Severn Tidal Power Equal Value Investigation

Report to the

Sustainable Development Commission

By

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Executive Summary

This report presents the results of a study commissioned by the Sustainable Development Commission (SDC) to review possible approaches to the development of “equal value” ecological compensation for residual impacts on the Severn Estuary and other European designated sites that might arise as a consequence of different options for generation of tidal power in the Severn Estuary.

This study formed the second phase of a two-phase “Equal Value Investigation” led by the SDC on behalf of the Department for Energy and Climate Change (DECC). The first phase took the form of two deliberative workshops involving a range of experts. These generated a range of ideas which have been further developed in this second phase. The “Equal Value Investigation” forms part of a wider Severn Tidal Power (STP) Feasibility Study. The impacts and mitigation requirements of alternative options for tidal power generation are being assessed and compared through other studies and it was outside the remit of this study to consider the results of these assessments or their acceptability within the requirements of the Habitats and Birds Directives (hereafter referred to as “the Directives”). In the case of the STP options, however, it is already apparent that ecological compensation opportunities using the current (non statutory) European Commission Guidance might be insufficient to maintain the conservation status of some designated features at Member State level.

TEC was commissioned to carry out a preliminary investigation into possible approaches that could be used to identify “equal value compensation” in cases such as this, where there may be insufficient local opportunity to meet requirements for ecological compensation for some habitats and species. There may be an increasing need for such approaches in future as availability of land for ecological compensation for impacts of large infrastructure proposals becomes more constrained.

The need for compensation comes into play in cases where the integrity of a designated site is compromised and it has not proved possible to ensure that it will be maintained through mitigation. Ability to compensate for adverse effects on European habitats and species depends on the ecology of those habitats and species and on the existence of opportunities to deliver sufficient compensation to offset impacts of the type and magnitude identified.

In this study we assume a hypothetical case in which the magnitude and type of impacts are such that it proves impossible to identify sufficient suitable land for local provision of compensatory habitat to comply with the requirements of the current, non-statutory European Commission guidance (EC 2007a). In such a case, ecological compensation requirements could only be met by making certain trade-offs, whether in terms of the geographic location where compensation is provided or the habitats and species which benefit from it. We set out to develop a framework which could be used to determine whether it would be possible to comply with the requirements of the Directives if such trade-offs are made. We also consider whether it is possible to identify principles and criteria (or tests) which could help determine whether this has been achieved. These are based on the premise that all ecological compensation should result in at least an “equivalent” outcome in terms of the conservation status of habitats and species (the main goal of the Directives).

We use ***hypothetical*** examples to illustrate a possible approach, albeit based on similar interests to those which might be affected if proposals for generation of tidal

power in the Severn Estuary were to be taken forward by the UK government. We did not set out to determine the acceptability or otherwise of proposed mitigation or compensation for the alternative options which are being developed, rather to suggest ways in which such a determination could potentially be carried out, based on a review of various other approaches that have been used to determine "ecological equivalence".

We considered only compensation approaches that are based on "resource equivalency" in terms of ecological units such as populations of fish or areas of habitat. Units of compensation are defined in terms of the type and amount of ecological resources themselves, not the cost of providing them or the environmental services they provide.

Key Conclusions:
Ecological compensation requirements under the Birds and Habitats Directives are likely to become increasingly challenging to meet as landscape transformation continues, with the added complexity of unpredictable outcomes due to climate change. Current approaches involve many subtle trade-offs which are not always made explicit. A method for validating design of ecological compensation could provide a stronger basis for monitoring and verification (and this would be an essential pre-requisite of any formal system of habitat banking or trading of ecological values). Any decision about the suitability or acceptability of proposed compensation needs to be made at the design stage, in advance of implementation and taking all uncertainties into account. It is suggested that principles could be established to ensure that key requirements will be met. Associated criteria can be identified as a basis for more detailed validation and also provide a basis for any subsequent monitoring or verification which might be required at a later stage to demonstrate that the compensation provided is appropriate and acceptable.

To meet the goals of the Directives, ecological compensation must deliver "equivalence" in terms of the conservation status of habitats and species and the coherence of the Natura 2000 network as a minimum.

The current guidance (EC 2007 a) encourages ecological compensation to be provided as close as possible to where impacts take place, but does not specify actual thresholds or limits other than to require compensation to be delivered within the Member State boundary. It does not define clearly what constitutes acceptable compensation or explain how "equivalence" should be determined. A recent paper by Kraimer (2009) strongly reinforces the need for more rigorous and transparent design, approval and monitoring of ecological compensation in Europe.

It is possible, in theory, to achieve "equivalence" even if some trade-offs are made in terms of the geographic location where compensation is provided, or the habitats and species which benefit from it.

We suggest that it might be possible to design compensation which will achieve "equivalence" in terms of conservation status of habitats and species, based on the parameters already used by Member States to monitor and report on conservation status at EU level, though further work is needed to confirm this. The extent to which "equivalence" is achievable depends on compensation opportunity, which increases as "allowable area for delivery" is extended. Current practice is based on compensation within Member State boundaries. For some of the habitats and species likely to be affected by the STP options, there is expected to be insufficient opportunity to deliver compensation of the type and scale required within the UK. We carried out preliminary investigations based on readily available information to test the achievability of equivalent outcomes in terms of conservation status if the allowable area for delivery of compensation is extended to include the whole Atlantic bio-geographic region. In theory there is no reason why compensation delivered at this scale should not comply with the requirements of the Directive if "equivalence" is clearly defined in terms of conservation status, but there are several barriers to be overcome to develop a robust approach in practice.

Given the likely effects of climate change, it is timely to consider scope for more adaptive approaches to compensation in which habitats and species are restored in climate resilient networks. This is likely to be pre-requisite for achievement of favourable conservation status for increasing numbers of habitats and species in Europe. The potential benefits of large scale climate resilient networks are maximised if conservation status is considered at a wider scale. This increases opportunities to provide compensation in locations where it has the greatest chances of success.

There is a tension between what is most likely to succeed in ecological terms and what might be deliverable in practice. From an ecological systems perspective, ability to compensate is constrained by the availability of suitable sites and there are some cases where this could potentially be addressed by widening the geographic area within which compensation could be delivered. This might mean delivering compensation in other Member States in order to maintain or enhance the conservation status of a habitat or species within the Biogeographic Region or the Natura 2000 network as a whole. The Severn Estuary forms part of the Atlantic bio-geographic region – which also includes France, Spain and Portugal. While delivery of compensation at the level of the Atlantic Bio-geographic Region could have some benefits from a theoretical ecological perspective, however, there would obviously be considerable legal, political and possibly financial hurdles to overcome. We were not able to consider these in this study and further work would be required to establish the desirability of a new approach.

The ability to make explicit trade-offs between designated interest features when designing compensation packages requires reliable, comprehensive and up to date monitoring information from similar schemes and relevant research. Without this, there is a risk that trade-offs might be accepted which result in irreversible (and undetected declines) in conservation status for some features at the expense of others. Standard habitat mapping across landscapes, using a single habitat classification that fully incorporates Annex 1 habitat types, without the need to translate from other systems, is seen as an essential requirement to support such an approach. This is not current practice. There may also be some habitats and species for which the knowledge base is inadequate to support reliable predictions concerning the likely success of alternative compensation measures. For such habitats and species conservation *in situ* may be the only reliable option.

It would be necessary to carry out further research into strategic tools designed to help identify where it would be possible and/or appropriate to deliver different types of compensation or to identify areas that would make a strategic contribution to linking up Natura 2000 sites or achieving Favourable Conservation Status. Some approaches and tools have been developed overseas for this purpose and are currently being explored in the UK, particularly at regional level, but further testing of their application in the context of ecological compensation would be required.

On the other hand systems based on habitat banking and the development of viable markets in conservation credits offer one possible way to encourage restoration methods to be tried and tested in advance of impacts taking place. The kind of approach we explore in this report could be readily adapted to support a habitat banking or other biodiversity offset system. Such systems have been used successfully in other countries (and their applicability in Europe is being investigated), but it would take some time for them to become established in the UK and reach the level of maturity required for a stock of established compensation credits to become available.

While we conclude it would be possible to develop alternative approaches to development of ecological compensation, based on a more systematic approach to determination of ecological equivalence, such approaches would need thorough investigation in terms of their legal and political acceptability with a range of stakeholders and would need to be tested in practice.

We conclude that, if the geographic limit for compensation remains as the Member State boundary, there are likely to be some habitats and species for which it will not be possible to achieve compensation for impacts associated with the STP options, either under the existing guidance (EC 2007a) or using conservation status to define “equivalence”.

CONTENTS

1 INTRODUCTION

This report presents the results of a study commissioned by the Sustainable Development Commission (SDC) to review possible approaches to the development of "equal value" ecological compensation for residual impacts on the Severn Estuary and other European designated sites that might arise as a consequence of different options for generation of tidal power in the Severn Estuary.

The study formed the second phase of a two-phase "Equal Value Investigation" led by the SDC on behalf of the Department for Energy and Climate Change (DECC). The first phase took the form of two deliberative workshops involving a range of experts. These generated a range of ideas which have been further developed in this second phase. The "Equal Value Investigation" forms part of a wider Severn Tidal Power (STP) Feasibility Study. The impacts and mitigation requirements of alternative options for tidal power generation are being assessed and compared through other studies and it is outside the remit of this study to consider the results of these assessments or their acceptability within the requirements of the Habitats and Birds Directives (hereafter referred to as "the Directives").

We assume a hypothetical case in which the magnitude and type of impacts caused by a proposed STP option are such that it proves impossible to identify sufficient suitable land for local provision of compensatory habitat to comply with the requirements of the current, non-statutory European Commission guidance (EC 2007a). In such a case, ecological compensation requirements could only be met by making certain trade-offs, whether in terms of the geographic location where compensation is provided or the habitats and species which benefit from it. We set out to develop a framework which could be used to determine whether it would be possible to comply with the requirements of the Directives if such trade-offs are made. We also consider whether it is possible to identify principles and criteria (or tests) which could help determine whether this has been achieved. These are based on the premise that all ecological compensation should result in at least an "equivalent" outcome in terms of the conservation status of habitats and species (the main goal of the Directives).

We have used ***hypothetical*** examples to illustrate a possible approach, based on similar interests to those which might be affected if proposals for generation of tidal power in the Severn Estuary were to be taken forward by the UK government. The study did not set out to determine the acceptability or otherwise of proposed mitigation or compensation for the alternative options which are being developed, rather to suggest ways in which such a determination could potentially be carried out, based on a review of various other approaches that have been used to determine "ecological equivalence".

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1.1 Summary of the contents of the report

The report presents:

- An explanation of the background and need for consideration of "Equal Value" or ecological equivalence in the context of the STP options (this chapter).
- A review of the requirements of the Habitats Directive with respect to compensation and identify key concepts or aspects that might be used to define "equivalence" in the context of the Directive (Chapter 2).
- A review of key issues that need to be addressed to demonstrate equivalence of compensation options (Chapter 3).
- A possible framework for validating compensation options based on principles and tests of equivalence and using examples of habitats and species that could be affected by the STP options (Chapter 4).

1.2 Background

The SDC's 'Turning the Tide: Tidal Power in the UK' report, published in 2007, presented a series of recommendations to Government on how to develop the UK's tidal resource to provide secure, low-carbon electricity for the long-term. The report also set out certain conditions which would have to be met for a tidal power generation Scheme on the Severn to be considered consistent with the principles of sustainable development. In particular the report recommended that any consideration of a barrage must be taken within a framework that placed a high value on the long-term public interest and on maintaining the overall integrity of internationally recognised wildlife sites and their associated habitats and species.

A feasibility study is currently being undertaken by the Government to explore the potential for tidal power generation in the Severn Estuary. The Severn Estuary is designated as a Special Protection Area and a Site of Community Importance (SCI) under the European Birds and Habitats Directives and, as such, is a part of the European Natura 2000 Network. It is also designated as a Ramsar site. The options being considered for development of tidal power in the Severn Estuary could result in damage to the designated interest features of the Severn Estuary as well as several other European designated sites, in particular SAC-designated rivers which discharge into the Severn Estuary including the Rivers Usk and Wye.

A Screening assessment carried out as part of a Habitat Regulations Assessment of possible Severn Tidal Power (STP) options in 2008 concluded that as many as 19 different European Sites, with a wide variety of designated interest features could be exposed to significant adverse effects as a result of environmental changes associated with construction of an STP scheme. The most significant change would be reduced tidal range and new water levels in the Severn Estuary itself, leading to a reduction of intertidal area upstream of a barrage. Impacts have not been confirmed at this stage, but could be on a considerable scale, possibly affecting up to 20 000 ha of inter-tidal habitat, 25 species of bird and fish species which are in decline globally. The migratory fish species Allis Shad and Twaite Shad could face local extinction (SDC, unpublished report 2009).

In identifying options for tidal power generation, the Government is obliged to comply with the requirements of the Habitats Directive and must demonstrate that all reasonable measures have been taken to avoid and minimise impacts, so that those remaining can be considered ‘residual’ and ‘unavoidable’ (Dodd, 2008). This is the subject of other ongoing studies which will not be completed until a later stage in the development of the STP options, but preliminary results suggest that it will be impossible to mitigate for all adverse impacts on European designated interest features and that ecological compensation will be necessary to comply with the requirements of the Habitats Directive.

In broad terms, ecological compensation under the Habitats Directive is required to maintain:

1. The conservation status of the designated interest features of the site(s).
2. The overall coherence of the Natura 2000 network.

The current European Commission guidance (which is non-statutory) suggests that compensatory measures should be based on those designated interest features of a site that would be affected by development and located as close as possible to where the losses would occur (EC 2007 a) but clear rules or requirements (for example to decide how close is close enough for an acceptable outcome to be achieved) are not specified.

There is growing awareness that the current emphasis on “local, like for like” compensation may not always result in optimal outcomes for conservation, however, for the following reasons:

- the current spatial configuration of ecological networks may not be sufficient or appropriate to maintain species populations in the long term, especially if climate changes;
- restoration potential differs between locations: the closest locations to the site of impact may not be the most suitable;
- compensation measures undertaken close to more distant, viable populations or where soil, water and other conditions are especially favourable may be more effective than attempting to support unsustainable populations or restore habitat in environments which are sub optimal for restoration locally;
- there may be benefits from consolidation of compensation effort to deliver large areas of habitat or climate resilient networks.

Some authors, for example Van Teeffelen, Opdam and Vos (2008), have suggested that current (reactive) approaches to compensation as practised under Article 6(4) may not be conducive to development of an effective, strategic approach to conservation that is flexible in response to ongoing changes (including climate change) and which is likely to be required increasingly in future. Furthermore, Kraimer (2009) reviewed 11 Commission “Opinions” concerning the acceptability of compensation under Article 6(4) and concluded that none of the 11 cases “lives up to the requirements of Article 6(4) of the Habitats Directive and the Commission’s guidance documents. He suggested a need for greater transparency concerning the acceptability of proposed compensation and also monitoring of its implementation. There is limited documented information available about the design and monitoring of ecological compensation under Article 6(4), but approaches appear to be quite variable in their interpretation of the current guidance.

2 COMPENSATION REQUIREMENTS UNDER THE EU BIRDS AND HABITATS DIRECTIVES

2.1 Introduction

The STP options potentially affect many Natura 2000 sites and it may not be possible to mitigate for all adverse effects, making compensation necessary. Compensation requirements under the EU Birds and Habitats Directives (the "Directives") are therefore reviewed in this chapter. Because it may not be possible to preserve the integrity of some of the European designated sites which might be affected, other options for achieving ecological equivalence or "equal value compensation" need to be considered. Review of the requirements of the Birds and Habitats Directives suggests that the conservation status of habitats and species and the overall coherence of the Natura 2000 network should be used as the key concepts to underpin a compensation framework. The primary goal of achieving "favourable conservation status" is underpinned by coherent networks of protected areas and a supportive intervening landscape. This chapter therefore outlines the main requirements of the Directives with respect to achievement of Favourable Conservation Status (FCS) and considers the relationship between FCS and the overall coherence of the Natura 2000 network.

In this chapter direct quotes from the Directives are presented in italics.

2.2 The main aims and requirements of the EU Birds and Habitats Directives

The EU Birds[1] and Habitats[2] Directives apply in both terrestrial and marine environments and cover the protection, management, control and exploitation of the EU's wildlife. They are framework policies, so detailed implementation is the responsibility of national governments (Ledoux *et al*., 2000).

Both directives adopt a twin-track approach to biodiversity conservation, using a combination of habitat conservation and species protection measures to attain the primary goal of achieving Favourable Conservation Status (FCS) for flora, fauna and habitats of European importance (Dodd, 2008). Habitat conservation is pursued primarily through the establishment of a coherent network of protected areas known as Natura 2000[3], which comprises special protection areas (SPAs) for birds and special areas of conservation (SACs) for other fauna, flora and habitats of Community importance. Article 3 of the Habitats Directive makes it clear that the Natura 2000 network is a key mechanism by which to maintain or, where appropriate, restore the FCS of species and habitats of European Community importance.

Wider measures to contribute to the achievement of FCS of species and habitat protected under the Birds and Habitats Directives outside of Natura 2000 sites have

[1] Council Directive 79/409/EEC of 2 April 1979 on the Conservation of Wild Birds (Birds Directive).
[2] Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora (Habitats Directive).
[3] Habitats Directive art 3(1).

been relatively neglected (Dodd, 2008)[4], despite the requirements set out in Articles 2(2) and Article 10 of the Habitats Directive and Article 2 of the Birds Directive.

2.2.1 How Favourable Conservation Status is Defined and Monitored

The key purpose of the Habitats Directive is to achieve the favourable conservation status (FCS) of species and habitats listed in the Annexes to the Directive as of Community Interest. The obligation to achieve FCS also extends to the Birds Directive: in (CEC, 2004) it is noted that, while not used explicitly in the Birds Directive, FCS is implicit in the requirements of Article 2 of that Directive "…*to maintain the population of the species referred to in Article 1 at a level which corresponds in particular to ecological, scientific and cultural requirements*…".

For habitats, conservation status is:
"*the sum of the influences acting on a natural habitat and its typical species that may affect its long-term natural distribution, structure and functions as well as the long-term survival of its typical species*[5]."

The conservation status of a habitat is favourable if:

> *i. its natural range and areas it covers within that range are stable or increasing, and*
> *ii. the species structure and functions which are necessary for its long term maintenance exist and are likely to continue to exist for the foreseeable future, and*
> *iii. the conservation status of its typical species is favourable as defined in Article 1(i).*

For species, conservation status is:
"*the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations*."

Conservation status of a species is favourable if:

> *i. the population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats;*
> *ii. the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*
> *iii. there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis* (Article 1(i)).

There are several important definitions included here which could form the basis for evaluation of compensation. They are reflected in the attributes used by Member States to report to the European Commission under Article 17 of the Habitats Directive on the conservation status of all Annex-listed habitats and species occurring in the relevant bio-geographic regions (the UK is all within the Atlantic bio- geographical region).

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[4] Birds Directive art 3 requires Member States to preserve, maintain and re-establish sufficient diversity and area of habitats for all wild birds through measures such as protected areas, habitat creation, restoration and management. Art 4 requires the taking of special conservation measures for migratory species and those listed on Annex I: SPAs are specified as one such measure. Habitats Directive art 10 gives Member States the power to encourage the management of features of the landscape of major importance for wild flora and fauna, in particular to improve the coherence of the Natura 2000 network. Such features are those essential to the migration, dispersal and genetic exchange of wild species.
[5] Habitats Directive Article 1(e)

The attributes used by Member States to report to the European Commission (EC) on conservation status are, for habitats:

- Range,
- Area,
- Structure
- Functions (including typical species), and
- Future Prospects (largely based on understanding of threats)

For species:

- Range,
- Population,
- Habitat for the Species,
- Future Prospects (largely based on understanding of threats)

Assessments of conservation status for each habitat and species are made at the Member State, biogeographic region and EU level. There is therefore precedent for considering status at different geographic scales. Four categories are used as follows:

1. Favourable ("Green") - where the species or habitat is at FCS as defined in the Directive and the habitat or species can be expected to prosper without any change to existing management or policies.
2. Unfavourable-inadequate ("Amber") - for situations where a change in management or policy is required but the danger of extinction is not so high.
3. Unfavourable-bad ("Red") - where the habitat or species is in serious danger of becoming extinct (at least locally).
4. Unknown ("Grey") – where there is insufficient information to make a judgement.

Optionally, trend information ("deteriorating" or "improving") can be added to the unfavourable status assessment.

Favourable Reference Values (FRVs) are an important concept in the evaluation of Conservation Status (DocHab-04-03/03 rev.3). Where habitats and species are reported as being at an unfavourable status, FRVs are used to establish targets for progress towards Favourable Conservation Status. Essentially these reflect a goal of increasing levels of range and area occupied by a habitat or range and population size for a species, based either on known historic levels or on hypothetical target levels. Member states are required to identify the appropriate reference range and area for the habitats of Annex I and the appropriate reference range and population for the species of Annexes II, IV & V in order to establish the reference values required.

A "traffic light" system is used to assess status at Member State level as follows:

Overall Status at Member State Level	
Favourable	All 'Green' OR three 'Green' and one 'Unknown'
Unfavourable – Inadequate	One or more 'Amber' but no 'Red'
Unfavourable – Bad	One or more 'Red'
Unknown	Two or more 'Unknown' combined with 'Green' OR all "Unknown"

Member state assessments are then aggregated into bio-geographic region assessments and EU wide assessments using similar approaches. There is no equivalent reporting under the Birds Directive, although Birdlife International has made the case to the EC that equivalent reporting should become mandatory, using Favourable Reference Values.

2.3 Compensation requirements

Article 6 of the Habitats Directive sets out a series of site management and site protection provisions and the European Court of Justice has confirmed that the underlying purpose of Article 6 is to prevent adverse effects on the integrity of Natura 2000 sites (European Court of Justice, 2004). The right to develop or manage land is recognised, provided it is done responsibly by avoiding damage to Natura 2000 sites or European protected species[6]. Consent to alter land use or develop Natura 2000 sites should only be granted when "…*there is no reasonable scientific doubt as to the absence of adverse effects*…" (see paragraph 58, (European Court of Justice, 2004), and paragraph 24, (European Court of Justice, 2006)). Article 6(4) does provide for exceptions to this general rule, provided strict tests on alternative solutions and overriding public interest are met.

There are specific requirements for ecological compensation in cases where the integrity of the Natura 2000 network might be compromised by development. 'Habitats Regulations Assessment' is required under the Habitats Directive for any plan or policy likely to have significant effects on any Natura 2000 site to determine whether it would damage the *ecological integrity* of the site or *compromise the overall coherence of the Natura 2000 Network*.

Stricter criteria are applied where a site contains a priority interest, in which case *"the only considerations which may be raised are those relating to human health or public safety to beneficial consequences of primary importance for the environment or further to an opinion from the Commission to other imperative reasons of overriding public interest"(*Habitats Directive Article 6*)*.

The EC non statutory Guidance (2007 a) explains that appropriate assessments should include all elements contributing to the site's integrity **and** to the overall coherence of the network as defined in the site's conservation objectives and Standard Data Form (as submitted to the EC at the time the site was proposed), and be based on best available scientific knowledge in the field. A need for information addressing the following issues is suggested:

- "*Structure and function, and the respective role of the site's ecological assets.*
- *Area, representativity and the conservation status of the priority and non-priority habitats in the site.*
- *Population size, degree of isolation, ecotype, genetic pool, age class structure, and conservation status of species under Annex II of the Habitats Directive or Annex I of the Birds Directive present in the site.*
- *Role of the site within the biographical region and in the coherence of the Natura 2000 network.*
- *Any other ecological assets and functions identified in the site*".

[6] Habitats Directive art 6(3) in respect of Natura 2000 sites and art 16 in respect of European Protected Species.

If assessment demonstrates adverse impacts, then the relevant competent authorities must seek to avoid or mitigate those impacts before considering the possible alternatives. The need for compensation under the Birds and Habitats Directive is therefore framed within a mitigation hierarchy and only comes into play if there are significant residual adverse effects which cannot be avoided.

The Guidance on Article 6(4) provided by the European Commission (EC, 2007 a) makes a distinction between mitigation and compensation, defining them as follows:

- *"mitigation measures"…. "are those measures which aim to minimise, or even cancel, the negative impacts on a site that are likely to arise as a result of the implementation of a plan or project. These measures are an integral part of the specifications of a plan or project.*
- *compensatory measures sensu stricto are independent of the project (including any associated mitigation measures). They are intended to offset the negative effects of the plan or project so that the overall ecological coherence of the Natura 2000 Network is maintained".*

We explore the relationship between the two further in the following section. If no viable alternatives are identified, and if the decision is taken by government to proceed on the basis of '*imperative reasons of overriding public interest*'[7], then the Directives set forth a compulsory requirement to provide compensation for habitats and species. The need for compensation to ensure that the overall coherence of the Natura 2000 network is maintained[8] is made explicit in the Directive in Article 6: "*If in spite of a negative assessment of the implications for the site and in the absence of alternative solutions a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take* ***all compensatory measures necessary*** *to ensure that the overall coherence of Natura 2000 is protected" (*bold added for emphasis*).*

Other European Directives also refer to the need to compensate for, or offset development impacts, as summarised in Box 1. Possibility of impacts on Natura 2000 sites can be a trigger for requirements under these directives and they create frameworks or contexts within which compensation must be delivered, but they are not considered in detail in this report.

[7] Habitats Directive art 6(4) states that where, in the absence of alternative solutions, damage to a Natura 2000 site is unavoidable, a plan or project can be permitted for imperative reasons of overriding public interest, including those of a social or economic nature. Where the Natura 2000 site hosts a priority habitat or species, the only considerations that can be raised are those relating to human health or public safety, to beneficial consequences of primary importance for the environment, or following an opinion from the Commission, other imperative reasons of overriding public interest. Article 16 states that a Member State can derogate from the protection regime for European protected species provided there is no satisfactory alternative and the derogation is not detrimental to the maintenance of the populations of the species concerned at a favourable conservation status. The derogations concerned include: (c) in the interests of public health and public safety, or for other imperative reasons of overriding public interest, including those of a social or economic nature and beneficial consequences of primary importance for the environment.

[8] Where damage is permitted to a Natura 2000 site, Habitats Directive art 6(4) requires Member States to take all necessary compensatory measures to ensure the overall coherence of the Natura 2000 network is protected.

Box 1

EIA Directive[9] [10]:
Article 5(3) *requires the developer to submit "a description of the measures envisaged […] to prevent, reduce and* ***where possible offset*** *any significant adverse effects to the environment".*

SEA Directive[11]:
Annex I - the report should *provide information regarding "the measures envisaged to prevent, reduce and* ***as fully as possible offset*** *significant effects on the environment of implementing the plan"*.

ELD Directive:
Annex II …re*storation of these natural resources to their baseline condition is to be achieved by way of so-called primary****, complementary and compensatory*** *remediation measures.*

2.3.1 Delivering compensation within the context of the mitigation hierarchy

It is important to clarify the relationship between mitigation and compensation as compensation is intended as a "last resort" after all appropriate mitigation measures have been identified. In the context of the Birds and Habitats Directives, the mitigation hierarchy is built on the following sequential approach (our interpretation):

1. Avoid impacts by identifying alternative solutions, for example by altering locations for development.
2. Mitigate for adverse impacts through measures to avoid, reduce or remedy their effects on Natura 2000 sites and their designated interest features, perhaps through modification to design or method.
3. Assuming there are no alternatives to the proposed development, and that residual adverse impacts will remain after mitigation, compensate for residual adverse effects to ensure that the overall coherence of the Natura 2000 network is maintained.

Compensation is essentially independent from the design of a proposed development, but is intended to achieve pre- and post-impact equivalence in ecological terms, the primary goal being achievement of Favourable Conservation Status (FCS) for habitats and species of European importance. Compensatory measures must therefore ensure that the overall coherence of Natura 2000 is protected (despite a residual negative effect on the integrity of a site) and should (a) address, in comparable proportions, the habitats and species negatively affected and (b) provide functions comparable to those which justified the selection criteria of the original site. The guidance (EC 2007 a) also refers to the need for compensatory measures to be targeted, effective, technically feasible and secured in perpetuity.

