Applying an Ecosystem Services Framework to Transport Appraisal

Final Report

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1. Introduction

1.1. WebTAG guidance is produced by the Department for Transport (DfT) and is used to inform the appraisal of transport related initiatives. It includes consideration of economic, environmental and social impacts and is used primarily to inform the development of the business case for funding for initiatives, particularly informing the economic and strategic cases[1] for their implementation. WebTAG follows the HM Treasury Green Book, as well as other relevant cross-department guidance.

1.2. In recent years, Defra has been leading research on behalf of the UK government into the use of an ecosystem approach for management of the natural environment and use of an ecosystem services framework for valuation of environmental impacts. This has led to supplementary guidance to the Green Book being published by HMT in 2012 (Dunn, 2012) that recommends the use of an ecosystem services framework for assessing environmental impacts in policy appraisal.

1.3. The purpose of this project was to consider where there may be gaps in the current assessment framework, in particular with regards to enabling monetisation of ESS impacts, and based on this provide recommendations on where initial amendments and additions could be made to WebTAG in order to take a first step towards bringing it into line with the new HMT Green Book guidance. The project does not provide recommendations for including assessment of all possible ecosystem service impacts, but seeks to provide recommendations on the structure and content of two assessment frameworks: one for undertaking screening of impacts that can be assessed in more detail later, and the other for undertaking a more detailed valuation assessment of potentially significant impacts. Specifically the project provides discussion and recommendations around:

- A simple qualitative screening framework, that could be used upfront in any WebTAG assessment in order to identify the extent to which ESS may be impacted by a transport project and therefore require detailed assessment;
- Detailed assessment framework for undertaking ESS impact assessment in monetary terms, based on (and therefore limited by) the existing literature base and developed with respect to the principle of proportionality.

1.4. It is expected that the conclusions and recommendations, if considered appropriate, will be taken forward for further consideration and testing by DfT to conclude on the most appropriate and practical was of incorporating an ESS framework into WebTAG.

1.5. The remainder of this report is set out as follows:

- Section 2: Transport appraisal and WebTAG
  This section briefly explains the background to transport appraisal. It identifies the purpose and evolution of WebTAG and how it fits with government policy and impact assessment requirements, and then goes on to articulate the core approaches to environmental assessment included in WebTAG and their interaction with other guidance.
- Section 3: Ecosystem services
  This section introduces the concept of ecosystem services, with reference to the HMT Treasury Green Book and the UK National Ecosystem Assessment (UK NEA).
- Section 4: Transport impact pathways and WebTAG

[1] The economic case and strategic case are two of the five cases in the HM Treasury Business Case model adopted by the DfT. The other three cases are the financial, management and commercial cases

This section considers the potential impact pathways and the extent to which ESS impacts are currently included in WebTAG.

- Section 5: Synthesis of valuation literature

  The core valuation literature on ecosystem services of relevance to the UK is considered in this section. Conclusions are provided on the aspects which may be useful in the context of transport appraisal.

- Section 6: Screening exercise: draft framework

  This section provides a discussion of the options for establishing an ESS screening framework, with consideration of the possible basic structure under which screening could be undertaken (in line with the Green Book) and examples of the key issues that could be considered for certain ESS to enable a quick and easy screening of impact significance.

- Section 7: Detailed assessment: draft framework examples and recommendations

  This section discusses how the valuation literature can be used in transport appraisal, operating within the framework of WebTAG . It outlines the steps required to undertake a detailed assessment, utilising a small number of examples, and concludes on the ESS impacts which offer the most immediate opportunity for potential inclusion in WebTAG.

- Section 8: Conclusions

  A summary of the report's key conclusions.

2. Transport Appraisal and WebTAG

Contents and role of WebTAG

2.1. WebTAG (Web-based Transport Analysis Guidance) is the Department for Transport's best practice guidance on transport analysis. Its aim is to provide the tools, approaches and guidance required to produce appraisals that provide information on the performance and value for money of transport related interventions that meet the Department's own quality requirements and the cross-government requirements of HM Treasury, as set out in the Green Book[2] and can therefore be used to inform business case development and decision making.

2.2. Completion of a WebTAG compliant appraisal is required for all transport related initiatives that seek government approval and/or funding (although with the recognition that proportionate application is appropriate where funding requirements are limited) and is considered best practice in other circumstances[3].

2.3. To meet these aims, the WebTAG units provide guidance on methods for appraising the impact of transport related initiatives on all aspects of society's welfare (economic, environmental, social and public accounts) in a manner that avoids double counting and meets the requirements of the appraisal and evaluation approach set out in the Green Book. This includes WebTAG units providing advice on the initial identification of the need for intervention and then generating and sifting appropriate options for action to identify a preferred shortlist, on the basis of increasingly detailed appraisal against identified criteria. The recommended process also involves taking account of stakeholder opinions obtained through engagement and setting the cost benefit analysis element of the appraisal in the context of supporting analysis considering factors such as the deliverability and public acceptability of the initiative. Processes should also be planned and established to ensure the monitoring and evaluation of completed initiatives.

2.4. To guide the appraisal process at all stages of intervention development, WebTAG aims to provide standardised approaches to assess relevant impacts and generate a summary that treats the different categories of impact evenly. The approach aims to provide sufficient information to provide a full understanding of the scope of impacts whilst limiting information to a manageable level for informing decision making (in particular, summarising a large volume of complex analysis and assessment results in a single page Appraisal Summary Table (AST) with supporting worksheets to provide more detail).

2.5. The standardised approaches for use to assess each potential impact considered in the appraisal draw on best practice from the transport sector and from other government departments[4] and are either set out within relevant WebTAG units or other referenced sources of guidance, in particular the Highway's Agency's Design Manual for Roads and Bridges[5].

2.6. Impacts are attributed monetary values where possible to provide a common unit of quantification, using the DfT's standard TUBA economic appraisal software where possible. For other impacts, other forms of quantitative assessment are used in the AST or qualitative entries made, drawn from a common seven point scale (large, moderate or slight adverse or positive or neutral impact).

[2] Green Book (Appraisal and Evaluation in Central Government), HM Treasury, 2007. http://www.hm-treasury.gov.uk/data_greenbook_index.htm
[3] Transport Appraisal Guidance: An Overview of Transport Appraisal, November 2011
[4] For instance using carbon values identified by DEFRA
[5] Design Manual Roads and Bridges, Highways Agency, http://www.dft.gov.uk/ha/standards/dmrb/index.htm

2.7. The majority of the impacts assessed rely on estimates of the influence that the intervention in question would have on travel demand and behaviour. Consequently several of the WebTAG units and tools (such as TEMPRO and output from the National Transport Model) provide guidance and information to support the development of robust transport models to inform forecasts of behaviour change.

WebTAG evolution and use

2.8. The current suite of WebTAG units has evolved over the nine years since the guidance was first published online in 2003 (further developing the previous Guidance on Multi Modal Studies and Highways Agency New Approach to Appraisal documents which were the first to draw together economic, environmental and social impacts in a single transport appraisal and dated from 1999 and 1998 respectively).

2.9. The guidance has expanded over this period with revisions and additions subject to a formal consultation and release process. This involves a period of consultation on proposals, subsequent redrafting to account for consultation responses and then release of final draft guidance for final minor comments in advance of the final release of a new or updated unit (which is now scheduled to occur in April of each year only).

2.10. The ongoing evolution of the guidance has resulted in an extensive body of reference information but with the side-effects of some complexity, elements of duplication and lack of clarity. These issues were recognised in the consultation process on updating the guidance undertaken in 2008 (the 'NATA Refresh' consultation) and the subsequent revisions made in 2009. They are also motivating the ongoing move towards WebTAG 2 during 2013 which will streamline existing guidance and improve the structure and accessibility of the units.

2.11. WebTAG is used widely in the transport industry in diverse applications, reflecting the wide range of both:

- users - including various tiers of central and local government, private and public sector operators and infrastructure providers and consultants and ranging from project sponsors requiring an overview of the process to technical practitioners applying the detailed approaches; and
- possible initiative types to be appraised - initiatives considered could vary from broad policies to detailed interventions (such as improvements at a public transport interchange) as well as varying in terms of the transport modes covered, geographical scale and area type of intervention (e.g. rural or urban) and the stage of development of the initiative (from early concept design to detailed final design).

2.12. The contents of WebTAG have therefore generally been developed to be sufficiently flexible to meet this range of requirements, further contributing to the volume of the current guidance.

Current environmental appraisal guidance

2.13. Environmental impacts form one of the four categories of impact considered in the current version of the WebTAG Appraisal Summary Table, along with economic, social and public accounts impacts[6].

[6] Although due to historical factors the units currently remain structured in terms of the five objectives for transport schemes previously used to structure the AST – i.e. Economy, Environment, Safety, Accessibility and Integration

2.14. The following eight individual environmental impacts are considered:

- Noise
- Air quality
- Greenhouse gases
- Landscape
- Townscape
- Heritage of historic resources
- Biodiversity
- Water environment

2.15. WebTAG contains one unit for each environmental impact, setting out the advised approach for assessing the scale of impact of a proposed intervention, differentiating between the appropriate approach for a strategy assessment (covering broadly defined interventions over a large geographic area) and that for a plan assessment (covering more specific interventions, defined in more detail and restricted to a more limited geographic area).

2.16. The approach identified for assessing the impact of transport initiatives on each of these environmental aspects falls into two main categories:

- Traffic based quantitative analysis; and
- Environmental capital approach.

Traffic based quantitative analysis

2.17. Traffic based quantitative analysis is used for the appraisal of noise, local air quality and greenhouse gas impacts. The approach is well developed and provides a clear quantitative assessment of intervention impacts.

2.18. In each case detailed information on forecast traffic flow (speeds, volumes and composition) across the study area is obtained (usually from transport models) for scenarios with and without the initiative being tested and is used within a specified function to produce a quantified estimate of the impact of the initiative on emissions of pollutants or noise associated with the movement of transport (public or private).

2.19. In all cases the impact assessed is limited to the impact of the operational emissions/noise of vehicles on the transport network (rather than for instance the impacts of construction or changes in vegetation). For noise and air quality the impacts considered are also focussed on an assessment of a subset of the impacts of the effects on human well being (annoyance at residential receptors for noise and impacts of NO_X and PM10 on human health for air quality). Where sufficiently detailed information is available, these quantified estimates are converted into estimates of the monetary value of at least some elements of the impact of the emissions. It should be noted that the monetary values used include some additional impacts which are not specified in the WebTAG units, The values applied to NOx include the value of crop yield damage, and the values applied to PM10 include the value of damage of the soiling of buildings[7].

Environmental capital approach

2.20. The Environmental Capital approach was devised in consultation with the Government's statutory environmental advisers (such as Natural England, English Hertiage and the Environment Agency)

[7] See original study: AEA Technology (2006). Damage Costs for Air Pollution. Defra

for WebTAG (and the preceding NATA and GOMMMS documents). It provides a means of summarising the impact of transport initiatives on landscape, townscape, heritage of historic resources, biodiversity and water environment, focussing on the potential impact of changes in traffic levels and land take for construction.

2.21. The approach is qualitative and in each case involves:

- describing relevant characteristic environmental features (e.g. of the landscape or townscape);
- assessing the scale of their importance and to whom it applies and their relationships with other environmental attributes and therefore how they contribute to environmental capital (using guidance on relevant considerations provided in the appropriate WebTAG unit); and
- identifying the likely impact of the proposed initiative on the features (in terms of distinctive quality and substantial local diversity) and therefore environmental capital.

2.22. The output from each assessment is a score from a seven point textual scale: large, moderate or slight beneficial effects; a neutral effect; and slight, moderate, large and very large adverse effects. A comparison between the environmental capital approach and the ecosystem service approach is provided in Section 4.

2.23. In general the approach is less well developed and subject to more variations in interpretation than the traffic based quantitative approach. However, it has been developed to be applicable with varying levels of data availability, ranging from very broad brush corridor or area wide data for a strategy level assessment, to more detailed data collected specifically for the assessment for a plan level assessment for an initiative for which an EIA has not been undertaken and finally to drawing on the detailed data already available for a plan level assessment with an existing EIA (i.e. Phase 3 of a DMRB assessment). Supporting worksheets in WebTAG provide a means of recording the data used and the justification for the assessment made.

Screening

2.24. The WebTAG Environment Units do not include advice on how to undertake screening exercises. Guidance in ‘Unit 2.1.2.c Option Development (Stage 1)’ provides high level support on utilising Level 3 units to undertake early assessments to help develop options. It notes that ‘the approach should be applied proportionately, reflecting the level of evidence required at this stage of the process, i.e. sufficient to be able to distinguish the relative benefits and impacts of options under consideration’.

2.25. In addition Unit 2.1.2.c references screening and scoping guidance provided in DMRB stating that the environment unit guidance provided in DMRB can be used to undertake screening of impacts for air quality, heritage, noise and water. DMRB provides a simple set of questions that can be used to determine whether there is likely to be no impact. If it is concluded that no impact is likely, then no further assessment is recommended.

2.26. Unit 2.1.2.c advises that the Option Appraisal Report can be used to determine ‘proportionality’ i.e. whether an impact is significant enough to warrant further appraisal, and be utilised to clarify the appraisal methodology.

Interaction with other guidance

2.27. WebTAG interacts with several other sets of government guidance. Each set of guidance has a distinct role but in some cases the linkages and interactions are complicated and can lack clarity, leading to the potential for variable interpretations between WebTAG users.

2.28. For environmental assessment the key sets of related guidance are:

- HM Treasury Green Book (Appraisal and Evaluation in Central Government);
- DfT Business Case Assessment Guidance[8] and associated Value for Money guidance;
- Strategic Environmental Assessment Guidance; and
- Design Manual for Roads and Bridges (DMRB).

HM Treasury Green Book

2.29. A key aim of WebTAG is to provide an interpretation of the Green Book requirements for the appraisal and evaluation of transport related initiatives. The two sources are therefore intended to be consistent.

DfT Business Case Assessment guidance and associated Value for Money guidance

2.30. This DfT guidance sets out the principles used by the Department in assessing the business case for major investments, following the HM Treasury Five Case Model[9] which considers the Economic, Strategic, Financial, Management and Commercial cases for an initiative. The documents therefore provide guidance for developing a business case to request DfT funding for a transport initiative.

2.31. The associated Value for Money guidance sets out how the Department assess the Economic Case on the basis of using WebTAG compliant appraisal and other analyses of the initiative's impact, to identify whether it delivers Value for Money.

2.32. In general, WebTAG provides guidance on undertaking appropriate analysis and appraisal to inform the Business Case development set out in the guidance, particularly for the Economic, Strategic and Financial cases.

Strategic Environmental Assessment Guidance

2.33. European Directive 2001/42/EC requires that strategic environmental assessments (SEA) are undertaken for certain plans and programmes, including Local Transport Plans. Meeting the SEA requirements involves producing an Environmental Report on baseline environmental conditions, the likely impacts of the plan upon them and potential mitigation measures. Consultation upon the report is also required with the report and consultation outcomes then to be used in the decision making process in developing the plan.

2.34. TAG unit 2.11[10] sets out how the SEA requirements relate to WebTAG appraisals, showing that whilst good practice appraisals can meet some of the SEA requirements, full completion would require additional work in a number of areas including on recording baseline conditions, potential mitigation approaches and consultation. There also remains some scope for varying interpretation in certain circumstances over when an SEA is required and the timing of the assessment in relation to the phases of the DMRB environmental assessment.

