LM0481: Assessment of the impact of agri-environment schemes on SSSI recovery

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List of Abbreviations

AES	Agri-Environment Schemes
CSF	Catchment Sensitive Farming
CS	Countryside Stewardship
CSS	Countryside Stewardship Scheme
CSM	Common Standards Monitoring
ELS	Entry Level Stewardship
ESA	Environmentally Sensitive Areas
EN	English Nature
ES	Environmental Stewardship
FC	Forestry Commission
GDPR	General Data Protection Regulation
HLS	Higher Level Stewardship
HT	Higher Tier
NCA	National Character Area
IoS	Indicators of Success
ISA	Integrated Site Assessments
IPR	Intellectual Property Rights
NNR	National Nature Reserve
NVC	National Vegetation Classification
NE	Natural England
MT	Mid-Tier
M&E	Monitoring and evaluation
SBI	Single Business Identifier
SSSIs	Sites of Special Scientific Interest
SAC	Special Areas of Conservation
SPA	Special Protection Areas
WFD	Water Framework Directive

Citing the report

When referring to the report please use:

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Executive Summary

Introduction

Agri-Environment Schemes (AES) were originally set up and designed to reduce the impact of human activity on the agricultural environment. AES prescriptions, developed over a period of years, have specific environmental objectives and outcomes in mind and biodiversity has always been a priority objective of AES since their inception. Sites of Special Scientific Interest (SSSIs) are statutory national designations that represent some of the best of England's biodiversity and geological sites. SSSI owners and managers with an AES agreement therefore have a different relationship with Natural England (NE) compared to other AES agreement holders. NE provides management advice for SSSI farmers and feedback on assessments of their SSSIs. Therefore, it is important to evaluate the contribution that AES's make in delivering for biodiversity when they occur on SSSIs.

The aim of this project is to review existing evidence regarding the impact of AES on SSSI condition in order to provide an enhanced understanding of the relationship between AES and SSSIs. Where appropriate the research also considers the potential for secondary analysis of existing data or new research to fill evidence gaps. The focus for this research is on biodiversity, and the contribution of AES options in enhancing habitats beyond that required by the statutory protections. Those SSSIs designated for geological features are not covered by this project.

The specific objectives were to:

- assess evidence of change in condition, across the range of SSSI features and AES options;
- assess evidence of a causal relationship between AES and changes in SSSI condition;
- understand attitudes and motivations of owners and occupiers of SSSIs.

Methods

The methodology had four tasks:

- Literature review focused on ecological surveys and datasets;
- Literature review on attitudes towards and motivations for managing protected sites;
- Identify existing datasets for potential re-analysis; and
- Identify the evidence gaps and suggestions for future work.

A protocol was prepared for the research team to follow in both Tasks 1 and Task 2. The research question that underpinned the search in both tasks was "*To determine the extent to which AES have contributed to the management and enhancement of SSSI and assess the attitudes and behaviours of those who manage SSSIs".* The review was undertaken using:

- Past projects under the Agri-Environment Monitoring and Evaluation Programme;
- Other Defra Publications and reports from NE Access to Evidence catalogue; and
- Peer-reviewed studies through Web of Science and Google Scholar.

The search yielded over 150 articles, which were uploaded to the reference management software, EndNote. The reference lists of the top 10-12 key papers and reports that appeared in each search (ecological condition; agreement holder attitudes and motivations) were examined for additional relevant references. In addition, relevant reports suggested by the Steering Group were also added, which resulted in a total of approximately 200 documents. The reference list in this report contains all those that were assessed in detail.

The literature analysis was undertaken on those papers and reports considered to have potential in the context of the study. The key elements of the review followed a clear protocol covering a range

of factors. These were important in determining which references to assess in detail and are recorded in the tables in Appendix 1 for Task 1 and 2.

Ecological condition

The literature review into ecological condition (Task 1) was focused on an assessment of the impact AES have on SSSI condition. In order to do this, existing literature was examined to identify evidence of change in condition, across the range of habitats and features as well as any links to AES options. Ultimately, the review also assessed the extent to which there is evidence of a causal relationship between AES and changes in SSSI condition.

The recovery trajectories of various habitats, and therefore the success of AES schemes, are subject to many factors. Lowland heathland is an example of a habitat where different recovery trajectories can be expected depending on the initial condition of the habitat and the type of management employed. Lowland grassland recovery trajectories have also been studied (Shellswell *et al.,* 2016a). Furthermore, the length of time expected to improve habitat condition depends on the initial condition and reasons for it when unfavourable, and the management type selected to address this. Alderson *et al*. (2019) conducted an analysis of blanket bog recovery trajectories and found that with the right management these habitats can recover relatively quickly. These trajectories provide an indication as to the extent of recovery possible within degraded SSSI habitats, and an anticipated minimum time required for a site to recover.

Early evaluation of AES described a 'lack of progress in wildlife enhancement' in general within AES schemes (Reid and Grice 2001). In a review of HLS agreements on selected habitats, Mountford and Smart (2014) found that grassland habitats were more frequently targeted by maintenance options, when restoration options were in fact necessary to promote improvements in site condition. Hamilton (2014) found that lower quality upland hay meadows showed evidence of slight improvement under HLS. Establishing a non-agreement counterfactual for high value habitats may be difficult as a very large proportion of SSSI sites are reportedly under AES of some kind. For example, 94% of the lowland heath SSSIs are managed through AES and 93% of all eligible SSSIs were under HLS agreements (NE, 2009). Hewins *et al*. (2017) found that the presence of AES on lowland heathland increased likelihood of positive management activity, though it was not yet translating into detectable habitat improvements.

Establishing a causal relationship between the AES management interventions and SSSI condition was not possible due to a lack of empirical data in the systematic analysis of the available literature. The only sources that suggested a link were related to individual case studies e.g. beneficial effects of CSS and HLS on SSSI wetland restoration at West Midland Meres and Mosses (Natural England (2009)). Few studies have attempted to directly assess the effectiveness of AES on SSSIs, focussing instead on samples of sites drawn independently, some of which may be designated. Mountford and Smart's work (2014) was inconclusive, as it was felt that the HLS agreements had not been in force for sufficient time for their full effect to become apparent. A major obstacle to developing further links is a lack of up-to-date comprehensive information concerning habitat condition on SSSIs to compare with the baseline from about 20 years ago (English Nature 2003). Individual condition assessments are conducted at a steady but low annual rate (2-3% a year) and published by NE. SSSI monitoring has routinely been undertaken as part of Natural England's Integrated Site Assessment (ISA) programme, which is applied to all SSSI sites, and combined the assessments of SSSIs and Higher Level Stewardship (HLS) agreements. However, Nisbet (2015) noted that SSSI-only assessments made up over half the total number of completed ISAs (64%) even if HLS was present, with only 6% being HLS only, resulting in 30% being integrated.

Key factors in influencing the interaction between AES and SSSI are: complexity of agreement establishment covering multiple habitats; wide range of ownership arrangements for SSSIs; multiple designations with higher designations being prioritised for additional management; and targeting of AES options.

Agreement holder attitudes and motivations

The Task 2 literature review sought to understand the motivations of owners and occupiers in managing their SSSIs and the associated features; and what factors encourage pro-environmental behaviour change. The review therefore reflected on key understandings of the barriers and motivations experienced by land owners and occupiers to effectively manage SSSIs, notably the ways in which farmers socially and culturally construct their environments and identities.

According to recent reviews (e.g. Riley, 2011), academic literature in geography and the social sciences has long understood farmer engagement and participation as central to scheme success. Wilson and Hart (2001) argue that a shift towards conservation-oriented attitudes of farmers through AES participation should be considered a key indicator for assessing the 'effectiveness' of schemes. Therefore, despite disagreement on the ways in which success can be quantified, farmer engagement has been widely considered as an alternative means for determining scheme success. AES participation can be understood as neither constant, deterministic nor reducible to single factors, but resulting from a complex interaction of individual land manager characteristics and wider social and cultural contexts (Riley, 2011; Ingram *et al.* (2013). Mills *et al.* (2013 & 2017) suggest there are three broad types: Profit maximisers; Food producers; and Custodians.

The farmer-scientist knowledge relationship is another area of movement in AES research exploring the different understandings of 'nature', 'the environment' and 'environmental management' held by farmers and conservationists who are participating in the implementation of schemes (Morris 2006; Mills *et al*. 2013). There is also evidence that increased networking and the building of close relationships among farmers, is more likely lead to sharing of information and knowledge and collaborative work Mills *et al*. (2011). Where farmers and conservationists can engage in constructive dialogue over time, then AES policy can both accommodate and benefit from farmers' expert agrarian knowledge and therefore influence on environmental decision-making.

The injection of multidisciplinary approaches into AES research has made significant contributions to our understanding of changing farmer attitudes and behaviours towards agri-environmental policy. This includes some AES monitoring and evaluation (M&E) evaluations, such as Staley *et al*. (2019) resurvey of a sample of HLS agreements (surveyed 6-7 years previously under Mountford *et al.* 2013), which included both ecological and farmers surveys in relation to AES management. The report found that HLS agreement holders were often over confident about achieving Indicators of Success (IoS). There was no analysis comparing agreement holder values and attitudes and the presence of an SSSI alongside the HLS agreement. The evaluation of CSF shows an increased awareness of the link between agriculture and water pollution and the potential for changes in practice to improve water quality.

The literature review has shown that a range of methodological approaches have been utilised from across the social science discipline. Increasingly this is a mixed-methods approach and often within inter or trans-disciplinary projects. Such approaches are more effective in capturing the complexity of farmer attitudes and behaviours, in particular actions associated with environmental behaviour and the consequences arising from these actions. However, the connection to SSSIs, and therefore the influence on environmental attitudes and behaviours amongst land managers, can be diluted as a result and the potential for re-analysis is reduced.

Summary of the current evidence base and evidence gaps

The evidence base suggests that while there is a great deal of data on SSSI and non-SSSI features from both an ecological condition perspective and on the undertaking of different AES programmes and the various tiers within them, the two areas are not well aligned, and studies generally do not separate SSSI and non-SSSI features in their analyses. The literature review identified a large range of studies that assess the performance of AES over time and during successive schemes. SSSIs in England cover different habitats and features. Consequently, where there is an attempt to assess both AES agreements and SSSI habitat condition (e.g. Staley *et al*., (2019)) the results are drawn from small sample sizes and there is difficulty in deriving robust results that can be scaled up to either habitat or SSSIs more widely. The strongest studies are those which assess a particular habitat type, but these are only relevant to that habitat rather than the AES programme or other SSSIs.

In terms of evidence related evidence gaps, the ecological area is missing a robust update to the 2003 work assessing the conditions of SSSIs (EN 2003). From an attitudinal and motivational perspective, the more farmers and land managers are enrolled in the AES and undertake SSSI management, the more their behaviours and motivations are likely to align with the anticipated outcomes of the AES and SSSI management plan. All of this is helpful in terms of going forward. However, it is more problematic in terms of looking back as such an approach is partially compromised by the inability to determine a causal link.

Opportunities to close evidence gaps through re-analysis

The benefit of reanalysing data collected under the Defra and NE AES M&E Programme is that this increases the likelihood that the Single Business Identifier (SBI) was used for sampling purposes. Where this is the case, the identification of those with an SSSI on all or part of the holding would be relatively straightforward as long as the SBI can be related to those parcels on the respective SSSIs with AES options present. However, M&E is frequently undertaken to address detailed, scheme-specific questions, which does not always lend itself to re-analysis or to being integrated into a wider monitoring dataset for SSSIs.

Studies where environmental behaviour has been included, show a wide range of views and confirm that famers and landowners are not a homogenous group. There is no reason to believe that owners and managers of SSSIs would be any different. Therefore, the typologies and grouping of samples chosen for large AES studies offer some potential for re-analysis in this area.

Consequently, there is a body of survey data collected over the respective periods of successive AES in England, notably under ES and CS, however SSSIs are rarely explicitly identified. This suggests it may be possible to create a locational link in any subsequent analysis and feasibility and effectiveness of doing this should be explored.

Conclusions

A greater integration of the monitoring of AES and SSSIs is required in order to establish a causal link between AES and SSSI condition as outlined in the objective for this report. The impact of AES on SSSIs is most clearly visible in the habitat specific studies. Here there was evidence that AES were improving SSSI habitats in some cases, as well as some non-SSSI sites, through positive management. However, this is not being seen across all SSSIs because SSSIs are not a heterogeneous group. Therefore, a more targeted approach to sampling would be best suited to both AES and SSSIs.

In terms of possible options for the development of future monitoring programmes, the review of the literature suggests that it would be worth considering:

- Having an AES tier that is dedicated to SSSIs, perhaps similar to the 'organic' options in both ES and CS. There is an example from Northern Ireland, the Management of Sensitive Sites scheme (MOSS) run by Department of Agriculture, Environment and Rural Affairs (DAERA). Norton and Bealey (2018) in reviewing the scheme note the need for *robust and reliable evidence to underpin changes in conservation status*.
- Including the identification of SSSIs within future surveys of AES M&E to ensure integration is a standard feature. This will increase the data available for the assessment of the impact AES have on SSSI recovery and the attitudes of farmers and land managers in a cost-effective manner. For this to be effective, it would also be essential that AES IoS on SSSIs parcels are strongly aligned with the respective targets in favourable condition tables and that monitoring protocols are consistent across AES and SSSI strands. It is important to recognise that projects are often related to specific features whereas an SSSI may be designated for a wider range of features.
- Using the EN 2003 report as a baseline to construct a statistically robust systematic review of SSSIs across all priority habitats and regions that reports every 'generation' (e.g. every 20-25 years) so the ecological condition of the best sites in England can be assessed. This would underpin the regular condition assessment monitoring and highlight areas of concern.
- The current rate of annual SSSI survey is slow and the means of selecting the sites is intentionally biased, meaning that there is never a point in time where a representative and current picture across the whole SSSI population or for particular habitats is available. The potential of remote sensing and self-monitoring by farmers and land managers is something that should be further explored.

Data sets potentially suitable for re-analysis

Accessibility of the original data sets referenced in these studies will be essential to successful re-analysis but it is outside the scope of this report to assess this. However, checks against GDPR compliance will need to be made. The publications below have been highlighted as key sources for analysis as they either reference large-scale data that is extensive in its spatial scope across England and potentially contains a high number of SSSIs or consider a single habitat in specific detail.

- Hewins *et al*. (2017) A field survey to evaluate the outcome of higher level stewardship options on lowland heathland. Natural England, ESME
  - Justification: Includes comparisons to non-SSSI sites and is working from a strong baseline but specific to lowland heathland only.
- Mountford & Smart (2014), Assessment of the effect of Environmental Stewardship on improving the ecological status of grassland, moorland and heath.,NECR156, Natural England Commissioned Report.
  - Justification: Extensive survey data collection to NVC standard, including a large number of SSSI sites.
- Nisbet, A. (2015), Integrated Site Assessments 2013/14 – A report on Natural England's assessments of Sites of Special Scientific Interest and Higher Level Stewardship agreement. Natural England Research Reports, Number 061.
  - Justification: 30% of Integrated Site Assessments are joint between SSSI and HLS agreements and would be a good source for re-analysis. This link is acknowledged but not examined further.
- Wheeler, B., Wilson, P. and Bealey, C. (2014) The long-term effectiveness of Environmental Stewardship in conserving lowland wet grassland. Report to Natural England.

- Justification: One of few studies with temporal depth comparing AES on SSSIs and non-SSSIs but specific to lowland wet grassland only.

- Jones *et al*. 2018 / Short *et al*. 2018 / Cao *et al*. 2018 Initial Evaluation of the Implementation of Countryside Stewardship (CS) in England. Objectives 1, 2, 3 & 4: Initial Evaluation of CS Implementation. Final Reports to Natural England.
  - Justification: Data from CS via agreement holder and applicant surveys as well as analysis of overall uptake but no specific consideration of SSSIs or comparison with non-SSSIs.
- Staley *et al*. (2019) The environmental effectiveness of HLS scheme; Resurveying the baseline agreement monitoring sample to quantify change between 2009 and 2016 ECM 6937, Natural England Research report http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=19360
  - Justification: Data arising from re survey of HLS agreement holders (Mountford et al 2013) involving both ecological and attitudinal analysis resulting in suggested motivation-based typologies.

1 Introduction

Agri-Environment Schemes (AES) were originally set up and designed to reduce the impact of human activity on the agricultural environment, through encouraging the sensitive management of important habitats, the restoration of degraded habitats and features and the creation of new habitats. This has been achieved through agreements with farmers and land managers, and implemented through a series of prescriptions with target outcomes that can be both measured and monitored.

AES prescriptions were developed over a period of years with specific environmental objectives and outcomes in mind. As a result, there are many different prescriptions across the current options available under the Environmental Stewardship Scheme. Prescriptions cover habitat and feature management, habitat creation, or specific interventions on farms to benefit target species or with explicit environmental outcomes (such as reduced chemical input in river catchments) as well as landscape character, historic environments, educational access and water quality.

Biodiversity has always been a priority objective of AES since their inception. It was a key objective of Environmental Stewardship (ES) and is one of the two 'main priorities' of Countryside Stewardship (CS), alongside water quality. Sites of Special Scientific Interest (SSSIs) represent some of the best of England's biodiversity sites, and we understand that it is important to Defra/NE to be able to evaluate the contribution that AES's make in delivering for biodiversity when they occur on SSSIs. There has been a strategic position to prioritise the involvement of SSSI land owners and managers in the higher level of both ES and CS in order to ensure that as many as possible are assessed as being in 'favourable condition'.

SSSI owners and managers have a different relationship with Natural England (NE) as compared to other agri-environment agreement holders. NE provides management advice for SSSI farmers and feedback on assessments of their SSSIs. In turn, farmers on SSSI land are required to consult with and obtain approval from Natural England for farming activities that could damage their SSSIs. The policy for agri-environment on SSSIs is that the agreements will support the agricultural management necessary to achieve and maintain favourable condition of the SSSIs. Therefore, it is also important to evaluate whether the use of AES on SSSIs is leading to favourable condition.

The context that underpins this research is that, while there has been significant investment in research to better understand the condition of SSSIs and effectiveness of AES programmes, the two elements have rarely been brought together or their connections examined. As designations SSSIs may have many features meaning that measuring and determining good condition is a complex process, as there are often multiple features per site with potentially conflicting management needs. Some SSSI features, such as grassland, have a close fit with AES options, while others, such as geological features do not. In addition, SSSI ongoing monitoring has moved from a 6-yearly cycle to a process based on perceived risk, although this is not connected to AES participation. Hence, SSSIs have not tended to be a primary focus for AES monitoring research. The rationale for AES monitoring has normally been to try to detect positive change in habitat condition, in order to determine scheme effectiveness and value for money over relatively short timescales. AES monitoring programmes often have only a three- or four-year timespan, and focus on sites where change can be seen and measured during this period. As a result, it has not been possible to identify a causal link between the presence of an AES agreement and an improvement in SSSI condition, which is likely to require longer timescales (see section 3.3.1).