[9] Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment
[10] Directive 97/11/EC of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the Council environment
[11] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment

2.3.2 EC Guidance on compensation

The guidance (EC 2007 a) has generally been interpreted to mean that compensation should be sought as close to the affected site as possible, and should focus on those designated interest features which are affected (often referred to as "like for like" or "in kind" compensation). Existing European guidance does not address the possibility of exchanging or habitat types or species to any significant degree when designing compensation, but this nevertheless occurs in practice to some extent. Furthermore, the extent to which ecological equivalence can be said to have been achieved has to be questioned when compensation makes provision for the same habitat as that affected, but in a location where it will not benefit the same populations of species as those which have suffered an adverse impact. The guidance (EC 2007a) does not explain clearly how to select suitable locations to ensure that compensation does deliver an equivalent outcome in terms of the habitats and species affected. In the following chapter we argue that it is necessary to make clearer distinctions between different types of mitigation and compensation with respect to "type" of feature addressed and geographic location when considering implications for the integrity of sites, the conservation status of habitats or species and the coherence of networks.

The need to achieve functional equivalence is reflected in supplementary guidance issued by the European Commission[12] which (in relation to the Birds Directive), stresses the need for compensation to be based on functional assessment of the role of sites in supporting the overall coherence of the network. It also suggests that the overall coherence of the network can only be assured if compensation is "accessible with certainty by the birds usually occurring on the site affected by the project." The supplementary guidance therefore hints at the need for functional equivalence to be addressed to achieve real "like for like" compensation, not just equivalence in terms of habitat type, but doesn't stipulate any absolute requirements.

2.4 Definitions of coherence and its relationship with Favourable Conservation Status.

Maintaining the coherence of the Natura 2000 network is referred to as an underlying objective of compensation in the Habitats Directive and measures of coherence could potentially be used as one way to demonstrate ecological equivalence. Ambiguity concerning the precise definition and meaning of coherence, however, makes it difficult to ascertain whether or not the Natura 2000 network as it currently stands could be said to be coherent, which in turn complicates discussions about how equal value compensation might maintain or increase coherence. It is not clear whether Natura 2000 represents a functional network consisting of European designated sites together with a connective intervening landscape (a type of coherence which could be referred to as "connective coherence"); or rather a collection of sites assembled to conserve habitats and species of European importance without overt concern for functional connectivity between them (a type of coherence which might be referred to as "site series coherence"). Review of the historical evolution of Natura 2000 suggests that the latter interpretation was intended, but enhancing the ecological role of land outside of Natura 2000 in order to enhance network functions is increasingly seen as an essential component of efforts to achieve Favourable Conservation Status.

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[12] European Commission (2007). Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC. Clarification of the concepts of: alternative solutions, imperative reasons of overriding public interest, compensatory measures, overall coherence, opinion of the Commission. Brussels.

2.4.1 References to coherence in the Habitats Directive and other international agreements

References to (ecological) coherence appear in the preamble (paragraph 10) to the Habitats Directive and also in Articles 3, 4 and 10. The use of the term coherence is also mentioned in the Commission guidelines on “Managing Natura 2000 sites: The provisions of Article 6 of the ‘Habitats’ Directive 92/43/EEC”, European Commission (2000, p.46) and “overall coherence” is used in Article 6 (4) with regard to compensatory measures.

References can also be found in the preamble (paragraph 9) and Article 4, paragraph 3 of the Birds Directive and in Ornis Committee decisions (1989) about the “Ornithological criteria to guide the selection of Special Protected Areas” under “Breeding sites” point 4.

Some examples are given below:

Art. 3(1) of the Habitats Directive states that Natura 2000 is “*a coherent European ecological network of special areas of conservation that shall enable the natural habitats types and species’ habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range*”. The emphasis here is on achievement of FCS and role of Natura 2000 sites in ensuring adequate geographical distribution in relation to the ranges of European habitats and species. This article emphasises the need for “site series coherence”.

Art. 3(3) stipulates that “*where they consider it necessary, Member States shall endeavour to improve the ecological coherence of Natura 2000 by maintaining, and where appropriate developing, features of the landscape which are of major importance for wild fauna and flora, as referred to in Article 10*.”

Art. 10 deals with land use planning and development policy and stipulates that “Member States shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence of the Natura 2000 network, to encourage the features of the landscape which are of major importance for wild fauna and flora. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species.” This article therefore promotes “connective coherence”.

The term coherence is therefore used in two distinct ways: according to Article 3.1, the “Coherent ecological network” appears to be synonymous with the completed Natura 2000 network and this appears to be supported by the 2007 (a) guidance. Other articles, however, suggest that the term “coherence” refers to integrity of ecological function in the landscape as a whole and to landscape connectivity in particular. Although “coherent ecological network” according to Article 3.1 appears to be synonymous with the constituent designated sites of the Natura 2000 network, this does not adequately reflect the underlying aim of the Directive to achieve “ecological coherence”. A network is more than simply a set of sites. Functional aspects of coherence (essential for the migration, dispersal and genetic exchange of wild species) and the important part played by intervening areas in maintaining habitats and species are clearly key considerations. To function as an ecological network, constituent sites must maintain a relationship to one another and to the surrounding environment. This is recognised in other international conventions and agreements that refer to coherent networks, including the Convention on Biological Diversity, the Ramsar Convention, the Convention on Migratory Species, the African Eurasian Migratory Waterbirds Agreement, AEWA, the Pan European Biological and Landscape Diversity Strategy (PEBLDS/PEEN) and the Bern Convention (Emerald Network).

In Europe, the OSPAR (Northeast Atlantic) and HELCOM (Baltic) Commissions have both agreed (e.g. OSPAR, 2007) that an ecologically coherent network should:

- Interact with and support the wider environment.
- Maintain the processes, functions, and structures of the intended protected features across their natural range.

Furthermore it should function synergistically as a whole, such that the individual protected sites benefit from each other to achieve the two objectives above. Additionally, it may also be designed to be resilient to changing conditions (for example those associated with climate change).

The above concept of ecological coherence fed into the development of a five-point package of scientific guidance for selecting areas to establish a representative network of MPAs, including in open ocean waters and deep-sea habitats, adopted in May 2008 at the 9th Conference of the Parties (COP) of the Convention on Biological Diversity (CBD). There it was agreed that MPA networks should possess the following five properties:

- Ecologically or biologically significant areas (EBSAs).
- Representativity.
- Connectivity.
- Replicated ecological features.
- Adequate and viable sites.

There are therefore several examples where the ability to create ecologically coherent networks has been seen as a fundamental requirement in designing protected area networks (e.g. as in WCPA/IUCN 2007). Natura 2000, however, while it portrays some properties of a coherent ecological network, was never really designed as such. Nevertheless the five properties identified above could be used to derive relevant measures of network coherence for testing the likely compliance of proposed compensation with the underlying goals and objectives of the Habitats Directive. In the remainder of this report, we suggest that the wider definition of network coherence is appropriate as it recognises the essential role of the landscape outside protected areas in achieving favourable conservation status.

3 THE DESIGN OF COMPENSATION TO ACHIEVE ECOLOGICAL EQUIVALENCE

3.1 Introduction

In this chapter we consider how ecological equivalence might be defined, drawing on the underlying objectives and requirements of the Directives as outlined in the previous chapter. We consider the extent to which current approaches demonstrate the achievement of ecological equivalence.

We explore some of the issues that need to be addressed when designing compensation to achieve ecological equivalence and review some of the approaches that have been used to factor these into the design of ecological compensation (further details are included as Appendix A).

Much of the experience we have drawn on to write this chapter has been gained through development of systems for biodiversity offsets in other countries. We have also consulted principles for the design and implementation of biodiversity offsets issued by the Business and Biodiversity Offset Programme [13] in 2009, as these embody the results of a long process of review and consultation between many stakeholders from different countries.

3.2 Types of compensation

Review of compensation undertaken to meet the requirements of the Directives suggests that the need to achieve "ecological equivalence" is assumed, but not made explicit in current practice. We consider that more emphasis should be given to demonstrating that an "equivalent" ecological outcome has been achieved. The compensation categories set out in Table 1 need to be recognised and made explicit before it will be possible to demonstrate achievement of ecological equivalence in a transparent manner. The proposed approach and case studies set out in the following chapter are based on the following definitions which are used in the table:

- "Within type" refers to measures that compensate for an adverse effect on a certain habitat type address the same type of habitat – e.g. impacts on Atlantic salt meadow are compensated through measures to enhance, restore or create Atlantic salt meadow.
- "Out of type" compensation is used to refer to measures that benefit a different habitat or species from that affected – e.g. impacts on Atlantic salt meadow are compensated through measures to enhance, restore or create mudflat.
- "functional ecological unit" means that the compensation is provided within the same ecosystem as that where the impact occurs. For example, compensatory habitat might be provided within the same flyway for migrating birds, or in a location within the normal dispersal distance for a plant. In this case it is

[13] Business and Biodiversity Offsets Programme (BBOP). 2009. Business, Biodiversity Offsets and BBOP: An Overview. BBOP, Washington,D.C.
www.forest-trends.org/biodiversityoffsetprogram/guidelines/overview.pdf

assumed that compensation will benefit the same populations of a species as those affected, rather than benefitting completely different populations of the same species.
- A useful distinction can be made between "same" features (as those affected) and "substitute" features (where the type of feature that benefits from compensation differs from the type that was affected).

Note that the four main categories of compensation identified in Table 1 are not necessarily mutually exclusive, as compensation packages may include a mix of measures, for example they may include a mix of the designated interest features affected and other types (M. Wilkinson, Natural England pers. comm.).

While it is generally accepted that, as far as possible, impacts on a particular habitat type should be offset or compensated through conservation, restoration, or creation of the same habitat type ("within type compensation"), there are some circumstances in which it may be appropriate to consider investment of limited funds and efforts in a designated interest feature which is of similar or higher conservation priority, but which has better prospects in terms of survival or sustainability. This might be the case where an impacted feature is unlikely to have a sustainable future with climate change, for example. There are important consequences that follow from this. In an English context, for example, "out of type" replacement requires precise definition of habitats and sufficient knowledge (and monitoring) of their relative priority for acceptable trade-offs between habitats to be determined. Is it acceptable to exchange saltmarsh habitat for freshwater grazing marsh, for example? Possible rules to define acceptable substitutions are considered in Chapter 4.

3.2.1 Examples of compensation provided to comply with the requirements of the Habitats Directive

Several ecological compensation schemes have been carried out to comply with the requirements of the Habitats Directive in coastal or intertidal contexts in the UK. These vary in the extent to which they replicate precisely the same features and ecological functions that have been lost to development. While land adjacent to an affected Natura 2000 sites is generally prioritised for compensation, compensation is often delivered some distance away and therefore falls into Category B in Table 1. It is difficult to obtain detailed information about how compensation has been designed or its acceptability determined and Kraimer (2009) makes a strong case for greater transparency in this area throughout Europe.

- Morecambe coastal defence works (2005) - compensation was delivered at Hesketh Out Marsh adjacent to the Ribble Estuary SPA (part of a larger scheme being implemented by the RSPB) to provide "suitable and sufficient" areas of intertidal habitat to act as compensation for 13 ha of intertidal habitat that will be affected by coastal defences to be constructed within the Morecambe Bay European Site (Environment Agency, 2005).
- Bathside Bay Container Terminal (2006) - not yet delivered as the port is still awaiting consent for road improvements. Compensatory habitat was provided adjacent to Hamford Water SPA, about 4-5 miles away and located in a similar outer estuary context, to offset the loss of 69 hectares of intertidal mudflats and saltmarsh at Bathside Bay.
- RSPB Titchwell Coastal Change project (2009) - compensation delivered and functioning in advance of works. Comprises creation of avocet breeding islands

and associated habitat on RSPB reserves adjacent to the Wash SPA on the Lincolnshire coast.

- Defra Wallasea managed realignment scheme. In this case, compensation was provided retrospectively following the 1997 ECJ/House of Lords ruling on Lappel Bank for two schemes consented prior to the requirements of the Habitats Directive for compensation coming into operation (Port of Felixstowe destruction of Fagbury Flats on the Orwell estuary and Port of Sheerness destruction of Lappel Bank on the Medway). The compensation scheme is on Wallasea Island which is situated on the East coast of Essex and adjoins the Crouch and Roach estuaries, both of which have both Special Protection Area (SPA) and Special Site of Scientific Interest (SSSI) status. The compensation scheme was located geographically between the two schemes for which it was intended to provide compensation. In July 2006 Defra completed a 115 hectare wetland on the North shore of the island to replace similar bird habitats to those lost to port development during the 1990s. The project started in 2004 and the site was flooded to create the wetland in July 2006. It will be subject to monitoring until 2011, by which time the site is expected to become a fully functioning natural wetland SPA. The objectives of the compensation scheme, as described by Defra (Haggett, 2003) were:
  a) To provide intertidal habitat for the number and range of bird species displaced as a result of the loss of Lappel Bank and Fagbury Flats (presumeably benefitting the same populations as those displaced);
  b) To offset any impacts on the integrity of the originally proposed SPAs caused by the developments at Lappel Bank and Fagbury Flats;
  c) To ensure that the compensatory measures do not have an adverse affect on the geo-morphological or ecological functioning of the area in which they are located;
  d) To construct a self-sustaining system which can evolve and which is able to maintain the bird populations for which it was created over a period of at least 50 years; and
  e) To provide compensatory measures for the loss of wetland functions, (if any), which cannot be adequately replaced.

  The 115 hectares Wallasea Island scheme replaced 22 hectares at Lappel Bank and 32 hectares at Fagbury Flats, a ratio of 2.1:1) (http://www.defra.gov.uk/rural/protected/wallasea.htm

We consider it appropriate for all compensation to achieve ecological “equivalence” as a minimum. This assumption is built into all policies and laws relating to biodiversity offsets (see following section), which are a form of ecological compensation.

Table 1 Possible compensation types and their likely implications in terms of conservation status and network coherence

Mitigation/ Compensation type	**Effect on Conservation Status**	**Effect on coherence**	**Examples of this type**
Mitigation: adverse effect reduced or avoided			
Measures may be implemented on- or off-site but address specific impacts and are intended to restore pre-impact conditions as far as possible (i.e. minimise residual adverse effects) so that the integrity of the site is maintained.	Conservation status remains the same post-mitigation.	The integrity of the affected site is maintained post-impact, so its contribution to the coherence of Natura 2000 is maintained.	Managing Natura 2000 (European Commission, 2000) provides examples of mitigation. "These include measures to avoid disturbance during the breeding season of a protected species; the use of particular tools to reduce disturbance of fragile habitats; and the restriction of access to particularly sensitive areas within a site, such as hibernation burrows." The provision of substitute habitat within the site would not normally be described as mitigation, because the loss of habitat affects site integrity (Planning Inspectorate, 2003, paragraph 8.29).
Compensation: offsets residual adverse effect on site integrity remaining after mitigation.			
A. Compensation "within type" (same features as those affected) and located within same ecosystem or functional unit.	Any residual adverse effects on the conservation status of the designated interest features are compensated for through actions undertaken within the same ecosystem. The same individuals/ populations are sustained. Conservation status should remain the same post-compensation	Adverse effects on site integrity are offset by compensation measures that address the same designated interest features as those affected. Compensation is delivered in a location which is functionally linked to the site affected. The compensation actions ensure that those ecological functions which underpin the integrity of the site are sustained. Provided that compensation is successful, the modified site (with compensation) may make a similar contribution to the coherence of Natura 2000.	Strict "like for like" compensation "*sensu stricto*". Assumed as the preferred outcome under current EU guidance. Functional ecological linkages between compensation and the affected site's habitats and species are the basis for the current guidance's emphasis on delivering compensation as close as possible to where the impact occurs (EC 2007a). Defra's Wallasea managed realignment scheme, provided as compensation for loss of wetland bird habitat at Lappel Bank and Fagbury Flats falls into this category because the compensatory habitat is of the same type as that lost and the same populations of birds benefit (Haggett, 2003) and: (http://www.defra.gov.uk/rural/protected/wallasea.htm
B. Compensation "within type" (same features as	Conservation status of designated interest features may be maintained (at	Contribution of site to the coherence of Natura 2000 likely	Broadly "like for like" compensation. Possible within current guidance (EC 2007a) but explicit guidance

those affected) but located within a different ecosystem or functional unit.	a wider geographic scale of consideration) despite loss of site integrity, if compensation boosts populations of the same species or increases area and/or quality of habitat elsewhere. Individuals or local populations associated with the affected site may be lost.	to be permanently affected. Coherence of the network as a whole may be maintained if compensation ensures that other sites are brought into the network and perform a similar role. Geographical configuration of coherent network permanently changed but new configurations could have equivalent value.	not given concerning thresholds of acceptability as distance increases between site affected and the location where compensation is delivered.
C. “Out of type” compensation (substitute features) in the same functional context.	It may be possible to maintain the conservation status of designated interest features overall (at the bio-geographic scale or within the Natura 2000 network as a whole), provided that certain conditions are met. There is a risk of losses unless trades between habitats and species can be tracked or monitored reliably and in real time.	Coherence depends on changing the representation and geographical distribution of habitats and species within the Natura 2000 network as a whole. This has potential benefits in terms of conferring climate resilience and consolidating conservation effort in optimal locations.	Note that many compensation measures undertaken to date have been a mix of the designated interest features affected and other types. This has been described as “close to type” compensation (M. Wilkinson, Natural England pers. comm.).
D. “Out of type” compensation (substitute features) in a different functional context.	Effect on conservation status becomes highly complex to model and monitor. Live monitoring of conservation status is essential to ensure that disproportionate impacts do not take place for certain interest features.	Compensation may deliver new sites which seek to achieve same conservation objectives. Effective monitoring essential to ensure that viable sites, habitats and populations are maintained throughout the network.	This occurs to some extent in current practice. In this report we suggest it might be possible in theory to carry out pair-wise exchanges between impacted and substitute features beyond Member State boundaries, and in so doing to deliver an optimal outcome in terms of conservation status and network coherence. This approach needs considerably more research and testing and compensation packages requiring more complex substitutions would be very difficult to model or monitor.

3.3 Defining ecological equivalence

Equivalence can be defined as a state whereby the expected benefit (credit) generated through compensation equals the damage (debit) incurred as a result of development, both quantified in terms of the same metric (or currency). In simple terms equivalence is achieved when losses due to an impact and gains due to compensation are balanced (this is sometimes referred to as achieving “no net loss” of biodiversity). Achieving equivalence between the pre- and post-impact situation is the main basis for compensation under the Birds and Habitats Directives. It is also the basis for many systems of biodiversity offsets currently in use, or being developed, around the world.

To demonstrate that equivalence has been achieved, transparent assessments are required, based on a suitable metric. Given that it is more or less impossible for compensation to achieve an exact facsimile of an affected site or habitat, certain trade-offs generally have to be made and it is important for these to be explicit. In the following chapter, we suggest that it is theoretically possible to achieve equivalence when the habitats and species which benefit from compensation differ from those which were affected by an impact, so long as certain key tests can be met. This does not mean that substituting habitats and species in this way is desirable in practice, but there are nevertheless cases where greater flexibility in this regard might have ecological benefits.

The question of “how much compensation is enough?”, however, is complicated by the need for any comparison of losses and gains to include consideration of the following factors in addition to “type”:

- Amount: the quantum of compensation (how much habitat is provided or the numbers of individuals of a population which benefit).
- Location or spatial context (it is possible that locations meeting key ecological criteria may only be found some distance away from the location affected by development. To deliver the necessary type and amount of compensation may also require different activities to be undertaken in different locations because there is no one alternative location which has all the attributes needed to support them).
- Timing: the extent of temporal congruence between delivery of compensation and the timing of impacts.
- Confidence or reliability of compensation methods.

All of these are important considerations when testing equivalence or the extent to which “no net loss” has been achieved, whether in terms of conservation status or the coherence of ecological networks. They need to be factored clearly into design of compensatory measures and are therefore considered further below.

3.4 Type

The Habitats Directive has a strongly implied requirement to compensate for impacts on habitats and species through compensation which benefits the same habitats and species. At a European level it is important to use consistent definitions for habitats and species. For the purposes of this study we have used the EUNIS (European Union Nature Information System) habitat classification for defining what constitutes “within type” compensation (EUNIS, 2010).

In some countries, however "out of type" compensation is allowed in certain cases if the habitats or species which benefit are of higher conservation priority than those exposed to a residual adverse impact. This is sometimes referred to as "trading up". There are examples of guidance about when trading up is appropriate or acceptable in the Western Cape of South Africa (Department of Environmental Affairs and Development Planning, 2008) and the State of Victoria, Australia (Victoria, Department of Sustainability and the Environment 2002). While "like for like" (same vegetation type, same bioregion, same conservation significance) is the presumption in Victoria, developers can choose to undertake offsets on higher conservation significance land than that affected by their proposals. If developers opt to trade up, they may be eligible for a 'discount' in the offset calculation through the application of a fraction multiplier that reduces the number of habitat hectares they're obliged to supply [14](see Appendix A).

In the context of the STP options, scope for "trading up" is constrained by the fact that the habitats and species which will be exposed to residual adverse impact are all, by definition, of equivalent, high conservation priority (see Chapter 4). We have therefore had to consider whether there are circumstances in which it would be legitimate to compensate for an impact on one designated interest feature through actions to benefit another. Clear rules would be required to support such an approach and in Chapter 4 we suggest some criteria that could possibly be used in the context of the STP options to decide which features could potentially be exchanged without compromising the goals of the Habitats Directive.

3.5 Amount

The question of how much compensation is enough has been explored in the development of biodiversity offset systems currently in operation worldwide (for much material on this issue go to www.forest-trends.org). Metrics used to compare losses (due to impacts) and gains (due to offsets or compensation) have included *inter alia* amounts or areas of habitat (of a particular type and condition), population number, levels of persistence of species' populations or levels of ecological function or service. In the context of the Birds and Habitats Directives measures of network coherence and site integrity also need to be considered, but there are few documented examples where this has been attempted in an explicit way.

Possible metrics which could be applied to compensation for the STP options include:

- Measures of integrity.
- Measures of conservation status.
- Measures of network coherence.
- Measures of habitat area (of a particular type or quality).
- Extinction risk.
- Carrying capacity in sustainable habitat networks.

These are described briefly below.

It is also common practice for amounts of compensation to be adjusted to allow for uncertainty or delay in implementation through the use of "multipliers", and this is explored further in 3.9.

[14] Appendix H p16 of the Framework (DSE 2002)

3.5.1 Measures of integrity

Ecosystems have integrity when they have their characteristic components intact, including: abiotic components, biodiversity (the composition and abundance of species and communities) and ecosystem processes. The concept is generally applied to sites and habitats, rather than species populations.

Various approaches to "ecological integrity assessment" have been developed in the United States to monitor and evaluate wetland mitigation success and to determine when compensation actions are leading to required improvements. These include an "ecological scorecard" approach described by Harwell *et al.* (1999) and later Parrish *et al*. (2003) in which information about key ecological attributes is used to derive suitable indicators, metrics and ratings. In general these methods are used to determine when integrity has been achieved, based on key structural and functional attributes. They can be used to compare pre- and post-impact conditions at a site or to compare an affected site with compensatory habitat.

In the context of the Birds and Habitats Directives, mitigation is required to maintain site integrity and compensation is required in cases where this cannot be achieved. The only way integrity of a site or system can be maintained is if compensation is delivered within the same functional unit as the site affected, benefits the same habitats and/or species and is in place in advance of impacts taking place, so that key processes and functions are sustained throughout.

3.5.2 Measures of conservation status of habitats and species

The goal of achieving Favourable Conservation Status underpins the Birds and Habitats Directives as discussed in the previous Chapter. It is therefore important to consider whether the concept can be used in any way to assess or quantify levels of ecological equivalence, especially as Member States are required to report to the European Commission concerning attributes of conservation status on the basis of certain attributes.

The attributes used by Member States to report to the European Commission on conservation status are, for habitats:

- Range,
- Area,
- Structure and Functions (including typical species), and
- Future Prospects (largely based on understanding of threats)

For species:

- Range,
- Population,
- Habitat for the Species,
- Future Prospects (largely based on understanding of threats)

The Favourable Reference Values defined by Member States as the basis for targets in cases where habitats or species are in unfavourable condition, are based predominantly on estimates of current and potential levels of occupancy of the range of habitats or species. Any increase in the proportion of the potential range which is occupied is an obvious indicator that conservation status is being improved, and this has therefore been factored in to the tests suggested in the following chapter.

Future prospects are assessed as favourable if the habitat prospects are excellent or good, no significant impact from threats are expected and long-term (defined as around 20 years) viability is assured (European Commission, 2006). These terms are not further defined. There is likely to be considerable variation in assessment across Europe.

3.5.3 Measures of network coherence

To demonstrate that there has been 'no net loss' in coherence, assessment of losses and gains in ecological composition and functionality is required, generally at a wider or landscape-scale. Clearly, in the context of the Directives, it would be important to establish what type of network coherence is intended (site series coherence or connective coherence).

It might be possible to preserve the overall coherence of an ecological network even if there are changes in individual constituent sites, but this requires the following conditions to be met:

1. There is at least some inter-changeability among the ingredients (sites, habitats, species, populations) which go to make up the network.
2. The same features in one location can be substituted for examples of the same features in another location.
3. The features of a site which is to be lost or damaged occur elsewhere in the network and their viability is not compromised by losses or damage at the site affected.
4. Losses in abundance at one site are equivalent to gains in abundance at one or more other sites.
5. Losses of, or declines in local (sub) populations do not matter as overall population size remains the same.

3.5.4 Measures of habitat area and/or quality

Many systems for designing biodiversity offsets which are currently used worldwide use "habitat hectares" as a metric. This reflects the simple logic that one unit of habitat lost should be compensated for by one unit of habitat gained. Hectares of habitat are never entirely equivalent, however. Differences in species composition, structure, management and location (or spatial context) all have a bearing on how "good" one hectare might be considered to be in ecological terms compared with another. Most systems therefore combine measures of area with measures of "quality" or "condition".

Possible metrics based on hectares of habitat were considered by Defra (2008) as a basis for biodiversity offsets in England. This approach was based on categories of habitat included in the UK's Biodiversity Action Plan. It has been reviewed and adapted to possible determination of "no net loss" in the context of the STP options (see Appendix B) and has potential application to determine amounts of compensation required in terms of:

- Hectares of the same habitat type as that affected.
- Hectares of a different habitat (provided certain conditions are met).
- Hectares of habitat required to support species populations (the same population as that affected or a different population (provided that certain conditions are met).

In the example given in Appendix B, habitat-hectares are scored with reference to a simple matrix of habitat value and condition, based on the assumption that the suitability or appropriateness of management is likely to be the main factor determining condition. Both residual impacts and compensatory habitat can be measured in terms of habitat-hectares, and the provision of sufficient compensation judged by achievement of an equivalent or higher score outcome. Trading up would be achieved by focusing compensation on a higher value habitat and condition can be enhanced by improvement in management. In the STP case all habitats are allocated a high value by virtue of their position as Annex 1 habitats, so options for "trading up" are limited. To develop such an approach further it would be necessary to give further consideration to how quality or condition of UK habitats is defined and to decide what levels of substitution between habitats of equivalent "value" might be considered acceptable.

3.6 Location or spatial context

There is considerable debate and uncertainty concerning the geographic area within which compensation might be considered acceptable. Existing European Commission guidance (2007 a) suggests that compensation should target habitat of the same type as that affected and deliver it "*within the same bioregion in which a Natura 2000 site is located"*. This allows considerable latitude in terms of location. While compensation under the Habitats Directive predominantly addresses the same habitats and species which have been affected by a development, there appears to be considerable variation in the extent to which compensation is achieved within the same functional ecosystem/unit (it is difficult to obtain comprehensive information concerning the design of compensation). Under the existing guidance (EC 2007a) it is possible to have an outcome where a site's species populations are unable to use compensatory habitat, e.g. because their dispersal ability or mobility is too low. The influence of location requires more explicit interpretation in compensation design. It can be addressed partially through more precise definition of types of compensation (as explored in Table 1) but if a wide geographic area is assigned within which trade-offs can occur (the whole of the Atlantic bio-region for example), there is more scope for optimizing location in the selection of suitable compensation areas. Some of the methods summarized in Appendix A are designed for precisely this purpose. Zonation[15], for example, is a spatial framework for large-scale conservation planning which identifies areas important for retaining high habitat quality and promoting connectivity for multiple biodiversity features (e.g. species). The overall intention is to provide a quantitative method for enhancing species' long term persistence in the landscape, for example by generating robust networks or ensuring that habitat is of sufficient quality and suitable location. Similarly Marxan[16] is a siting tool for landscape conservation analysis, which explicitly incorporates spatial design criteria into the site selection process and has been used to design ecological compensation for some large infrastructure projects. Similar approaches are being considered in the UK but are in early stages of development (e.g. Catchpole, 2006).

