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Valuation of Landscape Impacts of Transport Interventions & Mitigations Using an Ecosystem Services Approach

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Abbreviations

AST	Appraisal summary table
BBOP	Business Biodiversity Offset Programme
BEIS	Department for Business, Energy and Industrial Strategy
CBA	Cost Benefit Analysis
CEH	Centre for Ecology and Hydrology
DCLG	Department for Communities and Local Government
DfT	Department for Transport
CEP	Collingwood Environmental Planning
EIA	Environmental Impact Assessment
ELC	European Landscape Convention
EVL	Environmental Value Look-up
FCERM	Flood and coastal erosion risk management
GIS	Geographical Information Systems
GWME	Great Western Mainline Electrification
IMR	Impact Mitigation Regulation
LBAP	Local Biodiversity Action Partnership
LCA	Landscape Character Assessment
LU	London Underground
NC	Natural Capital
NCC	Natural Capital Committee
NERC	Natural Environment and Rural Communities
NIC	National Infrastructure Committee
ODPM	Office of the Deputy Prime Minister
OLE	Overhead line electrification
ONS	Office for National Statistics
ORVal	Outdoor Recreation Valuation tool
PES	Payment for ecosystem services
PV	Present value
QALY	Quality-Adjusted Life Years
RP	Revealed preference
RSPB	Royal Society for the Protection of Birds
SP	Stated preference
STPR	Standard time preference rate
TEV	Total Economic Value
TfL	Transport for London
UKNEA	United Kingdom Natural Ecosystem Assessment
WTA	Willingness to accept
WTP	Willingness to pay
VfM	Value for money

Executive Summary

This is the final report of the project "Valuation of Landscape Impacts of Transport Interventions & Mitigations Using an Ecosystem Services Approach". The aim of the project is to inform the methodology used by the Department for Transport (DfT) to value landscape impacts in the Landscape topic in Chapter 6 of the Government's online Transport Analysis Guidance (WebTAG): 'Environmental Impact Appraisal (TAG Unit A3)'. It examines the appraisal of the monetary value of landscape impacts using supplementary value for money (VfM) guidance.

The project has reviewed the current qualitative/quantitative and supplementary monetary approaches to appraising landscape impacts of transport schemes. The project has considered how to develop monetary values for landscape impacts, based on value transfer approaches. The aim was to identify suitable monetary valuation evidence that can be transferred from the context in which it was developed, to a new situation (e.g. new transport schemes).

The project also compared the use of ecosystem services approach with new value estimates and the approach in the supplementary guidance using three case studies of transport infrastructure schemes. The case studies gave insights into the ways impacts could be quantified and valued, covering both the impacts of transport schemes and of associated mitigation measures. Finally, the project reviewed the ecosystem service markets in the UK to inform how these can support mitigation approaches for transport schemes.

A key conclusion is that the current monetary values in the supplementary VfM guidance are no longer fit for purpose. An improved approach, although still with weaknesses, would be to value ecosystem services separately. Conclusions from the project are summarised here against the project objectives:

Objective	Outputs
Define landscape in terms of natural capital and consider how ecosystem services associated with 'landscape' can be identified. Recommend whether and how land should be categorised, when conducting transport appraisals using an ecosystem services approach.	Given the coverage of some benefits in other parts of WebTAG appraisal, there are six ecosystem services to capture if monetary landscape values are to be updated: i.e. recreation; landscape visual amenity; air quality; noise; local climate regulation; and carbon sequestration.
Develop the methodology to value landscape impacts of transport interventions, including where relevant associated mitigation activities.	The method to value ecosystem service impacts separately can be based on either the area of habitat destroyed or the viewshed of the scheme (which is already identified elsewhere in appraisal), as relevant to each service.
Using this approach, to recommend monetary values that could be used in transport appraisals.	Valuation approaches are proposed for valuation of recreation; air quality; and carbon sequestration. Landscape Visual Amenity requires primary valuation. Noise and local climate regulation are considered less significant, but evidence should be kept under review.
Suggest how the methodology and the proposed values can be incorporated into the Department for Transport's appraisal guidance (WebTAG) on landscape with a view to including landscape values in BCRs for transport schemes.	Valuation evidence is evolving for Recreation, indicative for air quality and established for carbon sequestration. Good primary valuation research for landscape visual amenity can generate indicative or established results. Noise mitigation values are still indicative, but its physical measurement is uncertain.
Identify data sources and if required carry out a data collection exercise to suggest the values that could be used in transport appraisals.	Suggested valuation approaches and data sources are described in the project technical summary.

Objective	Outputs
Give consideration to potential 'double counting' of impacts covered elsewhere in WebTAG, such as Biodiversity, Townscape, Historical Environment and the Water Environment.	Three of the benefits covered in the supplementary VfM guidance (ecology, cultural heritage and hydrology) are also assessed qualitatively elsewhere in WebTAG (under wildlife; historic environment; and water environment, respectively) leading to a risk they are double-counted.
Provide an update on the latest status of empirical evidence on creating markets for ecosystem services and whether there is any evidence of using this approach in transport appraisals.	The approaches suggested above are also suitable, with some adaptations, to appraising the impacts of mitigation actions for transport schemes. Ecosystem service markets in the UK relate to water quality, carbon sequestration and storage, and biodiversity commitments (such as net gain). They are currently mainly voluntary and tend to be locally defined, but have been used for transport projects, and can be influenced by transport policies on compensation requirements.

Some work may be needed to consolidate existing knowledge into guidance for WebTAG (e.g. on carbon sequestration and storage in different habitats). For recreation, further work is needed to investigate the marginal impact of transport schemes on the recreation value of sites impacted (e.g. within the scheme viewshed). Ongoing work (eftec & CEH in prep) is generating lookup values for air pollutant removal by vegetation by local authority but further modelling could help adapt these values to the impact of transport schemes (e.g. for roadside trees).

The appraisal process would also be improved through a better understanding of the overall impacts of transport schemes on land use (both in terms of scheme footprint and viewshed). This would inform priorities for ecosystem service valuation and 25-year environment plan objectives.

For the visual amenity of landscape, primary valuation work is required. Suitable methods are available: a repeat sales approach, looking at impacts of previous transport infrastructure schemes on property prices; and/or a stated preference study - previous pilot studies (eftec et al, 2007 & 2009) successfully tested the latter. Primary valuation research would need to provide results that reflect how values vary with the type of transport scheme, land-use, landscape and groups of people affected, including users (residents, visitors, passers-by) and non-users. Economic valuation (regardless of which method is used) would not capture what landscape professionals regard as the intrinsic value of landscape, so economic valuation would not replace the existing landscape appraisal approaches. However, it would significantly strengthen the evidence base for landscape appraisal.

Technical Summary of Appraisal Recommendations

Key findings:

- Appraisal of transport schemes can be updated by applying an ecosystem services approach to the valuation of the impacts covered by the supplementary value for money (VfM) guidance on landscape.
- The approach in the VfM guidance uses a 'landscape' value that represents a bundle of ecosystem services. This approach is too spatially simplistic, uses outdated evidence and is no longer tenable.
- Landscape impacts are assessed qualitatively in WebTAG, and the bundle of services valued in the VfM guidance under landscape does not include the aesthetic or visual amenity value of landscape. Therefore, it would be clearer if the VfM guidance did not refer to this category as 'landscape', but used an alternative term, or listed each ecosystem service separately.
- Appraisal can be improved through better use of existing information on the physical impacts that is already gathered in other parts of appraisal. For example, GIS viewshed analysis is routinely done in EIA and can be used to assess impacts on ecosystem services, such as the impact of changes in visual amenity on recreation sites.
- There are Government-backed valuation tools (e.g. ORVal), and guidance (e.g. BEIS non-traded price of carbon), that can be applied in a standardised manner, making them cost effective appraisal options.
- Some impacts of transport schemes do not yet have adequate monetary values to use in the UK. Most significantly, the impacts of transport infrastructure on landscape aesthetics / visual amenity requires primary research. This can be done with established techniques, which pilot studies have shown to be feasible.

Recommendations to revise appraisal approaches

Revision of the monetary valuation of a transport scheme's impacts on landscape needs to be considered in the context of qualitative landscape impact assessment. The latter is based on Landscape Character Areas and defines landscape as a combination of natural and man-made features. It attributes intrinsic value to these features, and to their combination in different cultural contexts. Thus, future landscape appraisal in WebTAG should distinguish the intrinsic value of landscapes from the monetary value of the visual amenity of landscape to people.

Natural Capital Committee guidance can be applied in transport scheme appraisal, using broad habitats to define natural capital assets, and assessing the impacts on the ecosystem services from these assets individually.

Three of the benefits from landscape considered in the supplementary guidance (ecology, cultural heritage and hydrology) are also assessed qualitatively elsewhere in WebTAG (under wildlife; historic environment; and water environment, respectively) leading to potential double-counting. This project identifies six benefits that could be valued in monetary terms: recreation; landscape aesthetics / visual quality (with further primary research); air quality; noise; local climate regulation and global climate regulation (carbon). Note that air quality and carbon from vehicle emissions are appraised elsewhere in WebTAG, but the ecosystem services considered here are air quality and

carbon sequestration benefits of land and vegetation. As these are different types of impacts, there is no risk of double-counting but a need for consistency between methods.

Future appraisal using monetary valuation of individual ecosystem services is recommended because transport schemes impact individual services differently and it allows measuring impacts in the best available physical units (e.g. per person, household, or hectare, rather than per-hectare bundles). In identifying the timing and distribution of impacts, the approach can also help inform mitigation options.

Suggested valuation approaches

The physical data used to identify and quantify ecosystem service impacts for valuation can be improved if analysis across the appraisal process is coordinated. For example:

- Land Cover Map is used to identify habitat types impacted;
- GIS is used to identify the viewshed of a proposed scheme, and
- The timing of different impacts (include any lag in mitigation measures taking effect).

The relevant spatial area of impact is different for different services according to their characteristics:

- For Air quality, Noise, Local climate regulation and Global climate regulation (carbon): the impact can be best assessed based on the area and type of habitat (or land use) damaged by the scheme (i.e. built on or removed to accommodate the scheme's footprint).
- For Recreation and Landscape Visual Amenity: impacts can arise some distance either side of the transport project according to its visibility. Appraisals already identify the viewshed of a transport scheme using GIS software, giving the zone of visual influence in the landscape assessment element of WebTAG - this aligns with good practice in landscape appraisal. Once the viewshed has been identified, related data can be generated for the area it covers to input to further analysis

The economic values of services differ with the different types of ecosystems, the context in which they are located (e.g. the size of surrounding human population) and the change being valued. The recommended approaches for valuing ecosystem services to update the current supplementary VfM guidance on landscape values are shown in Table T1. The available evidence on the six priority benefits is variable. Useable values are available for carbon and are being developed for air pollutant removal. Recreation values can also be assessed with existing evidence.

Table T1 also notes the robustness of suggested approaches. As the evidence improves, values for carbon, air pollutant removal and recreation could be integrated into the Appraisal Summary Tables for transport schemes in the short to medium term. Note that it is assumed that the qualitative appraisal of landscape impacts in WebTAG would continue alongside the use of these updated values, at least until primary research into the value of the visual amenity of landscape was completed.

Thresholds to guide appraisal effort can be determined for the lost global climate regulation (future carbon sequestration) value of destroying woodland. At typical sequestration rates for mature UK broadleaved woodland, loss of 1.83ha of woodland has a cost of £10,000, 18.3ha has a cost of £100,000, and so on (over 60 years, discounted at Green Book recommended declining rates).

Table T1. Recommended Valuation Approaches for Ecosystem Services

Service	Spatial area	Threshold[2]	Quantification	Monetary Value	*Robustness* and Type of Value
Climate regulation (carbon)	Area of habitat[1] destroyed by scheme footprint or created through mitigation	Lookup values to calculate the volume & value of carbon sequestration and storage per ha in woodland, saltmarsh and peatland habitats lost	Emissions of stored carbon lost from woodland/ peatland/ saltmarsh, and forgone future sequestration by woodland	BEIS Non-traded cost of Carbon (2013)	*Established* Abatement cost. .
Air Pollutant Removal	Area of woodland or other habitats[1] destroyed by scheme footprint or created through mitigation	Value of air pollutant removal per ha of trees lost (ONS, 2018; and eftec & CEH, in prep)	Lookup values of impact per ha of vegetation by local authority area (eftec & CEH, in prep) NOTE: See addendum on local value of air pollutant removal by vegetation.		*Indicative becoming established*. Health damage costs.
Recreation	Sites destroyed, OR areas within viewshed in which recreation take place (in England and Wales identified through ORVal)	Total value of recreation at major sites lost/ in viewshed, from ORVal	Total value for sites destroyed. For visually affected sites, use expert judgement to estimate the impact of the transport scheme to calculate a proportion of the total number and value of visits that is impacted		*Established for sites destroyed* *Indicative of marginal impact*. Welfare
Landscape aesthetics / visual quality	Viewshed of scheme. Evidence may relate to property type (residential/ commercial/ industrial), or other users/non-users	n/a	Use viewshed, and possibly other approaches (e.g. Swetnam et al 2017), to quantifying landscape impacts	Requires primary research[3]	Tbd
Noise	Integrate role of trees lost in a scheme into the existing appraisal of noise impacts elsewhere in WebTAG to estimate the net change in noise				*Evolving*. Health costs.
Urban cooling	Mainly an urban impact and unclear whether materially affected by a transport scheme				*Evolving* Avoided costs

[1] Habitat areas can be derived from EIA or through GIS analysis using Land Cover Map (CEH, 2017)

[2] Detailed appraisal is recommended if the impacts described are potentially material to scheme viability, choice of options or mitigation measures. This guidance is expected to work alongside expert. judgement, also considering evidence from elsewhere in the appraisal process where relevant.

[3] See research recommendations, below.

Use in appraisal

Appraisal should value the loss of benefits into the future because of loss of habitats due to transport schemes. The time period and the profile of the service values over that time period are separate, but related choices, and should be informed by the EIA. In general, the 60 years Green Book recommendation is acceptable as a time period. Where ecosystem services values do not last 60 years, this will be reflected in the present value calculation. Where significant service values may occur beyond 60 years, this should be flagged in appraisal.

The appraisal should use the Green Book recommended discount rates. The choice between standard and health-related discount rates depends on the type of valuation evidence. The values for some ecosystem services (e.g. air pollutant removal) are based on avoided health impacts, so the health-related discount rate is appropriate. Assumptions to inflate future values to reflect income uprating should be consistent with the wider scheme appraisal.

The approaches suggested for valuing the impacts of a transport scheme are also suitable for appraising the impacts of mitigation actions. This consistent approach will help assess and compare the appropriateness, scale and distribution of the impacts of schemes and mitigation measures. This is particularly important for larger schemes (such as the A14 case study) where the location of mitigation measures may be some distance (several kms) from the location of impacts.

It should be noted that there are subtle differences in valuation methods that should be reflected when bringing the methods together. However, even while valuation approaches remain incomplete, the evidence described will help express the valuation in relevant and sufficiently robust units to help appraise landscape impact and mitigation measures.

Further research

Further work should be undertaken to implement the recommended approaches to valuation of the ecosystem services considered as follows:

- The use of GIS software to calculate the viewshed of a transport scheme should be standardised and linked to the severity of visual impacts given distance from scheme and type of landscape (e.g. extent of existing infrastructure).
- Some work may be needed to consolidate existing knowledge (e.g. on carbon sequestration and storage in different habitats) into guidance for WebTAG on the value of carbon lost as a result of loss of habitats with high carbon storage and/or sequestration (including woodland, peatland and saltmarsh).
- There are other ecosystem services not currently captured in the appraisal of landscape within the supplementary VfM guidance, such as urban cooling and mitigation of light pollution. These are not currently considered significant enough for detailed investigation, mainly because the added impacts of transport schemes on these is expected to be relatively small. However, DfT should monitor developments in evidence on these services (e.g. in work for the UK natural capital accounts).
- The appraisal process would also be improved through a better understanding of the overall impacts of transport schemes on land use. DfT should track the annual impacts of different types of transport schemes (both in terms of scheme footprint and viewshed). This will inform priorities for ecosystem service valuation evidence – allowing it to be tailored to scheme types and habitats. It will also contribute to monitoring of the 25-year environment plan.

Further research is required to develop or improve the valuation of the following ecosystem services:

- For recreation, further work is needed to investigate the marginal impact of transport schemes on the recreation value of sites impacted (e.g. through visual impacts within the scheme viewshed and increased noise).
- Ongoing work (updating Jones et al 2017, in prep) is generating lookup values for air pollutant removal by vegetation by local authority. Further modelling could help tailor these values to the impact of transport schemes (e.g. to understand impacts at a finer spatial scale, such as for roadside trees).
- For the visual amenity of landscape, primary valuation studies are needed using stated preference methods and/or a repeat sales approach. These are described in more detail in the methodology report. Repeat sales measures values for owners/ residents of properties, and stated preference can be targeted to measure values in the rest of the population (i.e. visitors and non-users). Therefore, the two approaches could potentially be used in combination to measure the value of landscape impacts. Any primary valuation research would need to provide results that reflect how the impacts of transport infrastructure on the visual amenity of landscape will differ by type of transport scheme; land-use; landscape (including topography and hence visibility of infrastructure); and by groups affected, including on users (residents, visitors, passers-by) and non-users.

Economic valuation (regardless of which method is used) would not capture what landscape professionals regard as the intrinsic value of landscape, so they would not replace the existing landscape appraisal approaches. However, it would significantly strengthen the evidence base for landscape appraisal.

1.0 Introduction

This is the final report for the project "*Valuation of Landscape Impacts of Transport Interventions & Mitigations Using an Ecosystem Services Approach*" (henceforth "Landscape in WebTAG"). The project looks at the evidence and approach used in Central Government guidance on valuation of landscape impacts in transport project appraisal methods.

Following this introduction, which describes the project objectives and approach, this report covers:

- A discussion of terminology and methods used in appraisal of landscape, natural habitats and ecosystem services (Section 2).
- Types of transport schemes and how their impacts are appraised and mitigated (Section 3). This section also identifies three case studies in which proposed values from this report are tested.
- Section 4 summarises evidence on the environmental impacts of interest to this project, and the evidence gathered from relevant literature (including monetary values).
- Findings from tests applying these values in the three case studies are provided in Section 5.
- Section 6 discusses the development of markets for ecosystem services relevant to the impacts analysed in Section 4.
- Annexes contain the literature review that identified the evidence used in Section 4, and the case studies providing the findings in Section 5.

1.1 Project Aims and Objectives

The current transport investment appraisal process recognises the variety of landscapes, the range of ecosystem services they provide, and the difficulties in expressing their benefits in monetary terms for transport scheme appraisal (Department for Transport, 2016[1]).

The aim of this project is to inform the methodology used by the Department for Transport (DfT) to value landscape impacts in the appraisal of transport schemes. Currently, DfT's appraisal method follows an environmental capitals framework, as specified in the Landscape topic in Chapter 6 of WebTAG: 'Environmental Impact Appraisal (TAG Unit A3)'. All transport schemes seeking investment approval from DfT must follow this appraisal methodology.

Landscape valuation is described in supplementary value for money (VfM) guidance (discussed further in Section 5.1). This supplementary VfM guidance is based on values originating from a 2001 study and does not reflect latest guidance to government on the natural capital approach from the Natural Capital Committee. The aim of this project is therefore to inform the methods and valuation evidence used in the supplementary VfM guidance.

To do this, the objectives of the project are to:

[1] Referred to as DfT (2016) in the remainder of this report.

- Define landscape in terms of natural capital and consider how ecosystem services associated with 'landscape' can be identified. In doing so, it needs to recommend whether and how land should be categorised, when conducting transport appraisals using an ecosystem services approach;
- The to develop the methodology to value landscape impacts of transport interventions, including where relevant associated mitigation activities;
- Using this approach, to recommend monetary values that could be used in transport appraisals;
- Suggest how the methodology and the proposed values can be incorporated into the Department for Transport's appraisal guidance (WebTAG) on landscape with a view to including landscape values in BCRs for transport schemes;
- Identify data sources and if required carry out a data collection exercise to suggest the values that could be used in transport appraisals;
- Give consideration to potential 'double counting' of impacts covered elsewhere in WebTAG, such as Biodiversity, Townscape, Historical Environment and the Water Environment, and provide an update on the latest status of empirical evidence on creating markets for ecosystem services and whether there is any evidence of using this approach in transport appraisals.

This project has implications for other parts of WebTAG, including other topics in Chapter 6 (e.g. 'Townscape') and other chapters (e.g. Chapter 5 on natural capital and ecosystem services methods). These implications are considered when the results relating to 'Landscape' are interpreted, but are not the focus of the evidence review. Landscape values currently used in the appraisal process are described in supplementary guidance (DfT, 2016). These values are not included in the main 'value for money' assessment in WebTAG, but presented as indicative values and supplementary evidence for determining value for money, as values used include several services (recreation, biodiversity cultural, heritage, water environment, tranquillity) that may be double-counted (DfT, 2016, Section 2.2.2).

Therefore, the work aims to reflect the best available thinking and evidence, including developments since the last version of the guidance on ecosystem services and the natural capital approach. While the appraisal summary table (AST) of WebTAG can use qualitative and quantitative information, a key output from this project will be to inform the monetary values specific to the Landscape category in WebTAG.

Therefore, the main purpose of the project is to provide 'proposed values' and recommendations for their use within WebTAG, and an audit trail so that WebTAG:

1) screens significant impacts, and
2) values them with proportionate effort (e.g. through look-up values or value-transfer) within the existing appraisal process and timescales.

1.2 Approach

The project has been organised in five stages, as shown in Figure 1.1.