1.1 Objectives

The comprehensive review of evidence assessing the impact of AES on SSSI condition will provide an enhanced understanding of the relationship between AES and SSSIs and set a path for this to be tested in more detail through secondary analysis of existing data or new research.

Specific objectives are:

- To assess the extent to which there is evidence of change in condition, across the range of SSSI features and AES options;
- To assess the extent to which there is evidence of a causal relationship between AES and changes in SSSI condition;
- To understand what motivates owners and occupiers to manage their SSSIs appropriately for the interest features, and what factors encourage pro-environmental behaviour change.

Based on the findings from the review, the research identifies which factors influence the success or failure of current AES schemes on SSSI condition, including, but not limited to, environmental, economic and social factors, providing evidence to feed in to scheme improvements, developments and monitoring and evaluation. The findings will provide an improved understanding as to how AES link to the environmental outcomes on SSSIs, including long-term and long-lasting environmental behavioural changes amongst farmers and land managers and enhanced environmental quality manifesting itself in, for example, farmers' voluntarily undertaking unsubsidised environmental management practices.

The focus for this research is on biodiversity, although some SSSIs are designated because of their geological features. We acknowledge that, in the context of this research into the links between AES and SSSI enhancement, there is an evidence gap around the effect of AES on geological SSSIs. This is largely because until CS was introduced in 2015 there were no AES options specifically targeted at geology. Under CS there is a single capital item focussed on this objective. However, the approach taken in this project is likely to be relevant to geological SSSIs, and the focus on the environmental attitudes and behaviours of those farmers and land managers in AES where SSSIs are involved is likely to be relevant to geological SSSIs as well.

2 Method

The rationale for this research was to tease out of the literature any evidence of data, survey results or survey analyses that may show the impacts of AES schemes on SSSIs, to identify data gaps, draw appropriate conclusions and make recommendations for future work to help feed in to scheme improvements.

The proposed methodology had four tasks:

- Literature review focused on ecological surveys and datasets
- Literature review on attitudes towards and motivations for managing protected sites
- Identifying existing datasets for potential re-analysis
- Identifying the evidence gaps and recommendations for future work.

2.1 Literature Search (Tasks 1 & 2)

At the start of the literature search, a protocol (see Section 2.1.3) was prepared for the research team to follow in both Tasks 1 and Task 2. The research question that underpinned the search in both tasks was *"To determine the extent to which AES have contributed to the management and enhancement of SSSI and assess the attitudes and behaviours of those who manage SSSIs".*

The review was undertaken using:

- Past projects commissioned for the Agri-Environment Monitoring and Evaluation Programme;
- Other reports and studies from the Defra *Publications* pages and Natural England *Access to Evidence* catalogue;
- Published peer-reviewed studies within the social science and conservation literature through SCOPUS, Web of Science and Google Scholar.

It was considered good practice to use more than one search engine, as different search platforms were known to yield different results. Given the limited time period in which to conduct the search and analysis (one month) the decision was taken to focus on the most recent literature and restrict the focus of the search to between 2000-2018. The search was open to all geographical regions to capture experiences from other parts of the world.

2.1.1 Task 1: Literature Review (Ecology)

The search under Task 1 was to develop a structure for reporting evidence of SSSI impacts, searching by key word(s) and sort results, as far as possible, by relevance. The Reporting Matrix (at Appendix 1) rates the different evidence sources by relevance and quality, and by the direction (and where possible, magnitude) of effect (positive, neutral, negative).

The literature search sought to answer three broad questions:

a. To what extent was there evidence of a relationship between AES and SSSI improvement?
b. If a relationship was found, to what extent was there evidence that AES was the cause of SSSI improvements?
c. Did this vary between different habitats and interest features?

One issue that the research team were aware of from the start concerned the extent to which SSSIs were separately identified in any survey work, analysed in any data analysis and separately reported in any conclusions and recommendations. This applied to both the AES monitoring and evaluation (M&E) programme reports and wider literature.

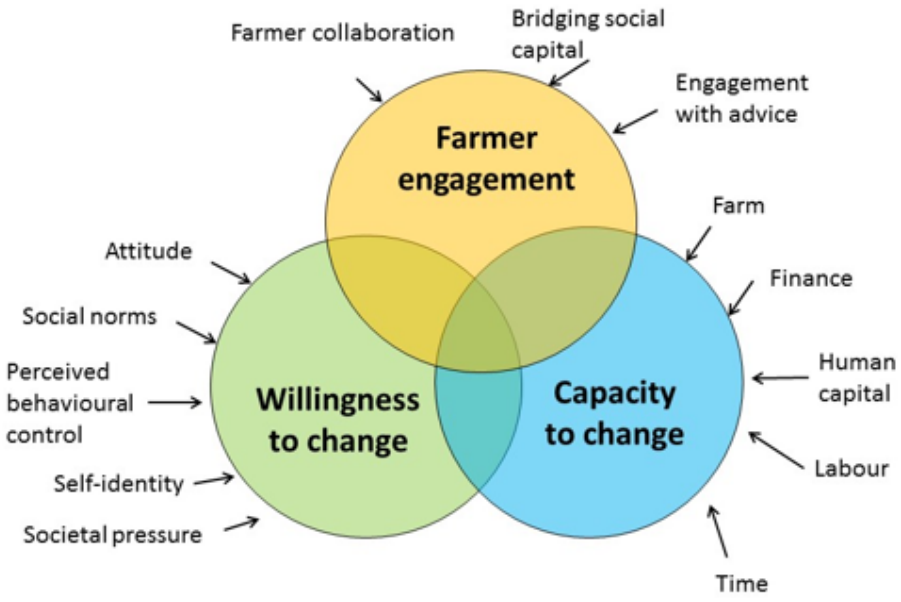
2.1.2 Task 2: Literature review (Environmental attitudes and motivations)

The aim in Task 2 was to establish what the existing literature told us about the attitude towards and owner/manager motivation for managing protected sites. The literature review specifically assessed what the evidence available told us about farmer/land manager beliefs and attitudes towards designated site status and the use of AES as a tool for managing those designated sites as present in recent farmer/land manager surveys, including recent studies involving interviews with AES agreement holders and the wider literature.

The broad context for this task was to recognise that land managers and associated farming systems face a diverse range of social, ecological, economic and political influences and changes. These changes – operating at a range of scales – included, amongst others, market fluctuations, climate change (severe weather events, diseases etc.), new technology and changes in governance structures. How farmers and land managers adapt to these 'disturbances' re-orientate their business in response to 'trigger' events was relevant in the context of effectively managing protected sites such as SSSIs. The focus of the literature review concerning farmers / land managers was around the identification of examples of attitudes towards SSSIs and utilising AES to manage these areas. Areas of enquiry included:

a. the influence of farm/land holding characteristics on farmer/land manager decision-making;
b. recent socio-economic trends in farm household characteristics, including succession status, pertaining to on-farm behaviour change;
c. effective approaches within existing innovation support services and the role of advisers, intermediaries and multipliers;
d. persistence, adaptation and transformation strategies and the role of 'trigger' events in influencing major change;
e. the role of similar designations and protected landscapes (e.g. National parks, AONBs, Nature Improvement Areas) in providing a family of similar areas for knowledge exchange.

Figure 1 Analytical framework guiding literature search (Dwyer *et al.* 2007)



An analytical framework was used to structure the review (see Figure 1). The framework was based on previous studies (Dwyer *et al.* 2007 and Ingram *et al.*, 2009) which have looked at factors that influence farmer environmental decision-making. It has long been recognised that in order to understand farmers' environmental behaviours and action, consideration is required of both internal factors and the external context in which the farmer operates. This has led researchers to examine the relationship between the *willingness* to adapt (attitude, beliefs, values and norms of the farmer towards the environment) and *capacity* to adapt (economic status of farm and compatibility with farming system, external drivers etc.), a central theme in a distinct body of research (see Dwyer *et al.*, 2007). In addition, farmer *engagement* is increasingly considered an important influence on environmental decision-making, which we define as an active engagement in environmental learning through advice and support networks, both in terms of receiving but also providing local expertise.

2.1.3 Literature Search process

In the literature search, the following two search strings were used:

Ecological condition:
Ecological condition/condition, habitats (possibly conservation, biodiversity, species, etc.), ecological enhancement, Agri-environment, SSSI
Agreement holder attitudes and motivations:
Agreement holder, Agri-environment (possibly conservation, biodiversity, agriculture and environment, etc.), attitudes (possibly motivations, behaviour etc.), SSSIs

Both search strings always included the word 'SSSIs' to ensure that this was the key focus of a study or article. Under the ecological condition search we looked for particular habitats using the headings in Section 3 as well as variations on this such as both 'heath' and 'heathland'. For the same reasons in both searches we included the term 'agri-environment', but also added alternative terms, such as 'conservation', 'biodiversity', 'agriculture and environment', in recognition that not all areas used the term agri-environment. These words were then followed by terms identified in previous studies that relate to factors affecting environmental decision-making.

The Defra science search site (http://sciencesearch.defra.gov.uk/) and NE publications catalogue (http://publications.naturalengland.org.uk/) were searched separately and comprehensively for relevant reports. The search functions of both sites are limited with only a single search field provided, e.g. by country. The NE publications catalogue was organised by categories and searches led to category headings, not individual publications, which makes efficient and targeted searching through the use of multiple search strings or and/or functions or similar very difficult. As a result, only the term "SSSI" was entered into the respective search fields and all publications returned from this were assessed for relevance to this project.

The literature searches for Task 1 and 2 were conducted between 29th November 2018 to 28th January 2019. The search terms yielded over 150 articles, which were uploaded to the reference management software, EndNote. The reference lists of the top 10-12 key papers and reports that appeared in each search (ecological condition; agreement holder attitudes and motivations) were examined for additional relevant references. In addition, relevant reports suggested by the Steering Group were also added, which resulted in a total of approximately 200 documents. The reference list in this report contains all those that were assessed in detail.

2.2 Literature screening

The team then screened each of the articles by examining the abstract and excluded those that were not relevant to the purpose of the study. The main reasons for exclusion were:

- The paper did not report on environmental outcomes or environmental attitudes
- The paper related to agricultural practices only, with no mention of agri-environment activity.
- The cultural context was not relevant to the UK situation. This particularly applied to papers based in African countries
- The paper was duplicated, so only one was present in the final list.

2.3 Literature Analysis

The literature analysis was undertaken on those papers and reports considered to have potential in the context of the study. The key elements of the review followed a clear protocol covering a range of factors. These were important in determining which references to assess in detail and are recorded in the tables in Appendix 1 for Task 1 and 2:

The focus on AES and/or SSSI:

- Relevance

high	study with a clear purpose of direct relevance to the project (e.g. covering issues of ecological condition or priority habitats and designations or attitudes to the environment.
medium	study in related area but not central to the research questions set out in this project.
low	study purpose not likely to provide anything relevant to this research project

- Strength of evidence:

high	well-designed study (e.g. large representative sample or robust qualitative data) providing clear evidence
medium	study design not ideal but still producing useful evidence of success or failure, with reasons
low	poorly designed study not producing conclusive evidence; small sample

Environmental outcomes had two criteria:

- Level of impact: For each key finding or outcome identified, a rating for level of impact was assigned based on the following 5-point scale.

++	major positive impact of factor on AES engagement/social outcomes
+	some positive impact but not substantial
0	no impact
-	small negative impact
--	substantial negative impact

- Strength of causal link between AES and environmental outcomes on SSSI (including +ve/-ve) on a 5 point scale:

++	major positive link between AES and environmental outcomes on SSSI
+	some positive link
0	no link
-	small negative link between AES and environmental outcomes on SSSI
--	substantial negative link

- Key environmental outcomes were then summarised
- Notes incl. context & caveats. For example, geographical limitations (such as study only at one site or region), weaknesses in study (being habitat specific or small scale)
- Key findings and detail on causal link.

3 Ecological Condition

3.1 Key research questions

This Section outlines the key areas of activity in the literature review concerning ecological condition. The key research questions considered in the review were to:

- assess the extent to which there is evidence of change in condition, across the range of SSSI features and AES options.
- assess the extent to which there is evidence of a causal relationship between AES and changes in SSSI condition
- identify evidence for a causal link between AES and successful environmental enhancement of SSSIs:
- consider issues of long-term pro-environmental change.
- indicate the strength of evidence.

3.2 Background to Agri-Environment Scheme development

Agri-environment schemes in England have undergone significant development since their first introduction in the 1980's. A simplified timeline of their evolution is shown in Figure 2 (Natural England, 2012). Environmentally Sensitive Areas (ESA) were one of the first mainstream schemes to be introduced (1987), with the objective to safeguard and enhance a selection of carefully targeted geographical areas of landscape, biodiversity and cultural importance.

ESAs were complemented by the Countryside Stewardship Scheme (CSS) in 1991, which provided wider access to AES by covering areas not included under the ESA programme. CSS aimed to improve the natural beauty and diversity of the countryside through management of landscape, wildlife habitats, historical features and public access. In addition to ESA and CSS a number of smaller, specialist schemes were also active, such as the Habitat Scheme.

Following a review of AE schemes in 2003 all pre-existing schemes were closed to new entrants, to be replaced by ES in 2005, which aimed to provide a comprehensive, nationally applicable scheme. ES comprised of two tiers; Entry Level Stewardship (ELS) and Higher Level Stewardship (HLS), and provided management options to target objectives such as biodiversity, historic environment, resource protection, access, and climate change.

HLS brought a renewed emphasis on the maintenance and pro-active restoration of existing habitats. The scheme became the main delivery mechanism to achieve targets for the condition of SSSIs, and was the main mechanism used to increase the percentage of SSSIs in favourable or unfavourable recovering condition (Natural England, 2009). However, the latter category of 'unfavourable recovering' is challenging as the presence of, rather than evidence of positive impact from, an AES agreement sometimes resulted in an SSSI being moved into this category under the assumption that the AES agreement would have a positive impact on the ecological condition of the SSSI.

Defra launched Countryside Stewardship (CS) in England during 2015, and the scheme brings together a range of environmental protection measures, formerly delivered as three separate schemes:

- Environmental Stewardship
- Catchment Sensitive Farming capital grant scheme
- Woodland Grant Scheme.

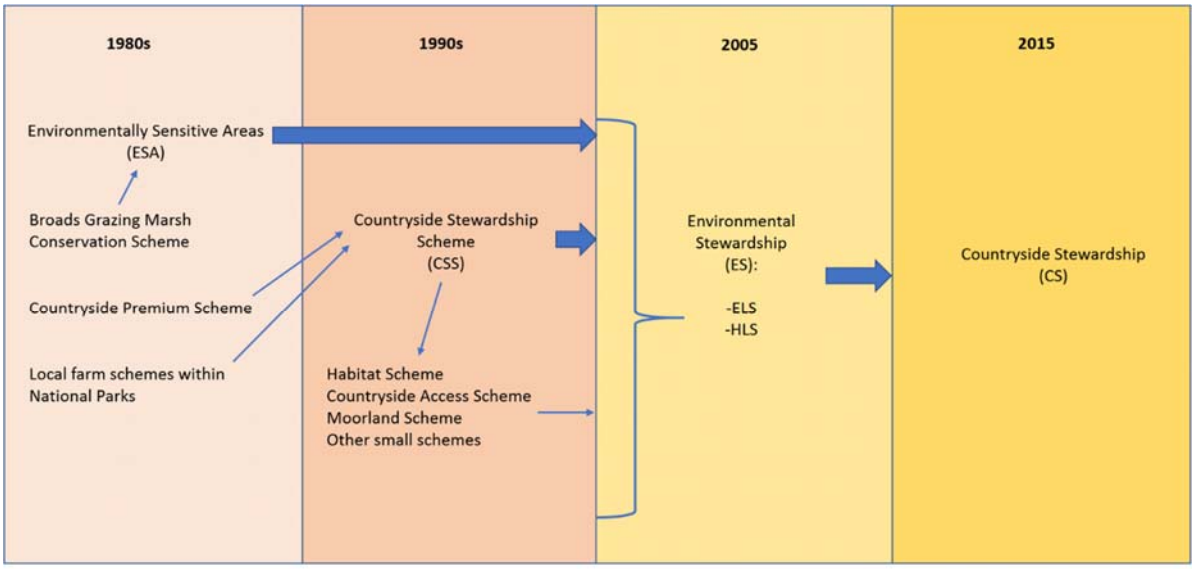
The core environmental issues addressed by the scheme are biodiversity and resource protection, notably water quality, as determined by the Water Framework Directive (WFD). Other aspects, such as historic environment, landscape and climate change are secondary objectives. It marks a move

away from the universal, open to all, entry level strand of ES towards a more targeted approach to environmental land management. Unlike ES, CS is a competitive scheme. Applications to all scheme elements are scored against the targeting priorities in their geographic area, which are available online for individual land parcels and as Statements of Priority for each National Character Area (NCA).

The most environmentally demanding strand of the scheme is the Higher Tier (HT), which is proactively targeted at the most environmentally important sites (including support for woodland management) and supported by advice from NE/Forestry Commission (FC). There is also a competitive Mid-Tier (MT) strand focused on addressing specific environmental issues in the wider countryside, such as reducing water pollution or improving the farmed environment for farmland birds or pollinators. Organic management options are available within MT and HT and can be used in combination with non-organic options on an agreement or alone to form a purely 'organic' agreement. Multi-annual agreements are now typically five years in length, though some options and agreements in complex settings can be undertaken for 10 years.

Task 1 of this project assesses the extent to which there is evidence of change in condition, across the range of SSSI features and AES options in primary AES literature since 2000 that records an impact on SSSIs. It further assesses the extent to which there is evidence of a causal relationship between AES and changes in SSSI condition and examines the evidence for linking AES and successful environmental enhancement of SSSI, regarding long-term pro-environmental change.

Figure 2. Evolution of agri-environment schemes in England from the 'Classic' schemes (ESA, CSS) to the present-day Countryside Stewardship scheme (based on Natural England, 2012).



The project considers the full range of schemes described above, but excludes schemes designed specifically for SSSIs (such as the Wildlife Enhancement Scheme), the Woodland Grant Scheme administered by the Forestry Commission, schemes supporting organic conversion and management, and non- agri-environment income support schemes.

3.3 Summary of key findings and evidence gaps

3.3.1 Recovery trajectories for habitats under appropriate management

Many of the management interventions designed under AES schemes were, and still are, are based on ecological research aimed at improving and maintaining the ecological condition of the site. A few have been developed around non-ecological objectives e.g. historic environment and public accessibility.

The ecological recovery trajectories various habitats, and therefore the success of schemes, are subject to many factors which are discussed in more detail in the following sections below. However, work carried out by Plantlife (Shellswell *et al*. 2016a&b) investigated the possible recovery trajectories for different habitat types, assuming appropriate management was in place.

