadmeadow and Matthews 2003.

H. Methods: ANGSt+ Assessment

The Accessible Natural Greenspace Standard (ANGSt) was developed by Natural England in the early 1990s. It is a framework for assessing the current level of accessible natural greenspace within a specific area as well as the population that can benefit from such accessible greenspace.[211] The purpose of an ANGSt assessment is to show where people have access to natural greenspace of a certain size within a certain distance from home. Here, the ANGSt has been advanced to an ANGSt+ with the aim to provide more detail about which areas are in greatest need of additional Accessible Natural Greenspace (ANG) to prioritise greenspace delivery on the ground.

For ANGSt, Natural England defines natural greenspace as *"places where human control and activities are not intensive so that a feeling of naturalness is allowed to predominate"*.[212] Four levels of 'naturalness' were defined:

[211] Natural England 2010.
[212] Ibid., 48.

Table A.47 ANGSt Levels of Naturalness

Level 1	• Nature conservation areas, including SSSIs • Local sites (including local wildlife sites, RIGs) • LNRs • NNRs • Woodland • Remnant countryside (within urban and urban fringe areas)
Level 2	• Formal and informal open space • Unimproved farmland • Rivers and canals • Unimproved grassland • Disused/derelict land, mosaics of formal and informal areas scrub etc. • Country Parks • Open access land
Level 3	• Allotments • Church yards and cemeteries • Formal recreation space
Level 4	• Improved farmland.

Source: ***Natural England 2010***

Within scope of this assessment Level 1 and 2 were included. Sites falling within Level 3 and 4 were not considered. Relevant natural greenspace sites were identified using GIS software. Spatial habitat information was provided by Shropshire County Council, Shropshire Wildlife Trust (SWT), Herefordshire Biological Records Centre (HBRC) and Natural England. Datasets that were assessed include:

- Conclusive Open Access Land
- Country Parks
- Dedicated Open Access Land
- Doorstep Greens
- Green Guarantee Sites
- Local Nature Reserves (LNRs)
- National Nature Reserves (NNRs)

- Planning Policy Guidance 17 (PPG 17) Sites (Selection)
- Public Recreation Sites (Selection)
- Sites of Special Scientific Interest (SSSIs) (Selection)
- Special Areas of Conservation (SACs) (Selection)
- Unimproved Grassland (Selection)
- Woodland (Selection)
- Wildlife Sites and Reserves (Selection)

Datasets marked with 'Selection' were analysed in more detail and those who prepared/held these datasets were consulted on how to best identify sites that are Accessible Natural Greenspace (ANG). Sometimes, such as for SSSIs, this selection was based on an individual site selection based on the expertise of the dataset holders. In cases where datasets were deemed to be natural but only a proportion of sites were accessible to the public and an individual site assessment was not possible, such as for woodland, accessible sites have been selected if they overlapped with Public Rights Of Way (PROW) layers to identify sites that are likely to be publicly accessible. This analysis resulted in a combined ANG layer for The Marches.

For layers available through Magic[213] such as LNRs these sites have also been included within a 1km buffer around The Marches because people in the Marches living close to the border may still benefit from accessible natural greenspace outside the Marches boundary. However, much information on ANG was only available for within The Marches which means that the identified demand for ANG close to the Marches boundary should be treated with some caution. Identified households demanding additional ANG may still benefit from ANG outside The Marches which has not been identified as part of this ANGSt+ assessment. Therefore it is recommended to individually assess ANG outside The Marches that may benefit people close to the border before action close to the Marches boundary is taken.

ANGSt recommends that everyone, wherever they live, should have an ANG:

- of at least 2 hectares in size, no more than 300 metres (5 minutes walk) from home;
- at least one accessible 20 hectare site within two kilometres of home;

[213] http://magic.defra.gov.uk/

- one accessible 100 hectare site within five kilometres of home; and
- one accessible 500 hectare site within ten kilometres of home; plus
- a minimum of one hectare of statutory Local Nature Reserves per thousand population.[214]

Within the scope of this analysis the focus was on shorter distances only. Larger sites of 20ha and more were not assessed separately for larger distances (2km+ from home). However, such sites were also part of the ANGSt+ assessment as they are still larger than 2ha. The proportion of LNR area per population was also not within scope of this ANGSt+ assessment.