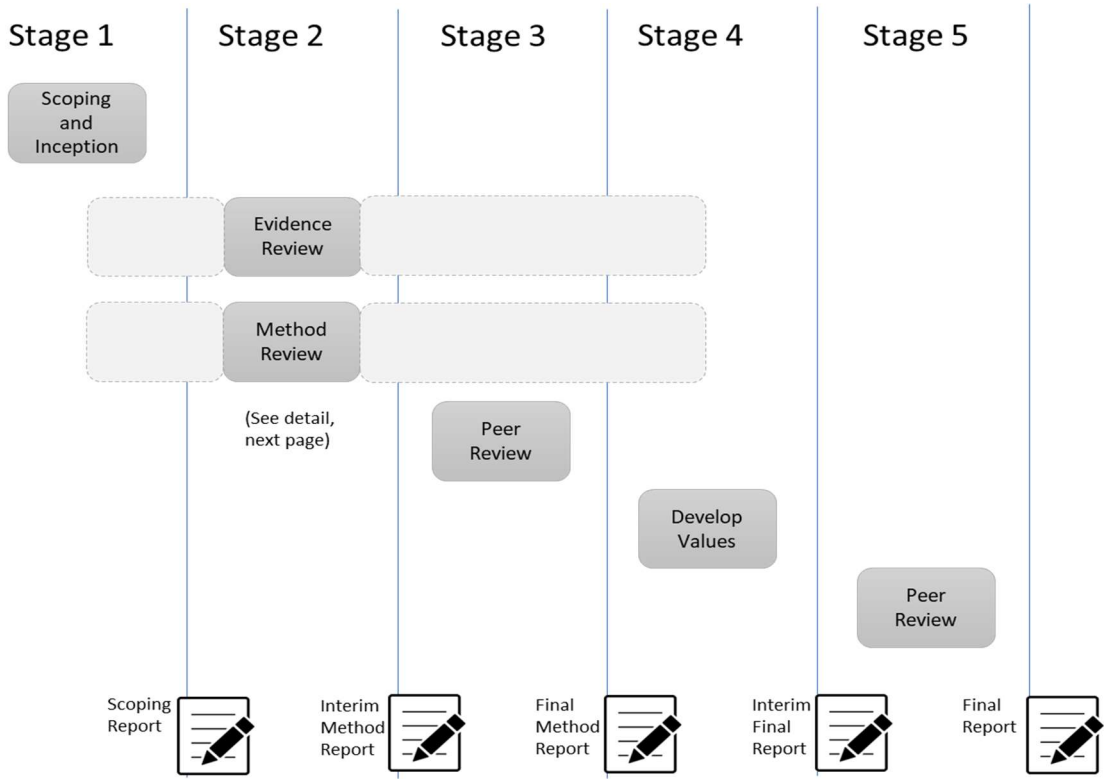

Figure 1.1: Project Stages

Following the scoping report, this methodology report looks in more detail at which 'Landscape' elements of WebTAG should be updated. This needs to consider the current 'Landscape' category, reflect the latest thinking and evidence on the value of natural capital and ecosystem services, and be relevant to transport scheme impacts and appraisal processes.

The project therefore combines inputs from different disciplines: transport scheme design and mitigation; natural capital and ecosystem services valuation, and transport scheme appraisal (WebTAG). Throughout this project, an important principle is that proposed approaches are supported by available evidence and are practical. In this context practical means that it can be undertaken using resources (time, skills and costs) usually applied in transport scheme appraisal, and that those resources are proportionate to the scale of the impacts concerned (i.e. enabling differentiation of effort between different scheme and impact scales). The approaches also need to produce sufficiently accurate evidence representing the priority benefits within the landscape category in WebTAG, in terms of the 'good' involved, changes in it, and whose values are represented.

Evidence from this report supports a suggested approach to updating the methodology and values in the 'Landscape' category of WebTAG.

1.3 Identifying Evidence

This report presents the findings of a review of the relevant literature. The review involved updating the research conducted to develop the Environmental Values Look-up (EVL) Tool for Defra in 2015. The EVL Tool was designed to provide a quick access and clear audit trailed summary of economic value evidence to inform appraisals by Government. Therefore, the review focused on new evidence published in academic journals between 2014 and 2017 and covered a range of ecosystem services.

The review has identified studies that could provide monetary values, how impacts are defined, methods and units used and other evidence to help apply them within the appraisal of Landscape in WebTAG.

The robustness of this evidence is assessed based on: (i) studies going through an appropriate review process (e.g. indicated by publication in peer-reviewed journals or following review for public policy purposes), and (ii) suitability of the evidence for value transfer (as reflected in value transfer criteria). Further details of the review can be found in Section 4 and Annex 1.

It is noted that as well as permanent impacts of new transport infrastructure, there can be impacts on the environment from construction activity. Particularly where transport schemes are very large and construction phase is long, environmental impacts during this phase should be taken into consideration in appraisal. Such impacts can relate to ecosystem services and other flows of impacts from transport (such as noise, air quality, in the water environment and greenhouse gases – see Section 4). While construction impacts are currently not a part of WebTAG landscape valuation, the applicability of the evidence from the review to both permanent and construction impacts is considered.

2.0 Terminology and Methods

The same terms can have different meanings and purpose across different disciplines that are involved in assessing the landscape impacts. To avoid confusion, this section lays out some key terms and methods that are used throughout the report:

- Landscape, natural capital and ecosystem services;
- Transport schemes;
- WebTAG Processes, and
- Economic values.

2.1 Landscape, Natural Capital and Ecosystem Services

Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (European Landscape Convention - ELC, 2000). National landscape character assessment guidance references this European definition (e.g. Natural England, 2014).

The current use of the term landscape in WebTAG has several dimensions:

i. It is defined through land characteristics and sense of place. The impacts worksheet assesses four 'features': Pattern, Tranquillity, Cultural and Land Cover.

ii. It is one of a set of environmental capitals[2], and

iii. It is subdivided through a combination of land cover and locations to value a range of services captured under the land types, represented in the supplementary value for money (VfM) guidance, from ODPM (2001)/ DCLG (2006) – these are described further in Section 4.

As DfT (2016) states: "…*within WebTAG, landscape is more than just views of the land, and encompasses physical and cultural characteristics of the land itself, how it is used and managed, and how people perceive those characteristics. This means that any approach to valuing the landscape needs to recognise the contributions that all of these characteristics make to both its intrinsic and economic value*".

In landscape assessment, 'landscape quality' relates to the condition or physical state of the landscape; 'scenic quality' relates to the pattern or composition of landscape elements within a landscape which appeals to the senses (mainly visual) and; both are used, along with other indicators such as tranquillity and natural/cultural heritage to determine 'landscape value'. The definitions and relationship between these terms are shown in Figure 2.1.

[2] Under the environmental capital approach, capital comprises a set of resources (grouped into the topics Landscape, Townscape, Historic Environment, Biodiversity and Water Environment) which are qualitatively assessed with no explicit distinction between capital stocks and flows of goods or services. Department of Transport (2015) – TAG Unit A3: Environmental Impact Assessment – Section 5, Box 1.

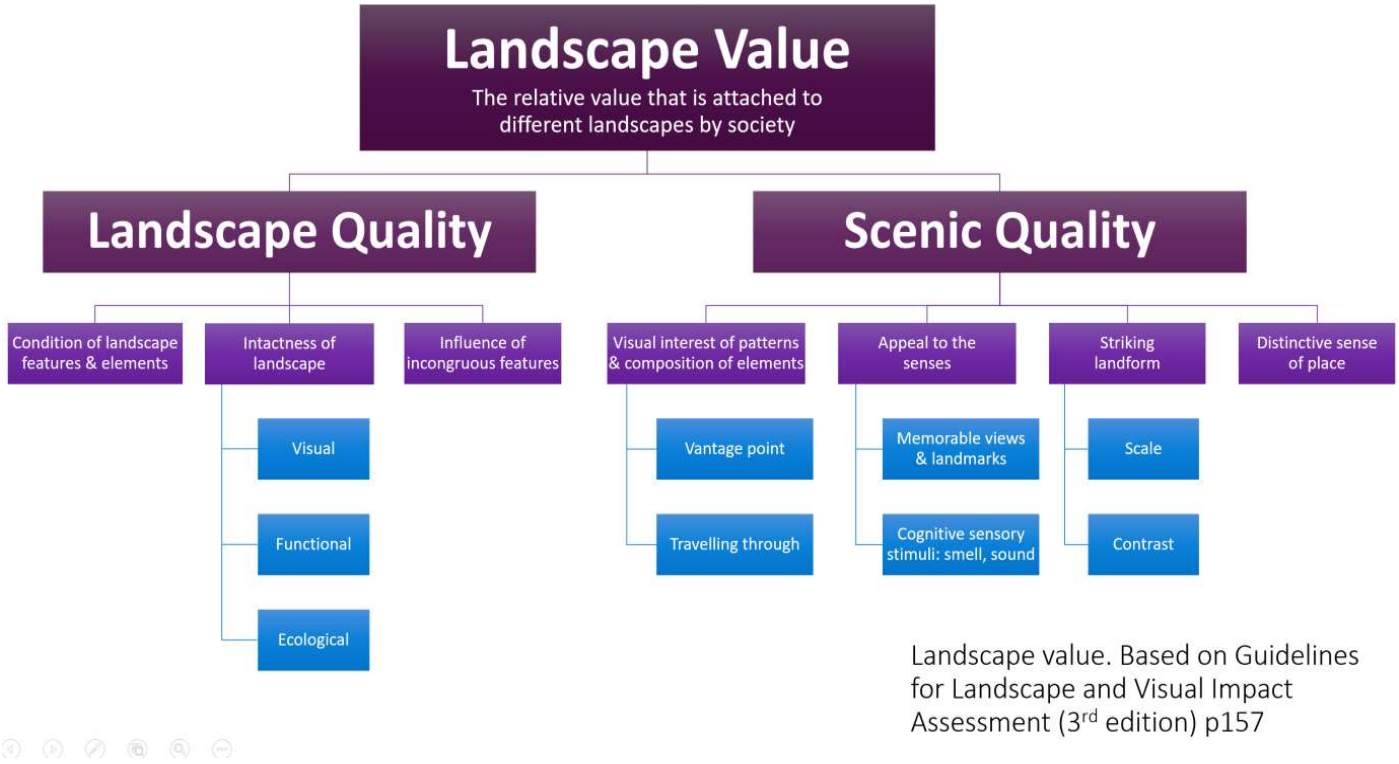

Figure 2.1 Components of landscape value

A further issue to consider is the extension of 'landscape' policies and assessments to also consider 'seascape'. These two areas are assumed to overlap within coastal margins. Therefore, it is suggested that 'Landscape' can be applied to coastal margins where most transport infrastructure impacts on the marine environment are likely to occur. 'Seascape' is used for the impacts transport schemes could have on the marine environment. For example, a port development on land could increase the size and frequency of shipping visible from shore. These impacts on seascape are considered to arise from transport operations rather than directly from the presence or use of transport infrastructure, and so seascape is outside the scope of this work.

It is important to note that appraisal of landscape impacts can distinguish between:

- 'landscape quality' – the condition or physical state of the landscape; and
- 'scenic quality' – the visible pattern or composition of a landscape.

Scenic quality is just one feature of landscape, and the combination of features is important: the holistic value of a landscape can be considered greater than the sum of its parts. Both landscape and scenic quality, along with other characteristics such as tranquillity and natural/cultural heritage, determine overall 'landscape value'.

Ecosystem services are the flows of benefits to people from nature, and have some biotic component (i.e. from an ecosystem) in their provision, including:

- Provisioning services, such as outputs of food or timber, which are often reflected in market transactions;

- Regulating services - regulating the condition of the environment (e.g. absorbing pollutants and resulting in better water quality or air quality), and
- Cultural services including visual amenity (which is closely linked to landscape), and benefits of maintaining biodiversity.

Ecosystem services frameworks also identify 'supporting services' which support the ecosystem in providing the other types of services. To avoid double counting, supporting services are not usually appraised in ecosystem assessments but assumed to support the provision of benefits considered in the assessment. Assessment also includes how the benefits are valued and by whom, and how the ecosystem services, benefits and economic values would change because of an action, such as a transport scheme.

Natural Capital comprises the elements of nature that directly and indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions (Natural Capital Committee, 2014). DfT (2016) recognises that landscape forms a key part of what is often referred to as natural capital. Typologies of natural capital and ecosystem services are described further in Section 4 as the basis for the evidence review.

It is important to carefully distinguish the use of the term 'landscape' as a descriptive term, from the technical scope and measurement of landscape in WebTAG, where it represents a specific set of natural capital assets and services.

There are some important overlaps between natural capital, ecosystem services and landscape:

- Natural capital assets produce ecosystem services as well as producing abiotic goods and services such as mineral resources.
- Using 'natural capital assets' as the measurement unit in appraisal offers some advantages over ecosystem services assessment:
    - Ecosystem services are flows of benefits over time. Natural capital recognises these flows, but also the quality and quantity of the stocks of assets that provide them, as established in the Natural Capital Committee (NCC) workbook (Natural Capital Committee, 2015). Thinking about stocks could reveal some early signs of decline in quality and quantity with related implications for decline in ecosystem services that focusing on the latter may not. National natural capital accounts measure physical stocks of assets, physical flows of benefits, monetary values of those flows and monetary values of assets (based on the present value of expected future flows).
    - Approaches to incorporating natural capital to business decision making (e.g. Natural Capital Coalition, 2016) define both dependencies on natural capital (e.g. provision of raw materials and assimilative capacity of the environment, and the influence of these on the cost of actions) and the impacts on ecosystem services (e.g. depletion of environmental quality and pollution).

The concepts of natural capital, ecosystem services and landscape can each be viewed as a component of the other. On the one hand, ecosystem services and natural capital are one component of Landscape which is the overall product of natural capital and built and cultural elements. On the other hand, the enjoyment of views of the landscape is part of the aesthetic benefits from natural capital (measured as an ecosystem service, described as "visual amenity"). Enjoyment of these views, and the knowledge that such views and landscapes are being preserved, are use

and non-use benefits, respectively, that can be valued as part of the benefits from natural capital. This work therefore makes careful use of the term landscape, distinguishing its meaning under the ELC, from the technical scope and measurement of a range of relevant natural capital assets and services under the supplementary VfM guidance. These typologies are shown in Table 2.1. The identification of the relevant natural capital assets and services is discussed in Section 4.

Table 2.1: WebTAG and Landscape Typologies

Environmental Capitals (WebTAG)	Habitat Types in NCC How-to-Guide	Land Types in WebTAG Supplementary Guidance	Notes
Historic Environment			Primarily about built capital.
Townscape	Urban: Natural land within urban or peri-urban areas	Urban core	Urban core assumed to be natural habitat within Townscape (urban areas).
Landscape		Urban Fringe (greenbelt)	A key source of value is recreation, and for this and other reasons proximity of impact to population is key. But urban fringe land has lower value than rural land, and values are given that represent average for accessible and inaccessible land.
		Urban Fringe (forested land)	
	Woodland: Broadleaved and coniferous (both natural and planted)	Rural forested land (amenity)	In WebTAG represents commercial and amenity forest, but given that one has recreation value and another does not, this is an unsupportable simplification. It is also illogical that, on average, accessible rural woodland has more value that accessible urban fringe woodland.
	Grassland: unimproved for agricultural purposes.	Agricultural Land (extensive)	
	Enclosed farmland: Arable, horticultural land and improved grassland.	Agricultural Land (intensive)	
	Mountain, moors and heathlands: Blanket bog, upland and lowland heath, rock and scree.	Natural and semi-natural land	Includes designated habitats, clearly overlaps with Biodiversity (and water environment) Environmental Capitals categories.
Water Environment	Freshwater: Rivers, streams, open waters, groundwaters and wetlands.		Water environment includes length of river impacted.
	Coastal margins		
Biodiversity			
Sources:			
DfT TAG Unit A3, Env.Impact Appraisal, 2015.	Natural Capital Committee (2017)	ODPM (2001)	

The relationships between these terms are something that appraisal of landscape needs to be aware of and clear about. This project refers to the value of 'visual amenity' as an ecosystem service from landscape (i.e. enjoyment of the view of the landscape) and distinguishes this from 'landscape value' which is used by landscape professionals to refer to the intrinsic qualities of landscape (and thus distinct from anthropocentric concepts of value used in economic appraisal).

2.2 Transport Construction, Infrastructure and Use Impacts

Environmental impacts from transport schemes, whether beneficial and adverse, can arise from different sources during the construction phase, from the presence of the infrastructure, and from its operation/use. Typically, impacts are divided into two main categories:

- Use: arising because of changes in traffic (road or rail traffic) such as noise, air pollution and greenhouse gases; and
- Infrastructure: arising from the physical presence of new or improved transport infrastructure and associated development, such as effects on land use, landscape, biodiversity, heritage and the water environment.

WebTAG advises (Department of Transport, 2015, paragraph 1.4.3) that it is usually not appropriate to consider environmental impacts during, or as a result of, construction activity as part of the appraisal process. This is an example where WebTAG may differ from an Environmental Impact Assessment, which is legally required to identify all significant environmental impacts regardless of how they occur. However, there are many circumstances, particularly where schemes are very large and construction goes on for a considerable period, when construction activity impacts are relevant and should be taken into consideration in appraisal.

Impacts of construction activity are most likely to be temporary, and relate to ecosystem service and other flows of impacts (such as noise, air quality, the water environment and greenhouse gases – see Section 4). However, there can also be impacts on land that affect agriculture or biodiversity as a result of land take for construction activity (e.g. site offices and to hold machinery or materials). They are not the focus of this project, but the methods investigated are considered for their suitability for application to appraise construction impacts.

There may also be impacts of some transport schemes that generate benefits in terms of ecosystem services, by improving people's access to the services. Cycling lanes are a case in point: they improve the quality of the journey for the user. However, cycling or other uses of transport infrastructure are not an ecosystem service, and these benefits should be captured in the benefits of a transport scheme. Including these in assessment of landscape or ecosystem services would be likely to double-count them. Therefore, they are outside the scope of this work.

2.3 WebTAG Process and Terms

The WebTAG appraisal methodology characterises impacts of schemes as monetised economic effects where possible, but a range of effects are either quantified (but not monetised) or qualitatively presented. These impacts are combined into an AST, which is the key tool for decision-makers.

The current Environmental Impact Appraisal (TAG Unit A3) in WebTAG adopts the Environmental Capital Approach. The environmental impacts covered in the guidance include Noise, Air quality, Greenhouse Gases, and the Environmental Capital Approach which includes Landscape, Townscape, Historic Environment, Biodiversity and Water Environment.

The coverage of Landscape in the transport scheme appraisal process is described below:

Step 1: Scoping and identification of study area	There is currently no landscape specific information for step 1.

Step 2: Identifying key environmental resources and describing their features

This starts with a description of 'countryside character'. National landscape character assessment guidance references this definition (e.g. Natural England, 2014) based on the 2002 'Landscape Character Assessment Guidance for England and Scotland' (LCA). It describes what currently exists in the landscape and whether this might degrade in the future in the absence of the scheme proposed. Other assessments (e.g. for Areas of Outstanding Natural Beauty or at county level) can also be helpful.

This is combined with consideration of the attributes defining the landscape resources affected by a scheme. This is done in terms of land use patterns, topography and form; tranquillity, including remoteness and isolation; cultural, historic or traditional factors; and landcover in terms of natural or semi-natural habitats.

Step 3: Appraise environmental capital

The appraisal of landscape is done for each category of feature, and considered in terms of the spatial scale it matters, rarity, importance and substitutability. Each of these considerations is also clearly important in terms of the value of landscape features.

Step 4: Appraise the proposal's impact

A scheme's impact on landscape is appraised by systematic description of its effects, which are then scored using the seven-point scale[3] defined in WebTAG. The views of relevant authorities, statutory bodies, organisations and residents are an important element of the qualitative appraisal, and should therefore have a bearing on the change in the value placed on landscape resources resulting from the proposed scheme.

Most road or rail schemes will be developed to include landscape proposals, either to improve the visual quality of an area if that is possible, or at least to help mitigate any adverse impacts on the quality and value of the landscape. These are considered in the appraisal once information is available on them.

Step 5: Determine the overall assessment

This builds on all the information recorded in appraisal using the definitions for overall impact scoring defined in WebTAG[4]. This is done for each individual landscape feature. Impacts are summarised using the AST standard seven-point scale, with the additional facility to identify exceptionally severe adverse impacts. The AST will also need to record the change in values placed on the landscape.

[3] Large/moderate/slight beneficial, neutral and large/moderate/slight adverse.

[4] Reported in the Appraisal Summary Table in the column headed "quantitative" – see paragraph 6.2.12 of TAG Unit A3. In short, an assessment score is derived for each key environmental resource (character area), based on an appraisal of the significance of each individual impact assessment for each landscape feature. How well a proposed scheme would fit with the grain of the landscape is also important and is recorded separately, as the overall score may not reflect this.

In the process above there is a distinction between the 'physical effects' or change to the landscape because of the scheme (e.g. if there is now a road through a national park), and the subsequent 'impact' on people (e.g. that people will stop coming to the national park). The economic evidence examined does not look at the expected duration of landscape impacts – negative impacts are considered ongoing and permanent.

Where possible, the valuation of landscape and other environmental impacts should be included in each step of the WebTAG appraisal process described above. Considering environmental impacts as scheme proposals are developed (rather than as a 'bolt on' at the end of the appraisal process) will help ensure that robust and defensible values are achieved in an effort proportionate to the scale of the proposed transport intervention.

Assessment of landscape impacts within this system should follow the process described in DfT (2016). This is shown in Table 2.1, which also notes key points from certain parts for this project.

Note that the assumptions about the area impacted in Step 4 (that the proposal will affect the landscape up to 500m either side of the scheme with a linearly declining impact) can be simplified to assume a footprint for each kilometer of the scheme of 100 hectares[5]. This assumption potentially over-simplifies landscape impacts, and is one of the reasons for this project's examination of alternative appraisal processes for landscape.

Table 2.2: Current process for assessment of Landscape Impacts in DfT (2016) supplementary guidance.

Part	Description	Key points
1. Identify landscape features	Utilises information from the landscape worksheet and an environmental constraints map (to identify moderate or large landscape impacts). This step comprises the WebTAG non-monetised assessment.	This screens out schemes with slight or minimal impacts from further appraisal – this is important to designing a proportionate appraisal effort.
2. Segment the scheme	Segment the scheme where landscape impacts vary significantly.	These steps require the practitioner to make a judgement and can be aided through a variety of spatial sources (maps; aerial photos; artists' impressions; digital sources) and/or a site visit and consultation. This information may be efficiently organised in GIS, but this is not required.
3. Determine Land Type	From scheme information or other sources (environmental constraints map/google maps) determine the appropriate (mix of) land type.	
4. Determine landscape 'footprint'	Determine the size of the area affected by the landscape changes.	Identifies the footprint (area) of the proposal, in terms of the area most affected. This is determined by type of scheme, setting/ topography, and people affected. A simplified assumption is of impacts declining from the scheme over a distance of 500m.
5. Mitigation	Identify any current mitigation structures or measures proposed to reduce impacts on the landscape.	These are discussed in Section 3.3.

[5] 1 hectare is 100m by 100m. Each kilometre includes 10 lengths of 100m, and a width of 500m gives 5. Multiplying 5 x 10 = 50 areas of 100m by 100m, i.e. 50 ha either side. See DfT supplementary guidance on landscape (p7, para 2.13).

Part	Description	Key points
6. Landscape impact valuation	Use the landscape values recommended in this guidance to assess the landscape impact. These are discussed further in Section 4.1.	Basic calculation in length (km of scheme) * area (ha per km) * monetary value (£ per ha), for each land type identified in Step 3.
7. Sensitivity tests	Sensitivity analysis for the key assumptions used in the assessment. This could include a range of values (upper and lower bounds).	