3.7 Timing

If there are delays in the implementation of compensation, such that replacement habitat only reaches a suitable quality or carrying capacity only after impacts have taken place, irreversible ecological damage may occur. It may therefore be appropriate to factor this into the design of compensation, possibly by requiring compensation to be provided in advance of impacts, or before a certain period has elapsed. It may also be fair to increase compensation requirements (for example the area over which

[15] (http://www.helsinki.fi/bioscience/consplan/software/Zonation/index.html)
[16] University of Queensland, Ball I. R. & Possingham H. P.

compensation is implemented) on the basis that it is inappropriate to compensate for immediate loss by future gain. EC Guidance (2007 a) recommends that compensatory measures are put in place before impacts from developments arise, but recognises that this may not always be fully possible. In any case, restored or created habitats can take many decades to deliver full ecological benefits (Morris *et al*., 2007). One way round this is to ensure that compensation is delivered in advance, and this is one of the main advantages of habitat or mitigation banking systems in which credits are not “released” for purchase by developers until habitat restoration is incomplete, or as reached a certain threshold or stage.

In some approaches to compensation and offsets, other adjustments have been made to allow for the fact that it can take many years for an equivalent outcome to be achieved in terms of impacted and restored ecosystems or habitats. In the example shown in Figure 1, it is assumed that the design and implementation of a managed realignment of a coastal flood defence takes 8 years from present and that the project destroys a certain area of mudflat in year 10. The compensatory mudflat habitat takes several years to develop and eventually only reaches 95% of the functionality of the original habitat in terms of its ability to support wetland birds. Because of the annual deficit in ecosystem services in the compensatory habitat compared with the original, the provision of 1.06 hectares of compensatory habitat is necessary to balance each hectare of habitat lost over the 100 year period.

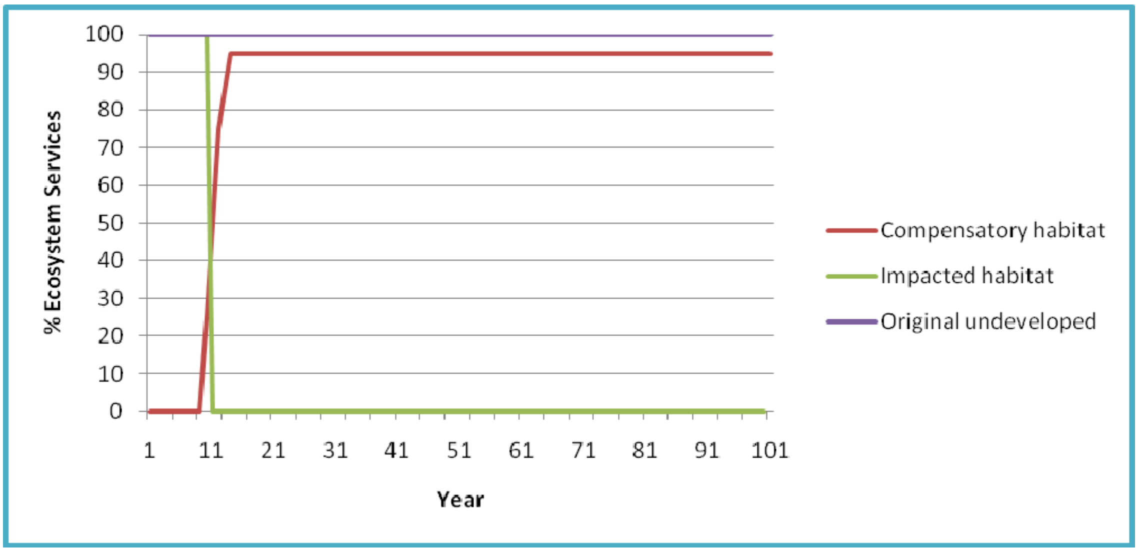


Figure 1 Ecosystem service profiles over time

In this example, the level of adjustment is strongly influenced by the annual deficit in ecosystem services in the compensatory habitat compared with the original, rather than the failure to achieve full quality in the compensatory habitat before the development occurs. This will clearly vary with the rate of ecosystem development with respect to any mismatch in timing between impact and compensation delivery. The ability to define a suitable level of adjustment for loss of interim value or delay in achieving equal value depends on thorough knowledge of timescales for restoration and the effectiveness of measures.

Most of the approaches developed to date have used principles of economic discounting to adjust compensation or offset requirements. Several recent analyses (e.g. Moilanen *et al*., 2009; REMEDE, 2008) have borrowed the concept of discount rates from economics to obtain a present value of ecosystem services in the future. However in ecological terms this may be flawed, as it essentially assumes that ecosystem services will be less valued in the future than at present. The converse may well be the case, implying that a negative discount rate should be used. It was beyond the remit of this report to consider economic approaches in any detail, but a comprehensive review can be found on the TEEB website[17].

3.8 Effectiveness uncertainty

While loss of biodiversity or "ecological value" due to an impact is certain, gains through compensation are relatively uncertain (levels varying between habitats and species). Uncertainty is therefore an important consideration if the aim is to avoid net loss. Some researchers, notably Moilanen *et al*., (2009) have proposed an evidence-based approach to conservation planning based on information-gap theory, which suggests that considerable multipliers might be needed to guarantee a high enough probability of the exchange producing at least as much conservation value through an offset (or compensation) as is lost due to development. As well as being used to deal with delays in ecological maturation, multipliers are therefore often used to factor uncertainty into compensation, as outlined in the following section. Uncertainty can be catered for by evaluating risks and then setting aside sufficient funds, perhaps through an insurance policy, to pay for remediation if an initial compensation action is unsuccessful. However in terms of ecological outcome this is generally unsatisfactory and it may also be prohibitively expensive to the developer. Failure of initial compensation action will, in many cases, result in permanent loss of an impacted species population as substitute habitat will not be established for it to colonise before impacts take place.

3.9 Use of multipliers to deal with uncertainty and delays

If there is likely to be either delay or uncertainty in ecological outcome, multipliers may be used to adjust compensation or offset requirements above 1:1. In practice, however, it is difficult to establish a clear rationale for selection of suitable multipliers (ten Kate *et al*, 2004). A simple, perhaps naive, ratio can be obtained by estimating the conservation value of a compensation site at a future date, and comparing it with the conservation value of the affected site. Under a "No Net Loss" compensation strategy, the quantity of compensation applied should be increased by a ratio reflecting the lost interim value, as suggested in Figure 1.

Moilanen *et al.*, (2009) have suggested that multipliers should reflect:

- uncertainty in the effectiveness of restoration action;
- correlation between success of different compensation areas;
- time discounting (as discussed in the previous section).

Uncertainty can arise from a number of sources:

- future value could be less than expected;
- proposed compensation sites might be poorly surveyed or understood so that potential gains are not accurately known;

[17] www.teebweb.org

- success and failure could be correlated between different restoration areas.

These aspects of uncertainty can be illustrated through the following example. Vendace is an endangered fish species which was adversely affected by siltation at one of its original, key sites in the UK. Between 1997 and 1999 the conservation agencies made two translocations (between 1997 and 1999) to new sites, one using stock from Derwentwater into Daer Reservoir, the other using stock from Bassenthwaite into Loch Skeen (Maitland and Hatton-Ellis, 2004). Ten years later, the Loch Skeen introduction has succeeded but the Daer Reservoir introduction has failed. Meanwhile the original Bassenthwaite population is believed to have suffered extinction. Effectively a 2:1 multiplier was used in this compensatory action. After intensive research and feasibility studies, both introductions were expected to succeed, but in the event only one did. Whether the failure was due to imperfect understanding of the species' requirements, imperfect knowledge of the habitat at the restoration site or operational failure (insufficient eggs translocated, for example) remains uncertain even after the event.

In future, without a multiplier to allow for uncertainty, there would be a 50% chance of failure, and the offset would not be robust. Figure 2 shows that if the chance of success of a compensation action is 50%, a much higher multiplier is actually needed in order to reduce the risk of failure overall to less than 5% (a widely accepted criterion for risk management): in fact, a multiplier as high as 5[18] would be needed. It is common for the area over which compensation is provided to be increased to compensate for uncertainty, but this would not have made any difference to the outcome in this case and probably applies more often to compensation for terrestrial habitat. Moilanen *et al*., (2009) recommend a hedge-betting strategy in response to this issue, through seeking a larger number of restoration sites with varying conditions in cases where the outcome is relatively uncertain.

In the context of the Birds and Habitats Directives, a guaranteed outcome is required and it is necessary to reduce risk of net loss to acceptable levels. There is no single multiplier that will apply in every situation. While the approach of Moilanen *et al*., (2009) is based on a sound rationale it can generate some very large ratios that may not always be practicable. The widely quoted 2:1 multiplier is not based on sound evidence, however, and is unlikely to generate robustly fair offsets. As far as possible, an evidence-based approach helps to reduce levels of uncertainty, but this has to be developed to reflect the specific risks associated with each individual case. For example, the multiplier used for compensation for a poorly known species such as Allis shad is likely to be very much higher than for a habitat feature such as Saltmarsh, where there is well researched evidence of the likely success rates of restoration actions (Morris *et al.,* 2007). Evidence from the success of previous habitat and species measures can be used to inform assessments of the risk of failure (Morris *et al*., 2006). Where there is no such previous experience available, expert opinion should be used, and failure risk is likely to be allocated a high number. Uncertainty can also be minimised through intensive research and modelling of compensation options, including feasibility studies and surveys at potential compensation locations

Theoretical, generic multipliers required for measures with varying degree of failure risk are shown in Figure 2.

[18] Actually 4.3, reading from Figure 3, but 5 is the smallest whole number meeting the criterion. The case under discussion is number of whole lakes used for translocation.

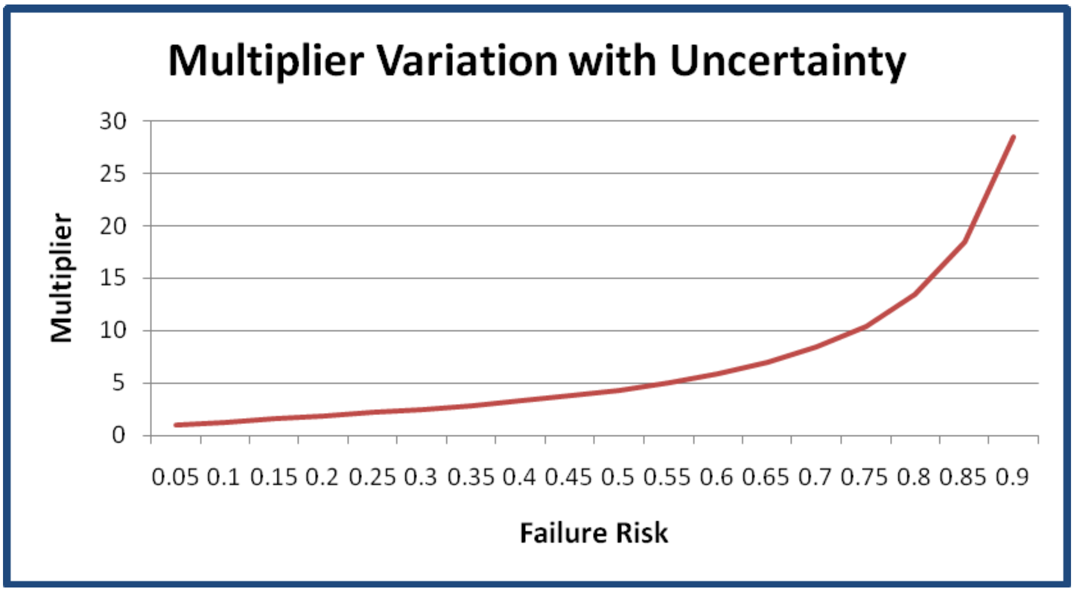


Figure 2 Variation in required multipliers with effectiveness uncertainty of compensatory measures

It can seen that the multiplier required for a measure with failure risk of 50% is five, rather than the intuitive two. The relationship also shows that the multiplier climbs rapidly as failure risk climbs above 0.7, at which point alternative compensation measures should be chosen in preference.

4 POSSIBLE FRAMEWORK FOR "EQUAL VALUE COMPENSATION"

4.1 Introduction

In this chapter we suggest a possible approach that could be used to guide development of compensation in cases where it proves impossible to safeguard site integrity. Uncontrolled substitution of one designated interest feature for another within an ecological compensation package would never be considered acceptable. We have therefore attempted to identify possible principles and tests which proposed compensation would have to meet to comply with the requirements of the Directives. Possible metrics are also suggested.

For purposes of testing the applicability of these principles and tests, two test cases are used (presented in Chapter 5). These are based on one of the designated habitats of the Severn Estuary SCI (mudflat) and one of the species (Allis shad) though it is recognised that many other Natura 2000 sites and their designated interest features could be affected by STP options. It has also not been possible within the scope of this project to explore approaches to compensation for habitat-mediated impacts on a species (for example implications of loss of mudflat for feeding waders).

4.2 Principles that might apply to review of ecological compensation measures under the Habitats Directive

Ecological compensation requirements under the Birds and Habitats Directives are likely to become increasingly challenging to meet as landscape transformation continues, with the added complexity of unpredictable outcomes due to climate change. Current approaches involve many subtle trade-offs which are not always made explicit. A method for validating design of ecological compensation could provide a stronger basis for monitoring and verification (and this would be an essential pre-requisite of any formal system of habitat banking or trading of ecological values). Any decision about the suitability or acceptability of proposed compensation needs to be made at the design stage, in advance of implementation and taking all uncertainties into account. We have therefore attempted to identify principles which might be used to inform the design of equal value compensation. Criteria and associated indicators are then considered which can be used to determine when a proposed compensation measure will be compatible with these principles. The principles must therefore embody the "spirit" of the Directives.

4.2.1 Examples of relevant principles

Relevant principles have been issued by several governments to support policy and regulatory requirements relating to "no net loss" of biodiversity, often achieved through systems of "biodiversity offsets". Such principles have been reviewed in a report by Defra (2008) and include examples from the United States, South Africa, Australia and Germany (Darbi *et. al*., 2009), amongst others. Principles have also been produced by some industry or business coalitions on a voluntary basis to guide good practice, including principles produced by the Business and Biodiversity Offsets Program (BBOP)[19].

Review of biodiversity offset principles is merited in the context of this study because of the extent to which consensus has been reached by stakeholders in many countries, with a considerable degree of overlap in scope and content. Ecological compensation under the Directives also constitutes a form of biodiversity offset, if widely accepted definitions (see BBOP, 2009) are used.

The review by Defra, (2008) concluded that the majority of offset principles currently in operation worldwide address the following issues:

- The need for design and implementation of biodiversity offsets to comply with all relevant national and international law(s).
- The fact that offsets should be used only for residual adverse impacts and impacts should first be avoided by using all reasonable and cost-effective prevention and mitigation measures (appropriate application of the mitigation hierarchy).
- The need for offsets to achieve no net loss of biodiversity or preferably a net gain "on the ground".
- The need for offsets to achieve "within type" replacement, or if this is not possible, the conservation of biodiversity of at least as high significance as that affected by a proposed development or "better". This is sometimes referred to as "trading up".
- The fact that offsets should not be pursued if there would be residual adverse impacts on biodiversity, where the biodiversity values lost cannot be replaced.
- The need for offsets, and any mitigation undertaken before offsets are agreed, to be enduring and enforceable (e.g. through conditions, covenants or contracts).
- The need for offsets to constitute 'new' or additional conservation activities. Existing or completed actions cannot be used to offset a new activity.

In addition the following are included in one or more sets of principles in current use:

- Offsets should be based on sound science and sufficient, reliable and relevant information.
- A precautionary approach should be taken in cases where there is a possibility of a residual adverse impact on important or "critical" biodiversity and levels of uncertainty are high, whether this relates to the likely significance of a residual adverse impact or the likely success of an offset.
- Offsets must be located appropriately[20], according to biodiversity priorities in the area and in support of any strategic biodiversity plans which are in place.
- Offsets in the most appropriate form must be secured before development commences, to give assurance of effectiveness.

[19] Business and Biodiversity Offsets Programme (BBOP). 2009. Business, Biodiversity Offsets and BBOP: An Overview. BBOP, Washington, D.C. www.forest-trends.org/biodiversityoffsetprogram/guidelines/overview.pdf

[20] Most offsets are '**off-site**' as they are most likely to come into play when options for on-site mitigation are limited or have already been used. This may make it necessary to define a geographical area within which delivery of an offset can be considered acceptable. 'Offset receiving' or 'offset service' areas may therefore be defined for this purpose, whether on the basis of ecosystem limits (e.g. within a water catchment) or on the basis of continued access to ecosystem services by the same communities that have been affected by the impact.

- Offsets must consider all significant impacts on biodiversity: direct, indirect and cumulative impacts.
- Offsets must consider the risks that they may not achieve ecological outcomes (i.e. include a contingency factor). This may be reflected in the use of multipliers.

EU requirements for compensation under the Birds and Habitats Directive constitute a form of biodiversity offset in that they relate to residual adverse impacts remaining after suitable mitigation measures have been identified, and are intended to achieve "no net loss" in the status of designated habitats and species or the coherence of the Natura 2000 network. Most of the principles outlined in the previous section are also applicable in the context of the Birds and Habitats Directives. Table 2 summarises principles (after BBOP, 2009) that appear directly relevant to development of acceptable ecological compensation measures under the Habitats Directive.

Table 2 How some of BBOP's principles might apply in the context of "Equal Value Compensation"

Principle (after BBOP 2009)	**How the principle applies in the context of "Equal Value Compensation"**
The need for design and implementation of biodiversity offsets to comply with all relevant national and international law(s).	Particular requirement in this case to comply with the requirements of the Birds and Habitats Directives.
No net loss: a biodiversity offset should be designed and implemented to achieve in situ, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity.	"Equal value compensation" seeks to achieve "no net loss" in conservation status or network coherence as a minimum. We have assumed that "no net loss" equates to achievement of "equivalence". Compensation should achieve equivalence for the designated features which are affected. The emphasis should be on "within type" compensation or, if this is not possible, positive outcomes for habitats or species of the same or higher conservation priority (in this case determined in relation to conservation status). Compensation should be delivered through 'better and positive' ratios, possibly through use of a multiplier.
Additional conservation outcomes: a biodiversity offset should achieve conservation outcomes above and beyond results that would have occurred if the offset had not taken place. Offset design and implementation should avoid displacing activities harmful to biodiversity to other locations.	Compensation should result in conservation outcomes above and beyond results that would or should have occurred anyway in the absence of compensation. Current EC Guidance makes it clear that compensatory measures should be additional to the actions that are normal practice under the Habitats and Birds Directives or obligations laid down in EC law.
Adherence to the mitigation hierarchy: a biodiversity offset is a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate avoidance, minimization and on-site rehabilitation measures have been taken according to the mitigation hierarchy.	Ecological Compensation is required in cases where site integrity cannot be assured through mitigation and adverse effects are both residual and unavoidable. Strict adherence to the mitigation hierarchy is therefore required. The Habitats Directive requires the proponent of a development to demonstrate that impacts are **'residual' and 'unavoidable'**.

Limits to what can be offset: there are situations where residual impacts cannot be fully compensated for by a biodiversity offset because of the irreplaceability or vulnerability of the biodiversity affected.	Compensation should not be pursued as an option in cases where effective compensation cannot be guaranteed or where failure to compensate for residual adverse impacts might drive a feature towards irreversible decline throughout its range. In cases where designated interest features must be preserved *in situ* for their survival to be assured, compensation targeting other features or in other locations would not be appropriate. Clear evidence would be required to demonstrate that the features could be substituted.
Landscape context: A biodiversity offset should be designed and implemented in a landscape context to achieve the expected measurable conservation outcomes taking into account available information on the full range of biological, social and cultural values of biodiversity and supporting an ecosystem approach.	It is not currently necessary to demonstrate that social and cultural values of European habitats and species have been taken into account when designing compensation under the guidance (2007 a). Further work is needed to generate reliable information at a landscape scale to support compensation and the ability to demonstrate measurable outcomes. This might involve comprehensive mapping of current and potential habitats and species distributions, using consistent approaches.
Long term outcomes: the design and implementation of a biodiversity offset should be based on an adaptive management approach, incorporating monitoring and evaluation, with the objective of securing outcomes that last at least as long as the project's impacts and preferably in perpetuity.	The Guidance on Article 6(4) provided by the European Commission (EC, 2007) suggests that compensatory measures should be targeted, effective, technically feasible and **secured in perpetuity**. The ability to deliver effective compensation should be a key test in determining the acceptability of proposed compensation. In this case use of multipliers is suggested to deal with uncertainty of outcome.

Achievement of "equal value" or "no net loss" is the primary goal of compensation and we have reflected this in our suggested framework, which only comes into play after the mitigation hierarchy can be shown to have been implemented appropriately. Reflecting this, the following sections suggest principles which could be included in the framework as well as criteria and indicators that might be used to determine whether a proposed compensation package will comply with these principles and will be implemented in such a way that it will deliver additional outcomes to those which would or should have happened anyway.

4.3 Possible criteria for testing compliance with the principles

In this approach, we suggest that more detailed criteria or conditions might have to be met to gain assurance that a proposed compensation measure or package is compatible with agreed principles (suggested principles are included in Table 3). Indicators might be used to measure this compliance and to demonstrate clearly that the criteria can be met. We have not been able to identify a full set of suitable indicators within the remit of this study, but give them some consideration in section 4.4.3 where we discuss suitable metrics. In a completed framework, the intention would be for compliance with criteria (as measured by indicators) to be the main mechanism by which assurance is gained that the proposed compensation would meet the requirements of the Directive. It is important to remember that this is a preliminary and exploratory approach which would require further development and rigorous testing in practice. Table 3 summarises relevant principles from the previous section and gives some examples of conditions which might have to be met to show that a compensation measure or package has been designed in accordance with each principle. This should not be regarded as comprehensive or final. The methods (and indicators) used to determine whether criteria can be met might vary between habitats and species depending on the availability of data, however.

Figure 3 gives an indication of how conditions might be used to test compliance with the requirements of the Habitats Directive. Assuming that compliance with Principle 1 (in Table 3) has been met, this figure shows how compliance might be measured in terms of Principles 2 and 3. Principle 4 relates to achievement of an appropriate landscape-scale and spatial approach to develop connective networks. It was outside the remit of this study to develop such approaches in any detail, but there are several being developed in other countries which merit further consideration. Principles 5 and 6 are very important, but require consideration of several practical, legal and political factors which were also outside the remit of this study.

4.3.1 Demonstrating that Principle 1 has been met

Allowing un-controlled trade-offs between sites, habitats and species populations within the Natura 2000 network is clearly unacceptable, hence efforts should be made to sustain the integrity of sites as far as possible through the mitigation hierarchy. This is assumed as the starting point for this approach.

4.3.2 Demonstrating that Principle 2 can be met

Criteria are required to confirm that impacts on a Natura 2000 site, or the loss of its integrity, will not compromise future ability to achieve favourable conservation status within the bio-geographic region for the habitats and species it supports. In other words, it is necessary to consider whether the site performs any unique or essential role in sustaining the designated interest features at a wider level which cannot be substituted. Ability to achieve FCS despite loss of a site or its integrity requires the following criteria to be met:

- The same habitats and species as those affected can be maintained in a viable and sustainable state despite loss of individuals or local populations at an affected site.
- Adequate alternative suitable sites or habitat are available.
- Achievement of favourable conservation status is possible with respect to each of the parameters used to assess conservation status.

4.3.3 Demonstrating that Principle 3 can be met

Meeting Principle 3 requires the compensation measure or package to achieve equivalent or better outcomes in terms of the:

- status of habitats and species which are represented on the sites affected; and the
- overall coherence of the Natura 2000 network.

We assume that opportunities for “within type” compensation in the same functional ecological unit as the site affected would be sought as a first priority, seeking to maintain the status of the habitats and features affected and their contribution to the Natura 2000 network. The approach presented allows substitution between habitats and species provided certain conditions can be met as discussed in 4.4.2.

However in any case where a substitute is used, it is reasonable to expect that a demonstrably positive or better outcome should be sought, to account for uncertainty and possible risks of substitution to the original feature affected. In other words if compensation effort is shifted to a different species or habitat, there should be compelling reasons to do so in terms of the conservation status or network coherence. These reasons would be embodied in the conditions used to test compensation. Possible criteria that could be used include:

- The ratio between current distribution and potential distribution if increased (for habitats) or the ratio of population to reference population is increased (for species). In other words, range occupancy is increased.
- A non viable/sustainable population is replaced with a sustainable one, for example because it is more likely to be resilient to climate change.
- Carrying capacity is increased in sustainable habitat networks, for example through provision of additional habitat or enhanced connectivity between previously unconnected sites.

The challenge here is to determine what constitutes a sufficient level of enhancement to justify substitution.

Compensation packages frequently aggregate both debits and credits across several ecological features. A more transparent approach is likely to be required to demonstrate equal value under the Birds and Habitat Directives, in which losses for each impacted habitat and species must be shown to have been adequately mitigated or compensated for. Once individual requirements have been confirmed, options for combination of compensation requirements can be considered to design a package that delivers adequate compensation for individual features and also optimises the overall outcome in terms of cost, efficiency, spatial configuration and so on.

4.3.4 Test cases

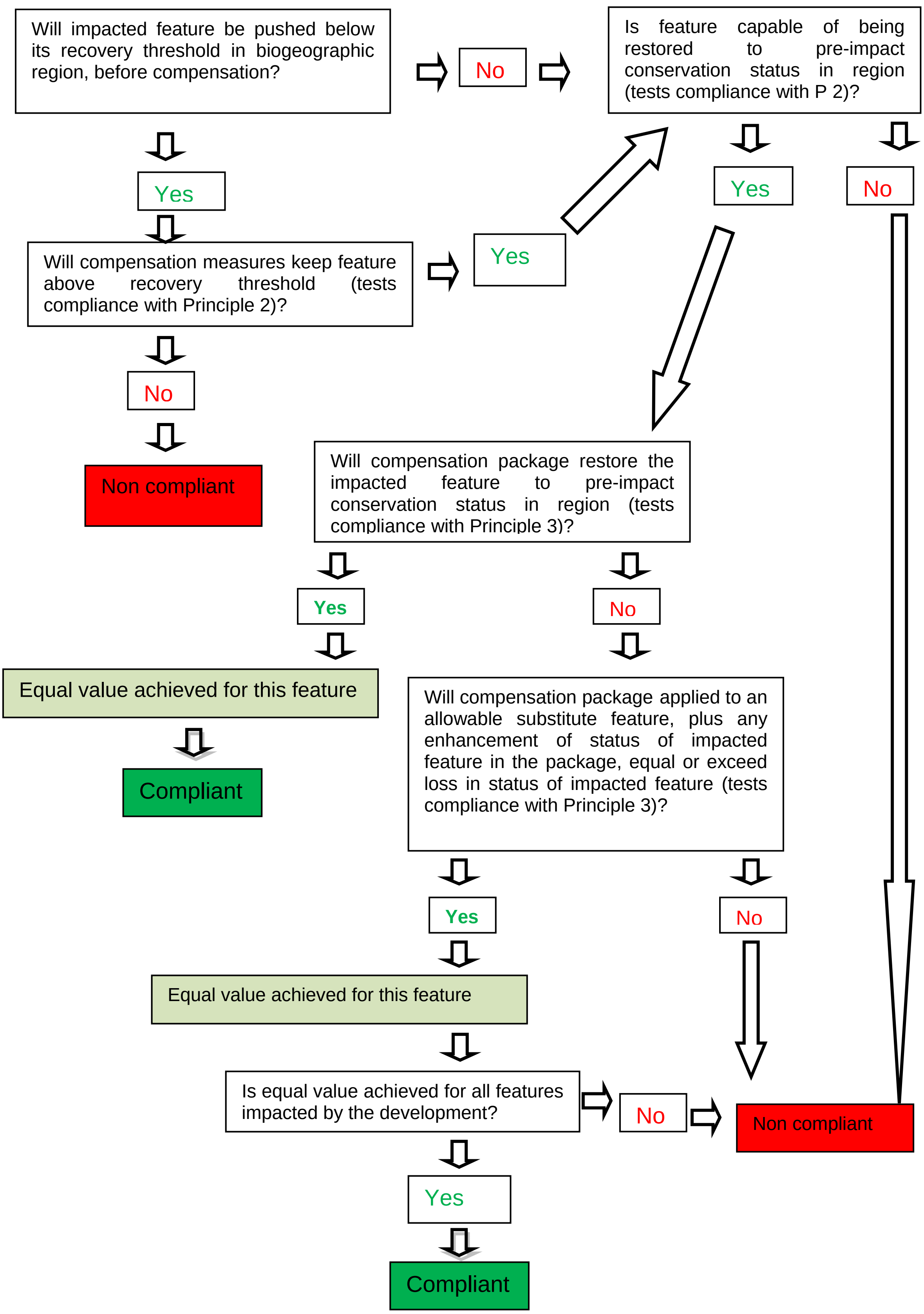
In Chapter 5 we present two examples which we have used to test the relevance and applicability of some of the criteria and indicators included in Table 3. These are preliminary case studies based on readily available evidence and carried out without access to final conclusions concerning likely significant residual impacts which will actually be associated with the Severn Tidal Power options.