The research showed that the time taken for habitats to reach favourable condition varies widely for different habitat types and depends on the starting condition, as well as the type of management and external influences, meaning that the recovery trajectory attainable will be different at each site. Failure to reach favourable status within the expected time frame may not indicate a failure of AES, but could be due to a variety of external factors, including successive dry or wet summers, wildfires, and extreme flood events, which can neutralise or reverse the effects of beneficial management, or prevent the required management being carried out (Shellswell *et al*., 2016a). In addition, management interventions designed to improve habitat condition can initially cause a decrease in habitat condition, forming an initial 'dip' in an otherwise upward trend. Therefore, if monitoring is undertaken too soon, the management may incorrectly be deemed to be detrimental (Shellswell *et al*., 2016b).

An example of this is scrub control where scrub regeneration can initially increase and regrowth is strong after initial control measures, especially where grazing regimes are relaxed too soon. Another example is the establishment of negative indicator species, such as bracken and grasses which can establish quickly after controlled burning for heathland condition management and compete with the desired regeneration of heather, especially where a high soil nutrient status is present, including those from atmospheric sources. In these instances, further rehabilitation management might be required to adjust the direction of the recovery trajectory.

Lowland heathland is an example of a habitat where different recovery trajectories can be expected depending on the initial condition of the habitat and the type of management employed. In some cases, it may not be possible to carry out what is believed to be the most effective management practice for financial and/or practical factors; for example, it may not be possible to burn sites in close proximity to urban areas, and there may not be sufficient fencing to facilitate stock grazing. These decisions influence the direction and rate of change which can be expected as a result.

Where the site requires intervention to increase the proportion of bare ground, the techniques of cutting, turf-stripping, burning or trampling/grazing can be employed. Cutting, turf-stripping and burning all produce immediate effects, but persist for variable periods (2-4 years for cutting and burning, around 10 years for turf-stripping), while grazing promotes gradual development of bare ground over 1-3 years in building-stage heather, or over 10 years in mature heather stands. Where the same management techniques are employed to improve the structural diversity of heathland sites, cutting may take 1-5 years, turf-stripping 3-12 years, burning 5-10 years, and grazing 4-10 years to achieve the desired results (Shellswell *et al*., 2016b).

Lowland grassland recovery trajectories have also been studied (Shellswell *et al*., 2016a). Again, the length of time expected to improve habitat condition depends on the nature and degree of the

problem, and the management type selected to address this. Addressing under-management through grazing can be expected to take 1-3 years where forbs are still present in the sward, or 4-10 years where forbs are absent. However, the type of stock as well as the stocking density creates a large degree of variability within these estimates. Where fertiliser inputs have affected a site, recovery can take anywhere between 1 and 30 years, depending on the level of nitrogen/phosphorus input, and the underlying soil type.

Alderson *et al*. (2019) conducted an analysis of blanket bog recovery trajectories. Their study found that on grip-blocking sites bare peat can be largely revegetated, and indicator species cover of 70-80% can be achieved, in six growing seasons with correct management. This involved fairly high input interventions, including re-planting of blanket bog species. The number of indicator species can be increased from 1 to 6 after approximately 5 years. The study also found that water table height can be raised by 24-37 mm per year following restoration activity supporting vegetation succession and/or peat recovery (Alderson *et al*., 2019).

These trajectories provide an indication as to the extent of recovery possible within degraded SSSI habitats, and an anticipated minimum time required for a site to transition either from 'unfavourable' to 'unfavourable-recovering', or from 'unfavourable recovering' to 'favourable' status, assuming that the management regime is properly designed and implemented.

While the timescales for observed habitat trajectories quoted above indicate relatively rapid recovery periods, it is worth noting that these findings were made under comparatively controlled, experimental conditions, including active conservation efforts rather than resulting from farmer interventions. Outside of such a setting, in the operational environment of live agreements, many other factors influence the outcomes and speed of the desired recovery; these are mostly related to the complexity of human influence on the execution of the required management actions. Progress will in many cases be slower, and rates of recovery will be variable, across habitats.

Some published examples of AES monitoring have been carried out relatively shortly after scheme introduction, preventing a full assessment of scheme effectiveness in relation to ecological condition. Furthermore, many sites have a long history of management under several AES schemes as the schemes evolved over time, but each scheme change introduces the possibility for a change in management focus/option targeting. While consistent site management across a succession of schemes will likely ensure on-going change towards desired condition improvement, this will require time to come into effect and to be measurable during ecological condition surveys.

These potential breaks in the continuity of site/habitat management create a more complex picture when analysing the success of AES in general. An alternative approach could analyse the success of individual schemes, accepting that this reduces the sample size available for each scheme/habitat type, and restricts the analysis to shorter time periods, which may not allow sufficient time for site recovery to take effect. This would require baseline monitoring at the outset and the conclusion of individual schemes and consider the presence of SSSIs. Any apparent success of schemes is further influenced by the history of land management on individual sites, i.e., whether the site was already in good condition when it entered the scheme, due to prior sympathetic management, either within or without an earlier scheme. Alternatively, if the land was in unfavourable condition it might never recover without significant active intervention.

In parallel, where sustained and enhanced long-term monitoring is unfeasible, it is important to maximise the use of existing monitoring effectively through comparable data collection and applying the principle of "collect once, use many times". Many of the potential data sources highlighted in Task

3 as potentially useful for re-analysis have been collected to specific protocols and do not fulfil this requirement, restricting their utility for future re-analysis.

3.3.2 Existing evidence relating to SSSIs

There have been a considerable number of studies investigating the outcomes and effectiveness of agri-environment schemes (AES) in general, although to date most have not focussed specifically on SSSIs. These studies encompass a range of sites (both designated and non-designated status), and analyse the data as a whole. In some cases, the outcomes on SSSIs are presented as case studies, but the purpose of these is to showcase positive impacts, and therefore the overall picture is not considered.

The main source of SSSI-specific information on the effectiveness of AES, is the NE Integrated Site Assessments (ISA) (Nisbet, 2015), which focussed on a selection of SSSIs. These were selected on a risk basis, and included sites that were more likely to have changed in their ecological condition. The programme was designed to assess SSSI condition status and HLS Indicators of Success (IoS) together where possible. It was reported that in some cases only SSSI condition status was assessed, even when an HLS agreement was present, resulting in an incomplete picture of the interaction of SSSI condition and HLS management interventions in the study. From the HLS perspective, 57% of sites were assigned a Green outlook for the likelihood of achieving the IoS. A Green outlook means that the IoS were comprehensive and appropriate, that targets were already being met, or there was a high level of confidence that the targets would be met by the due date. Moorland options had the highest proportion of Red and Amber outlooks (meaning that was a high or significant risk that IoS would not be met by the due date).

A previous study by Natural England (2009) discussed the condition assessment outcomes for SSSIs under AES relative to SSSIs that are not under AES. This concluded that 93% of SSSIs under AES were under favourable or unfavourable recovering condition, compared to 73% for non-AES SSSI sites. However, the non-AES SSSIs had a higher proportion of sites classed as in favourable condition, compared to unfavourable recovering. The same study reported that 93% of all eligible SSSIs were under HLS agreement and this therefore represents only a very low proportion of the total population. No supporting data were presented in this report (e.g. a breakdown of the proportion of each habitat type, or data on target species, present in both the AES and non-AES samples), so it is not currently possible to determine whether this was a significant difference, or to investigate possible explanations.

Studies that have focussed specifically on SSSIs have not, to date, focussed in depth on the effects of AES; this seems largely to be because the schemes were in their infancy at the time of site survey and the Common Standards Monitoring (CSM) methodology was not adopted. SSSI re-surveys were too infrequent to address this. As a result, an assessment of the effectiveness of the options/scheme was not possible. There is also some evidence that the timing of large-scale AES surveys does not always coincide with the ideal time for assessing specific SSSI features, such as bird presence.

Habitat-specific SSSI surveys, although not designed specifically to investigate the impacts of AES, provide some evidence as to the effectiveness of schemes on different habitat types if they can be linked to relevant AES management interventions. Complicating factors, such as land ownership type, and external influences should also be considered in any further detailed analysis.

3.4 Feature specific findings

SSSIs are designated for many different, and often for multiple, interest features, so it is hard to draw general conclusions about all SSSIs. Therefore, this section considers the specific evidence for some of the common SSSI habitats and features.

3.4.1.1 Grasslands

Reid and Grice (2001) described "a lack of progress in wildlife enhancement under AES" within grassland habitats, and attributed this to the tendency of the early AES programmes, for example 'Tier 1' prescriptions within the ESA programme, to 'maintain the status quo' rather than to restore and enhance a site, in addition to a lack of uptake of higher tiers. Furthermore, where higher tiers were adopted, the option targeting and seed-mixes used were not always optimal, resulting in limited progress being made. This review applied to the 'Classic' schemes (ESA, CSS) and no evidence was found that suggests that this remained a problem in later schemes.

A re-survey project, which focused on lowland wet grassland sites in the Avon Valley, Upper Thames Tributaries and Somerset Levels and Moors ESAs that subsequently entered HLS agreements (Wheeler *et al*., 2014), concluded that ESA was more effective at maintaining existing condition in certain types of permanent grassland habitat. It was less effective for species-rich wet grassland, where an increase in species-poor, Juncus-dominated vegetation was found. The study noted that, while most of the visited sites failed a CSM condition assessment of the grassland habitat, they were largely being managed under options targeted for breeding/wintering waders (the success of which was not assessed), not for improvements to grassland diversity.

A similar finding was reported more recently by Mountford and Smart (2014) when conducting a desk study of HLS agreements; this study found that grassland habitats were more likely to be targeted by maintenance options, when restoration options were in fact necessary to promote improvements in site condition. Neither Mountford and Smart (2014) or Wheeler *et al*. (2014) focussed exclusively on SSSIs, but considered a number of SSSI sites in their work.

A study by Hamilton (2014) to evaluate the effectiveness of Environmental Stewardship in conserving upland hay meadows found that the higher quality sites had experienced slight declines since their original designation as ESAs, but that meadows that had been of poorer quality showed evidence of slight improvement under HLS. However, changes in local climate and atmospheric N deposition were cited as possible contributing factors to decreased habitat quality. The study included a mixture of SSSI and non-SSSI sites.

Establishing a counterfactual for grassland habitats may be difficult, as a very large proportion of SSSI grasslands are reportedly under AES of some kind, covering 94% of lowland calcareous grassland; 80% of lowland meadows; 92% of lowland dry-acid grassland; 90% of upland hay meadows; and 85% of the coastal flood plain and grazing marsh SSSIs (Natural England, 2009).

3.4.1.2 Woodland

More than two-thirds of broadleaved woodland SSSIs were reported to be in favourable condition in 2004 (Townshend *et al.,* 2004) or under management that should bring it into this condition, with lack of management, inappropriate management, and deer grazing being the main causes of unfavourable condition.

3.4.1.3 Moorland

In an analysis of Integrated Site Assessment outcomes, Nisbet (2015) found that moorland habitats had a higher proportion of Red and Amber status (ISA categories) than other habitat types; Grass moorland and rough grazing, upland heath, fragmented heath and blanket bog all had 70% or more

of assessments flagged as either Red or Amber, despite restoration of moorland being one of the most common prescriptions. 21% of moorland maintenance areas had a Red outlook. The study did not analyse the reasons for the Red or Amber assessments, but highlighted this as a priority for future work.

3.4.1.4 Lowland heathland

AES cover a significant proportion of the area of lowland heath priority habitat (86%) and 94% of the lowland heath SSSI resource (Natural England, 2009). Conservation management agreements and/or incentive schemes were judged to be particularly significant influences on the condition of lowland heathland SSSIs (Brown *et al.,* 1998). This was because the types of management required to preserve or enhance the conservation interest of heathlands provided little economic return for the site owner. Therefore, incentive schemes can play a vital role in making appropriate management a viable option.

Low financial returns from heathlands can lead to management neglect, resulting in scrub and tree invasion; the survey by Brown *et al*. (1998) noted several SSSIs under threat of neglect, and that all but one of these was areas in unfavourable condition.

A more recent survey by Hewins *et al*. (2017) found an extremely variable effect of HO1/HO2 HLS management options on SSSI sites, although in general the areas of heathland managed under the options were judged to be in better condition than those not being managed under HO1/HO2. Management under HO1 and HO2 was found to encourage management activity that promoted bare ground creation, and higher levels of bare ground were recorded as a result. However, the effect of the options on vegetation composition was found to be very mixed. The presence of an agreement increased the likelihood of positive management activity, though this is not yet translating into robustly detectable habitat improvements. It was not known if sites that entered HLS under these options were already in better condition at the time of the agreement becoming active, than those that did not.

In terms of vegetation composition, undesirable changes such as increased scrub and bracken cover, and decreased frequency of positive indicator species, were found under the HO1/HO2 options, but so was increased dwarf-shrub and graminoid species richness. The analysis of SSSI site data was hindered by a lack of baseline survey data, which meant it was not possible to determine whether the SSSI sites had improved or declined in condition overall and what their condition was at the time they joined the scheme. In addition, some of the sites had only been under agreement for one or two years when surveyed, which is insufficient time for many significant changes in habitat condition to develop (Shellswell *et al*., 2016b).

3.4.1.5 Coastal and grazing marsh

Wetland and coastal habitats were not a major target of classic schemes, so analysis of AES effectiveness in these habitats is restricted to ES. This results in a lack of data, as the schemes have not been in effect for sufficient time.

A study of 99 wet grassland sites was carried out by Wheeler *et al.* (2012) to investigate the effectiveness of ES on this habitat type. The grasslands were assessed using CSM for SSSIs. Many sites which failed the CSM botanical assessments were under HLS options for breeding or wintering waders. However, bird surveys were beyond the scope of the project and so the success of HLS with respect to the specific feature it was designed to enhance, could not be assessed.

However, the study found that areas under HLS options designed to benefit breeding or wintering wildfowl/waders were less likely to pass the CSM condition assessment for grassland SSSIs than areas

under options designed to enhance botanical condition; particularly in lower value grasslands, the non-botanical options were associated with either no improvement or a decline in sward diversity.

There was evidence of a possible conflict between options targeting over-wintering breeding birds on SSSIs and the habitat management for botanic diversity aimed at fulfilling Common Standards Monitoring (CSM) requirements for favourable status (Wheeler *et al*., 2014).

3.4.1.6 Fen and reedbeds

There was insufficient independent scientific evidence to determine that AES have benefitted fens and reedbeds in general or on SSSI specifically. Uptake in CSS and ESA that would benefit these habitats was low, possibly due to lack of targeting. However, HLS covered a significant proportion of eligible wetland BAP priority habitats (Natural England, 2009). Since roughly half of HLS agreements are linked to SSSIs, it might be possible to assess the link between the condition of those agreements in AES and SSSI condition.

3.4.1.7 Lowland raised bog

Classic schemes provided little benefit to raised bogs (indeed there was no option for raised bog management), and there was no monitoring on raised bog under CSS or ESA. The addition of raised bog options to HLS provided limited scope for enhancing these habitats, as ownership of these sites is often complex and management can be very difficult due to terrain, the need for specialist equipment and lack of agricultural return from this habitat (Natural England, 2009). Furthermore, these habitats were not routinely monitored under ES, meaning the effects of the HLS options cannot be assessed.

Management of surrounding land is critical to restoration of raised bog, the marginal peatland often having been converted to pasture or arable. Previous incentives generally do not seem to have been sufficient to bring this land into agreement, meaning that historically a low percentage of this habitat type was managed under AES (around 20% of lowland raised bog priority habitat managed under CSS/ESA). The main obstacles appeared to be effective loss of land from production and provision of appropriate compensation. However, following the introduction of ES, 100% of SSSI lowland raised bog was managed under HLS agreements, and just over 40% of total priority habitat was managed under either ELS, HLS, CSS or ESA (Natural England, 2009).

3.4.1.8 Freshwater

In practice, a considerable component of CSM assessment within freshwater SSSIs relies on available EA monitoring data (e.g. chemistry, macrophytes, phytoplankton, fish, macroinvertebrates, diatoms), from routine WFD monitoring, other operational data gathering processes (e.g. connected to permitting processes), or arising from EA responsibilities to contribute to the management of SSSIs and Special Areas of Conservation (SAC). Although CSM is more explicit about impacts on habitat integrity, the use of WFD data means that some of the limitations of WFD monitoring are inherited by CSM assessments, particularly in relation to ecological assessment (Mainstone *et al*., 2018).

Freshwater SSSIs are often impacted by land use practices of the surrounding land, which may not be part of the SSSI designation or AES. Most river SSSIs and around 60 lake SSSIs were suffering from an excess of phosphorus, and this was the primary factor preventing them from reaching favourable condition (Reid and Grice, 2001). Where action has been taken to reduce pollution from agricultural sources under AES, water quality and SSSI status, as enhanced by the river Frome catchment (Natural England, 2009). The success rate of AES on freshwater SSSIs was therefore likely to be determined by the impact they have on nutrient and other pollutant inputs into the water system, relative to parts of the SSSI that were not under AES.

3.4.1.9 Feature specific monitoring requirements

Rare/localized species and their decline or increase might be better monitored by focussing on SSSIs where they are known to be present, while widespread species are more likely to be detected in representative numbers by landscape-level AES monitoring designed to cover a range of species groups.

In some cases, it appears to be difficult to tailor monitoring within a large-scale generic monitoring approach, such as the ISA, to the specific timing requirements to observe key species and their IoS; for example, contrasting survey timings for botanical species and breeding waders (Wheeler *et al.*, 2014).

3.5 Interaction between AES and SSSIs

The study set out to assess the extent to which there is a causal relationship between the AES management interventions and SSSI condition. However, there is a distinct lack of empirical data that allows such a relationship to be systematically evidenced through the available literature beyond isolated case studies. This is made more pronounced by the move away from a 6-yearly cycle of SSSI monitoring to a more reactive approach based on perception of risk to individual SSSI sites.

3.5.1 SSSI Condition monitoring

Positive condition changes and the rates of recovery will be determined by each site's starting condition, time since the commencement of the interventions, the relationship between management practices, particularly different combinations of interventions, and adverse factors that may influence condition. The ability of land managers to implement the intended management prescriptions is a further factor.

The complex interaction of these factors, as well as the considerable resource required to carry out rigorous monitoring, contributes to the difficulty in recording comparable site condition trajectory information and that was reflected in the sparsity of such data in the relevant literature. Furthermore, while condition on SSSIs was assessed under CSM, the underlying drivers of condition change and the detailed contributing factors to the overall condition assessment were not available from published survey data and analysis at the required detail.