2.4 Economic Value and Valuation

Before developing values in WebTAG, a structure is needed to understand different aspects of economic value and therefore what different valuation evidence represents.

Economic value reflects individuals' preferences for or against changes in the quality and quantity of goods and services, regardless of whether or not they are traded in markets. In actual markets, preferences are expressed through sale and purchase behaviour, where the market price represents the equilibrium between the maximum amount buyers are prepared to pay to receive the benefits from a good or service[6] and the minimum amount sellers are willing to accept to provide the good or service[7]. The behaviour of buyers is analysed through demand theory, which explains the variation in the quantity demanded and price paid by different types or groups of individuals.

The principles of demand theory are also assumed to apply for goods and services that are not traded in markets (or at least not directly). Most environmental resources, including landscape, are prime examples of such 'non-market' goods and services. Here, individuals' preferences to secure gains or to avoid losses in the quality and quantity of the environmental resource may be expressed via their willingness to pay (WTP) to secure the gain or avoid the loss in question[8]. Alternatively, preferences for non-market goods may be reflected by individuals' willingness to accept compensation (WTA) to forgo gains or to tolerate losses. It is also assumed that a gain (or a benefit) is any change that increases human welfare; and a loss (or a cost) is any change that decreases human welfare.

Two important aspects of economic value need to be emphasised: (i) economic value is defined by human preferences, therefore any notion that cannot be experienced by people (e.g. the 'intrinsic' value of the environment) is not included within economic value; and (ii) economic value is about changes in the quality and quantity of environmental resources: it is not a statement about the absolute value of the environment. The economic valuation methods outlined in Section 2.4.1 are designed to use market and hypothetical market data to express WTP and WTA in monetary terms.

[6] Note that buyers may actually be willing to pay more than the prevailing market price for a good or service. The difference between a buyer's willingness to pay and the actual price paid is known as 'consumer surplus'.

[7] Given certain assumptions about the degree of competition between sellers within the market.

[8] In this case willingness to pay is comprised solely of consumer surplus due to the non-market nature of the good or service.

Before the discussion of valuation methods, however, it is useful to understand the possible reasons why individuals may have WTP or WTA for changes in environmental resources. Environmental economics uses the Total Economic Value (TEV) typology to understand how people derive value from a good. TEV distinguishes between two broad types of economic value:

Use value involves some interaction with the resource, either directly or indirectly:

- Direct use value - individuals make use of a resource in either a consumptive way (e.g. fishing or agriculture) or a non-consumptive way (e.g. recreation).
- Indirect use value - individuals benefit from ecosystem services supported by a resource rather than actually using it (e.g. watershed protection for flood mitigation, cycling processes for agriculture or carbon sequestration).

Non-use value is associated with benefits derived simply from the knowledge that the natural environment is maintained. By definition non-use value is not associated with any use of the resource, even though users of a resource may also attribute non-use value to it. Non-use value can be split into three basic components:

- Altruistic value - derived from knowing that contemporaries can enjoy the environmental goods and services.
- Bequest value - associated with the knowledge that the environmental resources will be passed on to future generations.
- Existence value - derived simply from the satisfaction of knowing that the environmental good continues to exist, regardless of use made of it by oneself or others now or in the future.

Additionally, there are two categories not immediately associated with the initial distinction between use value and non-use value:

- Option value - individuals derive benefit from maintaining the option to make use of some aspect of the natural environment in the future, even though they do not currently plan to make such use. It is “an additional value to any utility that may arise if and when the good is actually consumed” (Perman et al., 2003), and only exists because of uncertainty concerning future preferences and/or the availability of the good, and only if the valuer is risk-averse. It can be regarded as the value of a form of insurance to provide for possible future use.
- Quasi-option value - a related value arising through avoiding or delaying irreversible decisions, where technological and knowledge improvements can alter the optimal management of a natural resource. It does not require risk aversion, and represents an economic expression of the precautionary principle. A common example of quasi-option value is the potential for the genetic information found in biodiversity hotspots to be used for creating pharmaceuticals or improved crop varieties.

2.4.1 Economic Valuation Methods

Economic valuation methods that are used in studies that could potentially provide evidence for WebTAG are summarised here. For a better understanding of the value evidence, appraisers should refer to the corresponding literature. Methods considered measure a change in the quality or quantity in the benefits provided by ecosystem services and/or natural capital assets, where change could be a deterioration (e.g. due to a transport scheme) or an improvement (e.g. due to mitigation measures). Qualitative understanding of the change, and usually quantification of impacts, is

required before monetary valuation of environmental effects can be undertaken (Ozdemiroglu and Hails, 2016).

The starting point in economic valuation is **market prices**, where the impacts valued are on goods and services traded in markets. Market prices are determined by the buyers and sellers in the market, and do not capture the full value to beneficiaries of the natural assets that provide the goods and services. For instance, the market price of timber cannot be used to represent all the ecosystem services of a forest. Given that most benefits derived from landscape are not traded in markets, using market price data would not be sufficient to value the landscape impacts of transport schemes.

Cost-based approaches are often used to value dependencies on regulating ecosystem services (NC Protocol, 2016) such as water purification and flood control services. Cost of replacement is used as a lower bound estimate for the value of benefits from such services because had the costs not deemed to be lower than benefit, replacement would not take place. Care is needed to ensure that the replacement has, or would, actually take place (i.e. not just that it is possible). The benefit of improving environmental quality can be valued in terms of the 'cost (of degradation) avoided'. For example, air pollution leads to human health impacts; reducing pollution reduces health impacts and avoids the associated medical and other costs.

Given that most environmental (including landscape) impacts are goods and services that are not traded in markets, the so-called 'non-market' valuation methods become important. These involve observing consumers' behaviour in actual markets and how such behaviour is affected by environmental quality (revealed preference methods); or creating hypothetical markets in which individuals can express their preferences through questionnaires (stated preference methods).

Revealed preference (RP) methods include:

- Hedonic property pricing - explores the influence of environmental, property, neighbourhood and socio-economic factors on the individuals' choices regarding property purchases. Analysis of the variation in property prices and environmental conditions can estimate the price premium environmental factors like clean air, views, peace and quiet etc fetches in the housing market.
- Avertive behaviour method - analyses consumer spending on goods and services that avoid or counteract environmental 'bads' such as water, air and noise pollution (e.g. spending on water filters, double glazing).
- Travel-cost method - examines individuals' choices on which recreational sites to visit and how much to spend on travelling there and back and while on site. This spending is a minimum expression of the value of the visit (on the assumption that otherwise the visit would not take place). By observing how costs and number of visits vary across people and sites, the demand (value) for recreational use of sites can be estimated.

Stated Preference (SP) methods are survey-based approaches that present a 'simulated' market choice for respondents to express their preferences for/ against environmental changes presented to them. SP methods can be used to estimate value of past, current and future changes to goods and services – the latter cannot be estimated through RP which only covers changes that are already experienced. SP is also the only set of methods that can estimate the values held by non-users, as other methods analyse data on use. Two types of stated preference methods exist:

- Contingent valuation - presents all the changes to the quality or quantity of a good or service and asks respondents' preferences for the entirety of changes in terms of their WTP or WTA for or again the changes; and

- Choice-modelling - defines a good and service in terms of its characteristics (attributes), presents the changes to each attribute separately, asks respondents to choose their favourite combination of attributes and infers the preferences for each attribute.

All economic valuation methods have their pros and cons and different levels of applicability to different valuation contexts. For example, market prices are limited to only marketed goods and services. RP methods are only limited to users' valuation of the environment and only for changes that have already been experiences. While SP methods can estimate the value of future changes, and values held by non-users, designing questionnaires to present complex information and to enable respondents to engage openly and completely with the survey is a difficult task.

2.4.2 Value Transfer

Where primary research using the above economic valuation methods is not desired or practical, existing value evidence from the literature is used. The process to select, where necessary adjust, and apply value evidence is called value (or benefit) transfer. The literature review in this project is undertaken to find the relevant evidence to conduct value transfer for appraising the landscape impacts of transport schemes.

Value transfer must take into account the types of impacts being valued and the context in which they occur. A full checklist of the factors to consider in value transfer is provided in UK guidelines (eftec, 2010). The key issues include understanding the valuation method used, and a comparison between the context of the source study and that of appraisal, in this case the proposed transport scheme. Contextual aspects to consider include:

- The type of natural capital asset and/or ecosystem service being changed;
- The nature of the change (e.g. scale, whether it is an improvement or deterioration);
- The geographical location (both whether UK or not, and where in the UK, e.g. in a similar landscape area);
- The people affected/whose values are being considered;
- The number and quantity of substitutes;
- The market construct, and
- Study quality (e.g. study year, method, sample size, analytical tools and the quality of statistical results).

Comparison of these factors allows conclusions to be drawn on the suitability of the evidence for value transfer. The literature review is required to record information necessary for such comparisons when conducting value transfer.

2.4.3 Valuing Natural Capital

The Natural Capital Committee's (NCC) 'how to' guide to valuation (2017) sets out the types of decisions for which economic values might be useful and provides some guiding principles for the choice of approaches to valuation. The Committee sees three decision contexts for which valuation may be helpful:

1) Determining priorities for investments in natural capital;

2) Determining actions affecting natural capital to

(i) achieve target improvements;

(ii) avoid deterioration; or

(iii) compensate for losses;

3) Determining overall progress with objectives to protect and improve natural capital.

The first context is concerned with allocating resources to natural capital investments that maximise benefits. Cost Benefit Analysis (CBA) is obviously an important tool for this type of decision which needs valuation evidence on the benefits provided by natural capital. The relevant valuation methods are described in Section 2.4.1 and in the literature referenced by the Committee (Champ, Boyle and Brown, 2017)[9], however the guide recognises that certain types of assets and benefits may be very difficult to value in monetary terms. In particular, biodiversity, landscape and heritage are challenging to value, and alternative approaches may be needed (Bateman et al. 2014). For example, for wildlife there may be existing targets and regulations for the conservation of certain species and habitats. A simple approach is to ensure that proposed investments do not have effects which run counter to those existing targets and regulations, and instead secure them or improve their status.

The second type of decision involves schemes with natural capital impacts. A key policy principle here is that there should be no net loss of natural capital or even net gain. If the loss of natural capital cannot be avoided, it should be offset by gain in natural capital either equivalent to the loss (no net loss principle) or greater than the loss (net gain). One approach to deliver these requirements efficiently is to determine the least cost approach to achieving these objectives.[10]

Finally, ongoing monitoring of the state of natural capital plays an important role in ensuring that targets and objectives are being met. This can be done at scheme, organisational, regional and national levels, and achieved in a variety of ways, including the establishment and maintenance of natural capital asset registers or the production of natural capital accounts at either the corporate[11] or national levels[12]. In natural capital accounts, assets are valued based on the present value of the future benefits they are expected to produce: calculating this combines economic value of the benefits with predictions of levels of those benefits into the future.

[9] High quality guides also discuss the limitations of such methods.

[10] It is important to remember that this principle belongs to NC Committee and not the Green Book or WebTAG. Thus, it reflects a policy objective rather than an appraisal objective.

[11] See Corporate Natural Capital Accounting, at: https://www.gov.uk/government/publications/natural-capital-committee-research-corporate-natural-capital-accounting

[12] See ONS approach to the development of Natural Capital Accounts at: https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital

3.0 Transport Impacts

This Section looks at the types of transport schemes, and their appraisal through WebTAG in the context of Environmental Impact Assessment (EIA). It also describes the mitigation of transport scheme impacts and presents the case studies used in this project.

3.1 Transport Schemes Typologies

WebTAG covers appraisal methods that are applicable for highways and public transport interventions (as opposed to service enhancement) schemes to build evidence to support business case development and inform investment funding decisions. 'Interventions' in this context cover the entire range of schemes from demand management measures through to major engineering projects. Analysis using WebTAG guidance is a requirement for all interventions that require government approval. For interventions that do not require government approval, WebTAG often serves as a best practice guide.

Therefore, the range of transport schemes to which WebTAG applies is potentially very broad. However, in practice its focus is typically on larger highways or public transport schemes such as a new/upgraded trunk road or a new light rail/tram scheme.

Table 3.1 below sets out a typology of transport schemes, and the extent to which landscape is likely to form a part of the WebTAG appraisal.

Table 3.1 Typology of Transport Infrastructure Schemes

Type	Mode	Relation to WebTAG	Extent of landscape effects
Surface	Motorways/Trunk Roads	Always used	Key consideration, particularly outside cities and towns.
	Local Highways	Sometimes used	Key consideration, particularly outside cities and towns.
	Traffic Management (including "Smart" roads)	Sometimes used	May be a consideration, particularly on roads outside cities and towns.
	Railways (including stations)	Sometimes used	Key consideration, particularly outside cities and towns.
	Light rail/Trams	Always used	May be a consideration in suburban or semi-rural areas.
	Bus Rapid Transit/ Busways	Sometimes used	May be a consideration in suburban or semi-rural areas.
	Other public transport infrastructure (e.g. bus stations)	Sometimes used	May be a consideration in suburban or semi-rural areas.
Water	Ports	Best practice guide	Key consideration, particularly outside cities and towns.
	Canals	Best practice guide	Key consideration, particularly outside cities and towns.
Aviation	Airports	Best practice guide	Key consideration, particularly outside cities and towns.
	Heliports	Best practice guide	May be a consideration in suburban or semi-rural areas.

3.2 Appraisal Effort at Different Stages of WebTAG

For some transport schemes, there is a statutory requirement to carry out an EIA and other specific assessments to meet the requirements of EU Directives and UK environmental regulations. Other schemes do not require statutory EIA, but may still require non-statutory EIA. In either case, the aim of EIA is to make sure environmental implications of schemes can inform the design and decision-making process.

WebTAG Unit A3 focusses on what it terms "environmental impact appraisal" rather than EIA per se. It defines this as *"the process of developing environmental impact information for inclusion in a transport appraisal"* (para 1.3.3). Unit A3 advises that this should build on baseline data and impact assessment work carried out as part of the EIA as illustrated below:

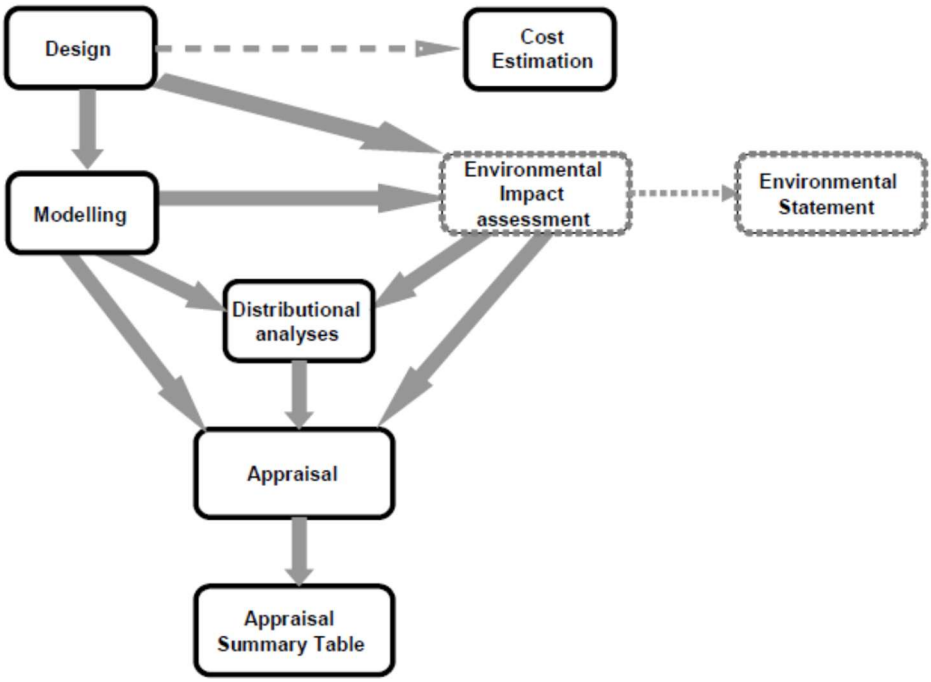

Figure 3.1: Relationship between the key components of appraisal work

The approach recommended in Unit A3 is not intended as an alternative to EIA but to complement that work and deliver a message that is consistent with it. As Figure 3.1 shows, it does presuppose that appraisal is preceded by the EIA and draws from it. However, depending on the programme for consenting and financial approvals, this may often not be the case.

Therefore, the scope of the EIA and environmental appraisal depends on the stage reached in the transport appraisal process[13]. For appraisal at Stage 1, this will be unlikely to go beyond scoping (i.e. identifying which environmental topics should be examined given the characteristics of the scheme and its location, and how they should be assessed). During Stage 2, further appraisal and

[13] Transport appraisal has three stages: Stage 1 – Option Development. Stage 2 – Further Appraisal. Stage 3 – Implementation, Monitoring and Evaluation. DfT (2014)

EIA is carried out at a level appropriate and proportionate to the information available on the scheme. This EIA typically would be used as the basis for the environmental impact appraisal process, using the methods set out in Unit A3.

A WebTAG appraisal of environmental effects should be possible at any stage in the development of proposals. However, at all stages a proportionate approach should be adopted that ensures the level of detail provided is no more than needed for robust decisions to be taken. This proportionality is reflected in the appraisal processes, described in Table 2.1.

More comprehensive information will become available as a transport scheme develops. This will allow a detailed environmental appraisal to be carried out. However, the methods set out in WebTAG can be applied using what data is available at any stage; where this is less than fully detailed, the limitations of the data should be identified as part of the appraisal process. Sensitivity testing should be carried out with any assumptions clearly stated. Where appropriate, a precautionary approach should be applied. Increasing confidence can be placed in the results of appraisal as the level of data certainty improves through the development of proposals.

As a proposal develops, a statutory EIA may be required as part of consent procedures. Table 3.2 below sets out where this will be the case.

Table 3.2 EIA Development[14]

Type	Mode	Always Requires EIA ("Schedule 1")	Sometimes Requires EIA ("Schedule 2")
Surface	Motorways/Trunk Roads	New roads or realignment and/or widening of an existing road to four or more lanes, 10 km or more in length.	No – always required.
	Local Highways		If the area of the works exceeds 1 ha.
	Traffic Management (including "Smart" roads)	No.	
	Railways (including stations)	Lines for long-distance railway traffic.	If the area of the works exceeds 1 ha.
	Light rail/Trams	No	If the area of the works exceeds 1 ha.
	Bus Rapid Transit/ Busways	No	If the area of the works exceeds 1 ha.
	Other public transport infrastructure (e.g. bus stations)	No	If the area of the works exceeds 1 ha.
Water	Ports	Trading ports, piers for loading and unloading connected to land and outside ports (excluding ferry piers) which can take vessels of over 1,350 t.	If the area of the works exceeds 1 ha. unless included in Schedule 1.

[14] As defined by The Town and Country Planning (Environmental Impact Assessment) Regulations 2017, Schedules 1 and 2. http://www.legislation.gov.uk/uksi/2017/571/pdfs/uksi_20170571_en.pdf

Type	Mode	Always Requires EIA ("Schedule 1")	Sometimes Requires EIA ("Schedule 2")
	Canals	Inland waterways and ports for inland-waterway traffic which permit the passage of vessels of over 1,350 t.	If the area of the works exceeds 1 ha.
Aviation	Airports	Airports with a basic runway length of 2,100m or more.	If development involves extension to a runway or the area of the works exceeds 1 ha.
	Heliports	No	If the area of the works exceeds 1 ha.

However, it should be noted that the requirements for EIA also depend on the consenting route. For example, if consent for a scheme is being sought through a Transport and Works Act Order application, then it is almost certain that an EIA will be required even where the scheme does not exceed the criteria set out in the Town and Country Planning regulations. So, for example, if a rail scheme is delivered through a Transport and Works Act Order, it would almost certainly require a full EIA; however, a rail scheme of the same scale delivered using Network Rail's permitted development rights may not.

3.3 Mitigation Options

Many transport schemes will include mitigation actions that are relevant to the impacts assessed under 'Landscape' within WebTAG from the outset. This means that the values in the supplementary VfM guidance are not only used to evaluate impacts. The WebTAG framework is used to help sift transport scheme options from early in their development, and the consideration of landscape impacts are important in this sifting, including at the crucial broader option choice stage (e.g. online or offline route options).

WebTAG Unit A3, Chapter 6 states that assessment should also consider mitigation measures as these may imply a lower footprint. Mitigation for landscape impacts can take various forms:

- Existing structures - where existing structures are nearby, the footprint of the existing and proposed development may overlap. For example, a proposal to widen an existing road is likely to have a smaller impact than developments that are offline. Similarly, existing housing or woodlands may act as a screen. The assessment should then only account for the marginal impact.
- Mitigation within the proposal design - the proposal may include mitigation directly, for example, through the use of tree planting or sympathetic materials.

If consideration of mitigation measures is included in the assessment, WebTAG requires that description of what these are, and how they have been incorporated, should be reported in the VfM Statement and Economic Case. As mitigation measures can be identified through different stages of different schemes, this may require iterations of the VfM assessment.

Therefore, the role of landscape appraisal within a transport scheme changes as the scheme develops. Initial values for impacts and updated values as scheme design develops and/or becomes

more specific indicate priorities to scheme developers with respect to mitigation. The values for the expected residual impacts after proposed mitigation measures are then appraised and inputted to decision-making on whether a scheme should be taken forward.

The appraisal of landscape impacts gives incentives to those developing schemes as to what to prioritise when they design scheme options and mitigation measures. This is investigated as part of the case studies (See Annex 2), and the role markets for ecosystem services can play in mitigation is covered in Section 5. As a result, care also needs to be taken to ensure values developed are robust enough to assess trade-offs, and guide and evaluate mitigation options, within transport schemes.

The qualitative appraisal of landscape impacts should also take mitigation into account. The landscape profession[15] increasingly looks for developments, such as new transport infrastructure, to deliver net environmental gain. In the first instance a 'good fit' between proposed infrastructure and landscape is sought. Following this, policy advice is to consider the trade-offs between loss of valued landscape/features and the creation of new landscape/features, not between landscape and benefits of transport.

3.4 Identifying Transport Scheme Case Studies

In consultation with the project board, three case studies were identified that illustrate a range of environmental contexts and impacts in which to test the use of the economic values for appraisal of landscape impacts:

- A3 Hindhead, new tunnelled section to remove trunk road from the ‘Devil’s Punchbowl’.
- A14 Dual Carriageway upgrade, Huntingdon.
- Great Western Mainline rail electrification – section between Reading and Didcot.

These case studies are presented in Annex 2.

[15] Defined through the chartered status of its professional body: https://members.landscapeinstitute.org/chartership/

4.0 Identifying Relevant Impacts

This section examines coverage of environmental impacts in WebTAG and related evidence that can inform economic valuation in the supplementary VfM guidance, such as on ecosystem services and natural capital. It also considers how the findings of this project will fit into WebTAG, especially use of monetary values. It summarises the more detailed evidence review in Annex 1.