Table 3 Principles and possible conditions which would have to be met and possible indicators that could be used to measure compliance

Principle	**Criteria or conditions which have to be met to demonstrate that the proposed compensation measure or package is in accordance with the principle**	**Possible indicators**
The proposed compensation measure or package must:		
1. Only be used where site integrity cannot be assured through mitigation.	Address adverse effects for which compensation is required are both residual and unavoidable (the starting point for this study).	Evidence that the mitigation hierarchy has been appropriately applied to identify avoidance and on-site mitigation measures.
2. Not be pursued as an option in cases where effective compensation cannot be guaranteed or where failure to compensate for residual adverse impacts might drive a feature towards irreversible decline throughout its range.	a) Not be considered if residual adverse impacts will be such that the impacted feature will be pushed below a critical recovery threshold. **AND/ OR**	Demonstrate that it is possible to: • Maintain the same habitats and species as those affected in a viable and sustainable state despite loss of individuals or local populations at the original site. • Demonstrate that adequate viable sites or habitat are available.
	b) Not be considered if pre-impact Conservation Status will be unachievable for a site's designated interest features within the geographic frame of reference which has been agreed.	• Demonstrate that achievement of pre-impact Conservation Status is possible with respect to each of the parameters used to assess Conservation Status (range, area, population size or number, habitat for the species, structures and functions, future prospects).
3. Achieve ecological equivalence within the chosen geographic frame of reference (Member State or Bio-geographic region) as a minimum.	a) Only be considered if the compensation package will restore the feature to its pre-impact conservation status in the region **OR:**	Demonstrate that it is possible to: • achieve equivalent or better outcomes in terms of the status of habitats and species which are represented on the sites affected; and the overall coherence of the Natura 2000 network. • Increase range occupancy for the designated interest feature. • Replace a non viable or unsustainable population with a sustainable one, for example because it is more likely to be resilient to climate change. • increase carrying capacity within sustainable habitat networks, for example through provision of additional habitat or

		enhanced connectivity between previously unconnected sites.
	b) An allowable substitute will have its conservation status enhanced in the bio-geographic region. (The compensation package will equal or exceed loss in status of the impacted feature when applied to an allowable substitute feature and considered together with any enhancement of status of the impacted feature which is included in the overall package).	Demonstrate that it is possible to: • Address an allowable substitute by complying with the exchange criteria which have been established (see section 4.4.2). • The overall coherence of the Natura 2000 network is enhanced so that the benefit to the network from a substitute is greater than the disbenefit incurred from the loss of the feature substituted for.
4. Be designed and implemented in a landscape context to optimise conservation outcome.	Enhance conservation status and network coherence based on reliable knowledge of habitat and species distributions, their abundance and the potential that exists for restoration or enhancement	Demonstrate that the: • Proposed compensation is within an area identified as suitable. • Proposed compensation increases the size, resilience or connectivity of a network.
5. Be additional to the actions that are normal practice under the Habitats and Birds Directives or obligations laid down in EC law.	Go beyond the normal/standard measures required for the protection and management of Natura 2000 sites or which constitute "normal" measures for a Member State.	Requires review of existing obligations as documented in management plans, or the proposal/ designation document for an area of Community importance.
6. Be targeted, effective, technically feasible and secured in perpetuity.	Delivered in advance of impacts taking place or strong assurances and evidence given that compensation will be delivered without interim losses occurring.	Demonstrate that: • There is documented evidence that the proposed compensation is achievable. • There is evidence on the ground that compensation has been delivered (for example in the form of a habitat bank).

Figure 3 Flowchart showing how conditions might be used to test compliance



4.4 Further considerations

4.4.1 The scale at which equivalence is demonstrated

As explored in earlier chapters, it may be possible to demonstrate equivalence in terms of the status of habitats and species and the overall coherence of the Natura 2000 network, depending on the geographic scale at which ecological equivalence is assessed and the extent to which certain trade-offs are considered acceptable. The possible approach suggested in this chapter requires consideration of conservation status at a particular geographic scale. It is possible that, in some cases, achievement of FCS for European habitats and species may be best achieved by allowing compensation options to be sought where they will deliver optimal outcomes in terms of conservation status at the scale of the Atlantic Bio-geographic Region. The current guidance (EC 2007a) requires delivery of compensation within the Member State and it would be possible to apply the same approach by evaluating outcomes at this level if it was considered necessary. Clearly this would reduce the options available to deliver compensation in compliance with the requirements of the Directives.

4.4.2 Exchange rules to identify allowable substitutes

As shown in Table 3, it is important to establish clear rules which can be used to determine whether a proposed substitution of habitat or species types is acceptable. The following are suggested as a possible set of rules:

- Habitats should be in the same EUNIS level 1 habitat group as impacted habitats, or they should be habitats which generally occur in direct functional connectivity with the impacted habitat types [21](e.g. fen could be substituted for saltmarsh, but not montane scrub).
- Substitute species should be in the same taxonomic group as the impacted species, and have their principal habitat requirement within the EUNIS level 1 habitat groups as defined by the habitats constraint above (e.g. one freshwater fish species could be substituted for another freshwater fish species, but not a butterfly species for a freshwater fish species).

Additionally, status constraints may be relevant when deciding whether substitution is acceptable. The Habitats and Bird Directives, (Article 17 Habitats Directive Reporting, and the Birds Directive equivalent) have been used as the basis for the following potential framework:

- Habitats should be on Annex 1 of the Habitats Directive, and have a favourable conservation status within the bio-geographic region at least as unfavourable as the impacted habitat, including the UK member state trends assessment (e.g. impacts on a habitat classified as “unfavourable bad” could be compensated for through actions to benefit a habitat classified as “unfavourable bad and deteriorating”).
- Species should be listed on an Annex of the Birds Directive or Habitats Directive, and have a favourable conservation status within the bio-geographic region at least as unfavourable as the impacted species, including the UK member state trends assessment.

[21] in this case Marine Habitats, Coastal Habitats, Inland Surface Waters, Mires, Bogs and Fens, Grasslands and lands dominated by forbs, mosses or lichens

In the case of the Severn Estuary, all of the designated interest features are in unfavourable condition, as shown in Table 4, based on the results of Article 17 reporting for the Severn Estuary's designated interest features for the 2001 – 2006 period. On the one hand, the fact that these are almost uniformly in unfavourable and/or deteriorating condition could make it difficult to justify further losses; on the other hand, in cases where future prospects are seen as poor, it may be better to implement compensation that benefits features for which future prospects are better. This is considered further in the test cases presented in the following Chapter.

Table 4 Conservation status of designated interest features of the Severn Estuary SAC

Designated interest feature	Conservation status UK (Atlantic bio-geographic region)
Estuaries	Unfavourable - bad and deteriorating
Atlantic salt meadow	Unfavourable - bad and deteriorating
Mudflats and sandflats	Unfavourable - bad and deteriorating
Sandbanks	Unfavourable - bad and deteriorating
Biogenic reefs	Unknown
Allis Shad	Unfavourable - bad
Twaite Shad	Unfavourable - inadequate
Sea Lamprey	Unfavourable - inadequate but improving
River Lamprey	Unfavourable - inadequate but improving

4.4.3 Indicators and metrics

In some cases it is necessary to select suitable metrics which can be used as the basis for measuring indicators and to determine whether the criteria can be met. There is no one metric which will apply in every case: no universal measure of biodiversity has been identified. We have used different metrics in the examples presented in Chapter 5, including *inter alia* habitat-hectares, measures of range occupancy and, population viability. There is no one universal metric and it is important to select metrics which support meaningful assessments of whether criteria can be met.

A metric based on habitat-hectares (capturing both area and condition for a particular habitat type), has much to recommend it for quantifying compensation requirements under the Birds and Habitats Directives where terrestrial habitat is concerned. For habitats, it can encompass enhancement of condition through restoration within habitat type and the use of substitutes. For species, provided compensatory actions are in the form of habitat intervention, the area and condition concepts are fundamental to the "habitat for the species" parameter used in assessment of favourable conservation status. Habitat-hectares can therefore form a bridge between habitats and species, the core objectives of the directives. In the case studies presented in this chapter, habitat-hectares are used as a metric (with a multiplier) to calculate the amount of compensatory habitat required. A possible method is presented in more detail in Appendix B.

4.4.4 Use of multipliers

Using the outline information that is available, it is clear that there could be considerable uncertainty associated with assessment of impacts and likelihood of compensation success associated with the STP options. It is noted that confidence in effectiveness of compensatory measures in this case has been assessed as "low" (APBMer, 2008). Use of multipliers to deal with effectiveness uncertainty and timing adjustments is considered likely to be necessary. For the purposes of equal value compensation it is considered appropriate to expect a risk of net loss no higher than 5%. Based on the discussion included in section 3.9, this translates into a multiplier of 5, but a default multiplier of four[22] is recommended for outline planning, pending further more detailed work to reduce levels of uncertainty.

4.5 Options for delivering compensation and measuring compensation gains

Practical methods are required to demonstrate that compliance conditions have been met. This is an area which would require further investigation to inform an approach to compensation based on demonstration of "equivalence". It is important to recognise that compensation might be delivered in different ways, as illustrated in **Figure 4**. This figure also refers to several approaches and methods which are summarised in Appendix A and which could potentially be developed for application in a UK context. The potential role of these methods as applied to compliance testing is explored for the test cases presented in Chapter 5.

There are different broad options for compensation, depending on the nature of the impacts. For impacts on habitats, measures based on compensatory habitat or enhancement of network coherence can be used. For species there is the option of compensation through provision of compensatory habitat, enhancement of network coherence or other measures, such as removal of migratory barriers, which act more directly to enhance populations. Loss of network coherence should be taken into account in any case where site integrity is affected, but can also be considered as an option for compensation in any case where enhanced coherence would translate into improved conservation status over and above other options. Habitat-based options are sometimes prioritised over others in line with well established principles of conservation planning, but this is not seen as essential. In this approach, network coherence is seen as one important way in which carrying capacity of the landscape might be enhanced, with associated benefits in terms of conservation status, as illustrated in **Figure 4**. Network coherence does not constitute an end in itself. It is important as one way to enhance the conservation status of habitats and species.

Various stakeholder workshops have been held to explore the types of compensation initiative that might deliver sufficient gains at the level of the Member State or the Natura 2000 network as a whole. These have included:

1. Enhancing other existing sites in the Natura 2000 network so that the conservation status of designated interest features is enhanced.
2. Adding new sites to the Natura 2000 network with a concomitant increase in the proportion of potential range occupied or resulting in the availability of sufficient sites to support viable areas or populations of designated interest features.
3. Strengthening existing requirements to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest.
4. Helping to build ecological networks which are more resilient to climate change etc., for example by reducing fragmentation.

The proposed approach could potentially be used to appraise such options and determine to what extent they might meet the requirements of the Habitats Directive.
It is important to remember that the ability to implement compensation depends on many practical, political and institutional considerations which need to be taken into

[22] using a mean failure risk of 0.4 and a small adjustment for timing

account. The approach set out in this chapter would need to be complemented by rigorous appraisal of compensation options in terms of their deliverability, particularly in cases where compensation options might be sought in another Member State. This is outside the remit of this study.

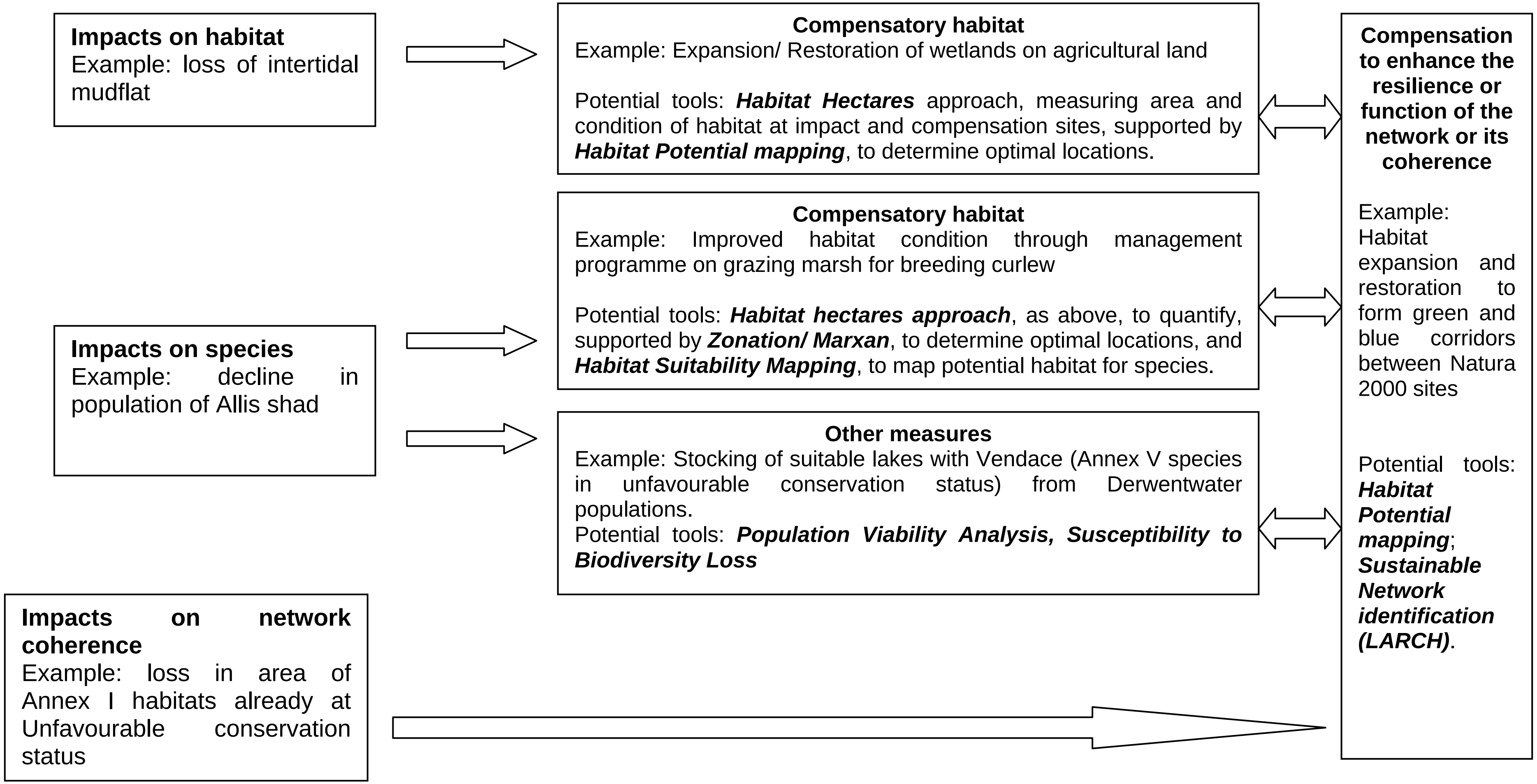


Figure 4 Different approaches that could be applied to quantify potential gains through different forms of compensation

5 TEST CASES

5.1 *The Severn Estuary's Designated Interest Features*

The Severn Estuary's designated interest features under the Birds and Habitats Directives include habitats and species as summarised below:

SCI Designated Interest Features				
Habitats				
Estuaries[23]	Atlantic salt meadow	Mudflats and sandflats not covered by seawater at low tide (but submerged at high tide)	Atlantic salt meadow[24]	Biogenic reefs[25]
Species				
	Allis Shad and Twaite Shad	Sea Lamprey	River Lamprey	

SPA Designated Interest Features		
Habitats		
Shingle and rocky shore (SPA sub-feature)		
Species		
Bewick's Swan	Gadwall	European White-fronted Goose
Redshank	Dunlin	Redshank
Wintering waterfowl assemblage		

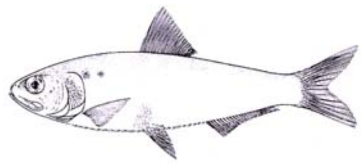
One example of a habitat (Mudflats and sandflats not covered by seawater at low tide but submerged at high tide) and one example of a species (Allis shad) have been selected as the basis for case studies.

5.2 *Allis Shad*

The purpose of this test case is to explore the possible application of the approach and not to undertake a full assessment of compliance with the requirements of the Directives. It has been carried out on the basis of readily available information and without knowledge of the actual impacts which might occur as a result of the STP options. The starting point for the assessment is that at which compliance with Principle 1 has been demonstrated.

[23] Semi enclosed bodies of water which have a free connection with the open sea and within which the seawater is measurably diluted by freshwater from the surrounding land
[24] Low to mid marsh and mid to upper marsh communities containing the National Vegetation Classification (NVC) communities which fall within Atlantic salt meadow in the EU Interpretation Manual
[25] Areas of rock or biological concretions formed by various invertebrate species

5.2.1 Background information



Allis Shad, a member of the herring family, is an anadromous fish, spending part of its life in the sea but moving up rivers to its birthplace to spawn. The habitat requirements for Allis shad are complex and imperfectly known, but some relevant information is available (for example Maitland and Hatton-Ellis, 2003).

All of the following habitat attributes are required:

- Coastal waters at depths up to 150 metres, for adults.
- A relatively unpolluted estuary with a good supply of small crustaceans, especially mysids.
- A clear migration route to the spawning grounds in larger rivers, with suitable river flows, free of obstacles, both natural (such as waterfalls) and man-made dams, weirs or pollution barriers.
- Suitable resting pools or glides not susceptible to strong flushing flows and clean gravels at the spawning areas.
- Predominantly gravel substrate at spawning grounds.
- Water depth of 0.5 to 1.5 metres at the spawning grounds with current ranging from 0.5 to 1.5 metres/ sec.
- River water temperatures above 18 degrees C in June and July.
- Slow-flowing nursery areas for juveniles in fresh water above the estuary after hatching.
- River water quality of at least chemical and biological GQA class B throughout the river range used.

This species is not at favourable conservation status in the UK, where it has only small, sporadic populations, but it is present in much larger populations in France. It could face local extinction under some of the STP options, but the individuals recorded in the Severn Estuary do not currently occur in a viable breeding population. It is possible that compensatory measures undertaken to boost French populations might deliver better overall outcomes.

5.2.2 Meeting Principle 2: Compensation will not be pursued as an option in cases where effective compensation cannot be guaranteed or where failure to compensate for residual adverse impacts might drive a feature towards irreversible decline throughout its range

The indicators and methods which might be used to test compliance with a sample criterion are summarised in Table 5.

Criterion 2a: the impacted feature will not be pushed below a critical recovery threshold.		
Indicator	**Possible metrics**	**Possible method or threshold**
i) The Allis shad population in the Atlantic bio-geographic region will be viable even if the Severn Estuary is no longer able to support the species post-impact.	Population viability, Measure of extinction risk	Population viability analysis using "baseline, before and after" scenarios. The risk of extinction should be less than 5% over an extended time scale, in this case assumed to be a minimum of a century. This is assumed as the **critical recovery threshold** in this case.
ii) Carrying capacity is maintained because adequate viable sites or an adequate area of suitable habitat are available.	Habitat hectares Carrying capacity	Up to date assessment or monitoring of the condition of sites, their carrying capacity and future prospects.
Criterion 2b: It is possible to restore the feature to its pre-impact status		
i) Each of the parameters used to assess Conservation Status is still capable of being restored to pre-impact levels.	• Range (proportion occupied or size) • Population size or number • Habitat for the species • Future prospects	For each parameter: assessment for baseline, then with impacts and with proposed compensatory measures in place.

Table 5 Indicators and methods to test compliance with Principle 2 for Allis shad

Some examples of how these indicators would be measured are explored further in the following sections.

5.2.3 Compliance with Criterion 2a: the impacted feature will not be pushed below a critical recovery threshold

Indicator 2ai): *The Allis shad population in the Atlantic bio-geographic region will be viable even if the Severn Estuary is no longer able to support the species post-impact.*

The population parameter for Allis Shad is assessed as "unfavourable-bad" for the UK (JNCC 2007b). The audit trail report for the species in its Article 17 report to the EU provides the following rationale for this conclusion:

> *"The two largest UK populations in the Severn and Thames have been virtually eradicated, with key spawning sites having been blocked (Aprahamian et al. 1998). Although a few small, scattered populations exist in southwest England and south Wales (see section 1) their viability is unknown. For these reasons, remaining A. alosa populations are considered to be at high risk from stochastic events (and were likely to have been when the Habitat Directive came into force). Therefore in accordance with the UK approach, although no quantitative estimate exists for the current population, it has been reported as more than 25% below the favourable reference population.*

> *Although current population cannot be quantified, based on stochastic risk, it is expected to be more than 25% below favourable reference population. A conclusion of Unfavourable-Bad has therefore been triggered. (Note: due to poor data, this judgement can only be made with low confidence)."*

The level of uncertainty around this species is also high: there is no quantitative estimate of either current population or favourable reference population.

Although the UK did not provide a population estimate for this species, several other Member States did so, as shown in Table 6.

Member State	region	popn minimum	popn maximum	popn size unit	popn trend	favourable popn
Germany	ATL			x	X	1
Spain	MATL	156	156	localities	=	
France	ATL	290000	850000	individuals	-	850000
France	MATL	700000	150000	individuals		
Ireland	ATL	25	25	grids	X	
Netherlands	ATL	0	10	individuals	=	
Portugal	ATL	1100	6000	individuals	-	6000
UK	ATL			x	=	

Table 6 Summary of Member State Article 17 reporting for Allis shad

Measuring against this indicator requires the assessment of the likely viability of the Allis shad population in the Atlantic bio-geographic region before and after the project impact. A suitable tool to apply would therefore be Population Viability Analysis (see Appendix A) applied to Allis shad across the Atlantic region for the current situation, for the post-impact situation and then with the proposed compensation measures in place. The risk of extinction should be less than 5% over an extended time scale, in this case assumed to be a minimum of a century, (Schaffer, 1981). This is one way to define a critical recovery threshold as referred to in the assessment criterion used for this example. Note that PVA can also be used to assess the relative merits of compensation options. It would be of interest, for example, to test whether measures near the core of the current population (France) would be more effective than measures near the northern limits (UK and Germany).

Subject to a full PVA, and confirmation that the France, Spain and Portugal populations remain robust, it appears that the STP impacts are unlikely to commit the species to extinction in the Atlantic bio-geographic region.

Indicator 2aii): *There are sufficient viable sites to support the species or maintain its carrying capacity in the Atlantic bio-geographic region.*

It must be demonstrated that adequate sites are available which can support the species in a viable state. The principal rivers supporting Allis shad are listed in **Table 7**. This list contains some Natura 2000 sites and some rivers outside of the current Natura 2000 network; Conservation Status is assessed across the whole range and is not restricted to the Natura 2000 network.

River	Country	Status
Adour	France	Present
Aulne	France	Recolonising
Charente	France	Abundant
Dordogne	France	Very Abundant
Douro	Portugal	Virtually Extinct
Elbe	Germany	Extinct
Garonne	France	Very Abundant
Guadiana	Spain,Portugal	Rare
Lima	Spain,Portugal	Abundant
Loire	France	Recovering
Meuse	Netherlands,Belgium,France	Extinct
Minho	Spain,Portugal	Much Reduced
Mondego	Portugal	Much Reduced
Nivelle	France	Present
Orne	France	Recolonising
Rhine	Netherlands,Germany,France	Extinct
Sebou	Morocco	Extinct
Seine	France	Extinct
Severn	UK	Very rare
Tagus (Tejo)	Spain,Portugal	Rare
Thames	UK	Extinct
Vilaine	France	Recolonising

Table 7 Principle rivers used by Allis shad for spawning in Europe (highlighted rows in Atlantic bio-geographic region)[26]

An up to date assessment of the carrying capacity and condition of sites supporting the species (particularly those supporting abundant or re-colonising populations) would be necessary to ensure sufficient confidence in the ability to maintain the viability of the species. It should be noted that this table is based on data at least a decade old and clearly it would be essential to ensure that the status has not deteriorated since. Although the French rivers Garonne, Charente and Loire appear to hold the most robust populations in Europe, it should be noted that the Member State Article 17 report nevertheless recorded the species at unfavourable bad conservation status, with a negative population trend. Subject to confirmation of data currency, the "adequate viable sites" indicator therefore appears to be met.

Demonstration that the species will not be committed to extinction in the region if it is lost from the Severn Estuary and that there are other adequate viable sites suggests that the feature will not be pushed below its recovery threshold. On the basis of these two indicators, it would be possible to meet criterion 2a.

5.2.4 Compliance with criterion 2b: It is possible to restore the feature to its pre-impact status

Indicator 2bi): Each of the parameters used to assess Conservation Status is still capable of being restored to pre-impact levels.

Using this indicator we need to demonstrate that each of the parameters used to assess conservation status is capable of being restored to pre-impact level. This is

[26] after Aprahamian *et al*. 1998 and Baglinière 2000). (From Ecology of the Allis and Twaite Shad, Peter S Maitland and Tristan W Hatton-Ellis, Conserving Natura 2000 Rivers Ecology Series No. 3, 2003).

intended as a consideration of the extent to which a designated interest feature can be substituted in theory, on the basis of its habitat requirements, population size and possible range. For this purpose we suggest use of the EU Conservation Status reporting scale of “Favourable”, “Unfavourable”, “Inadequate” and “Unfavourable Bad”. These are sometimes referred to on a traffic light system of green, amber and red. The Allis shad is currently assessed as being at “unfavourable (bad)” conservation status in the Atlantic bio-geographic region. The individual parameters that contribute to this assessment are assessed at UK Member State and Region levels as summarised in Table 8.

Parameter	UK level Status	Atlantic bio-geographic region Status
Range	Unknown	Unknown
Population	Unfavourable - Bad	Unfavourable - Bad
Habitat for the species	Unfavourable - Inadequate	Unfavourable - Inadequate
Future prospects	Unfavourable - Inadequate	Unfavourable - Inadequate
Overall assessment	Unfavourable - bad	Unfavourable - bad

Table 8 Parameters contributing to the assessment of "unfavourable - bad" at UK Member State and Atlantic bio-geographic region-level

Range is not known and therefore cannot be used in this assessment. Population is assessed at the bottom of the scale – “unfavourable bad” and it must be demonstrated whether the population is capable of recovery to pre-impact levels. Table 6 shows the estimated population levels in member states in the region. It can be seen that the Severn population is extremely small compared with that in many other areas. Conservation measures applied anywhere suitable are capable of being successful, so this is a low hurdle to cross.

The parameters “habitat for the species” and “future prospects” are both assessed as unfavourable – inadequate at each scale. This intermediate status is explained in the EU guidance on Article 17 reporting as in Figure 5.