Another complicating factor has been misinterpretation of guidance around the use of the condition category 'unfavourable recovering'. When an AES agreement was agreed on a SSSI that was previously in unfavourable condition it was sometimes moved into the 'unfavourable recovering' category because beneficial management had been agreed, but before recovery had actually taken place. Sometimes the management agreed did not address all the factors causing the site to be unfavourable, or recovery would not be achieved within the timeframe of the agreement, yet recovering condition would still be recorded. This compromises the ability to assess the relationship between SSSI condition and the actual impact of AES interventions considerably.

3.5.2 Evidence on AES and SSSI interaction

Few studies have attempted to assess the effectiveness of AES on SSSIs, focussing instead on a range of sites, some of which may be designated. The Mountford and Smart (2014) study attempted to assess the effectiveness of the ES in improving the ecological status of grassland, moorland and heath habitats, and sampled a range of sites which included both SSSIs and sites with no conservation designation. The study was inconclusive, as it was felt that the HLS agreements had not been in force for sufficient time for their full effect to become apparent. In Northern Ireland (NI) the Management of Sensitive Sites scheme (MOSS) required baseline data at the start of the agreement so that changes in conservation status could be based on robust and reliable evidence.

There was a lack of up-to-date comprehensive information concerning habitat condition and as a result, there was only a baseline from about 20 years ago. Analysis of data from every SSSI in England (English Nature, 2003) found that the main causes of unfavourable condition on SSSIs in 2003 were overgrazing (affecting >45% of total SSSI area), inappropriate moor burning (approximately 24% of total SSSI area), drainage (approx. 9%), lack of appropriate scrub control (approx. 6%) and inappropriate forestry and woodland management (approx. 6%). A large proportion of SSSI land was found to be affected by multiple inappropriate management factors, but particular habitat types are affected by some factors more than others. There was no similar information specific to SSSIs for the more recent ES and CS schemes meaning that the impact of these schemes on ecological condition cannot be determined with any confidence.

The 2003 report summarised the main reasons for unfavourable condition on each broad habitat type within the SSSIs, and stated that inappropriate CSS/ESA options contributed to unfavourable status of approximately 2.5% of total SSSI area, broken down by habitat as follows:

- ~17% of total inland rock SSSI area
- ~16% of total upland acid grassland SSSI area (and was the second biggest cause of unfavourable condition for this habitat type)
- ~11% of total standing water and canal SSSI area
- ~9% of total upland calcareous grassland SSSI area
- ~5% of total upland broadleaved and yew woodland SSSI area
- ~3.5% of total lowland neutral grassland SSSI area
- ~2.5% of total upland neutral grassland SSSI area
- ~2% of total lowland heath SSSI area
- ~1% of total bog SSSI area
- ~1% of total fen, marsh & swamp SSSI area
- ~1% of total calcareous grassland SSSI area
- ~1% of total upland heath SSSI area

However, this report formed a one-off assessment of the whole SSSI series and no holistic analysis of overall condition has since been published. Individual condition assessments have been conducted at a steady but low annual rate (currently 2-3% a year) and published by NE (NE 2019). The published data is organised by individual SSSIs as well as separate units and records each site's and unit's condition trajectory over time. However, it does not include the detailed ecological survey data that determined the overall condition assessment and therefore does not allow an assessment of the underlying factors. This includes potential AES management interventions that might have influenced the sites' condition status at the time of each individual survey, e.g., presence of problematic scrub and subsequent clearance as a result of the relevant option being implemented under various schemes.

Between the years of 2011 and 2017, SSSI monitoring was routinely undertaken as part of Natural England's ISA programme, which was applied to all SSSI sites, and combined the assessments of SSSIs and Higher Level Stewardship (HLS) agreements. Before this, SSSI condition was assessed separately to AES progress. NE is currently reviewing and reforming the way it carries out Protected Sites Monitoring.

A report by Nisbet (2015) analysed results of the 2013/14 year of ISA assessments. Despite the intention for these assessments to be 'integrated', Nisbet (2015) notes that SSSI-only assessments made up over half the total number of completed ISAs (64%) even if HLS was present, with only 6%

being HLS-only. There was also variation in the proportion of Joint (SSSI and HLS) and HLS-only assessments undertaken, with the West Midlands completing the highest proportion of Joint assessments (42%). The HLS elements provided valuable information on the delivery of HLS and the likelihood of the SSSI retaining or reaching favourable condition. It is possible that some regional variation resulted from local decisions to only assess SSSI features, even if there was also an HLS agreement.

It is important to note that the site selection of ISAs in 2013/14 was driven by a risk analysis and local delivery needs. Sites were not selected to provide a random or representative sample of SSSIs and/ or HLS agreements, and these findings should, therefore, be treated with caution when extrapolating to the whole population of SSSIs or HLS agreements (Nisbet, 2015).

Where sites are assessed outside the ISA framework there is commonly a divergence between the monitoring of SSSIs (through CSM) and the monitoring of constantly evolving AES schemes. Changes in schemes over time affect the comparability of collected data and sites fall in and out of scheme or have varying starting dates to agreements which affects the stage of recovery they might have reached, at any given moment in time. Representative whole country surveys are expensive and logistically challenging and therefore rarely undertaken.

ISAs provide a means of bridging this gap but as Nisbet (2015) details, due to practical constraints this data source is also limited.

3.5.3 Evidence gaps

There are varying levels of data and analysis across the different habitats and SSSI features. Most evidence is available on grassland habitats because there are many SSSIs on grassland sites. Beyond rare national surveys of specific habitats or SSSIs there is no data on national condition trajectories for SSSI's to establish change over time relating to specific management interactions.

Specific factors, such as management activity, which contribute to SSSI condition have not been systematically recorded and monitored over time. Additionally, SSSIs are not typically treated as a distinct subset in large-scale AES impact assessments and analysis (Smart and Mountford, 2014). As a result, there is a lack of empirical evidence on both the specific factors behind condition changes, particularly improvements, and the impact of AES on this.

While there are a number of datasets (see Section 8) that could be re-examined to allow for specific analysis of AES on SSSI, this is currently largely absent in the published evidence. Consequently, the ability to establish a causal link between AES intervention and SSSI ecological condition within the parameters of this study is severely limited.

There are a range of factors that can impact on SSSI condition and AES success, such as long-term changes in weather/hydrology patterns as well as extreme events, as well as influences from outside the site boundary, which can decrease suitability of the area for the original target habitat and prescribed management options e.g. deposition/N enrichment from adjacent enterprises.

Ideally, when analysing the impact of AES on SSSIs a study would compare data from an AES-SSSI with a control site, a comparable SSSI with no AES management. However, AES has been strongly targeted towards SSSIs, which means that the majority of SSSIs are already managed under AES agreements and those that are not under AES were often excluded for a reason which could make them atypical or non-representative as a counterfactual, making it difficult to establish a control group for each broad class of SSSI (woodland, wetland etc.). This literature review did not identify any study of AES on SSSIs which included a control group.

To illustrate this point, 93% of eligible SSSIs were under HLS agreements. Of the eligible SSSI area covered by AES, 93% are classed as being in favourable/unfavourable recovering condition compared to 73% for non-AES sites (Natural England, 2009). This makes establishing a counterfactual to empirically assess the impact of AES on SSSI condition almost impossible, beyond establishing comparable sites outside of the SSSI cohort which is outside the scope of this study.

3.6 Factors influencing the interaction between AES and SSSIs

3.6.1 Complexity of agreement set-up

HLS was targeted at sites of high environmental value, many of which are designated as SSSI. Particularly where such sites are complex and involve management of multiple habitats or for associated species, the agreement can (and ideally should) be supplemented by a management plan, and it would be expected that IoS for the HLS agreement would be consistent with the desired condition as described in Natural England's Favourable Condition Tables for the SSSI. This potentially added an additional level of complexity to the establishment of some HLS agreements and increased the likelihood of advice and support to the land owner to establish and execute a successful scheme.

3.6.2 Ownership of SSSIs

SSSI ownership is varied, and includes conservation groups, local authorities, utility companies as well as individual farmers. Site ownership has previously been found to be related to the condition status of heathland SSSIs, and this was attributed to the different strength of motivation, knowledge and financial resource available for site management. Unsurprisingly, the highest proportion of sites in favourable or recovering condition were owned by the conservation sector, with other organisations, agricultural sector owners, and individuals having higher proportions of unfavourable declining sites (Brown *et al*., 1998). Similarly, a study of HLS effectiveness on lowland heath habitats by Hewins *et al*. (2017) found that privately-owned heaths were more likely to be outside HO1/HO2 management options, and that heathland sites outside these options were more likely to be in less favourable condition. This survey contained a mixture of both SSSI and non-SSSI sites.

Even within the conservation sector, differences in site condition were observed (see Brown *et al*., 1998), which may represent differences in the level of funding available to the different conservation agencies; even though similar levels of expertise may be found across the agencies, some bodies may face resourcing or logistical challenges which inhibit effective management. Alternatively, certain bodies (e.g. the Wildlife Trusts) may be more likely to acquire new sites in a poorer starting condition, requiring longer intervention times to meet favourable condition. This evidences how the subtleties of site ownership can influence the ability to implement appropriate management, and the trajectories of recovery.

A sample survey of SSSI fen sites (Solly, 2000) found that a relatively small proportion were under the ownership of conservation bodies, with the majority under private ownership. Assuming that private individuals are more likely to require direction in the types of management activities appropriate to improve site condition as well as financial incentives to encourage uptake, AES might be expected to have greater impact on fen SSSIs than habitat types with a higher proportion of conservation body owners.

These studies reveal the importance of considering not only current site ownership, but also site ownership history when assessing outcomes under AES, as this can reveal practical constraints to improving site condition, which could limit the effectiveness of the management prescription. Any assessment of AES effectiveness should consider whether the prescribed management has been carried out as originally intended. Nisbet (2015) refers to the possibility that some IoS target due-dates

could be unrealistic, and do not allow sufficient time for a feature to improve. Site ownership, and the level of resources and skills available, present condition and management history are just some of the factors that should be considered when setting the target due-date.

3.6.3 Multiple designations

The incidence of multiple site designation (e.g. where a SSSI is also subject to a 'higher' designation such as National Nature Reserve (NNR), SAC, Special Protection Areas (SPA) can influence site condition, with higher-designation sites more likely to be prioritised for additional management funding and monitoring. This introduces another level of complexity when trying to establish the effects of AES on SSSIs. For example, Brown *et al*., 1998 found that heathlands were more commonly in favourable or recovering condition when they were not under management incentive schemes, but that these sites contained a number of NNRs, and so the site managers were likely to be better resourced and/or more motivated towards conservation.

3.6.4 External impacts

External impacts, covering those outside the direct control of the site manager, can have a significant impact on site condition. This is highlighted in a study of heathland SSSIs by Brown *et al*., 1998, which found that the main threats to heathland areas surveyed were a result of external parties, including activities such as rubbish tipping, motorbike scrambling, arson, pollution, and hydrological changes. Such external threats were recorded on 50% of the surveyed areas. Recreation and grazing by wild animals were identified as elements that could have either positive or negative impacts on heath condition, depending on the intensity of the activity.

Any comparison of AES outcomes on SSSI should therefore consider whether any significant external impacts are in effect, and whether this allows a reasonable comparison of condition between the sites. However, the condition of the surrounding landscape, which may be hard to quantify, would also influence the longer-term sustainability of the feature. Cao *et al.* (2018) found that the CS targeting approach had led to good landscape connectivity for mobile species such as birds and pollinators, which could support the specific species objectives of some SSSIs.

3.6.5 Targeting of HLS options

When analysing the effect of AES on SSSI condition, consideration should be given as to whether the AES prescriptions applied were appropriate at the time of adoption. Mountford and Smart (2014) found that HLS prescriptions were generally appropriate, but that some habitat/feature types were more likely to be accurately assessed than others. The study found that HLS options were most likely to be well-targeted in moorland and heathland habitats (98% appropriate targeting), and most likely to be inappropriate in grassland habitats (89% appropriate targeting). However, Hewins *et al.* (2017) found inconsistencies in the way HLS heathland options had been implemented; in some cases, the heathland options were applied to non-heathland habitat types, and in others the options were used to apply inappropriate IoS.

Mountford and Smart (2014) concluded that a common cause of inappropriate option allocation was the over-estimation of habitat quality, resulting in maintenance options being applied in areas where restoration would have been more appropriate. This study did not focus specifically on SSSI sites, but included a number of SSSIs in the analysis. It is unclear from the analysis whether HLS options were applied more or less effectively on SSSIs than non-designated sites.

More recently (Cao *et al.,* 2018) in assessing the implementation of CS, found differences in the effectiveness of option targeting depending on the type of habitat in question. The study found that 77% of priority habitat types were under appropriate options, but the variation between habitat types

this was high (between 0% and 93%). Moreover, habitats for which Middle Tier options were available under CS, were less likely to be under appropriate management, whereas more specialist habitats such as reedbeds and coastal habitats, were more likely to be well-targeted.

Clearly, the situation is complex given the changes in AES scheme from ES to CS, the breadth of SSSI habitats, the reasons for designation and the presence of external factors. The next section looks at the issue of motivations and attitudes amongst the agreement's holders and land managers.

4 Agreement holder attitudes and motivations

4.1 Key research questions

AES are viewed as important mechanisms in the delivery of sustainable countryside management in the UK. According to recent reviews (e.g. Riley, 2011), academic literature in geography and the social sciences has long understood farmer engagement and participation as central to scheme success. Primarily, the following review builds on this consensus by reflecting on key understandings of the barriers and motivations experienced by land owners and occupiers to effectively manage SSSIs. Emerging themes from research on AES adoption and implementation are considered (particularly those with an explicit mention of SSSIs), highlighting a more recent aspect of AES research which focuses on the ways in which farmers socially and culturally construct their environments and identities (Burton *et al*., 2008; Fish *et al*., 2003). Finally, it is considered whether AES serve to encourage pro-environmental attitudes and behaviour amongst those with SSSIs and the farming community, with a focus on the factors which are likely to promote such change.

4.2 Theme 1: Beyond economic incentive: the complexity of factors effecting AES participation

In both academic and political literature, farmers and land managers have long been referred to as 'stewards' of the environment (Burgess *et al*., 2000; Natural England, 2009). Whilst there has been much debate about the effectiveness of AES (and how this can be evaluated), there is a common understanding in the literature that farmers, as owners, occupiers, and managers of the land, play a central role in the success of schemes (Riley, 2011). For example, Wilson and Hart (2001) argue that a shift towards conservation-oriented attitudes of farmers through AES participation should be considered a key indicator for assessing the 'effectiveness' of schemes. Therefore, despite disagreement on the ways in which success can be quantified, farmer engagement has been widely considered as an alternative means for determining scheme success. This is confirmed by Mills *et al.* (2011), in a study of a farmer's group in Wales, which found that enhanced environmental outcomes were achieved due to collective commitment-making and a sense of collective efficacy.

Much of the recent literature has stressed the importance of understanding farmers' social and cultural contexts when assessing rationale for farmer participation in AES. One prevalent finding has been that economic reasons, rather than fundamental conservationist attitudes and beliefs, are reported in farmer surveys and interviews as a common factor in willingness to participate (e.g. Cross & Franks, 2007; Wilson & Hart, 2000). However, such literature stresses the importance of understanding farmers' social and cultural contexts when understanding rationale for farmer participation in AES, beyond exclusively focusing on economic rationale (e.g. when farmers are compensated for pro-environmental management practices by annual payments which function to change environmental attitudes and behaviours). For example, Wilson and Hart (2000, 2001) argue that considering farmer motivations for participation in AES as exclusively economic overlooks a complex interplay of social and cultural factors which can have a significant impact on farmers' rationale for scheme participation. Similarly, in their study of farmer attitudes towards the Environmental Stewardship (ES), Cross and Franks (2007) contend that "farmers do not make decisions in a vacuum" (p. 49) - whilst economic considerations have been the primary driving force for farmers to participate in AES, economic issues should not be considered the primary determinant for farmers' decision-making. Overall, social science research has made significant contributions to the ways in which AES participation can be understood as neither constant, deterministic nor reducible to single factors, but resulting from a complex interaction of both individual land manager characteristics and wider social and cultural contexts (Riley, 2011). Ingram *et al*. (2013) highlight that

lifecycle stages can be indicative of different motivations and pathways that have a direct impact on environmental decision-making. These stages might, for example include periods of major restructuring, farm expansion and landscape change or reflect approaching retirement and winding down. Whilst not fixed at any one time Mills *et al.* (2013 & 2017) suggest there are three broad types:

Profit maximisers: Some studies have detected farmers who identify themselves as profit maximisers, whose self-image is focused on running a profitable enterprise, and where environmental concerns are at best secondary, or possibly tertiary uses for quality farmland and generally a distraction from the project of farming. (Mills *et al.*, 2013).

Food producers: Other studies have found farmers who identify themselves as primarily food producers, who have an (moral) obligation to produce food to feed the world, are reluctant to remove land out of production for environmental benefits resulting in low biodiversity maintenance performance (Mills *et al.*, 2013).

Custodians: Those who identify themselves as custodians of the land with an obligation to pass the land on to future generation in a better condition were more likely to engage in environmental activities (Mills *et al.*, 2013). They consider themselves "the kind of person who does this", leading to the incorporation of the behaviour in the self.

4.3 Theme 2: Farmer-scientist knowledge relations

In some branches of AES research, including that which explicitly focuses on SSSI management, there has been a tendency to classify the role of farmers as merely recipients of environmental knowledge and practices which are produced by 'experts' elsewhere (Riley, 2011). Consequentially, there has been a movement in AES research towards exploring different understandings of 'nature', 'the environment' and 'environmental management' held by farmers and conservationists who are participating in the implementation of schemes (e.g. Burgess *et al*., 2000; Morris, 2006). These studies suggest that farmers hold different sets of meanings and values (different perceptions of, and attitudes towards nature and the environment) to scientists, which are constructed through their day-to-day farming practices. For example, Mills *et al.* (2017) found that in the arable areas of Eastern England some farmers viewed and valued game strips as an environmental activity, as they were felt to benefit smaller wild birds. There was evidence of experimentation with seed mixes and a holistic approach to locating these strips across the farm. Mills *et al.* (2013) in their study of 60 farmers' attitudes to the environment identified that those farmers who fully engaged in AES activity had a personal interest in wildlife and particularly birds, often since childhood.