4.1 Coverage of Landscape in WebTAG

In a transport scheme appraisal, landscape is most often included in a value for money assessment as a non-monetised impact, alongside other environmental impacts. WebTAG Unit A3, Section 6 provides guidance on how a non-monetised assessment of these impacts can be undertaken. This approach was developed by DfT together with Natural England, English Heritage and the Environment Agency.

As described in Section 2.1, the environmental impacts currently covered in the WebTAG guidance include Noise, Air quality, Greenhouse gases, and the Environmental Capital Approach which includes Landscape, Townscape, Historic Environment, Biodiversity and Water Environment.

Current WebTAG advice can be followed at all stages of the development of a scheme. Topography and form, tranquillity, the presence of historic or traditional landscape elements, and land cover can be examined from the earliest stages, and reported systematically using the WebTAG Landscape Appraisal Worksheet. The level of detail, and the robustness of the conclusions of the appraisal, will increase as the design of the scheme progresses. This will be particularly the case once surveys on site can be undertaken rather than relying on information that is already likely to be available from mapping and online sources. On this basis, it is relatively straightforward currently to deliver an appraisal that is proportionate to the stage that a scheme has reached.

Designing a proportionate appraisal effort should also be considered in relation to:

- The size of transport schemes, which can be defined as spatial area, financial value or volume of transport movement;
- The number of people likely to be affected by the impacts of the scheme;
- The expected sensitivity of overall results of WebTAG to the value of landscape impacts (for example, where a scheme with a lower landscape impact is already favoured in WebTAG, landscape appraisal becomes less critical); and
- The potential cost/extent of mitigation for landscape impacts. Where mitigation is greater, measurement and valuation of the impacts being mitigated becomes more important.

The current approaches described in Section 3.2 show that landscape assessment and economic valuation evidence for transport schemes use more detailed methods than the supplementary VfM guidance. Furthermore, the landscape assessment and VfM appraisal approaches are not particularly compatible. The landscape appraisal process is largely qualitative and discursive, specifying stakeholder input. Economic valuation is mainly quantitative and elicits information about preferences (and hence values) without necessarily engaging stakeholders. Note that this project is concerned with the economic appraisal of landscape, and in doing so considers its relationship with the qualitative landscape appraisal process but does not review the adequacy of the qualitative process from a landscape professional's point of view.

In landscape appraisal, assigning a numeric value to particular datasets based on presence, quantity and extent does not fully capture what a landscape character assessment identifies as creating a landscape of high scenic quality. The importance of a feature will also depend on how important it is to the distinctive character of the landscapes (such as the significance of tree groups or linear features in defining character).

Figure 4.1 is from the 2014 Landscape Character Assessment (LCA Approach directly adapted from the 2002 guidance) and shows the range of factors generally considered to be part of landscape. Note the inclusion of sound and smell – creating an interaction between these aspects of landscape assessment and other parts of WebTAG.

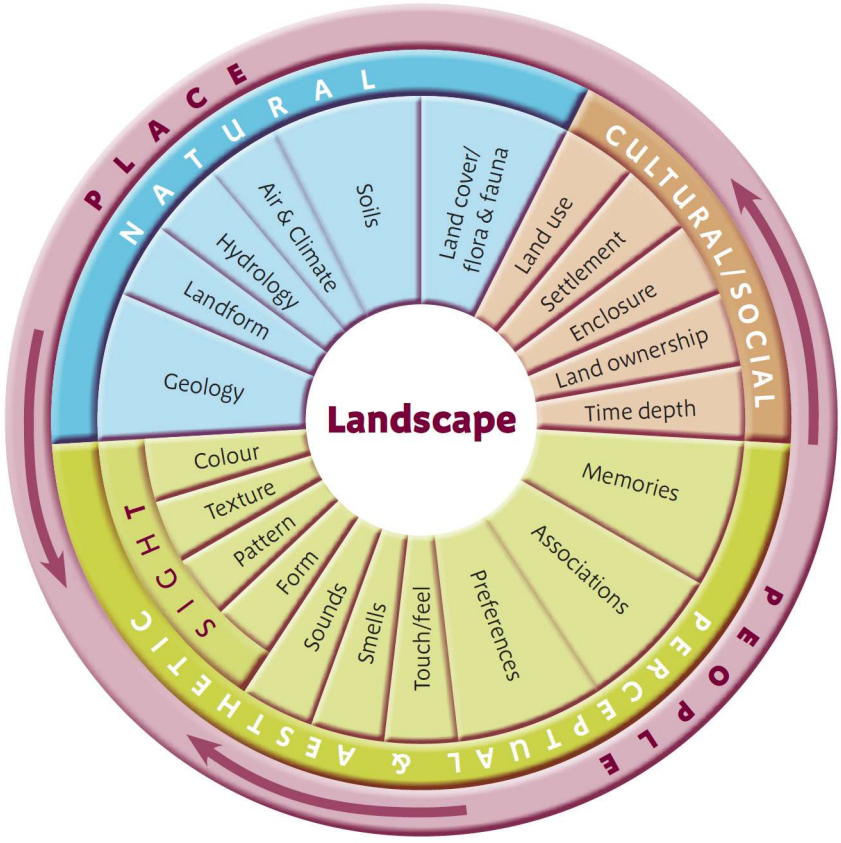

Figure 4.1. Components of Landscape

4.2 Valuation of Landscape in WebTAG

WebTAG states that "…*where possible, it is preferable for impacts to be measured in monetary values (monetisation)*" (#3.21). As noted in Section 2.1 of this report, landscape impacts are currently the subject of specific Supplementary Guidance. This sets out the current method for monetary valuation of landscape impacts (using the values in Table 4.2) and is the focus of this research project. At present, landscape is deemed to be a non-monetised impact for value for money purposes, due to uncertainties around the robustness of the monetisation approach. The presence

of non-monetary impacts in WebTAG appraisals helps capture non-monetised effects, but reduces decision-makers' ability to compare different impacts easily and consistently.

The current approach to valuing landscape in the supplementary VfM guidance uses values representing a bundle of ecosystem services. The values are differentiated across seven land types and range from £0.03m to £16.8m per ha (present value, 2017 prices). These are per hectare values representative of land types in ODPM (2001), as described in DCLG (2006). Those values were obtained from an extensive literature review which consolidated and considered evidence from 47 relevant studies, mainly from the UK but also from the US, Europe and Australia dating from 1984 to 2001.

The technical scope and measurement of the supplementary VfM landscape values is the specific set of natural capital assets and services as captured in the values in Table 4.1. This is different to the use of the term 'landscape' as a descriptive term, as assessed in non-monetary landscape appraisal techniques. These values represent a bundle of ecosystem services that reflect components of landscape, but do not represent all the features that make up landscape and do not capture the holistic value of a landscape. At the same time the values overlap with some other WebTAG categories and therefore create a risk of double-counting.

Table 4.1 shows the current coverage of the benefits from natural capital in WebTAG. It identifies five priority services for updating the landscape values in the supplementary VfM guidance.

The prioritisation in Table 4.1 is straightforward in most cases, but two services are ruled out for overlap and methodological reasons:

- Clean Water and hazard protection (flooding) is a gap in WebTAG and the supplementary VfM guidance, but is known to require locally specific modelling to appraise to an acceptable standard (ADAS & eftec, 2014).
- In the case of wildlife, the EVL Tool (eftec ,2015) only states that some biodiversity values are captured in valuations for other final goods and services (e.g. timber, carbon sequestration and recreation including wildlife watching). It excludes further elements of the value of biodiversity such as the benefits associated with the conservation of habitats and wildlife but provides a list of UK studies capturing these aspects of biodiversity. However, this has strong overlap with the 'Biodiversity' impact category in WebTAG.

This suggests that updating the landscape values in the supplementary VfM guidance to WebTAG should focus on:

- Landscape aesthetics/visual quality
- Air quality
- Noise/Tranquillity
- Recreation
- Global climate regulation.

Table 4.1: Coverage of Benefits from Natural Capital in Current Appraisal Process

Benefits	In current appraisal process?		Priority for 'Landscape' Guidance Update?
	In the supplementary landscape values	Other parts of WebTAG	
Aesthetics	Yes		Yes
Clean Air[1] (Regulation of Air quality)	No		Yes
Clean Water	Yes	Yes, under water environment	No, overlap and very local-context dependent benefit
Energy	No	Yes, under market impacts	No
Climate Regulation	No		Yes
Fibre	No	Yes, under market impacts	No
Food			
Hazard Protection (Flooding)	Yes	Yes, under water environment	No, overlap and very local-context dependent benefit
Recreation	Yes		Yes
Noise Regulation[1]	No		Yes
Wildlife	Yes, under ecology	Yes, under biodiversity	No, overlap and very challenging to value
Minerals	No	Yes, under market impacts	No

It should be noted that the coverage of benefits of the different land types in the supplementary guidance varies – not all benefits are captured in the values for all land types. This is mainly due to limitations of the available evidence.

(1) i.e. change in exposure due to the regulating effects of vegetation.

4.3 Landscape Valuation through Value Transfer

Value transfer (see Section 2.4.2) is an imperfect but frequently a valid alternative to primary valuation (Liu et al. 2012) – in particular when projects are in outline stage and when there are many hundreds and even thousands of small and similar assessments to make. In the UK, Defra published official guidance on how to select and adjust the existing evidence (eftec, 2010).

It may be possible to develop valuation evidence that links values from primary research into landscape, with scoring of landscape features such as in Swetnam's (2017) modelling of a visual quality index for different users (pedestrians, cyclists, car users) viewsheds. This approach is not expected to capture the holistic value of landscape. However, it can potentially capture a greater proportion of landscape value and/or do so more robustly (due to transfer validity being tested against the numerical indexes used) than current approaches.

4.4 Review of Economic Valuation Evidence

This Section examines the availability of economic valuation evidence that could be applied, through value transfer, in an update to the supplementary VfM guidance for landscape and WebTAG. The literature reviewed covers:

- The Environmental Values Lookup (EVL) Tool, which is referenced in WebTAG as a basis for valuation evidence in Government project appraisal.
- Economic valuation literature on the five areas prioritised based on consideration of WebTAG and the supplementary VfM guidance coverage in Section 4.2: Landscape aesthetics/visual quality, Air quality, Noise/ Tranquillity, Recreation and Global climate regulation.

Two pilot valuation studies, (eftec, 2007 and 2009) were undertaken specifically to address the question of whether and how landscape values in WebTAG can be updated. They did not reach the stage of a full economic valuation study, the results of which could have been integrated into WebTAG. Nevertheless, the typologies they use to classify impacts were informative for further work under this project.

4.4.1 EVL Tool

The EVL Tool (eftec, 2015) was developed for Defra to present a broad review of the economic valuation literature on a select set of broad habitats and ecosystem services in order to facilitate quick access to this literature for policy appraisal by Government departments. The EVL Tool covers all natural capital assets listed in the Natural Capital Committee's typology except atmosphere. Although not covered as an asset, impacts on atmosphere are covered through consideration of air quality. Greenhouse gas emissions and carbon sequestration are covered under global climate regulation. 'Hazard protection' is also covered through links to guidance on valuing reductions in flood risk and coastal erosion provided by the Environment Agency. This guidance provides a description of the approach to valuing the benefits of flood and coastal erosion risk management (FCERM) as a result of flood and coastal erosion projects or strategies but must be applied on a case by case basis, reflecting the highly context-dependent nature of flood risk reduction benefits.

4.4.2 Landscape Aesthetics

There are several methodologies described in the literature to produce an index of landscape quality (e.g. Swetnam, 2017) or monetary values for the aesthetic or visual quality value of landscape (e.g. Mourato et al, 2010). However, these values are for presence or complete destruction of landscape and cannot provide robust evidence to value the changes that alter (but not destroy) landscapes. The values from Mourato et al; 2010 relate to a view of nature by residents of properties and are expressed as £ per property. These estimates can be used to test the feasibility of applying valuation evidence based on the number of properties within the impacted proximity of a transport scheme.

New approaches to scoring landscape features are being developed using GIS (e.g. Swetnam et al, 2017), which could provide the basis for quantification of marginal impacts on landscape and therefore their valuation. However, it should be noted that the evolution of Landscape Character Assessment was in part inspired by disillusionment with attempts to quantify landscape value. Swanwick (2002) summarised this concern that "*many believed it is inappropriate to reduce something as complex, emotional and so intertwined in our culture, as landscape, to a series of numerical values and statistical formulae*."

It is important to note that economic valuation is about individuals' preferences, so values for all types of affected individuals should count. These include those who are directly and indirectly (positively or negatively) affected by the landscape change assessed. In line with landscape assessments they can be grouped into residents, visitors, non-users and passers-by (e.g. those who drive by).

Recommended economic value evidence for landscape aesthetics: No new monetary valuation evidence suitable for appraisal of marginal impacts on landscape in the UK has been identified.

4.4.3 Air Quality Regulation by Vegetation

The current UK Government methodology (Defra, 2011) for appraisal of local air quality impacts due to infrastructure projects considers NO_2 and PM10 concentrations and numbers of properties affected (using GIS). The role of vegetation in mitigating air pollution has been modelled for the UK natural capital accounts (Jones et al, 2017). This modelling has the potential to improve the appraisal of air quality impact in WebTAG.

The modelling by Jones et al (2017) can be disaggregated to show average value (£) per hectare for woodland and non-woodland habitats in urban and non-urban areas. They show a very large range and are only indicative of the order of magnitude of likely values. Further runs of the models are planned for the purposes of identifying representative values for types of vegetation in different local areas. The results are due during October 2018 and would be expected to be suitable for use as look-up values in transport scheme appraisal.

Several methods have been used in other air quality valuation studies worldwide, in particular related to individuals' willingness to pay to avoid associated damages.

Recommended economic value evidence for air quality regulation: The Jones et al (2017) approach generates value estimates of the benefit of vegetation improving air quality (in £ per ha). Their usefulness for transport appraisal is tested in the case studies – further refinement is expected later in 2018. **NOTE: See addendum on local value of air pollutant removal by vegetation**.

4.4.4 Noise Regulation by Vegetation

Vegetation can absorb noise, reducing the exposure and associated health impacts. This benefit was tested in a natural capital account for Greater Manchester (eftec et al, 2017). The test valued reduced night exposure of residential properties to noise by 1 and 2 dB, above a threshold of 55 dB, in terms of reduced sleep disturbance, and associated stress and ill-health. Subsequent work for Defra and ONS (eftec, CEH and CEP, 2018) refined this analysis and identified significantly lower values for this service in urban areas of the UK. These studies suggest there is significant uncertainty in the physical measurement of this ecosystem service, and this means there is also significant uncertainty in its monetary valuation.

The latest results suggest loss of noise regulation service may be a significant impact of a transport scheme only where a significant area of woodland is damaged, and if that woodland lies between a source of noise (e.g. existing transport infrastructure) and residential areas. This is a specific set of circumstances, which suggest impacts on noise regulation by vegetation may be small in most transport schemes, and only deserving of inclusion in such circumstances.

Alternative UK evidence is provided by Day (2010), which valued noise impacts from air, road and rail traffic in Birmingham: it found the marginal value of a decrease in noise increases with background noise levels. A 1 dB decrease in road and rail noise per property range from around £31 and £84 (from a base of 56dB) to around £89 and £137 (from a base of 80dB).

It should be noted that the health impacts of noise on households are appraised elsewhere in WebTAG. Therefore, use of separate approaches to value noise within WebTAG following the ecosystem services approach could lead to double-counting.

Recommended economic value evidence for noise regulation: The methods developed for the UK natural capital accounts suggest the value of noise mitigation by vegetation has significant uncertainty and may only be material in specific circumstances. Therefore, they are better suited for being appraised within the appraisal of noise impacts in WebTAG (to achieve a 'net' noise impact from transport schemes), rather than being included in any future Landscape guidance within WebTAG.

4.4.5 Recreation

WebTAG and the supplementary VfM guidance identify several ways that transport schemes can impact on recreation values:

i. Direct loss of formal recreational areas and/or loss of amenity value of formal recreational areas;

ii. Diversion of transport infrastructure and/or impacts from recreational sites, resulting in increased recreational value at that site, either through increased numbers of visitors and/or increased enjoyment per visit;

iii. Severance of (public) rights of way and/or loss of amenity value of rights of way, and

iv. Direct loss of public open space/common land and/or loss of amenity value on open areas.

There are numerous economic valuation studies of recreation. This project has focused on two major studies in the UK: the UK National Ecosystem Assessment (UKNEA) values and associated modelling by Sen at al. (2011), and the ORVal tool developed by the University of Exeter[16]. Both methods are suitable for estimating the total value of a recreational site, so can be used in relation to direct loss in (i) and (iv) above and severance of rights of way (iii). However, they do not provide values for changes in amenity in (i) and (iv), improvements in sites under (iii).

Using ORVal is generally preferable to the Sen values, as ORVal is a more comprehensive economic model, accounting for substitutes and site habitats, and can predict visitor numbers to sites. It is also consistent with other travel cost valuation approaches in WebTAG that use the value of time.

ORVal is not able to reflect higher visitor numbers and welfare values for special sites (e.g. sites with particular historical or cultural features, such as Greenwich Park). In these cases, if visitor numbers are known, the Sen et al (2011) values can be used. However, in general, as ORVal takes into account the influence of substitute sites, it is suitable for quick identification of the loss of value of recreation due to land loss due to transport schemes.

Recommended economic value evidence for recreation: The ORVal tool is suitable for appraisal of the value of accessible spaces that could be impacted by transport infrastructure. Significant assumptions, which are discussed further in Section 5.1, are required to appraise the effects of schemes on the amount and quality of recreation on adjacent areas of land.

[16] https://www.leep.exeter.ac.uk/orval/

4.4.6 Carbon storage and sequestration (Global climate Regulation)

Land take for transport projects also results in the loss of carbon stored in that land. Habitats with the highest stores of carbon per ha in the UK are those on peat soils and woodlands, and in coastal margins (UKNEA, 2011)[17]. Loss of woodland is the more realistic potential impact from transport projects, but they can also impact lowland peat soils (which occur in lowland raised bogs and wetlands) either by building over them or causing them to be drained.

The impact is both immediate (release of stored carbon) and long term (complete or partial loss of future sequestration by the habitat). For woodland, this impact can be quantified based on the average stock of carbon per ha of UK woodland, and valued using current carbon prices from BEIS (the central non-traded price for 2017is £64 / tCO_2e) giving a value of approximately £5,000 per ha.

For loss of future woodland sequestration, the ONS (2016) estimates of carbon sequestration across the UK woodland area, can be interpreted, assuming a proportional approach based on the estimated area of woodland within UK urban areas. Therefore, this is a crude approach based on average tree size and carbon sequestration factors. Based on a UK average of 5 tCO_2e sequestered per ha per year, the capitalised average value, over 100 years, of urban woodland (most likely to be impacted by transport projects) is £24,400 per ha. The combined total value of losing current carbon stored in woodlands and forgone future sequestration is estimated at approximately £30,000 per ha.

The additional carbon storage from woodland planting can be assessed using the methods developed to appraise planning under the woodland carbon code (See Section 5.3).

Recommended economic value evidence for carbon: appraisal of both the loss of carbon storage because of habitat damage and gains from mitigation can be quantified based on average rates of carbon storage and sequestration in the UK, and valued using the non-traded cost of carbon (BEIS, 2013).

4.4.7 Conclusion on Valuation Evidence

The information reviewed in this report provides:

- An understanding of the potential for updating WebTAG using the ecosystem service approach and natural capital framework: The ecosystem service approach is already used implicitly and explicitly within WebTAG and the supplementary VfM guidance. Values for specific services or benefits exist in external literature that could be applied in WebTAG, but the proportionality of doing so in transport appraisals requires further assessment. The relationship between specific services and the Landscape category of WebTAG is complex due to differences in terminology/definitions, most starkly in the bundle of services valued per ha by land use types in DCLG (2006) and the benefits typology outlined by the Natural Capital Committee (2017).
- The Landscape category in WebTAG does not directly value what is defined as Landscape under the European Landscape Convention (ELC) (2000). Valuation of impacts on the visual amenity of landscape in a manner that could support appraisal seems possible based on pilot work (eftec, 2007 & 2009), but would require primary research to generate values suitable for value transfer. Therefore, it is currently not possible.

[17] See chapter 14, Regulating Services: http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

- Five areas have been examined for literature that would support monetary valuation through value transfer in the supplementary guidance to WebTAG:
    - Landscape aesthetics / visual quality: no monetary values suitable to appraise the impact of transport infrastructure on landscape visual amenity has been found.
    - Air quality: recent modelling for national pollution removal in ecosystem accounts (Jones et al, 2017) could provide a basis for updating appraisal of transport schemes.
    - Noise: Day et al (2010) or current modelling of urban ecosystem services (eftec et al, 2018) could provide a basis for updating appraisal of transport schemes, but the latter suggests the service is of low value.
    - Recreation: both Sen et al (2014) values and the ORVal Tool can contribute to appraisal, the latter being the preferred approach.
    - Carbon storage and sequestration (Global climate regulation) in vegetation: using government guidance from BEIS. However, this relies on accurate estimation of the changes in the rates of loss of stored carbon and future rates of sequestration due to transport scheme appraised.

4.5 Potential Valuation approaches in WebTAG

This Section compares the existing approach in the supplementary VfM guidance to landscape appraisal to the evidence outside the guidance and considers how to integrate natural capital and ecosystem services into the current approach.

4.5.1 Comparison of WebTAG Landscape Values to Current Evidence

The values used in the supplementary VfM guidance from DCLG (2006) were generated across a range of benefit categories considered in ODPM (2001). Table 4.2 compares the current valuation evidence for the supplementary VfM guidance land types to the indicative valuation evidence reviewed in Section 4.4 and Section 2 of Annex 1. The key comparison is between the VfM guidance adjusted present values, and the Total Ecosystem Service present values (which sums the values for the four ecosystem services to its left). The data highlight the important role played by recreation in valuing loss of undeveloped land to transport infrastructure.

The comparisons in Table 4.2 suggest that the valuations in the supplementary VfM guidance are higher than would be suggested by current valuation evidence for some land types (e.g. urban core). However, this does not necessarily mean they are overestimates of total value. Some of the supplementary VfM values could have been discounted by the (lower) health discount rates (giving higher ecosystem service values). Some also include values for Soil which is not included in the current evidence. Furthermore, the current evidence base also includes values of avoided health costs due to physical inactivity, which are potentially of a similar order of magnitude to those for recreation (eftec et al, 2017). These are not included in the values in Table 4.2 as they are not part of the ecosystem services originally valued in the supplementary VfM guidance.