Habitat for the species

Favourable Area of habitat(s) of the species is sufficiently large (and stable or increasing)
AND
habitat quality is suitable for the long term survival of the species.

Unfavourable – Inadequate
Any combination other than those described under ‘Green’ or ‘Red’.

Unfavourable – Bad Area of habitat(s) is clearly not sufficiently large to ensure the long term survival of the species
OR
habitat quality is bad, clearly not allowing long term survival of the species.

Figure 5 Assessment of habitat for the species parameter in EU reporting

This parameter clearly lends itself to assessment through a combination of measures of habitat area and quality, which are the key components of the habitat-hectares metric (see Appendix B). The UK status assessment is based on the observation that restricted movement is hindering species survival (JNCC, 2006). The area and condition of accessible, suitable spawning sites can therefore be used as a measure. The requirement for this criterion is to demonstrate that that it is feasible ***in theory*** to implement measures which will bring the habitat assessment back to pre-impact levels, somewhere in the bio-geographic region. Further criteria are used to test whether the proposed compensation package will achieve pre-impact compensation status as part of compliance testing with Principle 3.

The method of assessment of the Future Prospects parameter is shown in Figure 6.

Future prospects
(as regards to population, range and habitat availability)

Favourable Main pressures and threats to the species not significant; species will remain viable on the long term.

Unfavourable – Inadequate
Any combination other than those described under 'Green' or 'Red'.

Unfavourable – Bad Severe influence of pressures and threats to the species; very bad prospects for its future, long-term viability at risk.

Figure 6 Assessment of future prospects parameter in EU reporting

The UK assessment of this parameter, leading to an unfavourable inadequate conclusion, is as follows (JNCC, 2007b):

> The species has been identified as being at risk from stochastic events. Removal of artificial river obstructions could help to lower this risk. However there is no current programme for such proposals. Further, habitat destruction by in-channel works continues to be a threat.
>
> It is possible that a warming climate will lead to improved recruitment and lead to favourable conditions for the re-establishment of populations, even over the next 12 years. Shad are sensitive to temperature changes; upstream migration from the estuary appears to be triggered by temperature and eggs are sensitive to water temperatures below 16-18°C. Additional research is required to assess this however, and as yet, the potential impacts of climate on this species are largely unconfirmed.

Clearly the STP will create a major new artificial river obstruction, and a consequent decline in Future Prospects for the species. To satisfy this element of the criterion would require demonstration of the capability to remove equivalent river obstructions in suitable locations so that prospects would be restored to at least pre-impact levels.

5.2.5 Meeting Principle 3: Compensation will achieve ecological equivalence within the chosen geographic frame of reference (Member State or Bio-geographic region) as a minimum.

To test compliance with this principle, we suggest two criteria, the first relating to the impacted feature and the second to apply in situations where substitute features are proposed (see Table 9).

Criterion 3a: The compensation package will restore the feature to its pre-impact conservation status in the region		
Possible Indicators	**Possible metrics**	**Possible method or threshold**
3ai) Population level is increased towards the favourable reference population.	Ratio of current population to favourable reference population	Direct population survey or Habitat Suitability Mapping to infer population size.
3aii) A non viable/sustainable population is replaced with a sustainable one, for example because it is more likely to be resilient to climate change.	Population viability Extinction risk	The LARCH and Zonation or Marxan models (see Appendix A) could be used to model current populations in the Atlantic region, and the benefits of restoring selected rivers for Allis shad spawning. The solution that added the most sustainable population would then be favoured for provision of compensation.
3aiii) Carrying capacity in sustainable habitat networks is increased.	Carrying capacity Sustainability of networks	Modelling using LARCH and Zonation/Marxan could inform this evaluation but further work would be required to explore possible methods in practice.
3aiv) The proportion of potential or suitable habitat occupied is increased.	Habitat –hectares Ratio of current range to reference range (range occupancy)	Habitat Suitability Mapping can be used to give an indication of how range might extended and a greater European population supported. A habitat hectares method could potentially be used to calculate amounts of suitable habitat required, possibly increased through a multiplier.
Criterion 3b: An allowable substitute will have its conservation status enhanced in the bio-geographic region. (The compensation package will equal or exceed loss in status of the impacted feature when applied to an allowable substitute feature and considered together with any enhancement of status of the impacted feature which is included in the overall package).		
Possible Indicators	**Possible metrics**	**Possible method or threshold**
3bi) Compensation addresses an allowable substitute by complying with the exchange criteria which have been established.	Pass or fail	Simple check that criteria have been applied
3bii to 3b iv: as for 3a	See above	See above
The overall coherence of the Natura 2000 network is enhanced so that the benefit to the network from a substitute is greater than the disbenefit incurred from the loss of the feature substituted for.	Network coherence	Modelling using LARCH and Zonation/Marxan could inform this evaluation, but further work is required to explore possible methods in practice.

Table 9 Possible criteria and associated indicators and methods to test compliance with Principle 3

5.2.6 Compliance with Criterion 3a: The compensation package will restore the feature to its pre-impact conservation status in the region

Indicator 3ai): Population level is increased towards the favourable reference population OR

Indicator 3aiv): The proportion of potential or suitable habitat occupied is increased

The generation of an Allis shad Habitat Suitability Map is beyond the scope of this case study, but an indication can be given of a possible approach that could be taken. For this species, opportunities to expand range are constrained by migration barriers and pollution, so habitat suitability maps may need to be modified accordingly. Removal of migration barriers would constitute the type of measure included under “other measures” in **Figure 4** and if this is a realistic possibility, it may be appropriate to demonstrate potential gains with barriers removed. Having developed a Habitat Suitability Map for the Atlantic bio-geographic region, the reduction in suitable habitat caused by the STP options would need to be assessed. Proposed compensation measures would then need to achieve occupation (spawning population) of currently unoccupied suitable habitat to more than balance the loss from the development. This sort of compensation measure addresses both the population and habitat parameters of FCS, using habitat to compensate for impacts on species. Approaches similar to the LARCH, Zonation or Marxan models (see Appendix A) could be used to model current populations in the Atlantic region, and the benefits of restoring selected rivers for Allis shad spawning. The solution that added the most sustainable population would then be favoured for provision of compensation. While for many species the use of the habitat-hectares metric will be suitable to test equivalence of habitat compensation for species impacts, the special circumstances of Allis shad biology does not lend itself to this approach, and more direct measurement using modelling is more suitable.

Indicator 3aii): A non viable/sustainable population is replaced with a sustainable one

Modelling of potential sustainable populations could show, for example, that a project in Western France, located close to robust Allis shad populations, would generate a stronger breeding population which might in turn provide more surplus individual adults for dispersal to UK sites. In this case, compensation would replace a currently non-viable population of Allis shad with a better one. Although the Severn has clearly supported a strong breeding population in the past, this has not been the position since the Habitats Directive came into force (JNCC, 2007). As the Severn population is no longer spawning, the clearest demonstration of enhancement would be for the compensation population to be spawning.

Indicator 3aiii): Carrying capacity in sustainable habitat networks is increased.

The final requirement is that the overall package should also deliver an increase in carrying capacity in sustainable habitat networks. Modelling using LARCH and Zonation/ Marxan will again inform this evaluation. In the case of the Allis shad there are two aspects of connectivity to consider – marine connectivity for adults, and connectivity between the sea, estuaries and river spawning and nursery grounds for adults and juveniles. Marine connectivity around the coastal waters between sites does not appear to be an issue for Allis Shad. It appears that adults are regularly found over a much wider area than the known spawning sites, presumably as surplus individuals disperse from the key populations in the metapopulation, mostly located in France.

Connectivity between the sea and spawning grounds through estuaries and suitable rivers, on the other hand, is the key issue. If a river with suitable spawning grounds is connected with a suitable estuary, then connectivity requirements are fully met; there is no additional connectivity consideration between sites along the rivers. The removal of migration barriers appears to be the most suitable mechanism for increasing carrying capacity in sustainable habitat networks. This mechanism would be categorised as functional network/ coherence compensation. The removal might involve physical removal of a weir or similar structure, or the installation of a vertical fish lift.

Man-made obstacles to allis shad migration can be overcome by the use of a vertical fish lift, like this one on the River Garonne in France. Up to 90,000 shad successfully pass through this lift each year. (Maitland and Hatton-Ellis, 2003).

5.2.7 Testing compliance with criterion 3b: The compensation package will equal or exceed loss in status of the impacted feature when applied to an allowable substitute feature and considered together with any enhancement of status of the impacted feature which is included in the overall package.

If all Allis shad measures are ruled out (e.g. they prove to be impossible implement in practice), it might be necessary to explore compensation based on a substitute species. It must be underlined that a substitute species can only be chosen if Principle 2 has been complied with for Allis shad.

Indicator 3bi): Compensation addresses an allowable substitute by complying with the exchange criteria which have been established.
Under the exchange criteria suggested in Section 4.4.2, only a freshwater fish of equal or less favourable conservation status can be selected. The following freshwater fish occurring in the UK are listed in an Annex of the Habitats Directive, in addition to the Allis shad:

Petromyzon marinus (sea lamprey)
Lampetra planeri (brook lamprey)
Lampetra fluviatilis (river lamprey)
Alosa fallax (twaite shad)
Salmo salar (Atlantic salmon)
Cobitis taenia (spined loach)
Cottus gobio (bullhead)
Coregonus albula (vendace)
Coregonus lavaretus (whitefish)
Barbus barbus (barbel)

Vendace (*Coregonus albula*) is a small, herring-like, freshwater fish on Annex V of the Habitats Directive. Although the species is in favourable condition in the Boreal and Continental biogeographical regions, owing to strong populations in countries such as Finland and Germany (ETCBD, Article 17 reporting database), vendace is in unfavourable bad and deteriorating condition in the Atlantic bio-geographic region. This is the only one of the species listed above which has an equal or less favourable conservation status than Allis shad. Compensation options for vendace are therefore considered using the same indicators as applied to criterion 3a.

Indicator 3bi): Population level is increased towards the favourable reference population or Indicator 3biv): The proportion of potential or suitable habitat occupied is increased

In substituting one species for another, it becomes necessary to compare losses and gains using some sort of common metric. To test whether the proportion of potential or suitable habitat occupied would be increased, a ratio of current population to favourable reference population can be used. Effectively, current position compared with favourable reference values is used as a metric to assess the position on the Conservation Status scale.

In the Atlantic bio-geographic region, the UK has the only occurrences of vendace, with just two sites holding original populations –Bassenthwaite Lake and Derwentwater in Cumbria. Of these the Environment Agency reported in 2008 that the Bassenthwaite population had almost certainly been lost. However fish from Bassenthwaite were used to stock a small lake in SW Scotland in the late 1990s, where the species has thrived, and it is hoped to improve habitat conditions at Bassenthwaite to allow re-introduction in due course (Winfield, Fletcher and James, 2006). Bassenthwaite Lake is part of the River Derwent and Bassenthwaite Lake SAC. Although vendace has been introduced to Loch Skeen in Scotland using eggs from the Bassenthwaite population, with apparent success (JNCC, 2007d), the Conservation Status of the species may be judged on the status of the populations in Bassenthwaite Lake and Derwentwater. These two locations represented the full range of the species when the Habitats Directive came into force.

The ratio of current population to favourable reference population in the bio-geographic region can be calculated as the basis for determining losses or gains in range occupancy. The data in the Article 17 database for these species is poorly populated, so some short cuts have been taken for purposes of illustration. Allis shad data are present for France and Portugal only; as France has the highest population this has been used to derive an approximation. There is an estimated population of 291100 individuals and a favourable reference population of 856600, a ratio of 0.340. The vendace is only present in the region in the UK and its population estimate is 1418.

There is no favourable reference population estimate but a maximum population estimate is given of 43601. Using that figure the ratio for vendace is 0.032.

There is no population estimate of Allis shad for the Severn Estuary, but let's assume a figure of 10,000 to illustrate the approach. Assuming total loss, the post-development Allis shad ratio would be 0.328, a reduction of 0.012. The vendace compensation now must raise its ratio to 0.044, which can be achieved by raising the population to at least 1941. Compensation measures for vendace would then have to be designed to ensure successful delivery of the required population, with a risk of failure of less than 5%.

Options for delivery of compensation

Bassenthwaite Lake and its catchment are in poor condition from the viewpoint of the vendace, as increased siltation from erosion has rendered the spawning grounds unusable, in addition to water quality and alien species introduction problems (Winfield, Fletcher and James, 2004). Derwentwater suffers the same problems to a degree, but much less severely. In this illustration two compensation options are evident, namely the restoration of either Derwentwater or Bassenthwaite Lake to a suitable condition.

Tests of additionality might be required as the Bassenthwaite Lake Restoration Programme is already attempting to restore some aspects of the site through measures such as Catchment Sensitive Farming (http://www.bassenthwaite-lake.co.uk/uploader/pdf/BLRP%20Business%20Plan%202009-10%20final.pdf). It should be noted that near certainty of successful outcome for the species is required for the selected compensation option – well intentioned activity designed to move the situation in the right direction is insufficient.

Options to implement compensation in the form of actions to enhance the functionality of the network appear to be limited in this case. Derwentwater and Bassenthwaite Lake are connected via the River Derwent, which theoretically offers the possibility of natural recolonisation of the latter by dispersal of individuals of the former. This unobstructed link also brings risk of introduction of possibly harmful alien species (Winfield, Fletcher and James, 2004). In these circumstances compensatory action involving functional network enhancements does not appear to be an option. Loch Skeen and Daer Reservoir are not connected with each other or the original sites, so populations here will be isolated, but there is little scope for connecting them in practice.

Other measures to compensate for species impacts

Species conservation measures for vendace could involve translocation to new sites. As described above an apparently successful translocation to Loch Skeen took place in the late 1990s. There was also an apparently unsuccessful translocation of Derwentwater stock to Daer Reservoir in Scotland, and an unsuccessful search for suitable introduction sites in Cumbria (Winfield, Fletcher and James, 2004). Other measures could include removal of predatory introduced fish in the original site, for example ruffe at Bassenthwaite Lake. The practicalities of such options would need to be explored in depth.

The use of multipliers to deliver robustly fair offsets can be illustrated for the translocation option. The objective, as described above is to establish a new, viable vendace population of at least 523 individuals. Using the evidence from previous translocation attempts to give a very approximate failure rate of 50%, the number of translocations should be at least 5 (the smallest whole number above 4.3, see Figure 2 to reduce the risk of all failing to less than 5%.

5.2.8 Summary of outcome

Based on the analyses outlined above, and recognising the many inherent uncertainties and need for further research, the following conclusions are reached for this test case:

Principle 2: It appears likely that loss of the species from the Severn Estuary would not make it impossible to achieve favourable conservation status for Allis Shad species in the Atlantic bio-geographic region. The predicted losses would be insignificant in terms of the conservation status of the species and there are other sites which support viable breeding populations.

Compensation options could therefore be developed for Allis shad or for an allowable substitute species provided that Principle 3 can also be met.

Principle 3: Provided that a biogeographic region approach is deemed acceptable, further research could potentially demonstrate that it will be possible, with near certainty of positive outcome, that the position of Allis Shad will be maintained or enhanced through a suitable compensation package. If further research cannot deliver such certainty, compensation measures applied to the equally vulnerable substitute species, Vendace, could deliver a positive outcome.

5.3 Mudflat

The purpose of example was to explore the application of a possible approach to compliance assessment and not to undertake a fully robust assessment of compensation requirements for mudflat. Readily available information was used and the assessment was carried out in the absence of knowledge about actual compensation requirements due to the STP options.

5.3.1 Background information

“Mudflats and sandflats not covered by seawater at low tide (but submerged at high tide)”, hereafter referred to as “mudflats”, is listed on Annex 1 of the Habitats Directive, and occurs extensively in the Severn Estuary. It is particularly important because it provides feeding habitat for important populations of wetland birds, but it was not possible to explore this aspect in this study.

Preliminary impact assessments of the five STP options have generated various figures for the area of mudflat that could be lost. The precise figure is not important for this illustration –10,000 hectares has been used for illustrative purposes. As for the Allis shad example, it is assumed that Principle 1 has been met through application of appropriate avoidance and mitigation measures, so this loss has been shown to be both residual and unavoidable.

5.3.2 Meeting Principle 2: Compensation will not be pursued as an option in cases where effective compensation cannot be guaranteed or where failure to compensate for residual adverse impacts might drive a feature towards irreversible decline throughout its range

The criteria associated with this test and possible methods to assess compliance are summarised in Table 10 together with sample indicators and possible metrics and methods.

Criterion 2a: the impacted feature will not be pushed below a critical recovery threshold.		
Possible indicators	**Possible metrics**	**Possible method**
Adequate viable sites are available	Number of sites assessed as "favourable" or "future favourable"	Up to date assessment or monitoring of the condition of sites and future prospects.
Criterion 2b: It is possible to restore the feature to its pre-impact status		
Each of the parameters used to assess conservation status is still capable of being restored to pre-impact levels	• Range (proportion occupied or size) • Area • Structures and functions • Future prospects	Assessment of FCS parameters for baseline, and then with impacts and with proposed compensatory measures in place.

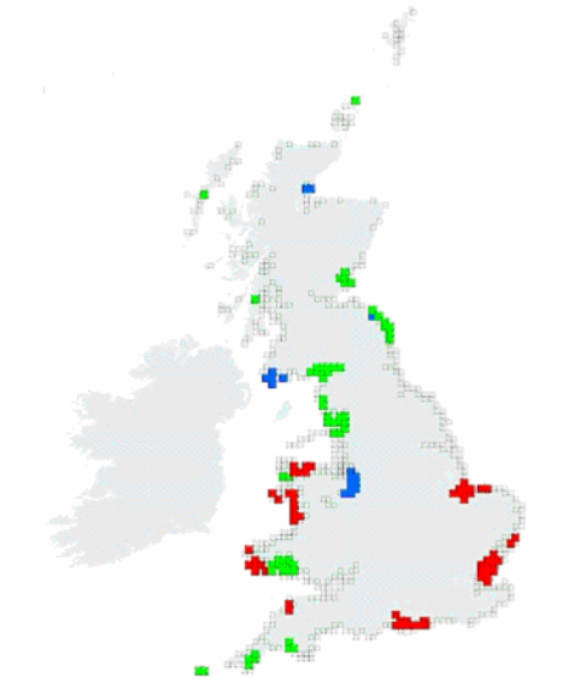
Table 10 Criteria to be met in order to meet Principle 2 for Mudflat habitat

Indicator 2ai): adequate viable sites are available

Figure 7 shows the "predicted future condition" assessment for mudflats in the UK, as reported by JNCC in its Article 17 report to the EU. Note that the Severn Estuary is not included as the SAC/ SCI was not fully designated at this time. The existence of numerous sites in the UK where the condition is assessed as "future-favourable" suggests that loss of integrity at the Severn might not cause inability to achieve FCS for this habitat in itself, though if this approach were being used in reality, checks would have to be made to ensure that available records represent substantive sites and that their condition remains as "future-favourable". A more detailed investigation of the conservation status of mudflats would be required, whether at Member State level or more widely.

Predicted Future Condition of H1140 based on Common Standard Monitoring condition assessments
(See Sections 5.2 and 7.2 for further information on these maps)

Map 5.2.1 SAC assessments



Key:
Red = Future-Unfavourable, i.e. the square contains one or more SACs where this habitat feature is present and has been predicted to be Future-Unfavourable
Green = Future-Favourable, i.e. the square contains at least one SAC where this habitat feature is present and has been predicted to be Future-Favourable
Blue = SAC not assessed, i.e. the square contains at least one SAC supporting this habitat feature but no assessment has been reported
Transparent = SAC feature not present, i.e. the square does not contain any SAC features of this habitat type

Figure 7 Predicted future condition of mudflat

Indicator 2bi) Each of the parameters used to assess conservation status is still capable of being restored to pre-impact levels

In addition to other viable sites being available to support the habitat, it is also necessary to consider whether the habitat can be restored to pre-impact levels, based on the parameters used to test conservation status. Mudflats currently have an overall assessment of "unfavourable – bad" conservation status in the Atlantic region (see Table 11).

Parameter	**Status in UK**	**Status in Atlantic Bio-geographic Region**
Range	Favourable	Favourable
Area	Favourable	Unfavourable - inadequate
Structure and functions	Unfavourable –bad and deteriorating	Unfavourable - bad
Future prospects	Unfavourable –bad and deteriorating	Unfavourable - bad
Overall assessment	Unfavourable –bad and deteriorating	Unfavourable - bad

Table 11 Assessment of FCS parameters for mudflat

Range is currently assessed as Favourable at UK and Atlantic region levels. JNCC reports on range as follows:

"Mudflats and sandflats are widespread along the open coast, bays and estuaries and encompass all parts of the coast where the sedimentary regime allows. The nature of this sedimentary process means that the geographic range of this feature is likely to have remained the same in recent geological times. Although the physical area of some individual sand and mudflats may have changed due to erosion, land claim or other anthropogenic pressures there is no evidence that this has significantly affected the range of the feature.

The current range is stable and not less than the favourable reference value. Therefore, in accordance with EC guidance, the conclusion is favourable" (JNCC, 2007c).

The Severn Estuary is not at the edge of range in the Atlantic region. While there may be some ambiguity in interpretation between range and area, it may be tentatively concluded that the loss of mudflats here would not materially alter the range assessment.

The current assessment of the **area** parameter is "favourable" at UK level and "unfavourable-inadequate" at the Atlantic region level (Table 11). The loss of 10,000 hectares (without compensation) would be highly likely to cause the UK assessment to be changed to "unfavourable" at the next reporting round. Unless it were possible to demonstrate with certainty that at least the same area of habitat could be provided, the predicted loss of mudflat in the Severn Estuary would result in failure to meet Principle 2. Whether assessed at Member state or bio-geographic region level, the requirement of criterion 2b is to demonstrate that at least an equal area to that lost can potentially be provided. A desk-based study of potential managed realignment sites in England and Wales identified 106,000 hectares of potential (APBMer, 2008). On the assumption that the greater part of this area would be mudflat, the creation of at least 10,000 hectares appears to be at least theoretically possible. The decision here is on potential restoration of area, on an extended timescale. Whether such compensation is actually delivered in response to the project is a Test 2 question, for consideration below.

The **Structures and Functions** parameter is assessed as "unfavourable bad and deteriorating" at the UK level and "unfavourable bad" at Atlantic level. JNCC reports its conclusion on structures and functions at the UK level as follows (JNCC, 2007 c)

The EC Guidance states that where "more than 25% of the area of the habitat is Unfavourable as regards its specific structures and functions", the conclusion should be Unfavourable – Bad. In the UK this was generally taken to mean that more than 25% of the habitat area in Unfavourable condition. Based on the CSM data for this feature, at least 22 % of the UK resource is in Unfavourable condition and declining. With such a large proportion of the assessed feature in Unfavourable condition, it is highly likely that at least another 3 % of the remaining feature area would also be Unfavourable; if the features within the SAC series are taken as representative of the wider feature, then approximately half of H1140 would be in Unfavourable condition at the UK level. Based on this, the conclusion is Unfavourable – Bad and deteriorating.

The assessment of structures and functions is clearly interpreted in the UK in terms of habitat condition, or quality, and related to habitat area. Area and condition are also the parameters of the habitat-hectares metric, suggesting the suitability of this metric for assessing compensation options against structures and functions.

As can be seen from Figure 7, the Severn Estuary SAC was not included in the Article 17 report to the EU as this pre-dated its designation. The condition of relevant SSSI units in the Severn Estuary is assessed as largely favourable (Natural England website). Since the mudflats on the Severn represent 2-3% of the UK resource, their loss would make it more difficult to reach favourable condition overall. The condition of the restored mudflat is important as well as its area: it must be demonstrated that it is possible to restore the equivalent area of mudflat at favourable condition.

The **future prospects** parameter is assessed as "unfavourable - bad and deteriorating" at UK level and "unfavourable – bad" at Atlantic region level. JNCC's report for Future Prospects is as follows (JNCC, 2007c):

"The EC Guidance states that where 'habitat prospects are bad, with severe impacts from threats expected and long-term viability not assured', the judgement should be Unfavourable – Bad. In the UK, this was generally taken to mean that habitat range and/or area are in decline, and/or less than 75% of the habitat area is likely to be in favourable condition in 12-15 years. Future threats are unlikely to cause a decline in range due to the inherent stability of this parameter for H1140. However, coastal development and erosion could have significant effects on the total area of the feature. At least 20% of the total area of the resource will remain Unfavourable even after current sympathetic management has improved the situation. In addition there are a number of serious but unquantified threats from other sources. The conclusion is therefore 'Unfavourable – bad and deteriorating'".

Clearly the loss of 10,000 hectares will bring about a significant deterioration in the Future Prospects parameter – indeed tidal barrage schemes are quoted as an area of concern, alongside sea level rise and coastal squeeze arising from climate change. Without any compensation measures applied to mudflats, this parameter could be pushed beyond its recovery threshold. Figure 7 showed the areas of the UK where SAC assessments for mudflats were "Future – unfavourable". Compensatory measures for mudflats may need to address the future prospects for mudflats throughout England and Wales in order to meet Principle 2. The requirement is to demonstrate that is possible to retrieve the pre-impact status of the habitat with respect to this parameter. If habitat area and condition measures are fully addressed in compensation, it may be possible to demonstrate that future prospects are no worse than the previous situation.

5.3.3 Meeting Principle 3: Compensation will achieve ecological equivalence within the chosen geographic frame of reference (Member State or Bio-geographic region) as a minimum.

Whether principle 3 can be met needs to be tested against criteria for impacted features and allowable substitutes as outlined below. For substitute habitats, criteria are more stringent and require conservation status to be enhanced in the biogeographic region. Addressing the impacted habitat itself, mudflats, it is necessary to consider whether the parameters of favourable conservation status are no worse than the previous position, after application of the compensation measures.

Criterion 3a: The compensation package will restore the impacted habitat to its pre-impact conservation status in the region		
Possible Indicators	**Possible metrics**	**Possible method or threshold**
3ai): None of the parameters used to assess conservation status show decline	• Range • Area • Structures and Functions • Future Prospects	Assessment of FCS parameters for baseline, and then with impacts and with proposed compensatory measures in place.
3aii): Area and/or condition of habitat provided through compensation is equal to (or greater than) the area and condition lost due to impact	Habitat-hectares	Assessment of area and condition for baseline, and then predicted with impacts and design of compensation plan.
Criterion 3b: An allowable substitute will have its conservation status enhanced in the bio-geographic region.		
3bi): Area and/or condition of the habitat is enhanced	Habitat-hectares	Assessment of area and condition for baseline, and then predicted with impacts and design of compensation plan.
Or:		
3bii): Carrying capacity in sustainable habitat networks of associated European protected species is increased (network coherence measures only)	Carrying capacity in sustainable habitat networks	Modelling using LARCH and Zonation/Marxan could inform this evaluation.

Table 12 Criteria to be met in order to demonstrate that Principle 3 can be met

5.3.4 Criterion 3a: The compensation package will restore the impacted habitat to its pre-impact conservation status in the region

Principle 2 establishes whether it is possible, in theory to restore a habitat to its pre-impact condition. For Principle 3 it is necessary to determine whether compensation can actually be realistically delivered. This assessment should be regarded as entirely hypothetical at this stage as we do not have information on practical aspects of implementation.

Indicator 3ai): None of the parameters used to assess conservation status show decline

The parameters for defining conservation status have been described and discussed with respect to Principle 2 and the interpretation is not repeated here. It is clear that creation or restoration of at least 10,000 hectares is without precedent in Europe. The critical point seems likely to be the availability of suitable potential sites capable of being delivered in the compressed time scale necessary for effective compensation. While investigation of such practicalities is beyond the scope of this report, this must be considered to be in considerable doubt.

Indicator 3aii): Area and/or condition of habitat provided through compensation is equal to (or greater than) the area and condition lost due to impact

A habitat hectares approach could be used to compare losses and gains in habitat area and condition (See Appendix B) with respect to both criteria. In the 3 x 3 matrix of inherent value and condition explained in Appendix B, mudflats occupy the high inherent value position as an Annex 1 habitat (see **Figure 8**).