[8] The Transport Business Case, Department for Transport, 2011.
https://www.gov.uk/government/publications/transport-business-case
[9] Business Case Guidance, HM Treasury. http://www.hm-treasury.gov.uk/data_greenbook_business.htm
[10] TAG Unit 2.11: Strategic Environmental Assessment for Transport Plans and Programmes, December 2004
http://www.dft.gov.uk/webtag/documents/project-manager/unit2.11.php

Design Manual for Roads and Bridges (DMRB)

2.35. DMRB is an extensive manual which provides detailed guidance on all aspects of designing and implementing a change to the trunk road network. It contains detailed guidance on assessing several types of scheme impacts and is referred to in WebTAG to provide an approach for assessing impacts on a range of issues including safety and environmental impacts.

2.36. The DMRB guidance sets out a three phase approach to environmental assessment; starting with an initial scoping stage and leading on to a detailed Phase 3 assessment which provides the basis for an Environmental Statement as required for Public Inquiries and meets the requirements of the EU environmental assessment directives and UK regulations on Environmental Impact Assessment

2.37. The environmental guidance in WebTAG was written to draw on the data collated for the relevant stage of the DMRB assessment where available. However a number of complexities exist in the relationship between DMRB and WebTAG leading to some potential for variations in interpretation between different appraisals. Firstly, DMRB directly applies to trunk road schemes only. Although the guidance is usually used wherever an EIA is required (i.e. wherever Transport and Works Act powers will be required), this typically involves an element of interpretation to adapt the guidance for non trunk road schemes. Further, for initiatives for which EIAs are not required, the DMRB assessment is unlikely to have been undertaken, meaning that the data available to support the WebTAG appraisal is likely to be limited, requiring additional collation and interpretation.

2.38. Where DMRB evidence is available, the differences between the requirements of DMRB and WebTAG can also lead to some variation in the interpretation of the required entries for the WebTAG worksheets and AST. The WebTAG entries are typically a summary of more extensive and detailed calculations for DMRB and in some instances vary in terms of factors such as the years represented. Finally, occasionally WebTAG also does not reflect the latest updates implemented in the DMRB guidance, influencing the application of WebTAG.

2.39. Despite the existence of some scope for variable interpretation, the relationship between WebTAG and DMRB is very important with DMRB providing the basis and methodology for the majority of the environmental assessment included in the WebTAG appraisal.

3. Ecosystem Services Approach

3.1. Ecosystem services can be defined as the outputs from ecosystems from which human's derive benefits (UK NEA, 2011)[11]. The identification and categorisation of individual ecosystem services provides a framework within which to discuss and assess the potential impacts of transport projects on ecosystems and human welfare. It ensures that all the different types of ecosystem services are visible to both the analysts and decision makers, providing a clear and consistent audit of what has and hasn't been assessed, and what has then been valued and included in any economic analysis. It does not however mean that assessment, and in particular valuation, of all individual ecosystem services is possible or necessarily useful to the decision-making process e.g. where significant effort is required to assess an impact of minor significance.

3.2. This section provides a short overview of the categorisation and classification of ecosystem services of relevance for UK policy appraisal, based primarily on the overarching guidance provided by the HM Treasury Green Book and Defra. Further details can be found in the sources referenced in this section.

Ecosystem service categorisation

3.3. The Millennium Ecosystem Assessment (MEA,2005)[12] established a generic framework of ecosystem services (ESS), categorising them into four typologies: provisioning services, regulating services, cultural services, and supporting services. It has been effectively adopted by the UK Government, as identified in Defra (2007)[13], as it seeks to incorporate an ecosystem services approach into policy appraisal and guidance. In doing this it draws substantially on leading studies such as the UK National Ecosystem Assessment (UK NEA, 2011). In turn therefore this also provides the starting point for categorising ecosystem services for use in WebTAG assessments. The categories of ESS set out in Defra (2007) and the new Green Book Supplementary Guidance (Dunn, 2012) are:

- Provisioning services: goods obtained from ecosystems, such as a supply of food and fibre.
- Regulating services: benefits obtained from the regulation of ecosystem processes, such as water and climate regulation.
- Cultural services: non-material benefits that people obtain from ecosystems, such as landscapes and recreation.
- Supporting services: services necessary for the production of all other ecosystem services, such as soil formation and habitats

Ecosystem services classification

3.4. The HMT Green Book (Dunn, 2012)[14] sets out the Government's overarching guidance for assessing impacts on ecosystem services in policy appraisal. It does not provide a definitive list of ecosystem services, but refers to that published in Defra (2007). Defra (2007) proposes an initial check list of ecosystem services under the four broad categories, as show in Table 1.

[11] UK National Ecosystem Assessment, 2011. The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, Cambridge.
[12] MEA, 2005. Ecosystems and Human Well-Being. Washington, DC: Island Press.
[13] Defra, 2007. An introductory guide to valuing ecosystem services. Defra
[14] Dunn, H. 2012. Accounting for environmental impacts: Supplementary Green Book guidance. HM Treasury

Table 1. Ecosystem services classification set out in HMT Green Book

Provisioning services	**Regulating services**
Food	Air-quality regulation
Fibre and fuel	Climate regulation
Genetic resources	Water regulation
Biochemicals, natural medicines, pharmaceuticals	Natural hazard regulation
Ornamental resources	Pest regulation
Fresh water	Disease regulation
	Erosion regulation
	Water purification and waste treatment
	Pollination
Cultural services	**Supporting services**
Cultural heritage	Soil formation
Recreation & tourism	Primary production
Aesthetic value	Nutrient cycling
	Water cycling
	Photosynthesis

Source: Defra, 2007

3.5. While Table 1 represents a commonly used classification, it is not the only one. Different classifications are used for different projects and studies depending on what is most appropriate, although most include many similar terms.

3.6. The UK NEA utilises the same categorisation as Defra (2007) and HMT Green Book, but presents slightly different classification of ESS. Most notably it includes a more detailed consideration of the difference between ecosystem processes, intermediate ecosystem services, final ecosystem services and the goods (or outputs) from ecosystem services from which humans derive benefits. It is the final ecosystem services that directly contribute to the goods that humans' value, and it is therefore these final ecosystem services that are typically the focus for management (UK NEA, 2011).

3.7. Whether an ecosystem services is an intermediate or final service depends on the categorisation and classification system used. The UK NEA notes that provisioning and cultural services are always classified as final ecosystem services, regulating services can be classified as either intermediate services/processes or final ecosystem services, while supporting services are always classified as intermediate ecosystem services/processes. The distinction between ecosystem process, intermediate ecosystem services and final ecosystem services is necessary in order to avoid double counting. In order to enable the valuation of final ecosystem services, the UK NEA further develops the distinction between intermediate services/processes and final ecosystem services, thereby explicitly placing supporting services as contributors to provisioning, cultural and regulating services, and not as the direct provider of any goods valued by humans.

3.8. For cultural ecosystem services, the UK NEA identifies environmental settings as the final ecosystem services and recreation, aesthetic value, and education as the goods that an ecosystem delivers (Table 2). In this sense it differs from the classification system set out in the HMT Green Book.

3.9. The UK NEA explicitly makes a distinction between final ecosystem services and the goods that are derived from those services. It is the goods that are ultimately valued in an assessment of ESS.

Table 2. Ecosystem services classification set out in UK NEA

Ecosystem Service Category	Final Ecosystem Service
Provisioning services	Crops Livestock/aquaculture Fish Trees, standing vegetation, peat Water supply
Provisioning / Cultural services	Wild species diversity
Cultural services	Environmental settings: local places Environmental settings: landscape
Regulating services	Climate regulation Hazard regulation Disease and pest regulation Pollination Noise regulation Water quality regulation Soil quality regulation Air quality regulation

Source: UK NEA

3.10. Discussion with WebTAG users found significant differences in interpretation of each ESS. Generally, the ESS included in the UNKEA were found to be more comprehensible that those in the Green Book. Therefore, and in order to enable consistent consideration of ecosystem services in transport appraisal, a simplified classification of ecosystem services has been proposed, drawing on that used by Defra and the HMT Green Book and that in the UK NEA.

3.11. It ensures that conceptual double counting issues are avoided and that no significant ecosystem services are potentially excluded. As such it focuses on the provisioning and cultural services, and on those regulating services that are considered as final. Supporting services, which are intermediate services that support provisioning, cultural and regulating services, have been removed from the list in order avoid potential double counting. It should be noted however that not valuing supporting services does not mean that they should not be considered as part of the broader impact pathway. Where transport projects affect supporting services, there may be knock on effects to the final ecosystem services.

3.12. Any inclusion of ESS within WebTAG will need to include clear definitions for each type of ESS. Ultimately it may be appropriate to test further the most appropriate classification of ESS to include in the guidance.

Table 3. Ecosystem services for transport appraisal

Ecosystem Service Category	Final Ecosystem Service
Provisioning services	Food Fuel and fibre Fresh water supply

Provisioning / Cultural services	Wild species diversity
Cultural services	Recreation Aesthetic value Cultural heritage
Regulating services	Climate regulation Hazard regulation Disease and pest regulation Pollination Noise regulation Water quality regulation Soil quality regulation Air quality regulation

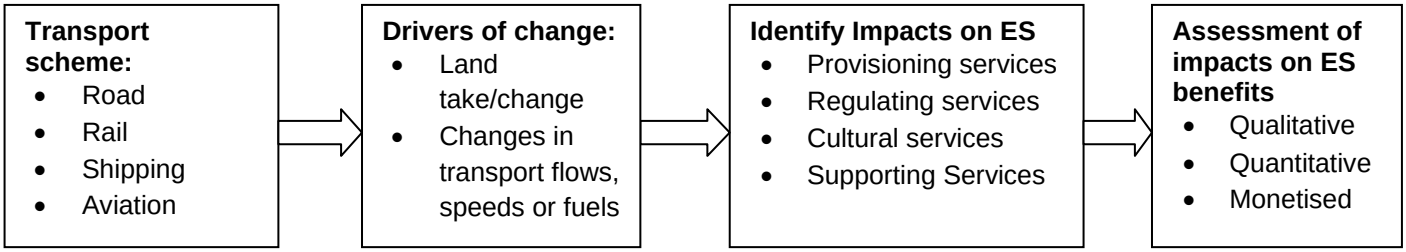
4. Transport Impact Pathways, Ecosystem Services and WebTAG

4.1. This chapter introduces the concept of impact pathways and provides a short summary of the impact pathway audit undertaken. It concludes with an initial consideration of the extent to which ecosystem service impacts are currently covered and not covered in WebTAG.

Impact pathways

4.2. An impact pathway identifies the links between a transport project, the drivers of change it generates and the impacts on ESS. It helps to clarify the relationships between ecosystems, ESS and the value of derived human benefits. Figure 1 provides a simplified, linear impact pathway for transport schemes.

Figure 1. Overview of impact pathway of transport schemes[15]



4.3. In reality there are numerous complex linkages between the different impact pathway stages. However it is not within the scope of this project, or within its timeframe, to undertake a detailed review of the impact pathways.

Drivers of change

4.4. Drivers of change are the drivers that result in ecosystem change, thereby impacting on ESS. They can be either direct or indirect. Direct drivers of change are primarily physical, chemical and biological. Over the past 60 years five key direct drivers of changes can be identified: i) habitat change and degradation, notably through the conversion and intensification of natural habitats to farmland; ii) exploitation of natural resources, especially marine fish; iii) air and aquatic pollution, especially nitrogen, sulphur and phosphorus; and to a lesser extent iv) climate change, and v) invasive species, including plant pests and animal diseases (UK NEA, 2011).

4.5. Table 4 sets out the relative scale of impact of these key direct drivers of change on habitats over the last 40 years. For the habitat change and pollution drivers of change, the trend (since 1990s) of the impact on ecosystem service delivery is either continuing or increasing across all ESS with the exception of pollution on wild fish, which is decreasing. The table indicates that habitat change has the most significant and wide ranging impacts. Notably certain ecosystem services such as crops and livestock have been impacted positively over the last 40 years, with an increase in their provision as a result of land use change and increased yields during a period that has seen agricultural expansion and intensification.

[15] Developed from Impact Pathway scheme in Defra (2007)

Table 4. Driver's Impact on Ecosystem Service Delivery Since the 1940s

Final Ecosystem Service	Habitat change	Pollution & nutrient enrichment	Overexploitation	Climate change	Invasive species
Crops	Very high	High	Low	Low	Low
Livestock	Very high	High	Moderate	Low	Moderate
Wild fish	Very high	Moderate	Very high	Moderate	Moderate
Farmed fish	High	Moderate	Moderate	Low	Low
Timber	Very high	High	Very high	Low	High
Water	Moderate	Very high	Very high	Low	Low
Peat	Very high	Low	High	Low	Low
Wild game	High	Moderate	Moderate	Low	High
Honey	Low	Low	Moderate	Low	Moderate
Ornamentals	Moderate	Low	High	Low	Low
Genetic resources	High	Low	Moderate	Low	Very high
Wild species diversity	Very high	Very high	Very high	Moderate	High
Environmental settings	Very high	High	Moderate	Low	Moderate
Climate	Very high	Low	High	Moderate	Low
Hazard	Very high	Low	High	Moderate	Moderate
Disease and pests	Very high	Moderate	Moderate	Moderate	High
Pollination	Very high	High	Low	Low	Very high
Noise	Very high	Low	Moderate	Low	Low
Water quality	High	Very high	High	Low	Moderate
Soil quality	Very high	Very high	High	Low	Low
Air quality	Very high	Very high	High	Moderate	Low

Source: UK NEA

4.6. The two key direct drivers of change of most relevance to transport projects are land use change, resulting from construction of infrastructure, and pollution, resulting from changes in traffic flows, speeds and fuel. It should be noted that these two core drivers of change apply to all transport modes, although the details and parameters associated with the whole impact pathway may differ. Understanding the potential magnitude of the driver of change is a key step in undertaking an assessment of the impact on ESS.

Assessment of impact on ESS

4.7. The ESS impact is generally a function of the magnitude of the effect of the driver of change, and a consideration of the importance of the benefits derived from the ESS and the resulting marginal change in the value of the benefits. Assessments can be undertaken qualitatively, however the aim is generally to be able to quantify and then monetise any impacts, particularly where outputs are relevant to economic arguments.

4.8. Different habitats are of different levels of importance in terms of ESS provision. Certain habitats are particularly valuable for certain ESS. The UK NEA provides a succinct summary of the relative importance of different habitats for the provision of ESS, as shown in Table 5.

Table 5. The UK importance of each habitat type for each ecosystem service

		Mountains, moorlands & heaths	Semi-natural grasslands	Enclosed farmland	Woodlands	Freshwaters (openwater, wetland, floodplain)	Urban	Coastal margin	Marine
Provisioning	Crops	-	L	H	-	L	M-L	L	-
	Livestock / aquaculture	M-L	M-L	H	L	L	M-L	M-L	H
	Fish	-	-	-	-	M-H	M-L	M-H	H
	Trees, standing veg, peat	M-H	M-L	M-H	H	M-H	M-H	M-L	-
	Water supply	H	L	M-H	M-L	H	M-H	L	-
Prov /Cult	Wild species diversity	H	H	M-L	H	H	M-L	H	H
Cultural	Env settings: local places	M-H	M-H	M-H	H	H	H	H	M-L
	Env settings: landscape	H	H	M-H	M-H	H	M-H	H	H
Regulating	Climate	H	M-H	H	H	M-L	H	M-H	H
	Hazard	H	M-H	H	M-H	H	M-H	H	M-H
	Disease / pests	L	L	H	M-L	M-H	M-L	L	M-H
	Pollination	M-L	H	H	L	-	M-H	M-L	-
	Noise	L	L	L	M-H	M-L	H	M-H	-
	Water quality	H	H	H	M-H	H	M-H	H	M-L
	Soil quality	H	H	H	H	M-H	M-H	M-L	-
	Air quality	M-L	M-H	M-H	H	L	H	L	H

This table is a simplified version of that presented in the UK NEA synthesis report http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Key: importance of habitat in delivery of the ESS at the UK scale – H: high importance; M-H: medium-to-high importance; M-L: medium-to-low importance; L: low importance; - : not provided.

