Assessment of the adaptive capacity of Agri-Environment Schemes to respond to the impacts of climate change

FINAL REPORT

To Defra/Natural England

BY THE COUNTRYSIDE AND COMMUNITY RESEARCH INSTITUTE,
LAND USE CONSULTANTS & ENVIRONMENT SYSTEMS LTD

Project Title:

Assessment of the adaptive capacity of Agri-Environment Schemes to respond to the impacts of climate change

Client Reference

Defra/Natural England

Start Date
30th March 2019

Project Manager
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Finish Date
31st March 2020

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Duration
11 months

Date of Report
15 Jan 2021

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When quoting this report use the following citation:

Short C, James N, Breyer J, Urquhart J, Roberts V, Lenormand T, Hickman M and Staddon P (2020) Assessment of the adaptive capacity of Agri-Environment Schemes to respond the impacts of climate change, Report to Defra/Natural England. Countryside and Community Research Institute: Cheltenham.

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Abbreviations

AES	Agri-Environment Schemes	**GAEC**	Good Agricultural and Environmental Condition
BPS	Basic Payment Scheme	HLS	Higher Level Stewardship
CSF	Catchment Sensitive Farming	HT	Higher Tier
CS	Countryside Stewardship	NE	Natural England
DEFRA	Department for Environment Food and Rural Affairs	MT	Mid-Tier
EA	Environment Agency	RPA	Rural Payments Agency
ELS	Entry Level Stewardship	SBI	Single Business Identifier
ESA	Environmentally Sensitive Areas	SSSIs	Sites of Special Scientific Interest
EN	English Nature	SAC	Special Areas of Conservation
ES	Environmental Stewardship	SPA	Special Protection Areas
FC	Forestry Commission	WFD	Water Framework Directive

Glossary of terms

AES agreement	Agreements under different AES programmes, available since 1987 in England, provide funding to farmers and land managers to farm in a way that supports specified objectives covering biodiversity, landscape, water quality, the historic environment and public access. Agreements are voluntary and for a specified period of time, normally 5 but sometimes 10 years.
AES options	AES agreements contain a number of options covering the agreed activity relating to features and habitats on the holding. The delivery of these options forms the core of the agreement. Examples include the planting and management of hedges and walls, the cutting of hay in species rich grassland, the planting of trees, and the reversion of arable fields to grassland to protect archaeological features.
AES prescriptions	Each AES option is supported by a specific prescription. The prescription outlines the activities that are required or should not be undertaken. Sometimes these have dates associated with them. For example, on low input grassland the application of fertiliser or farmyard manure may not be permitted. In the management of hedges there are certain dates when hedge cutting can be undertaken and when it can't. If the hedge has gaps that need to be filled there will be timings for this activity.
Common Land	Common land is land owned by one or more persons where other people, known as 'commoners' are entitled to use the land or take resources from it. Commoners have 'rights of common' registered with the Common Registration Authority. The most frequently used right is to graze livestock. About 3% of England is Common Land, but 21% of all SSSIs are common land , 87% are in protected landscapes and 38% of all Open Access Land. See https://foundationforcommonland.org.uk/
Derogation / Minor Temporary Adjustment	A derogation is a minor and temporary change to an AES agreement when the agreement holder cannot meet the rules for the options in an ES agreement. For example, if a hay crop needs to be cut earlier than specified in the AES agreement or the agreement holder wants to make changes to grazing, cropping and supplementary feeding requirements. Under CS this is now called a Minor Temporary Adjustment (MTA) and this process applies to current ES agreements as well.
Indicators of Success	These are included in HT CS and HLS ES agreements with the aim of providing the agreement holder with an easily accessible check list for each option to assist in the delivery of environmental outcomes associated with that option.
Protected Landscapes	The term refers to National Parks and Areas of Outstanding Natural Beauty, which are designated under the National Parks and Access to the Countryside Act 1949. These are nationally important landscapes, which have protection through the law and refer to designated areas with a recognised boundary. The first National Parks were designated in 1951 (the Peak District and the Lake District) and the most recent the New Forest (2005) and South Downs in England (2010).

Executive Summary

The aim of this project was to address two different but connected questions.

1. Is there evidence that climate change impacts are affecting the ability of agreement holders to deliver AES prescriptions and indicators of success?
2. Is the operation (both the design and implementation) of AES sufficiently flexible to ensure that it can accommodate changes to the natural environment as a result of climate change, without adverse impact on the desired environmental outcomes of schemes?

In this sense the projects assessed two different aspects of climate change, both:

- The gradual impacts of climate change; and
- Challenges due to the severity and frequency of extreme weather events.

The project comprised of three stages to assess a range of factors relating to AES options under ES and CS the Basic Payment Scheme. All three schemes are funded through the Common Agricultural Policy (CAP), which provides a range of income support and initiatives to farmers and land managers. The stages were:

- **Assessment of a range of AES options** and associated prescriptions which specify dates for required operations and where these relate to particular ecological events (e.g. bud burst)
- **An online survey of agreement holders** in Cumbria, Somerset and West Anglia, areas known to have experienced extreme weather in the last 5 years, to gather evidence regarding the impact of extreme weather events on the ability of agreement holders to deliver AES agreements and associated environmental outcomes.
- **Telephone interviews with agreement holders and advisers** from the study areas and elsewhere to collect more detailed information concerning the impacts of extreme weather and their experience of AES at the local level as well as links to climate data and trends.

The linking of phenological aspects and the fixed aspects of AES option prescription (Chapter 2) revealed that there are areas of overlap and potential concern as, while there are clear changes in phenology over the past 30 years, many AES options and the prescriptions associated with them have remained unchanged. Thirteen current AES options and GAEC regulations have management dates that clash with the earliest recordings of indicator species. Projections suggest that a further 14 indicator species are likely to become impacted by AES options and GAEC regulations in the near future. These concerns are evident using national data.

Further investigation looked at regional data associated with the three study areas over the past 5-6 years. This revealed that there are considerable year on year differences as well as regional variations. The robustness of this analysis would improved by:

- Broadening the range of species considered;
- Understanding how ecological events are impacted by complex or indirect response to changing climate;
- Extending the timeframe of the data used for the analysis.

The online survey (Chapter 3) received 420 replies with viable responses in the three study areas known to have experienced extreme weather according to Met Office (2020) definitions. As with other surveys focusing on AES, the holdings were larger than the national and regional figures and over three quarters are in or have been an AES agreement. Overall, the survey found that over 90% of the sample had been impacted by extreme weather, and for just over a third of the

respondents this was 'severe' on at least one occasion in the last 5 years. Over 70% reported experiencing extreme heat, 65% extreme wet, 68% unseasonal weather and timings (e.g. early spring or warm winter), 57% drought were the top four factors.

The impact from dry and hot weather appears more widespread across the country, impacting all three case study areas, compared to wet weather which was more localised with a range of impacts, which can be severe. The occurrence of extreme weather made meeting the environmental outcomes of AES agreements more challenging as there was a perceived lack of flexibility to respond to the circumstances around the agreement holder. Those who experience the administrative processes relating to the adjustment of an AES agreement suggest it is not simple and the process for derogations or MTAs is complex. The processes associated with BPS have similar challenges to those of AES and are seen as complex and remote by farmers and land managers.

The interviews with agreement holders and advisers (Chapter 4) show they are aware of the changes in weather patterns and the impact of extreme weather both on their farm businesses and AES agreements. Respondents offered examples of instances when prescriptions work against the desired environmental outcomes when responding to the impacts of climate change. Extreme weather does impact the effectiveness of dates for tasks such as the cutting of rushes and grass for hay, in some years the dates are too late suggesting that a more flexible approach would be more beneficial for meeting environmental outcomes.

Drought and heat are factors that have a widespread effect across England with specific impacts on different farming systems; flooding and wet extreme events tend to be focused more in the North and West. The type of soil and its management are key factors in reducing the impacts of extreme weather. Better soil structure and high levels of organic matter mean soils are able to retain moisture in times of heat and drought and higher soil porosity helps reduce surface run off. Establishment of some options can be challenging but peer-to-peer learning, knowledge exchange and the assistance of a local adviser helps alleviate these.

The occurrence of extreme weather made meeting environmental outcomes of AES agreements more challenging due to a perceived lack of flexibility in the operation of the schemes. Some farmers are asking for at least one derogation a year, while others are not requesting a derogation as the process takes too long to grant the request and is not rooted locally. Advisers and agreement holders favour the ability of local NE advisers to agree minor changes to AES agreements at the local level (e.g. earlier cutting dates). The current derogation system works reasonably well, for major change in the AES agreement, e.g. changing the sequencing of works and location. During and immediately after extreme events, the priorities for an AES agreement holder is the farm business (e.g. livestock) and its infrastructure (buildings). Extreme events benefit from being handled centrally to agreed criteria that are implemented locally, based on the current Farm Recovery Fund.

In terms of **next steps,** there are several areas in this report that would be worthwhile exploring in more detail. What is clear is that climate change and extreme weather is having an impact of agricultural holdings and in the effective delivery of AES agreements. This should be underpinned by a review of management best practice in light of changed phenology.

Further examination of data on **derogations and MTAs** would be beneficial and inform the implementation of recent and future changes. The data appears comprehensive, although some coding on the reasons might be more informative than the current system of notes. Being able to search by agreement holder as well as the number of parcels would improve the benefits from this resource. The aim should be an approach that allows the effective collation and reporting of data on derogations and MTAs so this can feedback into the development and revisions of AES. It would appear that extreme weather and climate change is a key factor in the current requests.

We now know that **heat and drought impacts** are widespread across England and the impacts of wet weather and flooding are more localised and can be destructive. In terms of areas that would add to our understanding, firstly, the issue of the financial cost of extreme weather on farm businesses and compliance with AES agreements was revealed but would warrant further investigation. About a fifth suggest that there is a 'large cost' in dealing with the impacts of extreme weather. This needs to be more fully explored in a separate project and the link to environmental impact explored. A key part of this might be, whether in extreme events, it is sensible to restore areas to their pre-impact state or use the opportunity to make holding more resilience to the effects of climate change.

In addition, **the link between extreme weather and AES agreement** could be more fully explored using a different approach, such as maps, satellite images and farm-based interviews. The use of telephone interviews restricted the ability to link particular events to the AES agreement and certain options. A more integrated approach using a range of data would be an interesting approach. Taking a holistic approach would mean that the issue of resilience can also be included in order to identify the areas where AES management can assist in developing a wider knowledge on the long-term health of these social-ecological areas. Part of such a study could be to assess the timeliness of responses and how information was handled and responded too.

When developing **future schemes,** the project resulted in some findings to be considered in the development of such schemes. Suggestions included:

- Greater simplicity and flexibility in option prescriptions allowing for changing local weather conditions.
- Accessible guidance and training for agreement holders and advisers on adapting to impacts of extreme weather. This could be by appropriately trained NE staff or knowledgeable local advisers as well as through knowledge exchange by farmers for peer-to-peer learning.
- Greater flexibility in option prescriptions for grazing and the establishment of arable options to allow for external factors such as extreme weather and year on year regional variation.
- Those who experience the administrative processes concerning adjusting an AES agreement suggest it is not simple and the process for derogations and MTAs is complex and does not lead to a response in a timely fashion.
- Minor changes to an AES agreement are best served through a local approach to checking and accountability. For more major changes the derogation and MTA system works reasonably well.

Currently there is a lack of scheme delivery that considers resilience to climate change. Future schemes need to be more clearly defined and prioritise an approach to increase the resilience of natural processes across farmed landscapes. A good example of this would be options that focus on soils and the management of soils. Increasing the resilience of soil processes would have multiple benefits and reduce the impact of drought and heat on the environment and the farm business.

More focus in future schemes on enhancing resilience to climate change, including soil management and soil functionality. Future schemes will need to be clear on the potential for AES to increase farm-level resilience to climate change and the links to the generation of public goods and services. High quality advice, clear regionally relevant targets backed up by nationally robust inventory data sets, collected in a spatial manner and held centrally accessible would underpin and strengthen scheme outcomes.

A move towards an outputs-based payment scheme under ELM could help focus management on the biodiversity outcomes desired rather than maintenance of a specific habitat. This could allow

greater flexibility in how habitats are managed, and provide space for agreement holders to bring their own knowledge and understanding of management techniques to create the desired outcomes. Monitoring of AES will need to be mindful of the natural fluctuation in species populations, climatic conditions that affect management of sensitive habitats, such as coastal and flood plain grazing marsh or upland blanket mire, and the local management and governance conditions. NE advisers will be instrumental in ensuring this approach is successful for both biodiversity and the agreement holders delivering the schemes.

1. Background and introduction

1.1 Aims of the project and report structure

Introduction

Agri-Environment Schemes (AES) were originally established and designed to reduce the impact of human activity on the agricultural environment (Ovenden et al 1998 and Wilson and Hart 2000). Various schemes over the past 30 years have included land management actions with the intention of restoring, enhancing and recreating habitats, species diversity, landscape, access and the historic environment (Smallshire et al 2004, Vickery et al 2004 and Riley 2011). This has been achieved through voluntary agreements with farmers and landowners, and implemented through a series of options, each with its own prescriptions that are linked to target outcomes so that these interventions can be both measured and monitored.

It has become increasingly clear that one of the key influences on habitat and species condition is climate change, both gradual change and especially changes to the severity and frequency of extreme weather events, such as excessive rainfall, storm events, excessive heat and drought. For example, the 2018 drought has brought into focus the vulnerability of moorland areas to damaging fires in dry periods, and the high rainfall of the 2020 winter highlights the impact that prolonged and intense periods of rain can have on communities. These are encompassed in the two challenges highlighted in this project report.

AES options and the associated prescriptions have been developed over a period of years, each with specific environmental objectives and outcomes in mind (Boatman et al 2007). By way of example, there are over 400 options across the Environmental Stewardship (ES) and almost 250 in the current Countryside Stewardship (CS) scheme. The associated prescriptions for each option cover the management of the habitat or feature and need to be followed in order to comply with the terms of the agreement. Options concerning the management of hedges include dates when the trimming needs to be undertaken and options relating to grassland include a date after which hay cut can be made. Some options concerning the creation of habitats include the timing for establishment and, in some cases, the composition of the seed mixture.

Compliance of the agreement by agreement holders is assessed in a number of ways, one of which is the timing of operations to ensure that these are in accordance with the prescriptions for particular options. A selection of agreement holders received 'Care and Maintenance' visits during the course of their agreement and one of the aspects assessed is the record of land management actions associated with each option.

Early AES schemes had a duration of 10 years with a review after 5 years. The introduction of the Entry Level Scheme (ELS) under ES was for 5 years and the majority of agreements under CS are for 5 years. As a general rule the higher management agreements, Higher Level Stewardship (HLS) in ES and Higher Tier in CS, have more flexibility and scope for adjusting the prescriptions to fit the site. This is because of the higher levels of NE adviser engagement and support (Jones et al 2015). Agreements with less NE adviser support, such as ELS and Mid-Tier under CS, have standard prescriptions associated with the options. When an agreement holder is not able to comply with the requirements of an option, for example if the ground is waterlogged and they can't plant the field margin, the field is ready for hay cutting and they consider there are no ground nesting birds, or there is a weed or pest problem, then the agreement holder can ask for a derogation under ES. Since 2015, under CS, both CS and ES agreement holders requesting similar changes need to ask for a minor and temporary adjustment (MTA) to the agreement. This is considered by NE officers and, where appropriate, a site visit may take place in order to make an assessment for the request. The outcome of the request is then relayed to the agreement holder. In extreme cases, such as severe storm damage, the agreement holder and NE may decide that the *force majeure* clause included in all agreements is appropriate to be applied. This essentially frees both parties from liability or obligation when an extraordinary event or circumstance beyond the control of the parties takes place.

Finally, by way of closing the context behind the project, the project is seeking to see if this fixed approach to dates and timings of land management activity contained within AES agreements is under stress because of the changes in our climate. This can take two main forms; first spring is earlier now than it was 30 years ago meaning that some operations may be too late or early and second extreme weather impacts may result in the environmental outcomes for some AES options not being met affecting the overall value of the agreement.

Aim of the project

The aim of this project is to assess whether the current AES provide sufficient flexibility to respond effectively to both: the gradual impacts of climate change; and changes to the severity and frequency of extreme weather events; in their ability to deliver their environmental outcomes.

In order to respond to this aim two aspects will be assessed.

1. Is there evidence that climate change impacts are affecting the ability of agreement holders to deliver AES prescriptions and indicators of success?
2. Is the operation (both the design and implementation) of AES sufficiently flexible to ensure that it can accommodate changes to the natural environment as a result of climate change, without adverse impact on the desired environmental outcomes of schemes?

In order to undertake this task this report will:

- Describe any impacts that climate driven gradual change and extreme weather events have had in recent years, on the ability of agreement holders to manage their land according to the required prescriptions, meet the indicators of success and, achieve the desired environmental outcomes.
- Determine how scheme design, targeting and compliance, options and prescriptions could be altered to help reduce the identified risks due to climate change.

Methodology

The methodology comprised of three main stages and applied a flexible and adaptive approach to enable the assessment of a range of factors and AES options under the two AES that currently make up agreements held by farmers and land managers. The three main schemes reviewed in this research concern the two AES outlined in the previous section and the Basic Payment Scheme. All three schemes are funded through the Common Agricultural Policy (CAP), which provides a range of income support and initiatives to farmers and land managers. Following a major CAP reform in 2005, there are two strands to CAP payments: one for direct income support (pillar 1) covering 81% of the £3 billion annual UK budget and the second for rural development (pillar 2) covering the remaining 19%. Pillar 2 is focused on rural development and can be used to direct payments to farmers to cover environmental management. Under Pillar 1 the BPS payment provides a 'basic payment' per hectare to all holdings over 5ha and appropriate entitlements in return for compliance with a range of measures concerning soil, cropping and the disposal of slurry as well as keeping land in 'Good Agricultural and Environmental Condition' (GAEC). All eligible holdings can be inspected by the Rural Payments Agency (RPA) and if found not to be complying with the BPS regulations of the terms of their AES agreement then this may have implications on their payments, which can include the application of penalties.

Table 1.1 Overview of ES and CS and Basic Payment Scheme

Scheme	Duration	Component Tiers	Replaced previous AES
Environmental Stewardship (AES under CAP Pillar 2)	2005-2014	Higher Level Stewardship, Entry Level Stewardship (ELS), Organic ELS and Upland ELS	Environmentally Sensitive Areas, Countryside Stewardship Scheme
Countryside Stewardship (AES under CAP Pillar 2)	2015-2024 (proposed)	Higher Tier and Mid-Tier	ES, Catchment Sensitive Farming capital grant scheme, Woodland Grant Scheme.
Basic Payment Scheme (under CAP Pillar 1)	2015-2024 (proposed)	n/a	Single Farm Payment Scheme

The options under both AES programmes are divided into Management options and Capital options. Management options are those which relate to annual activities on an agreed area of land, say a hay meadow, area of lowland heath or hedgerow. Capital options are those which related to a specific activity, such as fencing, tree planting or installing a water trough. In this sense they are one-off payments. Most of the prescriptions concerned in this report are management options with an annual set of activities. In order for them to fit with other farming activity there is a 'window' of opportunity when the activity would ideally take place. For example, you would not want to trim a hedge when there is a standing crop in an arable field, so the ideal time is after harvest and before a new crop is planted. More information is available in the Environmental Stewardship guidance website and the Countryside Stewardship grants website and where specific examples are used more detail will be added.

The next three sections outline the three main tasks that made up the project.

1.2 AES prescription review in relation to gradual climate change

The first task assessed a range of AES prescriptions in relation to climate change induced gradual change. This drew together three strands of information to consider the extent to which climate trends raise issues for AES options.

1. A review of AES options (mid and higher tier options and cross compliance measures) to identify a sample of about 30 options, which specify dates for required operations and where these relate to particular ecological events.
2. A detailed review of the scientific literature and relevant studies into the effect of climatic variables (typically temperature, sunshine and rainfall) on the timing of ecological events such as budburst, the length of the growing season, arrival and departure dates for migrant birds and nesting/hatching dates for breeding birds.
3. Drawing on past records and climate projections (including UKCP18), to track past and likely future climate trends for each of the key climate variables above. Key measures included were mean monthly temperature, rainfall, soil moisture and growing season length.

The preliminary outputs are presented in Chapter 2, these need to more formerly assessed by a range of experts.

1.3 Online and telephone interviews on extreme weather

Methodology and selection

The survey of agreement holders, advisers and stakeholders was designed to gather evidence regarding the impact of climate change driven extreme weather events on the ability of agreement holders to adhere to AES prescriptions within the current compliance and operational regime; and their ability to deliver indicators of success and desired environmental outcomes. Two surveys were undertaken:

- A focused online survey in the three selected regions (quantitative focus) (see Chapter 3).
- In-depth telephone interviews with advisers, agronomists and agreement holders (qualitative focus). (See Chapter 4)

The focus for each survey was intended to be in a location which had experienced extreme weather in the previous 5 years. In this sense the intention was to 'stress test' AES by selecting interviewees with AES agreements in areas where extreme weather events were known to have occurred (Met Office 2020).

The case study areas were:

- West Anglia (Cambridgeshire, Hertfordshire, Essex and Bedfordshire) – High temperature / low rainfall: Summer 2018, 2016, July 2015 [Farm type: mainly arable farming];
- Somerset– High Summer rainfall: April to July 2012, high temperature Summer 2018 [mixed livestock and arable farming]; and
- Cumbria – Heavy winter rainfall: December 2015, High temperature / low rainfall: Summer 2018, [Farm type: livestock & upland].

The online survey

The online survey was developed to target all eligible farmers and land managers in the case study areas in order to establish the impact of extreme weather events on existing schemes (ES and CS) as well as compliance issues with BPS (see section 1.1). This enabled the full scope of the impact of climate change to be assessed and the knowledge of respondents regarding the schemes in which they participate. The survey was available for a limited time and aimed to secure a large number of respondents in each study area in order for analysis to be statistically robust. The respondents were recruited via a list of AES agreement holders from NE, local advisers, agronomists and other key stakeholders, as well as social media.

The aim was for a margin of error of under 10% in each case study area to ensure statistically valid responses with a larger sample size, which is important given the small nature of the total population in each of the proposed case study areas. To assist in securing the required number of responses, the same survey was made available to all farmers and land managers in the three case study areas via various contacts and networks, and across the rest of England through social media and other opportunities.

The analysis included the experiences of AES agreement holders (ES (HLS and ELS) and CS (HT and MT)) regarding extreme weather and whether this had any impact on their ability to deliver the AES outcomes, meet existing prescriptions as well as their experience in requesting derogations for changes to agreements. Key areas explored were experiences of extreme weather, its impact on farming practice, the impact of delivering AES schemes and the experience of the processes associated with adjusting AES agreements when options or prescriptions can't be fulfilled.

The analysis of this survey is presented in Chapter 3.

The in-depth telephone interviews

The in-depth telephone interviews were undertaken with agreement holders, as well as, advisers and agronomists in the case study areas as well as in other parts of the country. Respondents were selected on the basis of self-nomination in the online survey followed by an assessment of their experiences in order to provide robust results on geography, AES schemes and impact. Qualitative information concerning these impacts and their experience of AES processes helped develop a strong narrative of the issues involved at the local level as well as being linked to climate data and trends. A key element of the in-depth interviews was to focus the discussions about particular options and prescriptions. The in-depth interviews would gather more detailed data on the following:

- Specific issues relating to the delivery of scheme objectives;
- Detailed examples of issues requiring derogation or special advisory guidance;
- Agreement holder's priorities during extreme events and the associated decision-making processes concerning animal welfare, income production and scheme regulations;
- Potential adjustments to option prescriptions and scheme flexibility linked to extreme weather.

The interviews also provided an opportunity to explore agreement holders and advisers' awareness and response to the more gradual patterns of climate change and the timing of ecological processes analysed in Task 1. The survey therefore also draws out findings in terms of:

- Key past changes in the timing of ecological events.
- Examples where past changes in the timing of ecological events could be raising practical issues in terms meeting the requirements of AES prescriptions, or where there is a risk of ecological impacts.
- Impact of climate change of farming systems (e.g. temporary or permanent changes to rotations).

The findings of the surveys enabled the project to provide a narrative on the awareness and impacts of gradual climate change on ecological processes and fulfilling AES prescriptions, which can be linked to the climate data from Task 1 and this is the final task of the project.

The analysis of these surveys is presented in Chapter 4.

1.4 Key messages

This final section draws together the findings from the desk-based analysis of the effects of gradual climate change and the stakeholder interviews in relation to extreme weather events, to provide an overall assessment of the current AES schemes and whether they offer sufficient flexibility to respond to both the gradual and more sudden changes associated with extreme weather. This focuses on the ability of the schemes to continue to deliver environmental outcomes in the face of climate change and the key messages to take forward in both changes to the current schemes and the development of new programmes.

Key aspects considered are:

- Agreement holders' experiences linked to particular climate variables where past patterns of climate change have impacted on the implementation of AES schemes and resulting environmental outcomes.
- Stakeholders' awareness of gradual climate change, its impact on key ecological processes and the implications for their land management practices in general, and implementation of AES option prescriptions more specifically;
- Stakeholders' experience of more extreme weather events and the impact on land management and farming systems as well as their approach to AES and the options they choose.

The chapter explores the implications of past and future gradual climate change and more extreme weather events on the operation of current AES prescriptions. This highlights where climatic factors currently or could potentially impact on the delivery of AES scheme objectives. Key conclusions are drawn in terms the types of AES prescription, ecological process, habitat and potential approaches to mitigate or adapt the AES processes. This includes the highlighting of:

- Types of AES option or prescription that cause the most challenges to agreement holders;
- The timings of ecological processes that cause the most challenges to the environmental outcomes of AES (e.g. growing season or breeding times)'
- The impact of location and holding specific characteristics on the fulfilment of AES agreements.

Finally, the chapter makes some suggestions for areas of further investigation based on the areas highlighted in this project that require additional data or analysis.

2. AES prescription review and data on gradual climate change

Headline findings

- The Natures Calendar and BTO dataset confirmed some distinct trends in the timing of ecological events, though this was not evident for all species.
- Past and projected trends in the timing of ecological events were mapped against fixed dates for operations such as hedge cutting, scrub clearance or cutting of vegetation.
- Thirteen current AES options and GAEC regulations are shown to have management dates that clash with the earliest recordings of indicator species. Annex 2b
- Projections suggest that a further 14 indicator species are likely to become impacted by AES options and GAEC regulations in the near future. Annex 2b

2.1 Comparing AES prescription and changing species phenology

AES agreements provide incentives to land managers to support environmentally friendly farming. As outlined in Section 1.1, many AES options have prescribed dates when land management operations such as hedge cutting or ditch maintenance should be undertaken or avoided. For schemes such as Entry Level Stewardship (ELS) under ES and Mid-Tier (MT) under Countryside Stewardship, that aim to encourage broad uptake, these dates are standardised for all agreements. For higher agreements, such as Higher Tier (HT) under CS and Higher Level Stewardship (HLS) under ES, these dates can be specified at agreement level, informed by the knowledge of farmers and their advisers. Many of these operations are needed to create or maintain the habitats, and the dates are designed to avoid damage from AES activities to events such as nesting or flowering. Most prescribed dates have remained unchanged from the introduction of AES in the 1980s and 1990s. For example, ESA regulations introduced in 1993 specified fixed dates for activities such as grazing, hay cutting and manuring (see UK Statutory Instrument 1993).

There is growing evidence that climate change is influencing ecological events such as onset of budburst, the timing and duration of bird nesting and period during which invertebrates are active (Met Office and Woodland Trust 2016, Collinson and Sparks 2008, Amano et al 2010 and Sparks and Crick 2015). This project explored whether this changing phenology means that some dates prescribed in AES options are no longer appropriate. It also explored the risk that gradual climate change could affect farmers' ability to undertake land management operations necessary to deliver the desired environmental outcomes.

2.2 Approach

This part of the work focused on the effects of gradual climate change (such as trends in temperature or rainfall) rather than on extreme events such as floods, droughts, heatwaves or unusually cold winters. Gradual climate change was assessed in terms of its impacts on the success of AES options as defined by each option's 'Indicators of Success' (in HT or HLS agreements) or other descriptions of anticipated environmental outcomes in MT or ELS agreements. It was recognised that gradual climate change could have two types of impact:

- Changing the timing of ecological events such as nesting or budburst such that there is a potential conflict with the periods when activities such as hedge cutting are permitted by agri-environment schemes. For example, warmer spring weather could result in budburst or nesting starting to take place before the end of the hedge cutting period.
- Climate trends could also affect land managers' ability to deliver the option, with knock on impacts on the desired ecological outcomes. Wetter winters, for example, could make it more difficult for land managers to use heavy machinery for hedge cutting or tree work. Equally, an extended thermal growing season could result in more vigorous plant growth making it more difficult to deliver options which require weed control or strictly timed cutting or grazing.

The nature of these effects would vary spatially across England, reflecting:

- Physical and topographic conditions;
- Patterns of land management;
- Distribution of habitats and species;
- Differential patterns of climate change, with the south east of England generally experiencing the biggest increases in temperatures, and the north west of England experiencing higher levels of rainfall.

It is important to note that the process of climate change is not linear, with considerable annual variation around the trend. While the study has aimed to reflect some of this variation, the focus has been on exploring the higher end of the emission scenarios, such as the global increase by 3.7C by 2100 as outlined in the Representative Concentration Pathway (RCP) 8.5 by the International Panel on Climate Change (IPCC) (IPCC 2020), as a way of identifying where there is a current or potential risk of AES prescriptions not being compatible with the timing of ecological events or farmers' ability to deliver the option. It is therefore an initial and much simplified study which is designed to help identify whether climate change is indeed impacting on the delivery of AES outcomes. Further analysis by specialist would be a logical next step.

Review of evidence

The assessment was guided, in part, by the availability of time series data relating to the date at which ecological events such as nesting, budburst, spawning or first sighting / emergence takes place. Two key data sources were identified:

- **Nature's Calendar** records of first sightings (invertebrate emergence, first flowering, spawning etc.) for a variety of English species. The extent of time series data varies between species, but in most cases provides a sound evidence base going back 20 or 30 years. Data can be analysed at county level allowing analysis at a national level and for areas likely to experience the most pronounced patterns of climate change.
- **Nesting dates** record by The British Trust for Ornithology (BTO). The BTO publish data on mean nesting dates going back to 1966 for a wide variety of bird species found across England. The published data do not allow spatial analysis and they represent the average nesting date rather than the earliest nesting date (which can be substantially earlier and thus more likely to coincide with prescribed agricultural operations). It was therefore necessary to interpret these data with information on the timing of the earliest nesting events, and, where available, regional differences.

It should be noted that the most robust and most comprehensive data often relates to more common species and may not represent the earliest nesting / emerging / spawning / flowering species, and those that are already rare and endangered. 'Indicator' species were used to explore suitability of the timing of land management operations (see Table A1 in Annex 1). The literature was reviewed to help identify:

- Species which are typical of different habitats (e.g. arable farmland, scrub, hedgerows, upland pasture, ditches);
- Species which typically nest / emerge / spawn / flower earliest;
- Species which have been identified as being particularly sensitive to changes in climate variables.

The literature was also reviewed to identify areas of uncertainty or contrary evidence. For each indicator species, trends in the timing of ecological events were plotted and trends identified. This evidence led approach focused on spring period and it is worth noting that there are also trends affecting the timing of ecological events at other times of year, particularly the autumn.

Review of AES options

Almost 30 AES options were examined, focusing on those with prescribed dates for land management operations such as cutting of hedges, scrub or trees, grazing or cutting of vegetation, or the management of ditches since these were most likely to be affected by changes in the climate. Prescribed dates were compared to the plots of species' ecological events allowing the amount of 'headroom' between prescribed operations and the beginning of an ecological event such as nesting to be analysed both now and in the future. As a result, it was possible to identify where changing phenology is already an issue, or where it could become an issue in the near future. It also considered the impact of the changing climate on the land management operations needed to deliver scheme options' environmental outcomes.

Past climate record

Trends in the timing of ecological events were then compared with Met Office temperature records for the same period. Regression analysis was undertaken to determine how much of the observed variation in the timing of ecological events can be attributed to variations in prevailing temperatures. This analysis typically considered mean temperatures for February, March and April, depending on the timing of the ecological event in question. It also focused on those regions

where temperatures are likely to be higher and events earlier, as a means of exploring the worst-case situation with respect to AES option dates which tend to be standardised across the country.

The results of this analysis identified considerable variation in the correlation between mean temperature in the selected months and the timing of the ecological event in question. Where a strong relationship was identified, we can be reasonably confident that, all other things being equal, future temperature change could result in further change in the timing of ecological events. However, where no such relationship was found, or where the relationship was weak, we cannot dismiss the influence of climate, especially as different species will exhibit different climatic thresholds to which they respond. The relationship between climate variables and the behaviour of different species is complex, reflecting factors such as the availability of food, the risk of predation or the impact of events such as late frosts in otherwise mild winters. They may also be influenced by weather conditions elsewhere in the world (e.g. prompting migration) and there is some evidence that the nesting behaviour of a number of species is influenced by prevailing weather one year previously. This underlines the complexity of the subject and the snap-shot view that this study has been able to provide.

This analysis was not carried out for all species since for some there was a sizeable buffer between the ecological event and the timing of relevant AES option prescriptions, together with trends which indicate that land management operations are unlikely to impact on the timing of the ecological event. See Table A1 in the Appendices, which sets out the species for which correlation with past climate records was undertaken.

Climate projections

For those species where the study identified a moderate to strong relationship between the timing of an ecological event and late winter / early springtime temperatures, the UK Climate Projections 18 (UKPC18) climate projections were used to analyse how the timing of the event in question might change over the next 30 years. The analysis used the Representative Concentration Pathway (RCP) 8.5 and the Model ID 1 which has global +2 degrees Celsius being passed in 2030 and +4 degrees Celsius being passed in 2063. It was selected as a mid-range estimate for these dates.

As previously, some caution is advised. Apart from the uncertainties associated with the climate projections themselves, it cannot be assumed that a linear relationship (however strong) will be maintained into the future. It is possible, for example, that rising temperatures or other climate variables could have unforeseen impacts on the species in question, for example by impacting on their habitat or previously reliable food sources. The analysis therefore represents an informed but qualified view of how future change could impact on the achievement of desired AES scheme outcomes.

Impacts on land management operations

As noted above, it is possible that gradual climate changes will affect land managers' ability to undertake required operations by prescribed dates. For example, increasingly wet winters, particularly in the north west of England, could make it more difficult to cut hedges before the end of March without soil compaction resulting from the use of heavy machinery. The effect could be to push activity to the start or end of the window when such operations are permitted, potentially increasing the risk that they could impact on ecological events whose timing has been influenced by climate change. In the event that climate change makes it impossible for land managers to deliver the option in question, it increases the likelihood that the ecological outcomes – as measured by the indicators of success – will not be achieved.

While evidence about past and projected climate trends can be analysed, the consideration of the likely impact on land management operations is necessarily qualitative. This forms the focus of the survey and provides a link between this part of the work and the agreement holder analysis is Chapters 3 and 4.

Scope of the analysis

This phase was a preliminary examination of the implications of gradual climate change on the timing of ecological events and what this could mean for prescribed operation dates for AES options. It is important to bear a number of important provisos in mind:

- The work is based on analysis of trends relating to 30 indicator species. Selection of these was based on the availability of good data, relevance to the habitat in question and understanding of the timing of nesting, spawning, emergence, budburst or flowering. There may be other species more affected by the changing climate. This could include rare or endangered species for which there is insufficient data to examine trends. It is also likely that some data sources over-represent visible and abundant species.
- Analysis has focused on trends affecting springtime events such as nesting or spawning. It is equally likely that autumn events could be affected by a longer, drier and warmer summers.
- With regards to ornithological events, the research has focused on the timing of nesting for a range of indicator species. There could equally be implications for the timing of migration and events such as fledging.
- The analysis has also focused on climate trends (past and projected) affecting England, or parts of England, and does not capture the effects of climate impacts elsewhere (e.g. on the timing of migration).

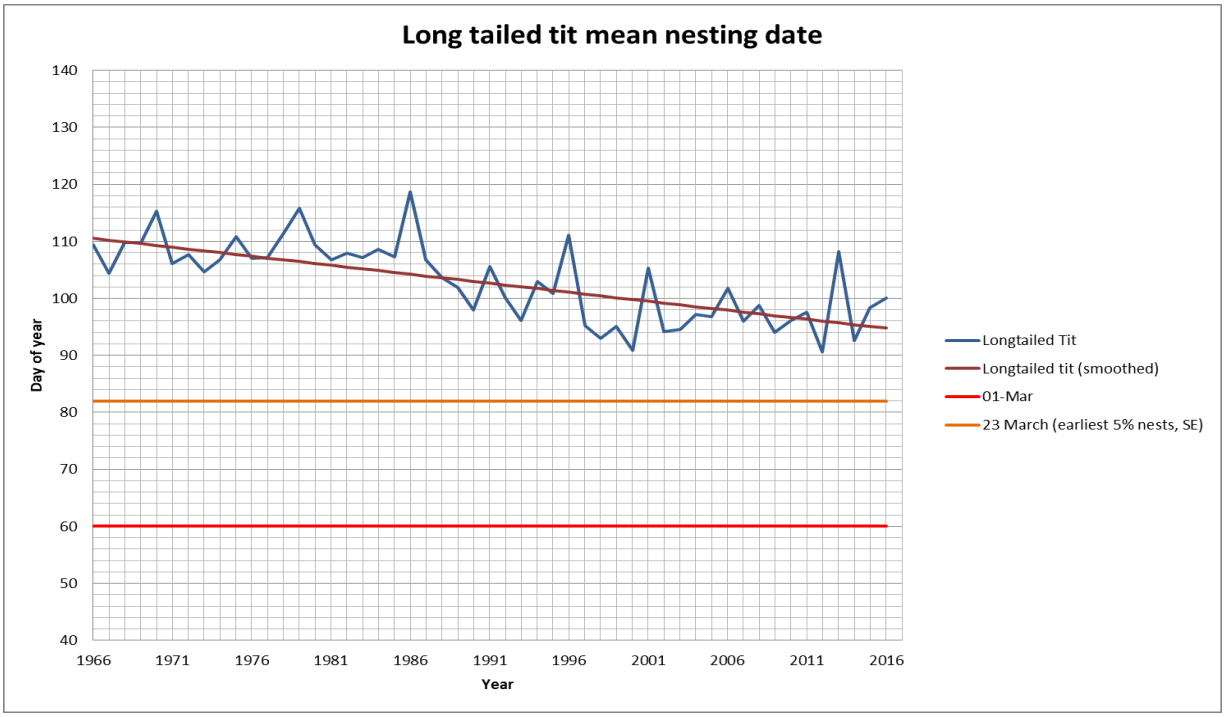
- The study has not been able to reflect the complexity of ecosystem or food chain dependencies.
- The study has focused on trends, and while it has noted inter-year variations in timing, it has not considered the impact of finer grain weather variations (such as late frost in an otherwise warmer spring);
- The study has not considered the effects of wider changes in agricultural practice such as changes in the use of machinery, sowing dates or land management activities.

2.3 Overview of findings

For each option and relevant indicator species, there was an assessment of whether trends in ecological events are already conflicting with the timing of prescribed operations, or whether this is likely to occur in the future. The scale used in the analysis is shown in Annex 2a. This was undertaken using a RAG rating with the 'red' category meaning that either the current or future situation suggested that the mean date for the ecological event occurs before the prescribed date for the management. An 'amber' rating was that there could be an impact currently or in the future. A 'green' rating suggests things are currently fine and a 'blue' rating shows there is a large buffer between any possible impact and the prescription dates. While in many cases the analysis considers the potential for direct impacts (e.g. the possibility that earlier nesting will coincide with the timing of hedge or scrub cutting), where appropriate it refers to indirect effects such as the potential loss of feeding habitats during the breeding season, even where nesting takes place elsewhere.

As outlined above the research focused on winter and spring events where the evidence of shifts in the timing of ecological events is most apparent. By way of example, Figure 2.1 shows the changes in the mean nesting date for the Long-Tailed Tit over the past 50 years. The figure suggests that the Long-Tailed Tits nesting date has come forward by about 2 weeks since the mid-1960s. Projections suggest that it will move forward by another 5 days by 2050. Figure 2.1 also shows the date that the earliest 5% of Long-Tailed Tit nests have started laying in the South East of England (orange line), based on data from 1990-2002 (Joys and Crick 2004). This is around 19 days earlier than the smoothed mean (1966 to 2017) would suggest it is likely that this date is subject to some inter-seasonal variation and that in some years the earliest 5% of nests start laying before this date. The graph also shows the cut off dates for land management operations specified in agri-environment options as a red line.

Figure 2.1: Long-Tailed Tit mean nesting date 1966-2016. (Source: Breeding Bird Survey)



Climate records show that temperature has been rising over the period since AES were introduced and the latest climate projections suggest this will continue. However, this change is not linear, with considerable variability from one year to the next. See Annex 3c. So, in some cases the spring might start much earlier, meaning that nesting for the Long-Tailed Tit varies from one year to the next, as the figure shows. The analysis confirmed some distinct trends in the timing of ecological events, though this was not evident for all species. For those where change was observed, the relationship between late winter and spring temperatures and the timing of ecological events is stronger for some species than others. This may

reflect the complexity or indirect nature of the relationship between climate and some species' responses. The timing of ecological events also demonstrates considerable variation from year to year in response to short term weather events, suggesting that for some species the impacts are likely to be more significant in some years than others.

Just under half of the species examined demonstrated a stronger than 50% correlation between temperature and the timing of the ecological events. These included Cuckoo Flower and Oxeye Daisy (first flowering), Long-Tailed Tit and Robin (nesting), Orange Tip Butterfly and Red-Tailed Bumblebee (first sighting), Horse Chestnut and Hawthorn (budburst) and Common Frog (spawning). See Annex 3c for the details of Long-Tailed Tit, Hawthorn and Common Frog, which are included in the analysis in the next chapter.

Past and projected trends in the timing of ecological events were mapped against fixed dates for operations such as hedge cutting, scrub clearance or cutting of vegetation. In some cases, there was a comfortable buffer, as outlined in the Song Thrush example, between the date for a land management operation and ecological events with no evidence that projected climate change would erode it significantly. For example, Song Thrush nest around two months after the end of the hedge cutting period with no trend to earlier laying, so impacts are unlikely. In other cases, trends in the timing of ecological events suggest that some, but by no means all, fall within the period when land management operations are being carried out. Sometimes this reflects significant year to year variations in timing, for others the extended period over which the ecological event occurs. For example, there are currently relatively few sightings of Oxeye Daisy first coming into flower during the period when cutting is permitted under some options. While this is projected to increase as temperatures rise, most plants are likely to continue coming into flower after cutting has ceased.

There are also a number of cases where ecological events already coincide with land management operations, or where a significant clash is likely in the future. In some years, the earliest examples of Long-Tailed Tit nesting already occur during the hedge cutting period, and trends suggest this will become increasingly common in the future. In the case of Common Frog, more than half of spawning already occurs before the end of the ditch maintenance period and earlier spawning is likely as temperatures continue to rise.

The study confirmed that decisions about the timing of land management operations associated with the delivery of AES options should be informed by an understanding of changing species phenology. It is however an initial examination and further work is needed to take account of changes at other times of year (particularly the autumn) and to further explore some species' more complex responses to the changing climate.

2.4 Discussion

There is a need to build on this initial examination of the effects of gradual climate change on agri-environment scheme option delivery by:

- Exploring changes in phenology of events at other times of year, particularly where rising temperatures result in species breeding and life cycles extending further into the autumn, Section 4.2;
- Developing a better understanding of ecological events where species have a more complex or indirect response to changing climate, for example by changing patterns of international migration, changes in habitat, food supply or predation and species where there is a time lag between a climate event (e.g. a particularly warm spring) and changes in the timing of events such as nesting. Reviewing the suggested RAG rating using a range of experts and specialists is recommended;
- Developing a better understanding of the risk that changing phenology and year to year variability presents to environmental outcomes and the challenges this brings to AES agreement holders. It is possible that some species' broad temporal spread of events means they are more resilient to potential clashes with land management operations. Others may be concentrated in a shorter period meaning that the effects of clashes could have a more serious impact on populations.

In identifying potential clashes between the timing of ecological events and the period when land management operations can be undertaken, this study has not considered the likely extent of habitats affected, nor the abundance or rarity of the species involved. Indeed, the data used under-represent rare or uncommon species where it is possible that any impact could be more significant.

The research has focused on the possibility that changes in the timing of ecological events could increase the potential for clashes with land management operations. While it has provided a commentary on the effects of climate change on farmers' ability to undertake land management operations necessary to deliver desired ecological outcomes, this has not been examined in a detailed and comprehensive way but provides a link to Tasks 2 and 3. This is an equally important influence on the success of agri-environment schemes and formed part of the discussion around choosing case study areas in Task 2. In the context of scheme prescriptions and best practice guidance, it was felt that the choice of case study areas should focus on known incidents of extreme weather as it would provide a 'stress test' of AES. A more widespread opportunity to respond would also provide an opportunity for all farmers to respond, as a control. This is discussed in more detail in the next section.