		Inherent value		
		Low[27]	Medium	High
Condition	High			Favourable Condition
	Medium			Unfavourable Recovering Condition
	Low			Unfavourable No Change or Declining Condition

Figure 8 Condition categories at varying levels of inherent value

The precision of the direct condition measurement metric could be enhanced through benchmarking against a reference condition status. The concept of favourable reference values is already employed in the reporting of favourable conservation status under Article 17 of the Habitats Directive. However, in respect of habitats reporting, these values apply only to range and area. The development of equivalents for condition (equivalent to the "structures and functions" attribute in European reporting) would be a powerful tool, allowing perhaps a 10 point scale to replace the three points used here. Common Standards Monitoring guidance could be developed for this purpose in the UK.

Natural England's latest data on SSSI condition for the Severn Estuary indicates that over 90% of "littoral sediment" (the closest habitat category equivalent) is in favourable condition. Let us suppose that precise habitat recording and condition assessment shows 90% of the SAC mudflat area as in favourable condition, 5% in unfavourable recovering condition and 5% in unfavourable declining condition. Using the multiplication factors in the standard habitat-hectares metric (see Appendix B), the habitat hectares score would then be 9495 (9000*1 + 500*0.66 + 500*0.33).

Before the application of a multiplier, compensatory measures could be creation of 9495 ha. of mudflat in favourable condition. Note that creation of new mudflats in any other condition is not an option, as the direction of movement on the matrix must not be negative on either axis (see Appendix B). In this case most of the impacted habitat is occupying the top right cell; therefore only habitat creation in the same cell would meet the rule. An alternative strategy would be to restore existing mudflat currently in unfavourable recovering condition to favourable condition. In this case 28,792 ha. would be required (9495 * 1/0.33). Another option would be to restore mudflat currently in unfavourable no change or declining condition to favourable condition. In this case 14,386 ha. would be required (9495 * 1/0.66). A mixture of the strategies could also be used provided the habitat hectares requirement is met. Note that these figures are also calculated before the application of the multiplier.

[27] Metrics for habitat parcels of low and medium inherent value are left blank in this matrix, as they are not relevant to this case. Condition, or a management-related surrogate may be used.

The application of a multiplier requires an assessment of the success probability for creation of mudflats through techniques such as managed realignment. This is beyond the scope of this case study, but such assessment would include analysis of the data behind reviews of previous schemes, such as Rupp-Armstrong *et al*., (2008). For illustrative purposes, let us assume a success probability of 70%, which translates to a required multiplier of 2.5:1, this being the multiplier required to reduce the risk of failure to below 5%.

The results of the habitat-hectares calculation above now need to be multiplied by 2.5 to arrive at the final requirement e.g. 9495*2.5 = 23,737 hectares of mudflats created in favourable condition. The area of search for restoration opportunities should be extended to the whole of the Atlantic bio-geographic region, and an optimal compensation design developed taking into account all habitat and species compensation requirements in the case.

As the Phase 1 report has pointed out, this sort of scale of inter-tidal habitat creation is unprecedented. Indeed it exceeds the totals created to date in the whole of NW Europe, and is two orders of magnitude greater than the area of mudflats created in the UK through managed realignment up to 2008 (Online Managed Realignment Guide, www.abpmer.net/omreg/). Under the definitions proposed in this report, much of this compensation would be in a different functional context and would not benefit the same individuals and populations of species using the habitat as those affected. This could usefully be addressed through a further case study to address interdependencies between habitat and associated species.

The challenges posed by such a large requirement for compensation suggests that the use of substitute habitats merits consideration. This does not imply that a compensation package with no work on mudflats would be acceptable; assessment against Principle 2 suggested that some direct measures would be required. This conclusion therefore concerns the sufficiency of habitat substitution in terms of achieving equal value.

Criterion 3b: An allowable substitute will have its conservation status enhanced in the bio-geographic region.

Under the rules proposed the substitute habitat must be an Annex 1 type drawn from the same EUNIS level 1 habitat group (as are all of the habitats impacted in this case) and have a conservation status at least as unfavourable in the region as the impacted habitat. Analysis of the EU Article 17 Database finds 36 habitats that meet these criteria, as listed in Table 13.

Habitat Code	Habitat Group	Habitat Short Name	Range	Area	Structure & Function	Future Prospects	Overall Conservation Status
7110	bogs, mires & fens	Active raised bogs	XX	U2	U2	U2	U2
7230	bogs, mires & fens	Alkaline fens	FV	U2	U2	U2	U2
7120	bogs, mires & fens	Degraded raised bogs capable of natural regeneration	FV	U1	U2	U1	U2
7150	bogs, mires & fens	Depressions on peat substrates of the Rhynchosporion	U1	U2	U1	U1	U2
7220	bogs, mires & fens	Petrifying springs with tufa formation (Cratoneurion)	U1	U1	U2	U2	U2
7140	bogs, mires & fens	Transition mires and quaking bogs	U1	U2	U2	U2	U2
1210	coastal	Annual vegetation of drift lines	XX	U1	U2	U2	U2
1150	coastal	Coastal lagoons	U2	U2	U2	XU	U2
1130	coastal	Estuaries	FV	FV	U2	U2	U2
1340	coastal	Inland salt meadows	U1	U2	FV	FV	U2
1160	coastal	Large shallow inlets and bays	FV	FV	U2	U2	U2
1140	coastal	Mudflats/sandflats not covered by sea water at low tide	FV	U1	U2	U2	U2
1220	coastal	Perennial vegetation of stony banks	FV	U1	U2	U1	U2
1110	coastal	Sandbanks slightly covered by sea water all time	U1	U1	U2	XU	U2
1320	coastal	Spartina swards (*Spartinion maritimae*)	U2	U2	U2	U2	U2
2150	dunes	Atlantic decalcified fixed dunes (*Calluno-Ulicetea*)	U1	U1	U2	U2	U2
2250	dunes	Coastal dunes with *Juniperus* spp.	FV	U2	U2	U2	U2
2320	dunes	Dry sand heaths with *Calluna* and *Empetrum nigrum*	XX	U1	U2	U1	U2
2310	dunes	Dry sand heaths with *Calluna* and *Genista*	FV	U1	U2	U2	U2
2110	dunes	Embryonic shifting dunes	U1	U2	U2	U1	U2
2130	dunes	Fixed coastal grey dunes with herbaceous vegetation	U1	U1	U2	U2	U2
2190	dunes	Humid dune slacks	FV	U2	U2	U2	U2
2330	dunes	Inland dunes with open *Corynephorus* & *Agrostis* grassl.	U1	U1	U2	U2	U2
21A0	dunes	Machairs (* in Ireland)	FV	FV	U2	U2	U2

2120	dunes	Shoreline shifting white dunes with *Ammophila arenaria*	FV	U2	U2	U2	U2
3150	freshwater	Natural eutrophic lakes Magnopotamion/ Hydrochachition	FV	XX	U2	U1	U2
3270	freshwater	Rivers with muddy banks (*Chenopodion rubri* & *Bidention*)	U1	U2	U2	U1	U2
3260	freshwater	Water courses of plain to montane level (*Ranunculion*..)	XX	XU	U2	U2	U2
6440	grasslands	Alluvial meadows of river valleys of the *Cnidion dubii*	XX	U2	U2	U2	U2
6130	grasslands	Calaminarian grasslands of the *Violetalia calaminariae*	FV	U1	U2	U1	U2
6430	grasslands	Hydrophilous tall herb fringe comm. of plains & montane	U1	FV	U2	U1	U2
6510	grasslands	Lowland hay meadows (*Alopecurus pratensis, Sanguisorba*)	XU	XU	U2	U1	U2
6420	grasslands	Med. tall humid grassl. of the *Molinio-Holoschoenion*	XX	U2	U2	U2	U2
6410	grasslands	Molinia meadows on calc./peaty/clayey-silt-laden soils	FV	U2	U2	U2	U2
6210	grasslands	Semi natural dry grassl. & scrubland facies on calc. sub	XX	U2	U2	U2	U2
6120	grasslands	Xeric sand calcareous grasslands	U1	U2	U2	U2	U2

Table 13 Annex 1 habitats within the same EUNIS level 1 habitat group as Mudflat

While it is beyond the scope of this project to analyse all of the options presented here, some observations can be noted:

1. These habitats differ considerably and it is likely that more precise criteria would be required.

2. Some of these habitats are also impacted by the STP development. This presents the possibility that compensation could be focused on fewer of the habitats than those impacted, provided all of the other criteria are met.

3. Some of these habitats have no representation in the UK.

4. Many of the habitats have a very restricted area and it may be difficult to find areas suitable for provision of compensatory habitat.

Indicator 3bi): Area and/or condition of the habitat is enhanced

Since all of the listed habitats are included in Annex 1 and have a conservation status at least as unfavourable as mudflats, a direct equivalence is allowed. Therefore the pre-multiplier calculation of habitat-hectares compensation required as calculated for mudflats above can be applied to any one or combination of several of these habitats.

So, for example, if the creation of habitat in favourable condition option is selected, then 9,495 hectares is required, before application of the multiplier.

The success probability of each habitat type creation then needs to be assessed, for application of the multiplier. For example, let us suppose there are opportunities to create some large coastal lagoons and, in a separate project, some large areas of Molinia meadows on calc./peaty/clayey-silt-laden soils. The success probability of the coastal lagoons is assessed at, say, 0.9 giving a multiplier of 1.4; however confidence in creation of Molinia meadows is much lower, at, say, 0.5, giving a multiplier of 4.4. An exclusively coastal lagoon solution would require 9,495*1.4 = 13,293 habitat hectares. An exclusively Molinia meadows solution would require 9,495*4.4 = 41,778 habitat hectares. Habitat combinations would be calculated pro rata.

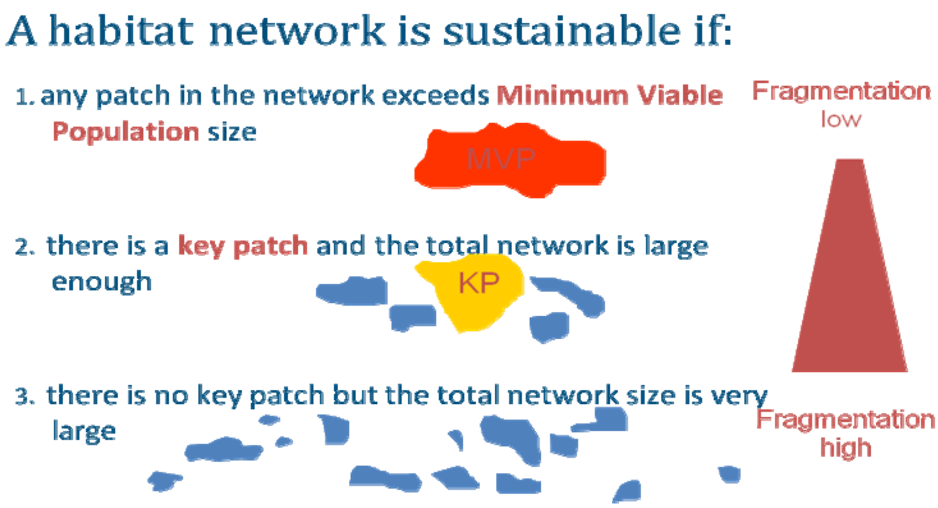
5.3.5 Indicator 3bii): Functional connectivity of network is increased and/or carrying capacity of associated species in sustainable habitat networks

If direct habitat compensation using substitute habitats also proves not to be feasible, measures based on functional network/ coherence compensation can be applied to substitute habitats. This might entail enhancement of the landscape matrix around and between Natura 2000 sites that contain the substitute habitats to improve functional networks and coherence of the network as a whole, within the Atlantic bio-geographic region. The spatial design could be undertaken using the Zonation tool supported by the use of LARCH modelling (see Appendix A). It is likely that an optimal design could be found with an intensive data collation and modelling effort.

The equivalence metrics would comprise habitat-hectares and the coherence of the Natura 2000 network could be indicated by carrying capacity (further work would be required to confirm the availability of data to support this). Compensatory habitat creation or restoration would need to exceed the habitat-hectares of mudflats lost to the development. In a functional network programme the habitats created or restored are likely to be drawn from a range of habitat groups and include non-Annex 1 as well as Annex 1 habitats. This is allowable, provided the habitat-hectares matrix is used to demonstrate equivalence.

Assessment of balance of impact on coherence needs to analyse effects on key species rather than habitat, as in this sense networks are only relevant from the species viewpoint (Vos *et al*., 2001). First, the impact on carrying capacity of the development site for Habitats Directive or Birds Directive Annex species must be assessed. Compensatory measures must increase the **carrying capacity in sustainable habitat networks** of the Atlantic bio-geographic region for these species by at least as much as the loss of carrying capacity to the impacted species, in locations that are capable of receiving dispersal from key source populations. If substitute species are used then they must be at conservation status in the region at least as unfavourable as the impacted species and in the same taxonomic group.

If multiple species are impacted the compensatory work must seek optimal landscape design in the region for all impacted species, or impacted and substitute species, taken together. Such compensatory measures could include or even exclusively comprise enhancement of the landscape matrix rather than core existing or prospective Natura 2000 sites. However the benefits must be measured in terms of effects on the Annex species. This can be illustrated by the spatial layout of model habitat networks in landscapes with varying fragmentation (from LARCH model, Alterra, Appendix A):



In a moderately or highly fragmented landscape, typical of the Atlantic region, the creation or restoration of habitat patches represented in blue, perhaps in green or blue corridors linking Natura 2000 sites, can change unsustainable networks into sustainable networks for key species. The metric of carrying capacity in sustainable habitat networks is thereby increased.

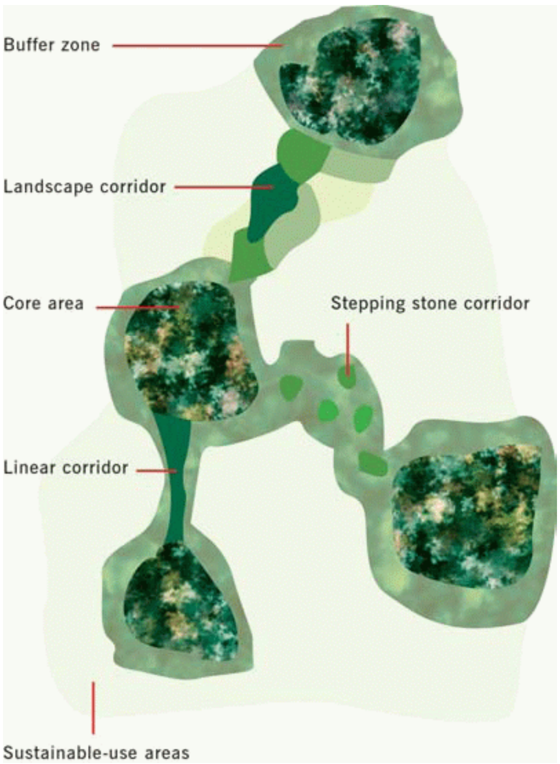


Figure 9 Elements of ecological networks (Countdown 2010)

Ecological networks are being widely promoted in support of the Habitats and Birds Directives, for example, the Pan European Ecological Network (PEEN), an implementation tool of the Pan-European Biological and Landscape Diversity Strategy. PEEN aims to link the different European and national protected areas and ecological networks with the goal of ensuring the favourable conservation status of Europe's key ecosystems, habitats, species and landscapes (Countdown 2010).

5.3.6 Summary of outcome

Compliance with Principle 1 is assumed as the starting point.

Compliance with Principle 2 is theoretically achievable, but only through significant compensatory measures applied directly to mudflats across the UK and perhaps elsewhere in the region. The availability of suitable sites for habitat creation/ restoration is unlikely to be sufficient in the near future to allow equal value compensation through mudflats alone.

Compliance with Principle 3 is therefore likely to require an unprecedented scale of compensatory measures on substitute habitat features, with equal value demonstrated through the habitat-hectares metric and/or measures of coherence of ecological networks.

Compliance with Principle 4 would be demonstrated through application of suitable measures designed to enhance coherence of ecological networks through a strategic, spatial approach.

Compliance with Principles 5 and 6 would address practical, legal and institutional aspects of compensation delivery to give an assured outcome.

5.4 Conclusions and next steps

The test cases presented in this chapter demonstrate the application of the framework set out in Chapter 4. Table 14 shows how compliance with all of the principles in the framework might be tracked for one of the test cases (Allis shad). In this case it appears that it would be possible to achieve equivalence in terms of conservation status IF equivalence is determined at the level of the Atlantic bio-geographic region as opposed to the Member State and provided that robust assessments of population viability have been carried out to demonstrate that the species will remain in a viable state. As demonstrated in Table 14, an approach such as the one suggested here can potentially improve the transparency of compensation design and make it easier to determine whether substitutions (in terms of where compensation is delivered or which features are addressed) are likely to be compliant with the requirements of the Directives, but further development and testing would be required in practice.

In this report we have focused largely on ecological aspects of compensation, as reflected in Principles 2 and 3. Further work would be required on Principle 4 to provide better guidance on enhancement or creation of connective networks and on Principles 5 and 6 to explore the important practical, legal and institutional aspects of implementing a framework such as the one we have suggested.

Table 14 Final outcome for Allis shad

Principles and criteria	Outcome
Principle 1: Compensation must only be used if site integrity cannot be assured through mitigation	The starting point for this example, where we assume Principle 1 has been met.
Principle 2: Compensation must not be pursued as an option in cases where effective compensation cannot be guaranteed….	**In this case we conclude that Principle 2 can be met on the basis of two assessment criteria as follows:**
Criterion 2a: the impacted feature will not be pushed below a critical recovery threshold	Subject to a full PVA, and confirmation that the France, Spain and Portugal populations remain robust, it appears that the STP impacts are unlikely to commit the species to extinction in the Atlantic bio-geographic region. There are alternative viable sites.
Criterion 2b: pre-impact conservation status	In theory pre-impact conservation status is achievable for this species if it is lost from the Severn Estuary
Principle 3: It is possible to achieve ecological equivalence within the chosen geographic frame of reference.	**We conclude that Principle 3 can be met on the basis of the following criteria:**
Criterion 3a: the compensation package will restore the feature to its pre-impact conservation status in the region OR:	It should be possible to maintain or enhance the conservation of status of Allis shad (provided that compensation options are available beyond the UK) OR alternatively:
Criterion 3b: an allowable substitute will have its conservation status enhanced	It would be possible to achieve an enhancement in the status of vendace which is equally vulnerable in the Atlantic bio-geographic region
Principle 4: Compensation will be designed and implemented in a landscape context to optimise conservation outcome	**Opportunities to enhance outcomes at the landscape scale need further investigation. One option might be to consider removal of barriers to movement throughout the current or potential range. This is outside the scope of this study,**
Principle 5: Compensation will be additional to actions that are normal practice…	**Simple check required.**
Principle 6: Compensation will be targeted, effective, technically feasible and secured in perpetuity.	**Further work is required to explore the practical, legal and institutional requirements for delivery of successful compensation. Habitat banks offer one option to ensure that compensation is provided in advance of impacts and is secured effectively in perpetuity.**

6 REFERENCES

APBMer, 2008 (Phase 1 report)

Akçakaya, H. R., McCarthy, M. A. and Pearce, J. (1995). Linking landscape data with population viability analysis: management options for the helmeted honeyeater. Biol Conserv 73:169-176.

Akçakaya H.R. and Sjögren-Gulve, P (2000). Population viability analysis in conservation planning: an overview. Ecological Bulletins 48:9-21.

Akçakaya H.R. (1998). RAMAS GIS: Linking Landscape data with Population Viability Analysis (Version 3.0) Applied Mathematics, Setauket, New York.

Akçakaya, H.R. (2000). Viability analyses with habitat-based metapopulation models. Popul Ecol 42:45-53.

Aprahamian MW, Lester SM and Aprahamian MW (1998). Shad conservation in England and Wales. Environment Agency Technical Report W110, 1–124.

Ball, I. R. and Possingham, H. P. (2000). MARXAN (V1.8.2): Marine Reserve Design Using Spatially Explicit Annealing, a Manual pdf (267KB).

Biodiversity Reporting and Information Group, (2007). *Report on the Species and Habitat Review*. Report to the UK Biodiversity Partnership.

BRANCH (2007). *Planning for biodiversity as climate changes*. BRANCH final report. www.branchproject.org.uk.

Business and Biodiversity Offsets Programme (BBOP). 2009. Business, Biodiversity Offsets and BBOP: An Overview. BBOP, Washington,D.C. © Forest Trends 2009. ISBN 978-1-932928-29-7 (paperback) ISBN 978-1-932928-30-3 (PDF) www.forest-trends.org/biodiversityoffsetprogram/guidelines/overview.pdf

Butcher (2008) Regional Habitat Data Project, Stage 2. West Midlands Biodiversity Partnership, unpublished report.

Catchpole, R. D. J. (2006). Planning for Biodiversity – opportunity mapping and habitat networks in practice: a technical guide. English Nature Research Reports, No 687. English Nature, Peterborough.

Catizzone, M., Larsson, T.B., Svensson, L. (1998). *Understanding Biodiversity. A research agenda prepared by the European Working Group on Research and Biodiversity (EWGRB)*. Ecosystems Research Report No 25. Directorate General Science, Research and Development, European Commission EUR 18444 EN.

Cox, J. (2008). Resource Equivalency Methods for Assessing Environmental Damage in the EU. Case Study D12: Use of REA in Calculation of Article 6(4) Compensation Arising from 'Coastal Squeeze' Jonathan Cox Associates, Lymington, UK.

Council for European Communities (1979). *Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds*. Brussels: European Union.

Council for European Communities (1992). *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wild flora and fauna*. Brussels: European Union.

Countdown 2010 (http://www.countdown2010.net/archive/paneuropean.html#peen)

Crooks, S. and Ledoux, L. (1999). Mitigation Banking as a Tool for Strategic Coastal Zone Management: A UK Perspective. CSERGE Working Paper GEC 99-02. School of Environmental Sciences, University of East Anglia, Norwich. www.uea.ac.uk/env/cserge/pub/wp/gec/gec_1999_02.pdf

Darbi, M.; Ohlenburg, H.; Herberg, A.; Wende, W., Skambracks, D. & Herbert, M. (2009). *International Approaches to Compensation for Impacts on Biological Diversity*. Final Report. Dresden, Berlin.

DCLG (2008a). *The Community Infrastructure Levy*. Department for Communities and Local Government, London. http://www.communities.gov.uk/documents/planningandbuilding/pdf/communityinfrastructurelevy.pdf

DCLG (2008b). *PPS12: Local Spatial Planning*. Planning Policy Statement 12. Department for Communities and Local Government, London.

Defra (2002). *Working with the Grain of Nature; A Biodiversity Strategy for England* (2002). Defra, London.

Defra (2008). Scoping study for the design and use of biodiversity offsets in an English context. Contract NE 0801. Jo Treweek with contributions from Kerry ten Kate, Bill Butcher, Orlando Venn, Lincoln Garland, Mike Wells, Dominic Moran and Stewart Thompson.

Defra (undated a). *Guidance for Local Authorities on Implementing the Biodiversity Duty*. http://www.defra.gov.uk/wildlife-countryside/pdfs/biodiversity/la-guid-english.pdf

Defra (undated b). *Guidance for Public Authorities on Implementing the Biodiversity Duty*. http://www.defra.gov.uk/wildlife-countryside/pdfs/biodiversity/pa-guid-english.pdf

Defra & Natural England (2008). *Securing biodiversity: A new framework for delivering priority habitats and species in England*. http://www.naturalengland.org.uk/ourwork/conservation/biodiversity/protectandmanage/framework.aspx

Department for Communities and Local Government (2006). *Planning for the Protection of European Sites: Appropriate Assessment Under The Conservation (Natural Habitats, &c.) Regulations 2006 – Guidance for Regional Spatial Strategies and Local Development Documents*. DCLG, London.

Department for Environment, Food and Rural Affairs (2002). *Working with the grain of nature: A biodiversity strategy for England.* Defra, London.

Department for Environment, Food and Rural Affairs (2007). *Conserving Biodiversity – the UK Approach*. Defra, London.

Department for Environment, Food and Rural Affairs (2008). *Habitat Connectivity – Developing an indicator for UK and country level reporting. Phase 1 Pilot Study - Unpublished contract report to Defra (Defra Contract CR0388) by*. Watts, K., Handley, P., Scholefield, P. and Norton, L. (2008).. Forest Research, Farnham, Centre for Ecology and Hydrology, Lancaster. Defra, London.

Department of Environmental Affairs & Development Planning, (2007). *Provincial Guideline on Biodiversity Offsets*. Edition 2. Republic of South Africa, Provincial Government of the Western Cape, Department of Environmental Affairs & Development Planning, Cape Town.

Department of Environment and Climate Change NSW (2008). *Biobanking. Biodiversity Offsets and Banking Scheme. Biobanking Handbook for Local Government*. DECC, Sydney.
http://www.environment.nsw.gov.au/resources/biobanking/08526bblocalgovhb.pdf

Department of Sustainability and the Environment (2002). *Victoria's Native Vegetation Management: A Framework for Action*. Melbourne, Victoria.

Dodd, A. M. (2007). EU Habitats Directive and Habitat Compensation. Spatial Planning in England and implementing habitat compensation under Article 6(4) of the Habitats Directive. MSc dissertation for Oxford Brookes University.

Dodd, A. (2008). *EU nature directives: rights, responsibilities and results – are we striking the right balance?* Environmental Law and Management: 237 -245

Dodd, A.M., Cleary, B. E., Dawkins, J. S., Byron, H. J., Palframan, L. J. & Williams, G. M. (2007). *The Appropriate Assessment of Spatial Plans in England.* Royal Society for the Protection of Birds, Sandy.

Dunford, R. W., Ginn, T. C. and Desvousges, W. S. (2004). *The use of habitat equivalency analysis in natural resource damage assessments*. Ecological Economics 48 (2004) (1).

Environment Agency (2005). Hesketh Out Marsh West Realignment Scheme Scoping Report, Corinna Simpson and Robert Harvey, Environment Agency, Preston.

EEA (European Environment Agency) (2006). *Using the market for cost-effective environmental policy. Market-based instruments in Europe*. EEA Report no. 1/2006. Copenhagen.

ETCBD (2010). Article 17 Reporting Database. EIONET
http://biodiversity.eionet.europa.eu/article17

European Commission (2007a). Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC. European Commission, Brussels.

European Commission (2007b). *Guidance document on the strict protection of animal species of community interest under the Habitats Directive 92/43/EEC*.
(http://circa.europa.eu/Public/irc/env/species_protection/library?l=/commission_guidance/final-completepdf/_EN_1.0_&a=d).

Fonseca, M.S., B.E. Julius, and W.J. Kenworthy. 2000. "Integrating biology and economics in seagrass restoration: How much is enough and why?" Ecological Engineering. Volume 15. Pages 227 to 237.

Fonseca, M.S., W.J. Kenworthy, and G.W. Thayer. 1998. "Appendix E: Example Propeller and Mooring Scar Restoration Plan." In: Guidelines for the conservation and restoration of seagrasses in the Unites States and adjacent waters, Fonseca M.S., W.J. Kenworthy, and G.W. Thayer eds. National Oceanic and Atmospheric Administration, Coastal Ocean Office. Silver Spring, MD.

Her Majesty's Stationary Office (1994). Statutory Instrument 1994 No. 2716. *The Conservation (Natural Habitats, &c.) Regulations, 1994*. HMSO, London.

Her Majesty's Stationary Office (2004). Statutory Instrument 2004 No. 1633. *The Environmental Assessment of Plans and Programmes Regulations, 2004*. HMSO, London.

Her Majesty's Stationary Office (2007). Statutory Instrument 2007 No. 1843. *The Conservation (Natural Habitats, &c.) (Amendment) Regulations, 2007*. HMSO, London.

Hopkins, J.J., Allison, H.M., Walmsley, C.A., Gaywood, M. and Thurgate, G. (2007). *Conserving biodiversity in a changing climate; guidance on building capacity to adapt*. Defra, London.

Joint Nature Conservation Committee (2007). *The deliberate disturbance of marine European Protected Species*: Interim guidance for English and Welsh territorial waters and the UK offshore marine area. Joint Nature Conservation Committee, Peterborough.