Impact pathway audit

4.9. An audit of potential impact pathways has been undertaken using the expert opinion of experienced transport appraisal and environmental specialists.

4.10. The purpose of this audit was to engage transport and environment specialists with the concept of ESS and the range of potential impacts of relevance. The outputs of the audit provided a starting point for considering which ESS should be considered in WebTAG, the key issues and questions that may need to be considered at a screening stage, and to identify the typical types of information used in more detailed assessments currently undertaken which may be of use in any detailed monetary valuation of ecosystem service impacts.

4.11. The audit was undertaken across the WebTAG environment objectives and identified a large number of potential impact pathways associated with transport projects. It enabled each individual specialist, or group of specialists, to identify the potential impact pathways associated with transport schemes, and identify the types of information and data that could be used in any ESS assessment at different WebTAG assessment stages. Specialists from each WebTAG environment objective undertook an audit using a pre-defined proforma.

4.12. Indirectly, the audit provided a method of understanding the extent to which specialists involved in WebTAG assessments currently understand the concept of ESS and the extent to which they are comfortable with the terminology and the impact pathway concept. This provided a useful gauge, helping to understand the level of complexity and guidance that could be associated with any screening and detailed frameworks.

4.13. General issues identified from the audit:

- Grasp of ESS and the concepts amongst WebTAG users varies considerably. This may limit the ability to introduce considerations of new impacts identified via an ESS framework;

- There are differing opinions on the usefulness of the addition of ecosystem services to the existing WebTAG framework. In particular there are concerns over the additional complications involved in including an additional assessment framework; that only impacts which can be fully and properly assessed should be considered, but that further research was required in a number of cases before this could be achieved; and that identification of a long list of potentially affected ecosystem services would likely end up in significant additional work for assessors, potentially for little additional decision-making benefit.

- There is a vast array of often complex interactions that make up the multitude of impact pathways and ESS impacts of transport projects. Many of these are likely to be small and efforts to quantify and monetise them would not meet the proportionality test in most cases. But there are some that are potentially important that it may be possible to monetise.

Ecosystem services and WebTAG gap analysis

4.14. The impact pathway audit enabled transport appraisal and environmental specialists to consider the wide variety of impact pathways that could be potentially generated through transport projects. This enabled an initial view to be taken of the extent to which certain ESS are already captured within WebTAG, as well as identifying certain ESS, or impact pathways, that are not currently captured with WebTAG. A summary of this is presented in the tables below[16]. It should be noted that ESS impacts identified as included in WebTAG do not all get the same level of assessment effort and coverage. Where monetary valuation is currently undertaken, this is noted in square brackets.

[16] Further details can be found in the unedited appendices of the draft report.

4.15. As the audit was undertaken over a very short space of time and based on expert opinion, it should not be considered to be a comprehensive review of all impact pathways and ESS impacts. There are likely to be areas where impact pathways have been overlooked, or where there is significant uncertainty over the likelihood of impacts occurring and the extent to which WebTAG is already set up to capture them. In addition, the audit does not provide conclusions on the likely significance or value of any potential impacts.

4.16. For the purposes of this project, the audit provides an initial view of impact pathways that are currently in WebTAG and those that are not. As such it provides an initial focus on where one might ideally want to focus any additional assessment guidance. However given the limitations likely to be imposed by the extent of the available valuation literature, and the parameters within which this project is being undertaken, it may be more useful as a checklist against which to start a review of any potential double counting of impacts that may result from introducing valuation guidance alongside the existing WebTAG documents.

4.17. The impacts identified as being 'in WebTAG' principally cover road, and to a lesser extent rail, projects. These are more typically the focus of WebTAG assessments, and the strong linkages between WebTAG and DMRB push the guidance in that direction. However many of the impacts are relevant for both aviation and ports and shipping projects. To reflect this broader coverage of transport modes, in the 'Not in WebTAG' sections the language used changes from 'traffic/vehicle flows' to 'transport flows' where appropriate.

Food
In WebTAG
Effect of land use change on food production is captured as a cost in terms of the cost of purchasing land [Monetary value] (Unit 3.5.9).
A limited consideration is given through the identification of the potential loss and destruction of soils as a result of land take for infrastructure construction (Biodiversity Unit)
Effect of change in road vehicle flows/speeds/composition on crop yields as a result of changes in air pollution (NOx based calculation) [Monetary value] (Air Quality Unit).
Not in WebTAG
Effect of change in transport flows/speeds/composition on fish and other non-crop food goods as a result of air pollution.
Effect of land use change on the productive performance of downstream aquatic crops (e.g. watercress), fish or fish farms as a result of the direct loss of a natural watercourse reach (from land take/change) or changes in water quality (from surface runoff pollution)
Effect of land use change on food gathered through non-commercial practices.

Fuel and Fibre
In WebTAG
Effect of land use change on fuel and fibre production is captured as a cost in terms of the cost of purchasing land [Monetary value] (Unit 3.5.9).
A limited consideration is given through the identification of the potential loss and destruction of soils as a result of land take for infrastructure construction (Biodiversity Unit)
Not in WebTAG
Effect of change in transport flows/speeds/composition on fuel and fibre crop yields as a result of nitrogen deposition from air pollution.
Impacts of land use change on the productive performance of downstream aquatic sources of fuel and fibre (e.g. reeds used for thatching) as a result of the direct loss of a natural watercourse

reach (from land take/change) or changes in water quality (from surface runoff pollution)

Water Supply
In WebTAG
Effect of changes in vehicle flows/speeds/fuel types on abstraction point water quality resulting from changes in the composition of surface runoff (Water Unit)
Effect of land use change on abstraction point water availability resulting from changes in groundwater levels from dewatering or lowering of the water table because of major groundworks (e.g. cuttings, tunnelling). (Water Unit)
Not in WebTAG

Wild Species Diversity
In WebTAG
Effect of changes in vehicle flows/speeds on wild species road casualties (Biodiversity Unit)
Effect of changes in vehicle flows/speeds/fuels on wild species sensitive to the resulting changes in noise intensity and frequency (Biodiversity/Noise Units)
Effect of changes in vehicle flows on sensitive habitats/species through changes in air quality (e.g. nitrogen deposition) and dust deposition (Air Quality/Biodiversity Unit)
Not in WebTAG

Environmental local and landscape settings: recreation, aesthetic value, cultural heritage
In WebTAG
Effect of land use change on cultural services through changes to the area and quality (including visual/noise intrusion) of designated habitats (e.g. Local Nature Reserve) (Biodiversity Unit)
Effect of land use change or traffic flows on the aesthetic value of a landscape/townscape through visual intrusion and its effect on valued views (Landscape & Townscape Units)
Effect of land use change (from undeveloped land to housing) on amenity values (Appraisal in the Context of Housing Development: Unit – in draft) [Monetary][17]
Effect of land use change or traffic flows on cultural heritage through the impact on and appreciation of heritage assets (Heritage Unit)
Effect of changes in vehicle flows/speeds/fuels and land use change on journey ambience through effects on traveller stress, views and car (Journey Ambience unit).
Not in WebTAG
Effect of land use change on cultural heritage that is reliant on ESS e.g. a woodland that provides protection to a heritage building against weathering
Effect of land use change or transport flows on volume and type of recreation activities and values

Climate Regulation
In WebTAG
Effect of change in vehicle flows/speeds/composition on climate as a result of CO2 emissions from vehicles [Monetised] (GHG Unit)

[17] Note that this is in relation to housing development enabled by transport projects, rather than directly by the transport project itself.

Not in WebTAG
Effect of land use change on net carbon emissions of that area of land.

Hazard Regulation
In WebTAG
Effect of land use change on flood risk (probability and property potentially affected) resulting from effects on the conveyance of flow, causing restriction of flow passing downstream or potential flooding upstream as a result of a new crossing over a water body or floodplain (Water Unit)
Not in WebTAG
Effect of land use change on flood risk resulting from effects on the physical structure of a surface water body as a result of a diversion of a water body
Effect of changes in traffic flow (road projects) on fire risk from ignition of adjacent habitats from car fires or increased access by members of the public resulting in an increase in incidences of arson.
Effect of land use change on erosion regulation due to altered terrestrial habitats (area and type of vegetation)

Disease and Pest Regulation
In WebTAG
Effect of land use change and/or change in traffic flows on the import, spread or removal of non-native and invasive species or diseases (WCA Sc9), resulting from the construction (import of material or species) and use of new or expanded infrastructure. (Biodiversity Unit)
Not in WebTAG

Pollination
In WebTAG
-
Not in WebTAG
Effect of changes in transport flows/speeds/composition on pollination due to changes in the abundance of plant species and associated pollinating species that are sensitive to noise or air pollution.

Noise Regulation
In WebTAG
Effect of changes in vehicle flows/speeds/composition on human welfare (through noise annoyance) as a result of changes in local noise levels (Noise Unit) [Monetised]
Not in WebTAG
-

Water Quality Regulation
In WebTAG
Effect of land use change on water quality regulation through the loss a water body's ability to purify itself, reducing carrying capacity for waste water discharges (minor impact for most crossings) and a change to the erosion regime; because of a resulting change in the physical structure of a surface water body and associated disruption to the natural processes within it, due to the need for diversion (e.g. for a skewed crossing to the proposed transport route or issues with vertical alignment) (Water Unit)
Effect of changes in vehicle flows/speeds/composition on water quality resulting from changes in the composition of surface runoff (Water Unit)
Not in WebTAG
Effect of changes in transport flows/speeds/composition on water quality as a result of air pollution

Soil Quality Regulation
In WebTAG
A limited consideration is given through the identification of the potential loss and destruction of soils as a result of land take for infrastructure construction (Biodiversity Unit)
Not in WebTAG
-

Air Quality Regulation
In WebTAG
Effect of changes in vehicle flows/speeds/composition on human health through changes in local concentrations of pollutants (NOx) (Air Quality Unit) [Monetised]
Effect of changes in vehicle flows/speeds/composition on human health and building condition (through soiling) through changes in local concentrations of pollutants (PM10) (Air Quality Unit) [Monetised]
Not in WebTAG
Effect of land use change on air quality through changes in the rates of removal of pollutants by ecosystems, and from the emission of pollutants by land use activities (e.g. ammonia emissions from agriculture)

WebTAG and ecosystem services

4.18. The ESS identified above will be affected as a result of transport projects where the environmental impacts are currently assessed in WebTAG under the headings of: air quality, greenhouse gases, noise, landscape, townscape, heritage, biodiversity, water and journey ambience. As the aim is to retain WebTAG as the organising framework, it will be necessary to map the different ESS into these categories, so that the specialists working on each category can expand their analysis of the impacts to take account of those ESS that are not being addressed at present. Table 6 provides

an initial assessment of the ESS that are currently accounted for in WebTAG and those that may need to be included[18].

Table 6. WebTAG Categories and ESS

WebTAG Unit / Ecosystem Service	AQ	GHG	Noise	Landsc	Townsc	Heritage	Biodiv	Water	Journey amb.
Food	M	P					Q	Q	
Fuel and fibre	P						Q	Q	
Water supply								Q	
Wild species diversity			Q				Q	Q	
Recreation	P		P	P	P	P	Q	P	
Aesthetic value				Q	Q	P	P	P	Q
Cultural heritage	Q					Q			
Climate regulation		M					P		
Hazard regulation							P	Q	
Disease and pest regulation							Q		
Noise regulation			M						
Water quality regulation	P						Q	Q	
Soil quality regulation		P					Q		
Air quality regulation	M								

Key: Q: Impact currently included (at least partially) through a qualitative assessment. M: Impact currently included in monetary terms. P: Potential impact that could be added to WebTAG. Blank: No/limited link between ESS and WebTAG unit.

4.19. Table 6 shows that several ESS are already covered under the WebTAG Environment Objective units, mostly in qualitative terms, represented by a 'Q'. Four are also covered in monetary terms, all stemming from changes in traffic flows:

- the impact of air quality on human health;
- the impact of air quality on building condition (through soiling)[19];
- the impact of air quality on crops, and therefore food[20]
- the impact of noise on human well being (annoyance);
- the impact of GHG emissions on climate regulation.

4.20. Four points should be noted from Table 6. First, some of the impacts of transport projects that are evaluated qualitatively could perhaps be valued in monetary terms, given the literature on valuation. Examples would be the effects of losses in habitat and biodiversity on recreation;

[18] Table 6 does not include the valuations of different kinds of undeveloped land given in the DCLG study (2006), which are included in the draft unit 3.16D in relation to housing development and provides some money values to the recreation and other amenity uses of landscape and townscape.
[19] Soiling of buildings: damage value are included in the values applied to PM10, WebTAG does not currently state this, but should be updated to reflect that it is not only human health values that are included in the values used,
[20] Crop damage values are included in the values applied to NOx. WebTAG does not currently state this, but should be updated to reflect that it is not only human health values that are included in the values used. Damage values for fuel and fibre have not been identified as being monetised as rapeseed is the only fuel crop included in the original study values,

changes in water flows and their impacts on recreation and aesthetic values; and the effects of changes in soil quality on GHGs. Section 5 explores this further and provides initial conclusions on the extent to which the key literature would allow early adoption of monetary valuation in WebTAG.

4.21. Secondly, a Q has been entered in some cells because WebTAG does partially address an issue, but the ESS approach could enrich our understanding of the range of relevant impacts and linkages between environmental impacts and ESS and between ESS, which may include linkages between WebTAG units.

4.22. An example would be invasive species introduced as a result of a new road or shipping development, or the spread of existing non-native species, which could result in change to disease and pest regulation and thereby cause damage to food or fibre production. It may be possible to assess and value these impacts in monetary terms. However only unintentional impacts of this nature – which are difficult to assess - should occur as a result of transport projects, as spread of disease and pests is identified in DMRB and should be mitigated for ensure that risk is kept to an acceptable level.

4.23. The ESS approach also draws attention to links between the WebTAG categories. Thus, land take for transport or development of a new harbour may affect a water body, which in turn will affect wild species diversity because it may affects terrestrial as well as aquatic biodiversity. Further inclusion of the variety of links between ESS that are not currently included in WebTAG may require either a significant extension to the existing guidance or overhaul of its current structure, and is therefore not currently considered feasible.

4.24. Third, where a P has been entered it is felt that WebTAG does not currently address a potential ESS impact. In general, being able to provide guidance on how to assess these impacts may require further research before they could be adequately understood.

4.25. A notable ESS which could be incorporated is the effect of land use change on the carbon value of land and the resulting impact on climate regulation. This assumes that adequate data on carbon sequestration rates can be identified. Any resulting outputs from its inclusion would need to be tested to ensure that the results are comprehensive and significant.

4.26. Recreation is partially included within environment units on biodiversity and occasionally may be utilised in units on landscape and townscape, although only as a minor factor which may help to define the importance of the feature being considered (in relation to the natural capital approach). However there is no obvious WebTAG avenue through which to take forward further impact assessment for recreation in terms of the market and non-market impacts. The economic units of WebTAG also do not provide specific guidance for considering the economic impacts on recreation as they concentrate on the economic impacts associated with changes in the functioning of the transportation system. Instances where recreation impacts are more thoroughly assessed only appear to occur through the socioeconomic chapter of an EIA. There is no set guidance on how to assess the market and non-market value of recreation. Establishing guidance for assessment of recreation is likely to require further work that is beyond what is achievable in this project.