ANGSt only considers sites of at least 2ha in size. However, it is arguable that also smaller sites can provide valuable recreational opportunities - especially in densely populated urban areas with high demand for ANG. To take such considerations into account also smaller sites between 0.5ha and 2ha were considered for this ANGSt+ assessment. To acknowledge the higher recreational value of larger sites (for example because of the limited feel of privacy and because they are more likely to be overcrowded) a smaller 'weight' has been applied to ANG sites <2ha.

Another modification made was that also sites further away from homes than 300m were considered because it is reasonable to assume that the recreational value does not fall to zero if a site is 301m away from home. Therefore also sites within 600m and 900m from home were part of the ANGSt+ assessment. However, the assumption underlies that such sites further away than 300m from homes have a reduced recreational value which is reflected by a lower weight. The following weighting matrix shows which weights were defined for ANGSt+.

Table A.48 ANGSt+ Weighting Matrix

Accessible Natural Greenspace Site Size	Distance From Home		
	Up to 300m	301m to 600m	601m to 900m
2ha+	1	0.5	0.25
0.5-2ha	0.5	0.25	0

Source: ***Author***

[214] Natural England 2010.

The weights indicate the degree to which a household can benefit from accessible natural greenspace where a weight of 1 means high benefit and a weight of 0 means very low/no benefit. The assumption underlies that households within 300m from ANG of at least 2ha are covered and do not necessarily demand additional ANG opportunities. Households within 300m from ANG of 0.5-2ha are partially covered but would still benefit from additional ANG and so on. Weights are not additive meaning that if a household has 2 ANG sites of 0.5-2ha available within 300m it still receives a weight of 0.5 rather than 1. Only the relevant highest weight applies.

The degree of people's demand for ANG can be assumed to be generally linked to the population density or number of households in an area. The more people living around an ANG the more people benefit from it. Whilst ANGSt does not explicitly take the degree of the demand into account (apart from proposing a minimum of 1ha of Local Nature Reserves per thousand population) ANGSt+ explicitly considers the demand by counting the households with full, some and no access to ANG within reasonable walking distance; depending on the weight.

To visualise the methods outlined above on a map GIS software was used to create different buffers around ANG. The following buffers were created:

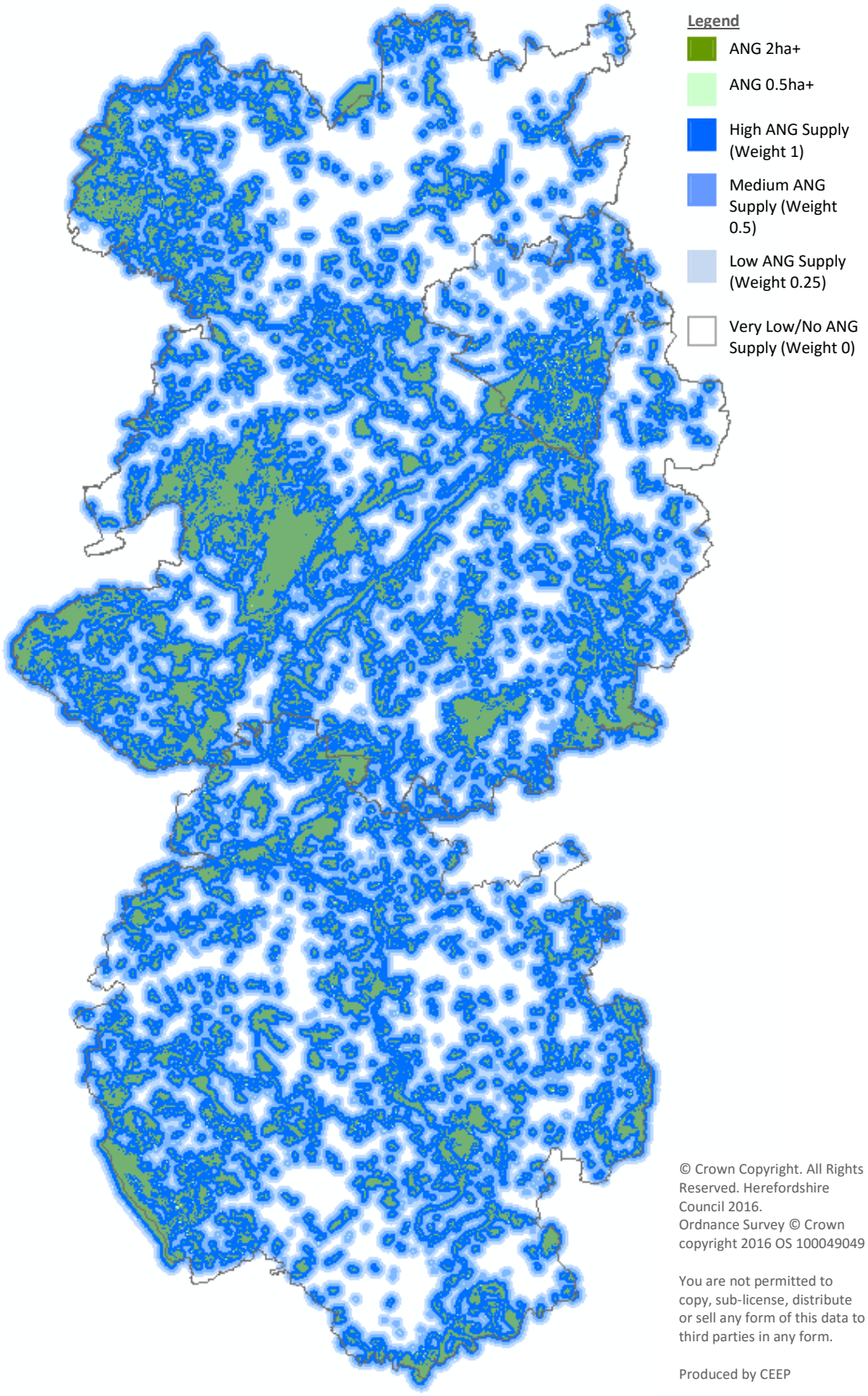
- 300m buffer around ANG of at least 2ha (weight: 1)
- 600m buffer around ANG of at least 2ha (weight: 0.5)
- 900m buffer around ANG of at least 2ha (weight: 0.25)
- 300m buffer around ANG of between 0.5ha and 2ha (weight: 0.5)
- 600m buffer around ANG of between 0.5ha and 2ha (weight: 0.25)