3. Online survey of farmers and land managers

Headline findings

- The three case study areas provided 266 responses (West Anglia 106, Cumbria 92 and Somerset 68) with 154 completing surveys from elsewhere in England;
- The holdings are larger than average, but this is typical of those with AES agreements;
- 79% of the sample have or had an AES agreement on the holding since 2015;
- Extreme heat (72%) and wet (65%) were the greatest impact on respondents followed by drought (56%) and unseasonal timings (58%);
- Of the 420 respondents all but 28 (6.7%) had experienced at least some direct impact from extreme weather on the farm in the last five years.
- 14% had one event, 28% had 2 events, 23% 3 events, 15% 4 or more in the last 5 years. 35% (147 respondents) had at least one severe event in the last 5 years
- The impact from dry and hot weather appears slightly greater than for wet weather but there are a range of impacts, many of these severe;
- Those who experience the administrative processes concerning adjusting an AES agreement suggest it is not simple and the process for derogations or MTAs is complex.
- The processes associated with BPS have similar challenges to those of AES in that they can be seen as complex and remote by farmers and land managers.

3.1 Sample selection, approach and response rates

Sample selection and approach

Selected sample

The intention was to select three study areas that reflected different farming systems which had experienced a range of extreme weather events over the past 5 years. Care was taken to where possible exclude areas where land owners were involved in other trials and pilots on related topics, such as the 'Payment By Results' trials, hence the decision to leave out Norfolk and Suffolk in East Anglia and focus on West Anglia. It was acknowledged that Cumbria and Somerset were both involved in possible Environmental Land Management Scheme (ELMS) Test and Trials but the start date for these was not likely to impact on this survey. Cumbria also had a Pioneer Project, but again this was linked to the ELMS Test & Trial and would have limited impact. Figure 3.1 shows a map of the study areas.

The sampling unit for the survey is AES agreement holders - in practice this will mean farmers enrolled in Environmental Stewardship (ES), Countryside Stewardship (CS) who will also be involved in the Basic Payment Scheme (BPS). The target population is defined at the level of the three case studies (i.e. Cumbria, part of East Anglia and Somerset), and consists of AES agreement holders, with data held by Natural England. AES agreement holders may be enrolled in HLS or ELS if in OELS (including organic options) or HT or MT if in CS. Those chosen also reflected a geographic spread across England and had similar number of AES agreement holders dating back to 1st January 2015.

Figure 3.1 Selected case study areas in England

- Cumbria (1,871 agreement holders) – Heavy winter rainfall: December 2015 [livestock & upland].
- West Anglia (Cambridgeshire, Hertfordshire, Essex and Bedfordshire) (1,205 agreement holders) – High temperature / low rainfall: Summer 2018, 2016, July 2015 [arable].
- Somerset (1,028 agreement holders) – High Summer rainfall: April to July 2012, high temperature Summer 2018 [mixed].

In order to maximise response rates and to reduce survey error, Dillman's Tailored Design Method (TDM) (Dillman 2014) was adopted. Survey error was reduced by employing a systematic approach to ensure that the sample frame contained a list of the population that was as representative as possible and satisfactory response rates were to be achieved through multiple contacts with the sample.

The objective of the sampling strategy was to obtain a sample that is representative of the target population. Representativeness was ensured through an appropriate sample size and stratification of the sample across HLS and ELS. The sample contained a sufficient number of AES agreement holders (in each case study) to guarantee a margin of error (ME) lower than 10% (for a significance level of 95%), which is a commonly accepted limit for social research. The ME was calculated using the following formula: $ME=z\ \sqrt{(p*(1-p))}/\sqrt{(((N-1)*n)/((N-n)))}$, where z is the z-score equal to 1.96 for 95% confidence; p is the proportion of the sample answering a question; n is sample dimension and N the population size. In all case studies, a sample size of 200 gave a margin of error lower than 10%, which is acceptable (Table 3.1). However, in order to achieve the required sample size, the population must be 'over-sampled' to account for non-responses. We proposed to increase the number of AES holders contacted by 40% in order to achieve the desired sample size. Therefore, 333 AES holders in each case study were invited to take part in the study, with the aim of achieving a sample of 200.

Table 3.1 Margin of error for expected samples across each case study.

Parameter	West Anglia	Somerset	Cumbria
n	200	200	200
N	1,205	1,028	1,871
P (%)	16.6	19.5	10.7
ME (%)	6	6	7

In line with the TDM approach, a sequence of four contacts will be made with AES agreement holders in the sample (see Annex 4 for copies):

- Brief pre-notice email/letter from Natural England (but mailed by CCRI);
- Questionnaire invitation email/letter from CCRI;
- Thank you email/postcard;
- Final contact by email/telephone.

Following the principles of TDM, the aim of the contacts was to demonstrate the benefits to the respondents of taking part, reduce the costs of taking part and build trust between the respondents and the researchers. The pre-notice letter (one page), from Natural England, informed the respondent that the questionnaire will arrive shortly, and outline aim of the project and who will be carrying out the survey.

The pre-notice letter was followed, several days later, by a letter from CCRI inviting the recipient to complete the survey online (see Annex 4 for copy of the survey). The letter reiterated the reasons why the survey was carried out and the importance of the respondent's participation. Letters were personally addressed in order to create a feeling of trust and respondents were given the opportunity to take part in a prize draw for a £100 Amazon voucher as a token of appreciation for taking part.

One week after the survey invitation was sent, a thank you postcard was sent to those who have not completed the survey. The postcard thanked recipients for their anticipated completion of the survey. Two weeks later, a paper version of the questionnaire was sent to non-responders, with a letter explaining that many other AES agreement holders had already responded and that opportunities to contribute in this way are scarce. Knowing others like them have completed the questionnaire can often influence people to respond (Groves et al 1992). A deadline for response was given to instil a sense of urgency.

If necessary, a final telephone contact was made one week later. Depending on the level of response at this point, potential respondents were telephoned and reminded that this is the last opportunity to participate.

Sample boost

Alongside the random sample recruited via letters, the sample was boosted within each case study by promoting the survey at a range of local events and meetings (Catchment Sensitive Farming (CSF), Facilitation Fund (FF) events or other NE or non-NE events) and through various local farmer networks. Contact was made through the NE local teams to collect the contact details of local advisers and CSF officers and non-NE advisers hosting FF networks. The contacts were engaged before the start of each case study to collect details on suitable events. The project developed arrange of materials for these events (see Annex 4).

Finally, this included social media promotion (e.g. Twitter and Facebook) to coincide with events and connect to those with relevant local links. Response from farmers who were not in AES but were involved in BPS were welcomed and their responses relating to their experience under BPS were relevant to the project. Contact was made with the three NE local team leaders to identify key NE officers and local gatekeepers e.g. advisers who could promote the survey via their networks and events. All the promotion was time limited to link to the DMN survey approach. The level of effort allocated to the sample boost was determined by the number of returns received on the online survey from the sampling techniques. Those involved in the events stressed that one response per holding was required to reduce the likelihood of multiple responses and the online system will not permit this anyway.

The project team were aware that some of the topics that will be discussed could potentially cause emotional distress to the respondents as they recall these events. Such topics might have included:

- Impact on farm business from extreme events such as high winter or summer rainfall.
- Loss of crops through drought or high temperatures.
- Loss of habitat from extreme events such as moorland fires.
- Loss of livestock due to flooding or high rainfall.
- And also including uncertainty due to Brexit.

Therefore, questions were framed sensitively initially in the online survey and in more depth through the phone surveys. A team of experienced interviewers who have had experience of conducting interviews with potentially sensitive issues conducted the research.

Response rates and statistics

The reliance on postal letters meant that there was a technological gap between the hard copy letter and postcard and the online survey. In addition, there was considerable uncertainty amongst the farming community due to Brexit and the 2019 General Election meaning that the survey might not have been a priority. Also, by choosing those farmers and land managers who had an agreement on 1st January 2015, we included some who were no longer in AES and some of these may have felt less inclined to participate in the survey. The table below shows the actual Margin of Error (ME) for the three study areas.

In order to have a 95% confidence level in the results, the ME should be below 10%. The responses received showed that for Somerset the ME was at 11%, Cumbria 10% and West Anglia 9%. Therefore, responses for Cumbria and West Anglia are within acceptable levels at 10 and 9% respectively because a larger percentage of the total population was surveyed. However, a 6.6% survey of the Somerset population remains acceptable for further statistical analysis. As a proportion of the total population of AES agreement holders in January 2015, the response is between 5 and 8.8% of the total population in all three study areas. This is sufficient for statistical analysis, especially given the opportunity to compare this with the outcome of the boost sample covering England as a whole, which raised the overall sample to 420 responses.

Table 3.2 Margin of error for actual samples across each case study.

Parameter	West Anglia	Somerset	Cumbria
n	106	68	92
N	1,205	1,028	1,871
P (%)	8.8	6.6	5.0
ME (%)	9	11	10

The sample boost was derived from social media, mainly Twitter and Facebook, and the advertising of the survey at events and through networks. Over a period of about 3 months a total of 425 responses were received. On analysis, five of these were found to be from outside England and so were not included in the further analysis in this report. All of those responses from counties within the three case study areas were added to the responses from that area. The 154 'Rest of England' responses were from all over England with the highest response including 23 responses from Hampshire, 20 from Devon but most counties represented. The analysis in the next section focuses mainly on the three case study areas with the sample boost included under the 'Rest England' category.

Most of the analysis in this chapter is based around crosstabulations. Where appropriate the differences between the samples have been statistically checked using the Chi-squared technique. Chi-square tests were used to test for differences between frequency distributions with significance difference defined as $p < 0.05$. In the figures, different letters mean a significance difference at $p < 0.05$ was observed using the Chi-square test. For example, if county x and county y are both labelled with 'a', there is no difference between them; if county x and county y are labelled differently with 'a' and 'b', then there is a significant difference between them; if county x is labelled with 'ab', then there is no difference with any county labelled 'a' or 'b'.

3.2 Sample characteristics

Comparing the sample to national and local characteristics

This section looks at two characteristics collected on the online survey, farm size and tenure and compares the data collected on the online survey with official national and local data as well as other similar studies. A common feature of studies focusing on AES agreements is a higher proportion of the holdings tend to be larger than the national average. Of the 420 responses over half (58%) fell into the 100 ha category compared to 24% nationally (Defra 2019). Only 8% were under 20 ha compared to 40% nationally. Tables in Annex 5 shows that this study is in line with other AES studies (Boatman et al 2014 and Short et al 2017).

Table 3.3 below shows the breakdown between the three study areas and the 'Rest of England' response.

Table 3.3 Farm size in three case study areas and Rest of England sample

	West Anglia[a]		Somerset[b]		Cumbria[b]		Rest of England	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
<20ha	3	2.8%	5	7.4%	13	14.3%	14	8.4%
20 to <50ha	12	11.3%	26	38.2%	20	22.0%	18	18.1%
50 to <100ha	13	12.3%	9	13.2%	28	30.9%	17	16.0%
100ha <250ha	34	32.1%	21	30.9%	19	20.9%	40	27.2%
250ha & over	44	41.5%	7	10.3%	11	12.1%	65	30.3%
Total	**106**	**100%**	**68**	**100%**	**92**	**100%**	**154**	**100%**

Letters [a] & [b] represent a significance difference at $p<0.05$.

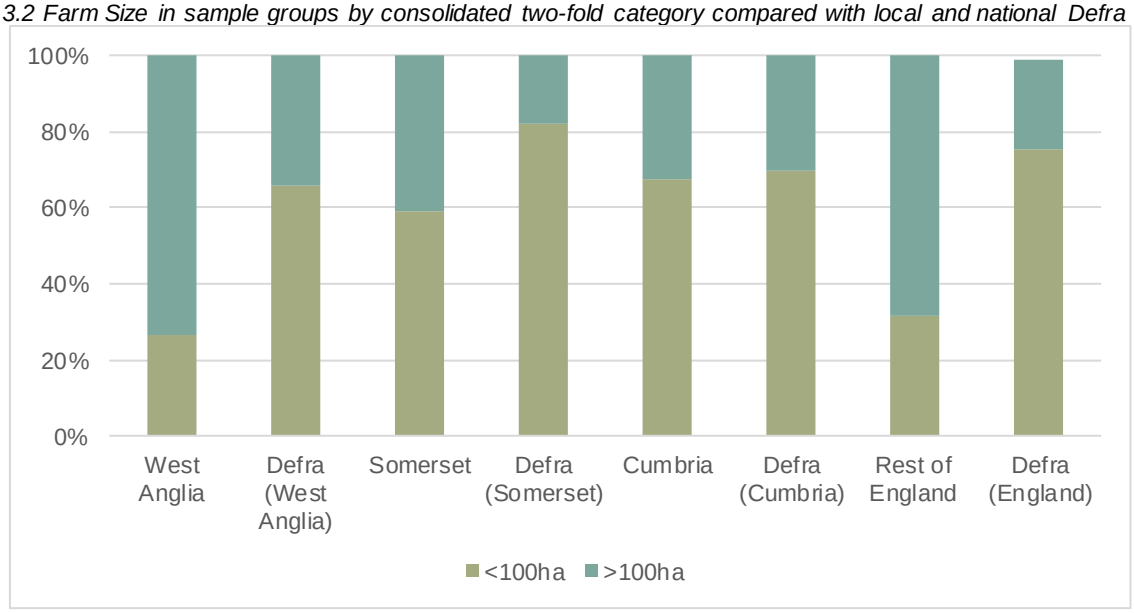
Comparing the three case study areas in more detail shows that West Anglia has the largest farms with over 40% 250 ha or larger and nearly three quarters (74%) holdings of 100 ha or more. There is a more even spread in Somerset with 41% holdings of 100 ha or more and 46% under 50 ha. Cumbria has the lowest number in the largest two categories with 33% 100 ha or more in size. However, this is the area with the most common land and 17 respondents had access to common land, of which 8 exercised their rights. The difference in farm size distribution between West Anglia on the one hand and Somerset and Cumbria on the other hand is significant at $p < 0.05$, as observed using the Chi-square test. The Rest of England group shows a trend towards larger holdings with 30% in the largest category (250ha or more) and 58% with holdings of 100 ha or more.

Comparing these figures with Defra's regional figures (Defra 2020) would support the initial analysis that the larger farmers are over represented. However, it is possible to compare the results with Regional Defra statistics for commercial holdings in 2016 using the boundaries of the Local Nature Partnerships (Defra 2020).

In order to help with further analysis and trends across the rest of the data, it makes sense to consolidate some of the categories. Two categories are used in Figure 3.2 below are under 100 ha and 100 ha and over, as this allows direct comparison with the Defra categories. The results are shown below.

In the West Anglia region there are far more holdings under 100 ha in the Defra statistics. The region was not an exact match as it includes some holdings around the Thames Gateway, but this accounts for only a handful of the total. The official figures for this region are much closer to the national figures than the sample collected for this survey. The most likely explanation for this is the trend of larger holdings entering into AES agreements. In Somerset there is less of a gap between the Defra data and the response to this survey, but 41% were in the larger category compared to 18% in the Defra data. Only in Cumbria were the two figures almost identical with about 30% in the larger category. As with West Anglia, the Rest of England sample was markedly different from the Defra data for the whole of England with only 32% under 100ha compared to 75% of commercial holdings in England.

Figure 3.2 Farm Size in sample groups by consolidated two-fold category compared with local and national Defra data



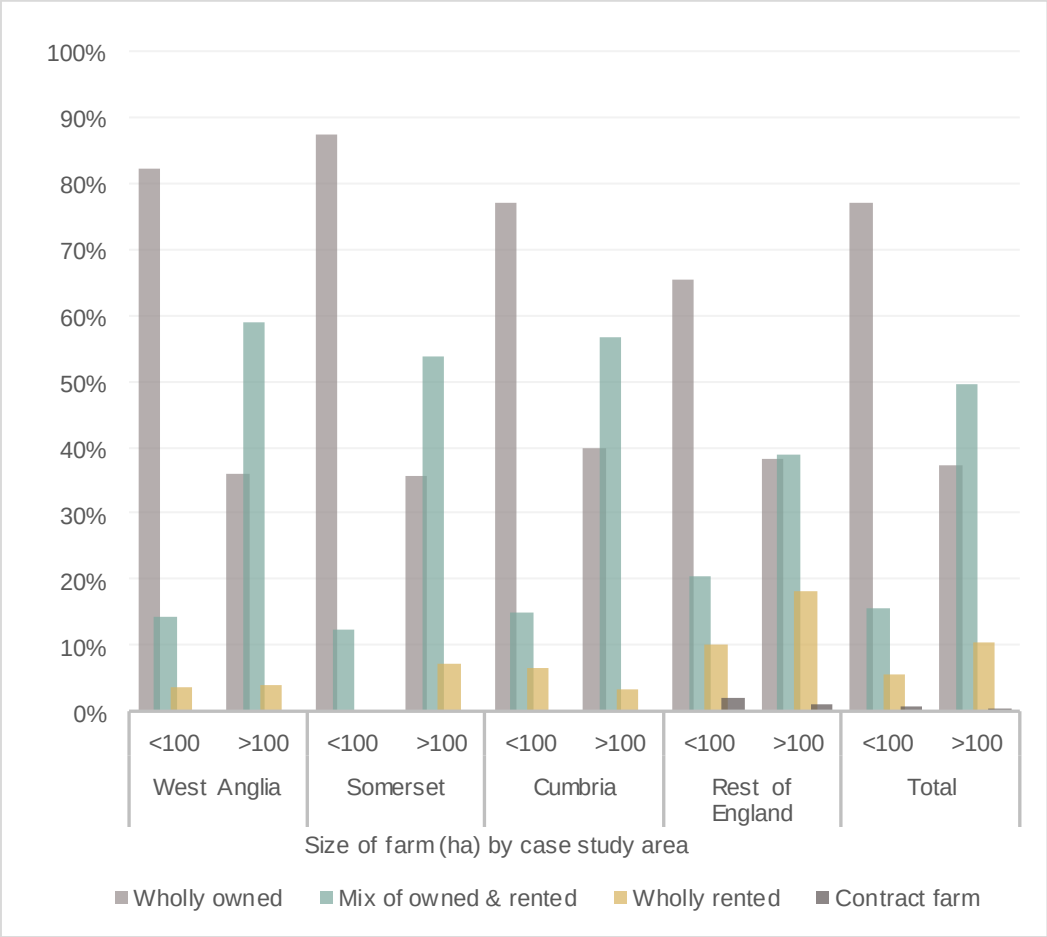
Another characteristic included in the online survey was that of land tenure, all respondents were asked if they owned or rented the land they farmed of if it was a mix of the two. The table below shows the results for each of the four categories.

Table 3.4 Land tenure on holding in three case study areas and Rest of England sample

	West Anglia		Somerset		Cumbria		Rest of England		Total	
	n	%	n	%	n	%	n	%	n	%
Wholly owned	51	48.1%	45	66.2%	60	65.2%	72	46.8%	228	54.3%
Mix of owned & rented	50	47.2%	20	29.4%	26	28.3%	51	33.1%	147	35.0%
Wholly rented	4	3.8%	2	2.9%	5	5.4%	24	15.6%	35	8.3%
Contract farm	0	-	0	-	0	-	2	1.3%	2	0.5%
Other	1	1%	1	1,5%	1	1.1%	5	3.2%	8	1.9%
Total	**106**	**100%**	**68**	**100%**	**92**	**100%**	**154**	**100%**	**420**	**100%**

The table shows that across all of the groups the biggest category is 'wholly owned'. This is particularly true of Somerset and Cumbria, which have the smaller farm sizes. In West Anglia, almost as many people had a mix of rented and owned as the wholly owned. Wholly rented was a small category across the country but largest in the 'Rest of England' group. Defra statistics are collected in relation to the area that is owned and rented. Using the same regional figures from 2016, 64% of the West Anglia area is owned, 70% in Somerset and 61% in Cumbria. The latter two figures are close to those collected in this survey but the West Anglia figure is lower, suggesting that much of the land in the Mix of owned and rented is actually owned. In order to use this variable in further analysis some consolidation need to take place and the owned category needs to be broken down. The approach taken was to see what impact farm size has on the results by splitting the analysis those under 100 ha in size and those which were 100 ha and larger. The results are shown in Figure 3.3 below.

Figure 3.3 Consolidated Land tenure variable by four sample groups



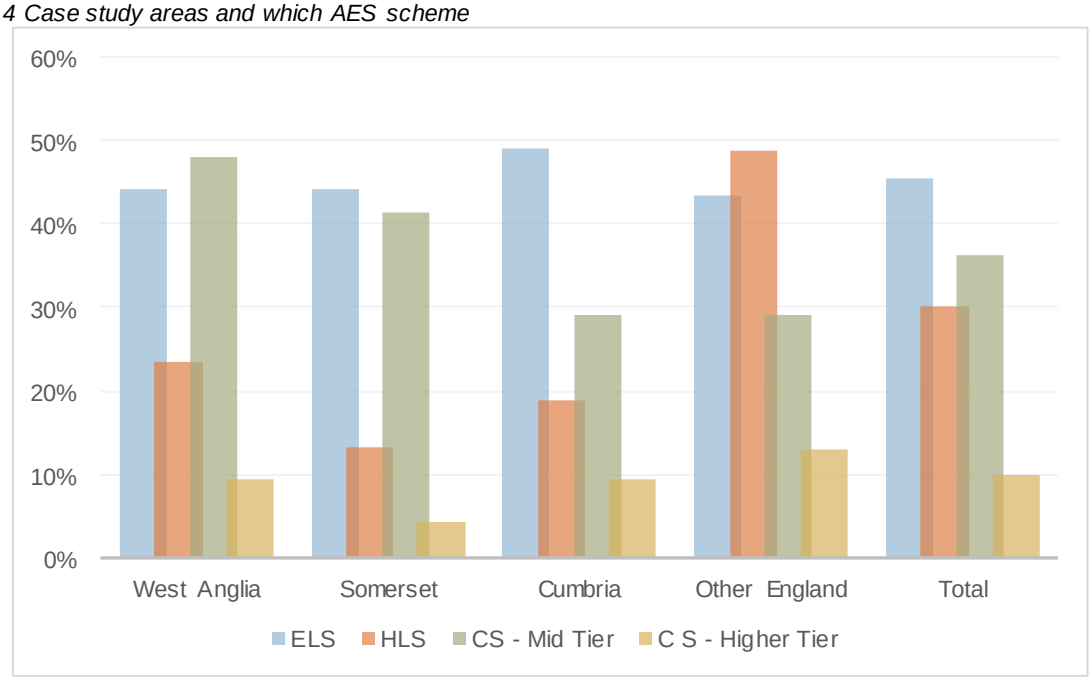
The figure shows that the under 100 ha group is largely made up of the wholly owned respondents, while the mix of 'owned and rented' is a higher proportion in the three case study areas in the over 100 ha group. The largest group in the '100 ha and over' group is the 'mix of owned and rented' category, except in the Rest of England group where the wholly owned group is almost the same size. If you look at the numbers is each category, the largest single group (137) are those who own a holding under 100 ha in size, followed by those who have a mix of owned and rented and are 100 ha or more in size (119). Those wholly owning the farm of 100 ha or more numbered 90. In further analysis, the wholly owned group will be split into those under 100 ha and those 100 ha or more, the mix of rented and owned will be combined with the other categories to provide a three-fold classification.

The sample has been shown to reflect the type of holdings entered into AES schemes and there are understandable variations across the three case study areas. The next set of results explores issues of common land , the presence of a Site of Special Scientific Interest (SSSI) on the holding and involvement in AES agreements. The detailed breakdown is contained in Annex 5. In total 95 respondents (23%) have an SSSI on their holding. The proportion is lowest in West Anglia (15%) and highest in Cumbria (30%) and the Rest of England (25%) sample. Given that the survey is mostly about the impact of extreme weather on AES agreements, perhaps this is not surprising as AES is one of the main mechanisms for funding appropriate management on SSSIs. In Cumbria a large proportion (64%) of the SSSIs are on wholly owned holdings, whereas in the other areas the proportions are more even across the different types of tenure.

The last characteristic to assess is regarding the presence of an AES agreement on the holding since Jan 1st 2015. This is a selection criterion for the three case studies so it would be anticipated that the response would be quite high. There are no selection issues for the Rest of England sample as it was gained through the sample boost process.

Overall, a high proportion (79%) of the sample have had an AES agreement on the holding since 2015. The estimate national coverage for 2015 was about 70% coverage compared to 79% of respondents in this project. This is highest in the Rest of England and Cumbria samples (82%), followed by West Anglia (76%) and Somerset (72%). This leaves 89 respondents (21%) who are not in an AES agreement, and for these it is assumed the vast majority would be receiving Basic Payment Scheme (BPS) support. All those who replied positively (331 respondents) were then asked which AES scheme they were in. The results are shown in Figure 3.4.

Figure 3.4 Case study areas and which AES scheme



Overall, the most common agreement is Entry Level Stewardship (ELS) with 46% of the sample in this scheme. Amongst the sample ELS is highest in Cumbria (49%) and equal in the other three samples at 44 or 43%. The second most frequent AES was Countryside Stewardship (CS) Mid-Tier (MT) with 36% of the sample. Here there is more variation with 48% of the West Anglia sample compared to only 29% of the Cumbria sample. This might be because the range of options in MT for upland farming systems is more limited. High Level Stewardship (HLS) is found on 30% of holdings. The highest group is the Rest of England sample (49%) and lowest in Somerset (13%). CS Higher Tier (HT) is found on 10% of holdings with little variation across the four groups.

Having shown the sample for this study to be typical of others studying AES agreement holders and active farmers, the next section looks at the impact of extreme weather on the farm and on AES agreements.

3.3 Key impacts of extreme weather on farmers and land managers

Impact of different types of extreme weather on farms

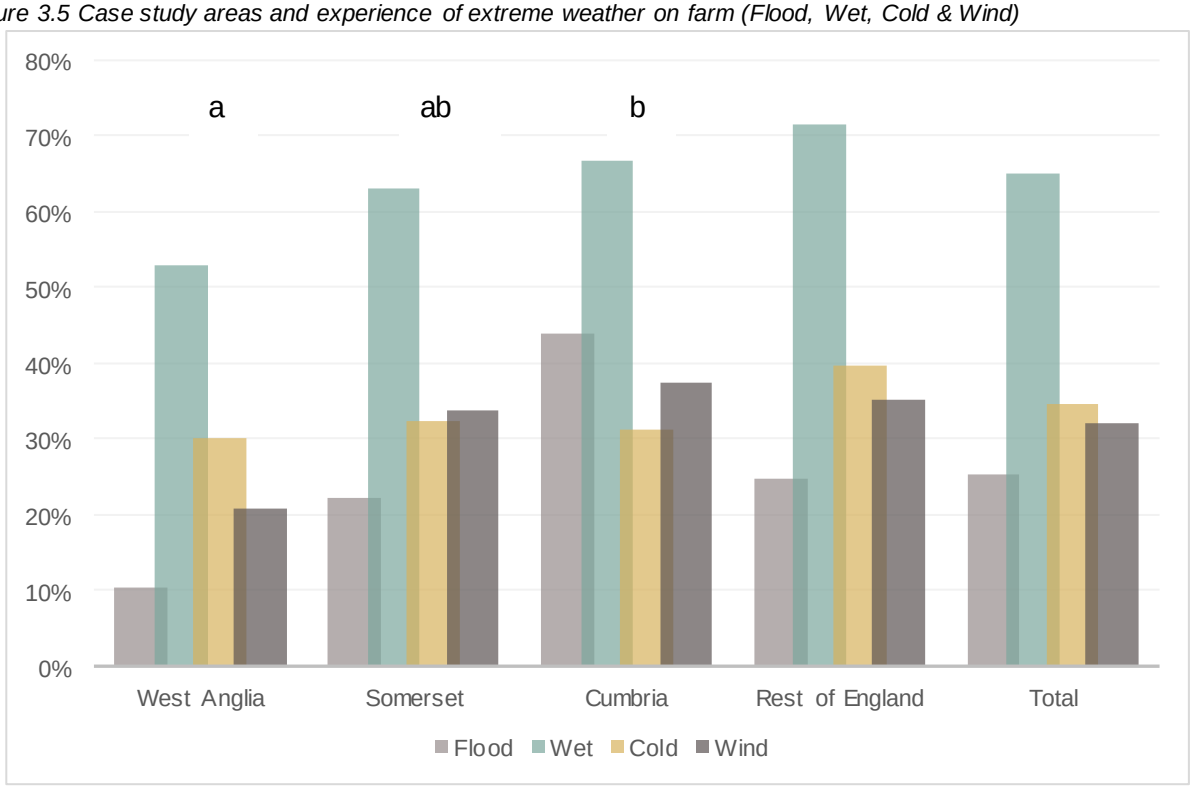
Types of extreme weather impacting farms

This section examines the response between 9 different impacts and the variations between the case study areas and the Rest of England sample in response to the question shown in the box below. These are presented in the next two figures, each showing four related responses with the first, Figure 3.5, dealing with issues of flooding, wet, wind and cold.

> Q8. Over the last 5 years have you experienced any of the following extreme weather events on your farm?
>
> - Heat
> - Wet
> - Cold
> - Wind
> - Drought
> - Flood
> - Unseasonal weather / timings (e.g. early spring/warm winter)
> - Unusual combination of factors (warm & wet / cold & dry)

It should be noted that the responses analysed in this section reflect the method used in that the three selected areas were known to have experienced a Met Office defined weather anomaly (Met Office 2020). The purpose was to assess the impact of these events on the delivery of AES agreements and the processes associated with them.

Figure 3.5 Case study areas and experience of extreme weather on farm (Flood, Wet, Cold & Wind)



Letters **a** *&* **b** *represent a significance difference at* p<0.05.

The highest response in this graph is for the impact of extreme 'wet' weather on the farm with an overall 65% response that ranged from 53% in West Anglia to 71% in the Rest of England sample. The timing of the survey was from June - October 2019, so this would not have been a factor. The response with the most variation is that of flooding. This had an overall response of 25%, but this ranges from 10% in West Anglia to 44% in Cumbria. Flooding, as experien ced in Storm

Desmond in 2015 was one of the factors for selecting Cumbria, so the peak here was anticipated (Met Office 2020). The Rest of England response is 25% and Somerset 22%, which is a little lower than one might expect. However, flooding is a relatively localised event in terms of surface area, whereas 'wet' is more widespread and possibly a better indicator of on-farm exposure to extreme weather.

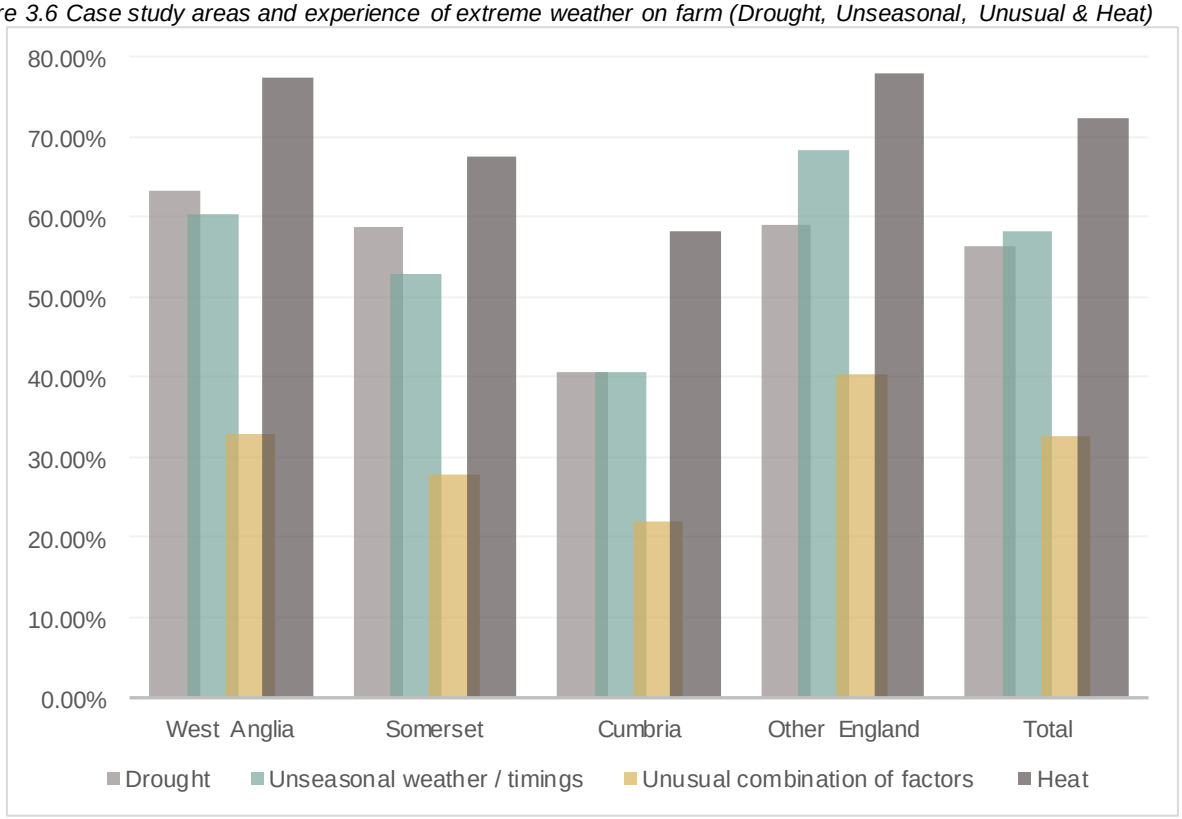
The other two factors are cold, overall 35%, and wind, overall 32%. Both of the response tended to be slightly lower in West Anglia compared to the other three categories, which are all similar to the overall response. Chi-square tests indicate the frequency distributions were significantly different at $p<0.05$ between ; West Anglia and Cumbria.

The next figure shows the response for heat, drought, unseasonal weather or timings (e.g. early spring warm winter) and unusual combination of factors (warm and wet or cold and dry). These are shown in Figure 3.6 below.

The figure shows that the highest response overall in this question is for extreme heat, with 72% of all respondents saying they have experienced this on the farm. The timing of the survey (Jun-Oct 2019) might have been a factor here as the survey was defined as a national drought (see Met Office 2019). There is variation between the four sample groups with West Anglia (77%) and the Rest of England (78%) having the highest response. Somerset (68%) and Cumbria (58%) are slightly lower but in each case heat is the highest response in each sample group. Drought and unseasonal weather or timings have similar responses of 56% and 58% overall. The responses from West Anglia, Somerset and Rest of England are similar at around 55-65% with Cumbria at 40% for both. The unusual combination response is the lowest at 33% with responses ranging from 40% in the Rest of England sample to 22% in Cumbria. Chi-square tests indicate that the frequency distributions for the three areas did not show any significant difference at $p<0.05$.

Having identified the range of extreme weather impacting farms across England and in the three study areas. It is worth seeing if characteristics such as farm size or presence of an AES agreement have an impact on these responses. There is no variation according to farm size with a similar pattern for those under 100 ha and those 100 ha or larger. Among the four sample groups the only variation is smaller farms in Cumbria to indicate that they experience extreme wet weather more than larger farms in the county. The same is true of the second set of factors (heat, drought and unseasonal or unusual weather patterns) with an even response according to farm size.

Figure 3.6 Case study areas and experience of extreme weather on farm (Drought, Unseasonal, Unusual & Heat)



Looking at land tenure, there is again little variation across the overall responses and four sample groups when the three-fold tenure categories (wholly owned, mix of owned and rented and wholly rented) are compared against the first set of extreme weather factors. There is a slight increase in the mixed tenure category for flooding when compared to the wholly owned group. For the second group of factors (heat, drought and unseasonal or unusual weather patterns) the overall response showed little variation. Amongst the four sample groups the only variation is in West Anglia where the 'mix of

owned and rented' group is more prone to these factors than the wholly owned sample. Early analysis suggests that the mixed tenure group are the larger farms in West Anglia but there is no variation when looking at farm size. The numbers are small, but potentially it is a combined factor that renting is the main opportunity for farm expansion given the price of productive farmland, often under short-term arrangements and this might make them more susceptible to the impact of extreme weather.

The next factors to consider are the presence of a SSSI or AES agreement on these various factors across the four sample groups. Looking first at the presence of SSSI, there is little difference overall with wet, cold and cold all having comparable response. Only with flood as there any variation as 42% (40 respondents) of those with an SSSI indicated they have experienced this type of extreme weather compared to 20% (64) of those without an SSSI. The only regional variation occurred in Cumbria where number responding to floods on SSSIs exceeded those with no SSSI. It is probable that the habitats within SSSIs, such as low lying biodiversity rich land, are more likely to be prone to flooding than non-designated land. There is no variation according to the other factors when compared with the presence of an SSSI.

The presence of an AES was high across the whole sample (79%), so the numbers of those without an AES (89) are small when spread across the four sample groups. Looking at the overall figures there is no variation in the wet, cold flood and wind categories. Those with AES agreements are slightly more likely to note heat as a factor (75%) to those with only BPS (63%) but this is the only variation in the second group of factors.

This review of the extreme weather factors mentioned by the respondents has shown a wide range of impacts that appear to be evenly distributed across the four sample groups. Subsequent questions asked those respondents who selected any of the factors, to indicate the impact of the extreme weather factor on the farm. A series of factors were offered and for each the respondent indicated if the extent of the damage was 'severe', 'moderate', 'somewhat', 'not at all' or 'not applicable'. The graphs are presented for each of the four sample groups and beginning with those with the highest response.

Direct impact of extreme weather on farm management decisions

Overall response for direct impacts of extreme weather on farm management decisions

This section of the questionnaire offered a series of options to all 420 respondents on possible impacts of extreme weather on their farm and the impact this has on farming practices and AES agreements. It is important to recall at this point that the three case study areas were chosen because they had experienced extreme weather during the past 5 years. The 'rest of England' sample is made up of those who responded to a request to complete an online survey on the impact of extreme weather. Therefore, the two samples were selected in different ways and their responses might reflect this.

Given that the survey is about the impact of extreme weather on farming and AES agreements, the responses are not an indication on the scale of the issues and could not be rounded up to national figures with any degree of confidence. Nevertheless, almost all (406) of the 420 respondents indicate that they had been affected in some way by extreme weather.

The first question asked about possible extreme weather events on the respondent's holdings. The question is shown in the box below.

> Q9. Please indicate to what extent these direct impacts have occurred in the last 5 years?
>
> For each response say if the impact was: Not applicable, Severely, Moderately, Somewhat, Not at all.
>
> - Flood damage to infrastructure buildings/wall/tracks
> - Flood damage to crops and grassland
> - Flood impact on livestock (stranded/lost)
> - Damage to crops due to dry/hot weather
> - Lack of grazing due to dry/hot weather
> - Wind damage to infrastructure buildings/walls/tracks
> - Crop loss due to extreme cold
> - Animal loss due to extreme cold
> - Wild fires damaging land

The analysis shows that of the 420 respondents all but 28 (6.7%) had experienced at least some direct impact from extreme weather on the farm in the last five years. The other headlines are that:

- 14% had one event, 28% had 2 events, 23% 3 events, 15% 4 or more in the last 5 years.

- Severe: 35% (147 respondents) had at least one severe event in the last 5 years. Of these, 20% had one event, 12% 2 events and 3% three or more. The highest was 6 events and a total of 241 'severe' events recorded from 147 responses.
- Moderate: 72% (302 respondents) had at least one moderate event in the last 5 years. Of these, 34% had one event, 20% had 2 and 8% had 3 or more. The highest was 6 events and a total of 419 'moderate' events recorded from 302 responses.

There is no difference across the case studies, especially at the severe level with 63.4% to 67.8% indicating that there had been no severe events. By farm size, it is the larger farms that are more affected with 37.3% of the 100 ha + category having at least one severe event or more compared to 20% of those under 20 ha.

It would therefore appear, that the impacts of extreme weather on farming are evenly distributed and widespread. The impact is most pronounced on the majority of farmers but larger farmers are more likely to be impacted by severe events. The next section breaks down the type of impact across the 8 options available to the respondents.

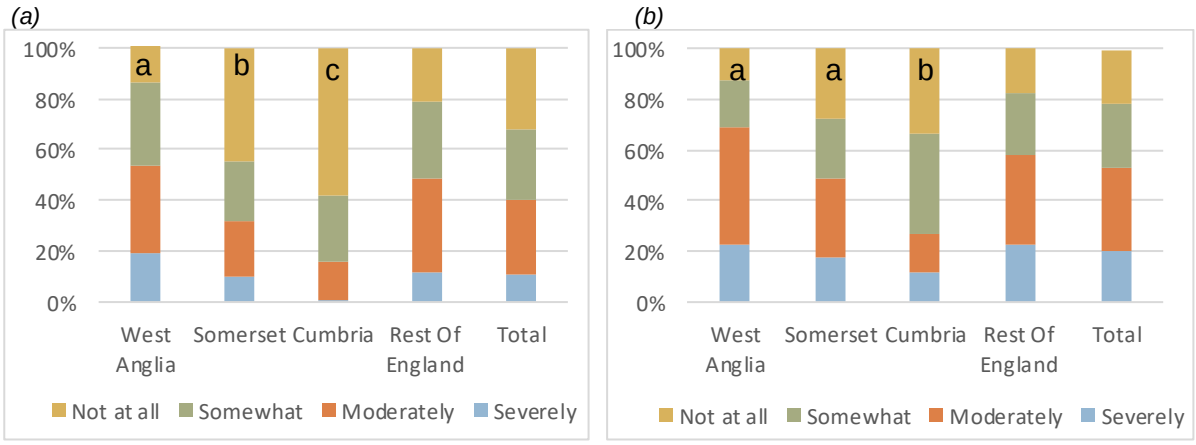
Direct impacts on farms as a result of extreme weather

The second question asked whether there were direct impacts resulting from extreme weather events that have occurred on the respondent's holdings. The question is shown in the box below and contained 7 options.

> Q10. Please indicate to what extent these indirect impacts have occurred in the last 5 years?
>
> For each response say if the impact was: Not applicable, Severely, Moderately, Somewhat, Not at all.
>
> - Dry conditions impacting crop choice & land management
> - Wet conditions impacting crop choice & land management
> - Cold conditions impacting crop choice & land management
> - Lack of water to sustain crops/grass
> - Flooding impacting on land management
> - Housing livestock challenges due to bad weather
> - Use of supplementary feed in bad weather

Given that the type of extreme weather with the highest response was heat, it is not surprising that the impacts that report the most affect on farms are also related to issues of extreme heat or dry weather. The first two graphs show the response to the occurrence of 'damage to crops due to dry/hot weather' and 'dry conditions impacting crop choice and land management' in the last five years.

Figure 3.7 Dry conditions impacting crop choice and land management (a) and Damage to crops due to dry/hot weather (b) by Sample group



Letters **a**, **b** & **c** *represent a significance difference at* p<0.05.

The graph in Figure 3.7b shows that 379 respondents (89%) provided a response to this question with a fifth of these respondents (20%) indicating a 'severe' impact from extreme weather in terms of 'Damage to crops due to dry/hot weather'. The issue of severity was quite consistent across the four sample groups ranging from 23% in West Anglia (n=101) and 12% in Cumbria (n=81). Adding in those moderately impacted the response rises to 53% of the sample. The impacts are most likely to be mild in the Rest of England (35%) (n=137). It is also applicable to most of the respondents, even if there were no impacts. Chi-square tests show the frequency distributions were significantly different at $p < 0.05$ between West Anglia and Somerset on the one hand and Cumbria on the other.

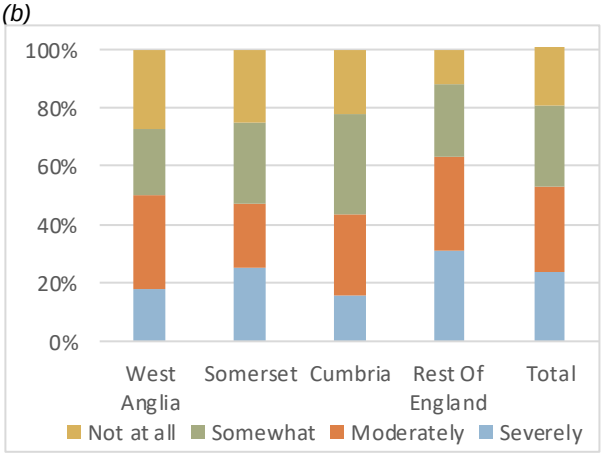
Dry conditions impacting crop choice and land management (Figure 3.7a) is another option that was applicable to most respondents (376, 90%). Those who are severely impacted are less (11%) but this rises to 19% in West Anglia (n=98) but only a single respondent (1%) in Cumbria (n=82). Adding in the 'moderately' responses the proportion in West Anglia rises to 54% but remains at only 16% in Cumbria. The slightly lower impact of crop choice is likely to be that farmers can, to some extent, select crops to suit the conditions. For example, planting spring crops if the autumn conditions are not suitable. This might explain the greater weighting for moderate impacts. The findings also suggest that the impact of heat and dry weather varies across the regions in England. Chi-square tests indicate the frequency distributions show a significant difference at $p < 0.05$ for all 3 regions, West Anglia, Somerset and Cumbria.