4.27. The fourth point to draw from Table 6 is that there are some impacts of transport projects that generate benefits in terms of ecosystem services, by making it possible for people to gain more from the services that are available. Cycling lanes are a case in point: they improve the quality of the journey for the user. This is currently included in WebTAG, but is not monetised. In the ESS framework it would be linked to the aesthetic value of an ecosystem. This can be done, and

monetary values in terms of willingness to pay could be applied to that component. There could also be other ESS benefits from transport projects, such a better access and therefore greater use of national parks which would result in recreation benefits. These links need to be taken into account when conducting an ESS based assessment. Positive ESS impacts from transport projects would also arise, for example, when compensatory reforestation is undertaken.

4.28. In view of the above, the WebTAG framework can still be used but will need to be modified and added to, to take account of these additional factors relating to ESS. Further, it may be more appropriate to consider a more comprehensive review of the presentation of WebTAG assessment outputs to align them with the Green Book's ESS requirements.

4.29. Sections 5, 6 and 7 return to these issues and the extent to which further assessment of ESS could be considered for inclusion at this first stage of DfT's ESS process.

ESS and the Environmental Capital Approach

4.30. The ESS approach has a number of features that are similar to the environmental capital approach currently used in WebTAG. This section provides a comparison of the two methods.

4.31. Fundamentally, both approaches seek to make a link between the environment and human welfare. Broadly speaking the ESS approach is a more formal and comprehensive way of tracking the services (and resulting benefits) provided by different types of environmental capital, but the two approaches can be linked, as shown in Table 6.

4.32. The environmental capital approach takes the view that there are various forms of capital made up of a set of environmental resources. These consist of landscape, townscape, heritage, biodiversity and the water environment. A transport project may modify the values derived from these resources and WebTAG provides some guidelines on how to assess these changes in qualitative terms. The notion of capital is not quantitative and the distinction between capital (which is a stock) and the values derived from it (which are a flow) is not formally spelt out. The guidelines show how one can score the effects of a transport intervention on a seven point scale for each impact and then provides advice on how to aggregate these scores (for example a particular option in the transport design is awarded the lowest category if even one environmental resource is ranked in that class and when several resources are slightly impacted the overall impact is one level more severe).

4.33. The ESS approach has a more formal relationship between environmental capital and the services it provides. The capital consists of a set of ecosystems, such as woodlands, lakes, rivers, etc. Each consists of communities of living organisms (plants, animals and microbes) in conjunction with nonliving ones (things like air, water and mineral soil), interacting as a system. The services that are provided by the system are termed ecosystem services, and are defined under four broad categories: provisioning, regulating, cultural and supporting (See Section 3). This categorisation is considered to be more complete than that of WebTAG's environmental capital approach. Further the ways in which the services are derived from the different types of capital have been elaborated on in some detail in the rapidly expanding literature.

4.34. The ESS approach is thus more comprehensive, but has a broader focus than the impacts of transport interventions. WebTAG's environmental capital approach is focused on the resources that are most likely to be impacted by transport projects. These resources may be made up of more than one ESS, so a mapping of the one to the other (ESS to WebTAG) is not simple. This report attempts to make such a cross-tabulation, by seeing which ESS are covered under the environmental capital's resource classification and which ones are not but could be included, while retaining that framework. In principle it should be possible to cover all of the key ESS using the

environmental capital approach, although how effectively this can be done should be the subject of a detailed assessment and comparison exercise.

4.35. There is also an issue of valuation and aggregation. The ESS approach is a mixture of monetary and non-monetary measures, while the environmental capital approach is mainly qualitative with notable non-linearities in the way scores are added. Many of the services provided by different ecosystems in different locations have been valued in money terms. Aggregation of the ESS impacts is done by summing the different values whilst also noting the qualitative impacts. It should be possible to transfer the monetised ESS estimates established within an environmental capital approach framework into the benefit cost analysis (through the AST NPV entry), but still carry out a qualitative assessment for the remainder using the WebTAG guidelines (entered in the qualitative AST entry for the objective). Presentation of a combination of qualitative, quantitative and monetary assessments is consistent with the general approach adopted in WebTAG ASTs for summarising impacts against different objectives; however there are not currently examples of a combined quantitative and qualitative assessment for an individual objective. Careful specification of the coverage of each entry would therefore be needed and process should be tested in some pilot cases prior to any recommendations to update WebTAG to establish the extent to which monetary valuation can be instead of, or need to be as well as, qualitative assessment scores.

4.36. Within WebTAG, but not within the units that use the environmental capital approach, valuation already occurs. Notably an 'in draft' unit (3.16D) establishes the value of undeveloped land in monetary terms in order to pick up a range of 'external' benefits that it provides. These values are closely aligned to the ESS approach and include a range of cultural services such as recreational use, landscape appreciation and habitats for plants and animals. However, these values are relatively crude when compared to the detailed qualitative assessments currently undertaken through the natural capital approach.

5. Synthesis of Valuation Literature

Introduction

5.1. There is a substantial literature valuing ESS.A recent review by leading researchers in the field identified over 320 publications with around 1,350 value estimates[21]. As one would expect, ESS vary by habitat (or biome) and while some studies focus on a particular ESS or set of ESS (e.g. provisioning) in a given habitat, most studies provide an overall estimate for a collection of ESS for the habitat. The de Groot et al. paper identifies ten broad habitats (marine, coral reefs, coastal systems, coastal wetlands, inland wetlands, freshwater (lakes and rivers), tropical forests, temperate forests, woodlands and grasslands) and makes a major effort to separate the values of individual ESS per habitat per year. This study, however, is a global review and gives average global values. Thus it is not possible to apply the figures directly to the United Kingdom. The most detailed assessment carried out in the UK is the National Ecosystem Assessment, which was published in 2010. It included a number of supporting studies that attempted to value combinations of habitats and specific ESS. Some on the other hand value neither of these but focus on species. Table 7 summarises the estimates available from the UK NEA background documentation. The purpose of this section is to review this literature and assess how useful it could be to valuing ESS in the context of transport projects.

Table 7. ESS Covered by Habitat and by Area of Service in UK NEA

Area of Study	ESS Covered	ESS Not Addressed
Woodlands (Habitat) Valatin and Starling, 2010	Wood production, deer hunting, carbon sequestration	Non timber, biodiversity, water flow regulation, soil fertility protection, recreation, non-use cultural services (aesthetics)
Urban Green Space Amenity (Habitat) Perino et al. 2011	Recreation, aesthetics, health, noise, air pollution reduction	Coverage is only for urban residents
Mountains, moorlands and Health (Habitat) Tinch et al. 2010	Livestock, game,	Air quality, water quality, flood risks, wildfire, carbon, cultural heritage, biodiversity.
Farmland Birds & Birds (Species ESS) Dugdale, 2010 Hulme and Siriwardena 2010	Not specified	Not specified
Agricultural Land (Provisioning) Fezzi et al. 2011	All cereals, oil seed rape, root crops, temporary grassland, permanent grassland rough grazing, dairy, beef and sheep.	Fruits, vegetables, biodiversity, cultural services
Recreational Value (Provisioning) Sen et al., 2011	Visits to recreational existing and potential sites	Only looks at this one ESS
Wetlands (Habitat) Morris and Camino, 2011	Covers all areas of ESS that are not marketed	But excludes marketed services such as food biomass
Freshwater (Provisioning) Morris and Camino, 2011	Water quantity and quality	Quality services are cultural and do not cover drinking water treatment
Coastal Margin and Marine (Habitat) Beaumont et al, 2010	Climate regulation, recreation, hazard regulation, food provision	Aesthetics, shipping services

[21] De Groot, R. et al. 2012, Global estimates of the value of ecosystems and their services in monetary units Ecosystem Services, 1, 50-61..

Biodiversity (Provisioning, species ESS) Morland, 2010	Indirect estimates of all services based on expenditure on management	
Climate ((Regulating) Abson et al. 2010	Carbon flows and stocks in woodland and agriculture	
Cultural Services (ESS Group) Mourato et al., 2010	Estimates of amenity values of different broad habitats, educational and health values of green space	

Sources: UK NEA

5.2. The approach in this review has been to focus mainly on the UK NEA valuation reports and background papers, to identify the main results obtained, to evaluate how reliable they are and to see how and what contexts they could be used in a transport project appraisal. In addition some other studies that look at ESS in the context of transport are also reviewed. In each case if the results of the studies are considered suitable some comments are offered on how they can be applied to the appraisal of transport projects and what supplementary work is needed for them to be integrated into the WebTAG approach, filling in the cells in Table 6 where appropriate.

Synthesis review

5.3. The UK NEA assessment shows that the information available is a mixture of values by habitat and by individual ESS, with five of the groups of studies looking at habitats and seven looking at specific services. The synthesis review starts with the main findings of each study and an assessment of how (if at all) it can be used in a transport appraisal context. The main results are presented in Table 8. Table 9 does the same for some additional studies undertaken outside the UK NEA, including the work by Eftec that looks at landscape valuation in a transport context.

5.4. Table 8 summarizes the main findings of the UK NEA exercise and relates it to transport appraisal. The literature is of some potential use to appraising transport projects but there are also a number of limitations. The main findings are the following:

5.5. In several cases the UK NEA assessments provide values of services that can also be obtained using market data on land prices. These prices reflect the present and future flows of services from the land, including (to the extent that people are aware of it) the expected change in services due to climate etc. Since the transport valuations already use such data, which has some limitations but is reliable, it would not be desirable to replace those values with values based on the UK NEA estimates. The latter could, however provide a second calculation in cases where land prices are considered unreliable or based on thin land markets. Market data are available for forest land (timber, game), mountain, moorland and heath habitats (MMH) that are privately owned and values of agricultural land.

5.6. Of course land values do not fully capture all external benefits and in particular a transport project that modifies the ambient environment would change those values. The UK NEA provides some methods for valuing such changes but the Department for Transport already has some estimates for different kinds of undeveloped land, based on a review carried out in 2006 that covers recreational, landscape and some ecological benefits of such land (See Table 9). These values cover a number of the ESS categories, but not all. In particular carbon benefits are not covered and neither are most of the other regulating services. Nevertheless the values are a good guide to the services provided ***on average*** by different kinds of undeveloped land: urban core public space, greenbelt, urban fringe forested land, rural forested land, intensive and extensive agricultural land and wetlands. These values could be updated from the current UK NEA assessment, which provides the basis of a more detailed spatially disaggregated valuation system.

5.7. The UK NEA literature provides some useful valuation functions and it may be possible to use these to update and extend the existing undeveloped land estimates. For example, if the project reduces the available green space in an urban area (study 2), or the share of a ward that is green belt (study 12) or the size of a wetland (study 7) it is possible to estimate the losses of value to users of these areas based on the more recent literature. The valuation functions include the amount of land in the relevant category and yield a marginal value of a unit area. Its application requires the number of households or dwelling units in the relevant area and possibly some other data, but that should be available. The UK NEA studies are more detailed in the specification of local conditions than the DfT's valuation of undeveloped land figures and so should provide more accurate estimates for local land values. It is also important to note that the transport development will have additional impacts on the landscape that are not picked up by such estimates. Nevertheless, they provide at least a good partial valuation.

5.8. There are, however, some valuation functions in the UK NEA literature that are less easy to use. For example estimates of aggregate values of MMH provide only average values per hectare, which may differ considerably from the marginal values. The same applies to the value of recreational sites outside urban areas (study 6). In such cases some further work is needed before the studies can be used for transport appraisal.

5.9. The assessment offers a number of carbon values that are not normally included in project appraisal studies. These include woodlands, wetlands, coastal margin habitats and agricultural ecosystems. Transport projects involving changes in these habitats could make use of these estimates[22].

5.10. There is some duplication of values in the valuation literature that needs to be resolved. For example the UK NEA studies on urban green space (Table 8, study 2) and on cultural services (Table 8, study 12) both cover urban green space and greenbelt land, as does the CCLG study (Table 9, study 5).

5.11. Related to that is the issue of double counting. The ESS estimates often provide figures for a habitat, while the existing WebTAG approach works on environmental resources and if we simply take the ESS values there is a risk of double counting. For example urban green space values are based on stated willingness to pay for these services, which may include some of the benefits of a less noisy environment and one that has cleaner air. These services, however, are valued separately in WebTAG. It is unlikely that the overlap is great but that conjecture should be verified. Another case would be the use of market land values combined with estimates of the external benefits of services such as carbon, soil formation and landscape. In some cases these so-called externalities are reflected in the price of the land; so a feature that prevents erosion and retains soil fertility will result in a higher market value for that land. It would be double counting to include the external costs as an additional item.

5.12. Some of the studies undertaken in the UK NEA provide useful non-monetary indicators that could be used in WebTAG, The studies on birds (studies 4 and 9) are examples of this: they do not provide any monetary benefits but they could be used to estimate possible impacts of transport developments on bird indices, which could inform a non-monetary assessment. This would require some work linking the index to transport flows.

[22] Further data on carbon land values by habitat may be obtainable. Other studies could be reviewed prior to final report submission e.g. Natural England (2007). Carbon Storage by habitat: Review of the evidence of the impacts of management decisions and condition of carbon stores and sources

5.13. Other estimates that could be of use include: water services (changes in quantity and quality of water), and coastal defence values of habitats such as sand dunes etc.

5.14. In most cases the mapping of the ESS studies to the webTAG categories is quite straightforward and Table 8 indicates where the respective ESS values could go. In some cases, such as wetlands and coastal habitats, however, there is an ambiguity. Wetlands are part of the landscape and the ESS could be classified in that column of Table 6. But they are also a source of biodiversity and the services they provide could also come under the biodiversity column. Likewise, for coastal and marine margin habitats they could go under landscape or under biodiversity. This is an issue of classification that is best decided on the basis of which group of specialists working on WebTAG is best equipped to carry out the ESS assessment.

5.15. The UK NEA assessment does not cover all the work carried out related to valuing the environmental impacts of transport projects. Other studies that are potentially important include the EFTEC studies on estimating the landscape impacts of roads, the study by CABI on the economic cost of invasive non-native species and various studies on flood risk and the economic valuation of the costs of flooding. The key points from these are summarized in Table 9. Attention is drawn to the following:

5.16. The EFTEC study on the possible impacts of road development on individual values of a given landscape is a very good start but it is only a start. The selected studies cover only a few landscapes and the results are not all what consistent with prior expectations. Hence it needs more studies before the landscape impacts of transport can be valued in this way. Of course where a project takes out a particular feature of a landscape at least part of the value can be obtained from the previous UK NEA assessments of the marginal value of such features as green space. Combining such studies with those that assess the effects of roads, railways etc. on the landscape itself will need some further work (e.g. it is not clear that the two effects can be added together).

5.17. The work on invasive species is also important in providing data on the sources of damages and on their magnitude. This data needs, however, to be used along with a detailed assessment of the type and number of additional invasive species as a result of a new transport development. This involves the pathway analysis referred to in Figure 1 (Section 4). The pathway starts with the pressure from the drivers in terms of species, which then has to be translated into additional impacts on different sectors (forestry, agriculture, transport itself, infrastructure, health etc.). These are major steps and the effort required should be assessed at a screening stage to ensure it meets the proportionality rule. Only after all that has been can valuation be applied based on data of potential estimates damages or costs of prevention/eradication from studies such as CABI, which identify unit costs for most sectoral impacts.

5.18. The third section in Table 9 deals with flood risk. Floodplains provide a flood protection service and if they are altered that function can be compromised. Some impacts of this kind can be expected as a result of climate change, which will result in increased flood damage. In the case of a transport project, however, any increase in the risk of floods would have to be addressed at the design stage. Hence such costs would be part of the project capital costs and additional valuation of ESS would not be required. In a small number of cases there may be potential beneficial impacts as a result of new transport infrastructure (the flood regime is affected so that water is held back by a road scheme and flooding takes place further upstream over agricultural land, protecting downstream properties.