The robustness of values in the supplementary VfM guidance is assessed through their classification as ‘established’, ‘evolving’ or ‘indicative’ effects. The values in Table 4.2 are classified as follows:

- Recreation: *evolving*, for sites that are completely or mostly lost to recreational user with higher certainty for more typical and smaller sites, and *indicative* for sites where there is a partial loss of recreational use and/or enjoyment.

- Air quality regulation: *indicative*, but with bespoke use of available modelling could become *established*.
- Carbon: *established* under BEIS approach to valuation of carbon emissions, although uncertainties remain in the quantification of carbon storage and sequestration in some habitats.
- Noise: *indicative*, given the uncertainty about the measurement of the impact.

The implications of these estimates for value for money reporting are examined through the case studies to inform the overall suggested approach.

The results in Table 4.2 represent values generated by a mixture of methods and in a mixture of units. The WTP estimates, representing the bulk of the literature, can be presented in three different units: WTP (i) per visit - to a site (from recreation studies); (ii) per household and (iii) per hectare per year. For comparison, per visit and per household values were converted into per hectare values.

Table 4.2: Comparison of supplementary VfM guidance Landscape values for different landscapes and updated UK valuation evidence

Land Type	Present Value per ha (£m/ha) (2017)		Current Evidence for Ecosystem Service Present Values[a] (2017) £/ha					Comparison
	In VfM Guidance	VfM Guidance Adjusted[a]	Recreation	Air quality	Global climate Regulation	Noise	Total (PV)[b]	
Urban core	16.8	***8.2***	1 - 1.8m	69 – 40,080	Low, except woodland Low	£0 - £200,000 for blocks of canopy > 200m^2	***1 – 2m***	VfM Guidance values much higher
Urban Fringe (greenbelt)	0.28	***0.13***	0.1 – 0.6m				***0.1 – 0.6m***	Similar order of magnitude, but large range in ES values
Urban Fringe (forested land)	0.84	***0.41***		40,080	30,000		***0.1 – 0.7m***	VfM Guidance value similar
Rural forested land (amenity)	2.1	***1.0***	12,000	3,448	30,000	?	***0.45m***	VfM Guidance value higher
Agricultural Land (extensive)	0.98	***0.48***	-	235	Low	0	***0***	Unclear
Agricultural Land (intensive)	0.03	***0.016***	-	235	0 or negative	0	***0***	VfM Guidance value higher
Natural and semi-natural land	2.1	***1.0***	94,000	235	Generally low	0	***0.1m***	VfM Guidance value much higher

Notes: (a) Source: see literature review Annex 1. Adjusted to apply current discounting guidance: Annual values are taken from VfM guidance. For this analysis they are converted to PV for 100 years using the HMT regular (not the health) declining discount rates and no income uplift to WTP. (b) Total is the sum of recreation, air quality, Global climate regulation and noise.

4.5.2 Integrating natural capital and ecosystem services

There are a range of ecosystem services typologies used in the economic valuation literature in the UK. This is reflected in the different typologies used in ODPM (2001) study from which the supplementary VfM guidance numbers originated and the literature reviewed in Section 2 of Annex 1. This variety also motivated the Natural Capital Committee to define a benefits typology (NCC, 2017).

The supplementary VfM guidance presents a mixture of benefits: recreation, landscape, ecology, cultural heritage, hydrology, air quality and local climate. Of this list, the following categories are appraised (qualitatively or quantitatively) elsewhere in WebTAG, posing a risk of double-counting: Ecology (Biodiversity category of environmental capitals); Cultural Heritage, and Hydrology (water environment). Air quality and noise impacts of vehicles are also appraised in WebTAG, but the impacts considered here are the air pollution and noise regulation functions of vegetation (which may be lost due to a scheme and gained due to mitigation), which are different. Thus, there is no risk of double-counting in these services, but a need for consistency of methods.

Analysis can examine these impacts directly, but also look at the environmental assets that provide them. The latter is the core of the natural capital approach. It can provide a more thorough basis for assessing impacts because it examines impacts on the ability of the environment to continue to provide benefits to people into the future. The value of the natural capital asset is then estimated as the present value of benefits provided over time. The expected benefits over time are assessed in the context of the current state (extent, condition and location), and future trends in, the assets.

The term ‘environmental capitals’ in WebTAG reflects this concept but is now out of sync with the prevailing terminology of ecosystem services and natural capital. Furthermore, as mentioned above, the values used to reflect Landscape impacts in the supplementary VfM guidance represent a range of benefits (or a ‘bundle’ of services) from different types of land. Not all of these are necessarily closely associated with ‘Landscape’. For example, values for recreation contribute to the high value for ‘urban core’ green space (see Table 4.2).

4.5.3 Options to Adjust WebTAG

In summary, the landscape values in the supplementary VfM guidance reflect a bundle of services. They may double-count with other parts of the WebTAG environmental capitals approach and may not fully represent what landscape professionals recognise as landscape impacts.

It is recommended that WebTAG adopt the Natural Capital Committee’s guidance to define natural capital assets based on the broad habitats from the UK National Ecosystem Assessment. However, it is noted that this implies adjustment of the broader WebTAG structure, which is beyond the scope of this work to resolve.

Annex 1 presents two broad value transfer options to adjust the WebTAG landscape approach to valuing ecosystem services. Firstly, ecosystem services currently bundled in the supplementary VfM guidance could be valued separately. Secondly, a new bundle of values for different land types could be estimated. These two options have been investigated further through the case studies (see Section 4.6).

4.6 Case Studies Findings

The project applied the valuation evidence discussed above to the appraisal of impacts for three transport schemes (see Section 3.4). Although the analysis has been partly hindered due to data limitations, there are several lessons learned regarding the proposed appraisal methods. The suggested appraisal methods (supplementary VfM guidance and current economic value evidence) performed very differently in terms of uncertainty and in fitting the available data within scheme appraisals.

- Landscape aesthetics / visual quality

Applying the Mourato et al (2010) value used for landscape aesthetics, which was already uncertain and subject to many assumptions from the original paper, added further uncertainty. The change in visual effects measured in the scheme appraisals in the case studies did not match the change valued by Mourato et al. Overall, there are large uncertainties around using this value and using valuation evidence for the appraisal of this impact is not considered suitable for transport scheme appraisal.

- Air quality

The air quality valuation using indicative values from Jones et al (2017) was relatively straightforward for vegetation impacted by the schemes. However, the high degree of uncertainty of the values, which are based on interpolation from models of air pollutant removal by vegetation, needs to be overcome with further research that will be ready later in 2018. This can produce a look-up table of the estimates for the value of air quality regulation in different land types and parts of the UK.

- Noise

The valuation of noise regulation by vegetation could not be tested through the case studies. This was due to a lack of quantitative site-specific modelling of the noise mitigating effects of vegetation. Such modelling requires detailed data on noise sources, tree canopy extent and properties, applied at a fine spatial scale (eftec et al, 2017).

The electrification case study gave an interesting trade-off in the scale of noise impacts. A benefit of electrification is the reduction in noise (of approx. 3dB). But electrification necessitates vegetation removal, and this could result in the loss of noise mitigation, giving a net impact on properties of a reduction of 2dB rather than 3dB.

- Global climate regulation

The appraisal of the carbon storage is well-established for some UK habitats and the values used are spatially insensitive. The carbon storage can be valued using the non-traded carbon value from BEIS guidance (2013). Therefore, changes to carbon sequestration capacity of vegetation can be readily valued based on the habitat changes in the case studies. Overall, we note that the value of carbon storage is relatively low. This is because of the relatively small areas of habitats with high carbon storage and/or sequestration potential (in these cases woodland) lost to the transport schemes. For example, they are lower than the impacts of losing vegetation in relation to air quality regulation.

- Recreation

Recreational areas and footpaths directly affected by schemes (i.e. lost or created) can be identified and valued using the ORVal tool. The indirect effects on recreation (changing the

quality of recreational activity or amenity) are more problematic. Accessible areas or footpaths affected can be identified, and their total value for recreation estimated using ORVal. However, there are two major uncertainties in applying this evidence in appraisal:

i) The distance from schemes over which recreational sites are indirectly affected is dependent on topography, type of recreation, type of transport scheme and types of impacts (e.g. visual amenity or noise). While sites within a scheme's viewshed, which can be several km, might be affected, the supplementary guidance limits the impacted area to within 500m of a scheme.

ii) The proportion of a site's value lost due to the indirect effects is uncertain. This might be estimated based on expert judgement but will have high uncertainty unless supported by further research.

- Benefits of mitigation / compensation

There are mitigation measures in place including new recreational areas around the A14, and habitat restoration around the A3. The costs of undertaking these mitigation actions are assumed to be captured elsewhere in the project appraisal process. The valuation methods used for ecosystem service impacts (recreation, air quality regulation and Global climate regulation) can also be used to appraise benefits from mitigation. This is effectively the reverse of the processes used to appraise negative impacts of schemes.

4.6.1 Appraisal assumptions

One of the objectives of the case studies was to test different combinations of discount rates and time horizons and understand the sensitivity of results. We tested two combination of declining discount rates, "STPR" and "Health", with the latter using lower discount rates. We tested them against two time horizons: 60 or 100 years. Therefore, we have four sets of present value calculations: PV60 STPR, PV100 STPR, PV60 Health, and PV100 Health[18].

As expected, higher discount rates and shorter time horizons have the effect of reducing the present value. More precisely, it is almost always true (except A3 landscape aesthetics which have significant variation over time) that:

- PV60 STPR < PV100 STPR < PV60 Health < PV100 Health if there are positive values to be discounted, and
- Vice versa if there are negative values.

Hence, we note that choosing "Health" discount rates instead of the "STPR" affects the present value more than changing the time horizon from 60 to 100 years.

Furthermore, we note that, if the impacts only occur in one direction (i.e. either only negative or only positive), and are constant over time, the scenario PV100 Health will produce a present value about twice the PV60 STPR. When the impacts are not constant over time, the ratio between the two scenarios is unpredictable. For instance, in the A3 carbon sequestration,

[18] The discount rates used were drawn from a draft guidance on discounting published in the Green Book 2018 update during the project, which enabled testing of different assumptions. They vary slightly from the final recommended approach in the Green Book so should be treated as illustrative, rather than a reflection of UK Government appraisal guidance. For example, our test does not include income uprating.

PV100 Health produces a present value over three times the PV60 STPR, as the price of carbon increases over time.

Further unpredictability is added when there is a variable time profile of benefits and negative impacts. If the time profile is asymmetrical, different discount rate assumptions can result in net impacts being assessed positive or negative. Overall, given the variety of size, direction and timing of the impacts from transport schemes, appraisal results are likely to be sensitive to assumptions on timescales and discount rates, and this can change the net impacts of a scheme on a particular ecosystem service (e.g. visual amenity) between positive and negative, or vice versa.

4.6.2 Comparison of the new valuations versus the current supplementary guidance on landscape

The case studies have demonstrated valuation of a range of ecosystem service, with varying levels of uncertainty. Bearing in mind these uncertainties, it is possible to aggregate the valuation of different services and compare this sum with the result of applying the Supplementary Guidance on Landscape for each case study. This comparison is summarised in Table 4.3.

- A14 Case study

Total ecosystem service value gives a total cost of £1.2 million under the PV60 STPR scenario and a benefit of £6.1 million under PV100 Health. Hence, it is not clear if the Scheme leads to a net benefit for ecosystem services overall. Under PV100 Health assumptions both the current guideline (partial) and the new valuation estimates gives a net benefit of £ 6.1 million, which should not be interpreted as convergence of methods.

This case study highlights the importance of assumptions about the project lifetime, the distribution of impacts over time and the discount rates used. In fact, in the methods investigated to for the valuation of both landscape aesthetics and air quality, the sign of the present value changes depending on the discount rate used, but not on the time horizon. This happened because most of the negative impacts occur in the near future, and the benefits further in the future. Low discount rates give more weight to the benefits from mitigation, which occur after a lag, and as a result the present value becomes positive.

- A3 case study

Total ecosystem services value using new value estimates shows a cost ranging from around £3 million under PV60 STPR to £7 million under PV100 Health. The loss of air quality regulation service due to lost vegetation is the largest contributor to this cost.

The supplementary VfM guidance has been applied only partially based on the data on the actual footprint alone. This application leads to a cost estimate ranging from around £16 million to £36 million depending on the scenario. Thus, implementing (partially) the supplementary guidance leads to an impact five times higher than using the new value estimates. This difference is mainly due to the classification of the land loss as “urban core”, which is assigned a very high value in the supplementary guidance.

- GWME Case Study

Total ecosystem service value using new value estimates shows a cost ranging from around £7 million to £14 million under PV60 STPR and PV100 Health, respectively. Again, the loss of air quality regulation service due to lost vegetation is the largest contribution to this cost.

Applying the Supplementary Guidance led to lower cost estimates (£2 to £5 million) when applied partially (to the footprint of the scheme). This is about three times less than using the new value estimates, but of a similar order of magnitude. When the Supplementary Guidance is applied in full, the cost estimates are significantly higher at around £190 to £409 million. The reason for this is that full application assumes the land loss extends for a further 250 meters on each side of the Scheme, along its 28 Km of length. Furthermore, the land cover data was not provided within the appraisal documentation used, and therefore we assumed the land adjacent was rural woodland. Although not a precise estimation, this shows the potential sensitivity of these appraisals to assumptions about the distance from the infrastructure over which impacts arise and the type of land cover.

The lineside habitat vegetation cleared as part of the scheme does not align to any of the land type categories in the supplementary VfM guidance. They also illustrate the significant differences in the spatial distribution of scheme impacts – some impacts are restricted to the few meters adjoining the infrastructure (e.g. carbon sequestration), whereas visual amenity can be impacted over several kms.

This example illustrates how the value of the bundle of ecosystem services proxied by land types has the same uncertainties as using the values for individual ecosystem services. However, the bundled approach introduces further inaccuracy by making the values of all ecosystem services vary in unison across different land types, and applying all the values via the same units of impact (area of land).

Table 4.3: Summary of Case Study Valuations using new value estimates and the supplementary guidance

	A14		**A3**		**GWME**	
(£ m)	**PV60 STPR**	**PV100 Health**	**PV60 STPR**	**PV100 Health**	**PV60 STPR**	**PV100 Health**
Aesthetics	-0.3	1.1	-0.4	-0.4	NA	NA
Air Quality	-2.9	1.2	-2.6	-5.4	-6.4	-13.4
Recreation	The change due to the scheme is not estimated, but potentially in the order of magnitude of £millions					
Carbon	1	3.8	-0.4	-1.4	-0.3	-0.9
Total	**-2.2**	**6.1**	**-3.4**	**-7.2**	**-6.7**	**-14.3**
Supplementary Guidance (partial)	2.8	6.1	-16.6	-35.8	-2.4	-5.1
Supplementary Guidance (full)	-1.2	-2.5	NA	NA	-189.8	-408.5

The results in Table 4.3 suggest that the choice of land type is important, and their values in the supplementary guidance vary significantly. Comparisons of the ecosystem service and land type values are inconclusive. However, even accounting for the uncertainty involved, the reasons for variations in ecosystem service values do not give confidence that the substantial differences between values for different land types in the supplementary guidance reflect actual impacts on people's welfare.

The ecosystem services values have significant uncertainties when applied to the case studies. Overall, they could not be used to appraise scheme investments either individually or summed into a bundled value. However, some of the valuations (e.g. of air quality, carbon)

can be used to unpick the scale and distribution of impacts. For example, they help understand the distances and spatial scale over which schemes have effects and identify winners and losers. In the case studies, analysis identified some groups which will experience negative impacts from schemes, even though the appraisal of landscape effects gives overall positive outcomes. The ecosystem services values, therefore, provide potentially important evidence on the distribution of impacts. This evidence can help with mitigation design/actions for schemes, in a way that bundled values in the supplementary guidance do not.

4.6.1 The Appraisal Process

The case studies suggest that the current assumptions on the distance over which schemes have an impact are not appropriate for applying current ecosystem services valuation approaches and value estimates.

For some services (global climate regulation, air pollutant removal) the relevant area of impact is the area of vegetation that is lost due to the scheme. For other services (recreation, landscape aesthetics / visual quality), impacts can arise some distance either side of the transport project. Therefore, the use of fixed distances is arbitrary, and not in line with available tools to identify the actual distance of impacts. A better approach, illustrated in the rail electrification case study is to identify the viewshed of the new scheme using GIS software. This approach can be standardised to be applied in a proportionate manner in appraisal and is already undertaken to identify the zone of visual influence in the Landscape appraisal element of WebTAG.

Another difficulty identified by the case studies is the use of land types in the supplementary landscape appraisal guidance for WebTAG:

- Some habitats affected (e.g. lineside vegetation in urban areas) do not obviously match a land type;
- Some habitats could fit in more than one category (e.g. public accessible heathland at A3 could be ‘public open space’ or ‘natural/semi-natural habitat’), and
- Land types are not consistently defined in relation to characteristics that determine value. For example, accessibility (and therefore recreational value) is identified through ‘rural amenity woodland’ but not for urban fringe land. Furthermore, some potential land types are missing, such as non-amenity rural woodland.

5.0 Recommended Valuation Approaches

This Section makes recommendations on the use of valuation evidence for the ecosystem services currently covered by the supplementary landscape guidance to WebTAG. The recommendations also have implications for some other parts of WebTAG.

5.1 Landscape Appraisal Options

The current approach to appraising Landscape within the supplementary VfM guidance uses values for bundles of ecosystem services that are no longer not considered fit for purpose for several reasons:

i. Calling this category 'landscape' is confusing because while it may cover some elements of what makes up a landscape, it also omits significant elements (such as visual amenity) and overlaps with the use of the term landscape to reflect its established meaning within landscape appraisal (i.e. based on landscape character assessment as covered elsewhere in WebTAG).

ii. The definition of the land use types is incomplete - there are some impacts on habitats that cannot be matched to an appropriate category (e.g. urban railway line-side vegetation) and inconsistencies in relation to current evidence (e.g. it is unlikely that rural woodland has a higher value than green belt woodland).

iii. The monetary values for the land use types are not defensible, being two decades old, and not in line with current evidence from published literature.

iv. The way the values are applied spatially (as a bundled value to an area of land either side of the transport infrastructure) does not reflect current understanding of ecosystem services and natural capital. In particular:

    - Some services are only impacted when habitat is lost (e.g. regulation of air quality, mitigation of noise, global climate regulation through sequestration and storage of carbon) and so are only relevant to the footprint of the scheme.

    - Other services (e.g. visual amenity, recreation) are impacted in areas adjacent to the infrastructure, but the way this area varies with local conditions can be assessed using standardised GIS approaches (e.g. to estimate viewshed). The effort required to apply these approaches is proportionate to scheme appraisal effort (it is already done in landscape assessment), and hence the current approach to assume impacts arise over a fixed distance (500m from the scheme) is an unnecessary simplification.

Given these issues, the review of the current approach and valuation evidence available led to consideration of different potential approaches to change the current system:

1. Value the priority benefits from each land type individually, replacing the monetary values in the supplementary VfM guidance on landscape where new evidence is available. This should include benefits already valued (e.g. air quality, recreation) and benefits that are not currently reflected in the supplementary guidance (e.g. global climate and noise regulation).

2. Create new bundled values for landscape impacts by:

a. Adding the values for further services (e.g. carbon storage, noise regulation by vegetation, air quality regulation) to the existing bundle of values in the supplementary VfM guidance. These services are omissions from the coverage of WebTAG and the supplementary guidance and are now feasible to appraise and value.

b. Recalculating bundled values for different land types reflecting all the priority landscape services (i.e. an update of the 2001 ODPM study).

Based on the review of valuation evidence and the case studies, the options to develop new 'bundled' approaches to valuation (2 (a) and (b) above) are not recommended because:

- The issues in the way values are applied spatially would not be resolved.
- The different services are known to vary for different reasons in different locations, so identifying an expanded typology of land types could be challenging.
- The important role of the supplementary landscape guidance in shaping mitigation options will be better informed through separate consideration of services. This is because different actions, in different locations, can be taken to mitigate impacts on different services. For example, in the A3 Hindhead case study:
    - Habitat restoration is undertaken in one location resulting in newly accessible areas for recreation, mitigating impacts on that service from the new infrastructure.
    - Tree planting is undertaken in a different location to mitigate visual amenity impacts of the scheme on households, but also providing new carbon sequestration.

Therefore, the suggested approach is for individual ecosystem services from the different land types to be valued separately.

5.2 Appraisal of Individual Ecosystem Services

There are several aspects to the approaches required for appraising different ecosystem services. These are described in this section in relation to:

i) The spatial area over which transport scheme impacts occur.

ii) Guidance on the threshold at which an impact on a particular ecosystem service is expected to be material and require further appraisal. This is important because appraisal effort is expected to be proportionate to the size/ cost of a scheme and its impacts. This guidance is expected to work alongside expert judgement, also taking into account evidence from elsewhere in the appraisal process where relevant.

iii) If material, the approach for measuring the change in the service due to the transport scheme and valuing it.

In this context 'material' means significant enough to influence a decision. This could be the decision to go ahead with a transport scheme, the choice of option (e.g. route) or the design of mitigation measures. Section 5.2.1 discusses the spatial area of change. Sections 5.2.2 – 5.2.6 summarises the (materiality) threshold and valuation (in quantitative and monetary terms) for each of the ecosystem services covered in this report.

The appraisal process is described for each service in terms of how the impact is quantified and how it is valued. How these approaches can be applied to appraise mitigation is discussed in Section 5.3.

Based on the evidence examined in this report and tested through the case studies, there are appraisal approaches available, or that could be developed with low cost, for some of the ecosystem services currently covered in the supplementary guidance on landscape. For other services, the valuation evidence requires further primary research before it can be applied in transport appraisal.

5.2.1 Spatial Area of Impact

The case studies suggest that the assumptions on the fixed distance over which schemes have an impact are not appropriate for applying current ecosystem services appraisal approaches.

For some services (global climate regulation, air pollutant removal) the relevant area of impact is the area of vegetation that is lost due to the footprint of the transport scheme. For recreation and landscape visual amenity, impacts relate to the visibility of infrastructure and can arise some distance either side of the transport project. Exactly what this distance is depends on the context of the scheme, location and type of recreation.

A better approach, which can be standardised to be applied in a proportionate manner in appraisal, is to adopt different approaches for different benefits. For recreation and landscape visual amenity, appraisal should identify the viewshed of the transport scheme using GIS software. For other services, the impact should be appraised based on the area of habitat lost due to the impact of the transport scheme. Both the viewshed and the area of habitat lost are already identified in other parts of the transport scheme appraisal process.

The viewshed approach is already undertaken to identify the zone of visual influence in the landscape appraisal element of WebTAG and aligns with good practice in landscape appraisal. It is a relatively straightforward function to run in GIS and can take into account tree/ building elevation data (as done in the appraisal of the A3 case study). Where elevations are not taken into account, it gives a worst-case assessment of the viewshed. An example of viewshed analysis was carried out for the Reading-Didcot rail electrification case study, described in Annex 2.