The other two impacts associated with dry weather concerned a lack of water to sustain crops or grass and a lack of grazing due to dry/hot weather. The results are presented in the next pairs of graphs below.

Figure 3.8 Lack of water to sustain crops/grass (a) and Lack of grazing due to dry/hot weather (b) by Sample group

(a)

(b)



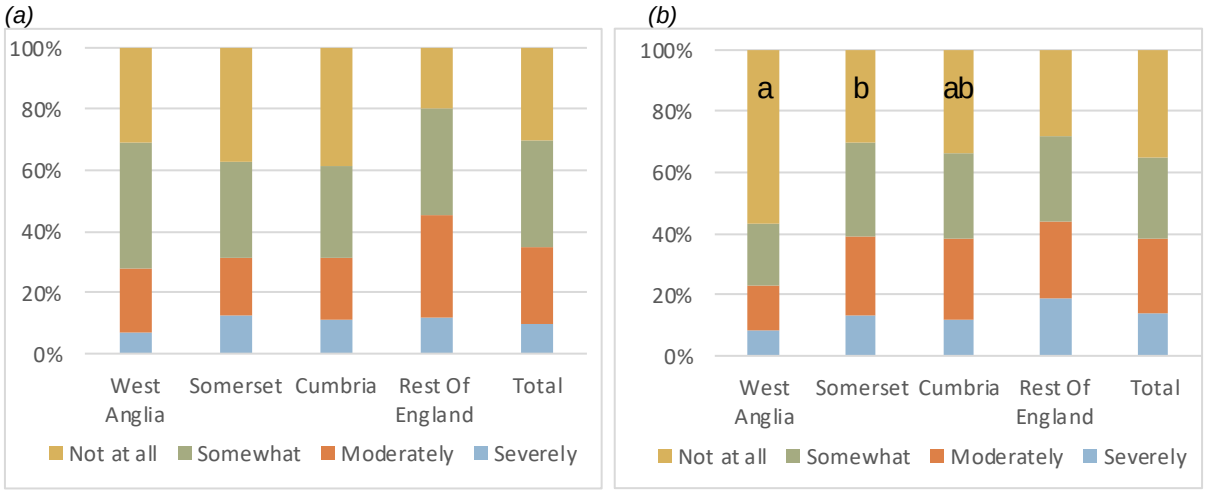
Letters **a** *&* **b** *represent a significance difference at* $p<0.05$.

The graphs show that a lack of water to sustain crops/grass is relevant in 400 cases (95% of all cases) and is rated as 'severe' in 18% of cases rising to 23% of those in the Rest of England sample (n=135) and 20% of West Anglia respondents (n=103). This falls to 10% in Cumbria (n=89). As a result, the responses are more even than in the previous two graphs This response is also applicable to all but 20 of the respondents suggesting a widespread impact. Over three quarters of respondents are impacted in some way, 80% in West Anglia and 78% in the Rest of England samples with 64% in Cumbria. Chi-square tests show the frequency distributions are significantly different at $p < 0.05$ for West Anglia and Cumbria only. This will be pursued in the next chapter, but it is possible to make some suggestions as to why the West Anglia responses is higher. Within AES agreements the issue of a 'lack of water' will impact the establishment of margins and the management of permanent grassland and both are present in a number of West Anglia agreements.

The impact of dry/hot weather on grazing (n=349) shows a reverse trend with the impacts most strongly felt in all sample groups, except West Anglia where 40 respondents (38%) said this aspect does not apply to them (n=66). This compares with 2% in Cumbria (n=90) and is because respondents in West Anglia had no livestock and/or grass. In terms of severe impacts in the Rest of England sample a lack of grazing impacted 31% of respondents (n=133) and 25% in Somerset (n=60) but only 16% in Cumbria. In terms of those with at least some impact, in Cumbria this is 78% and 88% in the Rest of England. Again, this suggests that impacts are regional but also specific to the farming system of the holding. Chi-square tests indicate the frequency distributions were not significantly different at $p < 0.05$ for the 3 regions. Again, the presence of particular options, reviewed in the next section, will assess the impacts that these changes in the farming approach will be needed which could be constrained by an agreement.

Turning now to the impacts associated with extreme wet weather the next set of graphs look at the response to 'wet conditions impacting crop choice and land management' (n=385) and 'use of supplementary feed in bad weather' (n=336). The responses are shown in the two graphs below.

Figure 3.9 Wet conditions impacting crop choice and land management grass (a) and Use of supplementary feed in bad weather (b) by Sample group



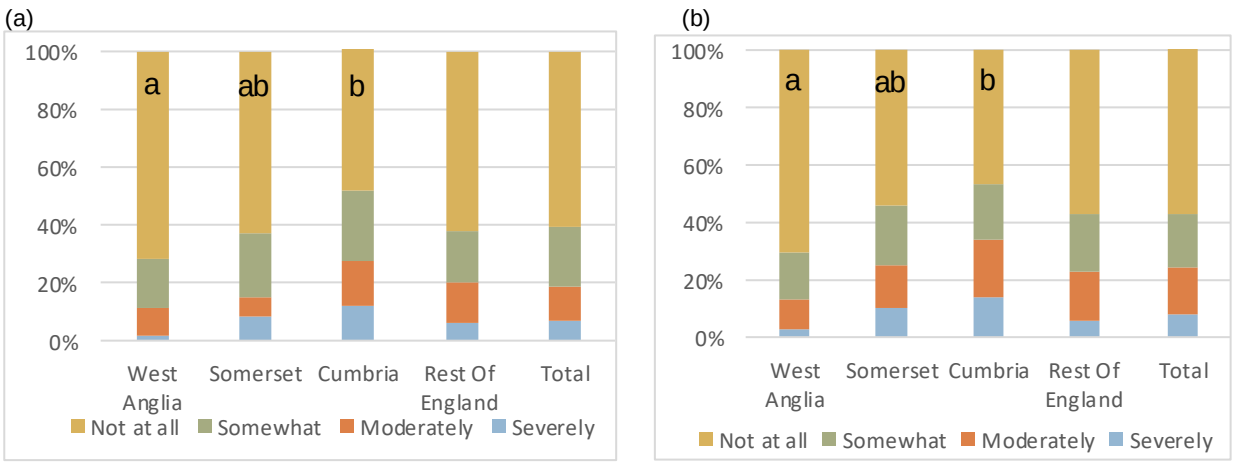
Letters **a** *&* **b** *represent a significance difference at* p<0.05.

The impact of wet conditions on crop choice and land management impacts over 60% of respondents. In 10% of cases the impact is severe, less than the cases reported due to dry or hot weather. The timing of the survey might be a factor here, coming at the end of the 'hot' 2019 (Met Office 2019) summer with 2018 still in the memory. Nevertheless, moderate impacts are mentioned by 25% of respondents, 33% in the Rest of England sample and 21% in West Anglia. The combined responses in the first two categories of the area case studies is very similar at around or just under 30% for this impact with the Rest of England higher at 45%. Chi-square tests showed that frequency distributions had no significance difference at $p < 0.05$ for the 3 regions.

In the case of use of supplementary feed in bad weather this impact is severe in 14% of cases overall, highest in the Rest of England sample (19%, n=128) and Somerset (13% n=61) but only 8% in West Anglia (n=60), where 44% said this impact is not applicable, presumably as they have no livestock over winter. The number registering some impact is highest in Somerset and Cumbria at about 70% (70% and 66% respectively) and 72% in the Rest of England sample, compared to 43% in West Anglia. Chi-square tests indicate the frequency distributions were significantly different at $p < 0.05$ for West Anglia and Somerset only.

The two other 'wet' related impacts with notable numbers recording an impact are 'flooding impacting on land management' (n=379) and flood damage to crops and grassland (n=341). These are shown in the two graphs below.

Figure 3.10 Flooding impacting on land management (a) and Flood damage to crops and grassland (b) by Sample group



Letters **a** *&* **b** *represent a significance difference at* p<0.05.

The responses for these two potential impacts are marked lower than the preceding ones covering wet weather. Both have an overall response of under 50% for all levels of impacts. In terms of Flooding impacting land management the

impact is most severe in Cumbria (n=89) (12% of responses) compared to 2% in West Anglia (n=99). The cumulative total of all impacts is 51% compared to 28% in West Anglia. It is likely that this would cover periods of extreme weather such as Storm Desmond (2012/13) that fell within the five-year period. Chi-square tests show the frequency distributions were a significantly different at $p < 0.05$ for West Anglia, and Cumbria only.

Flood damage to crops and grassland is considered to have an impact on 42% of holdings. In terms of severity, the impact is most pronounced in Cumbria (n=79) (14%) and least severe in West Anglia (n=90) (3%). The total for all those respondents reporting an impact in Cumbria is 53% and 46% in Somerset (n=57) compared to 30% in West Anglia with 42% overall. Chi-square tests show the frequency distributions were a significantly different at $p < 0.05$ for West Anglia, and Cumbria only.

There are a number of other statements offered to the respondents, but the numbers are too small to report by the sample group. Housing livestock in bad weather is not applicable to 97 (23%) of respondents, because they did not have any livestock. Looking at those who did reply (n=323), 7% of respondents said the impact is severe. The overall impact is 49% of which 24% was 'somewhat', the lowest level of impact. In Cumbria (n=84) this category is 33%, with overall impacts reaching 55%. But only 31% in West Anglia (n=59), where 44% indicate this aspect does not apply to them. In terms of flooding as before the responses are low as the impact is localised when compared to the 'wet' related statements. Concerning 'flood damage to infrastructure (buildings/walls/tracks) for 90 respondents (21%) this is not applicable, leaving 330 to offer a response. Of these 4% of respondents said that in the last 5 years they had severe impact with 37% reporting some level of impact. This is highest in Cumbria (n=82) where 55% reported some level of impact, of which 11% was severe. Likewise, 'flood impact on livestock (stranded/lost)' is not applicable to 30% (127) of the sample leaving a sample of 293 respondents. Of these 50 (17%) record any sort of impact with the highest proportion in Cumbria (n=79) at 25%.

The series of statements about wind or cold weather received the lowest level of response of all the statements offered , as suggested by the comments in previous sections. Wind damage to infrastructure (buildings/walls/tracks) is considered severe in 3% of cases and 'not at all' in half of cases. Crop loss due to extreme cold is severe three cases and not all in 72% of cases and not applicable in a further 16%. Animal losses from extreme cold are similarly rare (13 cases, 3%), as is damage from wild fires (three cases). Finally, cold conditions impacting crop choice and land management is noted as severe by seven respondents (under 2%) and not at all by 63% with a further 12% (51 respondents) saying this did not apply to them. The responses for all of these is fairly even across each sample group and the responses too low to report further.

Overall, as in the identification of individual types of extreme weather impacting on farming, the level of impact from dry and hot weather appears slightly greater than for wet weather. It is not possible to weight the response according to timing of the survey, and the results might be different had the survey been conducted in early 2020, which was the wettest February since records began. Nevertheless, it is possible to report that farmers are severely impacted by extreme weather, and the findings here go some way to showing the range and level of impacts.

The next section looks at the issue of AES agreements and BPS compliance with regard to the impacts of extreme weather.

3.4 Impact of extreme weather on AES agreements and BPS compliance

Impact of extreme weather on AES agreements

Overview of responses

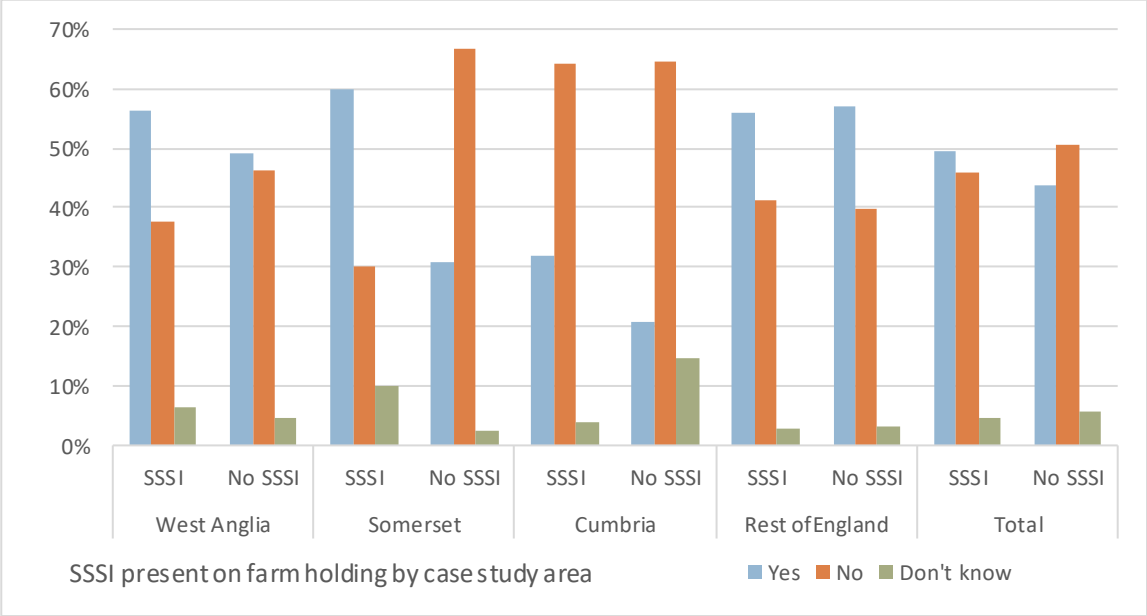
This section focuses on the impact of extreme weather on AES agreements. All 331 respondents who had an AES agreement in the last 5 years, were asked the question '*In the last 5 years, do you think extreme weather variability has affected your ability to deliver aspects of your agri-environment scheme (i.e. ELS/HLS/CS)'.* Of the 331, 45% (149 respondents) said that weather variability has affected their ability to deliver aspects of their AES agreement. Just under half (49.6%) say there has been no impact on their AES agreement (164 respondents), with 18 saying that they do not know.

There is some regional variation in the responses with 56% of the Rest of England sample saying that had been an impact, 51% of West Anglia, 37% of Somerset and 25% of Cumbria. It is worth reminding ourselves of the different sampling approaches as this is likely to be behind the different responses. The three specific areas were chosen because of the known extreme weather events that had taken place there and the sample were sent invitations to take part by letter, email or through events and contacts. The Rest of England sample picked up the link to the survey via

social media that was promoting a survey about the impact of extreme weather on AES and farming. So, the latter sample is more likely to be a choice to participate because of an impact they had experienced, whereas the former sample might participate because of the invitation. In subsequent analysis we might expect to see the Rest of England response to be more pronounced than the other three selected areas.

The link between these initial responses and some basic characteristics reveals that the impact on extreme weather does not have a strong relationship with farm size, only in Cumbria are the smaller farms (under 100 ha) likely to say they that extreme weather has impacted their agreements. Comparing those respondents who had an SSSI on their holding alongside the AES agreement and those who did not. The results for this are shown in the graph below.

Figure 3.11 Impact of extreme weather on AES agreements and presence of SSSI by Sample group



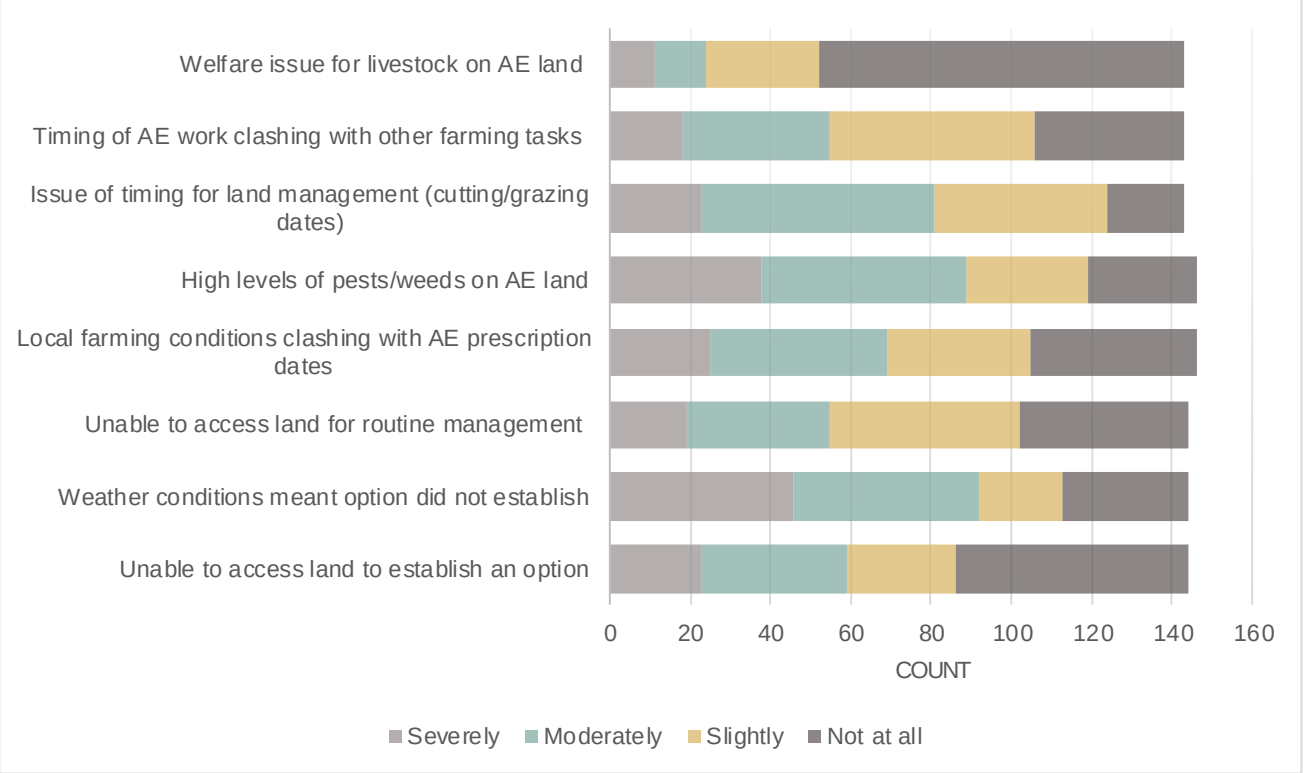
The graph shows that overall those with SSSIs are slightly more likely to say that extreme weather has impacted their AES agreement. In the Rest of England sample those with no SSSI are just as likely to report an impact on their AES agreement as those with an SSSI. In Cumbria, the low response of reporting an impact on the AES agreement is reflected in both categories, although those with an SSSI are slightly higher (32% compared to 20%). Those who don't know, highest in Cumbria at 10%, are mostly those who don't have an SSSI. In Somerset those with an SSSI are twice as likely (60% compared to 30%) to say there is an impact on the AES from extreme weather. It is possible that this is because the SSSI is Somerset are focused on low lying land that is prone to flooding. In the previous section, it was noted that In West Anglia the responses are fairly even. It is difficult to report a pattern here, but it does suggest that the presence of an SSSI can be a factor. For example, we know that the presence on a SSSI is linked to the presence of a higher more complex AES agreement so it is possible the management required is more likely to be affected by extreme weather.

Nature of impact on AES agreements from extreme weather

Having assessed the various characteristics of this group, the 149 respondents were then asked a series of supplementary questions about their agreement and the potential ways that extreme weather had an impact on the delivery of the AES agreement. The question asked the 149 respondents who said that there had been an impact on the EAS agreement to indicate '*to what extent you experience the following circumstances in the last 5 years, due to extreme weather'*. A list of 8 options then followed, each with a response indicating the severity of the impact. Due to the small numbers the response of the whole sample is considered with reference made to the four sample groups where an unusual response is received. The first figure in this section shows the overall response.

The figure shows that all of the options had impacted AES agreement holders at some point in the last 5 years. The most impacted activity amongst AES agreement holders is '*weather conditions meant option did not establish',* possibly because this is a broad category and not sector specific. About a third of respondents (32%) said they are 'severely' impacted, with a further 32% saying they are 'moderately' impacted. Only 21% are 'not at all' impacted. There are some interesting variations in the four sample groups. In West Anglia 48% (19 respondents) have been severely impacted and only 8% (3 respondents) not at all impacted, presumably as those in arable would be more likely to be impacted due to larger areas falling into this category. The Rest of England sample closely reflected the overall sample and the figures in the other two areas are too small to report.

Figure 3.12 Type of impact extreme weather has on AES agreements by severity for whole sample



The second option in terms of severity is '*high levels of pests/weeds on AE land*' with just over a quarter (26%) being impacted severely and 35% moderately. Only 19% are not impacted at all, again suggesting that this is a widespread issue for those with AES agreements. In West Anglia a third (32%) said they are impacted 'severely' and 51% 'moderately' compared to the Rest of England sample where only 4% (14 respondents) said they are 'severely' impacted. The highest response for severity is Somerset with 39%, but this is only 7 respondents and there was not room to enquiry what the direct link to extreme weather was.

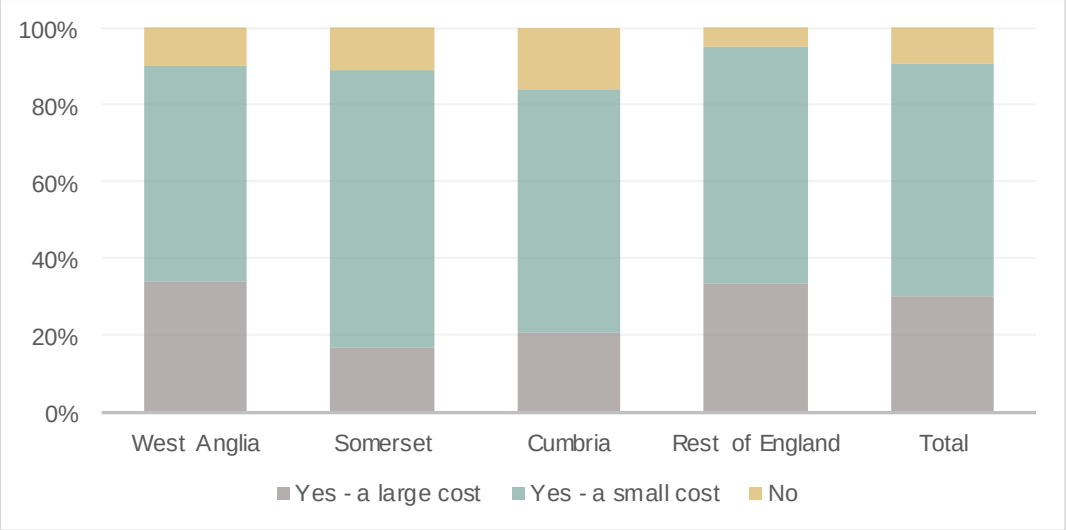
The third and fourth options in terms of severe impact covered issues concerning dates: '*local farming conditions clashing with AE prescription dates*' and '*'issue of timing for land management (cutting/grazing dates)*. Interpretation of this is difficult without a control sample, and so the impact of extreme weather is unclear but in extreme dry weather grass would be ready to cut for hay possibly earlier than the dates specified in the option prescription. The '*local conditions*' option recorded 17% saying the impact of this is 'severe' and 30% saying it is 'moderate'. In the Rest of England sample the 'severe' proportion rises to 22% (15 respondents) with a further quarter saying the impacts are 'moderate'. The level saying there is no impact 'not at all' is even across all four sample groups. For the *'issue of timing'* option 16% said the impact is 'severe', with 41% saying the impact is 'moderate'. Only 13% of the sample said the impact is 'not at all' over the last 5 years. The regional sample is interesting as West Anglia recorded a low response for 'severe' (5%, 2 respondents) but 56% (23 respondents) said the impact is 'moderate'. It is likely that these moderate impacts will be influenced by the popularity of different options within each of the case study areas. This will be examined in the next section, but the timing of hay cuts and establishment of margins and wildbird mixes would be possible examples of this.

The next two options covered issues concern an inability to access land to '*establish an option'* and to '*undertake routine management'*. The overall response for '*unable to access land to establish an option'* was found to be 'severe' in 16% of cases with 25% saying it was moderate. However, 40% said that they received no impact from extreme weather. This response is reflected in the four sample groups. In terms of routine management 13% said the impact is 'severe' and a further 25% that it is 'moderate', with 29% having no impact at all. The small numbers caveat the interpretation across the sample groups but Somerset and Cumbria were lower than the overall sample for 'not at all', 16% and 6% suggesting that there was some impact from this aspect in these areas.

The final two options look at the issue of '*timing of AE work clashing with other farming tasks'* and '*welfare issues for livestock on AE land'*. The issue of clashes between AE work and other farming tasks is felt to be 'severe' by 13% of the total sample and moderate in 26%. The impact is 'not at all' present in 26% of cases. In Cumbria 11 respondents (61%) said their AE agreements are 'slightly' impacted. The impact on the welfare of livestock received the lowest response with 8% saying this is 'severe' and 9% saying it was 'moderate'. In 64% of cases there is no impact at all.

The last question in this section asked those respondents who said that there was an impact from extreme weather on their AEs agreement, if these circumstances had resulted in additional financial cost to the farm business. The responses are shown in the figure below.

Figure 3.13 Financial cost to farm business from extreme weather impact on AES agreement by sample group



The figure shows that in 30% of cases (44 respondents) there has been a large cost and in 60% of cases the cost has been small. The samples with the highest response in the high cost category are both the larger sample, namely West Anglia (34%) and the Rest of England (32%). Four respondents in the Rest of England sample did not know if there had been a cost, so this response does not equal 100%. A consequence of this being an online survey, is that there is no opportunity for respondents to add any detail or to indicate what a 'large cost' was. The response is the perception of the respondent, partly as the different regions selected have very different farming sectors. What it was possible to do was to compare the response against other factors, such as farm size. Perhaps not surprisingly, those with larger farms (100 ha and over) are more likely (35%) to have larger costs as a result of extreme weather impacts. This is notably the case in the Rest of England sample (36%) and West Anglia (39%). The presence of a SSSI also means that you are more likely to have a large cost, 39% compared to 28% for those without an SSSI. It is concerning that extreme weather has a financial implication for farmers with AES agreements and in a about a third of cases this is a significant cost.

The next section focuses on the processes related to AES agreement when the agreement holder need s to adjust the agreement.

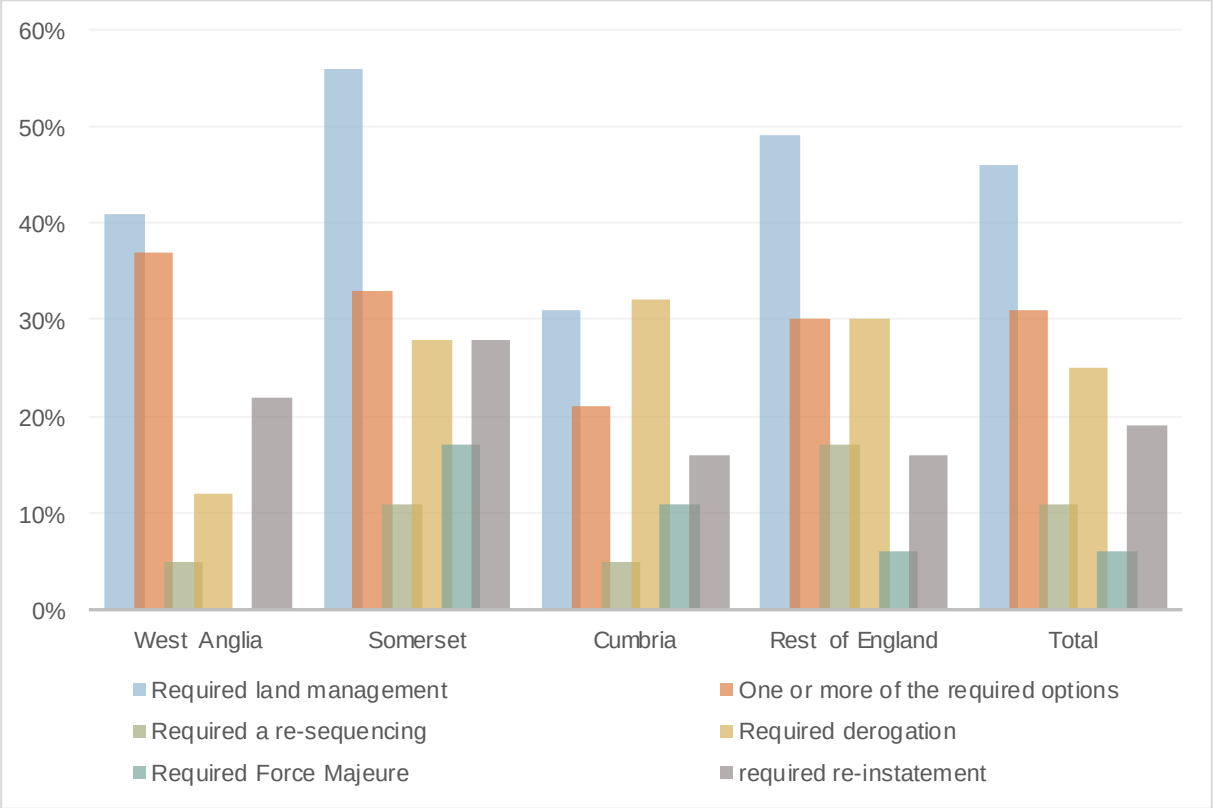
Outcomes of extreme weather on AES agreements and related processes

This next set of questions considered the outcomes of extreme weather on AES agreements in terms of the changes required and the processes involved in adjusting or altering the AES agreement. The first question asked all of the 149 respondents who said that extreme weather had impacted their agreement if 'this related in any of the following outcomes' and they could tick all that applied:

- Unable to undertake required land management operations within stipulated time
- Unable to fulfil one or more of the required options in correct year
- Required/requested a re-sequencing of AE options and management activity
- Required/requested derogation due to extreme weather event
- Required/requested Force Majeure on agreement due to extreme weather event
- Post event compliance requirements required re-instatement to meet requirements.

Of the six options offered, the most frequent response from the 149 respondents is '*unable to undertake the required land management operations within the stipulated time*'. This impact is mentioned by 46% of the 149 respondents. The responses from the sample group need to be considered with caution as the response for Somerset and Cumbria are from small populations (18 and 19 respondents respectively). The second most likely impact according to our sample is that of being '*unable to fulfil one or more of the required options in the correct year*', which was selected by 31% of respondents.

Figure 3.14 Did extreme weather result in various outcomes concerning AES agreement by sample group



The third highest response covers the issue of derogations or MTAs, these are the submission of a formal request to NE to undertake an operation outside of the prescribed dates (e.g. to cut hay earlier than the date specified in agreement). A quarter of the sample indicated that they had *'required or requested a derogation due to extreme weather'*. Such requests are considered by NE or RPA staff and require a response within a set time. The suggestion here is that over a 5-year period a quarter of those who indicated that they had been impacted by extreme weather seems important. The number responding is 11% of all those in this survey who have AES agreements.

Data regarding derogations under CS were not available but an analysis of derogations for a 10 year period under ES from 2010-2020 was undertaken. In total there were over 1,100 entries, but derogation requests relate to parcels rather than agreements and multiple entries were made for the same agreement in order to cover the land parcels that the derogation referred too. In the justification section, there are references to drought (e.g. *wish to cut hay on grass field due to drought, the grass is burning off and needs cutting before the 1st July* and *Cut conservation headlands due to drought to help alleviate shortage of winter feed stocks*). The latter was requested on 18 different parcels. Others were for the extension of grazing in the autumn as the drought had extended the grazing season. One such case took up 90 rows of the spreadsheet, detailing each parcel and the justification in most of these concerned drought conditions.

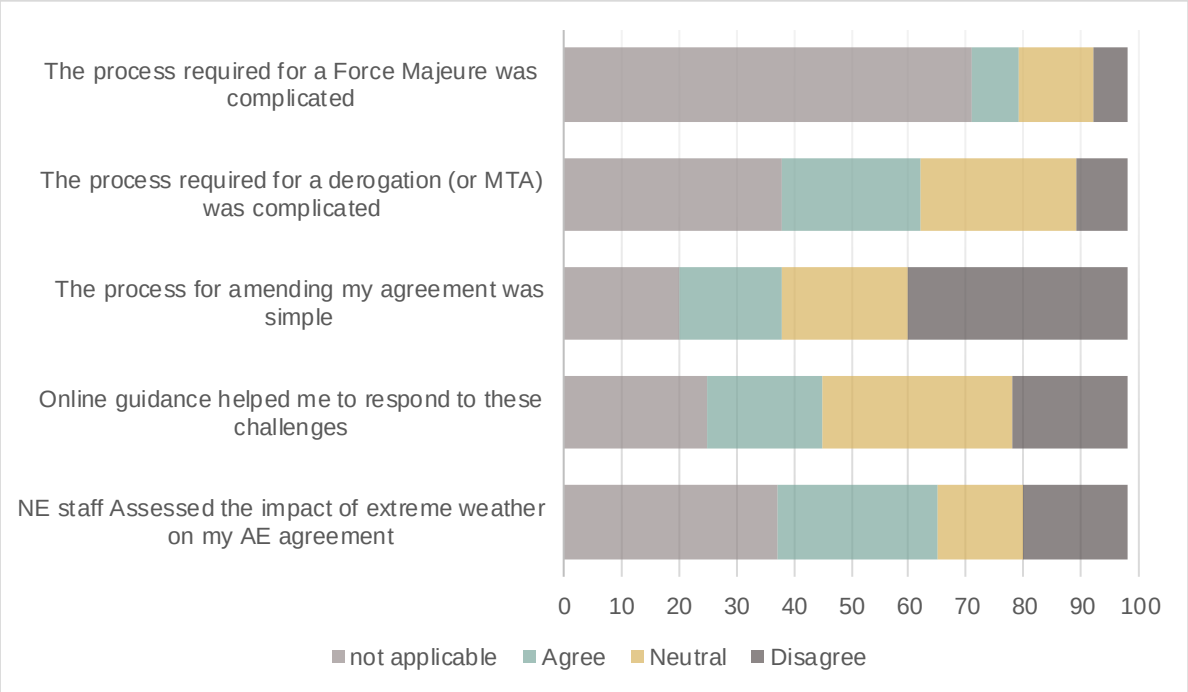
Using word search and manually registering a single count per holding, it was possible to estimate that there were:

- 24 requests by agreement holders for derogations referring to drought, of which 15 were linked to concerns about the amount of fodder for livestock.
- Flooding was an issue mentioned in far more cases, mostly relating to the impact of flooding and the inability to undertake work or the need to reinstate aspects related to the AES agreement.
- Of the 163 instances well over 30 were recorded as 'Cumbria flooding'.
- Very few are derogations in anticipation of flooding or linked to issues of prevention. Some are also linked to the Farm Recovery Fund applications (see section in Chapter 4).

The other three responses received less than 20% responses rates. Firstly, 19% indicated that they had to seek '*post extreme weather event compliance required for re-instatement*'. A request for '*re-sequencing of AE options and management activity*' was required in 11% of case. The outcome with the lowest response was '*required/requested Force Majeure on agreement due to extreme weather event*' and this was mentioned by 9 respondents (6% of cases). This is where the agreement holder and NE mutually agree that the delivery of the agreement cannot be met due to unforeseen factors beyond their control. As a result, there is no consequence for not delivering a specific option(s) but in most case the agreement continues and would be expected to return to normal.

Those who indicated that a change was required were asked a series of questions about the process and how effective the processes were in meeting the challenge they faced. In total 98 respondents provided a response, which is shown in the figure below.

Figure 3.15 Statements on effectiveness of administrative processes in meeting challenges faced extreme weather (n-98)



Looking at the size of responses, the statement with the most useable responses is that of '*the process of amending my agreement was simple'*. This was completed by 77 of the 98 respondents (79%), with nearly a half of those who stated a preference (48%) saying that they disagreed with the statement and 23% agreeing that it was simple. Some further statistical analysis in Table 3.5 shows that twice as many people disagreed with the statement that amending their AES agreement was simple as agreed, which is significant using the Chi-square test. The other statement with a significant response was *the process for derogations is considered complicated,* which more than twice as many agreed with (24) than disagreed (9).

There was no significant difference in the other responses with exactly the same number agreed as disagreed concerning the statement that the '*online guidance helped me to respond to these challenges'. The role of NE staff in assessing the impact of extreme weather on agreements* was affirmed in 28 cases and disputed in 18, with 15 remaining neutral. Only 27 respondents felt able to comment on the issue of Force Majeure meaning that little could be interpreted from these results.

Table 3.5 Further statistical analysis on Effectiveness of administrative processes in AES

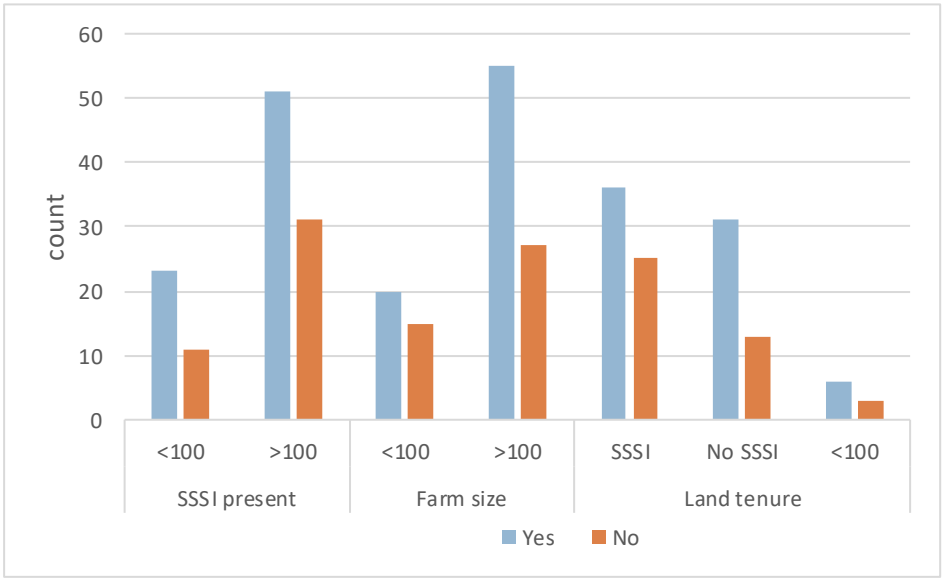
Statement	% difference disagree compared to agree	Chi-square significance	Result
The process required for a Force Majeure was complicated	-25%	ns, p = 0.59	no difference between number agreeing or disagreeing
The process required for a derogation (or MTA) was complicated	-63%	p = 0.009	more than twice as many agreed than disagreed
The process for amending my agreement was simple	111%	p = 0.007	twice as many disagreed than agreed
Online guidance helped me to respond to these challenges	0%	ns, p = 1	exactly the same number agreed or disagreed
NE staff assessed the impact of extreme weather on my AE agreement	-36%	ns, p = 0.14	no difference between number agreeing or disagreeing

ns = not significant at p<0.05.

Overall, the view from those who experience the administrative process concerning adjusting an AES agreement suggests that the process for adjusting and amending agreements is not simple and the process for derogations is complex. The information collected on derogations suggests that many are a result of extreme weather, although the data is not collected with a view to further analysis.

The final three questions in this section asked the 149 respondents about different aspects of the environmental delivery of their AE agreements with a particular focus on the impact of dates and timings of operations. In this sense the responses are all linked. The first state asked '*do you consider that the timings in your AE prescriptions have a negative effect on your ability to deliver your agreement?'* In total half of the eligible respondents (75 respondents) said 'Yes', 28% said 'No' and 22% 'Didn't know'. The responses are closest in West Anglia (42% Yes and 32% No). There are some interesting variations according to the key variables of farm size, land tenure and presence of an SSSI. These are shown in the figure below.

Figure 3.16 Do you consider that the timings in your AE prescriptions have a negative impact on your ability to deliver your agreement?

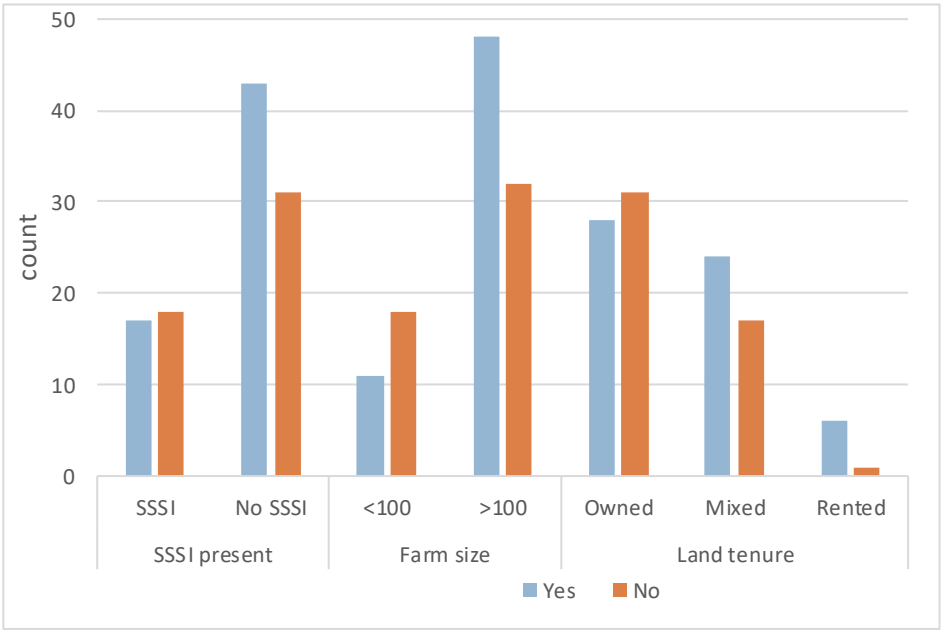


The figure reveals that those with a SSSI are slightly more likely to say that there is an impact, compared to those without an SSSI, possibly reflecting the more sensitive nature of these sites and a higher level of environmental awareness amongst agreement holders linked to these sites. In terms of farm size, farms which are 100 ha or larger are far more likely to say there is an impact from AE prescriptions on the ability to deliver. The differences according to tenure are less clear but those with mixed tenure (some rented and some owned) seem the most likely to say there are challenges presented by AE prescriptions. For this question the respondents were able to add further explanation, of which some examples are:

> *Some mowing options are too prescriptive, and don't always create the best result;*
>
> *The prescriptive dates did not allow flexibility in sowing of mixes, which would have been better suited to sowing when conditions were right, rather than by date;*
>
> *Late mowing for silage/haylage results in poorer quality fodder and shortage of grazing beforehand.*

The second statement asked '*do you consider that the timings in your AE prescriptions have a negative effect on the environmental outcomes of your agreement?'* In total 40% of the sample (60 respondents) said 'Yes', 34% said 'No' and 26% 'Didn't know'. The responses were closest in West Anglia (39% Yes and 42% No) and furthest apart in the Rest of England (45% Yes and 27% No). As before there are some interesting variations according to the key variables of farm size, land tenure and presence of an SSSI. These are shown in the figure below.

Figure 3.17 Do you consider that the timings in your AE prescriptions have a negative effect on the environmental outcomes of your agreement?