Burgess et al. (2000) make a significant contribution to this literature through their application of actor network theory to compare the role and identity ascribed to farmers by conservationists and farmers' self-constructed identities. They emphasise the importance of regarding farmers and conservation scientists as equal in policy decision-making (specifically concerning the Wildlife Enhancement Scheme, which provided funding explicitly for SSSIs), rather than giving precedence to conservationists as the 'listened to' voice when it comes to knowledge, understanding and action (Burgess *et al*., 2000 p. 120). This disparity between the roles of farmers and conservationists was highlighted in the context of SSSI management, where farmers' identity was constructed as limited to somewhat basic principles. Whilst farmers were treated as 'technicians' possessing the practical knowledge and skills required for countryside management, they were otherwise considered to be 'ignorant agents' who needed to be 'told what to do' by experts possessing the specialist knowledge, understanding and procedures required for successful AES implementation (Burgess *et al*., 2000 p. 124). However, through in-depth

discussions (focusing on the theme of 'translation' whereby particular roles and definitions are imposed onto others) with farmers it was revealed that, to an extent, the translation of their identities as purely managers of SSSI land was resisted. Instead, farmer identities were constructed through their long farming histories and the perceived rigidity of scheme prescriptions was contested. Burgess *et al*. (2000) conclude that 'neither farmers nor conservationists know best' and call for an approach which recognises the complexity of understandings of the environment and environmental management (p. 131). There is also evidence that increased networking and the building of close relationships among farmers, is more likely lead to sharing of information and knowledge and collaborative work. Mills *et al*. (2011) found that through group sharing of information, as well as, raising the visibility of individual farmer practices with their peers, perceptions of what is deemed acceptable behaviour becomes more explicit.

This theme of farmers being 'partially enrolled' in scheme prescriptions holds significance for more contemporary AES research (Riley, 2011). Reiterating findings from earlier attitudinal research in relation to successful AES implementation, Morris (2006) challenges the prioritisation of conservationists' knowledge and understanding in AES. Utilising the notion of 'knowledge culture' (that is, 'policy' versus 'agrarian' knowledge cultures), she reveals the 'porosity' of the boundary between state-led and farmer approaches to understanding nature – arguing that farmer identities are indeed constructed in a relatively constrained manner (Morris, 2006 p. 125). Notably, however, Morris (2006 p. 125) highlights a temporal aspect to the constructive exchange of knowledge between farmers and AES personnel, providing evidence that many farmers in fact were able to readily accommodate the 'policy knowledge culture' of AES after having experienced perhaps several AES agreements over a long period of time. Therefore, if farmers and conservationists can engage in constructive dialogue over time, then AES policy can both accommodate and benefit from farmers' expert agrarian knowledge – contributing to the overall successes of particular schemes. In addition, farmer engagement is increasingly considered an important influence on environmental decision-making, which is defined as an 'active engagement in environmental learning through advice and support networks' (Mills *et al*., 2017).

4.4 Theme 3: Changes in owner and land manager attitudes and behaviour

Engagement in an AES has been shown to increase awareness of environmental issues and make farmers more conscious of the environmental impact of their management actions (Mills, 2012). Developing a better understanding of farmers' behaviour regarding AES is often considered to advance further improvement to schemes (Schroeder, 2015). Whilst research has traditionally understood that participation in schemes is expected to cause observable changes in farmer attitudes and wider farming cultures (Riley, 2011), more recent studies (usually drawing on surveys or interviews with farmers with a longer history of scheme participation) have pointed towards less deterministic and more complex relationships between AES participation and pro-environmental attitudes and behaviour. In their study concerning the success of ESA and the previous CSS schemes, Fish *et al*. (2003) explore how participation in AES might encourage land owners and managers to become more 'committed agents' of environmentally friendly farming (p. 22). Although they find that over 90% of land managers surveyed 'responded positively when asked whether they were in sympathy with the conservation goals of the schemes', they reflect that this does not guarantee that attitudes are evolving due to scheme involvement (p. 23) – citing Wilson and Hart's (2000) findings that financial imperatives often accompanied conservation ethos. They critique efforts of previous research to 'typologise' farmers as either 'adopters' or 'nonadopters' of schemes as limited, concluding that levels of participation and relative success of schemes is likely much more complex than previous

behavioural research might suggest. Several evaluations of AES have identified a dislike of the paperwork involved (Mills *et al*., 2012) and of the AES administrative systems employed (Short *et al*., 2018; Staley *et al*., 2019).

In a study of perceptions of AES amongst 32 farmers (over half of which managed land identified as a SSSI), Schroeder (2015) applies the 'Theory of Planned Behaviour' (a psychological theory which links individual beliefs to actual behaviour). He found that despite generally positive attitudes towards particular schemes, these beliefs were complex and based upon a variety of ecological, landscape and social factors such as environmental quality and family pressures on environmental decision-making. Similarly, Fish (2014) makes a strong case for understanding the formation of attitudes and behaviours towards CSF in the context of wider structural, habitual and social factors which may serve to motivate or inhibit farmers' capacity to act environmentally. For example, those who had heard of, or interacted with the CSF Project were more likely to say that agriculture contributes at least a little to water pollution in their area (High Priority Areas: 91%; Moderate Priority Areas: 90%) than those who had not heard of, or interacted with the CSF Project (High Priority Areas: 75%; Moderate Priority Areas: 73%) (MORI, 2016). Comparatively, Carey *et al*. (2003) argue that monitoring the success of AES based on a single objective (e.g. exclusively environmental, social, or economic) does not reflect the complexity of scheme impacts, calling for a multidisciplinary and multi-objective approach towards agri-environmental monitoring and evaluation (p. 72).

The injection of multidisciplinary theory into AES research has made significant contributions to understandings of changing farmer attitudes and behaviours towards agri-environmental policy. Burton and Wilson (2006) critique 'traditional' behavioural studies which have adopted relatively deterministic and homogenous views on transitions in farmer self-identity, focusing on single attitudinal and behavioural attributes which imply 'positive' environmental management practices (p. 110). They introduce the socio-psychological and human geographical concept of 'self-structure', which when taken in the context of farming implies that dichotomising the typologies of farmers as either 'conservationists' or 'non-conservationists' overlooks the complex and multidimensional identities which farmers construct for themselves. Instead, Burton and Wilson (2006) suggest that the attitudinal and behavioural aspects of environmental management should not be considered as mutually exclusive. In a more practical sense, whilst current agri-environmental policy might foster a strong conservationist and pro-environmental climate, farmers' self-conceptualisation may not always mirror this - highlighting a potential 'gap' between policy and individual-level attitudes and behaviours. Burton *et al.* (2008) extend on this deviation in environmental attitudes by critiquing AES for limiting innovation and entrepreneurship in conservation amongst farmers, suggesting that for more sustainable agri-environmental policy, decision-makers should provide more opportunity for such change rather than focusing on providing financial rewards for environmental behaviours.

4.5 Review of NE reports

The Staley *et al*. (2019) report detailed the resurvey of a sample of HLS agreements (surveyed 6-7 years previously in Mountford *et al.* 2013), to assess environmental outcomes and in particular change in plant communities over time in relation to AES management. This included a semi-structured survey to quantify agreement holder characteristics and experience to test the relationship between these social attributes and environmental outcomes, in addition to quantifying the contribution of geographical and physical variables to environmental outcomes. In total, 173 HLS agreements, widely distributed across England, were resurveyed in 2015 and 2016. These agreements had been selected for baseline survey in 2009-11. A key finding of the research was that HLS agreement holders were

often over confident about achieving IoS. IoS were more likely to be met on agreements with SSSI land present. Overall, ecological change was difficult to determine on the re-surveys but change was noticeable on some lowland creation or restoration options, for example lowland heath or some grassland options. There was no analysis comparing agreement holder values and attitudes and the presence of an SSSI alongside the HLS agreement.

Catchment Sensitive Farming (CSF) is a voluntary initiative delivered by Natural England in partnership with Defra and the Environment Agency that started in 2007. CSF offers free practical advice to farmers and grant support for infrastructure improvements to reduce diffuse water pollution from agriculture (DWPA) across the priority areas for water in England. Evaluations of CSF have shown it to be a successful model for farmer engagement over the past decade (Evans *et al*. 2016 and Cook *et al*. 2016). The Ipsos MORI survey interviewed 250 farmers across 40 catchments in Spring 2016 and the review looks back across early evaluations from 2007 involving over 4,000 farmers. Many of the water courses involved would include some designated as SSSIs, and the farmers involved may themselves have SSSIs. Their involvement with CSF and resulting grant applications, potentially involving Countryside Stewardship since 2015, means they are aware of AES. The evaluation shows an increased awareness of the link between agriculture and water pollution and the potential for changes in practice to improve water quality. There is potential to separate out to see if those with SSSIs (land or river) or close to them have different views from those not close to SSSIs, assuming they are aware of the presence of the SSSI.

Beale (2017) undertook a qualitative survey of 57 SSSI land owners and managers, of which 41 were in AES. A range of positive and negative views were received, suggesting that the relationship between NE and SSSI land owners and managers is complex. Where it worked well it was a positive driver to the management of the SSSI, where the relationship was less than optimal this had a negative impact on the way in which the land owner / manager approached the management of the SSSI. A common thread that was present through every section of the survey was the lack of value land managers felt was given to their local and farming knowledge and experience, which is reinforced by the literature (Ingram *et al*. 2016).

Countryside Stewardship (CS) was launched across England in 2015. A recent project (Jones *et al*. 2018, Cao *et al*. 2018, Short *et al.* 2018) was to assess the quality of CS implementation in the first two application years and to understand the factors which have influenced landowners to apply (or not) their choice of options, the suitability and use of application support and advice and whether changes to the scheme and associated process could improve scheme implementation and applications. This project considers applications to multi-annual MT and HT agreements, including those with water capital grant and woodland agreements. In Phase 1 of the project, 170 interviews were undertaken between July and September 2016. In Phase 2, 246 interviews were undertaken between September and November 2017. Respondents were categorised according to the type of CS agreement applied for and the final outcome of any application made. Advice was central to the development of CS applications. There was a shift in the use of advice between Phase 1 and Phase 2, with a notable growth in the use of their own adviser by applicants in all categories with the level of influence the own adviser had on the agreement also growing. The survey also interviewed those who had withdrawn from CS, even though they were offered an agreement. There was no specific analysis according to SSSI ownership.

4.6 Evidence gaps in the literature

In terms of the motivational and attitudinal literature in this area, there is a lack of longitudinal studies, which are able to consider changes in farmer and land manager attitudes, behaviour and or motivations over time. In the context of this study it would be particularly beneficial to assess the influences on, and influence of, AES participation on the management and enhancement of SSSIs. The lack of a counterfactual in the context of how the motivations and attitudes of SSSI owners differ depending on whether you have or do not have an AES would also be relevant, as well as the vice versa situation.

The literature review has shown that a range of methodological approaches have been utilised from across the social science discipline. Increasingly this is a mixed-methods approach and often within inter or trans-disciplinary projects. Such approaches are more effective in capturing the complexity of farmer attitudes and behaviours, and in particular actions associated with environmental behaviour and the consequences arising from these actions.

The AES studies, especially those linked to M&E, tend to have an exclusive focus on one particular agri-environmental scheme, e.g. ES or a tier within a scheme e.g. HLS or MT. The connection to SSSIs, and therefore the influence on environmental attitudes and behaviours amongst land managers can be diluted as a result and the potential for re-analysis is reduced. There remains potential for re-analysis given the strong association between SSSIs and the higher tiers within both ES and CS, namely HLS and HT but this is limited by the initial lack of focus on SSSIs.

A specific study looking at SSSIs would need to recognise the complexity of SSSI habitat types and management, particularly the process of negotiating long-term management from an economic transaction perspective (see Falconer, 2000). The long-term engagement with AES should also be an important factor and the associated pathway of the farm business (Ingram *et al*. 2013) as well as the advice and support received (Mills *et al*. 2017). This may apply to all land which is designated, not just SSSIs. An assessment of the associated management costs and the role of AES in meeting the required funding is another potential line of enquiry.

The issue of land ownership in relation to SSSIs, especially those who might be under-represented in other surveys has not been assessed for over 20 years according to our searches. Changes in the type of land manager may be important in terms of how to engage with them. The literature on engagement has developed strongly over the past decade and a much more inclusive approach is clearly the way forward. There is an evidence gap as to how such approaches relate to SSSIs specifically. Here the MOSS scheme in NI, which specifically focuses on sensitive sites, might provide an interesting example.

The next Section brings together the findings of Task 1 and 2 and considers the current evidence base and its shortcomings.

5 Summary of the current evidence base and evidence gaps

5.1 Process related evidence gaps

The current evidence base, from an ecological point of view, suggests that while there is a great deal of data from both an ecological condition perspective and on the effectiveness of different AES programmes and the various tiers within them, the two areas are not as well aligned as they could be. The following key points were noted:

- Most of the management interventions prescribed under AES schemes are underpinned by ecological research to improve and maintain ecological condition of particular habitats;
- The time taken for habitats to reach favourable condition varies widely for different habitat types and depends on the starting condition, as well as the type of management and external influences as discussed in detail in Section 3;
- Habitat restoration can be a relatively slow process, potential longer than the duration of a 5 or 10-year AES agreement. What is clear is that progress will in many cases may take longer than the length of the scheme and rates of recovery will be variable across habitats; and
- Even where sites have a long history of management under several AES schemes, establishing a causal link is difficult as each scheme changes, introducing the possibility for a change in management focus and option targeting.

The literature review identified a large range of studies that assess the performance of AES over time and during the successive schemes, often providing data to National Vegetation Classification (NVC) level or detailed information on IoS against specific management options. However, it is a common feature that SSSIs are not separately identified either in surveys or analysis. In many cases, due to the strong link between the higher tiers of successive schemes (e.g., HLS and HT) and SSSI it is likely to be possible to address some of the evidence gaps through re-analysis by correlating SSSI location and AES focused data. However, this does not replace the need for robust and consistent baseline data to repeated protocols based around the favourable and unfavourable recovering categorisations.

Two specific studies highlight the issue of alignment between AES programmes and SSSIs. First the baseline study (Mountford *et al.* 2013) and subsequent re-survey of HLS agreements (Staley *et al*. 2019), which found that HLS IoS were not consistently aligned with SSSI targets. While IoS were intended as an easily accessible summary of the intended outcomes from an AES agreement the delivery proves to be challenging in practical terms. IoS needed to be based on evidence but also consistent so they aligned with scheme rules and this made local context difficult to incorporate. The second report (Nisbet, 2015) found that in only 30% of cases were the Integrated Site Assessments (ISA) completed on HLS sites where there was an SSSI. As a result, connecting the HLS with the SSSI was made significantly more difficult.

As hinted above, the processes associated with both AES and SSSIs make alignment challenging. Traditionally AES programmes change in terms of priorities, structure and format every decade or so, as indicated in Figure 2. Changes in scheme priorities were behind the stronger link between the management of SSSIs and HLS under ES and this has continued through to HT under CS. However, given AES is a voluntary programme there will be farmers and land managers who join as well as leave. Other changes such as the advice and support received will also have an impact.

There was also variation in the ~4,100 SSSIs across England as they cover different habitats and features. This report has explicitly focused on the ecological aspect of SSSI, rather than the geological. Even here the list of priority habitats was quite extensive and not evenly spread across these habitat types or the English counties. Consequently, where there was an attempt to assess both AES agreements and SSSI habitat condition, as in Staley *et al*. (2019), the results were drawn from small

samples. Consequently, there was difficulty in deriving robust results that can be scaled up to particular habitats or SSSIs more widely. The strongest studies were those which assess a particular habitat type, but these were only relevant to that habitat rather than AES programmes or other SSSIs.

5.2 Evidence related evidence gaps

One of the clear evidence gaps within the ecological aspect is the lack of a robust update to the 2003 evaluation of habitat condition by Natural England's predecessor English Nature (EN 2003). Whilst there has been continuous monitoring and condition assessments since 2003, this has not been part of a 6-yearly cycle of assessment. As a result, there is no robust stratified evidence to determine the changes in SSSI condition since 2003. This also coincides with the period of highest investment in AES through the HLS agreements linked to SSSIs. The 2003 data does form a sound baseline against which any new assessment can be checked. However, while the current monitoring suggests that the condition of SSSIs is stable and flat-lining, this is not a robust approach as the total number of sites involved in monitoring are small and selected on perceived risk rather than a statistically sound manner and so cannot be extrapolated to the whole population.

The proportion of SSSIs receiving condition assessment visits each year is also low and falling. Over the past six years only 15% of SSSIs have been assessed, a rate of between 2-3% a year (Everett, 2019) and the process of selecting these is those that are thought to be at risk. Consequently, any scaling up of these results needs to be treated with extreme caution due to the nature of the sample and it undermines any conclusions that might be drawn on the links to AES. Using the 2003 data based on the comprehensive SSSI assessment might be acceptable as a baseline in order to assess the impact of close to 20 years of AES.

The approach to AES monitoring and evaluation could involve SSSIs more centrally, especially where this is a significant part of the agreement being accepted. This is most notable in the HT and previously HLS tiers of CS and ES respectively. Since this was, or is, the case it should be recognised in the M&E evaluations, notably through determining value for money or accounting for the best use of public funds.

There is also a key evidence gap concerning habitats or other features of SSSIs that are less commonly found under AES agreements, meaning there is a lack of strong baseline data for target features such as lowland bogs, freshwater and coastal features such as sand dunes and salt marsh.

The review of the attitudinal and motivations literature shows the picture to be complex and covering a range of factors. These include an understanding of AES participation, which Dwyer *et al*. (2007) outlined as a combination of willingness, capacity and engagement. Whilst economic factors remain important, a range of other factors are also involved such as the long-term survival of the business, family succession, tradition and emotional attachment to the location and culture. Much of the recent literature has stressed the importance of understanding farmers' social and cultural contexts when assessing rationale for farmer participation in AES. The relationship between farmers and land managers and conservation experts is another area of exploration in this set of literature. The conclusion is that the more farmers and land managers are enrolled in the AES and SSSI management, the more their behaviours and motivations are likely to align with the anticipated outcomes of the AES and SSSI management plan.

All of this is helpful in terms of future thinking. However, it is more problematic in terms of looking back as such an approach is partially compromised by the inability to determine a causal link. This is the focus of the next section that assesses the potential for re-analysis going forward.

6 Opportunities to close evidence gaps through re-analysis

Previous sections have analysed and reviewed publications identified in Tasks 1 and 2 (Sections 3 and 4 respectively) as those holding data that may be suitable for re-analysis. The re-analysis might be able to fill some of the evidence gaps highlighted in Section 5 in or der to determine the impact of AES on SSSI from ecological and attitudinal perspectives.

As noted in Section 5, ecological surveys often collected data on relevant IoS to measure the effectiveness and impact of the prescribed AES option, there was not always a strong link between these IoS and the SSSI Condition Assessment criteria. Staley *et al*. (2019) note that IoS frequently are referred to as the most deficient element in agreement development, being often too general, not tailored to individual parcels of variable initial condition and not linked to targets set in SSSI favourable condition tables. This is a major issue to be addressed in any future re-analysis and likely to considerably reduce the value of otherwise spatially corresponding survey data in its ability to lead to meaningful conclusions of the impact of AES on SSSIs.