5.19. Table 9 includes reference to the literature on valuing undeveloped land, which is currently used by DfT in relation to housing development to complement the WebTAG assessment. As already

noted the values included therein cover a number of ESS but they are somewhat out of date. In addition, they are not spatially disaggregated enough to pick up important local differences in values.

5.20. Finally Table 9 refers to work on the link between air quality and forest growth, crop yields and the acidification and eutrophication of water bodies. These are studies establishing such links based on critical thresholds. Although the literature has wide bands of uncertainty and many gaps some impacts can be estimated quantitatively and possibly valued in monetary terms as well. They are only likely to be significant in the case of large transport projects. In addition there are also some studies that have established an uptake of harmful pollutants from grassland and some tree species. If a transport scheme involves the removal of such species or green space there could be negative effects on health or vice versa. The studies carried out show the impacts of fairly large greening schemes on health to be relatively small, so the exercise is only worth undertaking if the expected loss of green space is very large.

Conclusions

5.21. The ESS valuation literature indicates a number of areas where current transport appraisal methods can be strengthened. The following are the main areas that could be introduced with some additional effort.

a) Urban green space under 3 categories: (formal recreational areas in the city, areas on the city edge and general urban green spaces) have unit values in £/HH/Ha./Yr. The functions are given in equations 1 -4 of the Perino, 2011 et al study. Urban green space and green belt values are also provided by Mourato et al, Table 1. Perino et al. claim the overlap is minimal as the Mourato et al. analysis covers all green spaces, while theirs is only for urban space but some work is needed to review these results and see when one is the appropriate and when the other is. In most cases (but not all) estimating the costs of a loss of such space would require data on households and average income (by postcode) but this is available.

b) Values of marginal loss of wetlands can be obtained for England, Scotland, Wales and Northern Ireland in £/Ha./Yr from Table 6 in the Morris and Camino, 2011 study. All that is needed in the number of hectares lost. To this one would want to add a loss of carbon values for peat based wetlands of around £1,200/ha./yr in 2010. Future increases in value go in line with the DECC estimates to 2060 (see e) below).

c) Loss of water quantity requires estimates of the marginal value of raw water but consistent estimates that apply at the local level are not given. Hence any loss of water needs to be valued from additional data that would have to be collected. Values of changes in the quality of water in a water body are given in Morris and Camino, Table 11[23]. If a transport project causes such losses, valuations would require number of kilometres that were affected by the project.

d) Estimates of the value of defence against storm surges and flooding provided by coastal margins and sand dunes are given in £/M. of £/M for different kinds of coastal margin sub-habitats and for sand dunes in England and Wales. These could be used if a transport project involved a loss of some amount of such habitats and are given in Beaumont et al. 2010, Tables 5 and 6.

[23] The table gives we believe the wrong units. They should be £Mn./Km. and not £.

e) Carbon storage values lost as a result of a loss of woodlands, agricultural land and coastal margins are available from Valatin and Starling, 2010; Abson et al, 2010 and Beaumont et al., 2010, respectively. These estimates are for 2010 but Beaumont et al, Table 3 provides unit value in £/Ton C to 2060, which are taken from the DECC carbon values.

f) The UK NEA provides a bird diversity measures for different grid cells in the UK. A detailed assessment as described in the next section could be made to estimate the impact of a transport intervention to the landscape in each area on the diversity index. This would inform the biodiversity measure of the project in a non-monetary way. The relevant reports are Digdale, 2010 and Hulme and Siriwardene, 2010.

g) Likewise a detailed assessment of the impacts of transport projects on invasive species numbers could be carried out and the marginal impact of the increase on damages by sector calculated using the methods described in CABI (2010)

h) Where a transport project increases local ground level ozone concentrations and/or levels of NH3 and nitrogen there is a prima facie case to look at whether the new levels exceed thresholds and cause reductions in crop yields, reduce forest growth, acidify water bodies and cause eutrophication, resulting in lower cultural services and damage especially to marine ecosystems. Such impacts are not likely to be important in most cases of transport projects but they may occur with large schemes and should be screened for. If they are significant some quantification may be desirable. On the other side green spaces can also act as absorbers of harmful pollutants and so any loss of such assets could result in increased concentrations of these pollutants. Some studies have been carried out quantifying these impacts, which tend to be small. So again it would only be necessary to include them in an assessment that involved a loss of a large amount of such space.

5.22. From the above it is clear that the valuation literature does not address all the ESS and in some cases even where there are some aggregate measures, they cannot be used for a transport project appraisal without considerable additional work. The services that fall in this category include: biodiversity (other than birds), amenity values of MMH, values of recreational sites other than those in urban areas and marine habitats. Furthermore it is at present not possible to value all the amenity impacts of transport projects on landscapes, although some progress has been made in developing this capability.

5.23. The use of the valuation literature in the detailed assessment is discussed further in Section 7.

Table 8. Possible Application of UK NEA ESS Studies to Transport

Study	Impacts valued in monetary terms	Relevance to transport projects	Relation to WebTAG
Woodlands Habitats (1)	Supply of timber, deer hunting and carbon sequestration. Estimates of £281/ha are given for 2009. Future years can be worked out from DECC tables. Figure given is average for UK. The sequestration rates expected to fall by 50% in next two decades.	The timber and deer hunting values for any loss of woodland would be captured in land values. Carbon benefits are not captured.	Possible to use CO2 value as entry to the "GHG/fuel and fibre" cell. May need regional variations in sequestration. Account can be taken of future CO2 values and changes in sequestration.
Urban Green Space Amenity (2)	The value of different public spaces in urban areas to residents of the towns. Estimates are made for formal recreational areas in the city and on the city edge, as well as general urban spaces in the city.	Transport projects that reduce such spaces could be valued using the functions given in the report for the 3 kinds of urban space. May be some double counting with AQ and noise benefits, but it is likely to be small. Data needs are quite intensive but feasible.	Converts the recreational value of Townscape into monetary units.
Mountains, moorlands and heath (MMH) (3)	Livestock and game that use these habitats provide services and the value of the inputs of MMH are imputed backward. Estimates given are aggregate values of these services for all MMH in the UK. Changes in values are expected due to climate change and other factors.	Where the areas are private land, present valuation accounts for any loss of such services. If the land is public it may be possible to obtain values per ha. of land, depending on time of loss, location etc. But this needs more information than is given in the report. Issue of marginal vs. average values also needs to be addressed.	Could provide some monetary value to the "biodiversity/food" cell and the "biodiversity/recreation cell".
Farmland Birds (4)	No money values are provided. Detailed 10kmx10km database provides guild richness (sum of the number of species from the seeds and invertebrates guild present at each location) for the UK.	Transport developments involving farmland are likely to change this measure and method could be used to estimate changes. But it would need a link from transport to the indicator.	The data would inform the "biodiversity/wild species diversity" cell.
ESS of Agricultural Land (5)	Values of crops and livestock uses of 2kmx2km grid of all land in the UK, now and in the future under different climate scenarios	Current valuation of lost farmland (and other land) is based on market values, which reflect present and future returns. This analysis offers an alternative valuation of the land.	Could be used as a check to compare discounted values of returns against the price.
Value of Recreational Sites (6)	Provides values of visits to existing and potential sites in the UK.	Valuation function could provide value of a site that will be totally lost but losses of marginal land on nature experience due to a road are not modelled. Identification of potential sites could	Could be used to provide money values to the "landscape/recreation" cell but would need some more analysis.

		be useful for new road/rail developments.	
Wetlands (7)	Value function is defined for inland and coastal wetlands, giving values per site as function of site characteristics. (£/HA./YR). Carbon sequestration benefits are provided for peat bogs, peat-based wetlands and inland marshes (£/HA./YR.).	If a project involves total loss of a site the valuation functions can provide an estimate of loss of services. Partial losses can be valued assuming marginal losses are equal to average.	Could provide data linking "biodiversity" or "landscape" to "food, water supply, recreation, climate regulation and water quality regulation"
Water Services (7)	For quantity of water study uses estimates of the marginal value of raw water. Estimates vary widely according to use and will increase with climate change. For quality of water estimates are provided for changes in quality by river/region from "low" to "medium" to "high". (£/KM/YR.)	Losses of water sources as a result of a road development may be valued using estimates of marginal value of raw water by location and use. If a transport project results in a decline in water quality, estimates based on changes in quality of water may be used.	Links "water" or "landscape" to the cells of "water/water supply and "water/water quality" and provides possible monetary estimates for these.
Coastal Margin & Marine Habitats (8)	Aggregate values provided for the UK as a whole for a wide range of provisioning, regulating and cultural services. Carbon sequestration values given for coastal margin habitats but not for marine ones (£/HA./YR.). Coastal defence values of habitats estimated in terms of costs of replacing them if they disappear. Fishery values are based on catch landed in the UK but recognizing that where this is unsustainable the value will be incorrect.	Carbon and coastal defence values could be used in transport projects that involve loss of habitat.	Provides monetary estimates for the cells: "water/climate regulations" and "water/hazard regulation".
Birds (9)	No money values are provided. Simpson diversity index calculated for range of habitats in the UK	Transport developments are likely to change this index. Method could be used to estimate changes but it would need a link from transport to the indicator.	The data would inform the "biodiversity/wild species diversity" cell.
Climate ESS of Terrestrial Ecosystems(10)	Estimates carbon stocks and flows for different crops and soils in the UK and places monetary values now and in the future based on climate scenarios.	Data could be used to estimate carbon stock and flow changes resulting from land use changes caused by transport project.	Provides monetary estimates for the cells: "GHG/food" and "GHG/fuel and fibre"
Biodiversity (11)	Estimates amount spent on managing biodiversity and claims this is a surrogate for the value.	Difficult to see where it could be used in a transport assessment.	-

Cultural Services (12)	Covers (a) amenity value functions for broad habitats, (b) value of ecological knowledge on earnings, (c) non-use values from legacies to environmental charities and (d) health benefits of access to green space.	Amenity value functions could be applied to homes affected by transport projects where share of green space is reduced in various ways. Items (b) - (d) are not useful without more data.	Provides monetary estimates for "Townscape/recreation" benefits. Overlaps somewhat with study (2)

UK NEA ESS Study References:

(1) Valatin. G. and J. Starling. (2010). UK NEA Economic Analysis Report: Valuation of services from Woodlands

(2) Perino G. et al. (2011). UK NEA Economic Analysis Report: Urban Green Space Amenity

(3) Tinch. D., N. Hanley and N. Beharry-Borg (2010). UK NEA Economic Analysis Report: Mountains Moorlands and Heaths

(4) Dugdale, S. 2010. Report to the Economics Team of the UK National Ecosystem Assessment: Habitat Association Modelling for Farmland Birds

(5) Fezzi, C. et al. (2011). UK NEA Economic Analysis Report: Evaluating provisioning ecosystem service values: a scenario analysis for the United Kingdom

(6) Sen, A. et al. (2011). UK NEA Economic Analysis Report: Economic Assessment of the Recreational Value of Ecosystems in Great Britain

(7) Morris, J and M. Camino (2011). UK NEA Working Paper on Economic Assessment of Freshwater, Wetland and Floodplain Ecosystem Services

(8) Beaumont, N. et al. (2010). National Ecosystem Assessment (NEA): Economic Analysis Coastal Margin and Marine Habitats, Final Report

(9) Hulme, G. and G. Siriwardena (2010). UK National Ecosystems Assessment: Breeding Bird diversity as a function of Land Cover

(10) Abson, D et al. (2010). UK National Ecosystems Assessment: Valuing regulating services (climate regulation) from UK terrestrial ecosystems

(11) Morling, P. et al. (2010). UK National Ecosystems Assessment: Biodiversity.

(12) Mourato, S. et al. (2010). National Ecosystem Assessment (NEA): Economic Analysis of Cultural Services.

Table 9. Other Studies Relevant for Appraisal of Transport Projects

Study	Impacts valued in monetary terms	Relevance to transport projects	Relation to WebTAG
Impacts of Transport on Natural Landscape (1)	Reductions in willingness to pay of households for a given landscape as a result of new HSR, widening single to dual carriageway and other road schemes.	Estimates are for scheme in 7 potential road developments, 6 in lowlands and 1 on moors, hills and dales. Results are credible but limited and the pilot study needs to be followed by a wider survey before the estimates can be used.	Directly applicable to monetising the "Landscape/recreation" and "landscape/aesthetic value" cells.
Economic Cost of Invasive Non-Native Species (2)	Estimates made of damages from INNS to the British economy to agriculture, forestry, aquaculture, tourism & recreation, construction and infrastructure, transport, utilities, biodiversity and human health. Costs of quarantine and research are also provided. Estimates are a mixture of damages and costs of prevention and eradication.	Transport is one of the main methods through which INNS is spread between and within countries. Examples include Coypu for fur farming, American Signal Crayfish for food, Japanese knotweed as garden plants, ballast water of ships, etc. To be useful for transport projects the pathways by which INNS are increased as a result of such a transport project need to be quantified. Marginal values of impacts in terms of additional prevention/ eradication costs or damages can then draw on the literature.	Fits in the column titles "Biodiversity". Damages are then on food, fuel and fibre, hazard regulation, disease and pest regulation.
Flood Control (3) (4)	(3) Estimates of damages from floods to urban and agricultural land are made. (4) Estimates of damages from floods to properties, with damage cost estimates provided for a range of property types at different levels of detail. Costs are applied to a quantitative assessment of flood depth and probability.	If a transport project potentially increases the risk of flooding the modification of the engineering design and/or inclusion of mitigation will generally be included to bring the risk back down to the *ex ante* level. In a small number of cases there may be beneficial effects on flood risk as a result of a transport project. Hence valuation is unlikely to be something that will apply in many cases or be proportionate.	Fits in to the "Water/Hazard Regulation" cell.
Value of Undeveloped Land (5) (6)	Estimates of the external benefits of different kinds of undeveloped land were made for the UK, based on a literature review. Cover mainly recreation, habitats for plants and animals and landscape,	DfT have used these to value landscape and other benefits of undeveloped land for different kinds of urban land, agricultural land rural forested land and wetland areas.	Valuations are fed into the WebTAG assessment as part of the external cost assessment of housing development enabled through infrastructure.
Air quality impacts on crops, forests, water	Ground level ozone concentrations above 40 ppb cause a reduction in growth for forests and yields of crops. The accumulated stomatal flux of ozone above a threshold has similar effects. Acidification	In most cases the impacts are based on exceedence of thresholds. If ex ante levels are below these it is unlikely a transport project will take it above, If we are above the thresholds the	Links air quality to food, fuel and fibre and recreation.

bodies (7) (8) (9)	effects of sulphur and nitrogen on forests and lakes and eutrophication from deposits of NH3 and Nox are established. Positive impacts of plants on AQ have also been established.	impacts could be significant. However there are a lot of uncertainties about the dose response functions.	

Non UK NEA ESS Study References

(1) EFTEC (2007). R105. Valuing Transport's Impact on the Natural Landscape, Phase 1 Draft Progress Report to DfT. EFTEC (2009) R105. Valuing Transport's Impact on the Natural Landscape, Phase 2 Final Report to DfT

(2) CABI (2010). The Economic Cost of Invasive Non-Native Species on Great Britain, Study for DEFRA, the Scottish Government and the Welsh Assembly Government.

(3) Morris, J and M. Camino (2011). UK NEA Working Paper on Economic Assessment of Freshwater, Wetland and Floodplain Ecosystem Services (Although part of the UK NEA papers) this aspect is not addressed in the transport context as an ESS issue.