The case study tested the approach on a segment of 0.5km of rail line. LIDAR data (in the form of a Digital Surface Model[19]) is freely available. It can be used to represent surrounding elevations, such as buildings and vegetation, as well as the terrain surface. It has a spatial resolution of 1 meter[20].

[19] http://environment.data.gov.uk/ds/survey/#/survey?grid=SU67

[20] LIDAR flown information is made available for all Highways England projects/ schemes. Highways England have dedicated specialist team who manage and request various asset surveys such as Mobile Mapping Surveys delivering accurate surface visible asset inventory, HD imagery as well as grassed area inventory. Another team use a web-based system - Asset Visualisation & Information System (AVIS) – which allows users to view high definition images/videos and 60+ surface visible asset types to help inform scheme design. (H. Penner, pers com)

With the elevation data in GIS, a software plugin was used for Advanced Viewshed Analysis[21], allowing creation of a viewshed for multiple points – reflecting the linear nature of most transport infrastructure. These can be used to represent overhead line gantries for the rail electrification, or points along a new road. In the latter case they should represent the height of vehicles (i.e. a lorry) to accurately reflect what people will see. With these automated approaches available to use within standard GIS approaches, viewshed analysis is straightforward and proportionate to be consistently applied as standard practice for ecosystem services appraisal in WebTAG.

Once the viewshed has been identified for the transport project, data can be generated for the area it covers as input to further analysis:

- Land types can be identified based on broad habitats in the Land Cover Map (CEH 2017). DfT has vector data for this map to use in transport appraisals and can also source data on land cover based on shapefiles for a transport scheme route and buffer from CEH.
- Areas in which recreation takes place can be identified. In England and Wales this can be done through visual comparison of the viewshed with the ORVal Tool. This will be aided by adding an infrastructure data layer like Streetmap to the viewshed, to help correspond the two data sets. It is possible to undertake this process in GIS (i.e. identify the values for multiple sites within a boundary defined by a GIS layer), but at present capacity to do so only lies within Exeter University. Undertaking the process manually is more time consuming, but still feasible and proportionate – a large infrastructure project might be expected to impact up to 50 sites per 10km. eftec's experience of extracting data from ORVal suggests that doing so for 50 sites takes a researcher half a day.
- Properties can be identified within the viewshed and differentiated by type (residential/commercial/industrial). This can be done with the property data already used to appraise the impacts of the scheme elsewhere in WebTAG.

5.2.2 Recreation

Recreation is a benefit which can have significant influence on the value of green space. This is reflected in the high value of the amenity rural woodland in the current supplementary guidance land types.

The suggested approach to appraisal is based on the Outdoor Recreation Valuation Tool (ORVal) (University of Exeter, 2017). This online tool has been developed for Defra to estimate the recreational visit numbers and value (£) of open access green space sites in England and Wales. It is described in Section 2.6.2 of Annex 1.

ORVal can be used to identify the estimated total number and value of recreation sites (open area or footpaths) likely to be impacted by a transport scheme. This information should be identified in other appraisal of scheme impacts (e.g. through the EIA process). The use of ORVal or other data sources should be coordinated across these appraisal processes. The recreation sites identified should include sites which will be partly or completely lost because

[21] https://plugins.qgis.org/plugins/ViewshedAnalysis/

of the scheme. It also includes sites that will be indirectly impacted by the scheme, due to the scheme being visible and/or audible from the site.

The monetary values provided by ORVal are welfare values, calculated using the travel cost method, also used to value the cost of travel time already covered elsewhere in WebTAG. Like any model, ORVal has limitations. An understanding of what it models, the data sets it is based on and the nature of its limitations will be useful for interpreting the estimates it provides, including circumstances in which these might have significant inaccuracies (e.g. for culturally iconic recreation sites).

i. Threshold

If the total value of the recreation sites affected by the scheme is not material to the scheme design or mitigation of impacts, then changes to recreation do not need further analysis.

ii. Valuation

If the value of changes to recreation is considered material, then further analysis can use ORVal.

- Quantify & value

For sites directly destroyed by the transport scheme, the cost of this impact is their total value in ORVal. For sites indirectly impacted by the transport scheme, the marginal change in the total value identified in ORVal needs to be assessed.

Some aspects of a transport scheme's indirect impact on recreation (e.g. the size of a site) can be examined through ORVal. Other aspects of such impact cannot (e.g. change to visual amenity of a site). Across the range of factors that influence recreation values, whether the changes in these factors can be examined through ORVal, and whether they are likely to be impacted by a transport scheme, are listed in Table 5.1.

Table 5.1. Factors influencing appraisal of the indirect impacts of transport schemes on recreation

Factors that determine Recreation value	Included in ORVal?	Measure change in ORVal?	Can be affected by Transport Scheme
Environmental factors			
Size	Y	Y	Y
Habitats	Y	Y	Y
Access Points	Y	Y	Y
Surrounding population	Y	N	N *
Substitutes	Y	N	?
Complements	N	N	?
Surrounding landscape (visual amenity)	N	N	Y
Surrounding landscape (holistic quality)	N	N	Y
Noise	N	N	Y
Air Quality	N	N	Y
Contamination (e.g. no litter)	N	N	N
Other factors			
Car park	Y	N	N
Surfaced footpaths	N	N	N
Other facilities (e.g. viewpoint)	N	N	N

Other culturally distinctive features (e.g. archaeological, community coherence)	N	N	N
Information provision	N	N	N
Toilets	N	N	N
Cafe	N	N	N

* except when transport schemes are combined with housing provision.

The list of factors in Table 5.1 is not exhaustive. Other factors could be separately identified or regarded as nested within those listed (e.g. tranquillity, presence of wildlife).

Three of the factors (size, habitat type, access points) can be impacted by transport schemes and can be analysed in ORVal (users of ORVal can adjust them in an interactive map to provide revised values). For the rest of the factors, ORVal cannot be used in this way and assessment requires expert judgement.

To enable an illustrative calculation, the case studies assumed a range of impacts of a loss of between 10% and 50% of the total values identified from ORVal. This range was based on the study team's previous experience of recreation appraisal.

This expert judgement can be informed by:

- Assessment against the list in Table 5.1, for example by identifying which factors will be impacted by the transport scheme, and if so how significantly (e.g. high, medium, low impact).
- Change in the characteristics of the landscape (e.g. designations, or the extent of existing infrastructure).
- Degree of impact on the recreation site (taking into account proximity and how much of the site is in the viewshed of the transport infrastructure).
- The consultation in relation to a transport scheme, which may give an indication of which factors that influence recreation value are likely to be impacted, and how severely, by the scheme.

Further research is needed to establish the size of the marginal impact. The scale of the impact will be determined by how the scheme affects the factors in Table 5.1 and other characteristics of the site. Impacts can be on the number of visitors using a site for recreation, the duration of visits, and the enjoyment of the visit, all of which impact welfare:

- As stated above, if a site is built over by the transport scheme, all its value will obviously be lost.
- A site may not be completely lost, but could be severely impacted, for example if:
    - Half the area of a small site is built over, the remaining areas may no longer offer a useful recreational resource.
    - A scheme is built directly adjacent to a footpath and completely changes its characteristics (e.g. is a dual carriageway is built alongside an existing footpath). This may dramatically reduce the use of the site/footpath.

- In both these cases, the appropriate assumption to appraise the scheme's impact (as an upper bound to the assessment) could be that all the site's recreational value is lost.

- For a scheme that has a significant impact on a larger site, but leaving a significant part of it still useable, an assumption will need to be made about the proportion of the site's value that is lost.

- Recreation sites that are some distance from a scheme may still be impacted by the noise from vehicles and visual impact of the transport infrastructure (and possible also smell and light pollution). However, this type of impact will also depend on context, such as the amount of existing infrastructure in the surrounding landscape (i.e. landscape type).

5.2.3 Landscape Aesthetics / Visual Quality

This service covers the visual amenity aspect of landscape, but not other intangible aspects of landscape that combine to make up the holistic value of landscape covered in landscape appraisal. Visual Amenity impacts can arise in the viewshed of a scheme for both residents and visitors. Visitors may be undertaking recreation or in the area for other reasons, such as work or in transit (e.g. driving).

While it is not possible to value this impact with currently available evidence, this section proposed two options for primary research.

i. Threshold

A qualitative assessment of the severity of impacts on landscape, and the extent to which they are visible (viewshed) will be identified as part of scheme appraisal through WebTAG as scheme proposals are developed. Therefore, a threshold for significant impact can be defined from this evidence.

ii. Valuation

If the value of changes to landscape visual amenity is considered material, then further analysis can use the viewshed to quantify impacts.

- Quantify

The case studies demonstrate that the impact of transport schemes on visual amenity can be defined through viewshed analysis in GIS. The number of people impacted within the viewshed can be identified through property data for residents and businesses. This could omit those who do not always work at a property (e.g. in agriculture or forestry).

The electrification case study identified that visual impact of the overhead lines on properties could be quantified. It could also be possible to use the method developed by Swetnam (2017) to quantify the landscape features affected by the transport scheme to support valuation of some aspects of landscape.

- Value

No suitable valuation evidence has been identified for use in appraisal of transport scheme impacts on the visual amenity of landscape. Therefore, further primary research is needed if monetary valuation is to be undertaken in future. There are two broad options that could deliver this. Both methods could be designed so that they provide values suitable for use in value

transfer (see Section 2.4.2) to appraise transport scheme impacts. For both methods, the validity of value transfers using the results would be tested as part of the research process.

Firstly, a repeat sales approach (see Box 5.1) could be applied to properties affected by past transport schemes. This method could capture the value placed by residents on a bundle of goods impacted by the scheme (e.g. noise, air pollution, recreation and visual amenity). To provide values suitable for value transfer, data would need to be generated for a sufficiently large sample of property sales, affected in different ways from a sufficiently large number of past transport schemes.

Secondly, a stated preference study could be used to identify values for typical landscape impacts of transport studies. Scoping and pilot studies by eftec (2007, 2009) developed the specification for such a study and suggested it would be able to generate robust values for use in appraisal. Such a study should be designed to reflect variations in visual amenity value taking into account the:

- Type of transport infrastructure/scheme (which could reflect the common types of transport infrastructure that investments are expected in);
- Main landscape types affected;
- Description of all the relevant impacts of the transport schemes (e.g. number of properties affected in the viewshed and the scale of effect, impact on recreational opportunities etc.)

If both approaches are used, the questionnaire and sampling strategy need to be designed in such a way to avoid double counting between the approaches. For example, stated preference study could be done with those who visit or drive through the affected area, while property prices would reflect the preferences of the residents only. Stated preference study could also capture the preferences of non-users. However, the suitability of non-user values for transport scheme appraisal could be limited (e.g. non-use value would likely be held for special places which may already be protected by planning policy). Nevertheless, qualitative testing should be performed before concluding on which valuation approach to be used and how it should be designed.

A stated preference study could also be to use the landscape characteristics that can be consistently measured (as per Swetnam's (2017) scoring). However, this would be more likely to generate values for generic landscape characteristics, rather than the impact of transport schemes per se.

Box 5.1: Repeat Sales Approach[22]

The Repeat Sales Model is a variation of hedonic pricing. It uses a difference-in-difference model to estimate the change in housing prices after the "impact". Several types of transport schemes, such as the GWR electrification and new road bypasses are suitable settings to apply a Repeat Sales Approach, which is a variant of hedonic pricing. It enables estimation of the changes in the value of properties impacted by transport schemes (e.g. as identified in the electrification scheme case study).

Properties with the view on the overhead line electrification (OLE) gantries can be determined using a GIS viewshed function – they are referred to as the 'treatment' group. Properties without a view of the scheme but located near the treatment group are selected to form the 'control' group. Using repeat sale values from the same properties reduces the risk of omitted variable bias, giving a strong causal relationship between the changes in sales price and the impact (i.e. the construction of the OLE gantries). The transaction data are available from the Land Registry and are dated, allowing differentiation between properties that have been sold before and after scheme construction.

While the method is feasible, its appropriateness needs to be judged against three key factors. First, the impact of the change in the landscape on property prices cannot be distinguished from the impact of increased noise, emissions and other factors associated with the scheme. Thus, the method would estimate a bundle of impacts. Second, a distance decay relationship would need to be tested using GIS tools – as properties further from the OLE gantries would be impacted less. Third, the analysis should differentiate between different contexts, such as rural areas, where the OLE gantries affect a more natural landscape, and the urban areas, where it does not. The data to adjust for different contexts would be generated using GIS tools.

Producing a bundled value would lead to a risk of double-counting risk with other impacts covered in the supplementary landscape appraisal, and other parts of WebTAG. The method could be applied to only properties within the scheme viewshed, giving a bundled value for them. If a similar value could be derived for properties outside the viewshed but otherwise similarly impacted, then the differences between these samples could in theory isolate the impact on visual amenity. However, the controls and assumptions necessary in this analysis make it harder to implement.

The idea of 'differences-in-differences' is that observing the change in price of the same property before and after the change allows us to net out the impact of observed and unobserved characteristics of the properties; that's our first difference. If prices are following some general trend, then even after we've taken the first difference we might see a change in prices in the control group. Taking that general price trend away from the change in price seen in the treatment group, which is the second difference, allows us to identify the change in price caused solely by the transport scheme. This sort of approach has been used frequently in the literature; for example, to value transport infrastructure (Sun et al., 2015), water quality (No Kim et al., 2005), aircraft noise (Winke, 2016) and wind farms (Sunak and Madlener, 2016). The Repeat Sales Model could be used in an ex-post valuation, as several years are needed for housing prices to stabilise after a scheme. Nonetheless, the values estimated could be potentially used through value transfer for a priori valuation of future transport schemes.

There are ongoing academic debates over the accuracy of repeat sales and similar research approaches, and it is being applied in current post-graduate research to road bypass schemes (B. Day, pers comm.). While it can give robust estimates of the capitalisation of environmental change in property prices, this is not considered by some to be a valid measure of welfare change.

5.2.4 Air quality

This service relates to the removal of air pollutants by absorption into, or deposition onto, vegetation. The effectiveness of this service is determined by the type and quantity of pollutants and the surface area of vegetation. The value of the benefits provided are also dependent on the dispersal of pollutants and the numbers of people that would have been exposed to them if not absorbed by vegetation. Recent modelling for the UK natural capital accounts (Jones et al, 2017) suggests that the service has a significant value across the country.

Indicative values can be derived from Jones et al, (2017; see Annex 1) suggesting an average present value of this service from urban trees used in the case studies. When completed (expected in October 2018), it will provide lookup values at the local authority level. **NOTE: See addendum on local value of air pollutant removal by vegetation**.

i. Threshold

The indicative values derived from Jones et al (2017) only apply to habitat directly lost, with no buffer zone being relevant. This calculation can be quickly completed from the estimated habitat types under the footprint of a scheme. This can then determine whether the impact on this service is significant in relation to the scheme appraisal and/or the design of mitigation measures, such that it requires further appraisal.

ii. Valuation

The Jones et al (2017) model combines the quantification and valuation of this service. The model provides a current annual value and also asset values for vegetation that can provide the service into the future, taking into account expected air pollution trends over time.

In appraisal, the same calculation described above under thresholds would be implemented. It could be refined by subdividing values for different habitat types (e.g. crops, scrub, grassland). The disaggregated results can also be used to understand the distribution of the effects, reporting physical data on the number and type of health effects mitigated by the vegetation (e.g. ppm of PM2.5), and health effects (life years lost, QALY, respiratory admissions, etc.) as well as the monetary value of the service.

5.2.5 Noise

The most recent data for the UK natural capital accounts (eftec et al, 2018) suggest some ongoing uncertainty in the physical modelling of this ecosystem service, but that its value in urban areas may be relatively low. Mitigation of noise by vegetation is modelled and valued in the same way as the increases in noise from transport scheme are valued for appraisal.

Therefore, rather than quantify and value this service separately through the supplementary landscape guidance, it would be better to reflect the recent eftec et al (2018) modelling in the existing noise appraisal process in WebTAG. The eftec et al (2018) work suggests that noise may be mitigated by contiguous blocks of tree canopy of more than 200m^2 that lie between significant sources of noise (e.g. a main road) and areas of residential property. Representative per ha values for such areas cannot be determined, since the value depends on the level of noise and the number of properties benefitting from the mitigation. In these

[22] This box draws on advice from Prof Brett Day, University of Exeter, pers com.

circumstances, acoustics work undertaken as part of transport scheme appraisal should consider the role that changes in vegetation (particularly removal of blocks of trees) due to scheme design will have on noise impacts, making reference to the recent national modelling.

5.2.6 Global climate regulation (Carbon)

Vegetation can contribute to global climate regulation through the sequestration and storage of carbon. The habitat that sequesters carbon at the highest rate per ha are woodlands (and some wetland habitats can also be significant). Key habitats for carbon storage are peatlands and woodlands, with wetlands (e.g. saltmarshes) also possibly significant.

i. Threshold

The electrification case study illustrates that global climate regulation values for small areas of habitat may not be material to scheme appraisal even if the habitats have high carbon storage potential like woodland. Thus, there is a minimum threshold for the size of the area that needs to be affected by a scheme before the impact becomes material for appraisal or mitigation.

ii. Valuation

Assumptions about what happens to the habitat following construction affect the quantification and valuation for the stock levels and sequestration rates per ha of carbon-equivalent greenhouse gases.

- Quantify

eftec et al (2015) estimated that in 2012, UK woodlands held 213 $MtCO_2e$ across 2.78m hectares of woodland. This gives an average stock of 77tC per hectare. When scheme construction results in a loss of woodland, the carbon stored in that woodland is assumed to be released to the atmosphere. This assumption is dependent on the destination of the timber, as in some uses (e.g. if the wood is used in some types of construction) the loss of carbon may be reduced.

Similarly, it is assumed that carbon stored in peat soils would be released due to construction because the soil would need to be drained. The volume of carbon stored in peat soils is dependent on their depth. At depths of at least 40cm, peatlands can store 261tC per hectare (Milne & Brown, 1997). Soils under other land use types (e.g. grasslands) which can also store carbon, may be sealed by construction, resulting in no change in the volume of stored carbon.

Loss of habitats also results in the loss of their ability to sequester carbon in future. Rates of sequestration in woodland vary with species and age (eftec, 2015b), as shown in Table 5.3.

Table 5.3. Rates of carbon sequestration in UK Woodland

Species	**Average annual carbon sequestration**	
	Adult Trees (tCO_2e/ ha/yr)	Young Trees (0-10 Years) (tCO_2e/ ha/yr)
Broadleaved	4.71	2.20
Coniferous	4.47	2.64

In reality, rates vary extensively and are much higher during vigorous growth periods and will become negative at later life stages. However, to analyse the long-term effect on global

climate regulation, a simplifying assumption can be to apply average carbon sequestration rates for adult coniferous/ broadleaved trees.

Table 5.4 shows the areas of woodland and peatland which need to be lost to give an impact on global climate regulation (i.e. loss of stored carbon plus future carbon sequestration) at different monetary values. The woodland calculation is based on the loss of average carbon stored in hectare of UK woodland (77 tonnes of CO_2) based on the UK Woodland natural capital account (eftec et al, 2015), plus the loss of future carbon sequestration (based on the estimated average rate in mature UK broadleaved woodland of 4.71 tCO_2e/ha/yr - see Table 5.3). The peatland calculation is based on an assumption that 261 tonnes of CO_2 are stored in a typical ha of peatland[23], and this would be emitted if the land was developed.

The threshold value, where the value of this impact is material to the design or mitigation options for a transport intervention, will depend on the scale of the intervention.

Table 5.4 Areas (hectares) of UK habitat lost with carbon sequestration impacts of certain financial value

Habitat	Ha of habitat giving value of lost carbon sequestration[a]		
	£ 10,000	£ 100,000	£ 1,000,000
Broadleaved woodland	1.83	18.3	183.0
Peatland	0.002	0.02	0.24

[a] Value calculated over 60 years using HMT Green Book declining discount rates.

- Value

The release of carbon stocks and the lost quantity of future carbon sequestration can be valued using the BEIS Non-Traded Cost of Carbon (2013 – updated January 2018[24]). Valuing the average of 77t per hectare of woodland at current carbon prices (the central non-traded price for 2017 is £64 / tCO_2e[25], BEIS, 2013) gives a value of approximately £5,000 per ha. For the 261t per hectare for peatland, the value is £17,226/ha.

For the loss of future sequestration: based on a UK average of 5 tCO_{2e} sequestered per ha of woodland per year, the capitalised average value, over 100 years (most likely to be impacted by transport projects) is £24,400 per ha. The combined value of current carbon stored in woodlands and forgone future sequestration of emissions is estimated at approximately £30,000 per ha.

Further advice may be needed on the impacts on carbon sequestration and storage in the habitats most commonly affected by construction schemes.

5.2.7 Valuation Methods Proposed

It should be noted that the approaches discussed in Sections 5.2.2 to 5.2.6 deploy different valuation methods and definitions of beneficiaries. These are summarised in Table 5.5.

[23] see pg 18 of http://www.lakedistrict.gov.uk/__data/assets/pdf_file/0008/345482/Managing-land-for-carbon-booklet.pdf

[24] https://www.gov.uk/government/collections/carbon-valuation--2

[25] Note that values increase over time - for an explanation of traded and non-trade carbon values, see Annex 1.

Table 5.5: Valuation Methods in Proposed Ecosystem Service Appraisal Approaches

	Type of Monetary Value	Beneficiaries	Notes
Air quality	Avoided health costs	Exposed population	Could use QALY valuation to provide welfare value.
Global climate regulation	Costs to society of climate emissions	Global	
Noise	Incorporate in acoustic modelling to inform the WebTAG appraisal process (see Section 5.2.5)		
Recreation	Welfare values (under-) estimated through travel cost method	Visitor-based model	May be possible to adjust valuations to measure welfare more fully but would require greater appraisal effort.
Landscape visual amenity/ property values	Depends on framing of primary research, but available methods can capture total welfare impact.	Property or household based – all impacts	Potential for double-counting with other services/WebTAG units but overlaps small and can be adjusted for.

While the current valuation evidence in the supplementary VfM guidance is not considered fit for purpose, the best available current evidence has medium-high uncertainty. However, some simple short-term actions could reduce the uncertainty for several current values to a medium level making the evidence useable with appropriate caveats. These steps are described in Section 7.4.

5.3 Mitigation

The above analysis estimates the negative impacts on landscape only. In effect, the negative impacts are assumed to be ongoing and permanent. The positive impacts of compensation that could be provided by mitigation are considered in this Section. It examines how to use the ecosystem services approach to understand the impacts of mitigation measures. However, it does not seek to use ecosystem services as a way of classifying the mitigation measures themselves.