Although overall the response was much closer for this statement, those where there was no SSSI felt that the impact of the prescriptions was more likely to harm the delivery of the environmental outcomes. As previously, the larger farms felt this was more likely to be the case as well. Smaller farms were more likely to say that there was not an impact. The split across the land tenure samples was much more even. Some of the comments made by respondents are illustrative:

> *Forced into establishing options in less than ideal conditions to meet time frame;*
> *Timing of cutting pollen and nectar [margins] does not lead to best regrowth;*
> *Too much weed for ground nesting birds*

The final statement asked respondents if '*some of the options within your AE agreement have reduced the impact of extreme weather on your farm/holding.* In total 19% of the sample (28 respondents) said 'Yes', 64% said 'No' and 17% 'Didn't know'. The responses were closest in West Anglia (32% Yes and 59% No). There were no variations according to the key variables of farm size, land tenure and presence of an SSSI. Some of the comments made by respondents indicate a range of possible benefits arising from AES agreements, but the benefit of margins and buffers for soil erosion was the most frequent comment, as the first indicates:

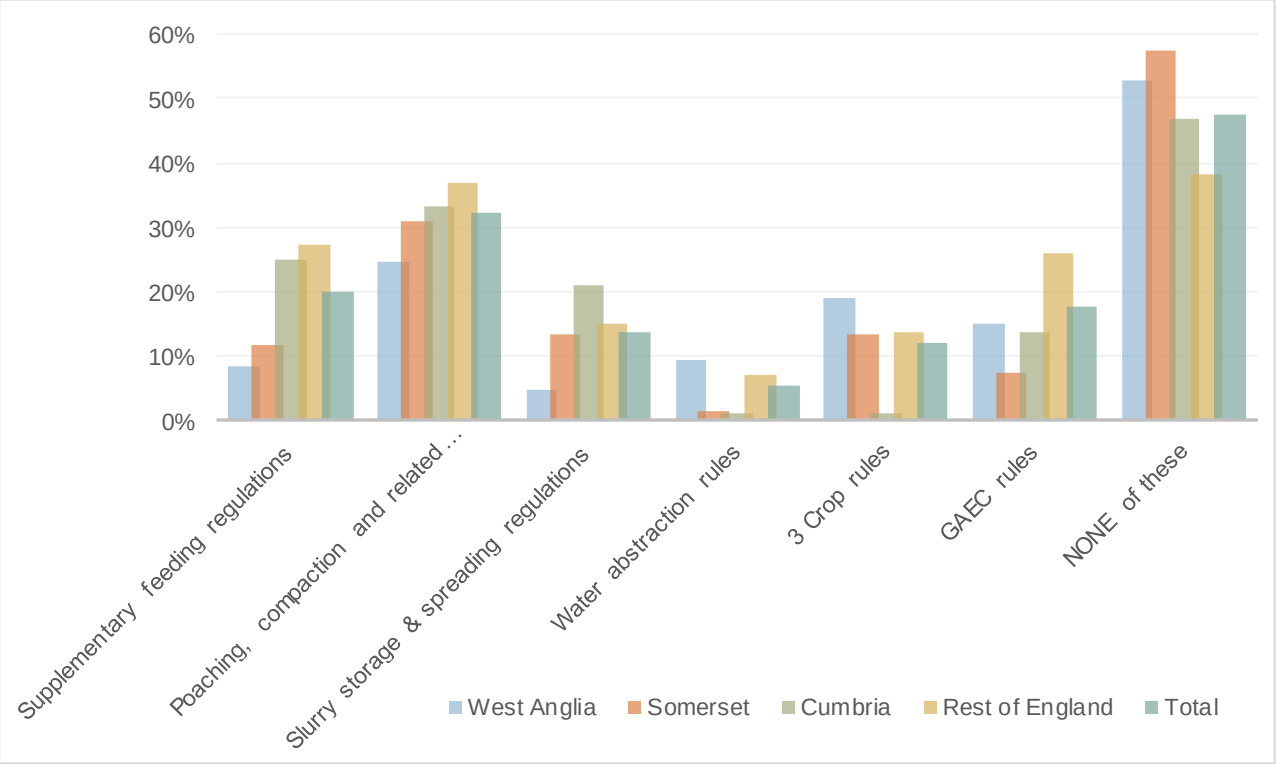
> *Buffer strips stop excess water reaching water course;*
> *Herbal leys retaining moisture=drought and flood resilience;*
> *Low stocking rate means there is plenty of grazing, though it could mean less hay. In practice the increased variety of clovers, vetches etc mean the crop carried on growing and was a good crop later on even though the amount of grass was less.*

While the numbers are small, this is a really positive message for AES and shows the potential for some options to act as nature-based solutions to challenges on agricultural holdings. The next section looks at the issue of the Basic Payment Scheme and possible impacts of extreme weather on this part of the agricultural support system

Outcomes of extreme weather on AES agreements and related processes

As well as impacting AE agreements, perhaps more widespread is the possibility that extreme weather might impact on a farmer or land managers ability to follow the regulatory requirements associated with the BPS. In order to assess this, all 420 respondents were asked if any of 6 listed regulations *'proved challenging to fulfil due to extreme weather-related issues'*. The list included all of the requirements in BPS such as supplementary feeding, soil management, slurry storage, water abstraction, the 3-crop rule and keeping land in Good Agricultural & Environmental Condition (GAEC). The results are shown in the figure below.

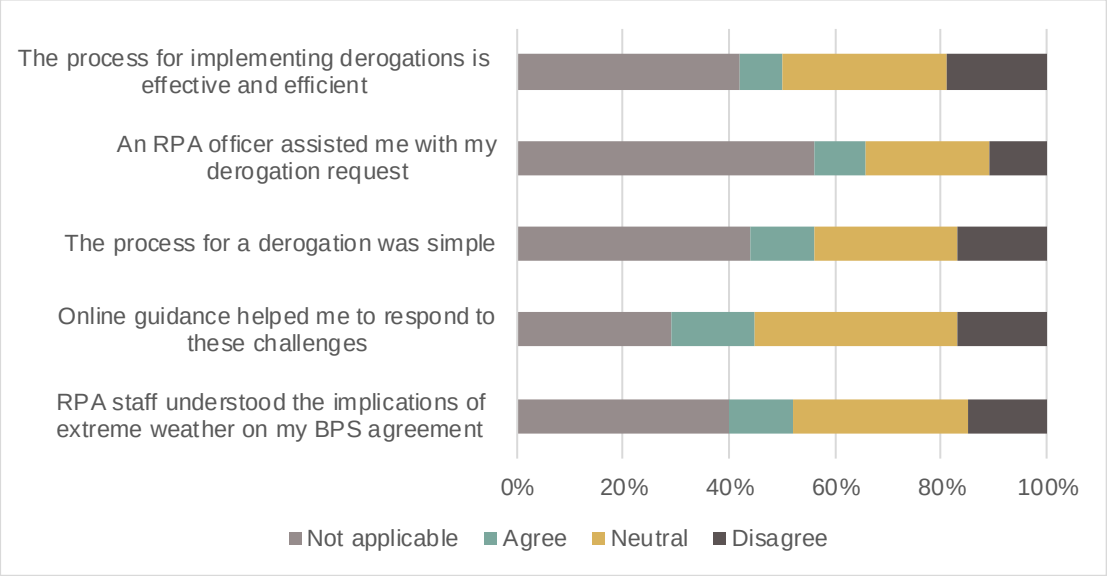
Figure 3.18 Regulatory requirements that proved challenge due to extreme weather



The figure shows that nearly half of the sample (47%) had not experienced any challenges in meeting regulations linked of BPS. This is highest in Wet Anglia (53%) and Somerset (57%) and lowest in the Rest of England sample (38%). The most likely area to cause concern is soil management (poaching, compaction and related soil management requirements) with almost a third (32%) saying they had difficulties. This is highest in the Rest of England (37%) and lowest in West Anglia (25%) suggesting that this was a widespread challenge. The second most challenging regulation is that of supplementary feeding with 20% identifying this. The Rest of England (27%) and Cumbria (25%) are highest with West Anglia lowest (9%), presumably as livestock numbers are lower. In terms of ES options, in West Anglia there were only 19 incidents of HR1 (grazing supplement for cattle) compared to 29 in Somerset and 37 in Cumbria. Following the GEAC rules is mentioned by 18% overall and highest in the Rest of England sample (25%). The three-crop rule is the only regulation where West Anglia is highest (19%) compared to the other sample groups, outlining the issues of a mainly arable area. Slurry storage is mentioned by 21% of respondents in Cumbria. Under 10% in any sample group mentioned water abstraction with 6% stating this overall. Looking at the other factors, there is no meaningful difference by land tenure, farm size or presence of an SSSI.

All of those who mentioned that meeting the BPS requirements was a challenge (220 respondents) were asked five further questions concerning links with Rural Payments Agency (RPA) staff, process around derogations and online guidance. The results are shown in the figure below.

Figure 3.19 Statements concerning effectiveness of processes associated with BPS and RPA (n=220)



Collectively, the responses offer an insight into the processes relating to BPS with a range of responses to the five statements. The one with the most valid responses concerned *the online guidance*. Here, 17% disagree with the statement 'online the guidance helped me to respond to these challenges', with 16% agreeing with it. Most (40%) are neutral on the issue. The numbers in the sample groups are small but there is no variation in their response. The next statement '*RPA staff understood the implications of extreme weather on my BPS agreement*' is answered by 60% of the sample. In all 15% disagree with the statement and 11% agree with 33% remaining neutral. Again, there is very little variation with the sample groups. The third statement with the most valid responses covers *the process for derogations or MTAs*. Here 58% of the 220 respondents provide a valid answer. Of these 19% disagreed with the sample and 8% agreed with 31% remaining neutral. The gap between agree and disagree remained fairly constant across the four sample groups. As with the similar set of questions concerning AES, some further statistical analysis is possible and this is set out in the table below, which reveals that this difference here is significant using Chi-squared as more than twice as many disagree as agree with the statement that the process for implementing derogations is effective and efficient.

Table 3.6 Further statistical analysis on Effectiveness of administrative processes in BPS

Statement	% difference disagree compared to agree	Chi-square significance	Result
The process for implementing derogations is effective and efficient	127	p = 0.003	more than twice as many disagreed than agreed
An RPA officer assisted me with my derogation request	24	ns, p = 0.42	no difference between number agreeing or disagreeing
The process for derogation was simple	44	ns, p = 0.15	no difference between number agreeing or disagreeing
Online guidance helped me to respond to these challenges	12	ns, p = 0.62	no difference between number agreeing or disagreeing
RPA staff understood the implications of extreme weather on my BPS agreement	24	ns, p = 0.42	no difference between number agreeing or disagreeing

ns = not significant at p<0.05.

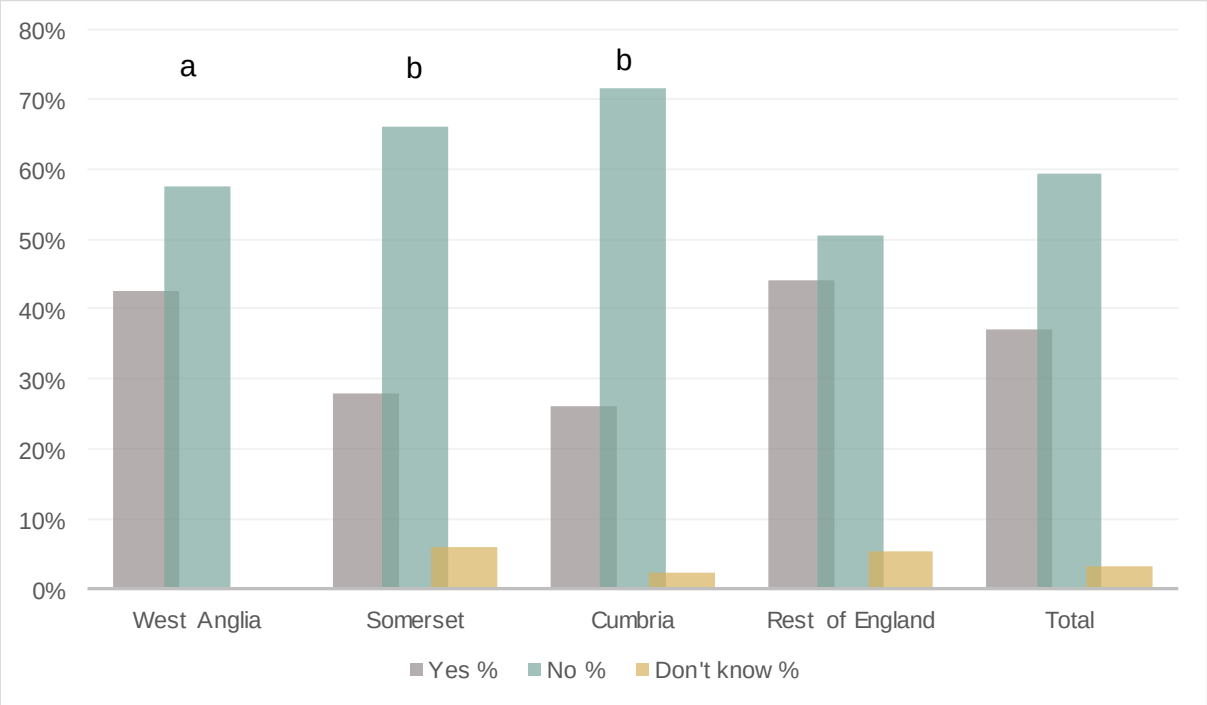
This further analysis shows that there is no discernible difference in the first two statements discussed and a similar response is received for the statement '*the process for a derogation was simple*' with 17% disagree and 12% agreeing and 28% remain neutral. Comparison with a similar statement regarding AES agreements is not straight forward as the number saying this was not applicable is higher in this instance but broadly similar numbers both disagreed and agreed. Finally, the statement with the highest number registering a not applicable response (56%) is *'an RPA officer assisted me with my derogation request'*. Of the remainder 11% disagree and 10% agree with 23% remain neutral. This would support the widely accepted understanding that the RPA operates at a distance and has few on-the-ground officers.

This section has shown that the processes associated with BPS have similar challenges to those of AES in that they can be seen as complex and remote by farmers and land managers. The next section looks at the role of advice and support to farmers and land managers when they considered changes to their AES or BPS agreements.

Role of advice and support for farmers and land managers when they are considering changes to AES and BPS agreements

This final section of the online questionnaire was asked of all 420 respondents and focuses on the role of advice and support when farmers and land managers considered making changes to AES agreements or meeting their BPS requirements. The first question was a straightforward yes/no question asking them 'did you seek advice regarding the implications and requirements of potential changes to your AE agreement or BOS requirements'. The answers are shown in the figure below.

Figure 3.20 Seeking of advice regarding AES agreement or BPS by sample group

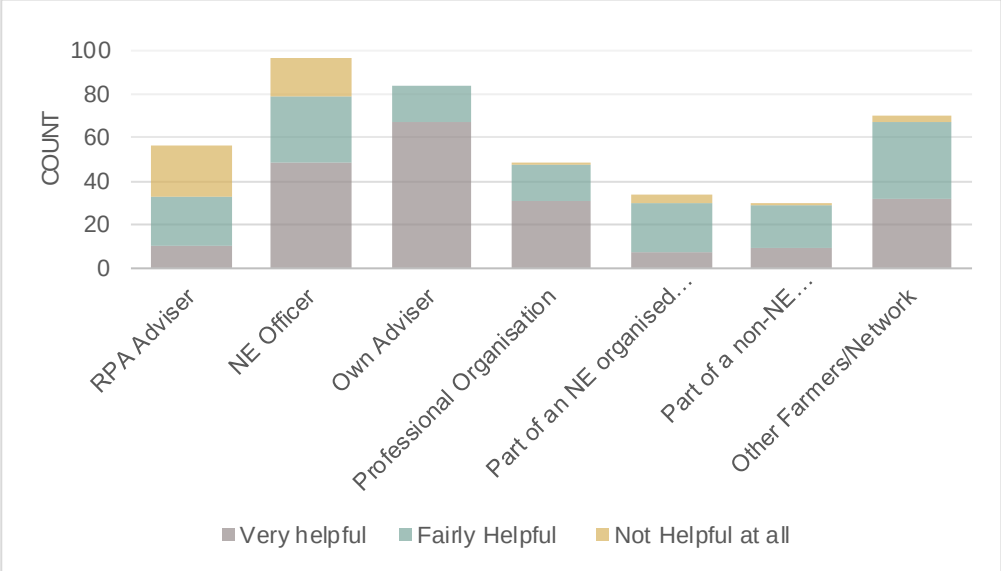


Letters **a** *&* **b** *represent a significance difference at* p<0.05.

The figure shows that overall 37% (156 respondents) did seek advice but the majority (60%) did not. There was some variation across the sample groups with the Rest of England and West Anglia samples highest for seeking advice (44% and 43% respectively) and Cumbria and Somerset notably lower (26% and 28% respectively). The reverse is true of those not receiving advice with a high in Cumbria of 72% and low in Rest of England of 51%. Chi-square tests indicate the frequency distributions were significantly different at $p < 0.05$ for West Anglia on the one hand, with Somerset and Cumbria on the other.

Looking at other factors, those with larger farms (100 ha and over) are much more likely to seek advice. To a lesser extent those with rented or mixed tenure and without an SSSI also sought advice. When looking at the different schemes the respondents are involved in the least likely to seek advice are those in CS Mid-Tier and ELS, but presumably this is because the schemes are either quite new (MT) or more straight forward (ELS). The 156 respondents were then asked some supplementary question regarding who they asked for advice and how helpful it was on a three-point scale of 'very helpful', 'fairly helpful' and 'not at all helpful'. The response is shown in Figure 3.21 below.

Figure 3.21 Whose advice was sought and how helpful was the advice



The figure shows that an NE adviser is the most likely source of advice in 62% of cases (97 respondents), and of these the advice is very helpful in over half (49 respondents). Only 18 respondents said the advice is not at all helpful. Advice from the farmer's own adviser is sought in 84 cases (54% of cases) and in three quarters of these it is rated as 'very helpful'. The role of other farmers and networks is highlighted as this is the third most important source of advice with 45% of respondents mentioning this. Of these just under half said the advice is 'very helpful' and only 3 respondents said it was 'not at all helpful'.

An RPA adviser is mentioned in 36% of cases with few rating the advice 'very helpful (10 respondents) and as many saying it was 'not at all helpful', as 'fairly helpful (23 respondents). The other responses are for professional organisations (e.g. FWAG or Wildlife Trust) with 49 responses, most of which said the advice was very helpful (31 respondents); an NE organised event (34 responses); and a non-NE organised event (30 responses).

This section has shown that advice and support is important to a large proportion of those who face challenges from extreme weather and that a wide range of sources are accessed. That alone is an interesting finding and it is clear there is no single route for advice and support in this area, increasing the need for a more coordinated response.

3.5 Discussion

This chapter has shown that the approach of selecting areas with a known experience of extreme weather according to the Met Office (2020) was worthwhile. The number of responses (420) was statistically robust with a Margin of Error or under or close to 10 in all three study areas, with an additional 154 responses covering the rest of England. As with many surveys concerning AES agreements, the farms were larger than official Defra figures for all commercial holdings.

A higher proportion of respondents were in AES agreements (79%) than the highest national estimate (70%), which is not a surprise given the aim and intention of the survey was to assess the impact of extreme weather on AES agreements. The most common AES agreement was ELS (46%), followed by MT (36%) and HLS (30%) with HT on 10%.

Selecting areas with records of extreme weather also secured a high proportion who had experienced different types of impacts. Over 70% reported experiencing extreme heat, 65% extreme wet, 68% unseasonal weather and timings (e.g. early spring or warm winter), 57% drought were the top four factors.

In terms of the direct impact on the farming business of the 420 respondent over 90% had experience at least one event over the last 5 years. Just over a third indicated that they had experience one severe event and 72% had experience at least one moderate event. It would therefore appear, that the impacts of extreme weather on farming are evenly distributed and widespread. The impact is most pronounced on the majority of farmers but larger farmers are more likely to be impacted by severe events.

The impact of these events is most likely to be on crop choice and damage to crops from heat and dry weather or a lack of water to sustain crops. Wet weather also had an impact. In 30% of cases the cost of these impacts was felt to be 'large' by the respondents and in 60% of cases there was a small cost. Only in 10% of cases was there no cost to the farm business. The presence on an SSSI was also a factor, as it is likely that these sites are more sensitive to extreme weather and those managing more aware of these impacts. In nearly a fifth of cases the agreement holders could identify AES options that had made the holding more resilient to the impacts of extreme weather. The next section will look at the impact of particular options and associated dates in more detail.

On the issue of prescriptions, a quarter of those who had been impacted by extreme weather indicated that as a result they had 'required or requested a derogation (or MTA). The suggestion here is that over a 5-year period a quarter of those who had been impacted by extreme weather needed a derogation or MTA to resolve things is important. This corresponds to 11% of all those with AES agreements. However, the processes associates with AES and BPS, such as derogations and MTAs, are both seen as challenging and the majority find them complex and time consuming. The presence of advice in AES is seen as helpful, and the online guidance is as likely to be positive as it is negative.

The next chapter looks in detail at the in-depth interviews with agreement holders and advisers.

4. In-depth survey of farmers and advisers

Key highlights

- Farmers and AES agreement holders are aware of the changing patterns in weather and increasingly volatile nature of localised weather events.
- Regional and yearly variations in phenology are not accounted for in some national AES prescriptions.
- During and immediately after extreme events the priorities for an AES agreement holder is the farm business (e.g. livestock) and its infrastructure (buildings).
- Agreement holders and advisers offered a few examples of instances when dates linked to prescriptions of certain AES options work against the desired environmental outcomes.
- Some farmers are asking for at least one derogation a year, while others are not requesting a derogation as the process takes to long to grant the request and is not rooted locally.
- Drought and heat are factors that have a widespread affect across England with specific impacts on different farming systems, flooding and wet extreme events tend to be focused more in the North and West.
- The type of soil and its management are key factors in reducing the impacts of extreme weather. Increased soil function is able to retain moisture in times of heat and drought and higher soil porosity helps reduce the impact of surface run off.
- Extreme weather does impact the effectiveness of dates for tasks such as the cutting of rushes and grass for hay, in some years the dates are too late suggesting that a more flexible approach might be more beneficial for meeting environmental outcomes.
- Establishment of some options can be challenging but peer-to-peer learning and knowledge exchange and the assistance of a local adviser helps alleviate these.
- Advisers and agreement holders favour the ability of local NE advisers to agree minor changes to AES agreements at the local level (e.g. earlier cutting dates).
- The current derogation system works reasonably well, for major change in the AES agreement, e.g. changing the sequencing of works and location.
- Extreme events benefit from being handled centrally to agreed criteria that are implemented locally, based on the current Farm Recovery Fund.

4.1 Sample characteristics

Overview

The in-depth telephone interviews were undertaken at the start of 2020 with 28 agreement holders, as well as, 9 advisers and agronomists. Most were in or covered the case study areas but other parts of the country were represented. In summary those taking part could be split into 16 upland (12 Cumbria and 4 Dartmoor), and 12 lowland (11 different counties across lowland England of which 10 are in the South) agreement holders with 2 national or regional advisers, 4 advisers covering upland areas (Cumbria and North Pennines) and 3 covering lowland (Suffolk, Hampshire and Somerset). The agreement holders were selected on the basis of self-nomination in the online survey followed by an assessment of their experiences in order to provide robust results on geography, AES schemes and impact. The advisers selected from the pool were those that had assisted with the sample boost for the online survey.

The aim of the interviews was to elicit more detailed information concerning the impact of extreme weather on the farm and their experience of AES processes. This narrative of the issues involved at the local level has been linked to climate data and trends. The intention of the in-depth interviews to focus discussions about particular options and prescriptions proved to be challenging over the telephone in the time available and the time difference between a particular event, the

AES options and associated prescriptions linked to the event and the interview. Nevertheless, some specific examples were received and these illustrate the challenges faced by farmers delivering AES in changing weather patterns and events. The interviews also provide an opportunity to explore agreement holders and advisers' awareness and response to the more gradual patterns of climate change and the timing of ecological processes analysed in Task 1.

This chapter is structured as follows:

- Assessing the trend for ever increasingly early springs, which is clear from the phenology data, and how is this impacting agreement holders and advisers;
- The impact of volatility and unpredictability of weather and the impact on agreement holders trying to deliver AES. This section includes looking at dates and subsequent clashes with prescriptions; and
- Incidents of extreme weather and how the process within AES works and is support both internally and through other avenues. This includes assessing the impact on the farmer/agreement older and the AES itself.

4.2 Gradual changes in weather patterns on agreement holders and advisers

Regional changes in phenology

In Task 1, outlined in Chapter 2, the project showed the changes across a range of species and the link to AES at a national level revealing the level of change over a 30 year period. Some of the data included a margin of error for earlier emergence or nesting dates as the BTO data is only available at a national level. However, regional analysis is possible for the three study areas (Cumbria, Somerset and West Anglia) using the Nature's Calendar data. The aim of this is to illustrate that there is variation year on year in a relatively short period and that there is additional regional variation within years. Both of these could prove challenging for AES prescriptions, which are set nationally and apply at the same level each year. To illustrate this, the project took two spring events, the emergence of hawthorn and first date of frog spawning. The full analysis is contained in Annex 6, and here we focus on the key differences for these two events across the three study areas.

Hawthorn

A wide range of data is available on bud burst (Murray et al 1989 and Mijnsbrugge et al 2015) but there was consistent data in each of the three study areas for Hawthorn, a common plant found in most hedges. It should be noted (see Jones et al. 2002) that Hawthorn hedges are very widely planted on farmland using nursery stock from a variety of provenances and that bud burst and flowering date are strongly influenced by the provenance of the stock. This will be a factor in the regional analysis for Hawthorn is shown in Figure 4.1. The figure shows, for each year, the timing of the first recorded hawthorn budburst in Cumbria, Somerset and West Anglia. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (28 February) when land managers must end hedge cutting and tree cutting operations. The number of records varies across the three study areas and from year to year depending on reported observations.

The figure shows that the mean level of the first observation is mostly about the cutting date for each study area, although on two occasions West Anglia does come below this line in 2002 and 2008. Focusing on the two aspects this section prioritising, firstly, is there yearly variation over the time scales? The answer is yes, with the mean first appearance dates differing by over 20 days for all three study areas from 2001 to 2018. The second area was regional variation. For the mean first appearance date the normal pattern is for West Anglia to be earlier than Somerset and then Cumbria. However, there is considerable variation on the first appearance date. Nearly all these dates are earlier than the AES cut-off date and in 2008, 2010 and 2017 Cumbria recorded a date before the other two case study areas.

Therefore, this shows for hedge management there will be occasions in all three study areas where management is permitted but hawthorn buds burst is occurring. However, this is not consistent year on year nor according to geography. A fixed date approach for the ending of hedge management will be problematic.

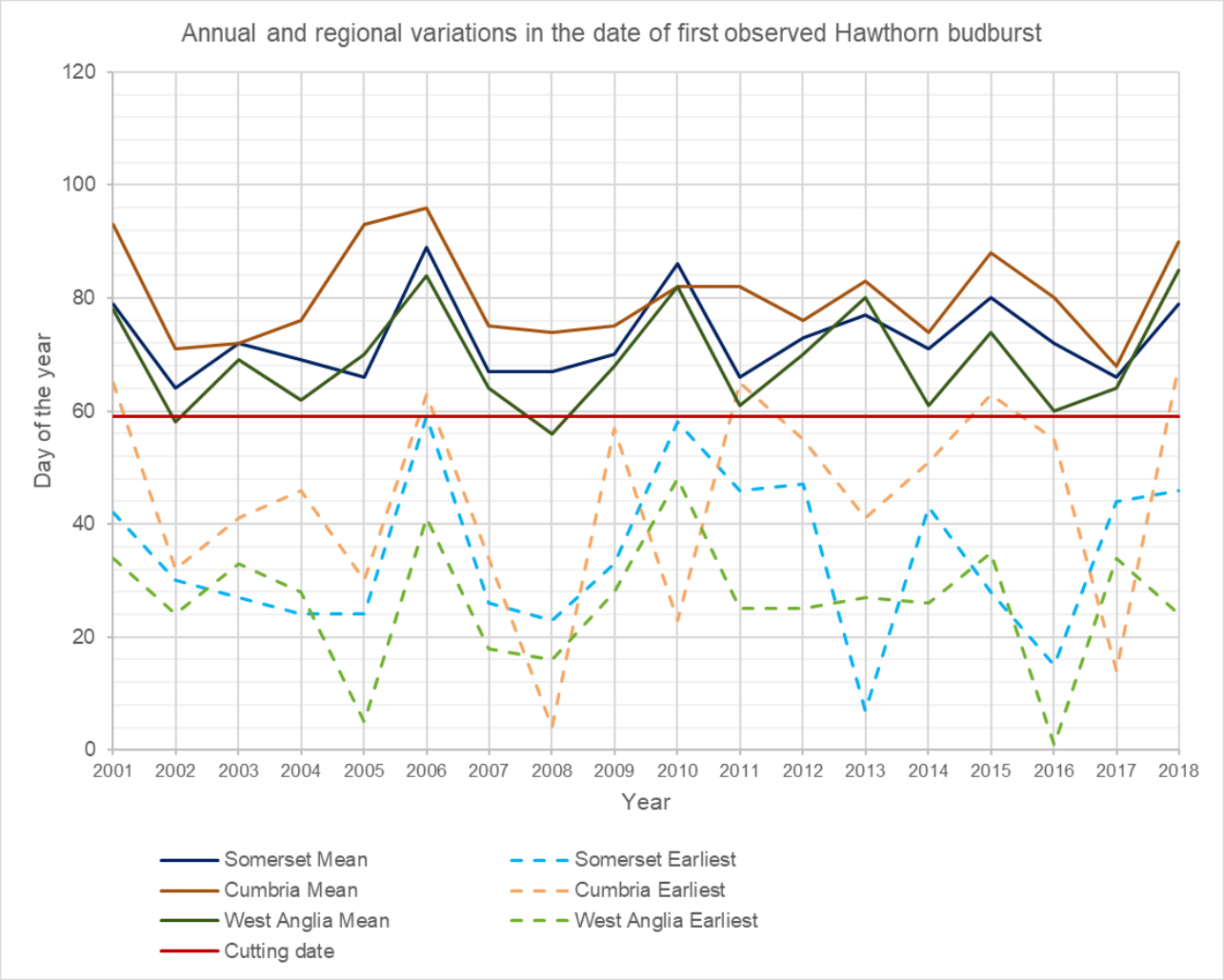


Figure 4.1 Nature Calendar budburst date for Hawthorn in Cumbria, Somerset and West Anglia.

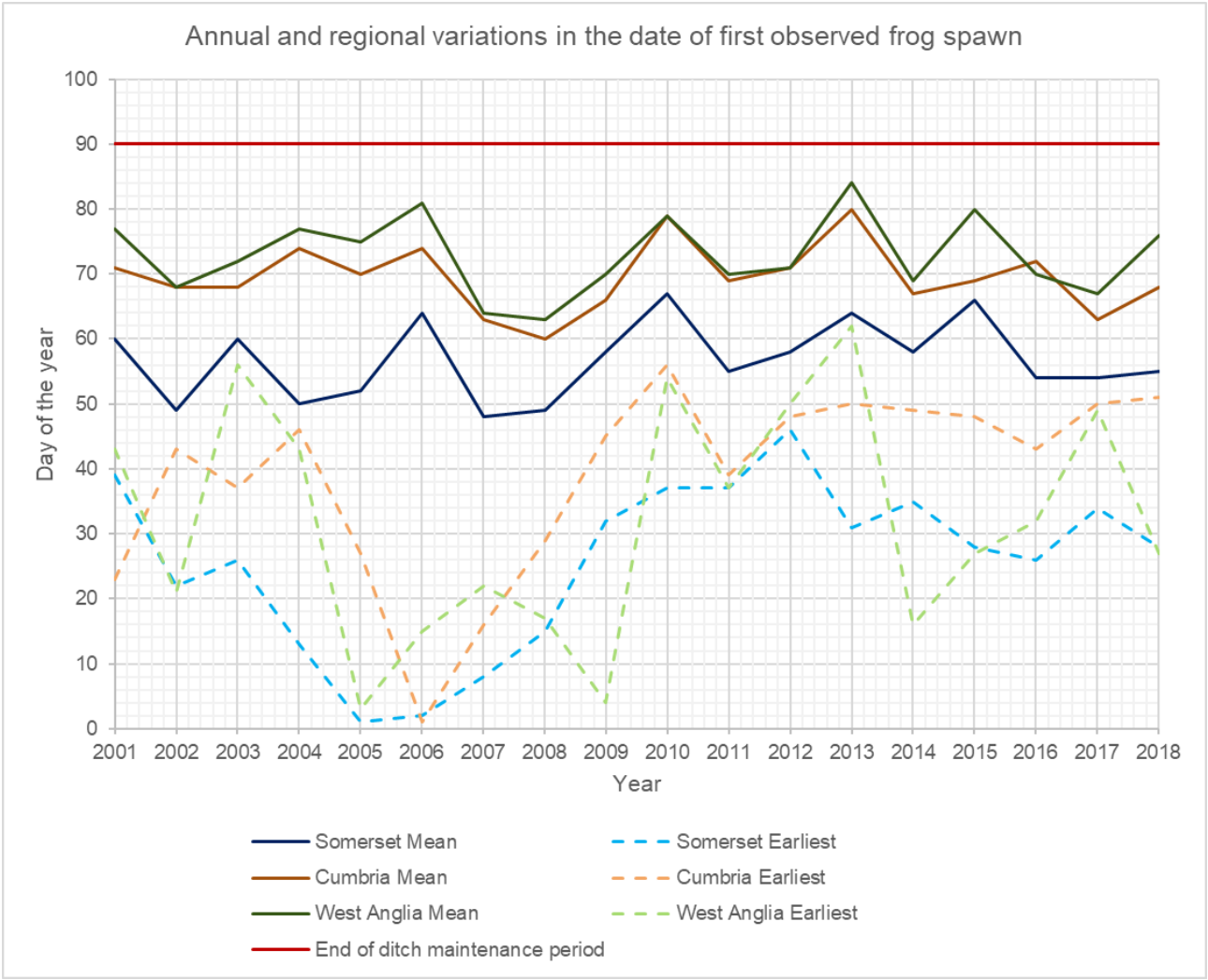
The second example is the first spawning date for the Common Frog.

Common Frog

Nature's Calendar data recording the first observed frogspawn were analysed for the three study areas. Figure 4.2 shows, for each year, the mean and earliest timing of the first observed frogspawn in the three study areas. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (31 March) when land managers must stop ditch maintenance operations. The graph shows the majority of observations occurring within the ditch maintenance period, suggesting the ditch management period overlaps with the likely appearance of frog spawn. Although not recorded here, the number of records varies across the three study areas and from year to year depending on reported observations.

Focusing on the two areas examined in this section, firstly, is there yearly variation over the time scales? The answer is yes, with the mean first appearance dates differing by about 18 days in all three study areas from 2001 to 2018. The second area was regional year on year variation. The solid line is the mean earliest date and, in each year, Somerset is earlier than the other two case studies, which are very similar. The dotted lines show the earliest record of spawning in all three study areas. In most cases Somerset is the earliest but in 2006 it is Somerset and in 2009 and 2014 it is West Anglia. All of these dates are considerably earlier than the 31 March date when ditch management is required to stop.

Figure 4.2 Nature Calendar spawning date for Common Frog in Cumbria, Somerset and West Anglia.



These two examples show that there is not a consistent pattern in recent years, even if the trend is towards early emergence and there is also regional variation year on year so while southern case studies tend to be first it is not always the case. Both of these factors are important when considering national fixed dates within AES option prescriptions.

The next section looks at the level of awareness of changes in weather patterns among AES agreement holders and advisers.

Awareness of changes in weather patterns among agreement holders and adviser

In terms of the discussion with agreement holders and advisers, the most common factor was that spring is a key point in the farming year. As these quotes illustrate:

> *Spring is the real breaking point for this farming system. [Upland AH 100% grass]*
>
> *No [spring] grass growth on flooded fields. So, I rent in some land and graze sheep elsewhere. [Upland AH]*
>
> *Persistent early springs has an impact on hay quality and mid-late July is too late to cut for hay. [Lowland beef & sheep farmer]*

There is also a recognition that the trend of warmer and wetter winters has set in as these quotes suggest:

The weather keeps getting milder and wetter we don't get any frosts.[Arable farmer Oxfordshire]

Change in weather patterns with milder and wetter winter with dryer and warmer summer. [Arable farmer Lincolnshire]

Milder climate with longer and wetter winter. When the rain comes it is bigger amounts than ever. [Dartmoor sheep farmer]

The final quote notes the increasingly volatile element to weather and this is causing some farmers to find ways to adapt as this quote suggests.

Adaptation to the weather conditions as well as global warning with a switch to no drill organic farming and various associations experiments (barley and peas). Built in resilience by retaining moisture and improving soil structure. Helps in wet or dry conditions. [Lowland AH]

The advisers note that extreme events, such as Storm Desmond, put the more gradual changes into perspective in terms of the overall change.

Significant increase in willingness following Storm Desmond because of the consequences on well-being of livestock. … some can see ELMs as way forward. 'Farming for carbon or water' is how one put it.

Farmers are very aware of CC and increasingly so. [I was] involved in GHG about 10 years ago and no interest, but people calling us to do this now.

The last comment suggests that some aspects of climate change, such as a need to tackle greenhouse gas (GHG) emissions are moving up the action list for farmers, the more general changes may not be. There is an increase in the housing of livestock over the winter months but this is not always attributed to climate change, as much as it is a link to increased productivity and specialisation within farm businesses. There is of course regional variation and fluctuation throughout the year and one way of assessing the changes over a five year period is to look at average monthly temperatures. The next two graphs show data for the North West and the East of England, showing evidence of between year variability such as occasional early springs and high summer temperatures.

Figure 4.3 Average monthly temperature North West England 2012-2017

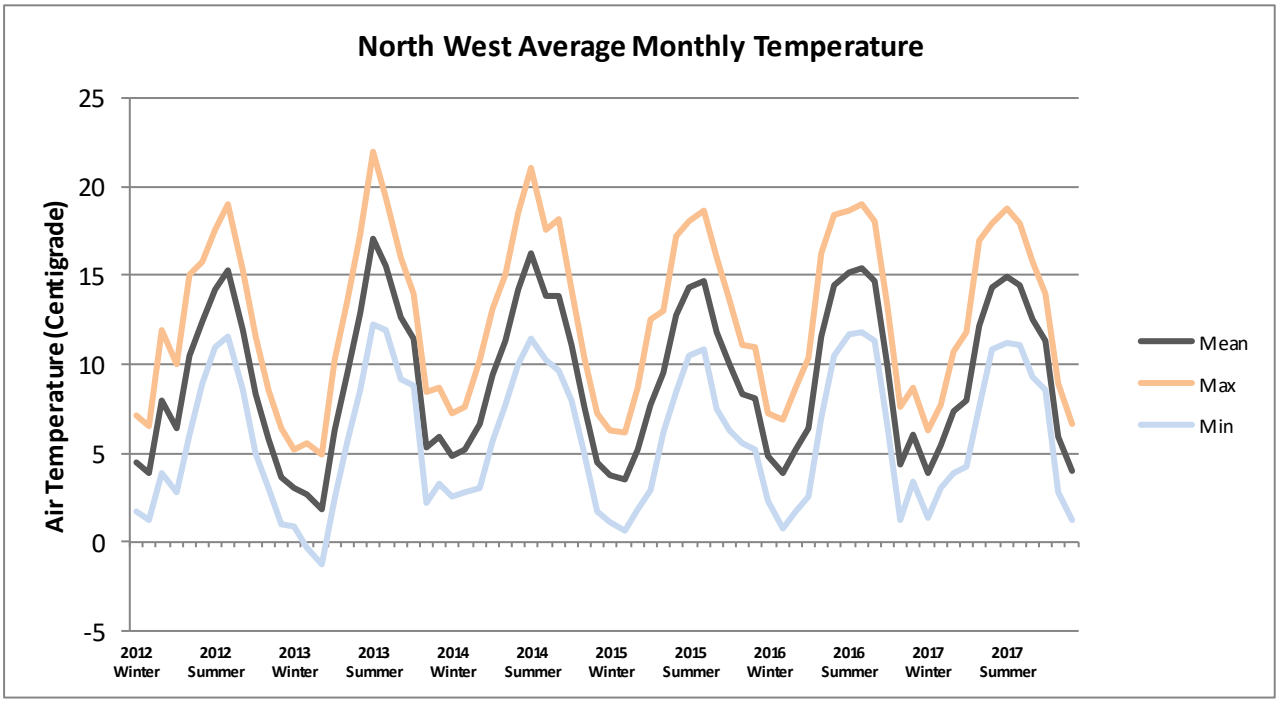
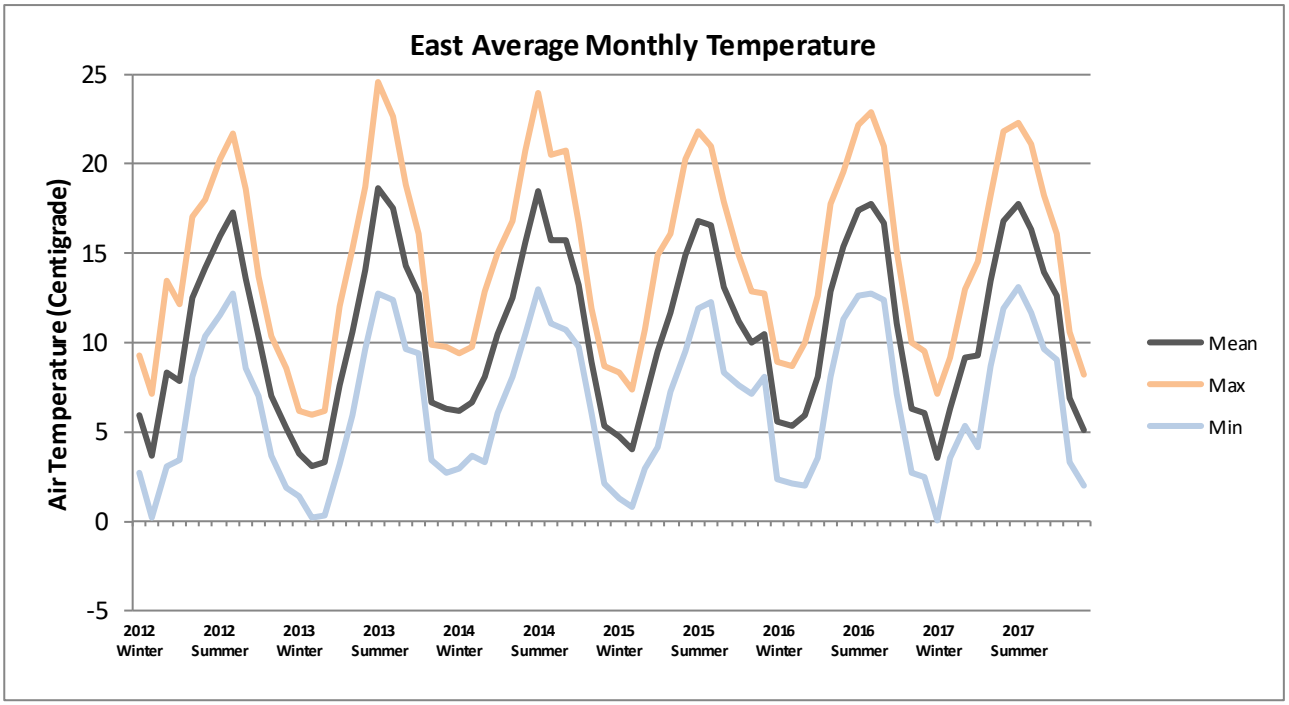


Figure 4.4 Average monthly temperature Eastern England 2012-2017



Although the monthly average temperature does reduce some of the local variations, it is still possible to see some instances of warmer springs (2012) and colder winters (2013.). The warmer spring is more noticeable in the East of England data and the colder winter in the North West. Warmer autumns occur in 2015 and the hotter summers in 2013 and 2014. However, what is clear from the monthly averages is that these are not consistent in any way so it is relatively easy to understand the comments of the respondents in terms of recognising the trend but not expecting it each year.

Impact of gradual changes in weather patterns on AES agreements

As illustrated in this section, throughout the interviews there were general comments about the shifting of the seasons, most notably earlier springs and warmer wetter winters. This survey focussed on extreme weather, and one characteristic of the responses was that such events can now happen at any time of the year as they did not correspond with the anticipated patterns of weather. The combination of comments being on extreme weather and the distraction of discussing 'weather' resulted in it being difficult to determine if weather patterns impacted AES agreements in any meaningful way.

There was one exception to this, which illustrates the gradual shift of weather patterns and the impact on AES agreements. The quotes that follow are from interviews with one agreement holder, supported by his NE adviser over the past 25 years, who demonstrates the impact of local climate change on farming and the shaping of 3 different AES agreements. The AES adviser has remained the same throughout and has witnessed the changes the farmer has had to make over this time. As the agreement holder illustrates here:

> *Gradual change across three AES. In ESA were wildflower meadows and wetland meadows. Then started HLS in land for breeding waders and wet grassland but reduced stock. New CS HT scheme is third one on this holding is based on creation of fen and wetland and planting more woodland. Seasons have changed and land now so wet it needs to be accommodated. Will be environmentalist if there is a programme to help me sustain a business! [Upland AH]*

The impact across 30 years in this part of the country means that through AES the farmer has had to adjust his business. The location close to the coast in a strong tidal area and close to upland areas means the land is liable to flood. This can be quick, dramatic and last for a sustained period of time.

> *Our stocking pattern takes account of the tides and weather. High tides mean the river water coming down can't go anywhere so fields do flood but get warnings. Can lose 120 ac of land under water at any one time. Lived with this climate change over many years but it is getting wetter for longer now.*

The changes have had an impact on the number of livestock the holding can sustain, but there are some additional benefits.

We had to cut back on stock as [the land] can't hold so many even though it is fertile as peat. Down about 50% on sheep and cattle back 20% and will cut back more. But getting more per unit as improved the sheep weight and better animal welfare.

Even with these changes some operations are difficult at any time of the year

Land on this farm wetter now than it has ever been. August used to be a dry month but not in last 10 years - wet and very wet sometimes so major change. 1 day's rain needs 7 days dry here before I can get back on land. Some so wet I can't go on with quad bike. Farm on raw peat so can't mess as it won't mend. Have a little tractor 60hp now to get some work done for the AES agreement as less damage. It is the flexibility to go and do tasks when the land is ready not when the dates on agreement say.

This change in the weather pattern has an impact on the AES, as this quote illustrates:

Seem to go for a derogation each year now. Can try and wait but can't always do that as the chance goes and I want to make the AES work. Not repeat on same issue but mostly in the same area about dates and when I can access land.