(4) FHRC (2010). The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques

(5) Department Communities and Local Government (2006). Valuing the external benefits of undeveloped land: main document

(6) Department of Transport (undated). Briefing on Department for Tansport's Value for Money Assessment of Landscape Impacts.

(7) ECOLAS (2007). Valuation of air pollution ecosystem damage, acid rain, zone, nitrogen and biodiversity – final report, European Commission 06/11867/SV.

(8) Tiwary, A., Sinnett, D., Peachey, C., Chalabi, Z., Vardoulakis, S., Fletcher, T., Leonardi, G., Grundy, C., Azapagic, A., Hutchings, T.R. (2009). An integrated tool to assess the role of new planting in PM10 capture and the human health benefits: A case study in London. Environmental Pollution 157, 2645-2653.

(9) Peachey, C.J., Sinnett, D., Wilkinson, M., Morgan, G.W., Freer-Smith, P.H. and Hutchings, T.R. (2009). Deposition and solubility of airborne metals to four plant species grown at varying distances from two heavily trafficked roads in London. *Environmental Pollution* 1–9.

6. A Screening Exercise Framework

Introduction

6.1. In future revisions to WebTAG it may be appropriate to establish a screening exercise for potential ESS impacts so as to improve both the linkages with WebTAG and ESS, as well as the coverage of ESS in WebTAG. This section sets out an overview of some key issues and options for screening, sets out appropriate parameters within which a screening framework should be designed, and then goes on to consider the potential operating structure of a screening framework. Further it includes examples of criteria that could be used in guidance for ESS screening.

6.2. Ultimately the aim of undertaking a screening exercise is to identify potentially significant impacts on ESS that might be taken forward for further more detailed assessment[24]. The purpose of the screening framework is to provide a generic framework that could be adopted into WebTAG and applied to transport projects at an upfront screening stage.

Screening issues and options

6.3. There are a number of broad issues that should be considered when making decisions on how to incorporate a screening exercise into WebTAG, which relate both to the screening exercise itself and its relationship with other WebTAG processes.

Issues

6.4. **Consistency of language**: Discussion with WebTAG users identified concerns about the ability for an ESS-based screening exercise to be appropriately included within the existing WebTAG structure and methodological approach. Section 4 of this report provides an overview on the extent to which potential ESS are currently included in WebTAG under each of the Environment Objective units – although not necessarily with the use of ecosystem service teminology. Whilst there is relatively wide coverage of ESS under the existing WebTAG process, the ESS framework results in a number of crossovers between WebTAG unit themes. Undertaking a screening exercise using an ESS framework, but then assessing impacts using the existing WebTAG framework may lead to confusion and inconsistency in how ESS impacts are interpreted and taken forward and the extent to which they are assessed. This may also make it harder to achieve acceptance and adoption of the screening exercise.

6.5. **Assessment workload**: Any screening exercise that does not replace or rationalise existing WebTAG guidance will ultimately be an additional step in the assessment process, which would be expected to add to the time and cost of WebTAG-compliant assessments.

6.6. **Relevance**: Without changes to the existing WebTAG Level 3 guidance to link it explicitly to ESS, it is likely that a number of ESS impacts (those already captured through the WebTAG structure) will be assessed regardless of whether the screening exercise identifies them as being potentially significantly impacted. Conversely, without changes to the existing Level 3 guidance potential ESS impacts may be identified through screening for which no Level 3 guidance is available. Discussion with WebTAG users raised concerns about:

[24] As defined in the project scope; the HMT Green Book (Dunn, 2007) and Defra's supporting document (Defra, 2007).

i. the relevance of undertaking screening if potential impacts were identified that could not be assessed in detail – potentially limiting the acceptability of an existing WebTAG-style assessment; and
ii. the relevance of undertaking detailed analysis, undertaken because of screening outcomes, if the detailed analysis outputs do not alter the balance of the assessment and therefore decision making. WebTAG users felt that testing of the differences in overall WebTAG assessment outcomes caused by incorporating wider ESS impacts should be undertaken prior to imposing any requirement to undertake such further assessments of ESS.

6.7. **Usefulness:** To maximise the usefulness of ESS screening, it should be undertaken early enough in the process to help inform option development, and be integrated enough with Level 3 guidance to influence what is assessed and how. This may require changes to Level 2 and Level 3 guidance.

Options

6.8. There are a number of options for how and where within WebTAG a screening exercise could be established. These include:

i. **A standalone, independent ESS screening WebTAG unit**: This option would create a new WebTAG unit focussed on ESS screening.
   - This option provides a good opportunity to ensure full coverage of ESS without being constrained by existing WebTAG structures and approaches.
   - It would enable screening to be done at any stage in the process, increasing its usefulness for both option development, and as a guide for detailed assessment.
   - Without any revisions to Level 2 and Level 3 WebTAG units, complications may arise by trying to operate using two different assessment frameworks: ESS and current WebTAG guidance. This may limit the perceived value of the unit and reduce support for the unit, as well as raise practical complications and potential inconsistencies in interpretation across different WebTAG project assessments. Such issues should not arise if ESS-based revisions to Level 2 and 3 guidance documents are also undertaken.
   - As an additional unit, if not replacing any existing guidance, it would potentially increase the time and cost of a WebTAG-compliant assessment.

ii. **An up-front exercise within existing Level 3 Units**: This option would see independent screening exercises established at the beginning of each relevant WebTAG Level 3 unit.
   - This option would start to overcome language inconsistencies by tailoring each ESS to its most relevant WebTAG unit. However this may lose some of the holistic nature of the ecosystem based approach to assessment. An ESS could be considered under multiple Units if relevant. However this would potentially be an inefficient and potentially ineffective way of assessing ESS impacts. Any division across WebTAG units should be lead by the most appropriate division for undertaking detailed assessment.
   - If referenced as the guidance to follow for ESS impacts in the existing Level 2 options development unit (2.1.2.c), which already refers to the Level 3 documents to guide early option assessments, this could enable its use for both option development and as a guide for detailed assessment.
   - As an additional step within existing assessment processes, it would potentially increase the time and cost of a WebTAG-compliant assessment.

iii. **An amendment to existing Level 2 Unit 2.1.2.c**: This option would revise the issues considered in Table 1.3 in the unit to include all, or a subset of the most relevant, ESS.
   - This would enable ESS to be taken into account early in the process, thereby contributing to the option development phase.
   - Existing 'challenges' listed in Table 1.3 that relate to quality of life i.e. the Environment Objective units, could be amended and rationalised, thereby ensuring a limited increase in assessment time and costs.
   - Unit 2.1.2.c indicates that guidance from Level 3 units and from DMRB should be utilised to guide early assessment. Keeping this format would therefore require detailed Level 3 guidance to be written for ESS. Alternatively specific screening guidance would need to be added to Unit 2.1.2.c to enable consideration of ESS.
   - Without any revisions to Level 3 WebTAG units, complications may arise by trying to operate using two different assessment frameworks: ESS and the current WebTAG.

iv. **An output of existing Level 3 Unit assessments**: This option would utilise the outputs of the detailed assessment to retrospectively screen for ESS impacts
   - This option limits the amount of additional work required to undertake the screening exercise by utilising existing analysis.
   - It enables the extent to which ESS have been considered to be demonstrated, which would provide an explicit link between a current WebTAG assessment and the supplementary Green Book guidance on ESS. However, unless further assessment is then undertaken, it will only enable those ESS currently captured by WebTAG to be considered. In this respect it is simply a re-packaging of existing WebTAG outputs, adding no specific analytical value beyond the ESS branding.
   - This option severely limits the usefulness of the screening exercise as it takes place after the environmental assessments have been undertaken, regardless of the potential significance of ESS impacts. As such, it would act only as a guide for whether further valuation analysis should be undertaken.
   - As the results of screening would only become apparent towards the end of the assessment process, there may be insufficient time to undertake any further assessment, particularly if primary valuation research was deemed to be required. In addition, it would potentially create inefficiencies in the methodological design by removing the ability to design together the environmental and valuation assessment methods.

General principles of screening

Purpose

6.9. The purpose of undertaking screening is to identify potentially significant impacts that require further, more detailed assessment and to provide a guide for the effort that should be expended to assess those impacts. The screening framework should be generic so that it can be adopted consistently into WebTAG and applied to different transport projects at the upfront screening stage.

6.10. The screening framework necessarily seeks to keep consideration of potential ESS impacts simple. Whilst this enables screening to be undertaken early in a project lifetime when limited data and information is available, it also means that the outcomes of a screening assessment are not of sufficient detail and confidence to enable conclusions on potential impacts to be drawn. There are a wide range of potential impact pathways, including many potentially complex interactions

between environmental effects, which further reinforces the danger of trying to use outputs of a screening exercise in any conclusions.

Framework design parameters

6.11. A framework should be designed within guiding parameters[25] (discussed during the inception meeting) so that the screening exercise:

- is largely qualitative;
- is relevant for a variety of different transport projects;
- does not significantly increase the burden of work on specialists using WebTAG;
- retains the existing WebTAG structure and content, and builds on rather than supersedes or makes redundant existing guidance;
- is in line with the general principles and framework suggestions set out in the HMT Green Book.

ESS coverage

6.12. HMT Green Book indicates that early in the process analysts should 'consider widely what costs and benefits may be relevant' for assessment in an impact assessment. This implies that all ESS should be considered for their relevance. Defra (2007) is more explicit, stating that 'the key to this stage [qualitative assessment] is that the assessment considers all ecosystem services. For many of these services, there may be no impacts at all. However, the point of this approach is to ensure a comprehensive view is taken at the start'.

6.13. The ESS classification should be generic in order to allow a consistent framework to be utilised across the wide range of transport projects and project options. This provides both consistency for assessment practitioners, and a consistent framework through which screening results of projects and their options can be compared.

6.14. Because the ecosystem services classification is generic, some ESS will be more relevant for some projects than for others, largely due to differences in project characteristics such as the type of project/option being considered, its scale and geographical location. The screening exercise itself implicitly incorporates this into its process.

Significance, magnitude and importance

6.15. The screening scoring mechanism should be linked, at least in part, to that suggested in the HMT Green Book which seeks to identify the likely significance of potential positive or negative impacts. Beyond a distinction between not significant and 'significant', the Green Book provides no definition of what a significant impact looks like.

6.16. Ultimately what constitutes a significant impact will vary across project types, scales and locations and at the screening stage will be determined with the use of professional judgement. However some further guidance can be provided. The significance term is already used in the WebTAG Units that use the Environmental Capital Approach, where it is typically taken to be a function of the magnitude of the environmental impact and the importance of the environmental attribute being considered. This is in keeping with the basic 'impact-pathway' approach identified in the Green Book and Defra (2007) in that it allows both consideration of the magnitude of the effect of the driver of change, as well as consideration of the importance of that impact from an anthropogenic perspective.

[25] As discussed during the inception meeting

6.17. A logical option therefore is that the screening framework keeps this distinction, and considers the importance of the ESS potentially affected, as well as the magnitude of the potential impact where:

- Magnitude encompasses an understanding of the environmental effect on the ESS, based on the drivers of change generated by the transport project.
- Importance acts as a proxy for the relative value of the ESS. The term 'value' is intentionally avoided to remove any confusion with the term as it is used in the existing 'natural capital approach' WebTAG guidance, as well as to make it distinct from the final process of undertaking actual monetary valuation.

Data requirements

6.18. As an up-front exercise in any assessment process, the screening exercise should utilise information that is readily available, either from existing evidence or with the use of professional judgement (Defra, 2007). As such, it is possible to undertake screening without the need for information from other forms of assessment, such as an EIA, which are often not available in the early stages of project formation.

Example of an independent screening framework

6.19. This section outlines the steps involved in a potential ESS screening framework that could be considered within WebTAG.

A four step process

6.20. The screening framework is made up of a 4-step assessment process that is closely aligned to the 'methodology for assessing plans; provided in each Natural Capital Approach Environment Unit:

- Step 1: establish the type and magnitude of the environmental impact on the ESS
- Step 2: establish the importance of the ESS
- Step 3: calculate the order of significance of the impact using the above
- Step 4: present the outputs of the screening exercise

Step 1: Establish the magnitude of the impact on the ecosystem service

6.21. For each ecosystem service, consider the set of guidance questions/issues, in order to establish the magnitude of the impact on the ESS on a scale of low to high.

6.22. The magnitude refers to the magnitude of the environmental effect, which is a measure of how much the transport driver of change impacts on the ecosystem. This requires working through the Impact Pathway approach (Figure 1) in as detailed a manner as the data allow, concentrating on a small number of the likely relevant primary factors affecting the driver of change. At a screening stage only a limited consideration is expected to be possible due to the availability of information on both the transport project and the environmental effect.

Step 2: Establish the importance of the ecosystem service

6.23. For each ESS, consider the set of guidance questions/issues, in order to establish the importance to humans of the ecosystem service affected on a scale of low to high.

6.24. Importance refers to the importance of the ESS to humans. This requires understanding what the flow of benefits is from the ESS being considered. As for 'magnitude', the ability to consider this at screening stage is limited.

6.25. For certain combinations of ESS impacts and habitats it may be possible to use the generic table of ESS importance by habitat type from the UK NEA (this table is recreated in Section 4 of this

report). This provides a simple look-up table that can provide an indication of the likely importance of the ESS, and could be simplified to a 3-point low-medium-high scale. However, the table considers importance at a UK scale and therefore does not allow for regional and local variations to be considered, including the local baseline condition. As such, in some instances it may be more appropriate to consider a small number of likely relevant factors affecting the importance of the ESS at the appropriate scale.

Step 3: Calculate the order of significance of the impact

6.26. For each ecosystem service, apply the importance and magnitude scores to the order of significance matrix set out in Table 10.

Table 10. Order of Significance Matrix

		Importance		
		1 – low	**2 – moderate**	**3 – high**
Magnitude	**1 – low**	0	0	-/+
	2 – moderate	0	-/+	--/++
	3 – high	-/+	--/++	--/++

Step 4: Reporting

6.27. A basic template for reporting the outputs of the screening exercise is suggested in order to ensure consistency across WebTAG units and allow core supporting information to be captured. Table 11 sets out the template:

Table 11. Screening Exercise Reporting Template

Ecosystem Service	Impact	Supporting qualitative information
Name of ESS	Score: +/-	Importance & Magnitude score and a qualitative description of impact and any other relevant information

Significance, magnitude and importance: impact criteria options

6.28. The example set out above utilises a 3-point scale for assessing the impact on magnitude and the impact on importance. This is purposefully a simpler scoring system than that used in Units 3.3.10 and 3.3.11 – where a similar approach is adopted[26] – in order to reflect the simplified nature of assessment at the screening stage.

[26] The two units use a similar style matrix to that shown in Table 9; although the scoring system is not consistent across the two units:

- Unit 3.3.10 Biodiversity
  - Magnitude: positive, neutral, minor negative, intermediate negative, major negative
  - Value: low, medium, high, very high
- Unit 3.3.11 Water
  - Magnitude: negligible, minor, moderate, major (for positive and negative)
  - Value: low, medium, high, very high

Factors to determine magnitude and importance: examples

6.29. If detailed Level 3 guidance is established for ESS assessment, following an impact pathway approach, then, depending on its form, screening guidance may be able to state that a qualitative, more proportionate interpretation of Level 3 guidance should be used for screening – as is the current WebTAG approach under Unit 2.1.2.c. However, it may be necessary or more appropriate to include specific guidance on undertaking ESS screening, in the form of specific questions, key factors or thresholds. This section provides examples of key questions/factors that could be included in such guidance – however any examples provided should be the subject of further research and testing prior to inclusion in any guidance. This section looks at five ESS impacts that have been identified (in Sections 5 and 7) as having appropriate valuation literature that could be used for further detailed assessments of impacts. These are:

- Impact on cultural ecosystem services as a result of changes in green space availability;
- Impacts on climate regulation as a result of changes in carbon sequestration;
- Impact on water quality regulation;
- Impacts on a bundled set of ecosystem services as a result of effects to wetland areas;
- Impacts on a bundled set of ecosystem services as a result of effects to coastal areas.