Looking at the habitat types that are most widely covered by the extant set of data, for example, lowland habitats such as grasslands and other habitats commonly present on farmland are proportionally over-represented in the data available for re-analysis. This is likely to be directly related to scheme uptake rates over time and which options have been repeatedly surveyed. In the existing survey data there is generally either a broad, large-scale targeting nationally or regionally which can result in low sample numbers for less frequent habitats and a lack of site-specific re-surveys or a spatially narrow focus on specific features with detailed data collections over a longer time period. As the Jones *et al*. (2018) survey of CS uptake indicates, a small number of options are disproportionately represented in agreements with only 19 options present in more than 5% of agreements and 26 options accounting for 75% of annual payments.

Datasets have commonly been collected in standard formats with Defra or Natural England holding the Intellectual Property Rights (IPR). However, a large number of different contractors have been involved over time in the gathering of survey data and it is likely that considerable differences exist in their internal data management protocols. This would have an impact on the ease with which data could be re-analysed, unless survey data organised to a common format was a specified deliverable of the respective contracts. The benefit of re-analysing data collected under the Defra and NE IPR is that it is likely that the SBI was used for sampling purposes. Where this is the case, the identification of those with an SSSI on all or part of the holding would be relatively straightforward as long as the SBI can be related to those parcels on the respective SSSIs with options present. However, this is not always straight forward as a condition of the CSF evaluation (Evans *et al*. 2016) was for the holding details to be destroyed once the survey was complete.

AES schemes in England have evolved in several successive iterations since 2000 and while a large number of ground surveys have been undertaken during this time, the collection of data for M&E is frequently undertaken to address detailed, scheme-specific questions, which does not always lend itself to re-analysis or to being integrated into a wider monitoring dataset for SSSIs. The more recent AES, namely ES and CS, cover the past 14 years or so and have the advantage of being divided into standard and higher levels. The presence of SSSI is most likely in the higher tiers where AES management can be more tailored and demanding.

When considering the impact of a single AES on SSSI condition these factors are heightened as the survey period relevant to the lifetime of the schemes might be shorter than allows for robust assessment of condition outcomes for many target features. Alternatively, surveys are undertaken too early after

the initial implementation of the scheme to allow for significant change. This underlines the need for robust and consistent baseline data.

Where a SSSI falls in and out of agreement over time this would also be a complicating factor, as there may not be continuity of management, but it is currently unknown how common this is. The survey by Beale (2017), while focused on only a few responses, shows the impact that frequent changes in project officer can have on the continuity of management of SSSIs. The initial survey on CS implementation (Short *et al*., 2018) may include a few SSSI owner/manager respondents who have not secured CS agreements for a range of reasons.

On the wider issue of agreement holder attitudes and motivations there is an increasingly detailed body of literature that supports the notion that the presence of an AES agreement is more than a solely economic transaction for farmers and land owners. Whilst important, it is one of a range of factors that influence the level of engagement and capacity to deliver AES options and improved SSSI condition. The involvement of farmers and landowners in AES developing agreements alongside conservationists is also a widely reported approach as this accommodates local knowledge and benefits from merging agrarian and ecological knowledge thus contributing to the overall successes of particular schemes. However, such innovation is limited to a small number of locally based programmes. Studies where environmental behaviour has been included show a wide range of views and confirms that famers and landowners are not a homogenous group. There is no reason to believe that owners and managers of SSSIs would be any different. Therefore, the typologies and grouping of large AES studies offer some potential for re-analysis in this area. However, lack of specific focus on the SSSI's and owners attitudes towards them within the data collected is very likely (alongside other factors discussed) to constrain the potential to draw robust conclusions about the success of the schemes for SSSI's.

In conclusion, there is a large body of survey data collected over the respective periods of successive AES in England, notably under ES and CS, however SSSIs rarely explicitly identified in the analysis. This suggests it may be possible to create a locational link in any subsequent analysis. However, this is likely to be a considerable undertaking and a lot of careful consideration would have to be given as to how to align data collected under changing schemes with evolving objectives and indicators of success over time. Additionally, integrating these with robust measures of condition for the wide range of target features on SSSIs in order to arrive at meaningful conclusions about the impact of AES schemes on SSSI condition would be challenging.

7 Conclusions and parameters for potential re-analysis

Neither SSSIs nor AES can be treated as homogenous entities. AES undergo regular changes in priorities and processes while SSSIs are often highly specific sites with varying habitats, landscape contexts and different management requirements. Both AES and SSSI are subject to various owner arrangements and have particular local contexts that will also influence the circumstances concerning management. Consequently, it is challenging to monitor condition changes on such sites effectively while maintaining a consistent approach, not least because these elements are subject to change.

In the habitat specific studies, the impact of AES on SSSIs is most clearly visible. Here AES were found to be improving these habitats. However, this is not being seen across all SSSIs because SSSIs are not a homogeneous group (Section 3.4). This suggests that a targeted approach towards re-analysis would be best suited to both AES and SSSIs.

In developing future programmes and M&E the findings of this report suggest that there would be mutual benefits, in terms of accounting for public funds provided to AES and for assessing ecological condition of prime nature conservation sites, for there to be a strategy of greater alignment in both monitoring approaches and targets on AES and SSSI. The connection would operate at national, regional/landscape-scale and local (e.g., site-specific) levels. This would establish a consistent pathway to feed data into a larger evidence database to track condition change trajectories over time. The study suggests that while such data exist, the lack of a common protocol of habitat definitions means that the results cannot be linked because they were prepared to meet different priorities.

As detailed in Sections 5 and 6 above, one of the main factors hindering the connection between AES data with regard to SSSI condition is the lack of the alignment of AES IoS with SSSI condition targets. The intention was to provide a stronger connection but this was not fulfilled, possibly because of tension between the need to audit scheme outcomes and the consistent application of prescriptions. The impact on SSSIs, which are likely to require specific locally tuned management, is not clear.

A greater integration of the monitoring of AES and SSSIs is required in order to establish a causal link between AES and SSSI condition as outlined in the objective for this report.

In terms of possible options in the development of future programmes, the review of the literature suggests that it would be worth considering:

- Having an AES tier that is dedicated to SSSIs, perhaps similar to the 'organic' options in both ES and CS. There is an example from Northern Ireland, the Management of Sensitive Sites scheme (MOSS) run by Department of Agriculture, Environment and Rural Affairs (DAERA) in Northern Ireland. Norton and Bealey (2018) in reviewing the scheme note the need for '*robust and reliable evidence to underpin changes in conservation status*'.
- Including the identification of SSSIs within future surveys of AES M&E to ensure integration as a standard feature. This will increase the data available for the assessment of the impact AES have on SSSI recovery and the attitudes of farmers and land managers in a cost-effective manner. For this to be effective, it would also be essential that AES IoS on SSSIs parcels are aligned with the respective targets in favourable condition tables and that monitoring protocols are consistent across AES and SSSI strands.
- Using the EN 2003 report as a baseline to construct a statistically robust systematic review of SSSIs across all priority habitats and regions that reports regularly, e.g. every generation (25 years), so the ecological condition of the best sites in England can be assessed. This would underpin the regular condition assessment monitoring and highlight areas of concern.

- The current rate of annual SSSI survey is slow and the means of selecting the sites is intentionally biased, meaning that there is never a point in time where a representative and current picture across the whole SSSI population or for particular habitats is available. The potential of remote sensing and self-monitoring by farmers and land managers is something that should be further explored to expand the monitoring and retain cost effectiveness.

There is some potential for re-analysis of existing data, as highlighted in the next section.

8 Data sets potentially suitable for re-analysis

This section outlines the parameters for any future re-analysis of existing data and summarises the focus of the studies that have been identified within this project, with a specific focus on the impact of AES on SSSI recovery. Each publication is individually summarised under key considerations of its utility for any future re-analysis.

Accessibility of the original data sets referenced in these studies will be essential to successful re-analysis but it is outside the scope of this report to assess this. It is assumed that most datasets will be available to NE as they were originally collected during work for the organisation. However, checks against GDPR compliance will need to be made.

The publications below have been highlighted as key sources for analysis as they either reference large-scale data that is extensive in its spatial scope across England and potentially contain a high number of SSSIs, albeit with varying proportions of key feature (Nisbet, A. 2015) or considers a single habitat in specific detail (Wheeler *et al*. 2014 and Hewins *et al*. 2017). However, none of these papers collected data to answer specifically the main research questions which this report has examined. Therefore, the purpose of these studies was different and this has to be considered during any re-analysis. The seven suggested are shown below, together with a brief justification.

8.1 Hewins, E., Groome, G., Mellings, J. and Alonso, I. (2017)

Justification: Includes comparisons to non-SSSI sites and is working from a strong baseline but specific to lowland heathland only.

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Hewins *et al*. (2017) A field survey to evaluate the outcome of higher-level stewardship options on lowland heathland. Natural England, ESME Heathland Project.	HLS and SSSI comparison with non SSSI sites	H01, H02 Lowland Heathland	116 SSSI sites	National	CSM targets used to compare all sites. Two-tailed t-tests. Chi-square tests,	NE	2015-2016
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			Covers sections on SSSI datasets generally, details of non-SSSI data compared to SSSI site. Project found inconsistencies in the way the heathland options have been implemented in HLS agreements.				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			N/A				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			Landowners may need further encouragement to improve heathland sites.				
SSSI habitat coverage – even coverage or specific focus;			Specific focus is on heathland and AES				
Links to other datasets in a similar format;			Yes, statistician reviews of relevant data sets mentioned in the methods. Extensive references to other studies.				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Yes, the paper is referring to a previous study from 2005 so this is already a revisited study.				
What was the data collected for?			To assess the effectiveness of the heathland H01, H02 for the restoration of lowland heathland from neglected sites				

8.2 Mountford, O. and Smart, S. (2014)

Justification: Extensive survey data collection to NVC standard, including a large number of SSSI sites.

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Mountford & Smart (2014), Assessment of the effect of Environmental Stewardship on improving the ecological status of grassland, moorland and heath.,NECR156, Natural England Commissioned Report.	Mainly Environmental Stewardship (ES), Environmentally Sensitive Areas (ESA's) and Countryside Stewardship Scheme (CSS). Does not mention SSSI.	Appears to be multiple sources with primary survey data taken from other data sets. Examines whether management is having desired impact on status of the site.	Large data set drawing on data from more than 1500 data sets, across England. Range of habitats covered e.g. grasslands, 'agricultural land', heathland, moorland, fen and bog.	All England data sets used.	MAVIS, Proc Mixed and Proc Glimmex	Standard. IPR with Natural England	Survey findings originally reported in reports dates 2010 - 2014
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.	No direct reference to SSSI relationship with AES. However, extensive NVC data held for various habitat types, along with information on trajectory of progress/objective realisation.						
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.	N/A						
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.	N/A						
SSSI habitat coverage – even coverage or specific focus;	SSSIs not considered in paper, but habitat spread largely related to 'agricultural' assemblages (grasslands, heath etc.)						
Links to other datasets in a similar format;	Yes, extensive referencing provided. Extensive referencing to original data sets from which this report has been extrapolated.						
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.	Yes, if site-specific data included in the report can be overlain with SSSI site boundaries and citations.						
What was the data collected for?	The study looks at the ecological status of key habitats: grassland, heath and moorland within and out with HLS agreements.						

8.3 Nisbet, A. (2015) Integrated Site Assessments 2013/14

Justification: 30% of Integrated Site Assessments link SSSI with HLS agreements resulting in potentially good source for re-analysis. This link is acknowledged but not examined further.

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Nisbet, A. (2015), Integrated Site Assessments 2013/14 – A report on Natural England's assessments of Sites of Special Scientific Interest and Higher Level Stewardship agreements. Natural England Research Reports, Number 061.	AES, HLS with links to SSSI via ISAs	Multiple sources. Correlative analysis of datasets to assess the degree of success in the delivery of ES objectives	2187. 30% of 2187 Integrated Site Assessments ISA's completed on SSSI and HLS sites.	Generally national coverage.	Software used, Database ISAT.	Standard. IPR with Natural England	2013/2014
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			Relates indicators of AES success directly to SSSI habitats but does not refer to SSSI condition.				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			N/a				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			N/a				
SSSI habitat coverage – even coverage or specific focus;			Wide range of habitats and national species				
Links to other datasets in a similar format;			No references provided				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Yes. Success indicators maybe useful.				
What was the data collected for?			The aim is to evaluate how well Government funded agri-environment interventions are providing improved trajectories towards the planned objectives of the schemes.				

8.4 Wheeler, B., Wilson, P. and Bealey, C. (2014)

Justification: One of few studies with temporal depth comparing AES on SSSIs and non-SSSIs but specific to lowland wet grassland only

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Wheeler, B., Wilson, P. and Bealey, C. (2014) The long-term effectiveness of Environmental Stewardship in conserving lowland wet grassland. Report to Natural England.	ESA's HK6, HK10, HK7, HD10	Multiple sources.	99	Clusters within England	N/a	Standard. IPR with Natural England	2012
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.	Extensive NVC data for target habitats within ESA's. Differentiation of SSSI and non-SSSI.						
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.	No						
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.	No						
SSSI habitat coverage – even coverage or specific focus;	Lowland wet grassland						
Links to other datasets in a similar format;	Reference made to previous 71 sites studies in the 1980's and 1990's						
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.	Yes, data distinctiveness between species richness in SSSIs and non-SSSIs.						
What was the data collected for?	Botanical comparison of SSSI and Non-SSSI sites to see how ES had influenced condition.						

8.5 Initial Evaluation of the implementation of Countryside Stewardship (2018)

Justification: Data from CS via agreement holder and applicant surveys and analysis of overall uptake analysis but no specific consideration of SSSIs or comparison with non-SSSIs.

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Jones *et al*. 2018 / Short *et al*. 2018 / Cao *et al*. 2018 Initial Evaluation of the Implementation of Countryside Stewardship (CS) in England. Objectives 1, 2 3 & 4: Initial Evaluation of CS Implementation. Final Reports to Natural England.	CS new applicants only. No specific mention of SSSI in process	Agreement holder & applicant experience of CS application process in 20015-6	416 agreement holders drawn from HT, MT, water capital grants and woodland agreements + unsuccessful HT & MT and non-applicants	CS agreements throughout England via SBIs	AH data analysed with SPSS (Objective 1) cross tabs, non-variant analysis) and Probit regression model (Objective 4)	Standard data formats. IPR with NE	AH survey = 170 in 2016 & 246 in 2017. All CS agreements in 15-16 assessed including option choices

Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.	Objective 2 report has good analysis of option take up, including spread of uptake (only 19 options in >5% of agreements; m26 options account for 75% of annual payments. The degree of change between ES and CS is assessed including move towards or away from options that are more beneficial.
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.	Advice was central to the development of CS applications. There was a shift in the use of advice between Phase 1 and Phase 2, with a notable growth in the use of 'own adviser' in all categories with the level of influence the own adviser had on the agreement also growing.
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.	The survey also interviewed those who had withdrawn from CS, even though they were offered an agreement. There was no specific analysis according to SSSI ownership or management
SSSI habitat coverage – even coverage or specific focus;	Unknown how many SSSIs or habitats included in the survey or in the analysis of all CS agreements but link to SBI means this could be determined in any re-analysis.
Links to other datasets in a similar format;	CS agreements and option choices compared back to ES to see what has not been dropped or adapted. AH asked about land moving between schemes.
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.	Yes, reasonable potential, large proportion of HT agreements will be linked with SSSIs (whole or part) and total analysis of CS agreements would show SSSIs included or dropping out of AES. SSSI was not a key variable within analysis so re-analysis would add too existing report. Would be possible to compare view towards CS and use of advice where SSSI present or not, including characteristics of AH. In addition, CS option take up on agreements where there is an SSSI compared to those without.
What was the data collected for?	Part of M&E framework assessing processes involved in implementing a new scheme experience and transition between old and new options.

8.6 The environmental effectiveness of the Higher Level Stewardship scheme (2018)

Justification: Data arising from re survey of HLS agreement holders involving both ecological and attitudinal analysis resulting in suggested motivation-based typologies.

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Staley *et al*. (2019) The environmental effectiveness of HLS scheme; Resurveying the baseline agreement monitoring sample to quantify change between 2009 and 2016 ECM 6937, Natural England Research report [Link]	HLS only. SSSI protocols included condition assessment on overlap between SSSI and HLS	Ecological change from baseline to resurvey, impact of options. Agreement holder characteristics	173 HLS agreements, of which 103 had SSSIs. Random stratified sample. Ecology survey and face-to-face interview	HLS agreements throughout England. SSSI parcels assessed using Common Standard Monitoring.	Multivariate analyses of vegetation data and Chi2 tests. AH data analysed with SPSS (cross tabs, Chi2 test) and QSR NVivo (text).	Standard data formats. IPR with NE	Original survey 2009-11, resurvey 2015-17.

Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.	Little evidence of change on majority of habitats, change most likely in lowlands. Indicators of success most likely to be met or progressed on land with SSSIs. Use of positive and negative indicator species assessed as useful. HLS schemes with SSSIs more likely to meet IoS.
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.	137 interviews carried out (80% response rate) of which 86 (63%) had SSSIs within their agreement. Most had been in an AES agreement before. 50% see significant benefit from HLS. Role of advice clearly important. Level of commitment to AES (not SSSI) split into 3 groups (low/intermediate/high).
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.	Proposed 4-group HLS typology (extensive experience/low level engagers/formal experience only/no-previous experience). Financial support, fit with farming system, continued environmental work and Altruistic proposed as 4 motivation HLS types. Neither assessed for SSSIs.
SSSI habitat coverage – even coverage or specific focus;	Most main habitats covered but 173 over all means individual numbers per habitat are not high. 110 parcels on 64 HLS agreements where SSSI was present covering 17 habitat types. Overall 103 agreements have SSSI
Links to other datasets in a similar format;	Nothing highlighted but Chapter 8 combines the ecological and AH data. HLS options split into maintenance/arable/creation/restoration.
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.	Yes, good potential, large proportion of HLS agreements SSSI (whole or part) and combines ecological and AH characteristics. SSSI was not a key variable within analysis so re-analysis would build on existing report. Would be possible to compare effectiveness of HLS where SSSI present or not, including characteristics of AH. Useful typologies developed that could be extended to cover SSSIs motivations and attitudes.
What was the data collected for?	Resurvey of HLS schemes involved in baseline (Mountford 2013)

- The original baseline survey would also be a useful source in any reanalysis

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Mountford, J.O., Cooke, A.I. (editors), Amy, S.R., Baker, A., Carey, P.D., Dean, H.J., Kirby, V.G., Nisbet, A., Peyton, J.M., Pywell, R.F., Redhead, J.W. and Smart, S.M. (2013) Monitoring the outcomes of Higher Level Stewardship: Results of a 3-year agreement monitoring programme. Natural England Commissioned Report, Number 114	HLS	Grasslands	174 (field survey) Partly stratified	National	Oracle 10g Relational database Anova	Standard format IPR with NE	2009-2011

Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.	Extensive survey data collected to NVC standard. With progress against HLS objectives measures against recognised parameters and indicators of success. Two thirds of sample sites included SSSIs (112 samples). However, despite extensive analysis, the authors have not compared SSSI and non-SSSI data sets
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.	Refers to stakeholder workshops as a means of understanding perceptions of scheme efficacy and success.
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.	N/a
SSSI habitat coverage – even coverage or specific focus;	Specific to grasslands.
Links to other datasets in a similar format;	Yes. Extensive referencing.
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.	Yes, although a comparison of SSSI and non-SSSI has not been made, it appears that the data could easily be reanalysed to provide valuable insight.
What was the data collected for?	Report of the findings of a 3-year monitoring programme of HLS grassland schemes.