The issue about derogations and timing will be picked up later in this section but it worth noting here the agreement holder desire to meet the intention of the AES agreement whilst noting that the restrictions of the AES are not providing the support he is looking for. The next section looks at regional changes in phenology and it also picks up a general recognition that the climate is changing.

The next section looks in more detail at the impact of extreme weather and how agreement holders respond to such events.

4.3 Extreme weather and delivery of AES

This section assesses the impact of extreme weather on agreement holders trying to deliver AES. The interviews did this in a number of ways. First interviewees were asked about their experiences of extreme weather in a range of setting and this was followed by a series of questions linking this to the delivery of AES.

Severe wet or flood events

While many of the agreement holders noted that land was wetter, several had experiences of severe flooding and outlined the impact this can have on the farm business. These quotes illustrate the range of impacts:

The 2012 downpour destroyed infrastructure of the yard and fields. About 200 tonnes of gravel had to be moved out of the yard.

Recent events caused landslides, taking out roads on the farm making areas inaccessible and needing repairs. Having to move sheep from the moors in winter, combined with the floods, this has caused the home farm fields to be more damaged then they would have been.

After the storm the sheds and bedding were wet and the farmhouse was flooded. Bit and pieces the fields were poached or turned into 'peat'. Feared for overflowing slurry pit as too much water and not a possibility to spread it. Some hedges and walls were knocked down and some streams banks washed away.

Can lose 120 ac of land under water at any one time. Lived with this climate change over many years.

In 2005 we had dreadful flooding up to 1.5 m in some parts, everything was ruined and the fields were not accessible for weeks and spoilt.

Flooding events after heavy rainfall in 2006, 2009, 2011, 2015. Sometimes have more than 24h uninterrupted rain resulting in waterlogged and poached fields.

About 70% of the enclosed land will be flooded at least once in any year. Less land available to graze cattle and sheep.

They show the range of impacts to buildings and infrastructure as well as the land and the impact on livestock and crops. The area of land involved will mean a knock on impact on areas not flooded and the subsequent decisions throughout

the year. The advisers were able to provide an interesting overview to the agreement holders' experiences as these three examples show:

> *Localized floods events prevent farmer from accessing their land. It is not possible to graze, to apply slurry or to work on the land. Some damages to infrastructure and building of the farm can be sustained. Some erosion and some habitat lost.*

> *Flash floods that basically washed away everything that was in their way. Including fodder (bales, hay...) walls, trees, livestock, buildings... The damages were heavy and it meant that people had little to keep going. The heavy rains during Desmond meant that slurry storage were overloaded and were too full to cope with the amount. Either sell some cattle, buy some straw or spread slurry in bad conditions (BPS problem).*

> *Some farmers have land that floods all the time, this part of land is flooded all the time, alter their cropping if susceptible to flooding. They have a choice, reduce the number of stock, take some more land in.*

Challenges within AES

The main challenges for such events in terms of the impact on the AES agreement are varied.

At its most extreme there is an impact on the current agreement or subsequent ones as this agreement holder indicated:

> *Flooding damaged grassland and habitats, the scoring would have been bad meaning a reduced payment.*

> *Main issue is that capital works can't be completed as access the land is not possible. Can't cast up banks if getting to the area will cause more mess than is necessary. Contractors can't get work done either.*

> *Rotting fence posts under some schemes, huge investments and now no good and puts large bill on farmer as not covered for second grant.*

In the first quote there is clearly a concern about subsequent agreements but the presence of the Farm Recovery Fund (see section below) means this is unlikely under a current agreement. In subsequent agreements the hope is that different options would be available either for restoration or creation of appropriate features and habitats.

The second quote makes references to the land management tasks with a set window such as hedge cutting or ditch management. If the land is too wet over consecutive years it is possible that some management functions will not be carried out. Where contractors under a significant amount of this work there is quite a pressure on them to fit in a large amount of work in a small window. In such circumstances a change to the agreement is required.

The final quote raises the impact of long-term wet weather on some capital items and the additional factor that this reduces the duration of their useful life. When the fence posts need replacing they are not eligible for funding as this would be a 'second' grant.

Severe heat or drought events

There have been several incidents of severe heat and drought in recent years and this has an impact on the farming system as well as the AES. Some of the incidents are over a short period while others are more prolonged periods without rain. A range of impacts were mentioned as this selection of quotes illustrates.

> *15% of the planted trees died every year (woodland management has always been part of the farm). Had to be replanted the following year.*

> *Due to drought and excessive dry conditions we have stopped or reduced cultivations so now direct drill crops and use cover crops more. Also changed rotation so it is more mixed and has different drilling timings. Have more spring cropping which didn't do until 4/5 years ago. This gives use more options to tackle weeds. Overall, we have diversified the business so not all eggs in one basket. Autumn crop is normally better return than spring but weather dependant. This autumn was wet so not got all done. But spring cropping will be challenging this year. Environmental side [to our business] is the same. We now do spring and autumn establishment of margins. First thing to grow is the weed not the seed. These changes are permanent in order to adapt to weather but will tweak if things don't work.*

The first quote shows the impact of heat and extreme weather on trees, which was not picked up in such a specific way in other interviews. The second quote is a detailed explanation of what many farmers are doing or considering in terms

of the wider changing to their practices as they adjust to changing conditions. Key to this outline is treating soil differently so that its porosity increases during wet periods and moisture is retained for longer to sustain crops during dry periods.

The advisers noticed similar patterns across the farms they worked with, particularly around the establishment of margins and farmland bird plots.

> *Spring establishment of crops - wildlife flowers or seed plot deemed impossible or delayed. Difficult to plant the cover crops at the end of the summer because of the rain or drought. Weed outburst that need addressing on low input land. Floristically rich margins need to be topped up in October, were not able to do it.*

> *Drought meant it is tough to plant cover crops and bird plots as well as a drop in yield. Problem for cutting grass too.*

These present challenges for the delivery of AES in drought and excessive dry conditions.

Challenges within AES: derogations and MTAs

One of the key challenges here is the length of time derogations take if an early hay cut is required or a margin requires some additional work in order to establish, as these quotes illustrate:

> *For drought-stricken hay meadows, useless due to the length of the derogation process.*

> *We struggle to establish options, esp. pollen and nectar margins. Topping is an issue. Needs to be within the date but not always best time with weather. If weed flowers not there then cutting is wasting my time but meets date of scheme. Or if there are flowers you want then need to delay cutting so they help pollinators and seed. In birdseed mix need to be careful the weeds don't germinate as will then have bigger burden. Need damp spring to make them germ and then can cultivate and avoid using herbicide.*

> *Have in past asked for derogation - but not bothered more recently. I make the decision at the time and not wait 4 weeks, Can't call the person in Cambs now as they are not there. (West Anglia agreement holder)*

The last comment of 'not worrying about a derogation' was mentioned off-record by others. In one case the agreement holder kept a record of the date and the reasoning 'in case people asked'. There seemed to be two separate issues at work here. Firstly, through experience agreement holders had found that confirmation of derogations (now called MTAs) takes too long to come through. In essence, they are meant to be swift as they are intended to cover unexpected situations. However, if you want to trim rushes early as you can see they are in flower before the cutting date, waiting 4 weeks for an answer is not going to help the situation. In essence, the quote shows that agreement holder wanted to deliver the purpose of the AES rather than abide by the letter of the option prescriptions.

The second issue raised in the quote is about who the agreement holder speaks to when they discuss the need for the derogation. The reference to the lack of a local adviser and this relates to a recent change in how requests for derogations are handled. All enquiries relating to AES are now handled through the RPA, who took over the of AES schemes in 2015. The RPA then decide if this needs to be handled by a central Farmland and Conservation Team within NE. If the query can be answered by the central team it will, if not it then it is sent out to the advisers in the local area teams to deal with. Exactly how MTAs are currently handled is not the purpose of this report, but what is clear is that the agreement holder's perception is that they take too long for outcomes to be received and the process is too centrally driven. The feeling of advisers and agreement holders is that a more locally driven process would lead to quicker and more effective outcomes for them and the environmental outcomes in the agreement.

The wider derogation available in extreme hot weather such as 2018 was mentioned by some advisers

> *For the drought [in 2018] under NFU lobbying and through NE officer project, a derogation was asked for. But it took 6 weeks to be validated and was therefore useless when it arrived. Too much bureaucracy.*

> *Grassland cutting dates as well as grazing are tricky in drought conditions. Prescription dates too tight, need a bit more flexibility. A lot of nervousness amongst the farming community.*

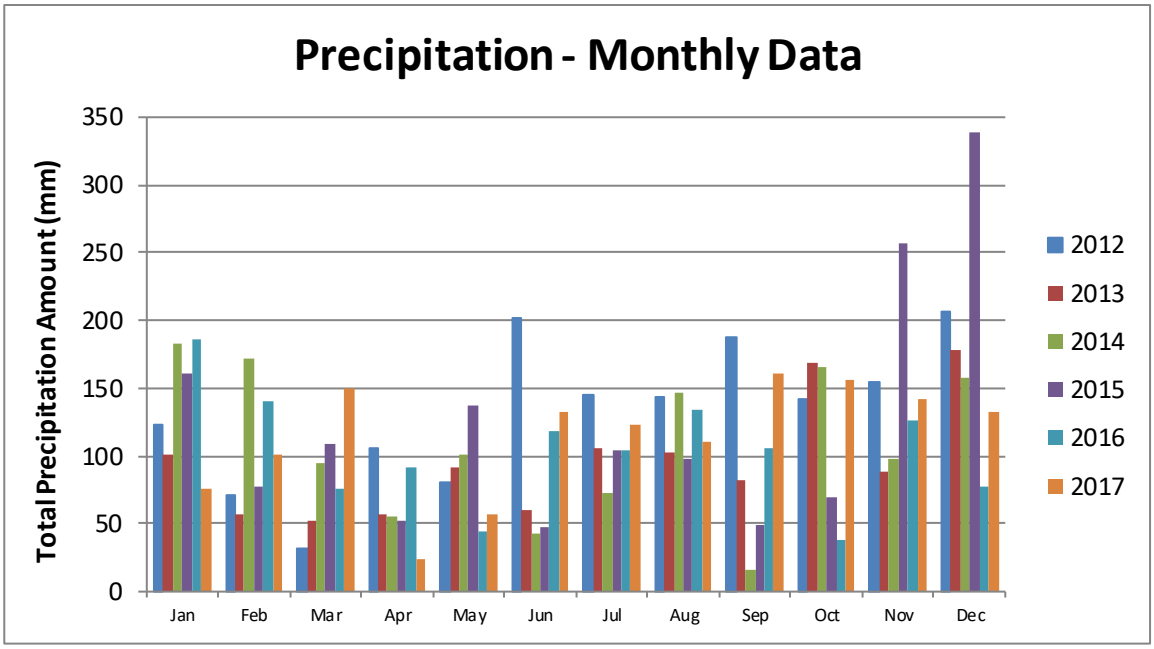
The second quote from an adviser suggests that the issue of dates extends beyond wet weather and is a general concern regarding the management of land under AES. The next section looks at comments relating to extreme cold.

Severe cold and wet events

Linking to weather patterns

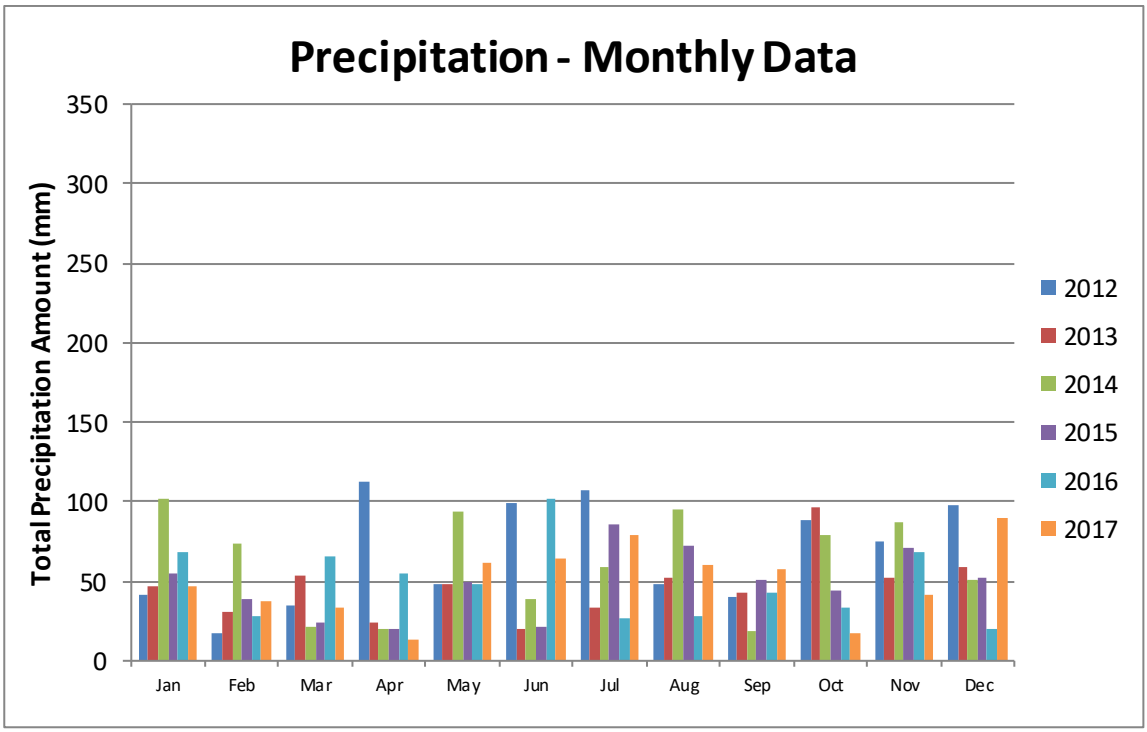
As with the phenology and average monthly temperatures, it is possible to look at the monthly rainfall data between the different regions in order to show the impact of regional variations in weather patterns. In terms of project design, the intention was to assess the impact of extreme weather on AES agreements in areas known to experience such events. Monthly data relating to rainfall is helpful in linking both wet and dry events. The next two figures show the precipitation levels for the North West (covering Cumbria) and East of England (covering West Anglia) between 2012-2017.

Figure 4.5 Monthly precipitation North West England 2012-2017



The figure shows heavy rainfall in Nov and Dec 2015 as well as wet summer months from June-Sep and on to Dec in 2012. The level of rainfall in December 2015 is extreme, four time the amount that fell in 2016. It is worth remembering that these are average figures for the region, however, the Met Office did record flooding in Cumbria from 4-6 December 2015, while also noting that it was the warmest December on record. In other months there is little rainfall, such as in the Spring of 2017 during Apr and May. There are 16 months where the rainfall exceeds 150mm and 7 where it is under 50mm.

Figure 4.6 Monthly precipitation East of England 2012-2017



The data for Eastern England is marked different when shown using the same scale. In the 5 years 2012-17 there are no months with over 150 mm and only 4 months where the levels were at or just over 100 mm. In terms of low rainfall 33 months, meaning 45% of the months in the six-year period, had levels of rain under 50 mm. Weather may have been a factor in 2012 with April, June and July recording levels of 100 mm of rain and so establishing spring crops and managing all crops might have been challenging for some on clay soils. There are many dry months, but in terms of a sequence 2017 started with 4 months offering less than 50 mm of rain and 2012 did the same for the first 3 months.

Rainfall data is useful in showing the yearly and regional variations in weather patterns. However, there is a local impact that is lost and extreme weather events linked to rainfall (flooding and wet) are known and have been shown by the online survey, to have a very localised impact.

Severe cold events

The overall trend is for a reduction in the number of frost days and instances of severe cold (Met Office et al 2019), however, as was experienced in the 'Beast from the East' it is still a type of extreme weather event that England will experience. For the most part severe cold for most farms meant livestock were housed inside for longer, more difficult to feed and time was taken checking livestock and repairing equipment. Both of these have cost implications in terms of extra feed, loss of livestock and new parts for machinery. Crops might be knocked back but could recover but might still impact the overall yield. For sheep farmers one concern is a late cold period in April that impacts lambing, as this quote illustrates.

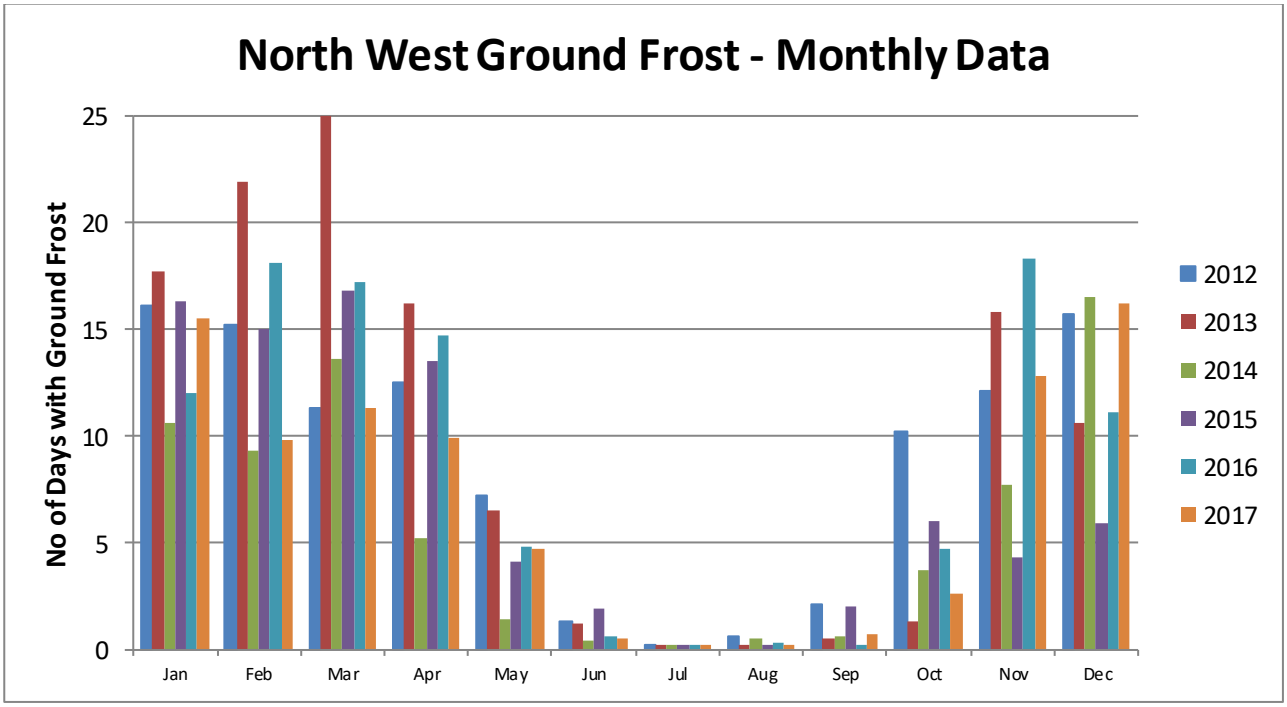
> *If cold and late in April then the impact is to stop grass for lambing. Worry with beast from the East is after sheep turned out but no grass or poor nutrition so sheep need feeding. This increases costs and might not be allowed.*
>
> *We had to re-establish crops and margins when cold and wet spring hit last year, did this 3 times - if want good outcome. I could do it once if you can live with the bad outcome. Need to treat [margin] as a crop.*

As such there are limited impacts on AES. The final point refers to establish margins and the same point was made under the heat and drought section. This is noted as a challenge that will have cost implications, either in terms of getting it right, as above, or if the options are not up to the expected standard.

Linking to weather patterns

The next two figures compare the data for the North West and South West of England from 2012-2017

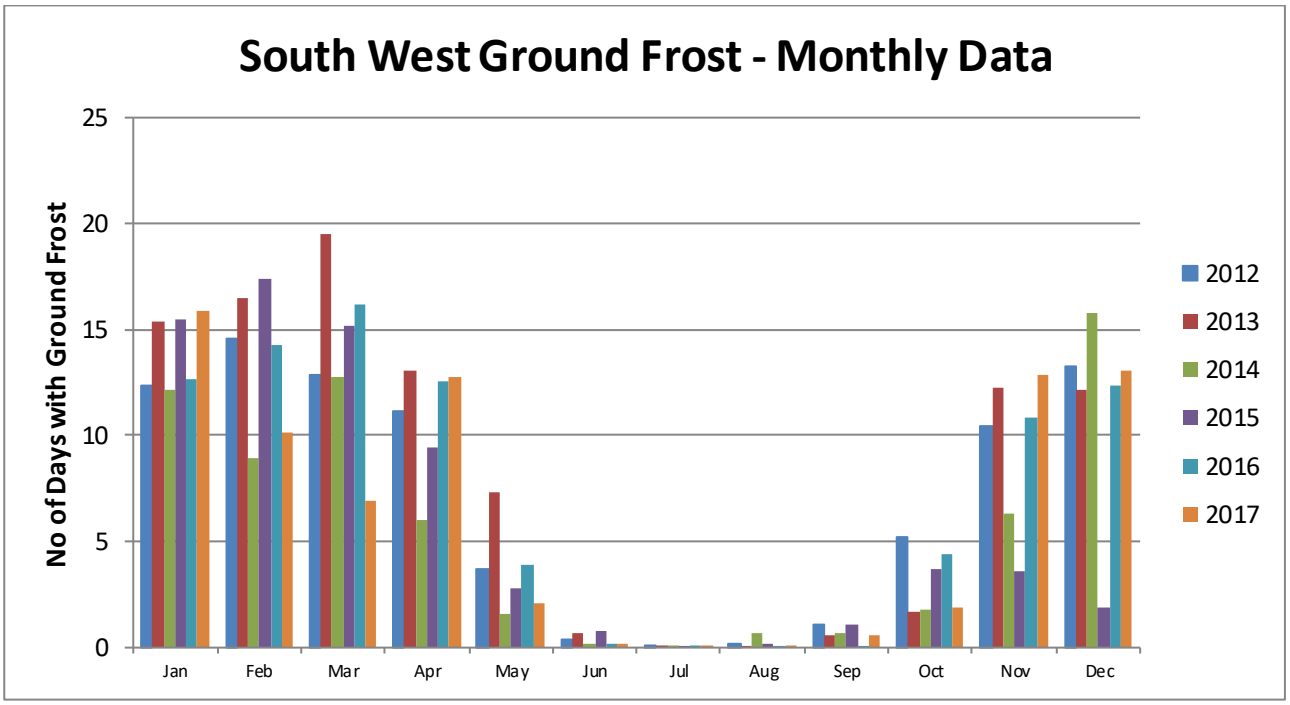
Figure 4.7 Number of days with ground frost North West England 2012-2017



The figure shows that the start of 2013 was exceptionally cold and this continued into May. If you add the months Oct-Dec 2012 to the 2013 months this was a prolonged cold period with over 10 and up to 25 days with ground frost for 7 months. The next year 2014 has fewer ground frost days from Jan-May, notably so in April and May.

The next chart shows the figures for the South West, rather than the East of England in order to show differences with the warmer maritime climate that dominates there.

Figure 4.8 Number of days with ground frost North West England 2012-2017



The graph for the South West, using the same scale, shows no months with over 25 days of ground frost, However the winter of 2012-13 is as cold as it was in the North West. The winter months of 2015 were warm with under 5 days of ground frost from Oct -Dec but the spring of 2014 does not stand out as being warm in the South West as much as it did in the North West as being warm.

This is the last of the regional weather comparisons, so it is worth reflecting back on the differences highlighted and the likely impacts on AES delivery. Firstly, what the maps have highlighted, even at an averaged regional scale, is that the three case study areas (Cumbria, Somerset and West Anglia) represented contrasting climate hazards over the past 5 years including drought, flood, heat, cold and wet. What it has also revealed is that there is a prevalence of extreme weather in areas where you might not expect it. For example, in Cumbria where agreement holders and advisers reported that drought and heat impacted on farming and AES delivery. When selecting the case studies, it was anticipated that West Anglia and Somerset would be impacted by heat and drought so it was interesting that Cumbria also report similar levels of impact from these weather extremes.

The reverse is not the case though, with the regional weather patterns not showing examples of high rainfall in West Anglia and the agreement holders and advisers did not report this. Therefore, it would seem that d rought and heat is a large scale impact covering much if not all of England. While there are differences between the case study areas the impact of these extremes is felt in wetter areas, such as Cumbria. The timing of the extremes in important and its impact will be different. In Cumbria there is less emphasis on the establishment of crops or the timing of harvest but more related to cutting grass for forage or the amount of pasture for grazing. In this sense in all areas the agricultural systems are adapted to optimum levels of rainfall in order to meet the needs of livestock or anticipated yields. In time of drought and heat rainfall is reduced then this may be a challenge to both farming systems and AES agreement even if it remains 'wet' relative to drier parts of the country.

On the other hand, flooding tends to be localised as this is caused by intense events that exceed the local capacity for managing rainfall. In this sense the greatest impact within the case studies is in Cumbria, with some events in Somerset but hardly any in West Anglia. The impact of extreme wet weather was more widely spread and this has a similar impact on farming systems as drought and heat, as it prevents the farming system rom operating at its optimum level.

There is a common determinate in all of this discussion and that relates to soil. The type of soil and how it is managed does make a difference and this is something that is considered further in the discussion and the final chapter.

The next section looks at the agreement holders' comments on unusual weather patterns and the link to AES prescriptions. The first two examples are the cutting dates associated with the management of rushes and hay cutting dates.

4.4 Unusual weather patterns and agri-environment experiences

Impact of an Early Spring

Management of rushes

The agreement holders and advisers noted some key issues concerning the management of rushes when there was an early spring. Under the make options for this, HK4/ EK4/EL4 Manage rush pastures (ES) and GS16 Rush infestation control supplement (CS), the prescriptions state that there is no cutting of rushes between 15 March and 15 July. The intention here is that this is potential land for breeding waders and restricting cutting outside these dates means that the nesting season will not be disturbed. However, dense rush will mean that the land is not attractive to breeding waders so the amount of rush needs to be maintained at a low level. Climate change can impact two aspects of this. It is possible that the breeding dates of any waders in these fields will be earlier as a result of warmer springs but also that they might attempt to have 2 broods. Also, the warmer springs might mean that the rush flower earlier, which would impact on the effectiveness of cutting after 15 July. Recent reviews of Google Earth images suggest rush cover has increased over a 13 year period (Ashby et al 2020).

A number of agreement holders mentioned having challenges with rush management as this quote illustrates, noting that access to fields can be difficult as the land is wet many times throughout the year.

> *Rush is an issue in the wet, marshy fields; given the need for mechanical control here it has proven difficult to keep on top of rush as the marsh is often too wet for machinery to access the land. [Upland agreement holder]*

One adviser and two agreement holders mentioned quite extreme examples that by keeping to the date the agreement holders were actually making the situation worse as by mid-July the rush had seeded. The subsequent cutting only helped spread the seeds meaning the situation was worse the next year, as these quotes illustrate.

> *Yes definitely, breeding waders here as not allowed to control rush before 14th July but when we do they are seeding and so all we are doing it helping them spread. Need date in May as best time but scheme says no as the waders are breeding but in reality, they have gone by then. [Upland agreement holder]*

> *[I] had issues with rush control, can't cut until 14th July. Had agreement changed to mid-July (so from 10th in my mind) and last year I got on the land on 10th and cut 95% of required land by 18th.*

> *One I come across most often is related to cutting rushes (soft rush especially) and link to nesting season dates. When dry enough to cut the rush, best early before it flowers and sets seed. But farmers can't before a certain date, so it sets seed and spreads then too dense for birds to nest. [Upland adviser]*

The agreement holders are aware of the reason for the date but, as the first agreement holders indicates above, any breeding birds have flown in an early spring. As another upland agreement holder suggests, maybe the answer is to:

> *Allow the farmer to assess for ground nesting birds - if none let them take action against rush.*

The phasing of the rush management options is also something to consider, as they should be undertaken every 4 years. In this sense they will happen twice in a 10 year agreement but the experiences of the agreement holders suggests this in the same way, so having some flexibility between years would permit tasks to be moved to years when the environmental benefits of the options are likely to be met.

> *Options need tweaking so they can deliver, some quite dramatically too. The cutting and control of rush … cut every 4 years.* In 10 year, agreement only twice but the weather gets in the way and can't say in 2000 what you are doing in 2010. If flex across years then better as the seasons differ.

Overall, it is widely understood that three have been changes in the spread of soft rush due to climate change and this has changed how they respond to cutting as a management tool. Kaczmarek-Dera et al (2018) looked at the management of soft rush in Norway and found a since cut in July reduced the spread when performed late in the growing season. Ashby et al (2020) refer to climatic factors such as the reduction in air frost days and levels of precipitation as well as the changes in management but are unable to pinpoint the major cause. The suggestion in the final quote would seem to suit current thinking on dates, that when an activity does not need to be undertaken annually it would make

sense to undertake the management when the cutting will be most effective and is within the prescriptions of the AES option.

Hay cut dates

Another farming practice that received a good deal of attention in the interviews was that of making hay. It is important separate the general concern about the impact of a fixed date and recognise that the payment for hay cutting in part recognises that there is a loss in yield and quality by cutting later when the herb plants have seeded. The focus in this project is on the impact of extreme weather. In upland farms this a key part of the year as this provides fodder for the wintering of stock. Livestock are traditionally put on to the hills and commons in order for the grass in the lower lying fields to remain ungrazed allowing a hay cut to be taken. In such situations, where the fields are unimproved it is possible for species rich hay meadows to occur and this has been a key option in the 30 years of AES. However, both agreement holders and advisers suggest that the date for hay cutting in mid-July (after August 1st for haylage) in both ES (HK18 Hay making supplement) and CS (GS15 Hay making supplement) can give rise to concern. These quotes from agreement holders illustrate some of the challenges:

> *For hay cutting 14th July may be too late in some years, the grass is ready earlier and the nesting birds fledged. Would prefer to cut early rather then, as last year, to wait until the date and then the weather turns so unable to cut until August. By then the hay is very poor and of no use for livestock. [Lowland AH]*

> *For drought stricken hay meadows it is useless asking for an earlier date due to the length of the derogation process. [Upland AH]*

Both of these quotes refer to climate extremes. The first quote relates to the changing weather patterns and the sense that August is now seen as a wetter month with farmers seemingly less certain that there will be enough clear spells to complete kay farming tasks. In the second the reference to drought is relevant as when the spring and early summer is dry and hot there is less volume produced and the grasses set seed earlier. The longer the grass is left the less palatable and nutritious it is too livestock and there is no environmental benefit to leave it once the seeding has occurred. Regional or yearly variations were an issue that advisers had witnessed on a number of farms, as these quotes illustrate:

> *With limestones the soils thin so grass burns off quickly. Cutting hay crops earlier or they would risk losing it as it means less fodder for winter. [Upland adviser]*

> *Where they can farmers get hay or silage crop but it can be very late cut as wet when dates are OK, in Sept/Oct goodness not there. Where used to make hay, can't make hay but possibly can make haylage and if silage is wet then loses the nutrition and high pollution risk. Big bales have been washed away in some instances - but ruined either way*. [Upland adviser]

> *Hay crops mature too early so urgent requests to cut them when ready. On limestone areas the sward shrivels and this means no grass to feed livestock. Then farmers worry if they can meet the grazing requirements. [Lowland adviser]*

> *On species rich grassland the cutting date for hay meadow varies locally as much as across the country. Early hot summer need to cut when fit not once the weather is OK after the dates – that might be too late.*

This seasonal variation where a warm and possibly dry spring means that fields of hay are ready early and the key species have set their seed, suggests that there is a benefit for both the farm and the environment by allowing a cut to come earlier. As already illustrated the derogation process takes too long in many cases as once the decision comes through the opportunity for an early cut has gone.

One adviser is clear that this 'comes down to the whole outcome approach', they go on to say:

> *Anything with dates focuses on when 'not' to do things, rather than this is when you should. All dates in times of unpredictable weather mean you can't be flexible, some can be OK but dates are restrictive in winter like this. Need to focus on the local conditions not dates or hay. If all flowers seeded [and ground nesting birds have fledged] then ready to be cut. Could ask to cut early but not get response in time, result is poor quality silage or hay and no benefit for the environment.*

While there are many comments about dates, it is possible from these quotes to see how extreme weather impacts the effectiveness of some options in some years. Moving to a more centralised system for dealing with derogations and MTAs is not going to help alleviate this as the next section outlines. However, what is clear is that AES agreements will need to be changed in a variety of forms because of extreme weather, sometimes the changes are minor while other

times there might be major changes required. The next section explores what agreement holders and advisers think is acceptable and feasible.

4.5 Key points for making AES work in times of climate change

Changes to AES processes

This section looks at the processes around AES and the thoughts of the agreement holders and advisers as to what might be suitable to change. The interviewees were asked three questions relating to AES with similar wording. The questions started '*Clearly any publicly funded scheme has to have a process (e.g. derogations or self-monitoring) to cover changes resulting from extreme weather. How do you feel this should be managed with regard to'.* Each of three questions then covered minor changes (such as tackling weeds/pests/extending dates), major changes (such as moving/changing options/waterlogged land) and regional and national events (such as Storm Desmond; Beast from the East etc.). The following sections looks as the responses in turn.

What is clear is that the recent changes in how enquiries are handled has not filtered through to all agreement holders. These changes were outlined in the section above and relate to the new system whereby all enquiries are handled by the RPA in a centralised system. If they cannot be answered by the RPA and require Natural England to deal with it then they are passed to another centralised team, the Farmland and Conservation Service Team to respond. If they are not able to respond then the query to sent out to the local NE advisers in that area. NE also retain a programme of aftercare calls and visits with agreement holders, and are able to retain that contact and provide advice. However, the current situation is very different from the previous models of local NE advisers helping with the development and delivery of AES agreements, which some of these comments relate to.

Minor changes

The advisers were very clear that for minor changes ELMs or a revised AES should:

> *Valuing farmers knowledge and trust their judgment. Every farm has it owns challenge.*

In terms of practical solutions, one adviser felt that the:

> *Easiest way is for AH to contact local adviser. Send photos as evidence and then have brief email with a technical decision. Can be checked and uploading on to a system. RPA to trust NE advisers to do this. Needs to have management system but provides more flexibility. Current stress is on the farmers.*

The final point was shared by other advisers who felt that for minor changes it was 'the outcome that matters.' One way round this would be for a:

> *A yearly examination/review with a payment adjustment with a local officer. Standardized forms with a proper record of what has happened, mapping/photos and a quick reply rate for example via an internet form*.

What is clear from the advisers is that minor decisions need to be made close to the ground and quickly. The farmers view of this was similar.

> *Should rely on flexibility and local advice. I can record the changes myself or use outside contact. It needs a more local person. [Lowland AH]*

> *Being flexible, having someone to talk to and some self-monitoring. A clear need for quicker answer response. [Lowland AH]*

> *Seek assistance with a quick response, need the OK, whatever you try and do but have to fit agreement. Need support just in case they don't work or not right. [Upland AH]*

Schemes should allow the farmers to prescribe their own dates that seem sensible for their own farm. With regular checks and if there is damage being done due to the dates that the farmer has set then they should get repercussions, whether that be losing their scheme or fines.

The final quote seems very close to the outline of a Results Based Payment (RBP) approach but this would also be dependent on a relation with a project officer and local adviser (NE and YDNP 2019). All of the responses stressed the need for some local contact – for minor changes a remote centre was not deemed suitable and some had examples of '*them not understanding what I was trying to do*' and the centralisation meant that the response took too long to come back in order to be effective. As one agreement holder put it:

A good scheme would have to be graduated and built with a bottom up approach with at least a base level of governance devolved to farmers. This means trust. And maybe an output based scheme but with relevant indicators that are not depending on the weather or extern factors but represent a good idea of the state of the environment in the territory.

Major changes

This question sought the views of advisers and agreement holders on a suitable process where major changes to an agreement were required, such as the moving or changing options, inability to deliver options because land could not be accessed as the land was waterlogged or adding new land to an existing agreement.

Here agreement holders recognised the need for a more detailed process, similar to the current derogation system. However, the ability to keep the area the same but switch location and fields would be welcome, depending how crops had established.

It would be nice to change location and switch fields. Need to have same area covered of course. [Upland AH]

Self-monitoring through apps, phones, cameras, GPS tracking... [Upland AH]

Local control by NE local advisers that could deal with it. A number of similar options to be taken up. Maybe an app. [Lowland AH]

The second and third quotes introduce the potential for technology and some element of self-monitoring, although this is linked to a local NE adviser. The reason for this is clear as all agreement holders either explicitly or implicitly were looking for a relationship build on trust.

Build a relationship based on trust and understanding with some continuity to assess the options. [Upland AH]

The addition of an advisor that knows the farm decisions could be more efficient as they could easily say whether the derogation is needed or not. [Lowland AH]

A key factor with these types of changes is that there was more time to prepare for them. Unlike the minor changes the opportunity will not be lost and you can plan ahead for them.

This is easier as more time, 6 weeks is about right. [Upland AH]

From an agreement holder's perspective, it seems that a process based around the current derogation system would be acceptable with more use of technology, self-assessment and discussion with local NE officers. The advisers interviewed were more detailed in some respects as this first quote illustrates:

Depends on the option, some need long term management commitment. Can't just change for one year. Need to work with it. Where short term options need to have volume not location have flexibility to amend, This exists now as declare where they are on the ground. Rotational options are ok if designed well. More if longer term mix, if wrong site then should be able to move. Varies depend on option - this is the challenge. [Lowland adviser].

Here the adviser is clear that some options can't be moved or changed within an agreement and for some short-term options it is an issue of amount rather than where the option is on the holding. One adviser felt this was possible under HLS but not under the current CS scheme.

Did this under HLS, concerned farmer was very stressed as water [levels] not going down. Couldn't meet indicators of success, had all the capital items in but not able to work. Changed options so amendment to

agreement even though beyond his control. Was permitted [then] but different system now as amendments not permitted. [Proposed change] Is assessed centrally. This example would be more difficult as scheme is more rigid. [Upland adviser]

Linked to this concern about a rigid structure a number of the advisers also referenced the need for contact between the agreement holder and the adviser.

Act as a contact for the case, develop a personal relationship so … wouldn't have to re-explain lots of time. Farmers involved and used to my situation. Would help delivery. [Regional adviser]

In this quote the advisers see themselves as a bridge between the agreement holder and the scheme itself, working together to find a way forward. However, under the current derogation/MTA process it is unclear as to whether they would have this opportunity.

Nevertheless, for the most part, the current derogation and MTA process would suit the types of major changes discussed in the interviews, certainly more than the minor changes. The addition of some local checking and an increased use of technology could be explored to see if it was able to speed up the swiftness of response. What is clear is that the new system is not well known amongst the agreement holders who prefer local contacts. The advisers would also appear to want to be part of the solution when currently it would appear that they are not involved as they might be. The next section looks at extreme weather events and the type of process that agreement holders and advisers think is suitable in these situations.

Extreme weather events

The question asked about the type of process required in response to a regional or national extreme weather event, such as Storm Desmond or the Beast from the East. As many of the interviewees pointed out such events are '*distressing enough for [farmers] without worrying about AES*'. There was a recognition that such events need a planned response that covers a range of issues, as this quote illustrates:

Automatic extension as well as an understanding that animal welfare is utmost priority over soils. A need for more local administration. To have precise and clear & smarter response plan - mitigation – build up the resiliency of the environment.

For some elements an automatic extension would be the best way forward and a prioritisation that animal welfare is a priority in the short-term. The reference to soils covers issues of poaching and potential impact on BPS compliance. The response plan would need to cover the initial response to minimise immediate damage and then to consider the recovery. Part of the recovery would be a back-check to see what has happened before adjusting the route forward.

Where you have no control and you have to take action, welfare of animal comes first. Process to assess and retrospectively look at this. Then adjust to get back on track. Not always revert to what it was before.

This quote ends with something that the advisers also picked up, the normal approach in AES to move things back to the way the agreement had set out the management at the start. This was taken further by two other agreement holders

It is really sad to see that agreements can't be modified or adapted to add new benefits such as planting more tree or a new phase of capital investment. 10 Year is too short farmers need more foresight to fully invest in this scheme, they feel unsecure and disadvantaged. [Upland AH]

In the area NE and rivers trust triggered a riverbed reframing thus elevating the water tabled which since then causes continuous flooding to this upland area for a very low impact downstream. It changed the ecosystem as it existed for 300 years to transform it into something more waterlogged and less efficient. It changes the environment and caused damages to the "ancient" trees. It would be good that farmers are able to participate to the design of AES schemes to better answer to these problems. Farmers in the area are well aware and keen toward their dual purpose: public goods service provider as well as food producer. [Upland AH]

In this sense there is a recognition in the first quote that AES agreement should adapt and change in order to deliver the best environmental outcomes. Climate change means things will change as the long quote in section 4.3 illustrates. When the change is quick and as a result of an extreme weather event, it should be a point of discussion that perhaps some adaptation is required. The second quote is a warning light that farmers impacted by these reworkings need to feel and physically be part of the process. If it is making changes then there should be a feedback route for those impacted to hear about the benefits and for them to report aspects they feel are not working well. Other examples were given of shifting rivers back to original route after extreme events, as this met the AES agreement, when it might have made more

sense to retain the current 'new' course. The discussion needs to centre around which is the best course of action, for the farm business, the environment and the environmental outcomes from AES.

Specific mention was made of the Farm Recovery Fund (FRF), which provides a contribution to help those farmers whose agricultural land has been affected by flooding that is declared a natural disaster by the Government. Administered by the RPA, it is there to cover certain uninsurable recovery works including:

- Repairing stone walls, fences, gates and gateways, tracks and bridges;
- Restoring land by removing debris, re-cultivating and reseeding with grass or cover crop.

For more information see the box below. As this quote illustrates, there is a need for this type of approach.

> *Will need something like FRF but if this is the approach if required more frequently or over a wider area then might need to change. Not here for future resilience.*

The later point is key, in that the FRF is not there to support the resilience of the farm holdings as they adjust to the impacts of climate change. It is there as a last resort. In this sense there does appear to be a gap as AES agreements are not really focusing on the resilience of the farm holding, although as this report has identified there are some options which do provide this aspect.

Farm Recovery Fund

The Farming Recovery Fund (FRF) provides assistance through an assessed grant to farmers whose agricultural land has been damaged by flooding and declared a natural disaster by the Government. The Fund provides financial assistance up to 100%, with a minimum grant level of £500 and a maximum grant level of £25,000. Financial assistance is made available within the scope of Article 30 and the general conditions of the Agricultural Block Exemption Regulation (EU) 702/2014, with assistance being provided to cover non-insurable items and activities such as re-cultivation, reseeding, reinstating field boundaries and removing debris from agricultural land.

In this sense the FRF is an approach to the national and local events related to climate change. It was re-instated in 2014/15 to cope with the response to floods in Somerset (2014) and Storm Desmond (2015) and in particular the land under AES agreements. In 2019 the FRF moved to the RPA, however, FRF and AES are separate. Eligibility for the scheme has to be pre-determined on the basis of satellite data of the flood extents during the time of the national emergence. Cost cover repairs to fences and walls or actions on the land so it can return to productive use. Noticeable that building resilience is not part of the approach within FRF, which is focused on re-building. Minor concessions possible to reduce likelihood of damage occurring again. No duplication of funding between FRF and AES so RPA clear that they fund different things. Discussions on AES is a separate conversation with someone else in the RPA. It is a pragmatic approach most of all for the monitoring side/checks.

Some of the advisers reported that there needed to be more recognition of the impact of extreme weather within any new scheme and this should be included in the advice applicants receive.

> *Any new scheme should consider extreme events so there is a system set up for landowners and farmers to report to - simple but effective. Needs photos and explanations to report so the AH can contact RPA or NE. When there are such events they can report in what is happening, then request and assess what is needed. Standard derogation should be a possibility - e.g. not able to complete grazing, taking livestock off the land. As simple a process as possible as time is crucial at times like this. [Upland adviser]*

This covers the immediate impact and gives the farmer some reassurance. As noted above, the building back afterwards is also important to consider. Timeliness is important, as was noted in the summer of 2019 referred to here.

> *I have seen wavers for last year but they come too late. Need a protocol and threshold that administer are quicker to implement. Can't wait 3-4 months for this before waver cutting dates or rolling over to next year etc. timeliness is key. [Lowland adviser]*

So, the consensus was for an approach within the AES programme that focus on the immediate impact and then the recovery.

The process needs to have a re-think of how we can respond more quickly and effectively. Currently the process requires a mountain of paperwork. Needs a system to access quickly, the day after the flood - not wait until it kicks in. Help straight away to report damage and request a derogation. Simple slick process for farmers on line (and those who don't) to allow other to support them. Costs rack up quick, would help NE and RPA advisers. National system for emergency situation, upload photos and not invent new system for each incident. Schemes working with set habitats and be more aware of the way in which event changes the landscape - rivers and hay meadows. Some design added to options and prescriptions for fluvial geo-morphology and transitional habitats. They can be important as they are mobile not fit a category. What to do when things don't fit neatly into categories (fen, bog, etc.). Pain in current scheme is where you have a variety of these habitats across a field parcel. Now you can have 1 option per field but it had area of reed bed then need to change the field to get separate field number - and this a year in advance of application. [Upland adviser]

This long quote from an adviser refers to a 'new system for each incident' and is presumably referring to the FRF, which comes on stream only after a major incident is called. The FRF covers natural disasters or similar out of the blue events. There is clearly a role for the FRF in terms of responding to climatic events, even those that focus on small areas but have high levels of impact. According to one adviser the FRF works best on small areas covering 30 farms. If the area covers over 1,000 farmers then the level of data checking and visits can lead to delays as it is quite resource intensive. The whole issue of resilience within farming is central to these issues it would be more effective than having to roll out FRF with an ever increasing frequency.