The impacts of mitigation usually change over time, for a variety of reasons:

- A delay in taking mitigating actions;
- A time lag between mitigation actions taking place and benefits being realised (e.g. the time taken for tree growth to provide visual screening), and
- If mitigation is to persist across the appraisal time horizon, this requires resources to be devoted to ongoing management and secure property rights for the areas where mitigation has taken place.

Mitigation is also driven and designed by qualitative landscape appraisal. The landscape profession increasingly looks for development to deliver net environmental benefit. In the first instance a 'good fit' between proposed infrastructure and landscape is sought. Following this, trade-offs are not considered between landscape and benefits of transport, but between loss of landscape/ features and the creation of new landscape / features considered to see if they result in a net environmental gain overall.

Both qualitative landscape appraisal and ecosystem services approaches can be used to apply the mitigation hierarchy (BBOP, 2009b) to transport schemes. This approach is leading

to several commitments in relation to the net impact of transport schemes, in particular in relation to biodiversity impacts (See Section 6).

5.3.1 Appraisal of Mitigation Impacts

In general, the impacts of mitigation can be appraised through the reverse of the analyses described for each of the ecosystem services above (Sections 5.2.2 – 5.2.6). However, this does not mean the value of a loss is the same as the value of an equivalent gain. Empirical evidence shows people value losses more highly than gains. Estimating the benefits of mitigation also needs to allow for time lags in delivering mitigation. Assessing mitigation benefits for each service is considered below.

- Recreation

Most mitigation of recreation impacts will create new sites or enhance existing sites, both of which can be assessed through using the online ORVal Tool taken note of the characteristics covered in Table 5.1. Marginal changes to the impacts of schemes from mitigation (e.g. a reduction in visual impacts on recreation sites as tree planting matures) can be analysed by altering the time-profile of the impacts identified (as described in Section 5.2.2).

- Landscape Aesthetics / Visual Quality

As with recreation, marginal changes to the impacts of schemes on visual amenity (e.g. a reduction in visual amenity impacts as tree planting matures) can be analysed by altering the time-profile of the impacts identified. Further work is required if monetary valuations are to be applied to this impact. The design of such work should enable value transfer that can be adjusted to take into account different levels of impact over time, to reflect the influence of mitigation actions.

- Air Quality

The marginal values for air pollution removal by vegetation derived from national modelling are based on avoided health costs. The air quality modelling and valuation approach can be applied equally to a gain or loss of habitat providing the services. These values need to be adjusted when used to take into account different levels of impact over time. In particular, sufficient time needs to be allowed for trees to mature and have sufficient surface area to provide the service at the typical rate for woodland.

- Noise

The proposed approach is to include the effects of vegetation in reducing noise within existing appraisal of noise impacts in WebTAG. This should include the influence of mitigation actions.

- Global climate regulation (carbon)

Woodland or other habitats gained through mitigation will sequester and store carbon. This can be valued with the same approaches as those for losses of carbon from habitat loss. Again, adjustments need to be made for lags in realising the benefits from mitigation. The Woodland Carbon Code (Forestry Commission, 2018) already tackles the problem of accounting for the variable time-profile of carbon sequestration from new woodland planting. It assumes a commitment for long-term management of the land as woodland habitat, and then ascribes the average annual rate of carbon sequestration to each year of woodland management. This approach is considered suitable for appraisal of mitigation measures for transport schemes, as these should be maintained in the long-term.

- Conclusions

The approaches for appraising the impacts of schemes on ecosystem services are also suitable, with some adaptions, to appraising the impacts of mitigation actions. Furthermore, this consistency will help assess the appropriateness of mitigation actions in the context of scheme impacts by comparing the scale and distribution of the impacts of schemes and mitigation measures. This is particularly important for larger schemes (such as the A14 case study) where the location of mitigation measures may be some distance (several kms) from the locations of impacts.

6.0 Ecosystem Service Markets

This section investigates the potential role of developments in ecosystem service markets for design and management of transport schemes. It examines the latest evidence on creating markets for ecosystem services, and whether there is any evidence of using this approach in transport appraisals. These ecosystem service markets present opportunities for investing in mitigation measures to offset the impact of transport schemes. They can also potentially generate price information for some ecosystem services, even though this evidence may reflect the regulations framing ecosystem service markets rather than the value of impacts on society.

Evidence on the development of these markets has been gathered from relevant publications, discussions with experts in the public[26] and private sectors, and discussions at relevant conferences and events[27].

The evidence gathered is organised in three sub-sections: the organisation of ecosystem services markets; relevant international approaches and the current UK activity. A final section draws conclusions in relation to future transport scheme appraisal and WebTAG's landscape category.

In this research, the markets of interest are those that could play a role in delivering mitigation. This is a narrower definition than is used for 'payments for ecosystem services' (PES). The definition of PES is a scheme that involves "payments to the managers of land or other natural resources in exchange for the provision of specified ecosystem services over-and-above what would be provided without payments" (Defra, p.9, 2013). PES includes government schemes to buy ecosystem services, such as through agri-environment schemes. It is not considered likely that transport scheme promoters could make purchases through this kind of PES structures. Therefore, the focus is on ecosystem services markets open to a variety of buyers which could include transport schemes. Nevertheless, different market types are examined because they can inform policy (such as on the types of ecosystem services traded).

Within current transport schemes, 'exchange land' commonly refers to land that is given in exchange for land required by the Highways Authority[28]. In the A3 Hindhead case study, agreement was reached with the National Trust to exchange land required for the tunnel portals and road for land that would help to better align and join parcels of land they already owned. Devil's Punch Bowl was one such area where the old A3 (made redundant by the scheme) was given in exchange. It can also be and was used for exchange of Common Land required by the scheme for an equivalent parcel of land. Both cases required considerable negotiation and cost for improvement works as part of mitigation. These costs formed part of the overall scheme cost, along with the value of the mitigation works agreed.

Transaction and management costs can be a significant aspect of ecosystem service markets. To ensure benefits are delivered in perpetuity, resources need to be devoted to ongoing management and there need to be secure property rights for the areas where mitigation takes place. This can create extra risk for delivering mitigation through markets, but there is

[26] With thanks to Dr Nick White, Senior Advisor - Net Gain & Green Infrastructure, Natural England.
[27] Such as the Fourteenth Business and Biodiversity Offsets Programme Advisory Group Meeting (BBOP14), November 2017, Edinburgh; The Net Impact Approaches Conference May 2018, London.
[28] Clause 256 of the Highway Act 1980, Power to exchange land to adjust boundaries of highways gives Highways England this authority.

experience of these issues and ways to manage them through good practice (e.g. having a costed mitigation plan and risk assessment) (BBOP, 2009), or policy mechanisms (e.g. bonds, insurance requirements).

These markets also have potential implications for scheme appraisal: if the cost of compensation through markets is less than the cost of mitigation measures, the purchase of compensation from the market may enhance the overall value of a scheme. However, for this comparison to be appropriate and acceptable, location matters. The distribution of impacts will matter to stakeholders - so the approach taken will need to factor in local practicality and acceptance as well as technical feasibility. For services other than carbon, impacts of the scheme and benefits of mitigation need to be sufficiently close to each other.

6.1 Organisation of ecosystem service markets

The market construct and the types of services traded are two key aspects of the markets that are relevant in this context.

There are examples of both voluntary ecosystem service markets and those that are mandated by policy or regulation. Voluntary markets often develop to internalise major externalities for which there is widespread awareness of market failure. These include carbon offsets markets, and some catchment protection schemes, such as where water companies pay farmers to reduce water pollution risks (see Section 6.3).

Payment mechanisms vary particularly outside the public sector (which in the UK has mainly used an 'income forgone' model to fix payments offered to farmers for various actions). Different approaches include targeting advice and payments (such as in the work of the West Country Rivers Trust) and auction approaches. For example, EnTrade[29] is an online trading platform that has been trialled over the last decade by Wessex Water, enabling it to purchase actions by farmers that reduce water pollution.

A further aspect of market structure is whether ecosystem services are traded individually, or as a 'bundle'. Services that are traded individually include carbon and water regulation. However, such trading of individual services can have wider environmental benefits, and these are sometimes characterised as part of the 'ecosystem service' sold. A typical example of this is carbon-offsets delivered through enhancement of natural habitat. The UK Woodland Carbon Code[30] evaluated its socio-economic and environmental 'co-benefits' to illustrate this link.

In biodiversity markets, it could be argued that habitat creation to compensate for measurable loss of residual impacts on biodiversity (biodiversity offsets) also provide a range of ecosystem services. However, delivery of these services is not always an explicit objective of such offsets. Understanding and measuring other ecosystem services delivered through biodiversity offsets is an area of ongoing research in the UK[31].

An alternative market structure is 'stacking' of ecosystem services. This is when different services are separately measured and sold into different markets. Fox et al (2011) describe how such an approach obviously brings opportunities, but also risks double-selling or low

[29] See: http://www.entrade.co.uk/
[30] UK Woodland Carbon Code registry can be accessed at: https://www.forestry.gov.uk/forestry/infd-863h7a
[31] See: http://bbop.forest-trends.org/pages/cnca_infographic

additionality. They require greater policy coordination and so can have higher transaction costs, such as monitoring standards, to be robust.

Globally, the major ecosystem market segments are biodiversity, carbon, forest, and water (Ecosystem Market Place, 2015). The main markets for services from UK ecosystem are:

- Water-related services, including payments to land managers (in particular farmers) by the Environment Agency[32] and by water companies[33];
- Biodiversity offsets markets, including some voluntary activity, and where compensation is required by local planning authorities[34], and
- Carbon, such as the Woodland Carbon Code and the Peatland Carbon Code[35].

These UK activities are discussed further in Section 6.3.

6.2 Worldwide ecosystem service markets

Ecosystem Marketplace (2015) identifies significant growth in demand by government, business, and communities to invest in the enhancement and protection of ecosystem services. Demand for forest carbon offsets, watershed services and biodiversity conservation is valued at an estimated $16.7bn-$18bn per annum funding sustainable management of more than 405 million ha globally (in 2015). The annual investments in ecosystem services are dominated by the Chinese government for watershed protection.

Mechanisms for each sector differ based on regulatory requirements, project location, standard, project type, and other attributes. There is also a significant market for carbon offsets bought from the UK but supplied overseas. This market has been identified as having the potential to stimulate significant finance in ecosystem restoration (eftec et al, 2012). Globally, offsets bought and sold on the voluntary carbon markets dropped to 63.4 million tons of carbon dioxide equivalent in 2016, a drop of 24% compared to 84.1 million tCO_2e traded in 2015. The total market value in 2016 was US$191.3m (Hamrick K and Gallant M, 2017).

In Europe there are significant activities in several other Member States, including:

- Biodiversity offsetting in Germany (Wende, Darbi and Stein, 2016), which is part of the mitigation hierarchy under the Impact Mitigation Regulation (IMR). This mandatory system builds on the provisions in the Federal Nature Conservation Act which sets the overall framework that is further elaborated in the nature conservation laws of the federal states. The IMR applies to all areas, scales of impact and sectors (excluding agriculture, forestry and fisheries). An example of the scale of activity is given for the State of Hesse, which had an average of 1,950ha/yr of compensation between 1992 and 2010. The types of projects for which compensation approaches are applied include transport schemes.

[32] For example, Catchment Sensitive Farming scheme: https://www.gov.uk/guidance/catchment-sensitive-farming-reduce-agricultural-water-pollution
[33] For example in ENTRADE: https://www.entrade.co.uk/ and Anglian Water's Slug it Out initiative: https://www.anglianwater.co.uk/environment/our-commitment/our-plans/slug-it-out.aspx
[34] Such as in Warwickshire where a housing development of 220 homes was unable to mitigate all biodiversity impacts on site but were instead able to be compensated off-site through a compensation scheme set up through s106.
[35] See: http://www.iucn-uk-peatlandprogramme.org/node/325

- The 'Grenelle II' compensation law in France mandated integrated sustainability and financial reporting for all large companies with a law called Grenelle de l'Environnement. It strengthened effective implementation of measures aimed at avoiding, reducing and offsetting impacts. Infrastructure and transport projects which are considered on the basis of an EIA must include the mitigation measures presented in the EIA document, including avoidance, reduction and compensation or offset measures (with their associated cost). This makes mitigation measures legally binding. This could be an example worth considering for mitigation of UK transport schemes.

  In 2016, France adopted a new law on "recovering" biodiversity, nature and landscape, which has further increased the demand for these compensation measures. The law included the creation of a National Inventory of suitable locations for biodiversity offsetting and abandoned land holdings, to be led by the Biodiversity Agency established under the law. Compensation measures in France are applied to transport schemes (Quétier, Malapert and Vaissière, 2016).

- Practices elsewhere include the 'ekologisk kompensation' in Sweden, where it is up to individual Municipalities whether they will make use of the 2016 guidance provided by Naturvardsverket (the Swedish EPA). Early experience in Sweden included a compensation project for a large transport scheme near the city of Umea[36]. Other approaches around the EU are summarised in academic research (e.g. Darbi et al, 2016).

6.3 UK ecosystem service markets

Table 6.1 summarises examples of the activity in the UK. Mitigation measures within transport schemes can already include securing new land to compensate for habitat damage (referred to as 'exchange land – see the A3 Hindhead case study) and other options can be considered in future.

Various UK organisations have net positive commitments, such as having a positive impact on biodiversity or being carbon neutral. These are described for various organisations including Network Rail and Highways England, various housing developers, local planning authorities, UK water companies and the National Infrastructure Commission, in Table 6.1.

The data show that ecosystem service markets are developing in the UK in several areas. For example, the first EnTrade auction was run in June 2016, where the aim was to offset 20 tonnes of nitrogen. The first auction received 147 bids from 19 farmers for 47.5 tonnes of nitrogen savings across 1,141 hectares of land. Two further auctions were run in February 2017, with one receiving bids for an additional 40 tonnes of nitrogen savings against a target of 15 tonnes, but at a lower price than the 2016 auction. The other auction was for arable reversion, which received bids for 8 tonnes of savings over 3 years across 66 hectares of land.

The Woodland Carbon Code provides a measurement framework for carbon sequestration by new woodland planted as part of transport scheme mitigation (see Section 5.3). As of March 2018, the Woodland Carbon Code consists of 239 projects, accounting for a total of 16,125

[36] See: http://www.umea.se/download/18.65c1214d14f38ac155364e3a/1446109856307/EGCA+2018+Ume%C3%A5+Sweden+4.+Nature+and+biodiversity.pdf

hectares of woodland. The World Land Trust sells 'biodiversity-friendly' carbon credits globally[37]. In both these examples, the quantified good is carbon, but associated benefits are an important differentiator of the product.

Table 6.1 illustrates the current makeup of ecosystem service market schemes and commitments in England:

- Some activities are for national organisations (housebuilders, National Infrastructure Commission), but most are locally or regional defined (e.g. for water companies or by county planning authorities).
- Key ecosystem services are supporting biodiversity and water services. Many schemes have additional services, such as for aesthetic quality, as part of their objectives.
- The main players are in construction (Transport infrastructure and housebuilders, and water companies). There are also some brokers/ trading systems emerging – such as EnTrade, The Environment Bank, and Woodland Carbon Code.
- Most commitments from local government for the planning system are an aim rather than an obligation. Only Devon and Warwickshire have binding commitments. Similarly in housing, some firms' biodiversity objectives are conditional.

Several of these markets offer opportunities for transport schemes to purchase mitigation for ecosystem service impacts. However, they are mainly focussed on water and biodiversity, which are appraised in WebTAG but have not been considered in detail in this project's review of the supplementary guidance on landscape. Markets for biodiversity compensation are clearly highly relevant to transport schemes, as illustrated by Network Rail and Highways England both having net impact approaches. Carbon offset markets, such as the Woodland Carbon Code, are also relevant for transport schemes and could be used to make schemes carbon neutral in terms of carbon released due to habitat loss. However, this would be a superficial measure in the context of carbon emissions from transport vehicles themselves.

These ecosystem markets should only apply in the final stage of the mitigation hierarchy, to unavoidable residual impacts after avoidance, minimisation and on-site mitigation measures during the siting and design of transport schemes. However, they do provide options for different mitigation approaches, including mitigation of unavoidable residual impacts. The appraisal processes described in Section 5 can be used to assess the wider impacts of these mitigation measures. For example, eftec & Forest Trends (2018)[38] examined some of the ecosystem service impacts of delivering no net loss (of biodiversity) on a transport scheme. It illustrated the potential of the natural capital approach (showing the long-term changes in the stock of assets affected) in appraising mitigation measures.

Compensation as a mitigation action is a rapidly developing area of activity, in particular in relation to land use development[39]. The majority of the compensation delivery is expected to take place through local bodies. As practices develop in the UK, different bodies may assume influence and define boundaries of activity in different areas, such as Local Nature

[37] According to the World Land Trust's most recent annual review (2016), they saved nearly 55,000 acres of forest across 20 countries accounting for an overall income of £3.3 million. See: https://www.worldlandtrust.org/wp-content/uploads/2018/01/2016-annual-review-and-accounts.pdf

[38] See: http://bbop.forest-trends.org/pages/cnca_infographic

[39] Ongoing work includes work on the financial viability of biodiversity net gain - Defra contract 3070018815.

Partnerships, Nature Improvements Areas, or new approaches/ bodies such as natural capital trusts. DfT should keep up to date with the development of these practices.

As these mitigation activities and ecosystem service market develop, DfT has the opportunity to shape the outcomes it wants from them. For example, by committing to and defining what biodiversity net gain should mean and how and where it should be achieved, it can provide certainty to suppliers over a minimum market size. This can help to stimulate supply and therefore reduce the per-unit costs and overall costs of mitigation.

Table 6.1. Examples of Ecosystem Service Markets and Commitments in the UK

Organisation	Headline commitment	Details of commitment	Goods/Services Targeted
Department for Transport related bodies			
Network Rail	Committed to minimising the impact of their current and new infrastructures to "positively change, protect and enhance Britain's environment" (Network Rail, 2017d)	Reflected in both Network Rails' Environment Policy (2017c) and, Energy and Carbon Policy (2017b). Network Rail are committed to having a net positive approach to biodiversity, which they describe as "replacing more natural habitat than is lost" (Network Rail, 2017a) during Network Rail's work.	Biodiversity Vegetation and habitats
Highways England	The Government's Road Investment Strategy and Highways England's Strategic Business plan complement each other in their commitment to delivering "no net loss of biodiversity by 2020, and delivering a net gain in biodiversity by 2040" (Highways England, 2015)	According to Highways England Biodiversity Plan (2015), they are aiming to: Reduce habitat fragmentation through landscape scale biodiversity projects; All new projects will enhance biodiversity value of the land, thus reducing the impacts of the projects Have managed woodland areas that aim to provide landscape screening, connectivity or biodiversity; Manage grassland areas with litter and debris removal strategies; and Provide 3,500 hectares of grassland rich in wildflowers and species to support pollinating insects.	Biodiversity Landscape screening Connectivity Support pollinators
Heathrow Airport	Heathrow Airport are looking to ensure "a halt to overall biodiversity loss is achieved by 2020" (Heathrow Airport, 2018) which reflects the Government's aims set out in the Natural Environment White Paper	The Heathrow Expansion Project has integrated the existing natural environment, as well as opportunities to mitigate negative environmental impacts, into the design approach of the Project (Heathrow Airport, 2018). Heathrow Airport have mainly considered the impact on biodiversity, landscape and visual amenity, and the water environment, but a full description of how the proposed design mitigates or accounts for these variables has not been released yet. Heathrow Airport are looking to compensate for loss of biodiversity through biodiversity offsets "within the general vicinity of the airport"	Biodiversity Landscape and visual amenity Water environment

Organisation	Headline commitment	Details of commitment	Goods/Services Targeted
		(Heathrow Airport, 2018) to maintain current animal and plant populations. The offset methodology itself will be developed with Natural England, so that the metric values both losses and gains.	
Transport for London	Transport for London (TfL) is "working to protect, connect and enhance the biodiversity of [their] track and highway verges" (TfL, 2018).	The London Underground's Environment Strategy for 2008-2013 (2011), set out TfL's environmental objectives which includes the maintenance and enhancement (where possible) of the quality of London's natural environment. Their objectives in this respect were two-fold: To conserve, and where practical to enhance, biodiversity; To raise the publics and staff's awareness of biodiversity.	Vegetation management Landscape-scale conservation via wildlife corridors
Crossrail 2	Commitment to "protect, and where possible, enhance, water and land quality, and…promote richer wildlife habitats, aiming for an overall gain in biodiversity" (TfL and Network Rail, 2016)	TfL and Network Rail have set out a sustainability policy for Crossrail 2 (2016), which sets out how the organisations will integrate seven sustainability objectives in the design and construction of the scheme. One of the sustainability objectives is to enhance the natural and built environment. The sustainability policy highlights how the seven policy objectives through promoting a sustainability culture, clear communication with stakeholders, adopt practices to ensure environmental and social performance, establish a framework to monitor and measure progress to achieving these seven objectives, and finally leave a positive legacy after the completion of the scheme.	Water and land quality Wildlife habitats Biodiversity
Housing Developers			
Berkeley Group	The Berkeley Group are committed to "develop and apply an approach which ensures that all [their] new developments create a net biodiversity gain" (Berkeley Group, 2017, p.3)	To achieve this, Berkeley Group are looking to apply the following nine concepts: green infrastructure, connectivity, buildings and hard landscaping, community, local ecological character and distinctiveness, habitats and vegetation type, seasonality and maturity, species diversity and adaptiveness, and management. All nine concepts may not be used at all development sites as each project is different. The Group will work with ecologists, landscape architects and Local Wildlife Trusts to meet their objectives.	Biodiversity Green infrastructure Connectivity Habitats and vegetation Species diversity and adaptiveness Ecological character and distinctiveness
Redrow Homes	Redrow Homes are looking to achieve "verified net biodiversity gain across all	They have been praised as one of the first housing developers to take a strategic approach to achieving a net biodiversity gain across	Biodiversity