The layers were then combined (dissolved) depending on the weight resulting in 3 layers with a weight of 1, 0.5 and 0.25, respectively. Figure A.3 shows a map with the supply with ANG where white means very low/no supply with ANG and dark blue means high supply with ANG.

However, identifying the areas with least access to ANG was only the first step of this ANGSt+. The next step was to identify the demand for ANG. If there is an area with poor

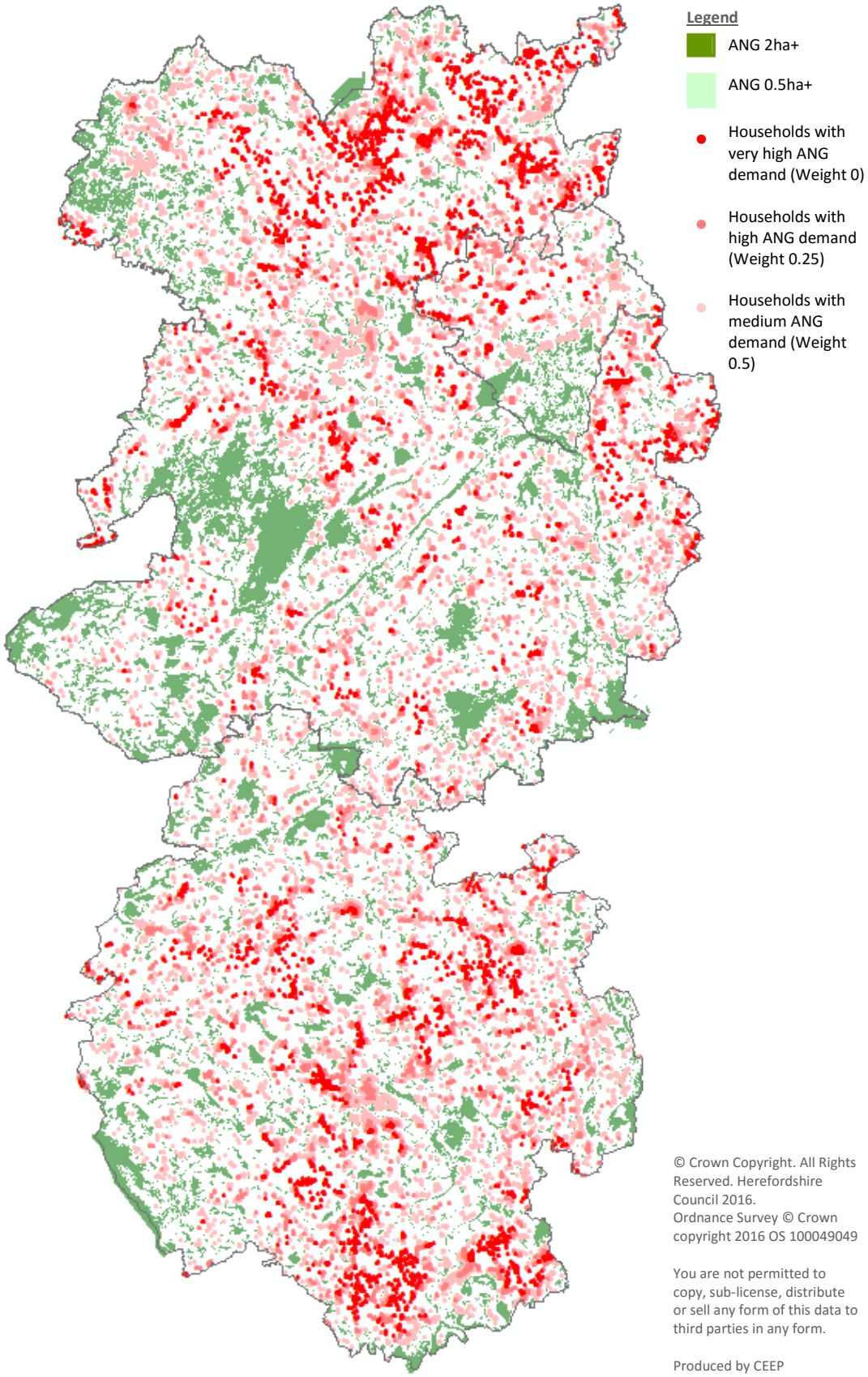
ANG supply but no one lives in that area then there is no need for ANG delivery (at least not for recreational purposes). The demand increases with the number of households with poor ANG supply (furthest away from ANG of reasonable size). Therefore another map has been produced for The Marches ANGSt+ displaying all households with demand for additional ANG (all households with a weight of less than 1). Figure A.4 shows all households with demand for additional ANG applying a colour code where dark red means very high demand and light red means medium demand.

Figure A.3 ANG Supply: Marches ANGSt+



Source: ***Based on GIS data provided by Shropshire County Council, SWT, HBRC and Natural England***

Figure A.4 Demand for additional ANG: Marches ANGSt+



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Produced by CEEP

Source: ***Based on GIS data provided by Shropshire County Council, SWT, HBRC and Natural England***