4.6 Discussion

This chapter has outlined in more detail the types of challenges that agreement holders face and how AES agreements are not as effective as they could be in terms of helping agreement holders meet the anticipated environmental outcomes and become more resilient as well. The data on Hawthorn and Common Frog showed that while the long-term trend for phenology is for earlier springs and subsequent emergence of plants and animals from winter, there are year on year and regional variations. These two examples revealed that there is not a consistent pattern in recent years, and there is also regional variation year on year so while the southern case studies tend to be first it is not always the case. Both of these factors are important when considering national fixed dates within AES option prescriptions.

The local variations on phenology were reflected in the average monthly temperatures with evidence of early springs, hotter summers, warmer autumns and colder winters clear from the 6 year charts. The regional variation was also evidence. The comments from the agreement holders and advisers confirms that farmers and land managers are more aware of climate change and the impact it is having on their holdings and businesses.

AES agreements can help mitigate the impacts of climate change as one AES agreement holder and their NE adviser illustrated. Climate change has resulted in land that is much wetter throughout the year in terms of water coming from the hills to the north and the impact of tide levels from the coast to the South. Through consecutive AES agreements the land on this holding has increased the levels of biodiversity but this has impacted on the agricultural operations.

The issue of derogations and MTAs was mentioned a few times and the previous section estimated how many had been requested by the respondents to the online survey. The interviews also revealed that agreement holders found the process for derogations inefficient and not rooted in the local NE offices. As a result, some mentioned that they did not ask for a derogation or MTA for some tasks, such as cutting rushes or hay early or establishing a margin. Exactly how MTAs are currently handled is not the purpose of this report, but what is clear is that the agreement holder's perception is that they take too long for outcomes to be received and the process is too centrally driven. The feeling of advisers and agreement holders is that a more locally driven process would lead to quicker and more effective outcomes for them and the environmental outcome sin the agreement.

The regional phenology, rainfall, temperature and days of ground front have highlighted, even at an averaged regional scale, that the three case study areas (Cumbria, Somerset and West Anglia) represented contrasting climate hazards over the past 5 years including drought, flood, heat, cold and wet. What it has also revealed is that there is a prevalence of extreme weather in areas where you might not expect it. Agreement holders and advisers from all three case study areas reported that drought and heat impacted on farming and AES delivery. The same was not the case for flooding with regional weather patterns not showing examples of high rainfall in West Anglia and the agreement holders and advisers reported few issues of flooding. Therefore, it would seem that drought and heat are large scale impacts covering much if not all of England. On the other hand, flooding tends to be localised as this is caused by intense events that exceed the local capacity for managing rainfall. In this sense the greatest impact within the case studies is in

Cumbria, with some events in Somerset but hardly any in West Anglia. The impact of extreme wet weather was more widespread and this has a similar impact on farming systems as drought and heat, as it prevents the farming system operating at its optimum level.

There is a common determinate in all of this discussion, the management of soil. The type of soil and how it is managed does make a difference. This goes beyond the scope of this report but how the soil is managed is clearly important. In the online survey that types of AES options that were reported as helping the holding become more resilient were herbal leys, arable margins to prevent surface run off and the correct grazing levels to maximise the grassland management. In the case of the herbal leys, the AES agreement holders made an important point, that this option 'improves' the soil by helping it retain water and increasing its porosity through the variety of species and their differing root depths. In times of extreme heat, the ideal is to have soil that does not dry out. This is partly down to soil type, but it is also a result of soil biology and functioning. If there are the right levels of organic matter then more moisture might be retained. During high levels of rain fall, soils with increased porosity will have less surface run off (Schwilch et al 2016 and Skaalsveen et al 2019).

Issues such as cutting fields with high levels of rush infestation and cutting pastures for hay or haylage were areas that the interviews revealed some common themes. The impact of drought and unseasonal weather, in this case warm and dry spring and early summer, resulted in fields that needed prescribed management earlier than the dates of the associated options warranted. Cutting rush on or after the required date in such circumstances would make the situation worse by spreading seeds which have set early than usual. In terms of hay and haylage there was a concern that the grass would be less palatable and if left to August, changes in the weather might mean it would be difficult to collect. There is some evidence to support the spread of soft rush (Ashby et al 2020) and the effectiveness of cutting as a management tool provided the timing is right (Kaczmarek-Dera et al 2018). The situation will vary from year to year and from one locality to the next as this chapter has shown, so some local verification of the need would be required unless the technology allowed for some remote verification of the circumstances.

When asked about the processes to accompany the management of AES agreement when they need to change, three main areas were discussed. First, the current system of derogations and MTAs is not supporting minor changes. Agreement holders and advisers felt these should be determined locally and swiftly by advisers. The current derogation and MTAs system was about right for major changes. In terms of support during episodes of extreme weather a key finding is that climate change means change, and AES need to reflect and manage appropriate change focusing on renovation rather than restoration. The FRF is a process that could be considered but it works best at the local scale and is focused mainly around restoration and those areas that are not insured. The issue of resilience is key here and needs to be considered as part of a whole system review – is the current farming system working for the holding in terms of resilience to climate a change and is the AES agreement also making the wider environment more resilient.

The final chapter outlines the main conclusions from this study and next steps.

5. Conclusions and next steps

5.1 Conclusions

Main findings

Chapter 2 involved the linking of phenological aspects in order to reveal the effects of gradual climate change on agri-environment scheme option delivery. The evidence points to areas of overlap and potential concern (Appendix 2). However, this initial enquiry would benefit from further investigation. For example:

- Consider broadening the range of species considered and making a stronger link to AES options by selecting soft rush and key species in species rich hay meadows, both of which this study revealed as areas of concern.
- Develop a better understanding of ecological events where species have a more complex or indirect response to changing climate, for example by changing patterns of international migration, changes in habitat, food supply or predation and species where there is a time lag between a climate event (e.g. a particularly warm spring) and changes in the timing of events such as nesting;
- Develop a better understanding of the risk that changing phenology and year to year variability presents to environmental outcomes and the challenges this brings to AES agreement holders. Reviewing the suggested RAG rating using a range of experts and specialists is recommended. It is possible that some species' broad temporal spread of events means they are more resilient to potential clashes with land management operations. Others may be concentrated in a shorter period meaning that the effects of clashes could have a more serious impact on populations.
- Such further investigations would highlight the need for AES to review and adjust the recommended approaches in light of changing environmental conditions.

In identifying potential clashes between the timing of ecological events and the period when land management operations can be undertaken, this study has not considered the likely extent of habitats affected, nor the abundance or rarity of the species involved. Indeed, the data used under-represent rare or uncommon species where it is possible that any impact could be more significant. Nevertheless, the research has focused on the possibility that changes in the timing of ecological events could increase the potential for clashes with land management operations.

The online survey (**Chapter 3**) received 420 replies with viable responses in the three study areas known to have experience extreme weather. As with other surveys focusing on AES, the holdings were larger than the national and regional figures and over three quarters are in or have been an AES agreement. Overall, the survey found that over 90% of the sample had been impacted by extreme weather and for just over a third of the respondents this was 'severe' on at least one occasion in the last 5 years. The impact from dry and hot weather appeared more widespread, impacting all three case study areas, than for wet weather but there are a range of impacts, which can be severe. Dealing with extreme weather has cost implications as indicated in 90% of cases where farmers were affected.

Key conclusions are that the occurrence of extreme weather made meeting the environmental outcomes of AES agreements more challenging as there was a perceived lack of flexibility to respond to the circumstances around the agreement holder. Those who experienced the administrative processes concerning adjusting an AES agreement suggested it is not simple and the process for derogations or MTAs is complex. The processes associated with BPS have similar challenges to those of AES in that they were often seen as complex and remote by farmers and land managers. A quarter of those who had been impacted by extreme weather had requested a derogation or MTA, if scaled up this is over 10% of all AES agreements.

The interviews with agreement holders and advisers (**Chapter 4**) showed they were aware of the changes in weather patterns and the impact of extreme weather both on their farm businesses and AES agreements. Regional and yearly variations in phenology are not accounted for in some national AES prescriptions where year on year and regional variations mean that fixed dates are problematic in all parts of the country. Agreement holders and advisers offered a few examples of instances when dates linked to prescriptions of certain AES options worked against the desired environmental outcomes. Extreme weather did impact the effectiveness of dates for tasks such as the cutting of rushes and grass for hay, in some years the dates were too late suggesting that a more flexible approach might be more beneficial for meeting environmental outcomes.

Drought and heat were factors that have a widespread affect across England with specific impacts on different farming systems, flooding and wet extreme events tended to be focused more in the North and West. The type of soil and its management were key factors in reducing the impacts of extreme weather. Increased soil function is able to retain moisture in times of heat and drought and higher soil porosity helps reduce the impact of surface run off. Establishment of some options could be challenging but peer-to-peer learning and knowledge exchange and the assistance of a local adviser helped alleviate these.

The process for managing changes in schemes was examined in detail. Some farmers were asking for at least one derogation a year, while others were not requesting a derogation as the process took too long to grant the request and was not rooted locally. Advisers and agreement holders favoured the ability of local NE advisers to agree minor changes to AES agreements at the local level (e.g. earlier cutting dates). The current derogation system works reasonably well, for major change in the AES agreement, e.g. changing the sequencing of works and location. During and immediately after extreme events the priorities for an AES agreement holder is the farm business (e.g. livestock) and its infrastructure (buildings). Extreme events benefit from being handled centrally to agreed criteria that are implemented locally, based on the current Farm Recovery Fund.

AES and SSSIs (and other designations)

If one is to assume that the SSSI and similar designations represent the best sites in England in terms of biodiversity, then there is much to be gained from ensuring that these sites are as resilient as possible. The findings in chapter 3 suggest that they are as likely, if not more likely, to be impacted directly by extreme weather events. Over 70% reported experiencing extreme heat, 65% extreme wet, 68% unseasonal weather and timings (e.g. early spring or warm winter), 57% drought were the top four factors. A key factor is the issue of resilience, the ability for the ecological and management systems to withstand shocks and sudden changes. In nearly a fifth of cases agreement holders could identify AES options that had made the holding more resilient to the impacts of extreme weather. This include options such as herbal lays to improve soil functions and margins to reduce the impact of surface run off.

Greater alignment between the ecological health of the SSSI and the management goals of the EAS agreement would be a good step forward to enhancing the SSSI. In developing future programmes and the associated monitoring and evaluation 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.

It might be worth considering a special process for SSSI where an AES is involved as there are clearly issues with derogations and MTAs. Those that request them find the process slow and bureaucratic while others do not request them for similar reasons. The processes associate with AES and BPS are both seen as challenging and the majority find them complex and time consuming. Nevertheless, the presence of advice in AES is seen as helpful and the online guidance is as likely to be positive as it is negative. For SSSIs, the presence of the AES is the main means of funding suitable management activity, so it is important that these schemes help such important sites become more resilient to the effects of climate change.

5.2 Next steps

There are several areas in this report that would be worth while exploring in more detail. What is clear is that climate change and extreme weather is having an impact of agricultural holdings and in the effective delivery of AES agreements.

Further examination of data on derogations and MTAs would be beneficial and inform the implementation of recent and future changes. The data appears comprehensive, although some coding on the reasons might be more informative than the current system of notes. Being able to search by agreement holder as well as the number of parcels would improve the learning from this resource. The aim should be an approach that allows the effective collation and reporting of data on derogations and MTAs so this can feedback into the development and revisions of AES. It would appear that extreme weather and climate change are key factors in the current requests.

We now know that heat and drought impacts are widespread across England and the impacts of wet and flooding are more localised and can be destructive. In terms of areas that would add to our understanding, firstly, the issue of the financial cost of extreme weather on farm businesses and compliance with AES agreements was revealed but would warrant further investigation. About a fifth suggest that there is a 'large cost' in dealing with the impacts of extreme weather. This needs to be more fully explored in a separate project and the link to environmental impact explored. A key

part of this might be, whether in extreme events, it is sensible to restore areas to their pre-impact state or use the opportunity to make holding more resilience to the effects of climate change.

In addition, the link between extreme weather and AES agreement could be more fully explored using a different approach, such as maps, satellite images and farm-based interviews. The use of telephone interviews restricted the ability to link particular events to the AES agreement and certain options. A more integrated approach using a range of data would be an interesting approach. Taking a holistic approach would mean that the issue of resilience can also be included in order to identify the areas where AES management can assist in developing a wider knowledge on the long-term health of these social-ecological areas. Part of such a study could be to assess the timeliness of responses and how information was handled and responded too.

Future schemes

The experiences of the agreement holders and advisers, together with the findings of the online survey resulted in some findings to be considered in the development of future land management schemes. Suggestions included:

- Simplicity in application process, agreement and option prescriptions would be welcome, in order to account for the increasing changeability of local weather conditions.
- Ongoing guidance and training for agreement holders and advisers concerning the main ways of adapting to the impacts of climate change and extreme weather. This could be by appropriately trained NE staff or knowledgeable local advisers as well as through knowledge exchange by farmers for peer-to-peer learning.
- Greater flexibility in option prescriptions for grazing and the establishment of arable options to allow for external factors such as extreme weather and year on year regional variation.
- Developing an administrative processes that suits the circumstances and acts in a timely and clear way combining local advisers and central requirements.
- Minor changes to an AES agreement is best served through a local approach to checking and accountability. For more major change the derogation and MTA system works reasonably well.

Currently there is a lack of scheme delivery that considers resilience to climate change and future schemes need to more clearly defined and target the approach to increase natural functions across farmed landscapes. A good example of this would be options that focus on soils and the management of soils. Increasing the resilience of soil processes would have multiple benefits and reduce the impact of drought and heat on the environment and the farm business.

Future scheme(s) will need to be clear on the potential for AES to increase farm-level resilience to climate change and the links to the generation of public goods and services. Here, consideration of the benefits of moving to an outcomes-based approach rather than a prescriptive approach should be assessed. High quality advice, clear regionally relevant targets backed up by nationally robust inventory data sets, collected in a spatial manner and held centrally accessible would underpin and strengthen scheme outcomes.

A move towards an outputs-based payment scheme under ELM could help focus management on the biodiversity outcomes desired rather than maintenance of a specific habitat. This could allow greater flexibility in how habitats are managed and provide space for agreement holders to bring their own knowledge and understanding of management techniques to create the desired outcomes. Monitoring of AES will need to be mindful of the natural fluctuation in species populations, climatic conditions that affect management of sensitive habitats, such as coastal and flood plain grazing marsh or upland blanket mire, and the local management and governance conditions. NE advisers will be instrumental in ensuring this approach is successful for both biodiversity and the agreement holders delivering the schemes.

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Appendices

Appendix 1 Species for which correlation with past climate records was undertaken.

Table A1: Indicator species, climate variable, regions and timescales for past and future climate analysis

Source	Species	Variable	Region(s)	Timescale
BTO BBS	Golden Plover	Temp	N	March April
BTO BBS	Grey Heron	Temp	N, SE	Feb March
BTO BBS	Hen Harrier	Temp	N	March April
BTO BBS	Lapwing	Temp	N, SE	March April
BTO BBS	Long-Tailed Tit	Temp	SE	March April
BTO BBS	Raven	Temp	SE/N	March April
BTO BBS	Redshank	Temp	SE/N	March April
BTO BBS	Ring Ouzel	Temp	N, SE	April May
BTO BBS	Robin	Temp	SE	Feb March
Nature's Calendar	Comma	Temp	SE	March
Nature's Calendar	Common Frog	Temp	SE	Feb March
Nature's Calendar	Cuckoo Flower	Temp	SE	Feb March
Nature's Calendar	Elder	Temp	SE	Feb March
Nature's Calendar	Hawthorn	Temp	SE	Feb March
Nature's Calendar	Horse Chestnut	Temp	SE	Feb March
Nature's Calendar	Newt	Temp	SE	Feb March
Nature's Calendar	Orange Tip	Temp	SE	Feb March April
Nature's Calendar	Oxeye Daisy	Temp	SE	March April
Nature's Calendar	Red Admiral	Temp	SE	Feb March
Nature's Calendar	Red-Tailed Bumblebee	Temp	SE	Feb March

Appendix 2a RAG rating for Options and Indicator species for correlation with past climate records.

	Current situation	Future Trends
	The mean date for the ecological event in question already occurs before the prescribed date for the land management operation in question.	Trend analysis suggests that the mean date for the ecological event in question will occur before the prescribed date for the land management operation in question.
	While the mean date for the ecological event in question occurs after the prescribed date for the land management operation in question a significant number of events take place before that date.	Trend analysis suggests that the mean date for the ecological event in question will occur after the prescribed date for the land management operation in question but that a significant number of events is likely to take place before that date.
	The mean date for the ecological event in question, and the majority of individual events, take place after the prescribed date for the land management operation in question.	Trend analysis suggests that mean date for the ecological event in question, and the majority of individual events, will take place after the prescribed date for the land management operation in question.
	There is currently a large buffer between most, if not all, examples of the ecological event and the prescribed date for the land management operation in question.	There is currently a large buffer between most, if not all, examples of the ecological event and the prescribed date for the land management operation in question.

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
AB1: Nectar flower mix	End of the cutting period	30 March	Comma	First sighting	Mean Comma butterfly emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the cutting / grazing period
AB1: Nectar flower mix	End of the cutting period	30 March	Red Admiral	First sighting	Mean Red Admiral butterfly emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the cutting / grazing period
AB1: Nectar flower mix	End of the cutting period	30 March	Red-Tailed Bumblebee	First sighting	Mean Red-Tailed Bumblebee emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of bumblebees emerging during the cutting / grazing period
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Comma	First sighting	Mean Comma and Red Admiral butterfly emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the cutting / grazing period
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Red Admiral	First sighting	Mean Comma and Red Admiral butterfly emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the cutting / grazing period

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Red-Tailed Bumblebee	First sighting	Mean Red-Tailed Bumblebee emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of bumblebees emerging during the cutting / grazing period
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Elder	Budburst	Mean budburst within the cutting period	Trend towards earlier mean budburst date
GAEC 6: Maintaining the level of organic matter in soil	End of upland burning period	15 April	Raven	Nesting	Mean nesting date within burning period	No clear trend in mean nesting date
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Elder	Budburst	Mean budburst within the cutting period	Trend towards earlier mean budburst date
GAEC 7c: Trees	End of the period when tree cutting is permitted	28 February	Long-Tailed Tit	Nesting	Earliest nesting already likely to be within the tree cutting period in the SE	Strong trend towards earlier nesting – increasing proportion likely to be within the tree cutting period Moderately strong relationship with temperature
GS2: Permanent grassland with very low inputs (outside SDA)	End of the cutting / grazing period	28 February	Cuckoo Flower	First flowering	Large number of records for first flowering before 15 March	Slight trend to later flowering, but likely to be large number of first flowering records before 15 March

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
GS5: Permanent grassland with very low inputs in SDA	end of the cutting / grazing period	28 February	Cuckoo Flower	First flowering	Large number of records for first flowering before 15 March	Slight trend to later flowering, but likely to be large number of first flowering records before 15 March
HS4: Scrub control on historic and archeological features	End of the period when cutting of scrub is permitted	28 February	Elder	Budburst	Mean budburst within the cutting period	Trend towards earlier mean budburst date
WD3: Woodland edges on arable land	End of the period when cutting of scrub is permitted	28 February	Elder	Budburst	Mean budburst within the cutting period	Trend towards earlier mean budburst date
WT3 Management of ditches of high environmental value	End of the ditch maintenance period	31 March	Newt	First sighting	Mean date of first sighting already before end of ditch maintenance period	Trend towards earlier first sighting
WT3 Management of ditches of high environmental value	End of the ditch maintenance period	31 March	Common Frog	Spawning	Mean date of first sighting of frogspawn already before end of ditch maintenance period	Trend towards earlier spawning
WT3: Management of ditches of high environmental value	End of the ditch maintenance period	31 March	Grey Heron	Nesting	Mean nesting already falls within the ditch maintenance period	Trend towards earlier nesting
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April	Red-Tailed Bumblebee	First sighting	Mean Red-Tailed Bumblebee emergence close to the start of the cutting / grazing period with around half sightings occurring within the cutting period	Trend towards earlier emergence likely to mean slight increase in proportion of bumblebees emerging before the

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April	Comma	First sighting	Mean Comma emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the cutting / grazing period
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April	Orange tip	First sighting	Most Orange Tip Butterfly emergence within the cutting / grazing period	Trend towards earlier emergence likely to mean a slight increase in the proportion of butterflies emerging before the cutting / grazing period
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April	Red Admiral	First sighting	Mean Red Admiral Butterfly emergence close to the end of the cutting / grazing period	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the cutting / grazing period
WD7: Management of successional areas and scrub	End of the period when cutting of scrub is permitted	28 February	Elder	Budburst	Mean budburst just before the end of the cutting period in the south east. Large number of budburst records during the cutting period.	Trend towards earlier mean budburst date
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Red Admiral	First sighting	Significant number of first sightings before 15 March topping cut off	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the topping period
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Red-Tailed Bumblebee	First sighting	Significant number of first sightings before 15 March topping cut off	Trend towards earlier emergence likely to mean increasing proportion of bumblebees emerging during the topping period
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Long-Tailed Tit	Nesting	Earliest laying close to the end of the cutting period	Trend towards earlier mean and earliest laying date

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
GAEC 6: Maintaining the level of organic matter in soil	End of upland burning period	15 April	Ring ouzel	Nesting	Mean nesting date after burning period. Possible that earliest nesting may take place within the burning period	Trend towards earlier nesting
GAEC 6: Maintaining the level of organic matter in soil:	End of upland burning period	15 April	Hen harrier	Nesting	Mean nesting date after burning period. Possible that earliest nesting may take place within the burning period	Trend towards earlier nesting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Long-Tailed Tit	Nesting	Earliest laying close to the end of the cutting period	Trend towards earlier mean and earliest laying date
GS2: Permanent grassland with very low inputs (outside SDA)	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Red-Tailed Bumblebee	First sighting	Significant number of first sightings before 15 March cut off	Trend towards earlier emergence likely to mean increasing proportion of bumblebees emerging during the management period
GS2: Permanent grassland with very low inputs (outside SDA)	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Comma	First sighting	Significant number of first sightings before 15 March cut off	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the management period

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
GS2: Permanent grassland with very low inputs (outside SDA)	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Red Admiral	First sighting	Significant number of first sightings before 15 March cut off	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the management period
GS5: Permanent grassland with very low inputs in SDA	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Red-Tailed Bumblebee	First sighting	Significant number of first sightings before 15 March cut off	Trend towards earlier emergence likely to mean increasing proportion of bumblebees emerging during the management period
GS5: Permanent grassland with very low inputs in SDA	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Comma	First sighting	Significant number of first sightings before 15 March cut off	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the management period
GS5: Permanent grassland with very low inputs in SDA	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Red Admiral	First sighting	Significant number of first sightings before 15 March cut off	Trend towards earlier emergence likely to mean increasing proportion of butterflies emerging during the management period

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April	Small White	First sighting	Most Small White butterfly emergence within the cutting / grazing period	Trend towards later emergence likely to mean a slight increase in the proportion of butterflies emerging within the cutting / grazing period
WT3: Management of ditches of high environmental value	End of the ditch maintenance period	31 March	Moorhen	Nesting	Earliest nesting coincides with end of the ditch maintenance period	Trend towards earlier nesting
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Long-Tailed Tit	Nesting	Earliest nesting already within the topping period	Trend to earlier nesting
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Long-Tailed Tit	Nesting	Earliest nesting already within the cutting period	Trend to earlier nesting
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Red Admiral	First sighting	Significant number of first sightings within the cutting period	Slight trend towards earlier mean date of first sighting

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Red-Tailed bumblebee	First sighting	Significant number of first sightings within the cutting period	Slight trend towards earlier mean date of first sighting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Red Admiral	First sighting	Significant number of first sightings within the cutting period	Slight trend towards earlier mean date of first sighting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Red-Tailed Bumblebee	First sighting	Significant number of first sightings within the cutting period	Slight trend towards earlier mean date of first sighting
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Red Admiral	First sighting	Significant number of first sightings within the cutting period	Slight trend towards earlier mean date of first sighting
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Red-Tailed Bumblebee	First sighting	Significant number of first sightings within the cutting period	Slight trend towards earlier mean date of first sighting
HS4: Scrub control on historic and archeological features	End of the period when cutting of scrub is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April	Long-Tailed Tit	Nesting	Earliest nesting date already occurring within the cutting / grazing period, particularly in the SE	Earliest nesting date likely to continue occurring within the cutting / grazing period, particularly in the SE

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
UP1: Enclosed rough grazing	End of the rush cutting period	15 March	Short-Eared Owl	Nesting	Earliest nesting of upland species considered – no trend data	Earliest nesting of upland species considered – no trend data
WD3: Woodland edges on arable land	End of the period when cutting of scrub is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date
WD7: Management of successional areas and scrub	End of the period when cutting of scrub is permitted	28 February	Hawthorn	Budburst	Mean budburst within the cutting period	Trend towards earlier mean budburst date
AB5: Nesting plots for lapwing and stone curlew	Date by when nesting plots should be created	20 March	Lapwing	Nesting	Possible that in exceptional years, first nesting takes place before end of period when plots created	Trend towards later nesting
GAEC 6 Maintaining the level of organic matter in soil	End of upland burning period	15 April	Redshank	Nesting	Mean nesting date after burning period. Possible that earliest nesting may take place close to or within the burning period	Trend towards later nesting
GS16: Rush infestation control supplement	End of the cutting / grazing period	15 March	Lapwing	Nesting	Possible that in exceptional years, first nesting takes place before end of rush cutting period	Trend towards later nesting No evidence from our analysis that warmer springs will result in earlier nesting
WT3: Management of ditches of high environmental value	End of the ditch maintenance period	31 March	Snipe	Nesting	Earliest nesting coincides with end of the ditch maintenance period	Trend towards later nesting
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Cuckoo Flower	First flowering	Most first sightings outside cutting / grazing period	Slight trend towards later flowering Strong relationship with temperature

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Oxeye Daisy	First flowering	Most first sightings outside cutting / grazing period	Slight trend towards earlier flowering Moderate – strong relationship with temperature
AB1: Nectar flower mix	End of the cutting period	30 March	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
AB1: Nectar flower mix	End of the cutting period	30 March	Orange Tip	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Oxeye Daisy	First flowering	Few records of first flowering before the 15 March cut off	Slight trend to earlier flowering, but good buffer
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Comma	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Orange tip	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Oxeye Daisy	First flowering	Good buffer between cutting period and first sightings	Sufficient buffer is likely to remain
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Orange Tip	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Comma	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Orange Tip	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Comma	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Orange Tip	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
GAEC 7c: Trees	End of the period when tree cutting is permitted	28 February	European Larch	Budburst	Some incidences of early budburst within the tree cutting period	No apparent trend towards earlier budburst
GAEC 7c: Trees	End of the period when tree cutting is permitted	28 February	Horse Chestnut	Budburst	Some incidences of early budburst within the tree cutting period	No apparent trend towards earlier budburst Moderately strong relationship with temperature
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Comma	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Orange Tip	First sighting	Few first sightings within the cutting period	Slight trend towards earlier mean date of first sighting
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
GS1: Take small areas out of management	End of the cutting / grazing period	28 February	Lapwing	Nesting	Possible that in exceptional years, first nesting takes place in mid-March	Trend towards later nesting
GS2: Permanent grassland with very low inputs (outside SDA)	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Oxeye Daisy	First flowering	Few records of first flowering before the 15 March cut off	Slight trend to earlier flowering, but good buffer
GS2: Permanent grassland with very low inputs (outside SDA)	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
GS2: Permanent grassland with very low inputs (outside SDA)	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Orange Tip	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
GS5: Permanent grassland with very low inputs in SDA	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Oxeye Daisy	First flowering	Few records of first flowering before the 15 March cut off	Slight trend to earlier flowering, but good buffer
GS5: Permanent grassland with very low inputs in SDA	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Small White	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
GS5: Permanent grassland with very low inputs in SDA	Fertilising, manuring, cutting, use of machinery or other activities that would disturb breeding birds	15 March	Orange Tip	First sighting	Few first sightings within the cutting period	Slight trend towards later mean date of first sighting
UP1 Enclosed rough grazing	End of the rush cutting period	15 March	Redshank	Nesting	Between 13 and 38 days buffer between end of cutting and the start of nesting	Trend towards later nesting
UP1: Enclosed rough grazing	End of the rush cutting period	15 March	Ring Ouzel	Nesting	Between 20- and 40-days buffer between end of cutting and the start of nesting	c.40 years' headroom at current trend in nesting dates
UP1 Enclosed rough grazing	End of the rush cutting period	15 March	Golden plover	Nesting	Around 20 days buffer between end of cutting period and the start of the nesting period	Slight trend towards earlier nesting but very large buffer

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Blackbird	Nesting	Good buffer between end of cutting period and nesting	Good buffer between end of cutting period and nesting
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Robin	Nesting	Good buffer between end of cutting period and nesting	Good buffer between end of cutting period and nesting
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Song Thrush	Nesting	Good buffer between end of cutting period and nesting	Good buffer between end of cutting period and nesting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Blackbird	Nesting	Good buffer between end of cutting period and nesting	Good buffer between end of cutting period and nesting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Robin	Nesting	Good buffer between end of cutting period and nesting	Good buffer between end of cutting period and nesting
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Song Thrush	Nesting	Good buffer between end of cutting period and nesting	Good buffer between end of cutting period and nesting
HS4: Scrub control on archaeological features	End of the period when cutting of scrub is permitted	28 February	Dunnock	Nesting	Earliest nesting not within the scrub cutting period	No trend towards earlier laying evident
HS4: Scrub control on archaeological features	End of the period when cutting of scrub is permitted	28 February	Song thrush	Nesting	Earliest nesting not within the scrub cutting period	No trend towards earlier laying evident

Appendix 2b Options, Indicator species and correlation with past climate records.

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
OP1: Overwintered stubble	Retention of stubble until this date	15 February	Corn Bunting	Nesting	No current conflict with the end of the stubble retention period	No projected conflict with the end of the stubble retention period
OP1: Overwintered stubble	Retention of stubble until this date	15 February	Lapwing	Nesting	No current conflict with the end of the stubble retention period	No projected conflict with the end
OP1: Overwintered stubble	Retention of stubble until this date	15 February	Skylark	Nesting	No current conflict with the end of the stubble retention period	No projected conflict with the end of the stubble retention period
OP1: Overwintered stubble	Retention of stubble until this date	15 February	Tree Sparrow	Nesting	No current conflict with the end of the stubble retention period	No projected conflict with the end
WD3: Woodland edges on arable land	End of the period when cutting of scrub is permitted	28 February	Dunnock	Nesting	Earliest nesting not within the scrub cutting period	No trend towards earlier laying evident
WD7: Management of successional areas and scrub	End of the period when cutting of scrub is permitted	28 February	Dunnock	Nesting	Earliest nesting not within the scrub cutting period	No trend towards earlier laying evident

Appendix 3 Key species

Appendix 3a Hawthorn: Budburst

Selection as indicator

Hawthorn is a common hedgerow species so was selected as an indicator to examine trends in the timing of budburst. This species is commonly found growing in hedgerows, woodland and scrub[1].

Relevant agri-environment options

Changes in the timing of hawthorn budburst are relevant to the following agri-environment options:

Option code	Relevant operation	Prescribed date
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February
HS4: Scrub control on historic and archeological features	End of the period when cutting of scrub is permitted	28 February
WD3: Woodland edges on arable land	End of the period when cutting of scrub is permitted	28 February
WD7: Management of successional areas and scrub	End of the period when cutting of scrub is permitted	28 February

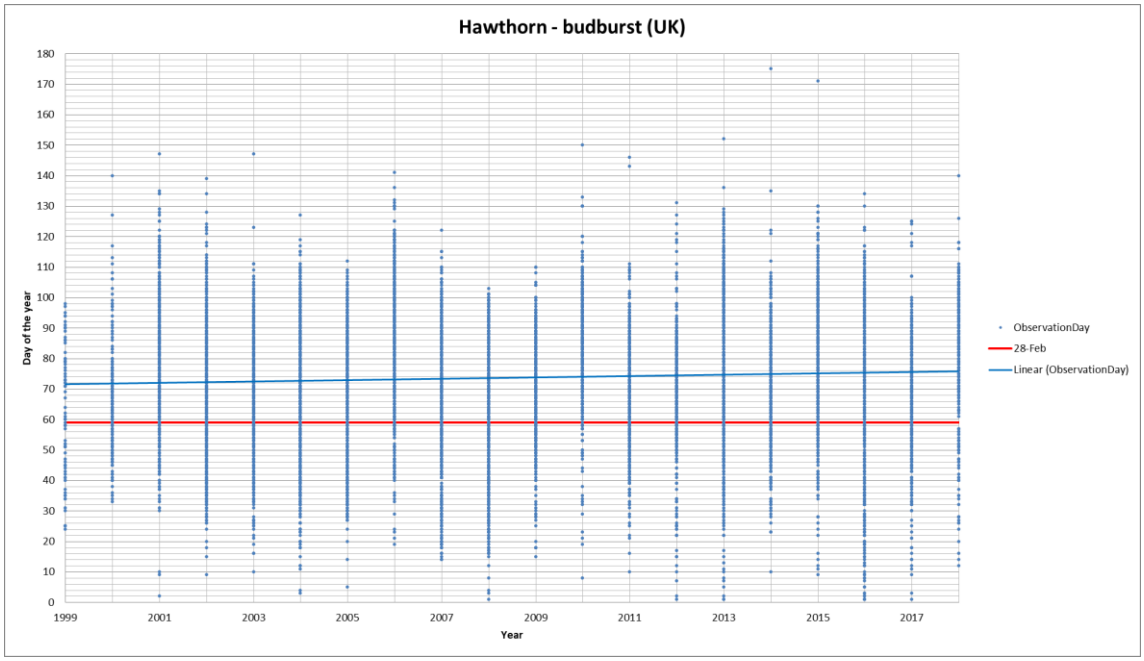
Evidence

Nature's Calendar provides information on the timing of Hawthorn budburst between 1999 and 2018. Figure 5.4.1 shows records for the whole of the UK. The data suggest that the average date of budburst has become slightly delayed, moving from around March 12 in 1999 to March 17 in 2018. However, the average figure masks the fact that a significant number of records of budburst occur in January and February. In some years (e.g. 2008, 2013 and 2016) several records suggest budburst during the first ten days of January.

The graph also shows the cut off dates for land management operations specified in agri-environment options as a red line.

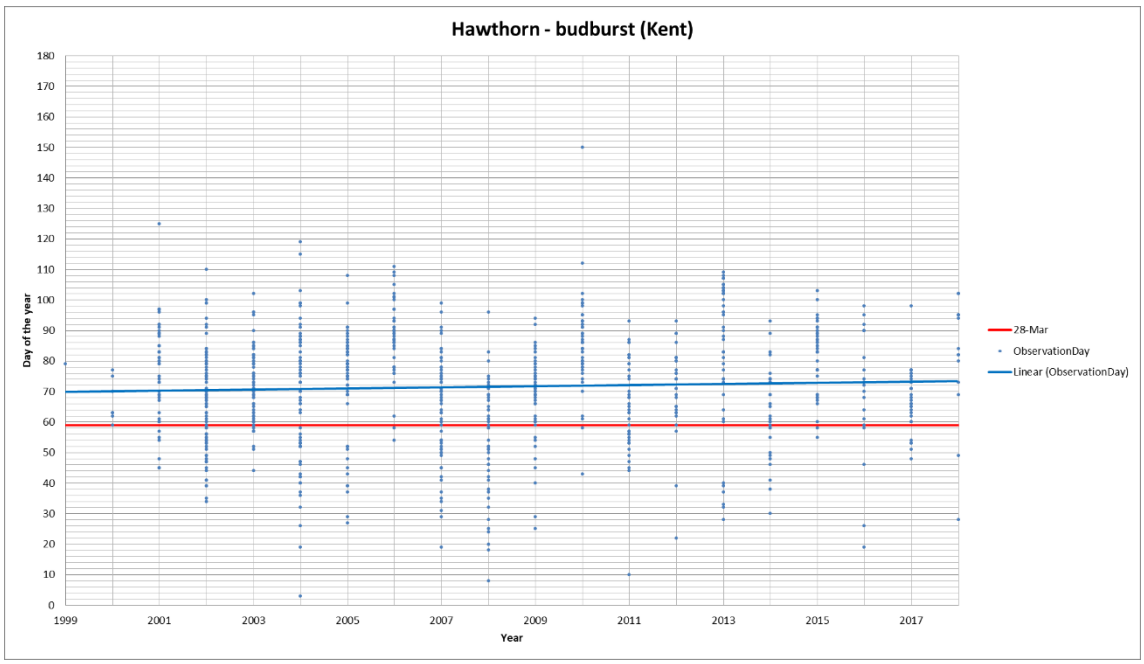
[1] https://www.woodlandtrust.org.uk/visiting-woods/trees-woods-and-wildlife/british-trees/a-z-of-uk-native-trees/hawthorn/

Figure 5.4.1: Hawthorn budburst – UK (n = 22,069)



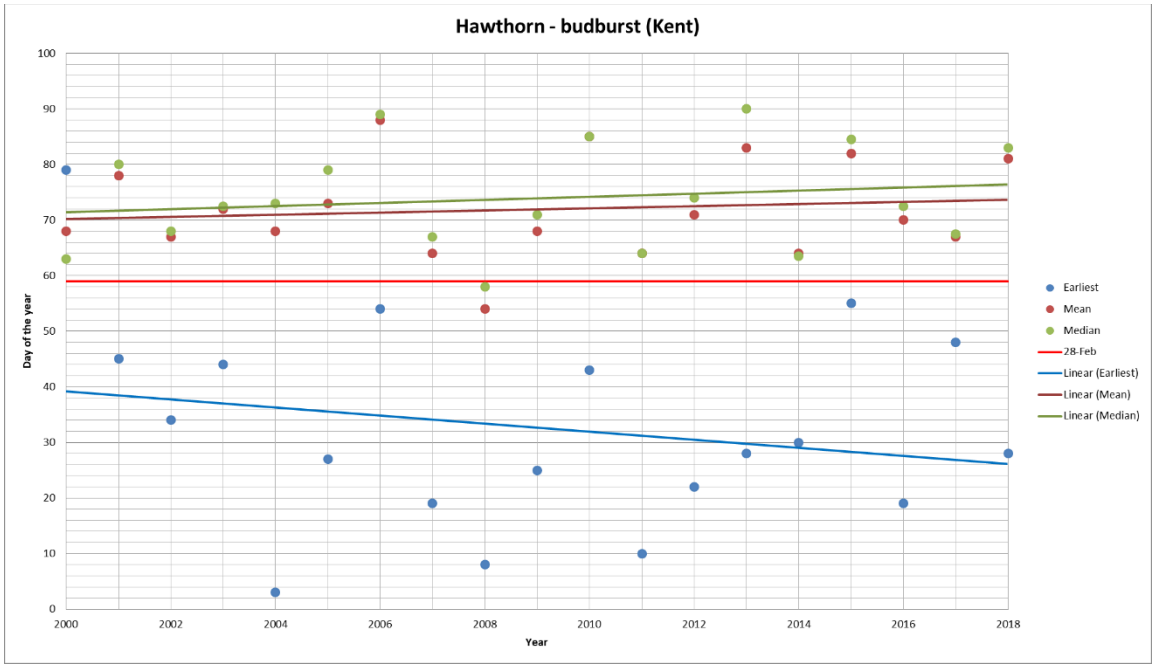
Kent was selected for further analysis because several of the early incidences of budburst were recorded in the county, and this area is likely to see the most pronounced increase in temperature in the future. The overall pattern reflects the national trend, with the average budburst becoming delayed by almost two days between 1999 (March 11) and 2018 (March 13). Again, however, there were a significant number of budburst records for January and February.

Figure 5.4.2: Hawthorn budburst – Kent (n = 844)



To explore this in more detail we identified the earliest recorded budburst for each year and the mean and median dates of the budburst records for each year. This showed that while the mean and median budburst dates in Kent became later over the period, there was a trend for the earliest recorded budburst to move forward (from around 9 February to January 28).

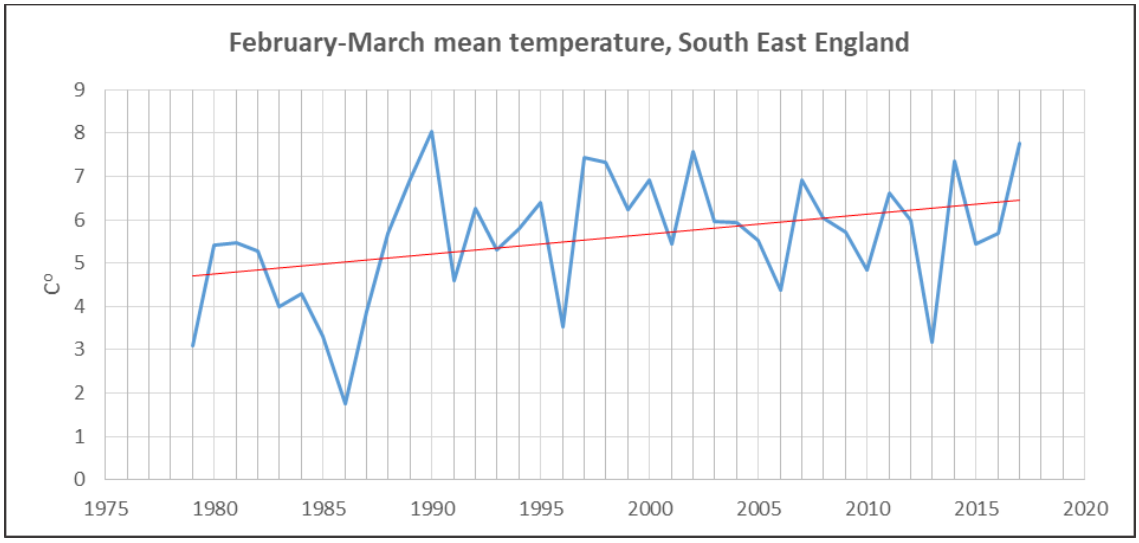
Figure 5.4.3: Hawthorn - date of first recorded budburst and mean and median budburst dates, Kent (n = 844)



Past climate change

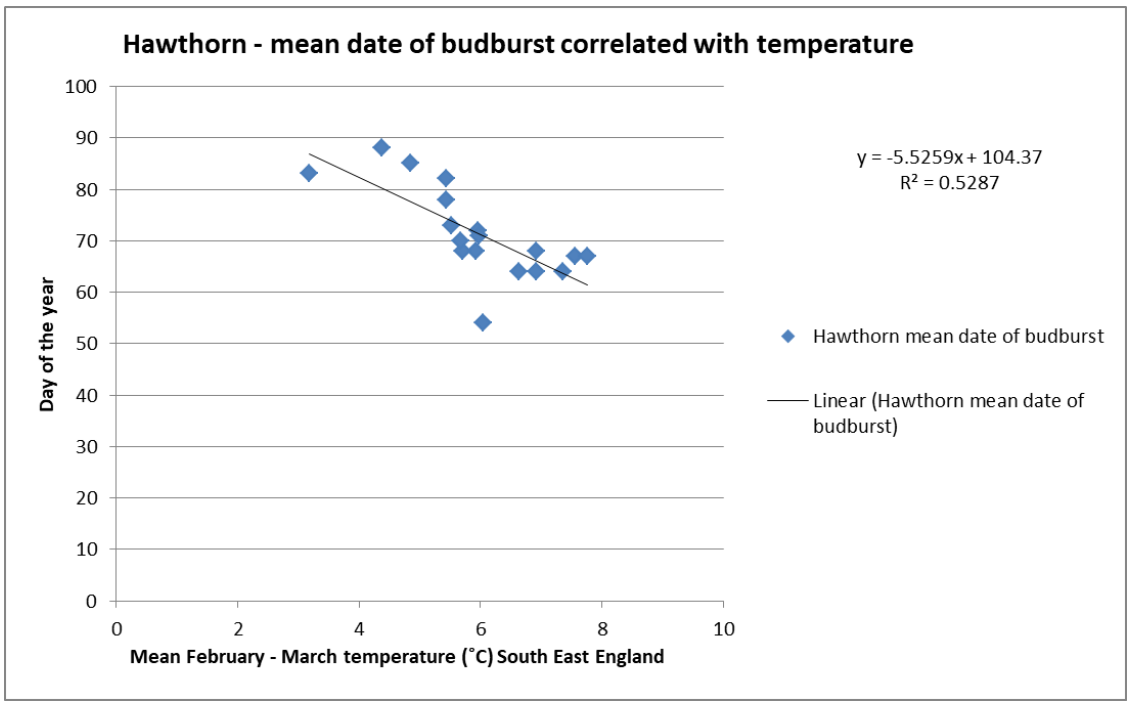
February to March temperature in the South East of England between 1980 and 2017 shows a distinct warming trend.