JNCC (2007 b) Second Report by the United Kingdom under Article 17 on the implementation of Directive 92/43/EEC from January 2001 to December 2006. Conservation status assessment for S1102: Alosa alosa - Allis shad. JNCC, Peterborough.

JNCC (2007 c) Second Report by the United Kingdom under Article 17 on the implementation of Directive 92/43/EEC from January 2001 to December 2006. Conservation status assessment for H1140: Mudflats and sandflats not covered by seawater at low tide JNCC, Peterborough.

JNCC (2007 d) Second Report by the United Kingdom under Article 17 on the implementation of Directive 92/43/EEC from January 2001 to December 2006. Conservation status assessment for S2492: Coregonus albula – Vendace. JNCC, Peterborough.

Kiesecker, J., Copeland H., Pocewicz , A., Nibbelink, N., Mckenney, B., Dahlke, J., Holloran, M., and Stroud, D., (2009). A Framework for Implementing Biodiversity Offsets: Selecting Sites and Determining Scale. BioScience 59 (1): 77–84. ISSN 0006-3568, electronic ISSN 1525-3244.

Kraimer, L. (2009). The European Commission's Opinions under Article 6(4) of the Habitats Directive. Journal of Environmental Law 21:1 (doi:10.1093/jel/eqn028 Advance Access published on 7 January 2009).

Latimer, W. & Hill, D. (2007). *Mitigation banking: securing no net loss to biodiversity? A UK perspective*. Planning, Practice & Research, 22, 155-175.

Ledoux, L., Crooks, S., Jordan, A., Turner, R. K., (2000). *Implementing EU Biodiversity Policy: A UK Case Study*. CSERGE Working Paper GEC 2000-03, University of East Anglia.

Mack, J. J. (2004). Integrated wetland assessment program, part 4: Vegetation Index of Biotic Integrity (VIBI) and Tiered Aquatic Life Uses (TALUs) for Ohio wetlands. Ohio EPA Technical Report WET/2004-4, Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Maitland P S & Hatton-Ellis TW (2003) Ecology of the Allis and Twaite Shad Conserving Natura 2000 Rivers, Ecology Series No. 3. Life-Nature Programme. English Nature, Peterborough, UK.

Moilanen, A., Van Teeffelen, A., Ben-Haim, Y. and Ferrier, S. (2008). How much compensation is enough? A framework for incorporating uncertainty and time discounting when calculating offset ratios for impacted habitat. Restoration Ecology, in press.

Morris, R. K. A., Alonso, I., Jefferson, R. G. and Kirby, K. J. (2006). *The creation of compensatory habitat - can it secure sustainable development*? Journal for Nature Conservation 14 (2006) 106 -116.

Morris, R. and Huggett, D. (2007). *Mitigation banking: practical reality or Trojan horse*? Town and Country Planning December 2007: 441 -448.

National Oceanic and Atmospheric Administration (1995; revised October 4, 2000 and May 23, 2006). Habitat Equivalency Analysis: An Overview. NOAA Damage Assessment and Restoration Program, Department of Commerce. http://www.darrp.noaa.gov/library/pdf/heaoverv.pdf

NOAA (National Oceanic and Atmospheric Administration). 1995. "Habitat Equivalency Analysis: How Much Restoration is Enough?" Fact Sheet. Available online at: http://www.darp.noaa.gov/pdf/heagenl.pdf

NOAA (National Oceanic and Atmospheric Administration). 1997. Natural Damage Assessment Guidance Document: Scaling Compensatory Restoration Actions (Oil Pollution Act of 1990). Damage Assessment and Restoration Program, NOAA. Silver Spring, MD. Available online at: http://www.darcnw.noaa.gov/scaling.pdf

NOAA (National Oceanic and Atmospheric Administration). 1999. Discounting and the Treatment of Uncertainty in Natural Resource Damage Assessment: Technical Paper 99-1. Silver Spring, MD. Available online at: http://www.darp.noaa.gov/pdf/discpdf2.pdf

NOAA (National Oceanic and Atmospheric Administration). 2000. Habitat Equivalency Analysis: An Overview. Damage Assessment and Restoration Program, National Oceanic and Atmospheric Administration. Silver Spring, MD. Available online at: http://www.darp.noaa.gov/pdf/heaoverv.pdf

OSPAR (2007). Background Document to Support the Assessment of Whether the OSPAR Network of Marine Protected Areas is Ecologically Coherent. OSPAR Biodiversity Series, 319.

Parkes, D., Newell, G. and Cheal, D. (2003). *Assessing the quality of native vegetation: the 'habitat hectares' approach*. Ecological Management and Restoration 4, S29-S38.

Parliamentary Office of Science and Technology (2008). *Ecological Networks*. POSTNote 300. POST, London.

Parrish, J. D., Braun, D. P. and Unnasch, R. S. (2003). Are we conserving what we say we are? Measuring ecological integrity within protected areas. BioScience 53: 851-860.

Possingham, H. P., Ball, I. R. and Andelman, S. (2000). Mathematical methods for identifying representative reserve networks. In: S. Ferson and M. Burgman (eds) Quantitative methods for conservation biology. Springer-Verlag, New York, pp. 291-305. pdf (223KB).

Ray, G. L. 2007. Habitat equivalency analysis: A potential tool for estimating environmental benefits. EMRRP Technical Notes Collection (ERDC TN-EMRRP-EI-02). Vicksburg, MS: U.S. Army Engineer Research and Development Center. Also available on: http://el.erdc.usace.army.mil/elpubs/pdf/ei02.pdf

REMEDE (2008). Resource Equivalency Methods for Assessing Environmental Damage in the EU. Toolkit for Performing Resource Equivalency Analysis to Assess and Scale Environmental Damage in the European Union. Stratus Consulting, Ghent University, Economics for the Environment Consultancy Ltd and Jonathan Cox Associates.

Rupp-Armstrong, S., Scott, C. and Nicholls, R., (2008). Managed realignment and regulated tidal exchange in northern Europe – lessons learned and more. Defra 43rd Flood and Coastal Management Conference, Manchester July 2008. 9p.

Shaffer, M. L. (1981). Minimum population sizes for species conservation. BioScience 31:131–134.

SERC (2007). *Integrated Habitat System Regional Dataset for SE England, South East England Local Records Centres*. Somerset Environmental Records Centre, Wellington.

SERC (2010). Integrated Habitat System. http://ihs.somerc.co.uk/

Somerset County Council (2009) Habitats Regulations Assessment, Hestercombe House Special Area of Conservation. Taunton Transport Strategy Review 2. SCC, Taunton.

South West Wildlife Trusts (2005). *Rebuilding Biodiversity in the South West*, Technical Manual (unpublished report).

Sustainable Development Commission Turning the Tide: Tidal Power in the UK (SDC 2007) p 143 http://www.sd-commission.org.uk/publications.php?id=607.

Sustainable Development Commission (2009). Equal Value Investigation. Contribution to Coherence of the Natura 2000 Network As Part of the Severn Tidal Power Feasibility Study. Phase One Report.

TEEB (2008). The Economics of Ecosystems and Biodiversity, An Interim Report. European Communities. ISBN-13 978-92-79-08960-2. Cambridge, UK.

ten Kate, K., Bishop, J. and Bayon, R. (2004). Biodiversity offsets: views, experience, and the business case. IUCN, Gland, Switzerland and Cambridge, UK and Insight Investment, London, United Kingdom.

TEC (2009). Regional Spatial Strategy Phase Three. Regional Habitats Targets Review. Technical Report Prepared for the West Midlands Regional Assembly.

UK BAP (2006). *Review of BAP Targets – Target Type Definitions, UK BAP 2006* www.ukbap.org.uk/library/brig/TargetsReview06/Final/BAPTargetDefinitionsGuidance.pdf.

Van Teeffelen, A. J. A., C. C. Vos, and P. F. M. Opdam. in prep. Species in a dynamic world: Reviewing consequences and opportunities of habitat network dynamics for conservation planning.

Victoria, Department of Sustainability and Environment (2008), Native Vegetation Net Gain Accounting First Approximation Report.

Vos C. C., Verboom,J., Opdam, P. F. M., and Ter Braak, C. J. F., (2001). Toward Ecologically Scaled Landscape Indices. The American Naturalist, 183, 1.

WCPA/IUCN (2007). Establishing networks of marine protected areas: A guide for developing national and regional capacity for building MPA networks. Non-technical summary report.

Winfield, I. J., Fletcher, J. M. & James, J, B. 2006. The Urban Waste Water Treatment Directive: Monitoring the vendace populations of Bassenthwaite Lake and Derwent Water, 2005. Report to Environment Agency, North West Region. LA/C01752/16. 46 pp.

Zafonte and Hampton, (2007). *Exploring welfare implications of resource equivalency analysis in natural resource damage assessments*. Ecological Economics 61: 124-145.

www.forest-trends.org

www.environmentbank.com

7 APPENDIX A: SUMMARIES OF SELECTED TOOLS AND MODELS

7.1 Zonation

7.1.1 Source

University of Helsinki, Atte Moilanen
(http://www.helsinki.fi/bioscience/consplan/software/Zonation/index.html)

7.1.2 Model purpose

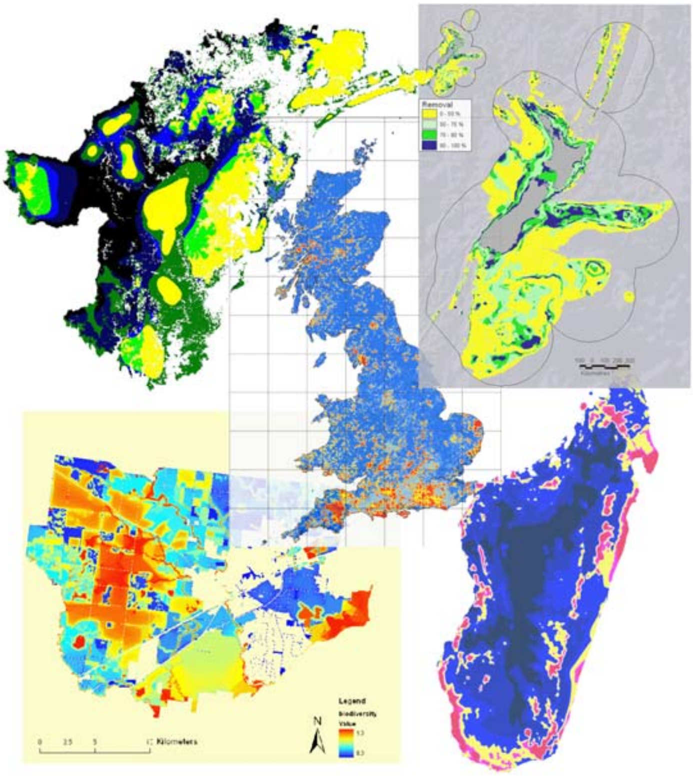
Zonation is a spatial conservation prioritization framework for large-scale conservation planning. It identifies areas, or landscapes, important for retaining high habitat quality and connectivity for multiple biodiversity features (e.g. species), providing a quantitative method for enhancing species' long term persistence.

Input data can be species distributions, either actual records or modelled output, such as the product of Habitat Suitability Mapping. Raster data from and to GIS is generally used. Cost layers (e.g. land cover data), mask layers (e.g. existing reserves), and planning units (e.g. water catchments) can be used. Connectivity rules and species specific responses to fragmentation can be applied. Multiple species are modelled simultaneously. An unusual and particularly valuable feature is the capability to handle poorly known species distributions.

Analyses in Zonation include the identification of optimal conservation areas, replacement cost analysis for current or proposed areas and identifying optimal spatial solutions that meet pre-defined targets.

7.1.3 Examples of Use

Illustrative Zonation output maps (source - Zonation website)



7.1.4 Potential use in this case

Zonation can potentially be used as a decision support tool to inform spatial aspects of habitat compensation for species impacts, and network coherence compensation. For example a sequence of tasks could be undertaken along the following lines.

1. Take all species which are interest features in the STP case requiring compensation, or permitted substitute species
2. Undertake Habitat Suitability Mapping of the Atlantic bio-geographic region for each species, based on existing records and published autecology studies. This provides a species distribution map for each which forms the input file for Zonation.
3. Run Zonation to find the optimal locations which have the greatest number of species.
4. Check the status of these locations in Natura 2000 and national designation terms.
5. Assess the optimal locations which are not Natura 2000 sites as to the contribution these sites could make to favourable conservation status.
6. Use Habitat Potential Mapping to identify locations where suitable habitats for the suite of species could be restored or created.
7. Use this output layer to re-run Zonation with the same datasets as previously.
8. Compare the two output maps, using the solution comparison tool, to identify optimal potential locations for habitat restoration or creation for these species.

7.2 Marxan

7.2.1 Source

University of Queensland, Ball I R & Possingham H P
Marxan – "Marine Reserve Design using Spatially Explicit Annealing"

7.2.2 Tool purpose

Marxan, a siting tool for landscape conservation analysis, explicitly incorporates spatial design criteria into the site selection process. Marxan operates as a stand-alone program and uses an algorithm called "simulated annealing with iterative improvement" as a heuristic method for efficiently selecting regionally representative sets of areas for biodiversity conservation (Possingham *et al*., 2000). Marxan allows inputs of target occurrences represented as points or polygons in a GIS environment, and makes it possible to state conservation goals in a variety of ways, such as percentage area or numbers of point occurrences. The program also allows the integration of many available spatial data sets on land-use patterns and conservation status, and enables a rapid evaluation of alternative configurations. The ultimate objective is to minimize the cost of the reserve system (i.e., cost = landscape integrity, conservation cost in dollars, size of the reserve, etc.) while still meeting conservation objectives.

7.2.3 Example of Use

Located in Wyoming's Upper Green River Valley, the 24,407- ha Jonah natural gas field is considered one of the most significant natural gas discoveries in the United States in recent times. The Bureau of Land Management (BLM) granted regulatory approval in 2006 to infill the existing 12,343-ha developed portion of the field with an additional 3100 wells. As a requirement of the infill project, an off-site mitigation fund of $24.5 million dollars was established. Marxan was used to determine an appropriate location and spatial extent for offset design. Criteria were developed to ensure offsets would serve to mitigate on-site impacts, then analyses at progressively broader spatial extents were run, with the intention of selecting offsets at the smallest spatial extent at which goals could be met (Kiesecker *et al*., 2009).

7.2.4 Potential use in this case

Marxan's application in this case is very similar to that of Zonation (see above). In depth trialling of the two models would be required to evaluate which is the most suitable.

7.3 Habitat Suitability Mapping

7.3.1 Source

This approach has been widely used in North America and Canada in combination with Habitat Evaluation Procedures (HEP). Tool supplied by United States Geological Survey, Fort Collins Science Center (http://www.fort.usgs.gov/Products/Software/HEP/)

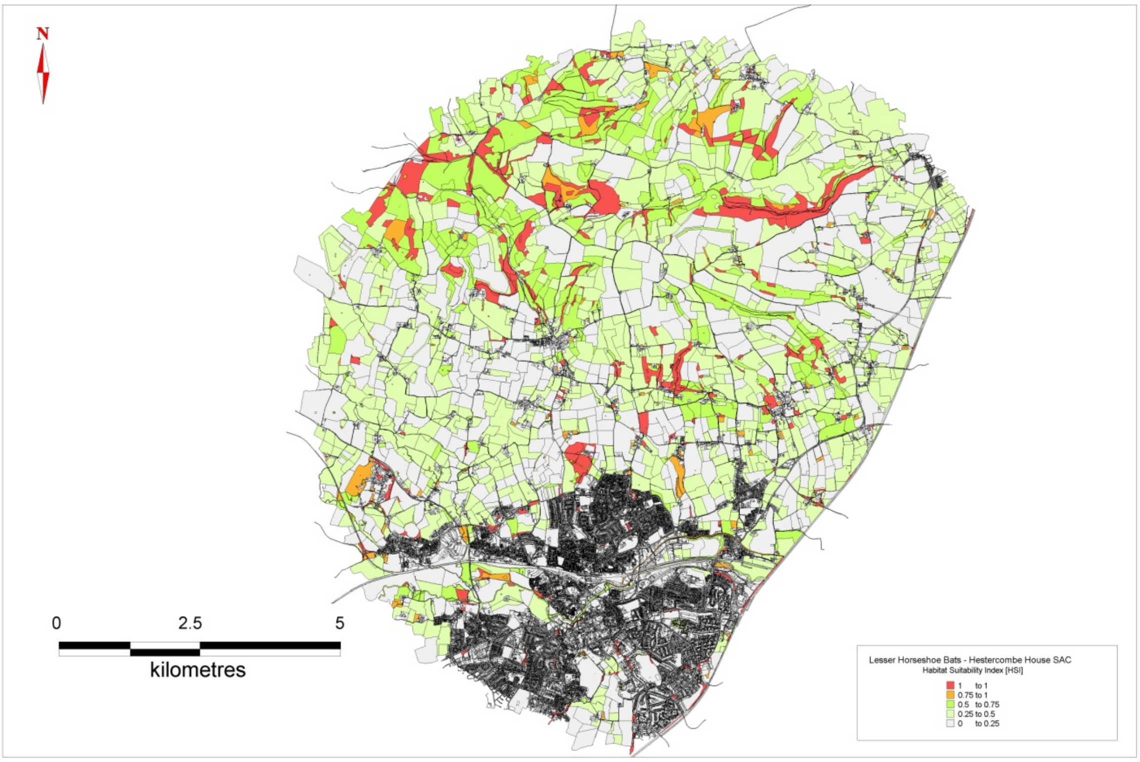
7.3.2 Tool purpose

Habitat Suitability Mapping seeks to map the landscape using the variability of habitat suitability of each habitat parcel for a particular species. For species with poorly known distributions, habitat data can then be used as a surrogate for species data.

Separate maps are generated for each species. The process uses a standard habitat classification, such as the Integrated Habitat System (SERC, 2010) and assigns a score to each habitat category according to autecology species requirements and records of species occurrence in habitats. A scale of 0 (entirely unsuitable) to 1 (optimal) is normally used. A landscape for which habitat mapping is available using that habitat classification can then be used to generate a habitat suitability map for the species. If robust data is available for species populations in relation to habitat parcels of varying suitability, then the habitat suitability map may be used to estimate the total population in a landscape, including locations where the species has not been recorded. The habitat suitability map can then be used to support design of mitigation and compensation packages for the species.

7.3.3 Example of use

Design of mitigation/ compensation package for Lesser Horseshoe Bats, Hestercombe House SAC, Somerset (Somerset County Council, 2009)



Lesser Horseshoe Bat Habitat Suitability Index - Hestercombe House SAC
6 km radius around ST240287

Figure 10 Habitat Suitability Mapping for Lesser Horseshoe Bats north of Taunton (SCC, 2009)

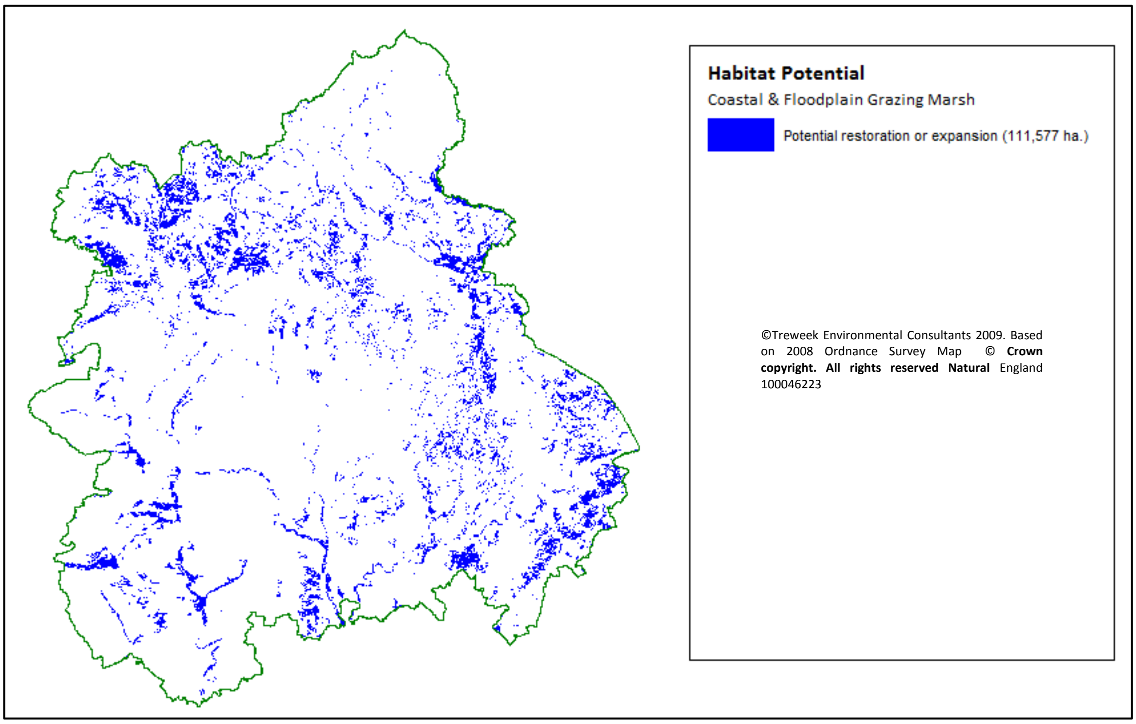
Habitat suitability mapping was used in the design of a mitigation/ compensation package by Somerset County Council, where proposed road and housing developments were assessed as having a potentially significant adverse effect on a Natura 2000 site. The mapping was based on standard habitat mapping using the Integrated Habitat System (IHS), which incorporates all BAP priority and Annex 1 habitats. The mapping was supported by radio-tracking data of the Annex 2 species, Lesser Horseshoe Bat, overlain in GIS.

7.3.4 Potential use in this case

This tool can contribute to the identification of suitable locations for habitat compensation in response to species impacts. Habitat suitability maps can be used as input data for the Zonation model (see 7.1). Habitat Suitability Maps are normally based on current habitat distribution. If combined with Habitat Potential maps (see **Figure 11** or options for habitat restoration and expansion, the potential species distribution and population can be estimated after compensation measures are delivered.

7.4 Habitat Potential Mapping

Figure 11 Potential for restoration or expansion of floodplain grazing marsh in the West Midlands Region



7.4.1 Source

Various methodologies have been used globally and no specific tool or software can be quoted; here we describe the approach used for identifying potential for habitats of a given category rather than potential for species.

7.4.2 Tool purpose

Habitat Potential Mapping seeks to map the landscape according to the potential for a habitat to be maintained, restored or expanded.

Separate maps are generated for each habitat. Physical parameters, such as temperature, rainfall, soil acidity, soil wetness and altitude are analysed in GIS with reference to the habitat definition and data on current distribution. The habitat potential map is a simple GIS polygon layer including all areas where the habitat currently occurs or could be restored or expanded.

7.4.3 Example of use

Habitat potential maps have been developed in the UK to support target setting in Regional Spatial Strategies for BAP Priority Habitats (TEC, 2009). **Figure 11** shows the potential for restoration or expansion of Floodplain Grazing Marsh in the West Midlands Region.

7.4.4 Potential use in this case

Habitat Potential Mapping could be used to support decision making in identification of potentially suitable areas for habitat restoration and expansion as compensation for impacts on habitats or species. Potential maps for each impacted habitat, or candidate substitute habitats, could be generated to act as areas of search for suitable restoration or expansion sites. Habitat potential maps can also be used as input layers for the Zonation tool (see 7.1).

7.5 Modelling Susceptibility to Biodiversity Loss

7.5.1 Source

Theo Stephens, New Zealand Department for Conservation, pers. comm.

7.5.2 Tool purpose

This model seeks to weight biodiversity features (e.g. habitats, species) according to parameters which provide a composite Susceptibility to Biodiversity Loss (SBL) index that can then be used to prioritise features for compensation. This procedure is based on species occupancy (how much of former area occupied remains occupied) and the species area relationship. The first derivative of the species-area relationship is used to construct an index of Susceptibility to Biodiversity Loss, a proxy measure of persistence probability. The scaling term can be altered to reflect spatial requirements of particular components (larger values for space demanding generalist taxa, smaller values very local specialists).

The full model, which is the subject of active development, goes on to use the changes to SBL caused by development impacts, and explore optimal solutions for a suite of impacted features, using options of varying compensation activity.

7.5.3 Example of use

In support of conservation prioritisation of fish taxa in New Zealand, the model seeks to identify taxon specific SBL values on the basis of estimates of potential area occupied and abundances, relevant traits and threat status categories. The model fitting goal is to find one that ranges from infinity (imminent extinction) to zero (secure and expanding) and best accounts for expert derived assessments of threat status. (pers. comm. Theo Stephens, New Zealand Department of Conservation)

7.5.4 Potential use in this case

While use of the full model may be inappropriate in this case because of the identified need to treat compensation of each feature separately, the SBL parameter, and the associated measure of carrying capacity, could be developed using favourable reference values as used in Article 17 reporting under the Habitats Directive (see 2.2.1). These could guide the exchange rate for evaluating compensation using habitats and species other than those impacted.

7.6 LARCH

7.6.1 Source:

(Alterra) Wageningen University, Netherlands
http://www.alterra.wur.nl/UK/research/Specialisation+Landscape/Fclts+mdls/larche/

7.6.2 Tool purpose

LARCH (Landscape ecological Analysis and Rules for the Configuration of Habitat) is a knowledge based system for mapping and identification of ecological networks for species, including the assessment of sustainable networks. LARCH uses the metapopulation concept of species occupying more or less connected habitat patches with dispersal between them, and key patches providing most surplus individuals for dispersal. Empirical data on species density in different habitats, home range size, dispersal distance and response to barriers is used to develop species specific sustainability standards. For each species, habitat maps are used in conjunction with the standard (e.g. minimum viable population) to identify potential networks, key patches and evaluate sustainable networks. An example is given in the figure overleaf (Fig 11), showing sustainable habitat networks for sand lizard.

7.6.3 Example of use

LARCH has been used to model the potential species benefits of the creation of a robust habitat corridor along the Netherlands Germany border. The Limburg Robust corridor, which includes 2,200 hectares of habitat creation is intended to improve links between habitats parts in the Dutch National Ecological Network (NEN) and the Natura 2000 network on both sides of the border(BRANCH, 2007).

7.6.4 Potential use in this case

LARCH could be used in support of design of ecological networks developed as network coherence compensation. Sustainability standards could be developed for impacted species, or allowable substitute species, and the potential contribution to network coherence evaluated through testing options for habitat restoration and expansion of patches between Natura 2000 sites. Potential links between the LARCH and Zonation models could be explored, with the aim of finding the optimal network solution that will contribute most to the suite of individual species networks across the species used for compensation.

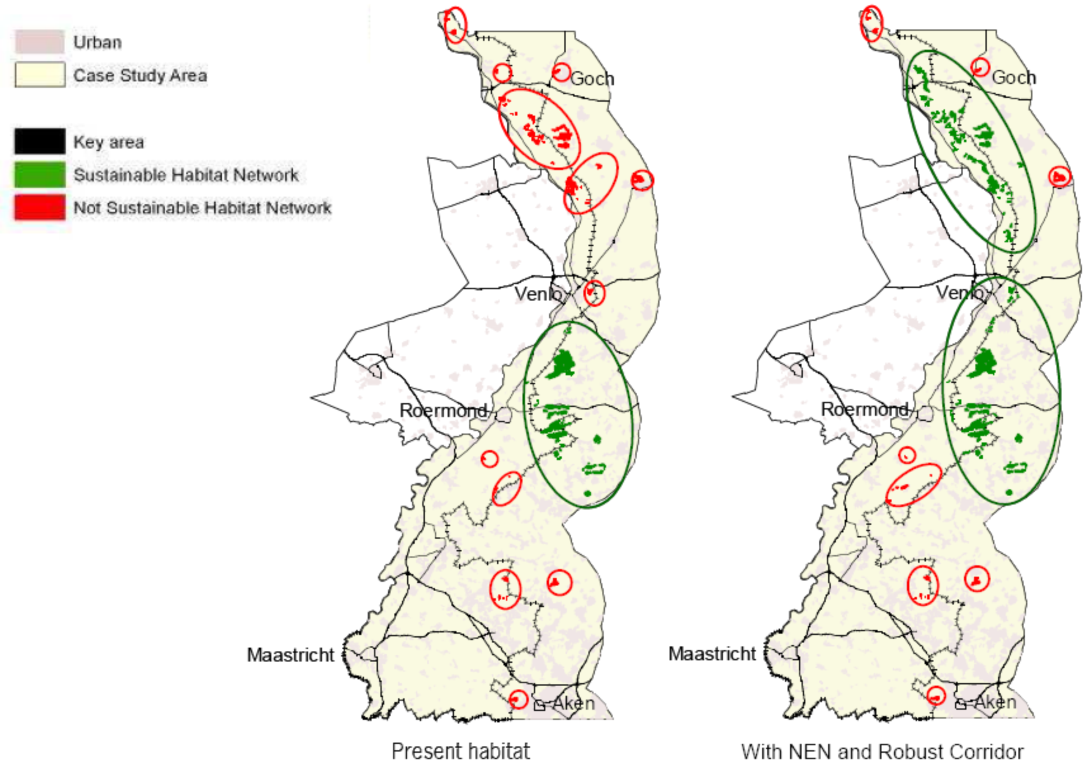


Figure 11 Sand Lizard habitat networks at 10% of optimal carrying capacity (T4).