Climate Regulation – Carbon Sequestration

6.30. It is likely to be most appropriate that this impact has links with the Biodiversity Unit. Possible considerations for the screening framework are set out below.

Factors affecting magnitude

6.31. The driver of change for impacts on carbon sequestration is land use change, including degradation. The area of land use changed is the fundamental factor that affects the magnitude of the impact. It is therefore anticipated that this would act as the sole indicator of 'magnitude' in a screening exercise. There are no pre-defined categories for what could be considered to be a large area or a small area.

6.32. It may be appropriate to assess the magnitude based on the nature of the project being undertaken, including a simple 3 point scale: no/insignificant land use change expected as project not expected to require new infrastructure; moderate land use change (including partial degradation) as project expected to include localised infrastructure construction; high land use change (including degradation) as project expected to include major new infrastructure.

Factors affecting importance

6.33. For this impact, importance is linked to the net volume of carbon that is sequestered by different habitat types. As the impact of CO_2 is typically considered at a national/global scale, local level factors are not a consideration. Therefore it is anticipated that 'habitat type affected' would be the sole indicator of importance. The condition of the habitat is likely to influence its carbon sequestration rate however data is unlikely to be able to take differences in habitat condition into account. The UK NEA provides a simple overview of the contribution of different habitats to carbon regulation, which includes consideration of the function of carbon sequestration. Interpretation allows a simple split to be made between those with a positive effect (net stores) and those with a negative effect (net emitters), aligned with their relative importance.

- Positive, high importance: MMH, semi-natural grassland (acid), woodlands, coastal margins, freshwaters (excluding rivers)
- Positive, moderate importance: semi-natural grassland (neutral)
- Negative, high importance: enclosed farmland, urban,

- Negative, moderate importance: semi-natural grasslands (farmed),

Cultural Services (bundled) – Urban Green Spaces

6.34. It is likely to be most appropriate that this impact has links with the Townscape Unit 3.3.8, however links could also be made with the landscape and biodiversity units. Possible considerations for the screening framework are set out below.

Factors affecting magnitude

6.35. The driver of change could be either land use change or changes in traffic flows. However, the limitations of the literature available for detailed ES valuation mean that only effects through land use change are likely to be able to be considered. The magnitude of land use change effects on green space can be considered in terms of the degree to which the feature is altered by the driver of change. An initial distinction would be expected to be between no/insignificant loss of green space; a partial loss of green space or a reduction in its functionality; and the complete loss of a functional area of green space.

Factors affecting importance

6.36. Key factors that affect the importance of green space include the catchment population of users of that green space, and the availability of substitutes.

6.37. There is no set hierarchical classification of green spaces, although some urban areas e.g. London do have some classification systems. Given this, it is not possible to establish a generic classification of the importance of an area of urban green space based on its type (and therefore catchment).

6.38. A simple indicator of the relative importance of urban green space can be derived from the total amount of green space within an area (e.g. a district or borough) and the total population of that area. Again there are no pre-defined benchmarks on what area per person is considered to be sufficient or deficient. As such it may be more appropriate to allow the importance of any green space provision to be determined based on a qualitative consideration of the green space provision within the area surrounding the project.

6.39. A simpler generic indicator would be to consider the nature of the area being considered – city centres are typically the most densely populated, are the furthest from non-urban green space and are often the most constrained in terms of being able to provide green space. As such a simple distinction could be made between city centres and outer urban areas. This could be combined with a definition of the size of an urban area e.g. using ONS urban-rural classifications.

Water Quality Regulation

6.40. It is likely to be most appropriate that this impact is linked to the WebTAG Water Unit 3.3.11. Possible considerations for the screening framework are set out below.

Factors affecting magnitude

6.41. The driver of change could occur through either land use change or changes in vehicle flows/speeds/composition.

6.42. Where the driver of change is changes in vehicle flows/speeds/composition, the key considerations are what is the change in (or absolute) traffic density and is it likely to affect surface or groundwater quality (through pollution runoff). Annual average daily traffic (AADT) could be

estimated, or may be available from transport modelling (depending on the project stage). Indicative traffic bands to use to understand the magnitude of impact could be <50,000, 50,000-100,000, and >100,000 AADT (further research should be undertaken to explore appropriate bandings).

6.43. Where the driver of change is land use change, key considerations relate both to impacts on watercourses and to groundwater. For watercourses, key issues that could be considered at a screening stage are whether diversions are required for watercourses and what length of channel may be lost due to straightening. For groundwater, the key issue that could be considered is whether groundworks associated with infrastructure construction are likely to affect the water table. For both of these issues (watercourses and groundwater) some scheme design information would be required, from which any expected canalisation or straightening (watercourse) or culverting (groundwater) could be identified.

Factors affecting importance

6.44. Understanding the potential importance of a water body in terms of water quality regulation could focus around its role in the transportation and dilution of waste products. Two key considerations are already included in WebTAG: the presence of surface water discharge points; and the contribution of discharges to total river flow.

6.45. Understanding the potential importance of potentially affected groundwater could focus on whether aquifers are present in the study area of the scheme, and whether there are headwaters present that may be affected in their ability to purify.

Multiple Ecosystem Services – Wetlands

6.46. Assessment of impacts on wetlands through a habitat based approach and would involve considering multiple ecosystem services as a bundle. Possible considerations for the screening framework are set out below.

Factors affecting magnitude

6.47. The driver of change for impacts on ecosystem services provided by wetland habitats is land use change. The area of wetland altered is the fundamental factor that affects the magnitude of the impact. It is therefore anticipated that this would act as the sole indicator of ‘magnitude’ in a screening exercise. There are not pre-defined categories for what could be considered to be a large area or a small area. Consideration could be given to whether the area of wetland affected would be large in absolute terms, or relative to the total area of the wetland habitat. Simple scoring categories could include: no/insignificant loss of habitat; a partial loss or degradation of habitat; and the complete loss of an area of habitat.

Factors affecting importance

6.48. The detailed assessment of impacts on wetland ecosystem services includes consideration of a broad bundle of ESS. As such the ability to derive a simple indicator of importance is limited. However wetland habitats (as a broader category including openwaters, wetlands and floodplains) are considered to be of high and very high importance for most of the ESS included in the bundle (based on UK NEA table – see Section 4), for example water quality. It may therefore be appropriate to consider that wetland habitat should always be identified at a screening stage as being of ‘high’ ESS importance.

Multiple Ecosystem Services – Coastal Margins

6.49. Assessment of impacts on coastal margins through a habitat based approach and would involve considering multiple ecosystem services as a bundle. Possible considerations for the screening framework are set out below.

Factors affecting magnitude

6.50. The main driver of change for impacts on ecosystem services provided by coastal margin habitats is land use change. The area of habitat altered is the fundamental factor that affects the magnitude of the impact. It is therefore anticipated that this would act as the sole indicator of 'magnitude' in a screening exercise. There are no pre-defined categories for what could be considered to be a large area or a small area. Consideration could be given to whether the area of habitat affected would be large in absolute terms, or relative to the total area of the affected habitat. Simple scoring categories could include: no/insignificant loss of habitat; a partial loss or degradation of habitat; and the complete loss of an area of habitat.

Factors affecting importance

6.51. The key ESS identified through the literature review that could be considered in the detailed assessment are carbon sequestration, natural hazard regulation (through coastal defence functions) and fishery values. Coastal margins are also of high importance for cultural services such as recreation. The UK NEA identifies that coastal margins are of high importance for the delivery of these ESS (specifically; fish: high; cultural: very high; natural hazard: very high; climate regulation: high). It may therefore be appropriate to consider that coastal margin habitat should always be identified at screening stage as being of 'high' importance.

6.52. Further criteria could be included in relation to fish (presence of a commercial fishery, or identification of the area as a nursery area or habitat typically considered to provide nursery areas); to natural hazard (presence of assets reliant on the coastal defence function of the habitat); for cultural services (popularity of area and number of recreation visitors, availability of substitute sites). However this information (particularly in relation to fish) may not be available at a screening stage.

Provisioning Services – Air Pollution

6.53. Impacts of air pollution on sensitive species/habitats could potentially require linkages with both the WebTAG air quality and biodiversity units. Possible considerations for the screening framework are set out below.

Factors affecting magnitude

6.54. The driver of change for impacts on the ESS is the net change in traffic flows over the affected road network (ARN)[27], combined with the source-receptor pathway distances. At a screening stage estimates of the likely magnitude of traffic flows are made, which provides an indication of whether air pollution impacts may be of relevance. Further information on the ARN and therefore the presence/absence of potentially sensitive species/habitats is only established during the detailed air quality assessment.

Factors affecting importance

[27] Or the equivalent for rail or aviation transport projects.

6.55. For this impact, importance is linked to the type of habitat being affected and its role in providing provisioning services. Therefore it is anticipated that 'habitat type affected' would be the sole indicator of importance. The UK NEA identifies the importance of different habitats for the delivery of provisioning services and the UK NEA table (see Section 4) could be used as a simple look-up table for the likely importance of a particular habitat type.

7. Detailed Assessment: Examples and Recommendations

Introduction

7.1. The screening exercise (see Section 6) will identify those environmental impacts of a transport project that merit a detailed assessment. In Section 5 a number of ESS were identified that could fit into the WebTAG framework. It is not appropriate that all the ones that were considered as capable of quantification or valuation should be valued or quantified in all cases: that is part of what will be determined by the screening exercise, which determines this based on qualitative indicators of magnitude and importance of the potential impact. This section looks at how those changes in ESS that are considered important could be assessed.

An introduction to the detailed assessment framework

7.2. The framework should consist of a number of steps by which a valuation of the environmental impact of a transport project could be made using a value transfer approach. It seeks to link the physical assessment to the WebTAG framework and the monetary assessment to the most recent evidence available in the UK-based literature, principally the UK NEA. Such an approach to monetisation (known as value transfer) is considered to be a 'proportionate and effective use of existing evidence' (Dunn, 2012).

Detailed assessment steps

7.3. The assessment steps will vary according to the impact: In some cases the additional information that is required will be relatively simple. In other cases a more complex impact pathway analysis will be required. In every case, however, the steps involved can be categorized as follows:

a) Defining the scheme
b) Identifying the environmental impact (and magnitude)
c) Quantifying affected population, or other receptor
d) Applying valuation evidence
e) Estimating the cost in terms of loss of ESS
f) Sensitivity analysis and other qualifications
g) Reporting

7.4. The steps are best illustrated by specific examples, based on the valuation literature. The following are elaborated further below:

- A road or rail scheme that takes out a certain amount of public green space in an urban area
- A coastal road or shipping development that destroys a certain amount of wetland
- A coastal development that removes the defence provided by a coastal margin
- An international transport corridor that will increase the risk of invasive species.
- A navigation canal that is opened for shipping, resulting in a decline in water quality

7.5. The above list of examples does not cover all possible areas where additional valuation work can be undertaken as part of a transport appraisal. Not covered are assessments involving flooding

and biodiversity, for example. The examples provide, however, a reasonable idea of the range of data requirements and steps likely to be involved[28].

Example 1: Loss of Urban Green Space

Step (a). A road scheme is expected to acquire some private land in an urban area but also remove 10 ha. of public green space, that is not a formal park within a town of 50,000 that has approximately 0.5 km^2 of green space in a total land area of 4 km^2.

Step (b). The main environmental impact is the loss of amenity to the residents of the town, who use such space for recreation, exercise etc.

Step (c). The affected population is taken as that of the town. It is assumed that non-residents are not affected by this kind of green space loss.

Step (d). Perino et al. (2011) propose the following valuation function per urban household for green space:

$$\text{Marginal Value} = 0.02268\ p2 - 4.53686\ p + 226.843 \qquad (1)$$

Where p is the percentage of green space per square kilometre of urban land. In this case the value of p is taken to be (0.5/4) = 12.5%.

Step (e). To estimate the loss of welfare, equation (1) needs to be integrated over the interval [0.1 -0.125]. The result of doing that gives a value of £5.66 per household in 2010 prices. This is the discounted value of loss of amenity per household due to the loss of amenity. Given the presence of 50,000 households, the total loss is £283,000 in 2010 prices.

Step (f). The above applies only to the present population but is a discounted benefit of present and future services. Hence if projections are available for increases (or decreases) in the population in the future, a correction should be made for such changes in resident numbers. The report does not provide any confidence interval for equation (1)[29] so a formal sensitivity analysis is not possible, but based on the standard errors of other functions for urban space that the authors estimate an interval of +/- 25 per cent would not be unreasonable, giving a loss value interval of [£212,000 – £354,000]. Note that this is much smaller than the value recommended in the Undeveloped Land study currently used by DfT (DCLG, 2006). Of course the actual numbers here depend on a lot of parameters and they could be much larger or smaller. The key point is that the numbers determined through the UK NEA values are based on more local factors than those in the DCLG (2006) study.

The use of this method to value green space raises the question, what is a green space? The Perino et al. study referred to above, and from which the valuation function was taken, uses the term green space rather loosely: it defines such space as formal recreation sites of at least one ha. in size including play parks and gardens and accessible recreation grounds. It is not clear that the space has to have grass or plants to qualify as “green”. This needs to be checked with the authors[30]. But in principle the valuation of any open space that is available for public recreation use could qualify, and the loss due to a transport project could be valued using the approach outlined above.

[28] Please do not take the numerical values literally: they are only intended as examples.
[29] The authors might be approached to get this and provide some more clarification on the equation.
[30] As do a number of details of the studies in the NEA.

Step (g). In writing up the results it is important to note that this approach is not picking up all the landscape impacts of the development, only those reflected in the users of green space. There are other effects on the landscape, such a visual intrusion, that are not included.

Example 2: Loss of wetland

Step (a). A coastal rail line will run through an area that is currently a wetland in Wales. The amount that has to be drained amounts to 300 ha.

Step (b). The wetland provides a wide range of services, including wetland grasses and tourism. In this case it is also a peat land providing energy and soil improvement materials. In addition water flow and water quality regulation, biodiversity and nutrient recycling are other benefits.

Step (c). The affected population includes local visitors, industries that extract peat and the wider community that benefits from the regulating and supporting services.

Step (d). Morris and Camino (2011) (Table 6, Page 15) propose a value range of £644-£992 /ha/yr for wetland ESS in Wales. They claim this covers all "non-marketed" ESS, thus there is no overlap with marketed services such as reeds, peat etc.

Step (e). Applying this value gives a loss ranging between £193,200 and £297,600. Once drained it is assumed that the loss is permanent. Assuming a growth rate of benefits equal to growth in productivity (2%) and applying a declining discount rate as per the Green Book (Annex 6), gives a discounted present value of losses of between £20 and £31 million[31]. In addition if the area is a peat-based wetland it would generate emissions equivalent to 24 t/CO_2e per ha. Based on the DECC CO_2 values to 2060 this amounts to a loss of £636,000 in 2013 and a present value over 200 years using the same discount rate as described above and unit values of CO_2 as given by DECC of £38 million.

Step (f). The main qualification relates to the treatment of carbon emissions generated from drainage against other uses of wetlands. If peat is being produced some carbon emissions would be realised by that process and so it may be appropriate that the drainage should not be debited with the full loss.