Figure 5.4.4: February to March mean temperature, South East England, 1980-2017



Analysis of the relationship between mean February and March temperatures and the timing of Hawthorn budburst in the South East of England found that around 53% of the variation in timing could be explained by differences in temperature. This suggests that other factors (including other climate variables – such as winter temperatures, rainfall or the onset of the growing season) have also influence the timing of Hawthorn budburst.

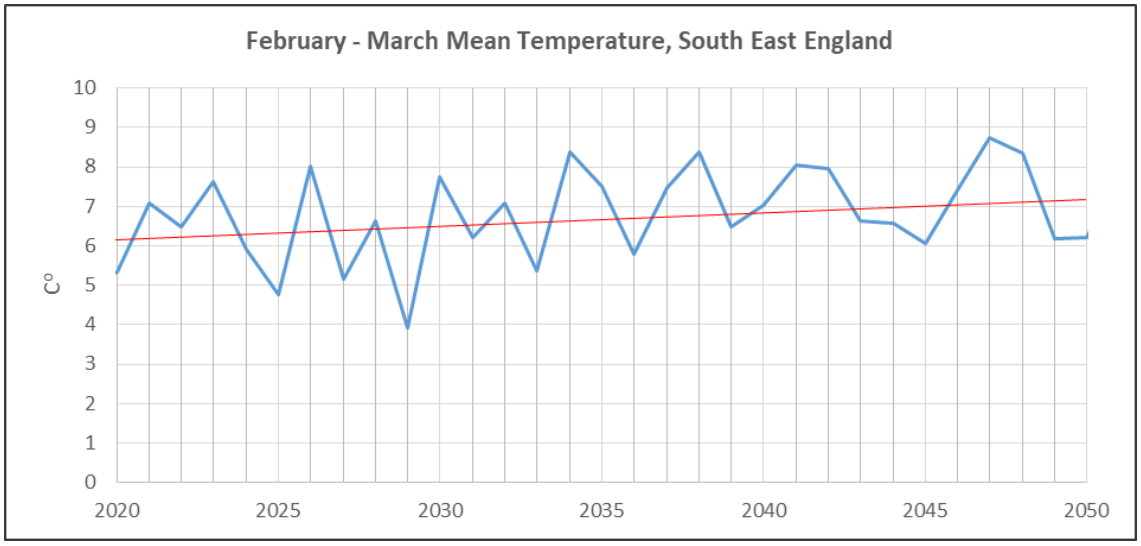
Figure 5.4.5: Hawthorn – correlation of budburst and temperature



Future climate change

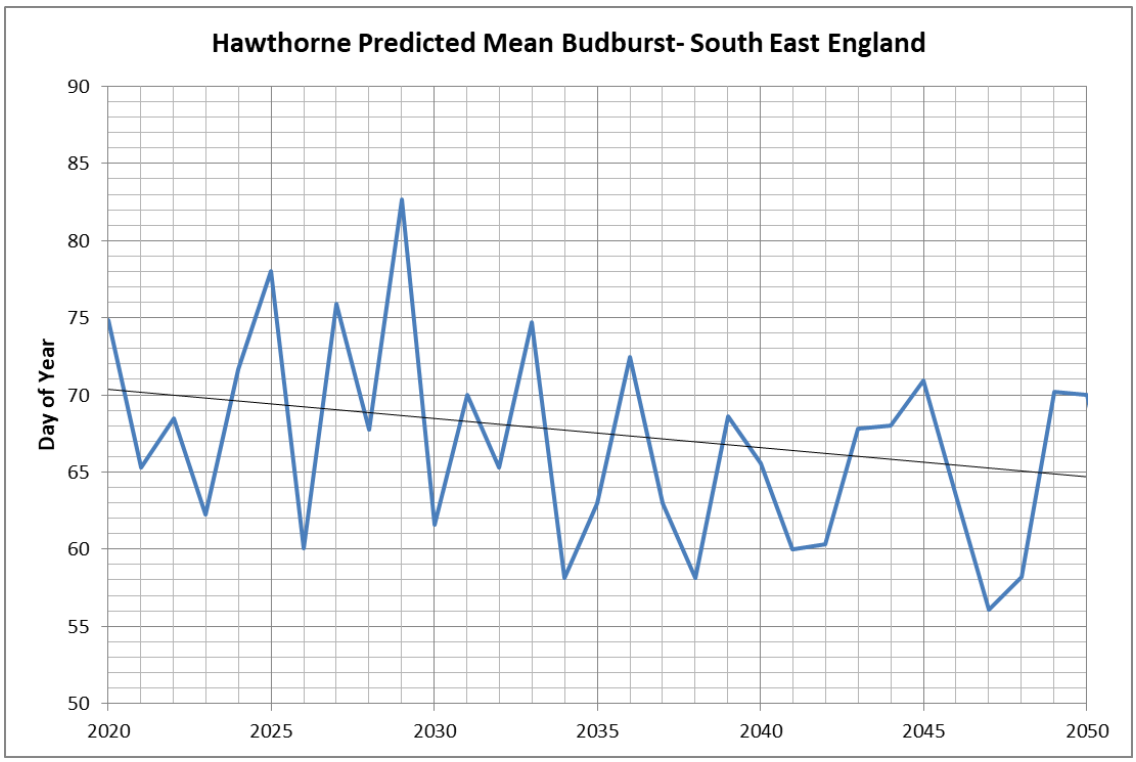
UKCP18 climate projections suggest that mean February-March temperatures will continue to rise.

Figure 5.4.6: February to March mean temperature projections, South East England, 2020-2050



Applying the observed past relationship between budburst and mean temperature to future projections for February and March in the South East of England suggests that the mean date of budburst could come forward a further five days by 2050.

Figure 5.4.7: Predicted mean Hawthorn budburst, South East England 2020-2050



Summary by agri-environment scheme option

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date
HS4: Scrub control on historic and archeological features	End of the period when cutting of scrub is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
WD3: Woodland edges on arable land	End of the period when cutting of scrub is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date
WD7: Management of successional areas and scrub	End of the period when cutting of scrub is permitted	28 February	Hawthorn	Budburst	Impact on earliest examples of budburst Trend towards later mean budburst date	Impact on earliest examples of budburst Trend towards later mean budburst date

Appendix 3b Common Frog: first spawning sighting

Selection as indicator

Nature's Calendar provides data for common frog providing one of two amphibian indicator species.

Relevant agri-environment options

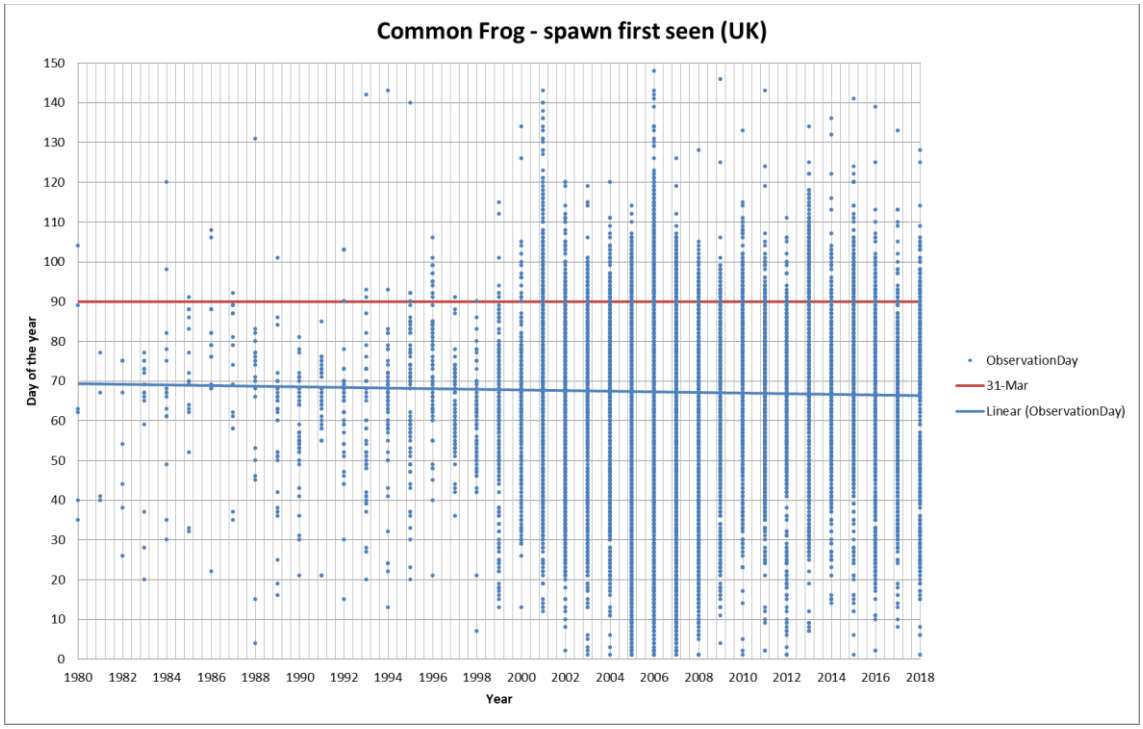
Changes in the timing of spawning are relevant to the following agri-environment options:

Option code	Relevant operation	Prescribed date
WT3 Management of ditches of high environmental value	Ditch maintenance	31 March

Evidence

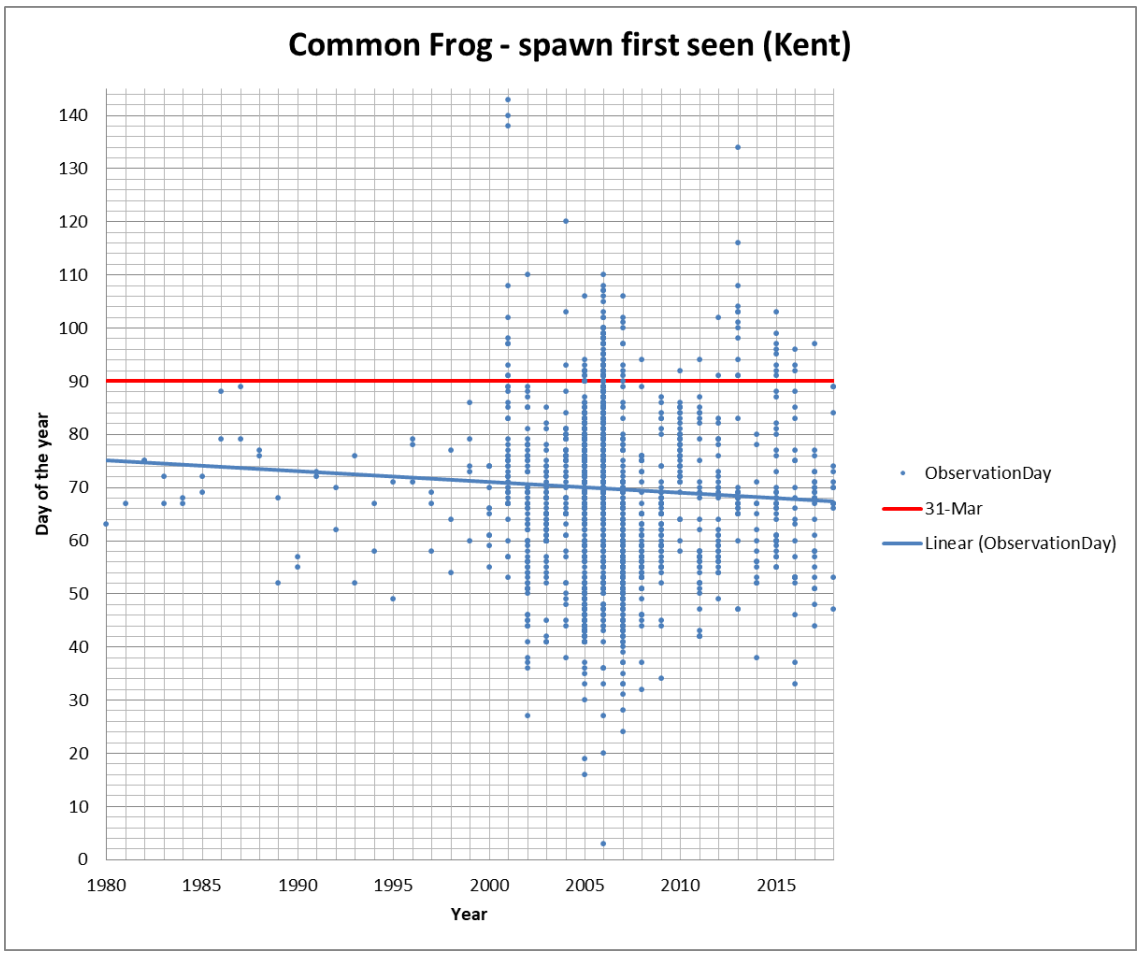
Nature's Calendar data for the UK (Figure 5.12.1), dating back to 1980 (with most records since around 2000), indicated that there first sightings of frog spawn have come forward by a few days over the last 30 years. The data need to be treated with caution given the low number of records for the first part of this period. The graph also shows the cutoff date for ditch management under the above agri-environment option as a red line.

Figure 5.12.1: Common Frog – date of first spawning UK (n = 83,794)



The same pattern is evident in Kent, with most first sightings of frogspawn coming before the end of the period when ditch maintenance can be undertaken.

Figure 5.12.2: Common Frog – date of first spawning Kent (n = 2,654)



Literature

A study carried out on populations of common frog in western Poland between 1978 and 2002 found that the spawning dates had become earlier by 8 to 9 days in this 25 year period, the authors have linked this change to the change in winter and spring temperatures in their study area[2].

A UK study of Common frog showed congregation and spawning dates had moved earlier and this was determined to be strongly associated with temperature changes[3]. However, another UK study found no significant changes in breeding dates over a 30-year period[4]

As noted in the NERC Report card[5], changes in amphibian phenology are difficult to detect due to large year on year variability, though this in itself underlines the potential vulnerability of the species.

[2] Tryjanowski, Piotr & Rybacki, Mariusz & Sparks, Tim. (2003). Changes in the first spawning dates of common frogs and common toads in Western Poland in 1978-2002. Annales Zoologici Fennici. 40. 459-464.

[3] Scott, Andy & Pithart, David & K. Adamson, John. (2008). Long-Term United Kingdom Trends in The Breeding Phenology of The Common Frog, Rana Temporaria. Journal of Herpetology - J HERPETOL. 42. 89-96. 10.1670/07-022.1.

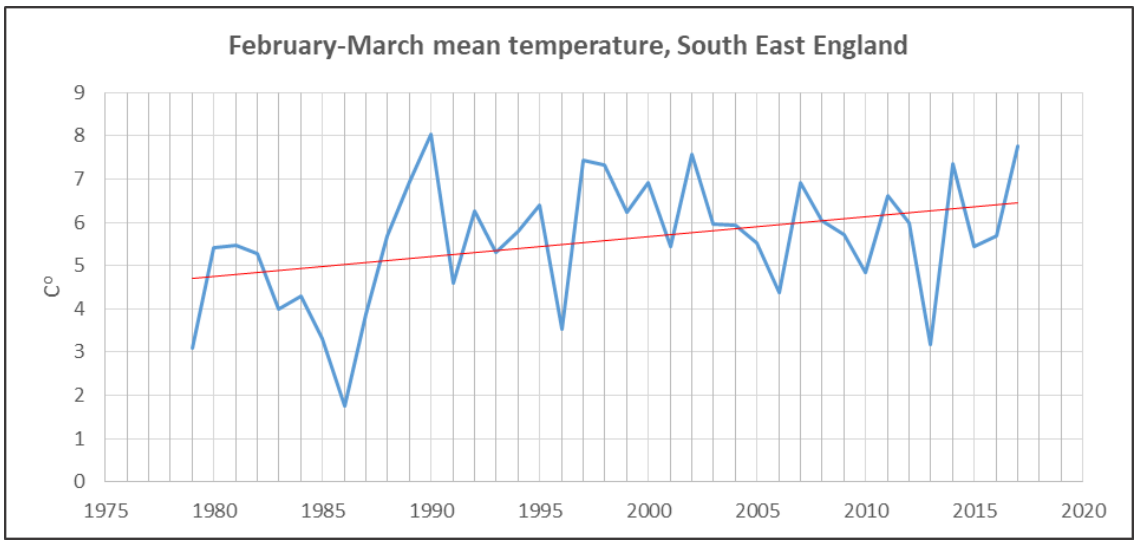
[4] Beebee, T.J.C. (2002) Amphibian phenology and climate change. Conservation Biology, 16 (6): 1454-1455.

[5] Sparks, T.H. & Crick, H. (2015) The implications of climate change for phenology in the UK. *Terrestrial biodiversity Climate change impacts report card Technical paper 12,* Coventry University, Coventry.

Past climate change

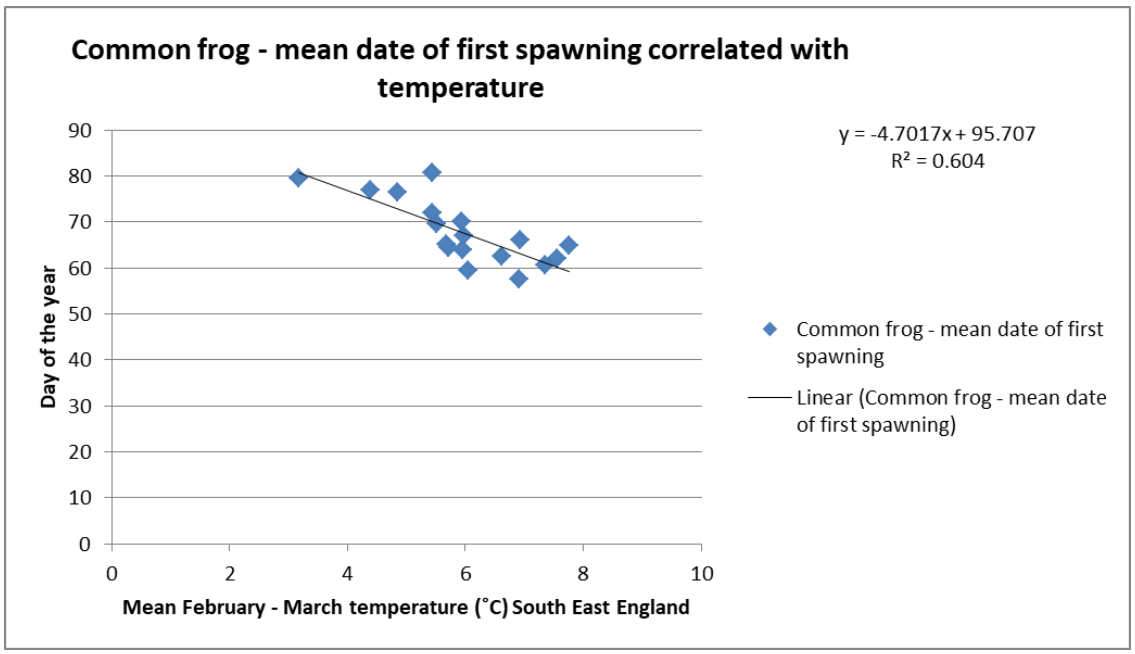
Mean February to March temperature in the South East of England between 1980 and 2017 shows a distinct warming trend.

Figure 5.12.3: February to March mean temperature, South East England, 1980-2017



Analysis of the relationship between mean February and March temperatures and the timing of first sighting of frogspawn in the South East of England found that around 60% of the variation in timing could be explained by differences in temperature. This suggests that temperature has a significant influence on the timing of frogspawn.

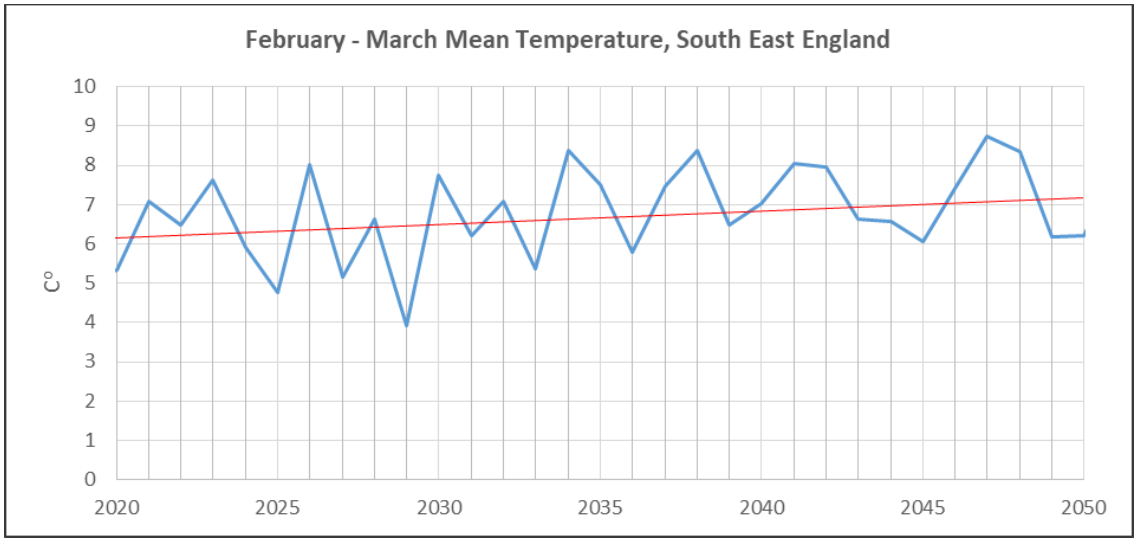
Figure 5.12.4: Common Frog – correlation of spawning and temperature



Future climate change

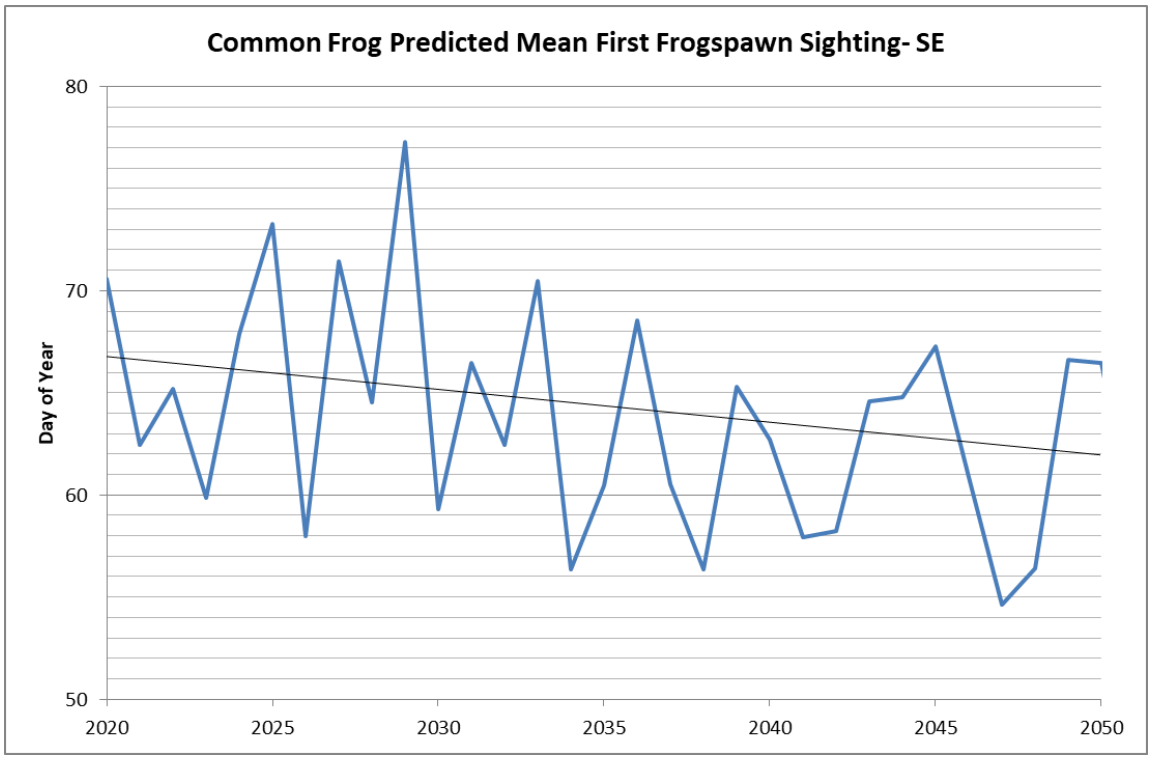
UKCP18 climate projections suggest that mean February to March temperatures will continue to rise.

Figure 5.12.5: February to March mean temperature projections, South East England, 2020-2050



Applying the observed past relationship between first spawning and mean temperature to future projections for February and March mean temperatures in the South East of England suggests that the mean date of first sighting could come forward a further five days by 2050.

Figure 5.12.6: Predicted mean date of Common Frog spawn first sighting, South East England 2020-2050



Summary results by agri-environment option

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
WT3 Management of ditches of high environmental value	End of the ditch maintenance period	31 March	Common Frog	Spawning	Mean date of first sighting of frogspawn already before end of ditch maintenance period	Trend towards earlier spawning

Appendix 3c Long-Tailed Tit: nesting

Selection as indicator

Long-Tailed tit was selected as an indicator species for farmland birds nesting in hedges and scrub. Based on the analysis of nest records between 1990 and 2002, Joys and Crick (2004) identified Robin, Song Thrush, Blackbird and Long-Tailed Tit as being the earliest nesting farmland birds. While Robin is the earliest to start laying, half of Long-Tailed Tit nests have started laying by 8 April, considerably earlier than the other species.

Table 5.17.1: farmland bird nesting dates (1990-2002)

	Dates by which laying has begun in 5% of nests	Dates by which laying has begun in 50% of nests	Sample size
Robin	19 March	18 April	931
Song Thrush	21 March	21 April	1558
Blackbird	22 March	22 April	1344
Long-Tailed Tit	24 March	8 April	608

Joys A. C. & Crick H. Q. P. (2004). Breeding periods for selected bird species in England. BTO Research Report No. 352. Thetford, BTO.

Joys and Crick 2004 also provides data on regional variation in first egg laying dates, with relevant information set out in Table 5.17.2. It suggests that the earliest laying date occurs in the South East of England.

Table 5.17.2: regional variation in farmland birds' earliest nesting dates

	Region	Dates by which 5% of nests where laying has begun	Sample size
Long tailed Tit	NW	31 March	170
	NE	30 March	123
	Y+H	26 March	108
	EM	1 April	153
	EE	25 March	159
	WM	26 March	182
	SE	**23 March**	**297**
	SW	25 March	148

Joys A.C. and H.Q.P. Crick (2004) Breeding periods for selected bird species in England - BTO Research Report No. 352

Relevant agri-environment options

Changes in the timing of long tailed tit nesting are relevant to the following agri-environment options:

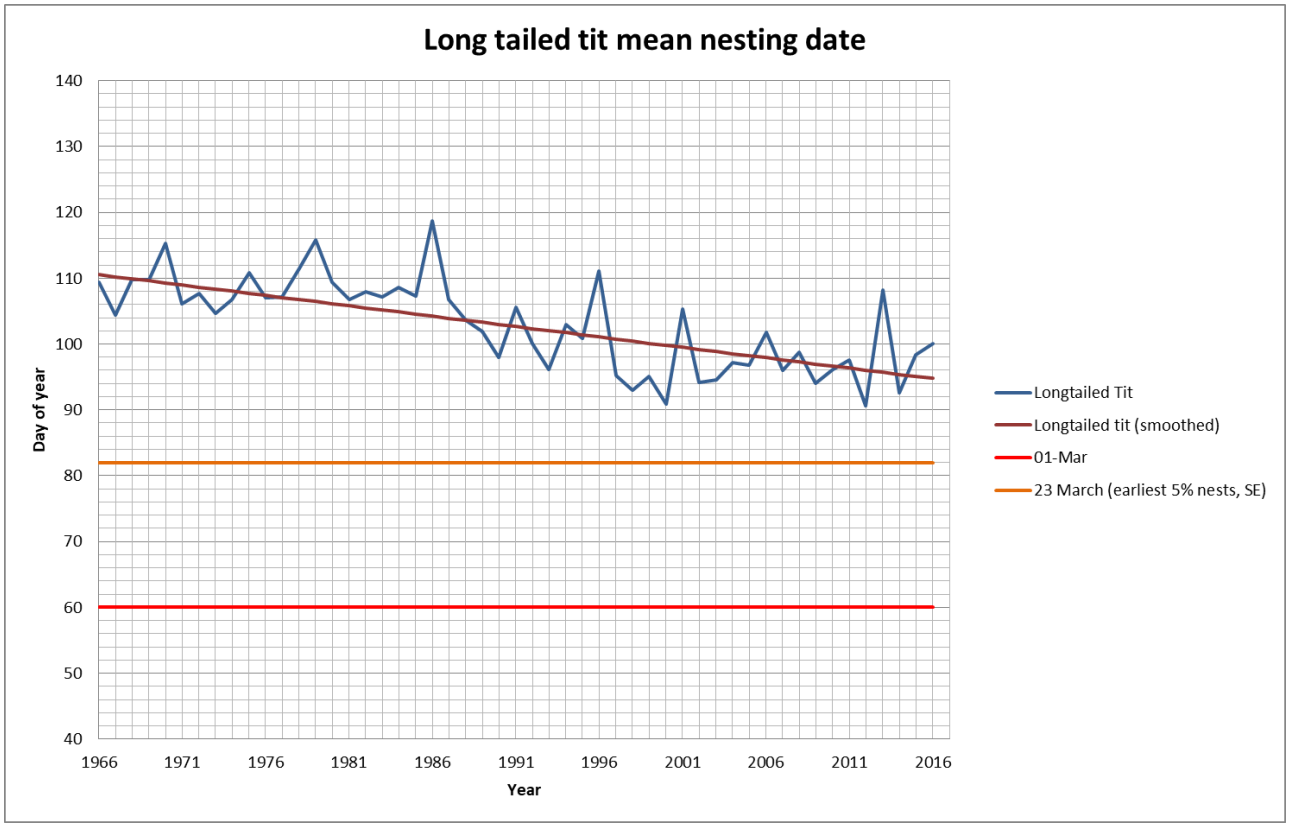
Option code	Relevant operation	Prescribed date
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March
BE3: Management of hedgerows	Last date when hedge cutting is permitted	28 February
GAEC 7a: Boundaries	Last date when hedge cutting is permitted	28 February
GAEC 7c: Trees	Last date when tree cutting is permitted	28 February
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April

Evidence

The BTO BBS data provides information on mean nesting dates between 1966 and 2017. Figure 5.17.1 shows Long-Tailed Tits saw a significant change in mean laying dates, with laying coming forward by around 15 days to 2 April. There was considerable inter season variation in mean nesting dates, suggesting that nesting could be between eight days earlier and twelve days later than the overall trend would suggest.

Figure 5.17.1 also shows the date that the earliest 5% of Long-Tailed Tit nests have started laying in the South East of England, based on data from 1990-2002 (Joys and Crick 2004). This is around 19 days earlier than the smoothed mean (1966 to 2017) would suggest. It is likely that this date is subject to some inter-seasonal variation and that in some years the earliest 5% of nests start laying before this date. The graph also shows the cut off dates for land management operations specified in agri-environment options as a red line.

Figure 5.17.1: Long-Tailed Tit – mean nesting date



Literature

As mentioned, Joys and Crick (2004) identified this species as one of the earliest nesting farm birds in the UK. Crick has also analysed data over a 25-year period which showed significant numbers of UK bird species had shown trends towards earlier laying dates[6]. Further analyses of this data indicated that the changes in laying dates were significantly related to spring temperatures[7].

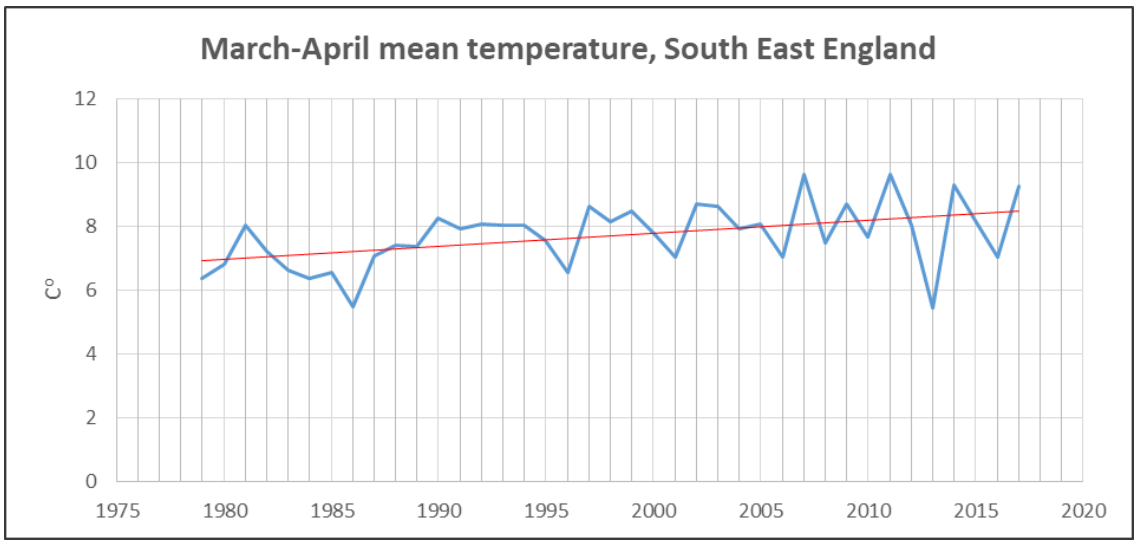
A study of resident woodland birds in the Netherlands found that 3 out of 4 species started clutches significantly earlier and that this change tracked the changes in climate[8].

Past climate change

Mean March to April temperature in the South East of England between 1980 and 2017 shows a distinct warming trend.

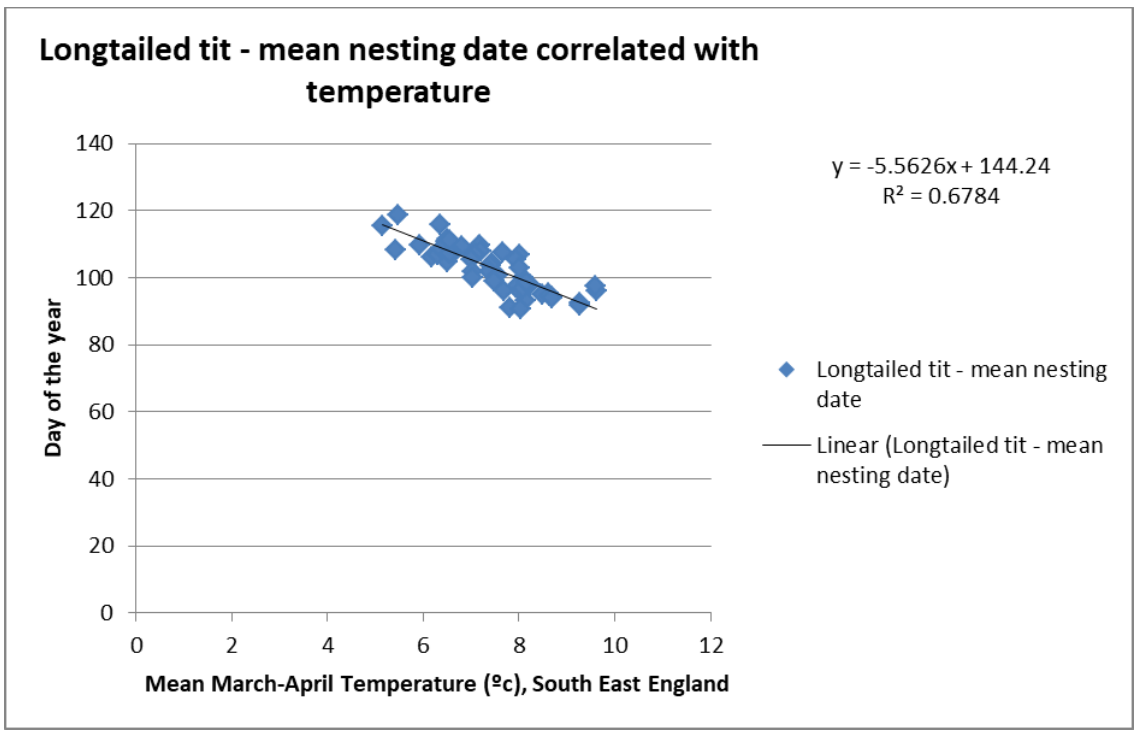
[6] Crick, H.Q.P., Dudley, C., Glue, D.E. & Thomson, D.L. 1997. UK birds are laying eggs earlier. Nature 388: 526.
[7] Crick, Humphrey & Sparks, Tim. (1999). Climate change and egg-laying trends. Nature. 399. 423-423. 10.1038/20839.
[8] Goodenough, A.E., Hart, A.G. & Stafford, R. Climatic Change (2010) 102: 687.

Figure 5.17.2: March to April mean temperature, South East England, 1980-2017



Analysis of the relationship between mean March and April temperatures and Long-Tailed Tit mean nesting date in the South East of England found that as much as 68% of the variation in timing could be explained by differences in temperature. This suggests that late winter and early spring temperature has a strong influence on the timing of Long-Tailed Tit nesting, though other factors (including other climate variables) are contributor factors.

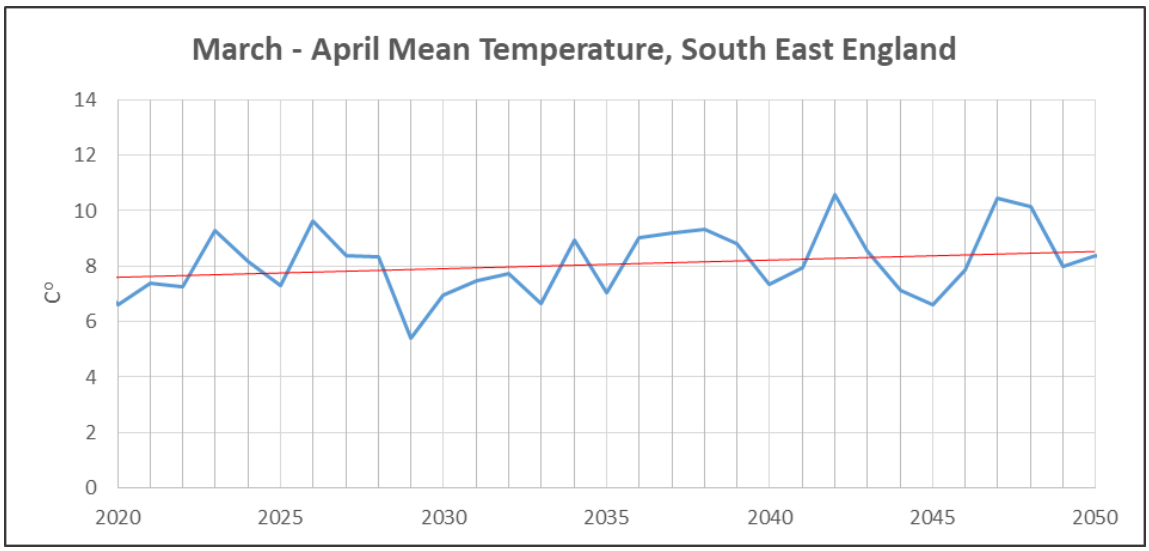
Figure 5.17.3: Long-Tailed Tit – nesting correlated with temperature



Future climate change

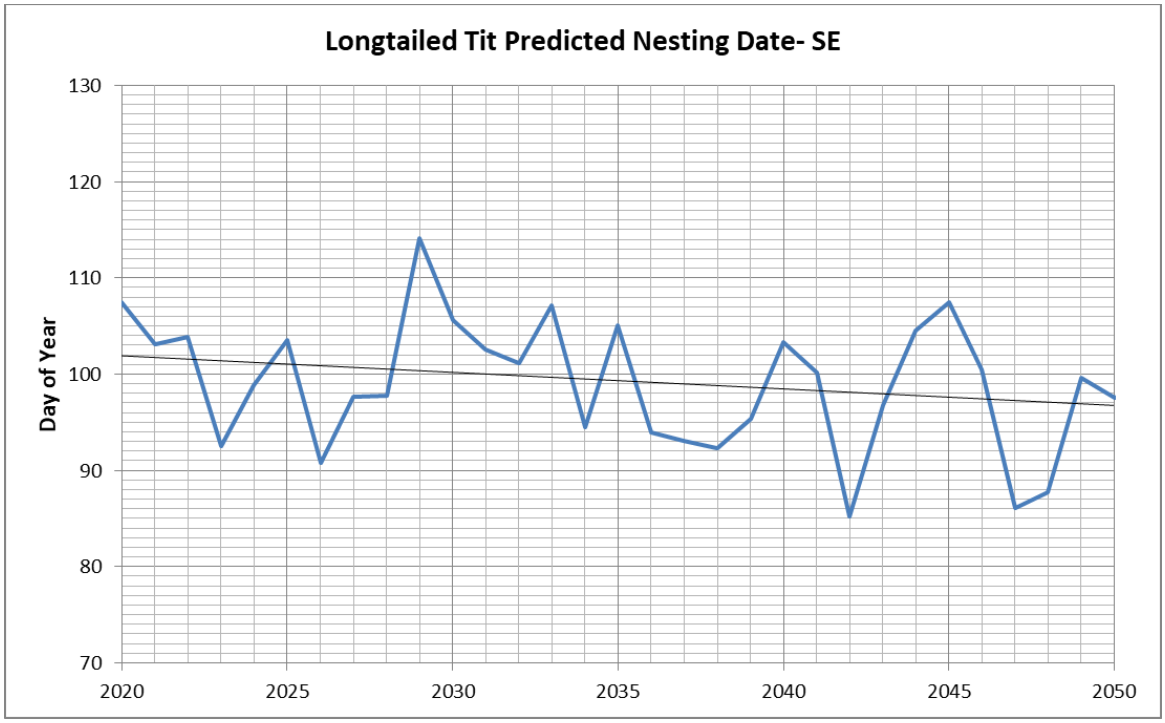
UKCP18 climate projections suggest that mean March to April temperatures will continue to rise.

Figure 5.17.4: March to April mean temperature projections, South East England, 2020-2050



Applying the observed past relationship between nesting and mean temperature to future projections for March and April mean temperatures, it is possible that projected climate change could result in average nesting dates coming forward by a further four or five days by 2050. Other influences could mean that the change is more or less than this.

Figure 5.17.5: Long-Tailed Tit predicted mean nesting date, South East England 2020-2050



Summary by agri-environment scheme option

Option code	Relevant operation	Prescribed date	Indicator species	Ecological event	Current situation	Future trends
AB16: Autumn sown bumblebird mix	Top the established mixture between mid-February and mid-March	15 March	Long-Tailed Tit	Nesting	Earliest nesting already within the topping period	Trend to earlier nesting
AB8: Flower-rich margins and plots	Cutting to ensure vegetation is short enough to allow flower species to grow without competition from dominant grasses	31 March	Long-Tailed Tit	Nesting	Earliest nesting already within the cutting period	Trend to earlier nesting
BE3: Management of hedgerows	End of the period when hedge cutting is permitted	28 February	Long-Tailed Tit	Nesting	Earliest laying close to the end of the cutting period	Trend towards earlier mean and earliest laying date
GAEC 7a: Boundaries	End of the period when hedge cutting is permitted	28 February	Long-Tailed Tit	Nesting	Earliest laying close to the end of the cutting period	Trend towards earlier mean and earliest laying date
GAEC 7c: Trees	End of the period when tree cutting is permitted	28 February	Long-Tailed Tit	Nesting	Earliest nesting already likely to be within the tree cutting period in the SE	Strong trend towards earlier nesting – increasing proportion likely to be within the tree cutting period Moderately strong relationship with temperature
OP4 Multi species ley	50% of area should not be cut until1 April, the other 50% until 15 May	1 April	Long-Tailed Tit	Nesting	Earliest nesting date already occurring within the cutting / grazing period, particularly in the SE	Earliest nesting date likely to continue occurring within the cutting / grazing period, particularly in the SE

Appendix 4
Copies of correspondence to the sample and online and telephone survey

4.1 Example of notification letter from Natural England

Department for Environment Food & Rural Affairs

NATURAL ENGLAND

Date

Dear [Salutation] [surname]

Research into the impact of climate change on agri-environment schemes

We are writing to request your help with a Defra funded project that will investigate whether the current agri-environment (AE) schemes provide sufficient flexibility for agreement holders to respond to extreme weather events. You have been selected randomly from a sample of agreement holders in one of the three case study areas (Cumbria, Somerset and parts of East of England).

The findings from this research will feed into the development of current and future schemes.