Organisation	Headline commitment	Details of commitment	Goods/Services Targeted
	developments by 2022" (Redrow PLC, 2018).	its developments. Redrow's suggested methodology to achieve their ambitious goal is to measure the ecological value of land prior to the development. This approach has been applied successfully in two locations so far: Caddington Woods in Bedfordshire and Saxon Brook in Exeter (Redrow, 2017).	
Barratt Developments	In their Ecology and Biodiversity Policy (2017), Barratt Developments set out to "where possible to enhance the ecology and biodiversity of our developments…by protecting existing ecological environments and/or restoring or creating new biodiverse habitats for species". Barratt are committed to have a net positive ecological impact by 2020, to ensure biodiversity is a factor they consider when buying land prior to development.	To achieve their objectives, each new development will have its own biodiversity action plan, that consider how flora and fauna on-site can be protected and enhanced throughout the development process (Barratt Developments, 2018). The developer is working alongside the RSPB to develop their biodiversity action plans.	Biodiversity
Planning Authorities			
Devon County Council	As part of Devon's Biodiversity and Geodiversity Action Plan (2009), biodiversity objectives and targets were set out for cirl bunting in Devon. There were three targets set in the Plan, (1) increase the population, (2) increase the range and (3) foster understanding and awareness of conservation of cirl bunting. Each objective has a set of targets that will help Devon County measure and monitor their progress.	Under the National Planning Policy Framework, the approach to conservation and enhancement of biodiversity follows the mitigation hierarchy. Where the preferred approach is "to always avoid impacts wherever possible, and to then mitigate as the next best choice" (Hay, p.5, 2017). To determine the impact of a proposed project or scheme on cirl bunting territory, a six step method is used. Following these steps will assess whether appropriate avoidance, mitigation, compensation and enhancement measures are in place. If compensation is required, then its form, scale and delivery are also determined through these steps (Hay, 2017).	Conservation of cirl bunting
Warwickshire County Council	Warwickshire County Council has a biodiversity strategy that describes how the County will work with partners "to protect	Their strategy is in compliance with the NERC Act (2006), and covers six strands each with their own biodiversity objectives. Warwickshire are also collaborating with Coventry and Solihull through a Local Biodiversity Action Partnership (LBAP) which	Biodiversity

Organisation	Headline commitment	Details of commitment	Goods/Services Targeted
	and enhance Warwickshire's wildlife" (Warwickshire County Council, n.d.).	devised actions to be taken between 2012 and 2014 (Warwickshire Wildlife Trust, 2018). The LBAP consists of 52 biodiversity action plans, of which 28 are for vulnerable species and 24 are for habitats in the area. LBAP is a local response to the Government's National Action Plans for vulnerable UK habitats and species.	
Greater Manchester Combined Authority	Under the Greater Manchester Spatial Framework (2016), biodiversity is mentioned throughout various areas of the policy, including but not limited to, nature conservation (Policy GM8) and green infrastructure (Policy GM7). Under nature conservation, the Framework states that "all developments should provide a net improvement in biodiversity value wherever practicable" (p.67).	Greater Manchester has set out several aims, indicating that they should be considering these environmental benefits but still allow for trade-offs with other non-environmental benefits.	Biodiversity and geological value
Oxfordshire County Council	Oxfordshire County Council developed their Biodiversity and Planning document (2014) which explains the County's biodiversity objectives which include "to protect, reconnect and enhance biodiversity" (BBOWT, Oxfordshire County Council and TVERC, p.1, 2014).	Oxford City Council have also set out a biodiversity action plan for 2015-2020, where the aims are for the City to act as a responsible landowner and manager, ensure continued protection of biodiversity resources and promote benefits of conservation and biodiversity enhancement to local communities (Oxford City Council, 2014).	Biodiversity
Dorset County Council	The Dorset Biodiversity Strategy has been put together by the Dorset Biodiversity Partnership, a group of organisations that "aim to reverse the decline of biodiversity in Dorset through positive, collaborative action" (Dorset Biodiversity Partnership, p.2, 2003).	The Strategy has been designed to contribute to the targets defined in the UK Biodiversity Action Plan. The Strategy is a local biodiversity initiative which aims to translate national targets into local ones, identify and reflect species and habitats with local value, develop partnerships to maintain biodiversity programmes in the long term, raise awareness in the local community, consider all opportunities for conservation and enhancement and devise a system to monitor progress in biodiversity conservation, both locally and nationally (Dorset Biodiversity Partnership, 2003).	Biodiversity
Cambridgeshire County Council	As part of the Cambridgeshire Green Infrastructure Strategy (2011), the County	This objective relates to the conservation and enhancement of biodiversity and geo-diversity. This is expected to be achieved	Biodiversity

Organisation	Headline commitment	Details of commitment	Goods/Services Targeted
	has an objective "to reverse the decline in biodiversity" (p.11).	"through the protection and enhancement of habitats and wildlife sites" (p.29). There are plenty of opportunities within Cambridgeshire support the rich biodiversity of the area.	
Cumbria	Cumbria aims to integrate biodiversity targets set out in the UK Biodiversity Action Plan, they want to put work towards local objectives/targets that were not addressed in the national plan as well as "engender greater awareness and understanding of Cumbria's biodiversity and wider participation in its conservation" (Cumbria Biodiversity Partnership, 2001).	Strategies have been put in place for 18 habitats, 21 species and 4 common themes which include land management and policy for the wider environment, legislation and planning, public involvement and awareness and, data and information.	Biodiversity
Water Companies			
Anglian Water – Slug it Out	Slug it Out aims to reduce the "levels of the slug control pesticide metaldehyde" (Anglian Water, 2018b) in the region's water before it reaches Anglian Water's treatment sites. Working with farmers to reduce the amount of metaldehyde in the water system has been a priority for Anglian Water's catchment advisors (Anglian Water, 2018b).	The Slug it Out campaign aims to provide a financial incentive for farmers to switch the pesticide they use for slug control. There are six reservoirs that are taking part in the trial, with 89 farmers have signed up to the scheme (Anglian Water, 2018a).	Water quality Farmland quality Pesticide use
South West Water – Upstream Thinking	Upstream Thinking is a partnership between South West Water, the Devon Wildlife Trust, the Cornwall Wildlife Trust, the Westcountry Rivers Trust and the Exmoor Park Authority. The partnership feeds into South West Water's "plan to reduce its environmental footprint and manage the impact of diffuse pollution on customers' bills" (Upstream Thinking, n.d.)	The programme focuses on 11 catchment areas in Devon and Cornwall. The scheme provides a wide range of benefits throughout the water cycle, and to wildlife and customers of South West Water (South West Water, n.d.).	Water quality Flood risk management through peat bog restoration Carbon sequestration through peat bog restoration Biodiversity Farmland quality

Organisation	Headline commitment	Details of commitment	Goods/Services Targeted
Wessex Water - EnTrade	Wessex Water developed the EnTrade online trading platform as a part of their aim "to reduce the amount of nitrogen entering Poole Harbour by 40 tonnes of nitrogen per year by 2020" (Wessex Water, n.d.)	EnTrade is trading platform that facilitates the efficient allocation of funding by allowing buyers and sellers to find the most cost effective combination of nitrogen reduction and environmental offsets (EnTrade, 2017).	Water quality Nitrogen use Farmland quality
Other Institutions			
National Infrastructure Committee (NIC)	The National Infrastructure Commission (NIC) released a report stating the importance of the link between Cambridge-Milton Keynes-Oxford arc in order to deliver new homes and infrastructure improvements. Under their recommendations to the Government, the NIC has stated that they should work with local authorities to "ensure that strategic infrastructure…are planned and developed to achieve net gains in biodiversity and natural capital across the arc" (NIC, p.11, 2017).	The NIC highlight that, in general, developers are willing to adopt 'net gain' approaches to biodiversity and natural capital, as has been illustrated in previous sections. In the NIC's interim report (2016), it is noted that the Oxford and Cambridge areas have high land values as they are encircled by large Green Belts.	Biodiversity

7.0 Conclusions

7.1 Current Landscape Appraisal

The current approach to landscape appraisal of transport schemes involves qualitative appraisal within WebTAG, and DfT supplementary Value for Money (VfM) guidance on valuation of landscape impacts. Within WebTAG landscape appraisal is based on national landscape character assessment guidance (Natural England, 2014) - with assessment of quantified (but not monetised) or qualitative impacts combined into the WebTAG appraisal summary table, which is the key tool for decision-makers. DfT's supplementary VfM guidance provides monetary values for different land types in the landscape category of the environmental capitals defined in WebTAG.

Landscape character assessment is largely qualitative and considers the intrinsic value of landscape, including the holistic value from the way its features combine. Economic appraisal considers instrumental values to people.

These monetary values for landscape impacts in the supplementary VfM guidance have not been considered robust enough to be included in the central or adjusted benefit cost ratio of a project appraisal summary table. They are now regarded as untenable because:

- The current practice uses monetary value estimates originating from a 2001 ODPM study (reproduced in DCLG, 2006). They no longer represent a good standard of evidence.
- The estimates use values for different categories of land that capture a bundle of benefits (recreation, landscape, ecology, cultural heritage, hydrology, air quality, local climate and soil depending on the land type). Three of these benefits from landscape are considered in the supplementary guidance (ecology, cultural heritage and hydrology) and also assessed qualitatively elsewhere in WebTAG (under wildlife; historic environment; and water environment, respectively) leading to potential double-counting. Note that air quality and greenhouse gas (carbon) from vehicle emissions are appraised elsewhere in WebTAG, and the air quality and global climate regulation (carbon) benefits of land and vegetation are covered in Landscape. As these are different types of impacts, there is no risk of double-counting but a need for consistency between methods.
- The bundled estimates are applied on a per ha basis, yet the different benefits are not all appropriate to assess in this manner. The area of habitat affected by a transport scheme is a strong determinant of some of its impacts, such as on carbon and air quality regulation services. However, it is a weaker factor in determining the value of other services, such as recreation and noise mitigation, which are more closely related to the number of people impacted than the area of land involved.

7.2 Future Landscape Appraisal

The recommended approach for future appraisal of the issues covered by the supplementary landscape VfM guidance is to undertake monetary valuation of individual ecosystem services. This is because transport schemes impact individual services differently. Valuing services separately also helps inform mitigation options.

Revision of the monetary valuation of a transport scheme's impacts on landscape needs to be considered in the context of the qualitative landscape impact assessment. The latter provides a qualitative landscape impact assessment, and is the technical approach favoured by landscape

professionals. It is based on landscape character areas and defines landscape as a combination of natural and man-made features. It attributes (intrinsic) value to these features, and to their combination in different cultural contexts. Thus, future landscape appraisal in WebTAG should distinguish the intrinsic value of landscapes from monetary values for the visual amenity of landscape to people in the supplementary landscape VfM guidance.

Given the coverage of some benefits in other parts of WebTAG appraisal, there are six priority benefits to capture if monetary landscape values are to be updated are Recreation; Landscape Aesthetics /Visual Quality; Air quality; Noise and local climate regulation; Global climate regulation. Based on the evidence examined in this study and tested through the case studies, the necessary approaches exist or could be developed. For landscape aesthetics, primary research would be required to generate the necessary economic value evidence before it can be applied in transport appraisal.

There are a number of aspects that are common to the appraisal of different ecosystem services:

- The spatial area over which transport scheme impacts occur.
- The thresholds at which an impact on a particular ecosystem service is expected to be material and require appraisal. This is important to keep appraisal effort proportionate to the size/ cost of a scheme and its impacts.
- If material, the approach for measuring the change in the service due to the transport scheme and valuing it.

These factors are discussed in the following subsections. In this context 'material' means significant enough to influence a decision. This could be the decision to go ahead with a transport scheme, the choice of option (e.g. route) or the design of mitigation measures.

7.2.1 Spatial Area of Change

For some services (carbon storage, air pollutant removal) the relevant area of impact is the area of vegetation that is lost due to the scheme. However, the distances for appraisals suggested by the supplementary VfM guidance are arbitrary, and not in line with available tools to identify actual distance of impacts. A better approach, which can be standardised to be applied in a proportionate manner in appraisal, is to allocate spatial area differently to different benefits according to their characteristics:

- For Air quality, Noise and Local climate regulation and Global climate regulation: the impact can be best assessed based on the area and type of habitat (or land use) damaged by the scheme (i.e. built on or removed to accommodate the scheme's footprint).
- For Recreation and Landscape Visual Amenity: impacts can arise some distance either side of the transport project according to its visibility. Appraisal can identify the viewshed of a transport scheme using GIS software. Such an approach is already undertaken to identify the zone of visual influence in the landscape appraisal element of WebTAG and aligns with good practice in landscape appraisal.

Once the viewshed has been identified for the transport project, data can be generated for the area it covers to input to further analysis identifying: broad habitats in the Land Cover Map (CEH 2017 - which is already used in transport appraisals); areas in which recreation take place (in England and Wales through visual comparison to the ORVal Tool); and properties differentiated by type (residential/commercial/industrial) again using data already used elsewhere in WebTAG.

7.2.2 Value evidence and valuation approaches

The available evidence on the six priority benefits is variable. Useable values are available for carbon and are being developed for air pollutant removal. Recreation values can also be assessed with existing evidence. However, primary research is needed to inform valuation of landscape aesthetics / visual amenity. A separate approach (in addition to existing WebTAG appraisals) is not recommended for noise mitigation by vegetation or local climate regulation, but evidence on these benefits should be kept under review.

The economic values of services differ with the different types of ecosystems, the context in which they are located (e.g. the size of surrounding human population) and the change being valued. The recommended approaches for valuing ecosystem services to update current supplementary guidance on landscape values are shown in Table 7.1.

It should be noted that there are subtle differences in valuation methods that should be reflected when bringing the methods together. However, while valuation approaches remain incomplete, the evidence described will help express the valuation in relevant and sufficiently robust units to help appraise landscape impact and mitigation measures.

Table 7.1. Recommended Valuation Approaches for Ecosystem Services

Service	Threshold*	Quantify	Monetary Value
Global climate regulation (carbon)	Lookup values to calculate the volume & value of carbon sequestration and storage from habitats lost	Emissions of stored carbon from woodland/ peatland/ saltmarsh, and forgone future sequestration by woodland	BEIS Non-traded cost of Carbon (2013)
Air Pollutant Removal	Value of air pollutant removal by area of trees lost	Lookup values of impact per ha of vegetation by local authority (to be completed October 2018). NOTE: See addendum on local value of air pollutant removal by vegetation.	
Recreation	Total value of recreation at major sites lost/ in viewshed, from ORVal	For the total number and value of visits identified for affected sites, use expert judgement to estimate the impact of the transport scheme	
Landscape aesthetics / visual quality	n/a	Use viewshed, and possibly other approaches (e.g. Swetnam et al 2017), to quantifying landscape impacts	Requires primary research
Integrate in existing: Noise	n/a	Integrate role of trees lost in a scheme into the existing appraisal of noise impacts elsewhere in WebTAG to estimate the net change in noise	
Local climate regulation	n/a	Mainly an urban impact and unlikely to be materially affected by a transport scheme	

* Detailed appraisal is recommended if the impacts described are material. This guidance is expected to work alongside expert judgement, also considering evidence from elsewhere in the appraisal process where relevant.

7.2.3 Other Parts of WebTAG

The approach to ecosystem services has implications for other parts of WebTAG, including other topics in Chapter 6 (e.g. 'Townscape') and other chapters (e.g. Chapter 5 on natural capital and ecosystem services methods). A key aspect of the approaches recommended is that they utilise

evidence already generated elsewhere in WebTAG (e.g. calculation of viewshed) and consistent valuation methods (e.g. in relation to air pollution impacts and the valuation of time for travel-cost approaches). The methods recommended also have potential to be applied to some impacts that arise during construction of schemes. These are not currently included in WebTAG, but the ability to appraise them could be useful for larger schemes.

7.3 Mitigation and Ecosystem Service Markets

The approaches outlined in Table 7.1 are also suitable, with some adaptations, to appraising the impacts of mitigation actions for transport schemes. This consistent approach will help assess and compare the appropriateness, scale and distribution of the impacts of schemes and mitigation measures. This is particularly important for larger schemes (such as the A14 case study) where the location of mitigation measures may be some distance (several kms) from the location of impacts.

Mitigation of residual impacts (those remaining after application of the preceding steps of the mitigation hierarchy) of transport schemes can also potentially be purchased from ecosystem service markets. These markets have expanded internationally in the last decade, providing experience of best practice. Markets in the UK are mainly voluntary and relate to water quality, carbon sequestration and storage, and biodiversity commitments (such as net gain).

Markets tend to be locally defined and (other than for carbon) would need to deliver mitigation locally to a transport scheme. Therefore, there is uncertainty over the role they can play in supporting mitigation of transport scheme impacts. Experience in these markets has demonstrated problems from inadequate regulation (eftec et al. 2010), and that market liquidity can bring down prices. As a result, DfT has the opportunity to shape the outcomes it wants from ecosystem service markets. For example, by committing to and defining what biodiversity net gain should mean and how and where it should be achieved, it can provide certainty to suppliers over a minimum market size, which will help to stimulate supply and reduce costs.

Ecosystem service markets also provide some useful established methods to quantify and value ecosystem service changes from mitigation actions. For example, assuming commitments for long term management of woodland habitat, the woodland carbon code provides a method for quantifying carbon sequestration and storage by new woodland over time (Forestry Commission, 2018).

7.4 Further Research

Further work should be undertaken to implement the recommended approaches to valuation of the ecosystem services considered as follows:

- The use of GIS software to calculate the viewshed of transport scheme should be standardised and linked to the severity of visual impacts given distance from scheme and type of landscape (e.g. extent of existing infrastructure).
- Some work may be needed to consolidate existing knowledge (e.g. on carbon sequestration and storage in different habitats) into guidance for WebTAG.
- For recreation, further work is needed to investigate the marginal impact of transport schemes on the recreation value of sites impacted (e.g. within the scheme viewshed).
- While ongoing work (updating Jones et al 2017, in prep) is generating lookup values for air pollutant removal by vegetation by local authority, further modelling could help tailor

these values to the impact of transport schemes (e.g. to understand impacts at a finer spatial scale, such as for roadside trees).

- There are other ecosystem services not currently captured in the appraisal of landscape within the supplementary guidance to WebTAG, such as local climate regulation (urban cooling) and mitigation of light pollution. These are not currently not significant enough for detailed investigation, mainly because the added impacts of transport schemes on these is expected to be relatively small. However, DfT should monitor developments in evidence on these services (e.g. in work for the UK natural capital accounts).

The appraisal process would also be improved through a better understanding of the overall impacts of transport schemes on land use. DfT should track the annual impacts of different types of transport schemes (both in terms of scheme footprint and viewshed). This will inform priorities for ecosystem service valuation evidence – allowing it to be tailored to scheme types and habitats. It will also contribute to monitoring the objectives under the 25-year environment plan.

7.4.1 Valuing impacts on the visual amenity of landscape

For the visual amenity of landscape, there is no monetary valuation evidence that can be used to replace the current appraisal approach. This leaves the task to trade-off landscape impacts and the range of other complex socio-economic impacts of transport projects (including scheme costs, other environmental impacts, time savings and contribution to economic growth) to decision-makers. Previous pilot studies (eftec et al, 2007 & 2009) suggest such monetary values could be generated through primary stated preference research.

Alternatively, a repeat sales approach looking at previous transport infrastructure schemes can be tested to generate values for the change in property prices due to these schemes. However, the repeat sales approach would not fully capture welfare values in the way stated preference can – in particular non-use values.

Repeat sales measure values for owners/ residents of properties, and stated preference can be targeted to measure values in the rest of the population (i.e. visitors and non-users). Therefore, the two approaches could potentially be used in combination to measure the value of landscape impacts. Any primary valuation research would need to provide results that reflect how the impacts of transport infrastructure on the visual amenity of landscape will differ by:

- Type of transport scheme;
- Type of land-use;
- Type of landscape (including topography and hence visibility of infrastructure); and
- Groups affected, including users (residents, visitors, passers-by) and non-users.

Economic valuation (regardless of which method is used) would not capture what landscape professionals regard as the intrinsic value of landscape, so they would not replace the existing landscape appraisal approaches. However, it would significantly strengthen the evidence base for landscape appraisal.

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Appendix B – Typologies of Natural Capital Assets and Benefits

Natural Capital Assets
Species - All living organisms including plants, animals, fungi and micro-organisms; the product of ongoing evolutionary processes;
Ecological Communities - A group of actually or potentially interacting species living in the same place. Groups of interacting species form distinctive assemblages interacting with their physical environment;
Soils - The combination of weathered minerals, organic materials, and living organisms and the interactions between these;
Freshwaters - Freshwater bodies (rivers, lakes, ponds and ground-waters) and wetlands. This includes water, sediments, living organisms and the interactions between these;
Land - The physical surface of the Earth and space for human activity. This includes the various landforms and processes which shape these (weathering and erosion);
Atmosphere - The layer of gases surrounding the Earth including oxygen, carbon dioxide and nitrogen used by all living organisms, and the processes which give rise to climate, weather (wind, precipitation) and temperature regulation;
Minerals - Naturally occurring, non-living substances with a specific chemical composition formed by geologic processes;
Sub-soil assets - Other non-living substances in the Earth's crust including rocks and aggregates as well as non-mineral substances such as fossil fuels;
Oceans - Saline bodies of water that occupy the majority of the Earth's surface. This includes water, sediments, living organisms and the interactions between these;
Coasts - The transitional zone between land and oceans. This includes water, sediments, living organisms and the interactions between these.

Service Type	Benefits
Provisioning	**Food -** plant, animal and fungi consumed by people; both wild and cultivated sources;
	Fibre - plant and animal materials used by people for building, clothing and other objects, including timber;
	Energy - all sources of energy used by people (fossil fuels, wind, tidal, wave, hydro, biomass and solar);
	Minerals* - aggregates and rock extracted to be used as materials by people for building;
Regulating	**Clean water -** water for human use (for example, drinking, bathing, industrial processes); a combination of quality and quantity;
	Clean air - air quality that has no adverse impact upon human health or wellbeing;
	Protection from hazards - natural regulation of extreme events such as flooding, drought and landslips;
Cultural	**Recreation -** active enjoyment of the natural environment, for example, walking, fishing, and canoeing;
	Aesthetics - passive enjoyment of the natural environment, for example, landscape appreciation and views;
	Wildlife - wild species diversity and abundance which has aesthetic and recreational value and has cultural and spiritual significance. Distinct from the natural assets, species and ecological communities, in that these represent the species that are significant to England and that people care about;
	Equable climate - a comfortable climate that has no adverse impact upon human health or wellbeing. This is the result of both global scale and local scale effects (for example, urban cooling by trees).
* Added as abiotic Benefit	

Appendix C – Principles of Good Guidance

1. **Robust Mandate:** is there sufficient rationale for the change?
2. **Quality Assurance:** is there sufficient quality assurance around the change and how will the change affect the WebTAG unit analytical assurance statement?
3. **Proportionate changes in modelling and appraisal costs:** have the impacts of the changes on the costs of modelling and appraisal been set out, have relevant stakeholders been consulted and are these impacts justified and proportionate?
4. **Appropriate consultation on the change:** has the impact on the Transport Business case been calculated for a range of projects and have relevant stakeholders been consulted on this?
5. **Proportionate plan for implementing the change:** is the plan for implementing the change proportionate to the implications of the guidance change? Will the change require public consultation?
6. **Consistency across methods and modes.**
7. **Improving Analytical Assurance –** How will the change in guidance affect analytical assurance of the transport business cases that draw upon this evidence. Specifically, how will the change affect issues of presentation, complexity, innovation, risk of error and uncertainty?

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