The write up should note the uncertainties in the methodology as described in the background papers.

Example 3: Coastal Development that Removes Sand Dunes

Step (a). A marine transport development on a coastline will remove sand dunes in England covering a length of 30 km. These will have to be replaced by a sea wall.

Step (b). In the absence of action the impact would be damage from storm surges and sea level rise in the future. It is assumed that the affected dunes fall into this category.

Step (c). The affected population consists of residents in the area.

Step (d). Beaumont et al. (2010) provide estimates of replacement costs of sea walls in England to replace sand dunes of £1.49 million per km. This estimate was calculated using the linear length of dune systems with a protective function but lacking artificial defence structures.

[31] Taking a 200 year horizon.

Step (e). The total replacement cost for the affected stretch amounts to £44.7 million, with an assumed lifetime of 100 years.

Step (f). It is important to establish that the area being protected by the sand dunes is indeed worth the additional expenditure. This would need a separate calculation. If the area affected turned out to be such that the estimated damages were much less than the replacement cost, then that lower figure should be taken as the relevant estimate and the sea wall not be built.

Example 4: Invasive species

Step (a). A new highway that carries international traffic is expected to increase the presence of invasive species such as Japanese Knotweed, giant hogweed and Asian Longhorn Beetle.

Step (b). These species pose an increased risk to the transport network itself but also to agriculture, housing, construction, utilities and human health. The first step in the impact pathway approach therefore would be to estimate the increase in the number of each of the relevant species that would be generated in the absence of any corrective measures.

Step (c). Quantifying the affected population and other receptors is a major exercise that needs each of the species to be linked to the different sectors that have been identified. This is the second step in the pathway.

Step (d). The valuation of the damage has to look at the different alternatives. The main study identified here (Cabi, 2010), considers each of the sectors and identifies a combination of preventive measures as one of the components of the cost. In addition a residual cost is included to account for the damages that have not been avoided by the preventive measures taken. For each sector one has to consider both elements of the cost, but taking account of the fact that the impact is marginal – i.e. it is on top of what is already present.

Step (e). The various assumptions needed to make the assessment will involve a number of uncertainties that are dealt with through a sensitivity analysis.

Step (f). Clearly the analysis will involve a number of additional steps that are not addressed in the literature and these should be spelt out in the write up. It is also evident that such a major effort will only be justified in the case where the screening exercise shows that this problem is likely to be significant.

Example 5: Widening a section of a river for navigation

Step (a). The widening of a section of a river and building of a marina will increase the traffic on it causing a decline in the quality of the water. The section is part of a river in the South West of the UK, which currently is classified as having high water quality.

Step (b). In the absence of additional measures, emissions of air pollutants and the discharge of waste illegally into the river will impact on its water quality. This has an impact on biodiversity (in terms of fish and other aquatic life), aesthetic quality (viewing, clarity, smell, insects) and recreation (suitability for relaxing, in stream and near stream activities). It is estimated that water quality will decline from high to medium for a stretch of 5 kilometres.

Step (c).The affected population is the group of users of the affected stretch of the canal; uses include walking along the bank, fishing, boating and swimming.

Step (d) Defra and the Environment Agency have identified the increments in water quality required to meet the objectives of the Water Framework Directive (WFD), namely to achieve Good Ecological Quality status, on each length of river and area of lake, based on compliance with chemical, biological and hydro morphological conditions. Estimates of willingness to pay (WTP) for given increments in water quality (from low to moderate, moderate to high) are based on the marginal rates of WTP derived from choice experiment estimates, which provide estimates of this value per household per year. Based on this approach Morris and Camino (2011) estimate that a decline in the quality of a river in the South West of the UK from high to medium reduces value of biodiversity, aesthetics and recreational activities by £11.9 million per km per year. Therefore the total loss, over the 5km of river affected, is £59.5 million per year, or £1.6 billion at a 3 per cent discount rate over 60 years[32].

Step (e). The range based on the WTP values cited in the paper would be between £818 million and £1,545 million.

Step (f). The key to the analysis is the assessment of the change in water quality. This will depend on transport flows but also on how the regulations on use are enforced. The assumptions need to be spelt out and further sensitivity analysis based on these assumptions need to be undertaken.

Overall recommendations on detailed assessment

7.6. The review of the core ESS literature has done two things as far as transport appraisal is concerned. First it has identified some possible additional impacts that can be valued and, second in some cases, it has provided estimates of the unit values. In some cases these values can be used directly for transport appraisal and this report has indicated where that may be possible. The exercise will require some additional data collection but in general that should be feasible. In other cases the additional work that is needed is more substantial. This may be partly analytical and partly involve data collection. Again the report has listed the main areas where this applies. Whether such action is justified or not of course requires the analyst to go through the screening process, which is outlined in Section 6.

7.7. Defra (2007) notes that 'it is important to attempt to assess as many aspects of the ecosystem services as possible, in order that the whole ecosystem is considered'. This advice is valid, but what is possible is circumscribed by data availability. A decision has to be taken, driven by the proportionality factor, on whether or not to collect primary data. In cases where the transport intervention is very large or where the consequent impacts are big and outside the scope of what has been estimated in existing studies, a primary valuation may be required. This would apply, for example, when an ecosystem will be subject to a major disruption or when the effects of the transport project take a form that changes the system in ways that have not been previously studied. One has to bear in mind that primary valuation studies can be costly and time consuming so this is something that should be undertaken only when it is proportionate and when the policy context demands it.

7.8. The use of monetary values for some but not all the impacts on ESS is not something new. Within WebTAG some environmental impacts are valued in monetary terms and others in qualitative terms. The important point is that those impacts treated qualitatively should not be relegated to a footnote. They can be very important and they should feature in the final report of the environmental assessment on a par with the monetary ones.

[32] The published study quotes a value of £7.7 per km per year, which is clearly wrong. We have assumed that the authors have forgotten to insert the million, but that needs to be verified.

7.9. The next steps involved in “mainstreaming” ESS valuation into transport appraisal are the following:

- Carry out a pilot analysis using data from past appraisal studies to test the significance, robustness and other practical difficulties in applying the easier ESS values that can be transferred. These include: carbon sequestration, urban green spaces, green belts and recreational areas, wetlands, changes in water quality and coastal habitats.
- Continue with the research linking transport interventions to landscape and other impacts, biodiversity, including links to indices such as bird diversity and guild richness.
- Use the ESS literature as a basis for further developing measures of impacts of transport on water quantity, national or regional recreational sites, flooding and introduction of invasive species. This needs some more analytical work as well as an identification of the relevant databases.

8. Conclusions and Recommendations

8.1. This section sets out the headline conclusions of the project in terms of the scope for including the ESS assessment approach in WebTAG, and the appropriateness of a screening and detailed assessment of ESS impacts. Any recommendations to include ESS in WebTAG are to be considered a first step. They should be proportionate to the need and reasonable for the WebTAG user community. Consequently, our conclusions consider the extent to which WebTAG users themselves are likely to be able to take forward any future consideration of ESS, and the extent to which the existing literature will allow detailed assessment and monetisation of ESS impacts to be undertaken through the use of generic guidance.

8.2. WebTAG users have a varied depth of understanding of the concept of ESS and the definitions of individual ESS. As such, the scope for including ESS should be treated with caution for this 'first step'. Similarly, where ESS are to be considered, an explanation of the meaning of that ESS should be included to ensure consistent interpretation by WebTAG users.

8.3. The ESS approach has a more formal relationship between environmental capital and the services it provides than WebTAG's environmental capital approach. This ESS categorisation is considered to be more complete than that of the environmental capital approach and therefore provide a more comprehensive approach.

8.4. There are a significant number of transport project ESS impact pathways that can be identified, some of which are included in WebTAG and some of which are not. Further work (potentially through a series of test cases) is required to establish the extent to which those that are missing or only partially considered may add value to understanding the business case of a transport project. In turn, the inclusion and level of detail of any additional WebTAG guidance should be proportionate to the impact significance. It has not been possible to undertake test cases within this project. Therefore no guidance-related recommendations are made at this stage, and it is suggested that no significant guidance revisions are taken forward until after such testing and subsequent development has been carried out. **Guidance development should be undertaken over an extended period in partnership with WebTAG users in order to engender support for any subsequent WebTAG revisions**.

8.5. Given the ESS coverage of the existing WebTAG guidance, as an initial step, **the Environment Objective (Unit 3.3.1) and the Natural Capital Approach (Unit 3.3.6) documents should be updated to demonstrate the cross-over with the ESS approach and linkages and coverage of ESS by WebTAG units**. This will raise awareness of the ESS approach amongst WebTAG users, potentially allowing early adoption of relevant ESS language, and will demonstrate that WebTAG already has a level of compliance with the supplementary Green Book guidance document 'Accounting for environmental impacts', despite not using an ESS framework.

8.6. A screening exercise would provide an approach for an initial assessment of the extent to which a transport project might impact on the range of ESS, based on relatively limited data and implied input requirements. There are a number of different ways that such an exercise could be incorporated into WebTAG (see Section 6). The most appropriate option depends on the nature of the wider revisions currently being undertaken in WebTAG, and whether revisions can be made to establish detailed ESS guidance. Existing guidance for Early Option Assessment (Unit 2.1.2.c) indicates a proportionate use of the detailed assessment guidance. A similar approach could be taken for ESS screening once the detailed guidance has been revised to explicitly incorporate ESS. However, as it is unlikely that detailed guidance is developed incrementally this may not be

appropriate. **The simplest and most flexible way to include a screening exercise is likely to be as a standalone unit**.

8.7. Identifying at screening stage potentially significant impacts for which no detailed guidance is provided on how and to what extent detailed assessment should be undertaken may result in differences in approaches taken, opening up potential inconsistencies in and criticism of the WebTAG assessment outcomes. However it is not expected that detailed generic guidance could be devised for all ESS impacts, let alone produced in time to be included at the same time as screening guidance. There is therefore a trade off between coverage of ESS and the ability to provide detailed guidance. It may be appropriate to consider providing less detailed guidance than is traditionally provided in WebTAG Level 3 units to ensure that potentially significant impacts are not overlooked due to a lack of more detailed generic guidance.

8.8. It should be possible to cover all ESS within the existing WebTAG structure. A number of ESS are already considered, at least in part, through WebTAG assessments (see Table 6). Detailed assessment and valuation of ESS impacts could be woven into the WebTAG structure rather than requested as an additional piece of assessment and reporting. However the greater the depth and coverage of detailed ESS assessment, the more likely that a broader overhaul of the WebTAG environment units structure may be appropriate.

8.9. **There will always be gaps in ESS impact coverage**, where there is insufficient evidence to demonstrate the impact, or in particular insufficient evidence to establish a monetary valuation of the impact. It has not been possible within the timeframe of this project to undertake any research or testing that would allow conclusions to be drawn on the extent to which those ESS already considered in WebTAG cover the full value of ESS impacts.

8.10. Detailed assessment and valuation of ESS impacts utilising the existing literature base may be possible for a subset of ESS impacts. However **further research and testing is required on each ESS impact before it is possible to understand the potential significance of each to the business case**. This should be established as a priority under the next WebTAG update programme. It will ensure the level of analysis advised is proportionate and the associated guidance comprehensive. For example, there are a range of sources of habitat-based carbon sequestration rate data. This should be subject to a full literature review[33], and data analysed to establish a comprehensive dataset(s) at an appropriate level of detail and disaggregation that could be applied to both land-take and vegetation planting by transport projects. Testing should be carried out to establish the rates and scales at which such impacts become of relevance to the outputs of a WebTAG assessment – compared to carbon emissions by vehicles and embodied carbon in infrastructure, there may be a limited case for analysis of carbon sequestration in the majority of transport projects. This evidence can then be used to establish specific threshold criteria for a screening exercise and to develop detailed guidance.

8.11. A number of ESS were identified for which the core valuation literature provides the potential for early inclusion into WebTAG:

- **Carbon sequestration**: carbon emissions from transport vehicles are already monetised in WebTAG, and there is research currently being carried out into valuing embodied carbon. Including changes in carbon emission as a result of changes in land use and habitat would enable another important source of carbon emissions to be monetised through WebTAG. The UK NEA provides some headline data on habitat carbon sequestration rates. A review could be undertaken to establish typical rates for habitat

[33] Within the timeframes of this study it was only feasible to review the headline literature, such as the UKNEA supporting papers.

change and degradation of most relevance to transport projects, including beneficial impacts associated with landscaping. Testing should be undertaken to ensure inclusion of such carbon values are proportionate.

- **Urban green spaces, green belts and recreational areas**: amenity values of undeveloped land are already included in WebTAG, but only in relation to housing development. There is the potential to expand such valuation to the more direct effects of transport projects. The UK NEA assessment (Mourato *et* al, 2010; Perino et al., 2010) provides the basis for updating the DCLG (2006) study with a more detailed spatially disaggregated valuation system, which would provide a basis for bringing local parameters into the valuation process (which would be in keeping with the existing detailed qualitative assessments). A study could be undertaken to build on this work to establish an improved system for WebTAG. Amenity values are relevant to a number of WebTAG units, as such a standalone, additional valuation unit could be considered.

8.12. Other ESS which could lend themselves to early inclusion through use of the core valuation literature:

- Wetlands;
- Changes in water quality;
- Coastal habitats.

8.13. Other ESS impacts which could merit further/continued research include:

- Building on the research undertaken by Eftec (2010) that linked transport interventions to landscape;
- Further analytical work and identification of appropriate databases from the available literature to develop measures of impacts of transport on water quantity, national or regional recreational sites, flooding and introduction of invasive species.

8.14. One of the advantages of the ESS approach is the ability to apply it at a spatially disaggregated level and the UK NEA has made a major start in that direction. Using this body of work allows the impacts of transport projects to be evaluated at a local scale and for any monetary values to reflect local conditions. In this report we have shown how some of the results can be applied in this fashion. There is on-going work to provide a GIS-based tool that would link the values of ESS for different habitats on a digitised map of the UK and make local applications easier and even more accurate. **Modifications to WebTAG should allow for the possibility to make use of GIS-based tool developments that enable more locally specific values to be utilised**. Notably, as WebTAG assessments are relatively detailed, it would not be appropriate to apply values that are overly generic at the end of it, as this would potentially mask the local variations between project options and projects that are currently picked up through the qualitative assessments.

8.15. Where ESS impacts could be valued for an individual habitat e.g. wetlands, it is considered appropriate that such a **habitat based assessments of bundled ESS should only be included where the potential impacts are significant or that habitat is the primary habitat affected**. This is because there is a risk that including impacts for only one habitat where many are affected will provide only a partial picture of impacts which could be misleading, particularly once assessment results are summarised. Further, the bundled nature of habitat-based ESS valuations means that there may be overlap, but not linkages, with the qualitative WebTAG environment assessments.

8.16. **It is unlikely to be possible to estimate all the economic values associated with changes in environmental/ecosystem services effects. This should not however be used as a reason not to value those changes for which it is possible**. Assessments could be presented as a

combination of valued and qualitative impacts, although this would require care, which would be in keeping with the approach that is currently taken in the development of WebTAG guidance.

8.17. **Where there is no relevant valuation study available in the existing literature that can be used to provide generic values in WebTAG and/or the cost-benefit analysis is seen to depend significantly on the scale of the environmental/ecosystem services effects, undertaking bespoke value transfer or a primary valuation study may be justified**. This may be appropriate for transport projects of particular significance, or with particularly important environmental/ESS effects. Primary valuation studies can be costly and time consuming so it is something that should be undertaken only when it is proportionate and when the policy context demands it. Advice could be sought from Defra, DfT and/or ESS experts on when this is the case.

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