8.7 Other sources considered but not recommended for secondary analysis

Reference	AES included & SSSI focus	Data focus & purpose	Sample size and type	Spatial	Software used	Data format and IPR	Time period covered by research
Darlaston & Glaves (2004), Effects of Exmoor ESA Moorland Restoration tier on Heather Condition and extent at Winsford Allotment, 1993-2003.	ESA Tier 2 prescriptions	Moorland agreements and options	100 sample points	Exmoor, England	N/a	Standard data format.	1993-2003

Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.	10-year study comparing data from 1993 to 2003. Implementation of Tier2 prescriptions (reduction in grazing pressure) positively influenced habitat (heath) regeneration on site.
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.	N/a
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.	N/a
SSSI habitat coverage – even coverage or specific focus;	Specific focus on heathland at Exmoor site.
Links to other datasets in a similar format;	No. Specific case study, references are not in connection to other AES schemes
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.	Yes, data is limited value due to the age of the study but provides good evidence of how AES prescriptions can cause positive effects on habitat restoration. Data could be re-visited to determine what effects have influenced the site over the last 16 years since the study was done.
What was the data collected for?	Assess positive effects of Exmoor ESA and to aid production of Moorland Management Plan. Part of a monitoring of Tier 2 prescriptions of an ESA.

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
English Nature (2003), England's best wildlife and geological sites- The condition of Sites of Special Scientific Interest in England in 2003.	SSSI focus, all SSSIs in England surveyed at least once. National assessment.	Multiple sources, overview of condition	4112 sites	National	N/a	Standard IPR –NE	1998-2003

Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.	Reference to AES management influencing SSSIs. Overgrazing, burning, under grazing and lack of scrub control account for 75% of SSSI unfavourable condition. Shows the effects agriculture has on SSSIs as well.
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.	N/a
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.	N/a
SSSI habitat coverage – even coverage or specific focus;	Even coverage
Links to other datasets in a similar format;	
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.	Yes assuming the data can be gathered from all the SSSIs with connecting AES schemes can be re-surveyed. The document does not split out SSSI and AES specifically but refers to the influences of Agriculture on SSSI condition.
What was the data collected for?	National monitoring of SSSIs in England. Condition of sites; understanding of the feasibility of reaching the 2010 target of 95% in favourable condition.

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Evans M, Townend R and Wheeler A (2016) Countryside Stewardship Baseline Report for the Environment Agency, report by Ipsos MORI: London.	CSF only, no specific SSSI focus but many present in CSF areas	Evaluation of farmers involved in CSF both in 2016 and looking back over past data from 2007 onwards	250 farmers across 40 catchments, reference to previous evaluations 2007 onwards involving over 4,000 farmers	CSF priority areas in England, in high or moderate priority areas.	AH data analysed with statistical software	Telephone interviews, Standard data formats. IPR with NE	2007 onwards, most recent in 2016
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			Evaluation shows an increased awareness of the link between agriculture and water pollution and the potential for changes in practice to improve water quality. Exposure to CSF increases likelihood of being willing to acknowledge that their own farm contributes at least a little to water pollution in their area.				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			Levels of awareness thoroughly investigated from a number of perspectives but not matched with ecological data.				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			Appetite to do more to reduce water pollution is the same across priority areas, with more than a third of farmers saying they want to do more. The report clearly demonstrates the CSF Project's potential and effectiveness at promoting awareness and encouraging change in High Priority Areas.				
SSSI habitat coverage – even coverage or specific focus;			Nothing in these reports but ecological surveys have been undertaken and positive benefits identified (ref?)				
Links to other datasets in a similar format;			Nothing highlighted. Could utilise HLS re-surveys split of HLS options into maintenance/arable/ creation/restoration.				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Yes, good potential, large proportion of CSF-based agreements would involve SSSI rivers and holdings (whole or part). Would require combining of ecological and AH characteristics. SSSI was implicit in the report so re-analysis would build on existing analysis. There is potential to separate out to see if those with SSSIs (land or river), or close to them, have different views from those not close to SSSIs.				
What was the data collected for?			Reflective analysis and evaluation of farmers involved in CSF.				

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Hewins *et al.* (2013), A Survey of selected agri-environment grassland creation and restoration sites Survey. Natural England Commissioned Report- NECR107–Part 1 2010 Natural England (2013), A Survey of selected agri-environment grassland and heathland creation and restoration sites. Natural England Commissioned Report NECR107- part 2	HLS and FEP HLS (HK8,HK7)	HLS, FEP Multiple review of method success	24 sites 42 stands 62 sites	National	N/a	Standard IPR –NE	2010-2013
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			No Specific reference to SSSIs. The report reviews the success of HK8/ HK7 in relation to initial objectives only.				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			N/a				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			N/a				
SSSI habitat coverage – even coverage or specific focus;			N/a				
Links to other datasets in a similar format;			no				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Potentially, only if data reported can be overlaid with SSSI boundaries and condition can be extrapolated.				
What was the data collected for?			To assess how effects of AES have affected grassland, heathland sites.				

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Hewins *et al.* (2005), The condition of lowland BAP priority grasslands: results from a sample of non-statutory stands in England. English Nature Research Reports- 636.	AES referenced but no specific schemes detailed. SSSI mentioned not a focus	Multiple sources. Focused on condition monitoring	Sample size of 500	National	TABLEFIT	Standard. IPR with Natural England	2002=2005
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			Extensive analysis of grassland habitat condition in both AES and non-AES sites. Analysis suggests significant positive effort resulting from AES. However, the study does not look into SSSI sites.				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			N/a				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			N/a				
SSSI habitat coverage – even coverage or specific focus;			N/a				
Links to other datasets in a similar format;			Extensive referencing				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Yes. While the report provides extensive analysis of the benefits of the AES, SSSIs are deliberately scoped out. It may be possible to re-analyse this data set in conjunction with others.				
What was the data collected for?			To review the condition of BAP grasslands across England.				

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Natural England (2012), Environmental Monitoring in Natural England	ELS, HLS and SSSI	Comparing the monitoring work and the differences/similarities in how different requirements are approached	3900 ISAS/3100 SSSI units , 800 non-SSSI	National	N/a	Standard IPR –NE	2011-2012
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			RAG scheme to demonstrate HLS performance in relation to SSSI. Condition discussed. No empirical data or information on habitat type (very High level)				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			Not SSSI specific overview but no detail				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			As above				
SSSI habitat coverage – even coverage or specific focus;			Unknown				
Links to other datasets in a similar format;			Extensive referencing				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Yes				
What was the data collected for?			Comparing the monitoring work and the differences/similarities in how different requirements are approached				

Reference	AES included & SSSI focus	Data focus & purpose	Sample size and type	Spatial	Software used	Data format and IPR	Time period covered by research
Natural England (2009) Agri-environment schemes in England 2009 (NE194), Natural England Commissioned Report	AES focus and SSSI heavily mentioned but not the sole focus	Multiple AES: focus on ESA's, CSS and ES	170 data sets; multiple different studies.	National in England	N/a	Standard data format, IPR with NE	1987-2009 The paper covers a huge range of studies with several AES
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.				The paper suggests that 93% of SSSIs under AES are in favourable/ unfavourable recovering condition compared to 73% of non-AES sites. NVC is not specifically mentioned. Condition of sites is discussed in several studies.			
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.				Social data is covered well, direct and indirect evidence. Statistics on number of jobs as influenced by AES management comparing several different studies.			
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.				Covers details of Costs relating to AES (not SSSI exclusively). Economic value of schemes discussed in multiple studies and at several locations across England.			
SSSI habitat coverage – even coverage or specific focus;				Even coverage- really good information on coverage on Figure 20			
Links to other datasets in a similar format;				Multiple references of several related studies			
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.				Yes, report references many data that could answer the question. If the original study data can be accessed/replicated and are not too old.			
What was the data collected for?				Review of the AES schemes			

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Natural England (2008), State of the Natural Environment.	No specific reference to AES	Overview of environmental evidence for 2008	National sample, various types, including SSSIs	National	unknown	Standard. IPR with Natural England	Various from 2003 - 2007
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			Chapter 2: Brief references to the quality of SSSI within and out with 'common land', noting the absence of agri-environment funding in common land. Chapter 3: Refers to 2004 and 2006 studies of SSSI grasslands within and out with Agri-Environment schemes. Also refers to similar studies involving marshes, arable habitats etc. 'Favourable status' terminology regularly used.				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			Chapter 4: Provides information in relation to accessibility of areas under agri-environment schemes, recognising that some of these are SSSI.				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			Chapter 5: Provides some information in relation to 'risks' posed by recreation and agricultural pressure, generally relating these to economic influences. No specific references to combined AES/SSSI data sets. Chapter 6: Provides a detailed historical account of AES and their efficacy, although there is no specific reference to SSSIs.				
SSSI habitat coverage – even coverage or specific focus;			National with reference to broad range of habitat types				
Links to other datasets in a similar format;			Yes, extensive referencing provided.				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Yes, reference to a wide range of AES and SSSI data sets suggest that re-analysis could be useful and beneficial.				
What was the data collected for?			General overview of the state of the environment in 2008				

Reference	AES & SSSI focus	Data focus & purpose	Sample size & type	Spatial	Software used	Data format & IPR	Time period
Wheeler and Wilson (2016), The effectiveness of Higher Level Stewardship for maintaining and restoring species-rich grasslands: a resurvey of a sample of grasslands under HLS options HK6 and HK7.	HK6, HK9, HK8	Multiple sites focussed on grassland habitats	National sample, various types, including SSSIs	National	Canoco 4.5, NVC, FEP/HLS keys, Common standards methodology	Standard. IPR with Natural England	2006-2014
Notes on environmental data on SSSIs, links to AES management, especially NVC, habitat extent and condition and management options.			Data on NVC and condition of habitats. General data on habitat condition				
Notes on social data on SSSIs, links to AES management, especially attitudinal and behavioural aspects with links to condition and management options.			Mentions comments from farmers on management prior to AES and after AES.				
Notes on economic data on SSSIs, links to AES management, especially financial aspects and farm/holding business approach with links to condition and management options.			Discusses the economic input to farmer, subsidies etc.				
SSSI habitat coverage – even coverage or specific focus;			Grasslands only				
Links to other datasets in a similar format;			Yes this is a re-analysis of 2006/7 data				
Conclusion: can source be reanalysed to provide robust and meaningful conclusions about the impact of AES schemes on SSSI condition.			Yes.				
What was the data collected for?			Effects of AES on grasslands.				

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Appendices for Tasks 1 and 2

Literature Search: Task 1 Ecological condition on SSSIs and link to AES							
Reference	**AES included** (by scheme/s)	**SSSI mention** (explicit, implicit)	**Relevance** (high, medium, low)	**Strength of evidence** (high, medium, low)	**Level of impact** (++, +, 0, -, --)	**Strength of causal link** (++, +, 0, -, --)	**Environmental outcomes**
Brown, A., Hinton, G., Porter, K. and Soden, D. (1998). National SSSI Sample Survey of lowland heathland	**CSS**	**Explicit**	**Medium**	**High**	**+**	**0**	**Progress in achieving favourable status could be limited by many factors; a lack of resources, lack of awareness about appropriate management, ineffective incentive schemes, conflicts between conservation management and other objectives**
Notes: [1] Analysis of heathland site condition, broken down by owner/occupier groups. External impacts are also discussed and ranked in terms of significance to this habitat. **Key findings:** 1) More than 70% of heathland units within schemes were found to be in favourable or recovering condition (figure includes Reserves Enhancement Scheme, Wildlife Enhancement Scheme and CSS incentive schemes, but does not provide a breakdown by individual scheme) 2) Heathland units managed by conservation organisations and local authorities were more likely to be in favourable condition than those managed for agriculture, or by other organisations. **Causal link:** No causal link between AES and SSSI condition.							
Critchley, C.N., Towers, J., Jones, N.E. (2016). LM0431: Moorland Habitat Monitoring: A Resurvey of Selected Moorland Agri-environment Agreement Sites	**HLS, ESA, CSS**	**Implicit**	**Medium**	**Medium**	**0**	**0**	**None of the habitats assessed for condition (dry heath, mires, wet heath and calcareous grassland), were above all the favourable condition thresholds relating to species composition (i.e. the frequency of indicator species or relative abundance of key species)**
Notes: [1] Non-random site selection based on availability of baseline data and geographic spread. **Key findings:** 1) Re-establishment of dry heath, mire, wet heath and calcareous grassland plant communities simply by reducing grazing is clearly difficult, and might be inhibited by dominant graminoids or heather, poor species dispersal, inappropriate burning or external factors such as nitrogen deposition. 2) HLS implicated in encouraging higher stocking densities, leading to a decreased rate of habitat condition improvement. **Causal link:** No causal link between AES and SSSI condition.							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Darlaston, M. & Glaves, D.J. (2004). Effects of Exmoor ESA moorland restoration tier on heather condition and extent at Winsford Allotment, 1993–2003. Defra Rural Development Service, Exeter	**ESA**	**Explicit**	**Low**	**High**	**++**	**++**	**Significant increase in heather cover and mean dwarf-shrub height, and decrease in grassland vegetation types over the ten year agreement period.**
Notes: [1] Focusses on extent and recovery of heather on a single site which had been subject to overgrazing, in response to lowering stocking rates. **Key findings:** 1) Exmoor ESA Tier 2 found to be producing good results with respect to heathland restoration. 2) Even with good early regeneration, the rate of recovery over part of the site (achieving 43% Heather cover after ten years) suggested that targets of 40–50% dwarf-shrub cover (in cases after five years) in some agri-environment schemes may be over-ambitious. **Causal link:** Strong causal link between ESA Moorland Restoration management and improvement in heathland condition at this site.							
Hewins, E., Groome, G., Mellings, J., Alonso, I. (2017). LM0455: A field survey to evaluate the outcome of Higher Level Stewardship options on lowland heathland	**HLS**	**Explicit**	**High**	**High**	**0**	**+**	**38% of stands in HO1/HO2 declined in condition over time. Stands in HO1/HO2 showed more improvement in graminoid diversity, lichens and bryophyte cover, dwarf-shrub richness and overall bare-ground.**
Notes: [1] Two samples drawn from SSSI and non-SSSI sites, both containing wet and dry heath types. SSSI samples had no baseline. Focusses on HO1 and HO2 options. **Key findings:** 1) The HLS options brought in management regimes that were deemed to be more positive for heathland sites, but the impact of these management changes was not always detectable. 2) The project found inconsistencies in the way that the heathland options have been implemented or targeted in HLS agreements: for example, in some cases the agreement area included non-heathland habitats; sites originally in unfavourable condition were put under management options; or the Indicators of Success were not appropriate for the site. **Causal link:** Evidence of causal link in cases where AES scheme set up appropriately. Potential for secondary analysis.							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Hewins *et al*. (2005). The condition of lowland BAP priority grasslands. Results from a sample survey of non-statutory stands.	**ESA**	**Implicit**	**Low**	**Medium**	**0**	**0**	**Upland Hay Meadows and Lowland Meadows were in the poorest condition of the priority grassland types when non-statutory condition assessment targets and thresholds were applied.**
Key findings: 1) Grasslands within agri-environment agreements were almost twice as likely to be in favourable condition as those outside agreement. However, grassland condition at the agreement start date was unknown. 2) Any cause and effect relationship between condition and the presence of an agri-environment agreement could not be reliably determined from this baseline; future re-survey of the stands would be needed for this, when differences in changes over time can be assessed for sites within and without agri-environment agreements. **Causal link:** No causal link between AES and SSSI condition.							
Natural England (2012). Environmental Monitoring in Natural England 2012	**HLS**	**Explicit**	**High**	**Medium**	**+**	**0**	**Detailed interpretation of results is needed due to the complexity of the information and its constraints**
Notes: [1] Not all SSSI features were assessable through ISAs at the time of study e.g. standing waters **Key findings:** 1) For the SSSI units assessed 50% were found to be meeting the targets set in the FCT's for favourable condition, whilst another 37% were judged on track to achieve favourable condition with time. 2) The 2011/12 programme carried out approximately 1000 joint ISA assessments, which considered both SSSI and HLS management. **Causal link:** No causal link between AES and SSSI condition.							
Natural England (2009). Agri-environment schemes in England 2009	**HLS, ESA, CSS**	**Explicit**	**High**	**Low**	**+**	**0**	**93% of eligible SSSI was under AES at the time of study.**
Key findings: 1) HLS has been the main mechanism used to increase the percentage of SSSIs in favourable or unfavourable recovering condition since its inception. 2) Of the eligible SSSI area covered by AES, 93% was classed as being in favourable/ unfavourable recovering condition compared to 73% for non-AES sites, although the proportion classed as in favourable condition was higher on non-AES sites. **Causal link:** No causal link between AES and SSSI condition but link between AES and SSSI clearly evidenced. Consider for secondary analysis.							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Nisbet, A. (2015). Integrated Site Assessments 2013/14: A report on Natural England's assessments of Sites of Special Scientific Interest and Higher Level Stewardship agreement	**HLS**	**Explicit**	**High**	**High**	**+**	**0**	**9% of Joint assessments were given a Red status, 38% Amber and 53% Green overall, with variations by habitat type.**

Notes:

[1] On HLS agreements advisers recorded their judgement of the likelihood of the option's Indicators of Success being met using three categories:

- Red – high risk or likelihood that IoS will not be met (by due date).
- Amber – significant risk of IoS not being met or uncertainty about meeting targets.
- Green – Indicators are appropriate and comprehensive. Targets already met and/or confidence that targets will be met (by due date).

[2] An ISA may gather data on the condition of an SSSI alone (SSSI only), HLS features and options alone (HLS only) or both of these (Joint survey). If a SSSI and HLS agreement overlap then a Joint ISA should be carried out, but this was not always the case, resulting in data gaps which may have a geographic bias.

[3] Draws on data from 1243 Joint surveys.