Figure A.4 can be used to identify areas within The Marches that are likely to benefit most from the creation of additional ANG (or providing access to existing so far inaccessible natural greenspace). The ANGSt+ assessment provides a starting point for prioritising action. If an area has been identified for action then further investigations on the ground would be recommended to establish if the ANGSt+ map reflects the circumstances on the ground. It could be, for example, that there is an ANG site that has not been identified in the ANGSt+ assessment. This is particularly important in areas close to the boundary of The Marches as only few ANG sites outside have been included in the ANGSt+ assessment. It is also important to check if there is opportunity to create ANG locally and what the preferences of the local community are in this respect. The numbers of households with additional demand for ANG are outlined in Table A.49. Please note that in a 'common' ANGSt assessment only households with a weight of 1 would meet the ANGSt criteria.

Table A.49 Number of Households within The Marches with Access to ANG

Weight	Definition	Number of Households				Demand for new ANG
		Herefordshire	Shropshire	Telford and Wrekin	Total Marches	
1	Households within 300m from ANG of at least 2ha	44,134 (50%)	84,408 (58%)	66,967 (89%)	195,509 (63%)	Low
0.5	Households within 301m to 600m from ANG of at least 2ha and/or within 300m of ANG of between 0.5ha and 2ha	29,835 (34%)	43,433 (30%)	7,035 (9%)	80,303 (26%)	Medium
0.25	Households within 601m to 900m from ANG of at least 2ha and/or within 301m to 600m of ANG of between 0.5ha and 2ha	10,010 (11%)	10,435 (7%)	466 (0.6%)	20,911 (7%)	High
0	Households further away than 900m from ANG of at least 2ha and further away than 600m from ANG of between 0.5ha and 2ha	4,245 (5%)	7,133 (5%)	368 (0.5%)	11,746 (4%)	Very High

Source: ***Author calculations***