7.7 Population Viability Analysis

7.7.1 Source

Population Viability Analysis (PVA) is widely used in species conservation management; there is not a single model of its application. An example of PVA software tool is RAMAS GIS (Akçakaya, 1998).

7.7.2 Tool purpose

Population viability analysis is a process of identifying the viability requirements of, and threats faced by, a species and evaluating the likelihood that the population(s) under study will persist for a given time into the future (Akçakaya H.R. and P. Sjögren-Gulve. 2000). Population viability analysis is often oriented towards the management of rare and threatened species, with two broad objectives. The short-term objective is to minimize the risk of extinction. The longer-term objective is to promote conditions in which species retain their potential for evolutionary change without intensive management.

PVA can be used to address various conservation management questions. Most relevant to this case are:

- Impact assessment. PVA may be used to assess the impact of human activities (exploitation of natural resources, development, pollution) by comparing results of models with and without the population-level consequences of the human activity.
- Ranking management options. PVA may be used to predict the likely responses of species to reintroduction, captive breeding, prescribed burning, weed control, habitat rehabilitation, or different designs for nature reserves or corridor networks.

7.7.3 Example of use

A habitat-based metapopulation model of PVA has been used to assess the effectiveness of translocating individuals as a management option for the endangered helmeted honeyeater in Australia. In this model translocation of ten individuals to a new population reduced the risk of extinction over 50 years from about 0.4 to less than 0.1. (Akçakaya *et al*.,1995).

7.7.4 Potential use in this case

Population Viability Analysis could be used in this case to evaluate management options for species compensation, addressing residual impacts after habitat measures have been applied. The approach could be equally applicable to impacted species or allowable substitute species.

7.8 Habitat Equivalency Analysis

Habitat equivalency analysis (HEA) is a methodology developed by the National Oceanographic and Atmospheric Administration (NOAA) in the United States to determine compensation requirements for environmental damage caused by incidents such as oil spills or leakages from hazardous waste sites (NOAA 1997). Habitats restored have included seagrasses, coral reefs, tidal wetlands, salmon streams, and estuarine soft-bottom sediments. When the approach is applied to species populations it is sometimes termed resource equivalency analysis (REA).

The method focuses on complete, in-kind replacement of services lost between the time of impact and when the restored or created habitat becomes fully functional. HEA accomplishes this by incorporating the concept of discounting from economic theory.

The method is essentially based on time discounting with respect to levels of ecosystem service provision, using a standard annual discount rate to derive a multiplier for areas of compensatory habitat required. Discounting assumes that people place a greater value on services they can enjoy today than on those put off into the future. A standard discount rate of 3 percent is assumed; thus, for every year it takes to replace a specific amount of service, an amount of habitat capable of producing an additional 3 percent of the remaining lost service must also be constructed. For a more detailed account of discounting, see NOAA (1999).

If the compensation project continues to provide services for a long period of time (300 years) and the interim loss of services is a relatively short period of time (15 years), then the area required for compensation of the lost services will be smaller than the original injured area, because the services accrue over time. Likewise, because the value of future benefits and costs must be discounted, restoration that occurs some time after an injury is worth less in present-value terms than are plantings conducted shortly after impact, and therefore, more restoration must be done as time elapses.

The four basic requirements needed for an HEA are the following (Fonseca and others, 2000; NOAA 2000):

- the primary services lost are biological (as opposed to human-use services)
- there exists a means of quantifying the level of lost services due to the injury and the level of services gained by the compensatory restoration
- an estimate of recovery rates is available (i.e., natural recovery if applicable and restoration recovery)
- suitable restoration sites exist (e.g., same habitat type as injured area, close by, likely to succeed).

The tractability of HEA is enhanced by the following assumptions (Dunford, 2004):

- a single metric is used to measure services
- services provided by the injured habitat are the same as the services gained by restored habitat
- the relationship of habitat services to habitat value does not change over time
- recovery rates are linear
- baseline services are constant.

Often in NRDA cases, restoring habitat that is the same as the injured habitat (e.g., bottom sediments of lakes, rivers, or coastal areas) may not be practical, feasible, or appropriate. However, creation of other habitats (e.g., wetlands) could provide other valuable, but different, services. The use of HEA ***can include services that are functionally equivalent, though not the same type and quality***. The use of conversion factors can be used for equating dissimilar services, which could be calculated from ratios of functional or structural characteristics (Dunford 2004; NOAA 1997). The relative values of the habitat types should be based on measured or modelled attributes of the habitats; however, in many cases, professional judgment would be needed, resulting in an increase in uncertainty.

Example equations for calculating habitat equivalents available at:
http://www.csc.noaa.gov/coastal/economics/habitatequ.htm

Not all parcels of habitat are of equal quality or yield the same quantity of services. A number of different techniques have been developed that can assist in estimating the appropriate amount of habitat to restore, including the Habitat Evaluation Procedure (HEP) (U.S. Fish and Wildlife Service (USFWS) 1980) and functional analysis based on hydrogeomorphic classification of wetlands, HGM (Smith *et al*., 1995). These methods are mostly specific to individual habitat types and may not be readily applicable to different spatial scales. Estimates of precisely how much habitat should be restored (the replacement or mitigation ratio) ***have often been based primarily on value judgments, and as a result have varied widely*** (Fonseca *et al*., 2000).

There may also be some uncertainty as to whether or not lost services have been completely replaced.

The structure of Habitat Equivalency Analysis is relatively simple. Calculations of how much habitat to restore or replace are based on estimates of the total loss in services supplied by the damaged or lost habitat. Total loss is estimated from the degree of initial damage to the resource and the loss in service that occurs during the time between the initial damage and when the restored or replaced habitat becomes fully functional. In a sense, it is analogous to paying off a bank debt. The borrower is required to pay back not just the principal (the amount of the debt) but also interest on any remaining debt incurred during the length of the payback. In this case the debt is the loss in ecological services and the payback is replacement of these services by restoration of the damaged site and/or by construction of new habitat.

Three critical pieces of information are necessary to make these calculations: 1) the nature of the service that has been damaged, 2) the extent of the initial damage, and 3) the rate at which recovery is likely to occur. Determining which service is most appropriate to replace and the degree to which the study area provided this service prior to impact are probably the most important and potentially the most controversial steps in the HEA process. Habitats provide multiple services and opinions may differ concerning which service should be the focus of restoration efforts. This is not an issue that HEA is capable of resolving but is one that must be negotiated by the interested parties. Likewise, estimating the degree of service supplied by a specific parcel of habitat prior to damage and the extent to which it has been damaged can be difficult, particularly when there is little supporting evidence or opinions differ regarding the original quality of the habitat. Again, this is an issue that must be negotiated between the interested parties and is not a function of HEA.

There must also be reliable information on the recovery rate of the service in order to accurately assess losses that occur while the restored habitat is developing to its maximum possible functionality. This type of information is generally available from the scientific literature, although in some cases it may require collection of field data or modelling efforts. Together with the estimated initial losses, this information yields the total amount of service lost over the period of the project and is used to scale the estimate of how much habitat must be constructed or restored.

It is essential that the amount of service to be restored is small compared to the total available such that no change occurs in the underlying value per unit of service (NOAA 1997). NOAA (1997) uses the example of a fishery to illustrate this point. The value of a salmon fishery will vary as stocks become increasingly more abundant or scarce. In order to apply HEA, replacement of a portion of this stock should not be so large as to influence the overall value of the fishery, otherwise the appropriate amount of habitat to restore would change.

The structure of HEA and example calculations for analyses have been described by NOAA (1997), King (1997), Fonseca *et al*. (2000), and Allen *et al*. (2005a). An excellent overview is also provided by NOAA (online at http://www.csc.noaa.gov/coastal/economics/habitatequ.htm).

7.9 Victoria Habitat Hectares Scoring Method

The method involves assessment of a number of site-based habitat and landscape components against a pre-determined ‘benchmark’ relevant to the vegetation type being assessed.

Assessors must first determine the bioregion(s) in which a habitat hectares assessment is to be conducted. Bioregions are landscape units based on a range of environmental attributes such as climate, geomorphology, lithology or vegetation. A statewide bioregion map (and bioregion layer within the DSE Geospatial Data Library) identifies 28 bioregions within Victoria and shows their distribution.

The habitat hectares approach requires the condition of native vegetation at a site to be assessed in comparison to a ‘benchmark’ that represents the average characteristics of a mature and apparently long-undisturbed state for the same vegetation type (Parkes *et al.* 2003). Habitat hectare assessments are conducted with reference to a bioregional benchmark for the vegetation type in question. Bioregional benchmarks for Victoria are available from the DSE website. They might specify the number of species that should be present, typical dominant or ‘character’ species, average canopy height and percentage cover for different life forms. Benchmarks apply to particular ‘Ecological Vegetation Classes’ (EVCs) within a particular bioregion.

EVCs are aggregations of botanical communities that are defined by a combination of species composition, life form, position in the landscape and an inferred fidelity to particular environments. The habitat hectares approach is constrained to a single EVC of similar ‘quality’. There is guidance to explain how quality should be assessed. Each unique EVC/ quality combination is referred to as a ‘habitat zone’. A patch of native vegetation may contain one or more ‘habitat zones’ due to localised variation in ‘quality’. The number and size of habitat zones depends on a number of factors including the size of the area being assessed, the variability of the vegetation and the context of the assessment.

The habitat hectares assessment approach involves assigning a habitat score to a habitat zone, to indicate the quality of the vegetation relative to the EVC benchmark. A total score of 1.0 is built up from constituent scores for a series of separate attributes, for example ‘absence of weeds’, ‘% cover of high native herb diversity’. The final habitat hectare value is a measure of both the quality (habitat score) and quantity (hectares) of the vegetation, and therefore requires consideration of the total number of hectares present. It is determined by multiplying the habitat score (as a decimal) of the habitat zone by the number of hectares in the habitat zone.

When applied to offset calculations, the habitat hectares method can be used to determine the type and number of habitat hectares likely to be lost due to a development proposal and therefore the type and number required to be provided.

8 APPENDIX B: POSSIBLE HABITAT HECTARES METHOD

This is an updated version of the framework used in Defra, 2008 as a possible basis for design of biodiversity offsets in England. It was therefore not designed explicitly with compensation under the Habitats Directive in mind, but could be adapted as a tool to determine "equal value" in terms of habitat types, amounts (hectares) and condition. The method was based on enhancements required to deliver the UK Biodiversity Action Plan and therefore used BAP target type definitions as opposed to European habitat type definitions.

8.1 Introduction

The metrics used to measure losses due to a development and gains due to an offset or compensation need to apply to both:

1. Land[28] that is impacted by development
2. Land on which compensation actions would be undertaken.

This is essential to the transparent comparison of biodiversity losses and gains. In the case of land impacted by development, the metrics conceptually need to cover both:

1. land that is directly lost to development, and
2. land that will remain post development but may be the subject of decline in conservation status[29], habitat quality/ integrity[30] or status of key species populations.[31]

8.1.1 Habitat as the primary metric

Conceptually habitat is the most suitable basis for the metric as it reflects use of land by species and therefore links consideration of sites and species. Sites can be measured in terms of their component habitats; species populations can often be measured with reference to the habitats (type, area, condition) required to support them. Some species-related compensation, however, cannot be related directly to measures of habitat, and another metric would be needed.

The proposed metric is **Habitat Hectares** reflecting approaches used in other countries and currently being developed by BBOP (www.forest-trends.org)**.** Land impacted by development or land subject to an offset can be mapped and recorded on the basis of 'habitat parcels', in which each parcel is allocated to a single habitat category and is assigned a single condition or quality measure.

8.1.2 Habitat Evaluation/ Definition

Habitat parcels can be evaluated/ defined in terms of inherent properties such as rarity, species composition, species richness…) and in terms of their condition/ conservation status (see Figure 12).

[28] Sensuo lato - Land, water, sea
[29] Statutory sites
[30] Non-statutory sites, BAP habitat, semi-natural habitat
[31] European protected, UK protected or BAP species

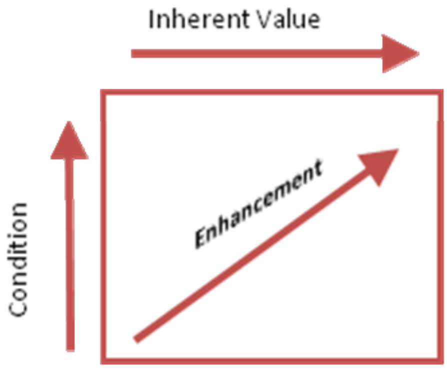


Figure 12 Evaluation against inherent value and condition

It can be argued that inherent value should be given greater weight than condition, as it is a more fundamental characteristic of an area of land, whereas condition can be altered through management. 'Inherent Value' would therefore be weighted as suggested in Figure 13. It is proposed that a 3x3 matrix is used to evaluate habitat parcels according to their inherent 'value' and their condition. A larger matrix might give a closer fit to reality but would be less straightforward to apply in practice. Habitats would be assigned to an 'inherent value' category of 'low', 'medium' or 'high'. The simple 3x3 matrix suggested in Figure 13 gives a numeric scale for any given habitat parcel from 2 to 18: (Inherent value assigned 2-6, condition 1-3, cells are products of rows and columns).

		Inherent value		
		Low (2)	Medium (4)	High (6)
Condition	High (3)	6	12	18
	Medium (2)	4	8	12
	Low (1)	2	4	6

Figure 13 Habitat Parcel Evaluation Matrix

These scores could be calibrated as required e.g. against a scale of 0 to 1 (Figure 14). The precise numbers are irrelevant provided it is understandable.

		Inherent value		
		Low	Medium	High
Conditio n	High	0.33	0.67	1.00
	Medium	0.22	0.44	0.67
	Low	0.11	0.22	0.33

Figure 14 Matrix calibration

Measurement of Inherent Value and Condition

The inherent value of habitat parcels could be measured with reference to categories in a standard habitat classification such as IHS (Integrated Habitat System) which encompasses all UK terrestrial, freshwater and marine habitats, including European and BAP habitats (www.ihs.somerc.co.uk). It is also now widely used at local and regional scales for mapping and collating habitat data recorded in other classifications (e.g. Butcher, 2008; SERC 2007). IHS habitat categories can be assigned an inherent value score of 2, 4 or 6 using the following criteria:

Inherent Value Score	Criteria	Example
6	Categories on Annex 1 of the EU Habitats Directive or Section 41 of the NERC Act (BAP Habitats)	Lowland calcareous grassland
4	Other semi-natural habitats, including degraded BAP habitats capable of restoration	Mixed woodland – plantation on ancient woodland site
2	Artificial habitats	Improved grassland

Figure 15 Inherent Value Criteria

It is proposed that condition should be measured primarily with reference to the suitability of management relevant to the habitat type under consideration. Habitat parcels can be assigned a condition score of 1, 2 or 3 using the following criteria:

Condition Score	Criteria	Example
3	Management is optimal/ close to ideal for the purpose of maximising the biodiversity value of the habitat	Sheep grazing of moderate intensity on lowland calcareous grassland
2	Management is sub-optimal but is not seriously damaging the biodiversity value of the habitat	Intermittent light cattle grazing on lowland calcareous grassland
1	Management is seriously damaging the biodiversity value of the habitat	Intensive pig rearing on lowland calcareous grassland

Figure 16 Condition Criteria

Condition scores can be assigned to a list of known impacts and management interventions, using a matrix against IHS habitat categories (some impacts are positive in one habitat but negative in another). The Centre for Evidence Based Conservation[32] could be used to inform these decisions, or, in the absence of evidence, statutory agency management advice.

Direct condition measurement is normally preferred as current management may not reflect the overall condition of the parcel. However direct condition measurement is highly resource intensive and management recording can be a useful surrogate. We propose the use of direct condition measurement on parcels of high inherent value and

[32] Centre for Evidence Based Conservation www.cebc.bangor.ac.uk/

the use of the management surrogate measure on parcels of medium and low inherent value. This allows the focus of monitoring resources on the most valuable types of habitat, broadly corresponding to protected sites. The proposal is summarised in Figure 17.

		Inherent value		
		Low	Medium	High
Condition	High	Optimal management	Optimal management	Favourable Condition
	Medium	Sub-optimal management	Sub-optimal management	Unfavourable Recovering Condition
	Low	Damaging management	Damaging management	Unfavourable No Change or Declining Condition

Figure 17 Condition categories at varying levels of inherent value

An enhancement of the precision of the direct condition measurement metric could be achieved through benchmarking against a reference condition status. The concept of favourable reference values is already employed in the reporting of favourable conservation status under Article 17 of the Habitats Directive. However, in respect of habitats reporting, these values apply only to range and area. The development of equivalents for condition (equivalent to the “structures and functions” attribute in European reporting) would be a powerful tool, allowing perhaps a 10 point scale to replace the three points used here. Common Standards Monitoring guidance could be developed for this purpose in the UK.

8.2 Application of metrics – a hypothetical example

An area of land that will be impacted by a proposed development uses existing data, or has a standard survey if required, mapped using IHS, and a condition assessment of each habitat parcel. There are three habitat parcels identified, each with a unique combination of habitat category (and hence inherent value score) and condition. The habitat evaluation score is assigned with reference to the matrix (see Figure 18). The area of the parcel is multiplied by the score to give the habitat-hectares metric. These are totalled for all of the land impacted by development.

	Hectares	**Value**	**Condition**	**Score**	**Hab-Ha**
Parcel 1	14	High	High	1	14
Parcel 2	30	High	Medium	0.67	20.1
Parcel 3	24	Medium	Low	0.22	5.28
TOTAL	**68**				**39.38**

Figure 18 Development evaluation example

If all of this land is to be lost to development the total number of habitat-hectares is a measure of the compensation requirement. If a proportion of the habitat parcels will survive or remain post-development, then the size, value and condition of the remnants will require predictive evaluation in the scheme design. In this the compensation requirement would be the difference between current and outcome states.

8.2.1 Measurement of the offset

The land proposed for compensation provision would be evaluated using the same metrics. It is necessary always to achieve a higher habitat-hectare net outcome than that being lost. Arguably, it should be substantially higher, to allow for uncertainty in prediction and temporary loss of value in transition (in other words use of multipliers might be appropriate). The compensation land could be 'low' category habitat restored to medium or high value, or high value habitat with the ideal management put in place in perpetuity – the direction must be positive on one or both axes, and never negative on either axis.

In the example given above, the offset must provide a **minimum** of 39.38 habitat-hectares. There could be a choice of locations/ methods to achieve this.

A hypothetical Site 1 currently has 60 hectares of high value habitat that is in poor condition through damaging management. It therefore has a habitat-hectares score of 20 (60 * 0.33 see Figure 14). Securing favourable conservation status in perpetuity through putting in place ideal management would raise the site score to 60 (60 * 1.00), an improvement of 40 habitat hectares, thus achieving the minimum offset target.

Alternative Site 2 currently has 80 hectares of degraded BAP habitat, inherent value score 4, in moderate condition currently, condition score 2. Its current score is therefore 35.2 habitat hectares (80 * 0.44). Putting in place ideal management is assessed as capable of restoring the parcel to BAP habitat over a period of time, and it will therefore be raised to score 80 (80 * 1.00), an improvement of 44.8 habitat-hectares, again achieving the offset target. Note that this example has made an improvement on both axes – achieving condition and changing the habitat type to one of higher inherent value.

		Hectares	Value	Condition	Score	Hab-Ha
Site 1(1Parcel)	Before	60	High	Low	0.33	20.0
	After	60	High	High	1.00	60.0
	Net Change					**40.0**
Site 2(1Parcel)	Before	80	Medium	Medium	0.44	35.2
	After	80	High	High	1.00	80.0
	Net Change					**44.8**

Figure 19 Offset land options evaluation example

8.3 Relationship with UK BAP

This section explores how possible biodiversity enhancements achieved on offset land using these metrics could be related to biodiversity targets in the UK BAP (UK BAP, 2006).

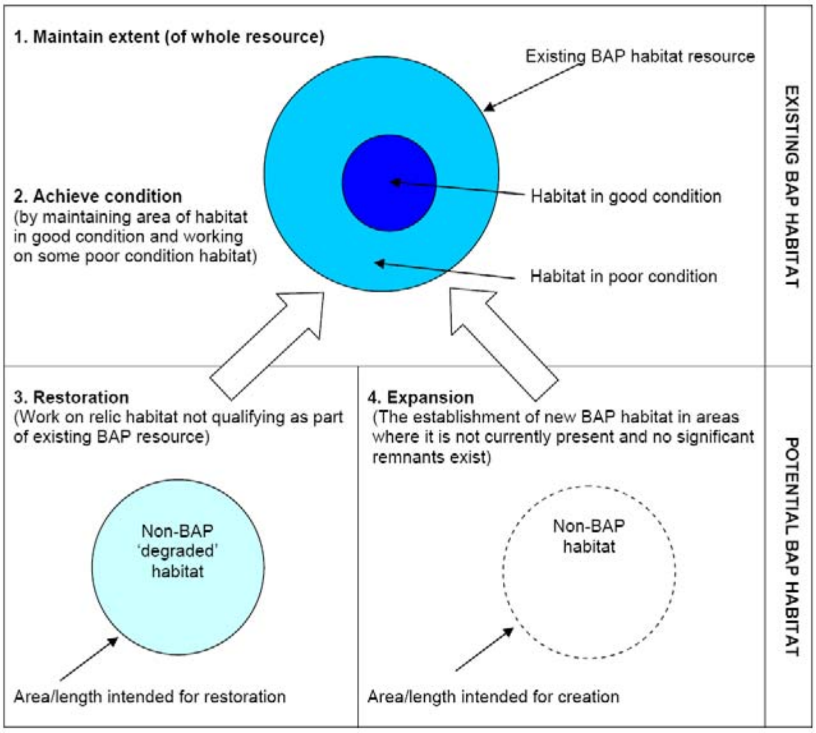


Figure 20 Definition of UK BAP Targets (UK BAP, 2006)

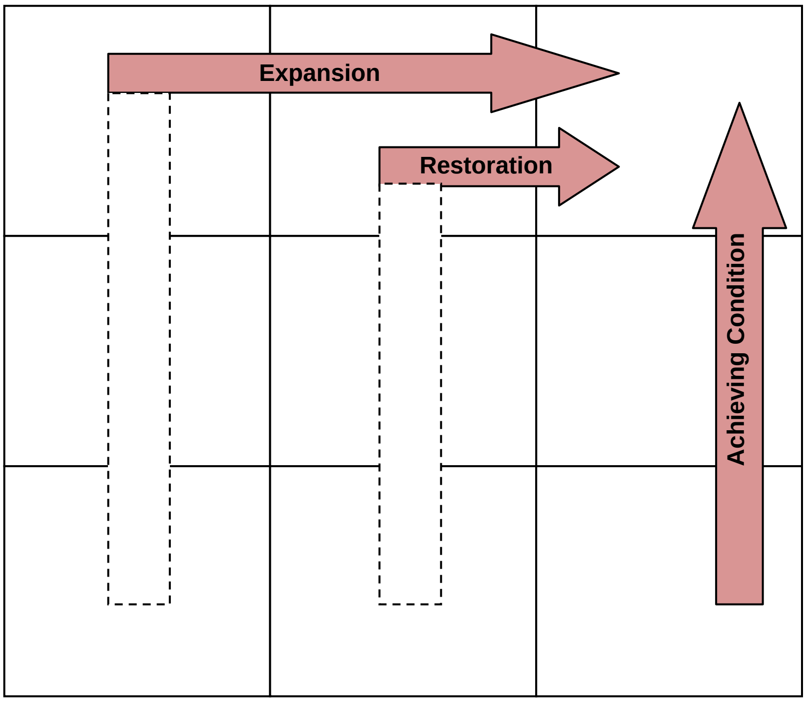


Figure 21 Enhancement directions on the offset matrix

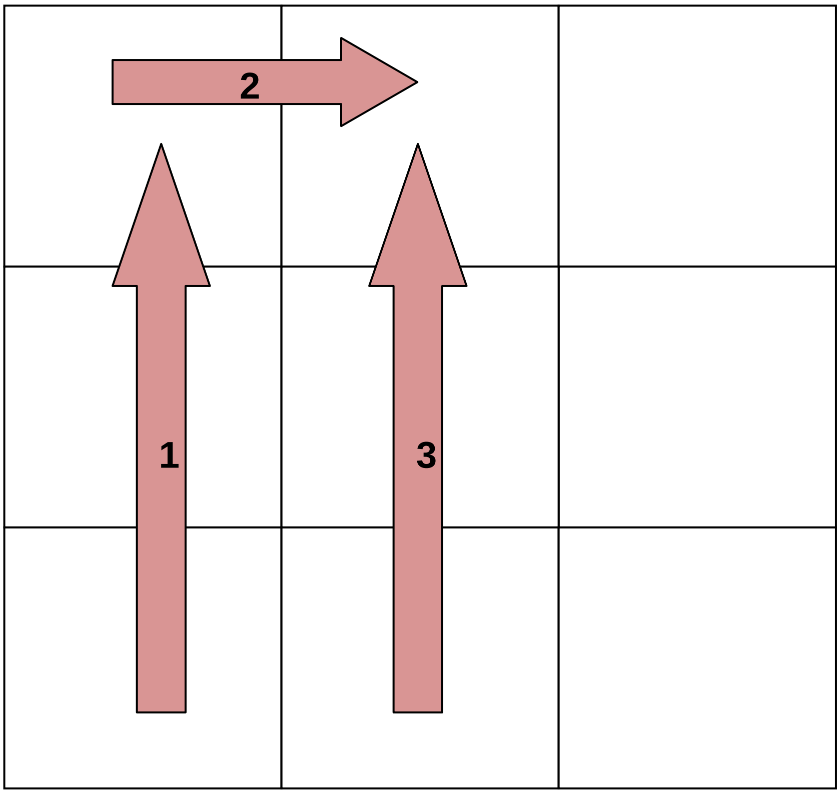


Figure 22 Non BAP-related enhancements on the offset matrix

Definitions of target types in the UK BAP are shown in Figure 20. The three types of target that involve change are shown against the offset matrix in Figure 21. ***Achieving condition*** entails a management change within land that already meets the definition of BAP habitat, and is therefore represented by upwards movement in the third column. ***Restoration*** entails a change of habitat type from degraded BAP habitat (i.e. former BAP habitat that no longer meets the definition) to the point where it meets the definition of BAP habitat. This is therefore represented by a horizontal movement from column 2 to column 3. Near ideal management will normally be essential to achieve this, so the movement will usually be across the top row; often the management will need to be improved first, represented by an upwards movement in the central column. ***Expansion*** involves moving from a non BAP habitat to a BAP habitat and is therefore represented by a left to right movement; again management improvement will be a frequent precursor.

The offset matrix can also accommodate biodiversity enhancements unrelated to BAP habitat, as shown in Figure 21. Movement 1 could be, for example, introducing small scale habitat features into a previously intensively managed urban park. Movement 2 could be, for example, developing a garden pond, that, while valuable, does not meet the BAP criteria for ponds. Movement 3 could be, for example, stopping damaging management of a parcel of rough grassland, and starting a timely annual mowing regime.