Key findings:

1) The HLS assessments examined 86 different management options, but 66% of all assessments were carried out on just 10 options
2) Restoration of wet grassland for breeding waders (HK11) and restoration of lowland heathland (H02) showed the highest percentage of green outlooks, 81% and 73% respectively. The two moorland options (HL10 and HL9 (maintenance of moorland)) showed the lowest percentage of green outlooks (both 28%) and subsequently the highest percentage of red outlooks, 27% and 21% respectively, though it is not clear if these figures relate to HLS-only or Joint assessments.
3) Reasons for Red or Amber assessments were not explored. Possible reasons could include failure to carry out required management options, or unrealistic targets/recovery rates being expected in the IoS/prescriptions.

Causal link:

No causal link between AES and SSSI condition. Potential for secondary analysis.

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Staley *et al.* (2019). The environmental effectiveness of the Higher Level Stewardship scheme; Resurveying the baseline agreement monitoring sample to quantify change between 2009 and 2016	**HLS**	**Explicit**	**High**	**High**	**++**	**0**	**Ecological change over 6-7 years hard to show except in creation or restoration options - AH characteristics influence outcomes**

Notes:

[1] Ecological survey of 173 HLS agreements in England using a stratified random sample, of which 103 agreements had SSSIs. SSSI is a key variable.

[2] Original survey undertaken in 2009-11, re-survey in 2015-17, SSSI parcels assessed using Common Standard Monitoring.

[3] 137 face-to-face interviews of which 86 have SSSI. Resulting HLS and AH motivation typology potentially useful.

Key findings:

1) Broad and priority habitats did not change between the two surveys, apart from a minority of habitats under lowland creation or restoration options. Plant communities under lowland heath options showed a more towards more characteristic heathland flora.
2) Agreement holder characteristics could be related to botanical outcomes for several HLS options. For grassland, woodland and moorland options, an agreement holder rating of management as easy or very easy was linked to improved botanical outcomes between the two surveys.
3) At the larger agreement-scale, agreement holder characteristics did not relate to outcomes for habitat condition, IoS or botanical characteristics.
4) Agreement holders were often over confident about achieving IoS. IoS were more likely to be met on agreements with SSSI land present.

Causal link:

No causal link between AES and SSSI condition but suggestions that presence of AES impacts on the approach to managing the SSSI and the options selected. Potential for secondary analysis.

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Wheeler *et al*., 2016. LM0443: Resurvey of HLS Baseline for options HK6 and HK7: Species-Rich Grassland Maintenance/Restoration. Report to Natural England.	**HLS**	**Explicit**	**High**	**High**	**0**	**0**	**Significant increase in species richness in areas managed under HK7. Net decline in overall condition of HK7 sites. Net improvement in overall condition of HK6 sites.**

Key findings:

1) The change in condition of the grasslands from 2007 to 2014 was contrary to the expected result, with greater success under HK6 (maintenance of existing species-rich grassland) than HK7 (restoration of species-rich, semi-improved or improved grassland).
2) This result was attributed to issues with initial option targeting; inappropriate targeting at the outset was considered likely to result in 32% of the sample being unlikely to deliver the desired outcome.

Causal link:

No causal link between AES and SSSI condition, but potential for data re-analysis to investigate this.

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Wheeler *et al*., 2014. The long-term effectiveness of Environmental Stewardship in conserving lowland wet grassland. Report to Natural England.	**ESA, HLS**	**Explicit**	**High**	**High**	**+**	**0**	**Some sites showed increases in species-richness, a decline in frequency of more nitrogen-responsive species, and an increase in the frequency of less competitive species**

Key findings:

1) Condition change was difficult to assess in some cases, where vegetation may be shifting from one community type to another, e.g. MG8 wet pasture to M22 fen meadow.
2) Results suggest that management under the former ESA scheme and the current HLS scheme has benefited the sites in the Norfolk Broads, and some sites in the Somerset Levels, Avon Valley and Upper Thames Valley.
3) On some sites it was concluded that a combination of raised water levels (both natural and controlled), poorly targeted management objectives or ineffectual/inappropriate management resulted in declines in the quality of the vegetation. In some sites including those in the Itchen Valley high soil (Phosphorous) fertility was also a contributing factor

Causal link:

No causal link between AES and SSSI condition, but potential for data re-analysis to investigate this.

Literature Search: Task 2 Owner/Manager attitudes towards managing protected sites							
Reference	**AES included** (by scheme/s)	**SSSI mention** (explicit, implicit)	**Relevance** (high, medium, low)	**Strength of evidence** (high, medium, low)	**Level of impact** (++, +, 0, -, --)	**Strength of causal link** (++, +, 0, -, --)	**Environmental outcomes**
Theme 1 Complexity of factors effecting AES participation							
Cross M & Franks J (2007) Farmers and Advisor's attitudes towards the Environmental Stewardship Scheme, Journal of Farm Management, Vol 13 (1) 47-68	**ES**	**Explicit**	**Medium**	**Medium**	**+**	**0**	**All farmers have/intended to join ELS, however less than 30% have/intended to apply for HLS**
Key findings: 1) Enrolment into ELS is predominantly an economic decision, however financial incentive should not be considered a primary determinant for farmers' environmental decision-making. 2) ELS had been successful in recruiting large numbers of farmers in the Norfolk case study, however was not likely to instil change in attitude toward farming or conservation. **Causal link:** No causal link between AES and SSSI condition, but work exposes motivations and links between entering AES and view of environment							
Riley, M. (2011). Turning Farmers into Conservationists? Progress and Prospects. Geography Compass, 5(6), 369–389	**ES**	**Implicit**	**Medium**	**High**	**0**	**+**	**Farmer participation and engagement is central to the success of AESs**
Notes: [1] Comprehensive literature review of prominent themes in AES research. [2] Critically reflects upon a variety of multi-disciplinary studies over the last two decades of agri-environmental policy research. **Key findings:** 1) Geographers and social scientists have a central role in investigating the complexity of attitudes and behaviours beyond single, cause-and-effect factors by acknowledging the significance of farmers' social and cultural contexts. 2) Evidence from much of the existing literature suggests that, to an extent, farmer attitudes and farming cultures are changing as a result of participation in AESs. Whilst generally positive attitudes towards conservation goals have been found, a variety of inconsistencies in policy and individual-level attitudes have been noted by numerous studies – highlighting the importance of understanding farmers' complex identities. **Causal link:** Limited causal link between AES and SSSI condition. Levels of farmer engagement and participation in deciding management likely to impact perspectives on SSSIs							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Wilson, G. A., & Hart, K. (2001). Farmer Participation in Agri-Environmental Schemes: Towards Conservation-Oriented Thinking? Sociologia Ruralis, 41(2), 254–274.	**ESA and CS**	**Implicit**	**High**	**High**	**+**	**+**	**Schemes can only be considered 'successful' if they contribute to long-term changes in the ways farmers think about the environment**
Key findings: 1) Agri-environmental policy should encourage the uptake of conservation-oriented farmers (post-production), which will in turn help bring about pro-environmental farming behaviours. 2) Evaluating schemes needs to be approached with caution when interpreting results, e.g. considering differing operational characteristics. **Causal link:** Limited causal link between AES and SSSI condition. Levels of behaviour change likely to impact agreement holder perspectives on SSSIs							
Ingram, J., Gaskell, P., Mills, J., & Short, C. (2013). Incorporating agri-environment schemes into farm development pathways: A temporal analysis of farmer motivations. Land Use Policy, 31, 267–279.	**Tir Gofal (Wales)**	**Implicit**	**High**	**High**	**+**	**0**	**Understanding a temporal dimension in farmers' participation in AES helps understanding of farmers' behaviour**
Key findings: 1) Continuance of the family farm is an important goal for agreement and non-agreement holders alike, and this is linked to enduring commercially or traditionally oriented values. 2) Three broad sets of development pathways (Low-intensity traditional; Traditional but productive; Commercial agricultural) were identified and the extent to which TG fits in with these pathways is considered, with particular reference to different periods in the farm life cycle. **Causal link:** No causal link between AES and SSSI condition, but work examines farmer behaviour in detail and outlines different pathways							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Theme 2: Farmer-scientist knowledge relations							
Burgess, J., Clark, J., & Harrison, C. M. (2000). Knowledges in action: An actor network analysis of a wetland agri-environment scheme. Ecological Economics, 35(1), 119–132	**Wildlife Enhancement Scheme (WES)**	**Explicit**	**High**	**Medium**	**-**	**-**	**Reveals contest between conservation scientist and farmer views of 'nature'**
Key findings: 1) Applies actor network theory (ANT) to a comparison of the role and identity ascribed to farmers by conservationists with the identity that farmers create of themselves, finding that 'nature' is translated differently between both agents. 2) AES research should adopt an approach which recognises the complexity of understandings of the environment and environmental management. **Causal link:** Suggests negative causal link between AES and SSSI condition resulting from contested views of management by scientists and farmers.							
Morris, C. (2006). Negotiating the boundary between state-led and farmer approaches to knowing nature: An analysis of UK agri-environment schemes. Geoforum, 37(1), 113–127.	**ESA and CSS**	**Implicit**	**Medium**	**Medium**	**0**	**0**	**Challenges assumed knowledge hierarchies in AES implementation**
Key findings: 1) Utilises notion of 'knowledge culture' to reveal 'porosity' of the boundary between state-led and farmer approaches to understanding nature. 2) Highlights a temporal aspect to the effective and constructive exchange of knowledge between farmers and conservationists – that they can change over time, contributing to the overall success of schemes. **Causal link:** No causal link between AES and SSSI condition.							
Mills, J., Gaskell, P., Ingram, J., & Chaplin, S. (2018). Understanding farmers' motivations for providing unsubsidised environmental benefits. Land Use Policy, 76, 697–707.	**ELS and other AES**	**Implicit**	**High**	**High**	**+**	**0**	**farmers' motivations for voluntary unsubsidised practices that benefit the environment and associated advice/support.**
Key findings: 1) 25% of all environmental activity on arable farms in England is unsubsidised, although some of this activity sits alongside subsidised activity. 2) Financial reasons dominated farmers' motivations for engaging in subsidised agri-environment scheme practices, whilst agronomic and environmental motivations were of greater importance for unsubsidised activity. **Causal link:** No causal link between AES and SSSI condition but clear evidence that design of advice and message framing to encourage uptake of more widespread voluntary environmental behaviour is essential.							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Theme 3: Changes in land manager attitudes and behaviours							
Burton, R. and Wilson G (2006) Injecting social psychology theory into conceptualisations of agricultural agency: towards a post-productivist farmer self-identity? Journal of Rural Studies	**Community Forest Scheme (CFS)**	**N/A**	**High**	**High**	**+**	**0**	**There may be a 'gap' between policy-level and farmer-level environmental attitudes and behaviours**
Key findings: 1) Introduces the interdisciplinary concept of 'self-structure', which critiques simplified categorisations of farmer participation and points towards a more inclusive 'spectrum' of environmental attitudes and behaviours. 2) Highlights a gap between policy and individual-level attitudes and behaviours: whilst agri-environmental policy might encourage a strong conservationist ethos, farmers and land managers' self-identity may not always mirror this. *Burton et al. (2008) extends on this apparent deviation between macro and micro-level environmental attitudes and behaviours.* **Causal link:** No causal link between AES and SSSI condition.							
Carey, P., *et al*. (2003) The multi-disciplinary evaluation of a national agri-environment scheme Journal of Environmental Management. 69 (1). pp. 71-91.	**CS**	**Implicit**	**High**	**High**	**+**	**0**	**Monitoring the success of AESs should be based on a multidisciplinary and multi-objective approach**
Key findings: 1) Critiques the evaluation of AES success based on singular objectives (such as exclusively environmental, social or economic). 2) Calls for a multidisciplinary and multi-objective approach towards agri-environmental monitoring and evaluation. **Causal link:** No causal link between AES and SSSI condition.							
Mills, J., *et al*. 2016. Engaging farmers in environmental management through a better understanding of behaviour. Agriculture and Human Values:1-17.	**Campaign for the Farmed Environment and other AES farmer is involved in**	**Implicit**	**High**	**High**	**+**	**0**	
Key findings: 1) in-depth understanding of farmer's willingness and ability to adopt environmental management practices. 2) Engagement with advice and support are necessary to achieve sustained and durable environmental management. **Causal link:** No causal link between AES and SSSI condition.							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Schroeder, L. a, Chaplin, S., & Isselstein, J. (2015). What influences farmers' acceptance of agri- environment schemes ? An ex-post application of the 'Theory of Planned Behaviour.' Appl Agric Forestry Res, 2015(65), 15–28	**ES**	**Explicit**	**High**	**High**	**+**	**+**	**Attitudes towards AESs are generally positive, but complex**
Key findings: 1) Applies psychological Theory of Planned Behaviour (TPB) to AES research, finding that despite generally positive attitudes towards agri-environmental policy, attitudes were based on a complexity of ecological, economic, environmental and social factors. 2) When taken together, these complex factors strongly influenced farmers' willingness to participate in agri-environmental schemes. **Causal link:** Limited causal link between AES and SSSI condition but shows factors that influence AES participation and would be relevant to SSSIs							
Fish, R. (2014). Influencing farmers to engage in catchment sensitive farming, 0–29.	**Catchment Sensitive Farming (CSF)**	**Implicit**	**Medium**	**High**	**0**	**0**	**Must understand attitudes (environmental and economic) in context of wider structural, habitual and social factors**
Key findings: 1) Highlights four key factors commonly assumed to underpin environmental behaviour amongst farmers: attitudes (practical expression of beliefs and values); norms (defined expectations of conduct); agency (real and imagined capacities to act); and habits (routines and ways of working). 2) Makes a strong argument for participation on both environmental and economic groups, considering a wider set of structural, social and habitual factors which may either encourage or inhibit farmers' capacities to act environmentally. **Causal link:** No causal link between AES and SSSI condition.							
Fish, R, Seymour S and Watkins C (2003) Conserving English Landscapes: Land Managers and Agri-Environmental Policy, Environment & Planning A 35 (1) 19-41	**ESA & CS**	**Explicit**	**High**	**High**	**+**	**+**	**Participation in AESs can encourage land managers to become more committed to environmental management procedures**
Key findings: 1) Whilst support for conservation goals was generally very high, 'participation' or 'nonparticipation' alone is not necessarily a direct indication of an evolution in pro-environmental behaviour. 2) Taking a contextualised approach to analysing the role of AESs in the formation of pro-environmental attitudes and behaviour is essential, taking into account diverse land manager values, knowledges, and practices. **Causal link:** No causal link between AES and SSSI condition but suggests extended exposure to AES does increase commitment to environmental management.							

Reference	AES included (by scheme/s)	SSSI mention (explicit, implicit)	Relevance (high, medium, low)	Strength of evidence (high, medium, low)	Level of impact (++, +, 0, -, --)	Strength of causal link (++, +, 0, -, --)	Environmental outcomes
Review of NE reports							
Evans M, Townend R and Wheeler A (2016) Countryside Stewardship Baseline Report for the Environment Agency, report by Ipsos MORI: London. Cook *et al*. 2016	**Catchment Sensitive farming (CSF)**	**Implicit**	**High**	**High**	**++**	**+**	**Increased awareness of the link between agriculture and water pollution and the potential for changes in practice to improve water quality**
Notes: [1] Survey of 250 farmers across 40 catchments in 2016, review also looks back across early evaluations from 2007 involving over 4,000 farmers [2] No specific mention of SSSIs but many of the rivers concerned would be designated, including those farmers surveyed. **Key findings:** 1) Evaluation shows an increased awareness of the link between agriculture and water pollution and the potential for changes in practice to improve water quality 2) Potential to separate out to see if those with SSSIs (land or river) or close to them have different views from those not close to SSSIs. **Causal link:** Potential causal link between AES and SSSI condition through increased awareness of impact farming has on water environment. Suggested for re-analysis.							
Jones N, *et al.* (2018) Initial Evaluation of the implementation of Countryside Stewardship in England in 2015/16: Objective 2 Report of CS Uptake analysis, to Natural England by the Fera Consortium. Fera: York../Short *et al.* / Cao *et al*. (2016)	**Countryside Stewardship (first 2 years of implement-ation)**	**Implicit**	**High**	**Medium**	**+**	**0**	**Importance of advice to the establishment of an AES agreement and choice of options. Link from ES to CS explored.**
Notes: [1] Survey of 416 agreement holders and applicants across England (170 in 2016 & 246 in 2017), sample chosen from HT, MT, water capital grants and woodland agreements (successful) plus unsuccessful HT, withdrawn MT and non-applicants who expressed an interest. [2] Some questions similar to survey of ES agreement holders on face-to-face interviews. No specific mention of SSSIs, including in sampling but some of the agreements will be designated. Agreements selected by SBI so determine which have SSSIs would be possible. **Key findings:** 1) Advice was central to the development of CS applications. There was a shift in the use of advice between Phase 1 and Phase 2, with a notable growth in the use of 'own adviser' in all categories with the level of influence the own adviser had on the agreement also growing. 2) The survey also interviewed those who had withdrawn from CS, even though they were offered an agreement. There was no specific analysis according to SSSI ownership. **Causal link:** No causal link between AES and SSSI condition but potential to examine links between SSSI and non-SSSI AES agreement holders through re-analysis.							

Reference	**AES included** (by scheme/s)	**SSSI mention** (explicit, implicit)	**Relevance** (high, medium, low)	**Strength of evidence** (high, medium, low)	**Level of impact** (++, +, 0, -, --)	**Strength of causal link** (++, +, 0, -, --)	**Environmental outcomes**
Staley *et al*. (2019). The environmental effectiveness of the Higher Level Stewardship scheme; Resurveying the baseline agreement monitoring sample to quantify change between 2009 and 2016	**HLS**	**Explicit**	**High**	**High**	**++**	**+**	**Ecological change over 6-7 years hard to show except in creation or restoration options - AH characteristics influence outcomes**

Notes:

[1] Ecological survey of 173 HLS agreements in England using a stratified random sample, of which 103 agreements had SSSIs. SSSI is a key variable.

[2] Original survey undertaken in 2009-11, re-survey in 2015-17, SSSI parcels assessed using Common Standard Monitoring.

[3] 137 face-to-face interviews of which 86 have SSSI. Resulting HLS and AH motivation typology potentially useful.

Key findings:

1) Broad and priority habitats did not change between the two surveys, apart from a minority of habitats under lowland creation or restoration options. Plant communities under lowland heath options showed a more towards more characteristic heathland flora.

2) Agreement holder characteristics could be related to botanical outcomes for several HLS options. For grassland, woodland and moorland options, an agreement holder rating of management as easy or very easy was linked to improved botanical outcomes between the two surveys.

3) At the larger agreement-scale, agreement holder characteristics did not relate to outcomes for habitat condition, IoS or botanical characteristics.

4) Agreement holders were often over confident about achieving IoS. IoS were more likely to be met on agreements with SSSI land present.

Causal link:

Suggested causal link between AES and SSSI condition as IoS more likely to be met on agreements with SSSIs. Consider for re-analysis.