The survey is being organised by the Countryside and Community Research Institute (CCRI) at the University of Gloucestershire. They will be contacting you in the next few days with a follow up letter providing details of the survey and how you can get involved. Participation in the survey is voluntary and the information you provide is covered by the 2018 Data Protection Act; it will not be used for any purpose other than for this study. The final project report will present the overall findings and no individual respondent will be identifiable.

I hope that you will be able to help us by providing the benefit of your experiences with agri-environment schemes, notably the challenges that extreme weather events had on your AES agreement, both in terms of weather events preventing you from managing your land generally and the impact on the scheme objectives. We are interested in your views, even if you do not feel that any extreme weather events have affected your AES agreement. If you would be interested in receiving a two-page summary of the final report, and/or a link to the full version of the report, you will be able to request this when you complete the survey.

Your participation in this research is greatly appreciated, as it is important to get a range of views and experiences to ensure we have schemes that can meet the challenges of severe weather and climate change. If you have any queries about the research please contact Chris Short at CCRI on 01242 714122, cshort@glos.ac.uk or Simon Duffield at Natural England on 07789 650661 or simon.duffield@naturalengland.org.uk.

Yours sincerely,

Simon Duffield
Senior Specialist-Climate Change

4.2 Example of invitation letter from CCRI

Date

Dear [SALUTATION] [LAST NAME],

Invitation to participate in a survey on the impact of climate change on agri-environment schemes

You recently received a letter from Natural England regarding some research that aims to assess the impact of climate change on agri-environment schemes (AES). Natural England is keen to better understand how climate change driven extreme weather events affect your ability to deliver your AES prescriptions, indicators of success and resulting environmental outcomes.

Your name has been randomly selected from the list of agri-environment scheme holders in [CASE STUDY] held by the Rural Payments Agency to take part in an online survey. The survey will take around 10 minutes to complete and can be accessed via this link:

https://glos.onlinesurveys.ac.uk/necc

However, if you would prefer to receive a paper version of the survey, or complete the survey by telephone with one of our researchers, please contact Isabel Fielden on 01242 714121. The survey will be open between 10 June 2019 and 31 July 2019.

Your participation in the survey is voluntary and the information you provide is covered by the 2018 Data Protection Act. Your answers are **completely anonymous** and you will not be identified in any outputs from the project. Although the survey is voluntary, you will help us very much by taking a few minutes to complete the questionnaire and sharing your experiences as an agreement holder.

As a token of appreciation for taking part, you will be have the opportunity to enter into a prize draw with the chance to win a £100 Amazon voucher.

If you have any questions or comments about this study, please feel free to contact me on 01242 714122 or cshort@glos.ac.uk.

Thank you very much for helping with this important study.

Yours sincerely,

Chris Short
Project Lead CCRI

4.3 Example of post card reminder from CCRI

Somerset

Photo © Matt Reed 2018

Last week we sent you a letter inviting you to complete a survey about the impact of extreme weather events on current agri-environment schemes. Your name was drawn randomly from a list of agreement holders in Cumbria, Somerset and parts of East Anglia.

If you have already completed the online survey, please accept our sincere thanks. If not, we would greatly appreciate it if you could do so today. We are especially grateful for your help because it is only by asking people like you to share your experiences that we can improve the development of current and future agri-environment schemes.

If you did not receive the invitation, or if it was misplaced, here's the link to the survey: https://glos.onlinesurveys.ac.uk/necc

If you have any queries, please call us on 01242 715377 or email jurquhart1@glos.ac.uk.

With thanks,
Countryside and Community Research Institute
University of Gloucestershire
Francis Close Hall Campus, Swindon Road,
Cheltenham, Gloucestershire GL50 4AZ

UNIVERSITY OF GLOUCESTERSHIRE

ccri countryside and community research institute

4.4 Example of sample boost leaflet for local advisers from CCRI

Assessing the adaptive capacity of Agri-Environment Schemes to respond to the impacts of extreme weather

Defra is funding this project to improve our understanding of the ability of current Agri-environment schemes (AES) to respond to extreme weather. In this research, led by CCRI in conjunction with Lands Use Consultants and Environment Systems Ltd, there are two distinct objectives.

1. Reviewing a sample of AES options, which specify dates for required operations and matching these against the timing of ecological events such as bud burst, arrival and departure dates for migrant birds and nesting/hatching dates for breeding birds to reveal areas of concern.

2. A survey of farmers to gather evidence regarding the impact of extreme weather events on AES and BPS. Looking at issues of adhering to AES prescriptions within the current compliance and operational regime; and their ability to deliver the desired environmental outcomes.

How can I help?

If you are an AES agreement holder (past or present), please complete the survey

https://glos.onlinesurveys.ac.uk/neccopen

The final report, due in March 2020, will highlight changes in weather patterns and potential impact on AES options; evidence from farmers of climate change impact on schemes. This will feed directly into developing policy discussions.

Thank you

Simon Duffield simon.duffield@naturalengland.org.uk

Chris Short cshort@glos.ac.uk

4.5 Text from Online Survey

1. **Front page:**

Who we are?

The Countryside and Community Research Institute at the University of Gloucestershire, in partnership with Environment System Ltd and Land Use Consultants, has been tasked with seeking the views of farmers/land managers about how extreme weather events have impacted the effectiveness of agri-environment (AE) schemes. The work, funded by Defra, is seeking to understand how current AE and future land management schemes can be more responsive to extreme weather and contribute to greater local resilience to climate change. If you want to know more about the project go to [link]

Why we need your help

We need the help of farmers and landowners who have experience of agri-environment schemes including the Basic Payment Scheme.

This survey should take no more than 10-15 minutes to complete for a single farm holding/unit. If you manage more than one farm holding please choose one that most closely aligns to the study areas of Cumbria, Somerset and West Anglia. [Sentence omitted from open survey.]

2. **Consent page:**

Q1 **All answers are confidential** and no individual will be identifiable as a result of the analysis. All of the data is protected and will only be used on this project and has been checked to meet the required standards on personal data. If you would like a summary of the results and/or wish to take part in further surveys related to the project there is an opportunity to provide contact details at the end.

Do you agree to these T&Cs and wish to continue with the survey? Yes … No …

For those who have received a letter:

Q1a Please enter the code on your letter exactly as it appears: …….

For those completing this at an event or following link via social media:

Q1b How did you find out about this survey?

Saw link on Twitter/social media ☐

Received details at NE event ☐

Received details at non-NE event ☐

3. **Survey:**

Q2 What is the size of your farm? ……

Q2a Is this Acres ☐ or Hectares ☐?

Q3 Is the land that you farm (please select one)

Wholly owned ☐
Mix of owned & rented ☐
Wholly rented ☐
Contract farm ☐
Other ☐ (please specify) ……..……...

Q4 Does your holding include a Site of Special Scientific Interest SSSI Yes ☐ No ☐

Q5 What AE schemes are you currently involved in? (Please select all that apply)

None (Basic Payment Scheme only) ☐
Environmental Stewardship (Organic) HLS ☐
Environmental Stewardship (Organic) ELS ☐
Countryside Stewardship HT ☐
Countryside Stewardship MT ☐
Other ☐ Please specify ……..

Q6 At the start of 2015, what schemes were you involved in? (Please select all that apply)

None (Basic Payment Scheme only)	☐	
Environmental Stewardship (Organic) HLS	☐	
Environmental Stewardship (Organic) ELS	☐	
Other	☐	Please specify ……..

Q7 In your view have there been any extreme weather related events over the past 5 years on your farm? (*Please select all that apply*)

Heat	☐	
Wet	☐	
Cold	☐	
Wind	☐	
Drought	☐	
Flood	☐	
Unseasonal weather / timings (early spring)	☐	
Unusual combination of factors	☐	
Other	☐	Please specify ……..

Q8 Please indicate which of these has occurred in the past 5 years? *(please indicate on the four point scale the level of impact)*

Direct impacts:	**Severely**	**Moderately**	**Somewhat**	**Not at all**
Flood damage to buildings and infrastructure				
Flood damage to crops and fields				
Animals stranded or lost in floods				
Lack of grazing due to dry/hot weather				
Damage to crops due to dry/hot weather				
Wild fires damaging land areas (crops, grazing land etc.)				
Wind damage to buildings and infrastructure				
Loss of crops through extreme cold				
Other direct impact (please specify ……)				

Indirect impacts:	**Severely**	**Moderately**	**Somewhat**	**Not at all**
Drought conditions impacting crop choice and management of land				
Wet conditions impacting crop choice and management of land				
Lack of water to sustain crops				
Flooding of farm land impacting management				
Livestock challenges due to bad weather				
Using supplementary feeding in bad weather				
Other direct impact (please specify ……)				

The next series of questions are for all respondents and concerns the Basic Payments scheme.

Q9 Have any of the following proved challenging in the last 5 years due to weather related issues making them difficult to fulfil:

Three crop rule, ☐
Poaching and soil management, ☐
Supplementary feeding requirements, ☐
Water abstraction rules, ☐
GAEC rules, ☐
Slurry spreading regulations ☐

Q9a Please indicate your views on the effectiveness of the process regarding these challenges (where 1 is strongly agree and 5 is strongly disagree)

	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
RPA staff assessed then implications of extreme weather on my BPS agreement					
The online guidance was sufficient for me to respond to these challenges					
The process required for a derogation was straightforward					
An RPA officer was able to assist me with my derogation request					
The process for implementing derogations is ineffective and inefficient					

The next series of questions for those in AE agreements from Jan 2015 onwards, for those without an AE agreement please go to Q16

Q10 Do you think variability in the weather has affected your ability to deliver any aspect of your agri-environment scheme (i.e. Environmental Stewardship or Countryside Stewardship)?

Yes ☐ No ☐ Don't Know ☐ (If no, go to Q 13)

Q10a If yes, did you experience any of the following (*please indicate on the four point scale the level of impact)*

Direct impacts:	**Severely**	**Moderately**	**Somewhat**	**Not at all**
Unable to access land to establish scheme option				
Weather conditions meant option did not establish successfully				
Unable to access land for required routine management				
High levels of pest and weeds on land covered by AE prescriptions,				
Issue of timing for land management activities				
Clash of AE work with other farming or management operations				
Livestock welfare challenges on land with AE prescriptions.				

Q10b Did this present you with an additional cost

Yes ☐ No ☐ Don't Know ☐

Q11 Where you had challenges with your AE agreement, did these result in any of the following outcomes? (*tick all that apply*):

Unable to undertake required land management operations within stipulated window ☐
Unable to implement one or more of the required operations in correct period ☐
Required/requested a re-sequencing of AE options and management activity ☐
Required/requested derogation due to extreme weather event ☐
Required/requested Force Majeure on agreement due to extreme weather event ☐
Post event compliance requirements required re-instatement to meet requirements ☐
Other, please specify …….……..……..…… ☐

Q12 Please indicate your views on the effectiveness of the administrative processes in AE regarding these challenges (*where 1 is strongly agree and 5 is strongly disagree)*

	Strongly disagree	Disagree	No opinion	Agree	Strongly agree
NE staff assessed the implications of extreme weather on my AE agreement					
The online guidance was sufficient for me to respond to these challenges					
The process for amending my agreement was clear and straight forward					
The process required for a derogation (or MTA) was straightforward					
The process required for a Force Majeure was straightforward					

Q13 Do you consider that the timings around particular activities within your AE prescriptions are having an impact on your ability to deliver your prescriptions?

Yes ☐ No ☐ Don't Know ☐ (if no go to Q14)

Q13a In what way are the timings associated with prescriptions impacting the effectiveness of your AE agreement? (*tick all that apply)*

The timing restrictions on certain options are not suitable (e.g. hay cutting or grazing) ☐

The mechanical operation window does not fit the farming system ☐

Other, please specify ☐

Q14 Do you consider that the timings around particular activities within your AE prescriptions are having a negative impact of the environmental outcomes of your agreement?

Yes ☐ No ☐ Don't Know ☐

Q14a please add additional comments ……

Q15 Did you find any evidence that options under the AE agreement reduced the impact of the extreme weather on your farm/ holding?

Yes ☐ No ☐ Don't Know ☐

Q15a If Yes, in what way

Shading for stock, ☐

Reduced soil erosion, ☐

Increasing water infiltration within soil ☐

Other (please specify) ☐

Final questions for all respondents.

Q16 Did you seek advice regarding the implications and requirements of potential changes to your AE agreement or BPS requirements?

Yes ☐ No ☐ Don't Know ☐ (if no go to Q17)

Q16a If Yes, Where did you seek advice from and how helpful was it to you? (1=very helpful to 3 very unhelpful)

Direct impacts:	**Yes** ✓	**Very helpful**	**Fairly helpful**	**not at all helpful**
NE officer (CS/CSF)				
RPA adviser				
Own adviser / agent adviser				
Professional organisation (NFU/TFA)				
Part of an NE organized event				
Part of a non-NE organized event				
Other farmers / network or society				
Other (please specify)				

Q17 What impacts of gradual or extreme climate change/weather events on farming practice have you noticed on your farm/holding? [open question]

……..……..……..……..……..……..……..……..

Q18 If you could change one thing in relation to your AE agreement or BPS in relation to extreme weather/climate change what would it be? [open question]

……..……..……..……..……..……..……..……..

Q19 Are you involved in any other projects such as:

- Cumbria Test & trials ☐
- Somerset Levels Test & Trials ☐
- East Anglia Payment by Results ☐
- Other local project ☐

Q20 Further engagement with the project

If you would like to take part in a follow on survey to look at some of these issues in more detail through a telephone interview as part of this project please click on link below - you will be asked to provide your name and email address.

Your details are not linked to the answers you have given in this survey and will be stored in line with current data protection legislation.

http://www.ccri.ac.uk/data-protection/

Thank you very much for taking the time to complete this survey, we greatly appreciate your comments and input.

4.5 Email invitation to participate in telephone survey

Date

Dear

Invitation to participate in telephone survey on the impact of extreme weather on AES agreements

You recently completed an online survey funded by Defra and Natural England concerning the impact of extreme weather on agri-environment schemes (AES). You indicated that you would be interested in contributing to future aspects of the project. We would like to speak with you further in a telephone interview to explore in more detail how extreme weather has affected you.

In the coming days a researcher from the CCRI will contact you to identify a time to conduct the interview, which should take no more than 30 minutes. **To do this we would be grateful if you could supply us with an appropriate telephone number**.

Your participation in the survey is voluntary and the information you provide is covered by data protection legislation. Your answers are **completely anonymous** and you will not be identified in any outputs from the project. You can read our privacy statement here http://www.ccri.ac.uk/data-protection/ When the researcher contacts we will check if you are content with these terms and conditions before the interview begins.

If you have any questions or comments about this study, please feel free to email me directly on cshort@glos.ac.uk.

Thank you very much for helping with this important study.

Yours sincerely,

Chris Short
Project Lead CCRI

4.6 Copy of AES agreement holder telephone survey

LM0484: Adaptive capacity of Agri-env Schemes to respond to the impacts of climate change

Agreement Holder Telephone Questionnaire

Sample No (UID):	Interviewer Name:
Interviewee Name:	
Interviewee Position with respect of AES agreement:	

Introduction

Interviewer: *The purpose of this interview is to discuss in more detail the impact of extreme weather on your farm/holding and the impact on your ability to deliver your AES and/or BPS scheme(s). Thank you for taking the time to complete the online survey. The questions in this survey are more open to allow the issues to be explored in more depth but there might be some minor areas of overlap. We have kept this to a minimum as much as possible and your involvement in the survey remains voluntary.*

Check: that they have received a letter outlining the research and covering details on anonymity, data handling, withdrawal, what will be asked in the interview, how consent will be taken. Check that interviewee understands these. Give a brief reminder that:

- *The key purpose of the interview is to determine how; scheme design, targeting and compliance, options and prescriptions could be altered to help reduce the identified risks due to climate change.*
- *The interview is in 5 parts: - First, details of the farm business, subsequent sections look at the impact of extreme weather on farming systems; extreme weather and BPS; extreme weather and AES; and scheme design and flexibility.*
- Indicate to the agreement holder that you would like to record the interview for the purposes of providing a clear record for use of quotes and partial transcribing. Reassure them that it helps make sure that important points that come up during the interview are not missed but is not used in any other way.
- *Are you happy for the interview to be recorded, this is only for the purpose of writing up the interviews and capture your responses*. Note verbal consent for recording of interview.
- The interviews *usually take about 30 minutes*. Suggested timings are given for each section.

Terms and conditions accepted ☐
Consent to record interview ☐

Privacy statement: to be read out before start of the interview

- The survey is confidential and no details will be released to third parties.
- The project complies with Data Protection Legislation. Data will be stored in a database on the University of Gloucestershire's secure computer network and will only be available in its original form to the research team for purposes relating to this project.
- Data that we collect is anonymised and will not be reported at an individual level. You can read a full statement http://www.ccri.ac.uk/data-protection.

Section 1 You and your holding

- Background aspects to the holding like tenure and structure
- Factors influencing decision making in the future

Land tenure and Enterprises

1. What is the total area of the holding/farm? …… (*Offer option to record in hectares or acres*)

   ☐ hectares ☐ Acres

2. Is your farm/holding (*Read all and ask them to choose one*)

   Wholly owned / Mainly owned / Mix of owned & rented / Mainly rented / Wholly rented / Contract farm / Other (please specify)

3. Which best describes your farm type? (*Read all and ask them to choose one*)

   Mainly arable / mainly dairy / upland beef & sheep / lowland beef & sheep / pigs / poultry / horticulture / mixed / other

4. What county is the farm based in? …….

5. Approximately how much of your business income comes from the agricultural enterprises on the holding? (*Includes all on-farm agricultural activity and BPS and AES payments*) *(If business income not know tick 'unknown', for holdings with non-business focus (e.g. Wildlife Trust) enter 'Not Applicable')*

   All of it / most of it / about half / less than half / very little / none
   Unknown / Not applicable

   Comments (*record any further explanation offered, including where they declined to respond*):

Section 2 Impact of Extreme weather on farming system

- Questions about the impact of extreme weather on the holding and how it operates.

6. What are the main types of extreme weather events that you have experienced over the last 5 years on your holding: (*circle all those that apply*)

Heat	Wet	Cold	Wind	Drought
Flood	Unseasonal weather/timings		Unusual combination of factors	

   Comment: (*record any response relating to the changing patterns of weather in terms of extremity or frequency)*

7. What is the impact of these weather events on you the operations on the farm? (*list from the online survey contained in interviewer guidance document*):

7a.
7b.
7c.
7d.

8. Has your farming practice changed as a result the extreme weather discussed in Q6? If how? (*Prompt: changes in farming system (more intensive/extensive), crops grown, type of cultivations, type of feed, agrochemical inputs, type of machinery, etc.). Note if change is temporary or permanent*

8a.
8b.
8c.
8d.

Section 3 Extreme weather and BPS

- Looks in more detail about the challenges of extreme weather on AES/BPS processes
- Where there is interaction with NE or RPA who effective this was

Taking those events that we discussed in Q6 and Q7, this section looks at the impact on BPS.

9. Do you feel that any of those events impacted on your ability to meet the requirements of BPS? Such as:
   Supplementary feeding regulations / poaching, compaction & soil / slurry storage / Water abstraction rules / 3 crop rule / GAEC

   Yes ☐ No ☐ Don't know ☐ If No or Don't know go to Q13

   If Yes, can you outline the nature of these challenges?

9a.
9b.
9c.

10.

11. Did you seek any assistance as to what you should do?

Yes ☐ No ☐ Don't know ☐ If Don't know go to Q12

If No, why not? (Then go to Q12)

If Yes, who from and how helpful was this? [*note categories in online survey: use of online guidance, asked for derogation, RPA officer directly involved*] [See *interviewer guidance document for areas of possible discussion*]

12. Looking back, what are your thoughts on the efficiency of this process and how effective it was? [*Prompt for both reflections on formal and informal parts of the process as well as thoughts on what they would do differently]*

Section 4 Extreme weather and AES requirements

- Investigates the impact of extreme weather on AES compliance and outcomes
- AES prescriptions and NE staff and the challenges of AES and extreme weather

13. Thinking back to those events we discussed in Q6 and Q7, did they impact an AES agreement that you had at the time?

Yes ☐ No ☐ Don't know ☐ If No or Don't know go to Q20

14. If Yes, what scheme was this?

ELS (inclu. O-ELS & U-ELS)	☐
HLS including O-HLS	☐
CS Mid-Tier	☐
CS Higher Tier	☐
England Woodland Grant Scheme	☐
Other (……..……)	☐

15. Can you describe how the extreme weather impacted on your AES? [*See Interview guidance document for areas to explore.*] [*Use the online responses as initial prompts: unable to establish an option e.g., couldn't prepare ground, lack of germination, AES dates didn't fit, weed or pest problems, clash with farming operations, livestock welfare issues*]

15a.
15b.
15c.
15d.

16. Did you seek any assistance as to what you should do?
    Yes ☐ No ☐ DK ☐

    If No, why not? [Prompt for issues of trust and bad previous experience]

17. If Yes, who from and how helpful was this?
    [Focus on NE connections. Prompt – ask for further explanation: use of online guidance, asked for derogation, NE officer directly involved] [See *interviewer guidance document for areas of possible discussion*]

18. How was the issue resolved? How successful was this in overcoming the issue? Was it a one-off or have you had to go back to NE for further discussions? (*note if there was a permanent or temporary change to the agreement/options or prescriptions)*

19. In hindsight were there other sources of help you think would have been beneficial?

20. Looking back, what are your thoughts on the efficiency of this process and how effective it was? [*Prompt for both reflections on formal and informal parts of the process as well as thoughts on what they would do differently] For the interviewer guidance document: [Focusing on the communication and the outcomes, time taken for decision, impact of the process on AES outcomes. Look for comments on scheme design, advice & guidance, eligibility criteria, prescriptions and Indicators of Success].* Then go to Q22

Those saying No or DK to Q12

21. If No or Don't know, are you in an AES agreement? If so, which is it?

ELS (inclu. O-ELS & U-ELS)	☐
HLS including O-HLS	☐
CS Mid-Tier	☐
CS Higher Tier	☐
England Woodland Grant Scheme	☐
Other (……..…)	☐
No AES agreement	☐

22. Have you ever had to make changes to your agreement for any reasons? If so, what was this regarding? [*Prompt for both reflections on formal and informal parts of the process as well as thoughts on what they would do differently]*

All

23. Have you noticed any occasions when the AES dates or prescriptions would seem to go against what is best for the natural environment on your holding (*e.g. first nesting date or bud burst, bare ground at wrong time of year*)?

24. Are there options which are not able to deliver the intended outcome on your holding because of changes in weather patterns? (*e.g. reduced surface run-off, maintaining high water levels, wild bird food during winter*)

25. Do you feel that there are some AES activities or options that could increase the ability of your farm to cope with extreme weather?

    Yes … No … Don't know …

    If Yes, which ones?

Section 5 Scheme design and flexibility

- Considers what might change within the current schemes to help them be more effective in response to extreme weather

26. What changes would you like to see within the current schemes to help them operate effectively in the face of extreme weather? [*Prompt: flexibility in option choice, fewer prescriptions, flexible location, targets or goals more than prescription etc.]*

    How might this work?

    What do you think might be the barriers/challenges from your perspective as an agreement holder?

27. Clearly any publicly funded scheme has to have a process (e.g. derogations or self-monitoring) to cover changes resulting from extreme weather. How do you feel this should be managed with regard to …

    - minor changes (tackling weeds/pest outbreaks/extending dates):

    - more major changes (moving or changing options, waterlogged land)

    - regional/national events (Storm Desmond, Beast from the East, heatwaves etc).

28. That is the end of the interview but before closing the interview do you have any suggestions as to how a new AES scheme could respond better to extreme weather events?

29. Are there any other comments that you would like to make?

Thank you very much for taking part in this survey. Your contribution has been very helpful and will contribute to the reviews of existing schemes and the development of new schemes in the next few years. Your assistance is therefore much appreciated.

Record time interview closed …

Appendix 5
Background analysis of the sample

The table below shows the overall spread of the 420 responses compared with the statistics for agricultural holdings in England and two previous studies into AES schemes in England.

Table A5.1 Comparison of farm size in AES & CC survey with Defra and recent AES surveys

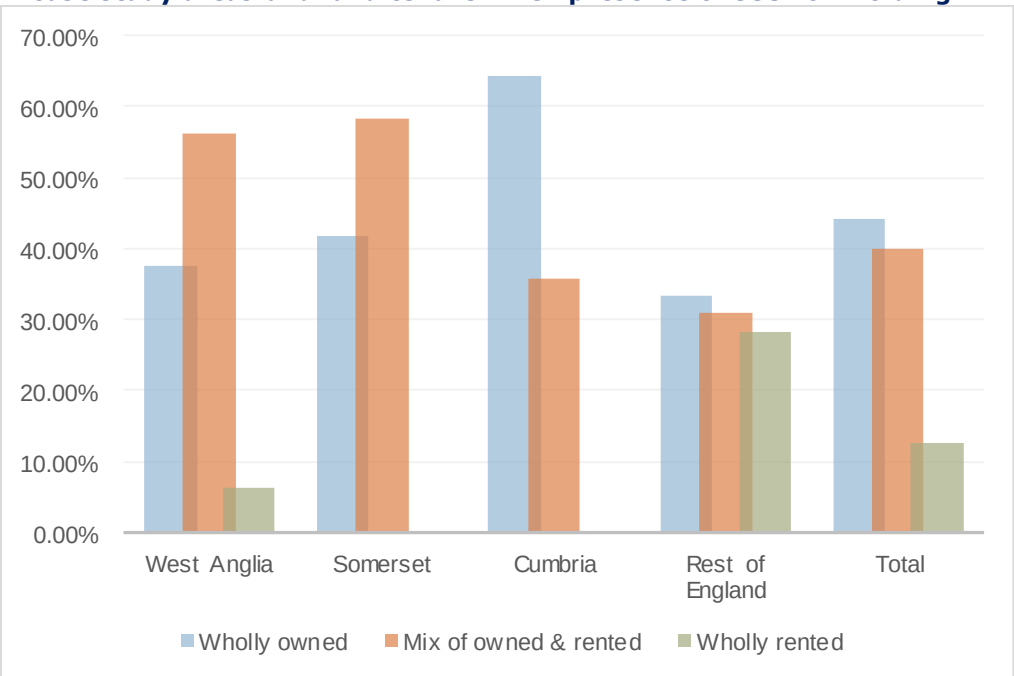
	Online Sample (2020)		*England June 2017**		Previous Studies	
	Number	Percent	*Number (000)*	*Percent*	2014 (n=99)**	2017 (n=403)***
<20ha	35	8.4%	*42*	*39.9%*	15.2%	9.2%
20 to <50ha	76	18.2%	*21*	*19.5%*	15.2%	14.1%
50 to <100ha	67	16.0%	*18*	*16.9%*	16.2%	16.6%
100ha & over	241	57.5%	*25*	*23.7%*	53.5%	60.1%
Total	**420**	**100%**	***106***	***100%***	**100%**	**100%**

Sources: *Defra et al (2019), ** Boatman et al (2014) *** Short et al (2017).

The table shows that in this study the majority of the farms are in the largest category 'over 100 ha' with almost a third (30%) 250 ha or larger. The table shows that against the Defra statistics for main holdings, the online survey was not very representative, with far fewer holding of under 20 ha. In reality, these will be horticultural and housed pig and poultry units that are less likely to be entered into AES schemes. A better match is found with two recent AES surveys where the proportion in the largest category is much closer to those in the online survey. The 2014 survey was with HLS agreement holders and the 2017 with a range of interviewees who had either entered Countryside Stewardship or had considered doing so.

Common land refers to areas owned by a private landowners which others have the right to graze their livestock on. There is common land in every county of England with most of it in the North and South West of the country. Not surprisingly then, of the 41 respondents (10%) who had common rights 17 were in Cumbria, making up 19% of this sample. There was only 1 in West Anglia and 4 in Somerset. In the Rest of England sample 19 (12%) had common rights. The exercising of common rights is perhaps more important than actually have the rights attached to you farm, especially in terms of land management activity. Over half of all commons are designated SSSIs, almost all are open access and most are in protected landscapes. In the event half of the Cumbrian respondents exercised their rights and 11 of the 19 in the Rest of England so overall 22 of the 41 did exercise their common rights.

Figure A5.1 Case study areas and land tenure when presence of SSSI on holding



The next background question asked the respondent if their holding includes a SSSI. In total 95 respondents (23%) have an SSSI on their holding. The proportion is lowest in West Anglia (15%) and highest in Cumbria (30%) and the Rest of England (25%) sample. Given that the survey is mostly about the impact of extreme weather on AES agreements, perhaps this is not surprising as AES is one of the main mechanisms for funding appropriate management on SSSIs. It is worth looking at the characteristics of farm size and tenure on those holding with a SSSI. First looking at land tenure, the figure below charts the type of tenure against the presence of a SSSI. The results are shown in Figure A3.1 below.

The figure shows quite a marked variation across the whole sample but the numbers are small. In those areas with the highest number of holdings containing an SSSI, the differences are marked. In Cumbria most are wholly owned (64%) with 36% a mix of owned and rented, this is statistically different from West Anglia and Somerset (Significance at $p < 0.05$). In the Rest of England sample the responses are evenly split between all three groups at around a third each. The wholly rented category is notably higher in this sample than the other three case studies, however the sample size is too small to deduce anything further.

Appendix 6 Regional analysis for Hawthorn budburst and Common Frog spawning

Cumbria

Hawthorn

Nature's Calendar data recording the first Hawthorn budburst were analysed for Cumbria. Records are relatively sparse before 2002, so the analysis focused on the period between 2002 and 2018.

Figure A6.1 shows, for each year, the timing of the first recorded hawthorn budburst across Cumbria. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (28 February) when land managers must end hedge cutting and tree cutting operations. The graph shows the majority of budburst taking place after the end of the hedge and tree cutting period, though in a few years (e.g. 2002, 2005, 2017) there are a number of records for the period before the end of February, suggesting the potential for a clash with management activity. The blue dotted line shows a trend towards very slightly later budburst occurring in Cumbria, suggesting risk of budburst occurring before the end of the cutting period has not increased over this relatively short period.

Figure A6.1 Nature Calendar budburst date for Hawthorn in Cumbria

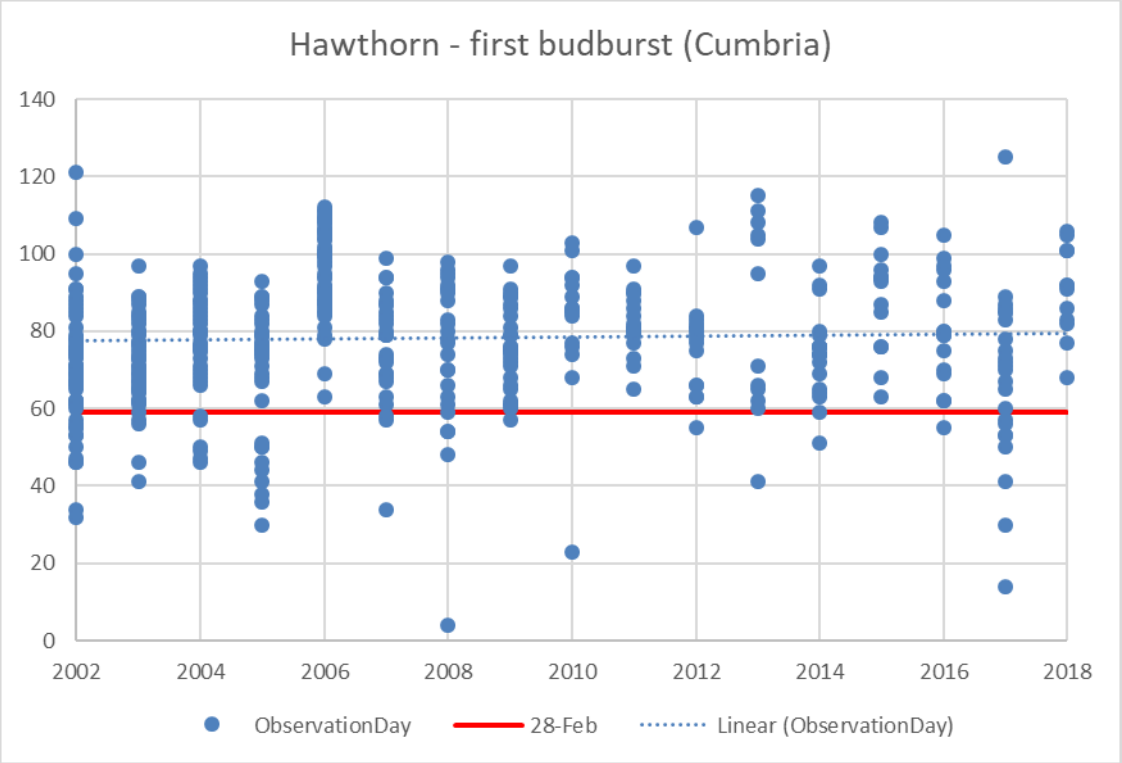
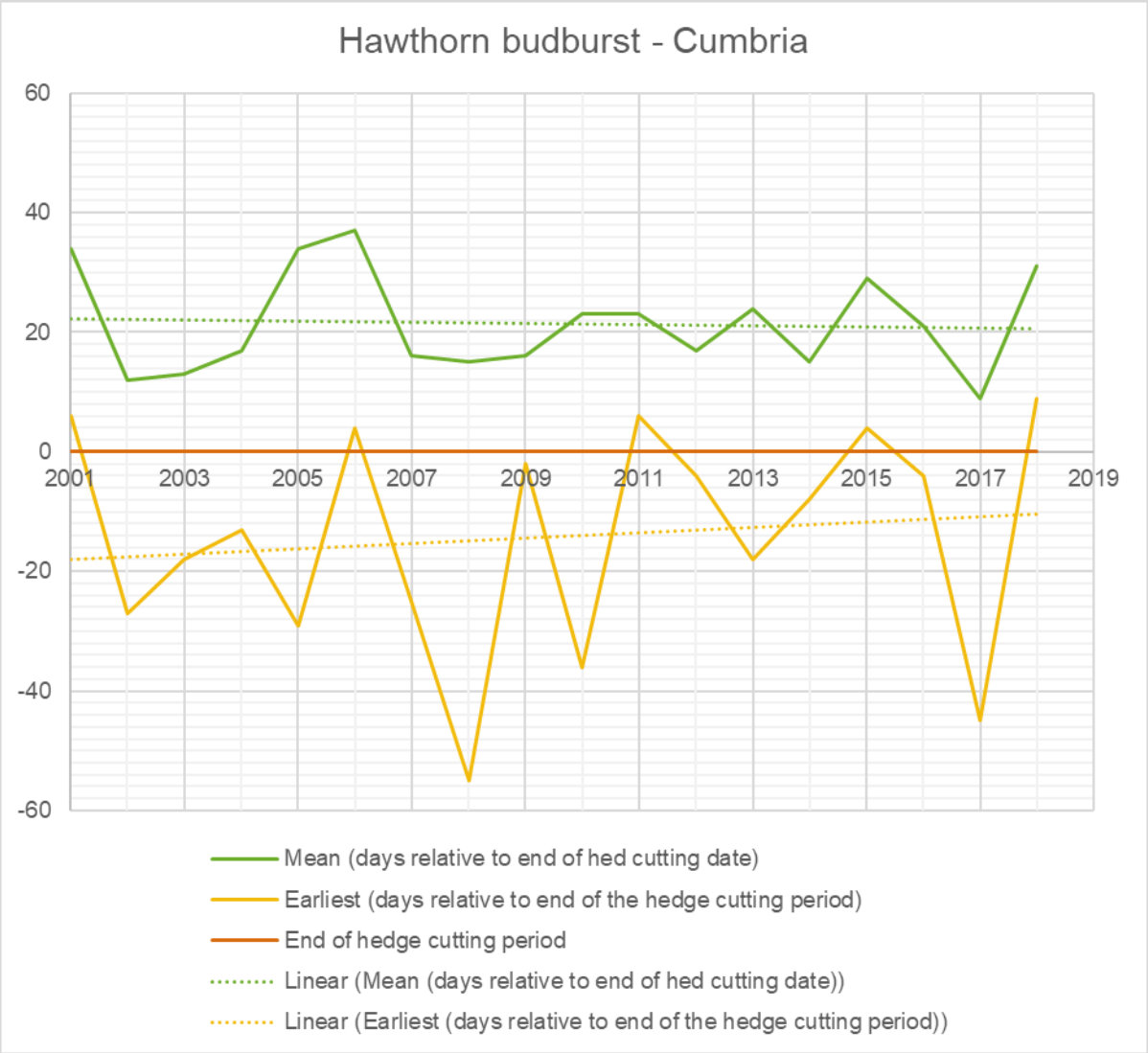


Figure A6.2, taking the same data, examines the relationship with the end of the cutting period in more detail. It plots the average date of first budburst over the period from 2002 to 2018 (blue dots) and tracks the trend in this date (solid blue line). It shows that the mean budburst date for Hawthorn in Cumbria consistently occurs at least 10 days after the end of the cutting period. Over these 17 years, the trend suggests that the mean date of budburst has come forwards by one day. The graph also plots the timing of the earliest single recorded budburst in Cumbria over this period. This shows considerable variation from year to year, with budburst in all but a handful of years starting during the cutting period. In 2008 and 2017, the earliest recorded budburst occurred at least 40 days before the end of the hedge and tree cutting period. Over these 17 years, the trend suggests that the earliest recorded budburst has moved back by around eight days, though the scale of year to year variation suggests this may not be a good representation of longer-term trends.

Figure A6.2 Nature Calendar budburst date for Hawthorn in Cumbria, mean and earliest



Common Frog

Nature's Calendar data recording the first observed frogspawn were analysed for Cumbria. Records are relatively sparse before 2002, so the analysis focused on the period between 2001 and 2018.

Figure A6.3 shows, for each year, the timing of the first observed frogspawn across Cumbria. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (31 March) when land managers must ditch maintenance operations. The graph shows the majority of observations occurring within the ditch maintenance period, suggesting the potential for a clash with management activity. The blue dotted line shows a trend towards earlier spawning occurring in Cumbria, with a decrease in the number of spawning observations occurring after the end of the ditch maintenance period.

Figure A6.3 Nature Calendar spawning date for Common Frog in Cumbria

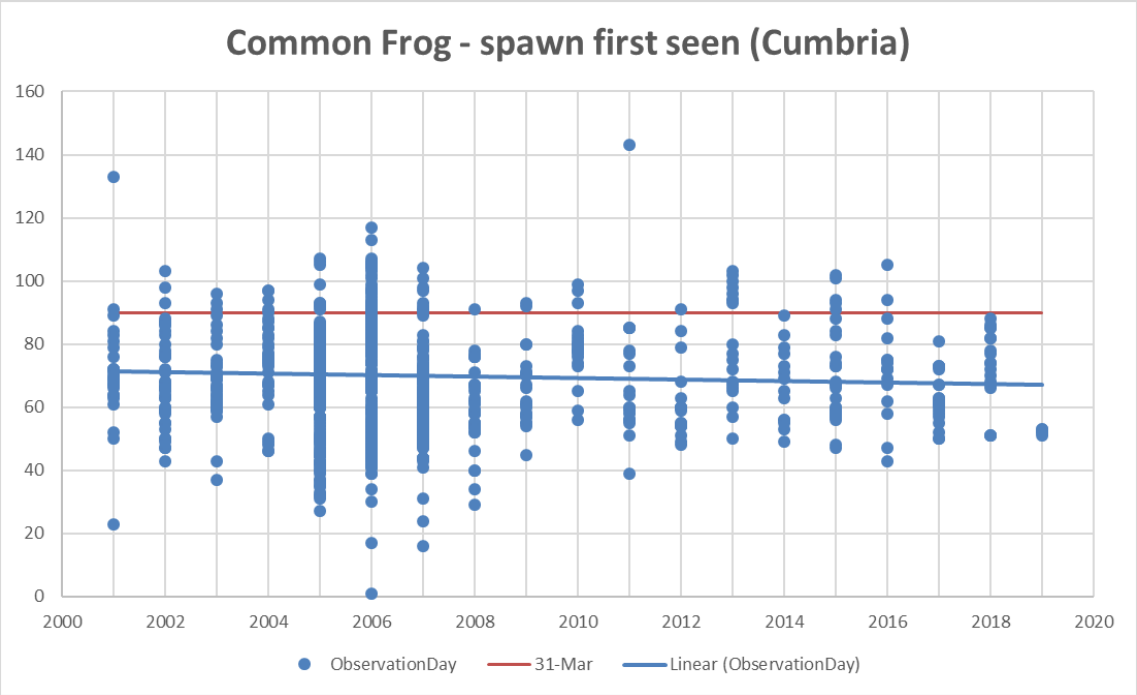
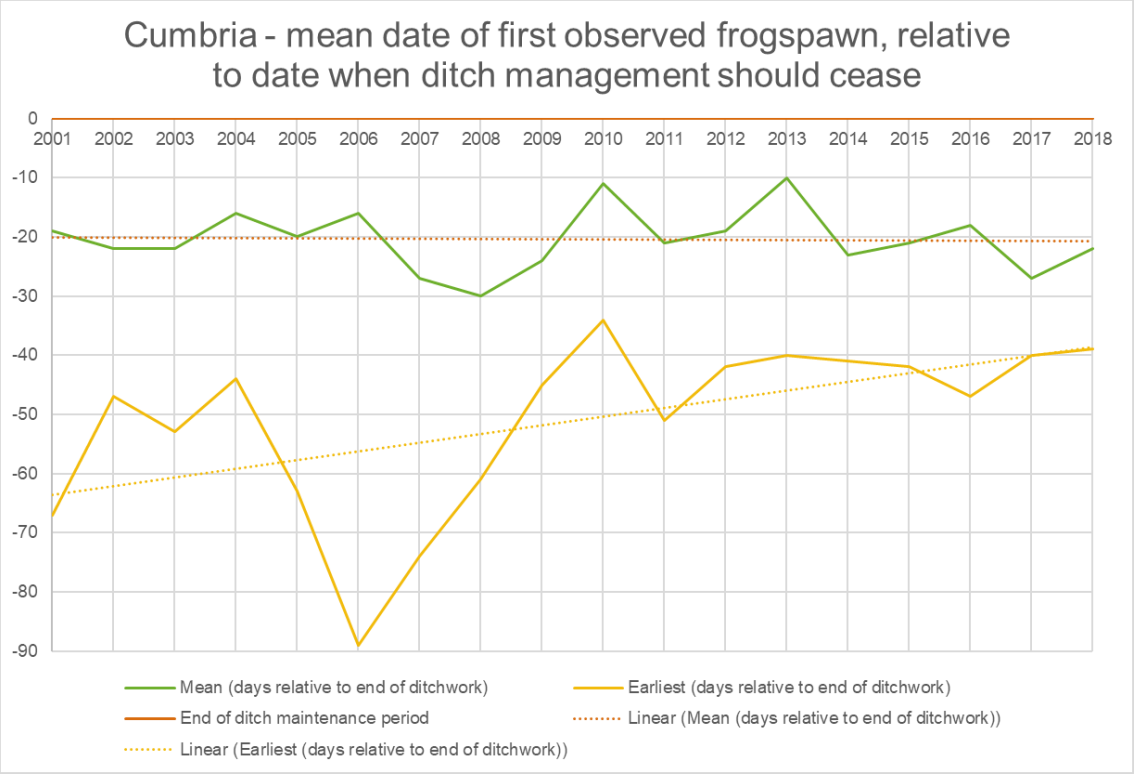


Figure A6.4, taking the same data, examines the relationship with the end of the ditch maintenance period in more detail. It plots the average date of first observed spawning over the period from 2001 to 2018 (blue dots) and tracks the trend in this date (solid blue line). It shows that the mean frog spawn date in Cumbria consistently occurs at least 10 days before the end of the maintenance period. Over these 17 years, the trend suggests that the mean date of spawning has changed very little. The graph also plots the timing of the earliest single recorded spawning in Cumbria over this period. This shows considerable variation from year to year, with one record in 2006 recording an observation on January 1. Over these 17 years, the trend suggests that the earliest recorded spawning has moved back by around twenty days, though the scale of year to year variation suggests this may not be a good representation of longer-term trends.

Figure A6.4 Nature Calendar spawning date for Common Frog in Cumbria, mean and earliest



Somerset

Hawthorn

Nature's Calendar data recording the first Hawthorn budburst were analysed for Somerset. Records are relatively sparse before 2001, so the analysis focused on the period between 2002 and 2018.

Figure A6.5 shows, for each year, the timing of the first recorded hawthorn budburst across Somerset. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (28 February) when land managers must end hedge cutting and tree cutting operations. The graph shows the majority of budburst taking place after the end of the hedge and tree cutting period, though in several years (e.g. 2002, 2004, 2005, 2007 and 2008) there are a number of records for the period before the end of February, suggesting the potential for a clash with management activity. The blue line shows a trend towards slightly later budburst occurring in Somerset, suggesting risk of budburst occurring before the end of the cutting period has not increased over this relatively short period.

Figure A6.5 Nature Calendar budburst date for Hawthorn in Somerset

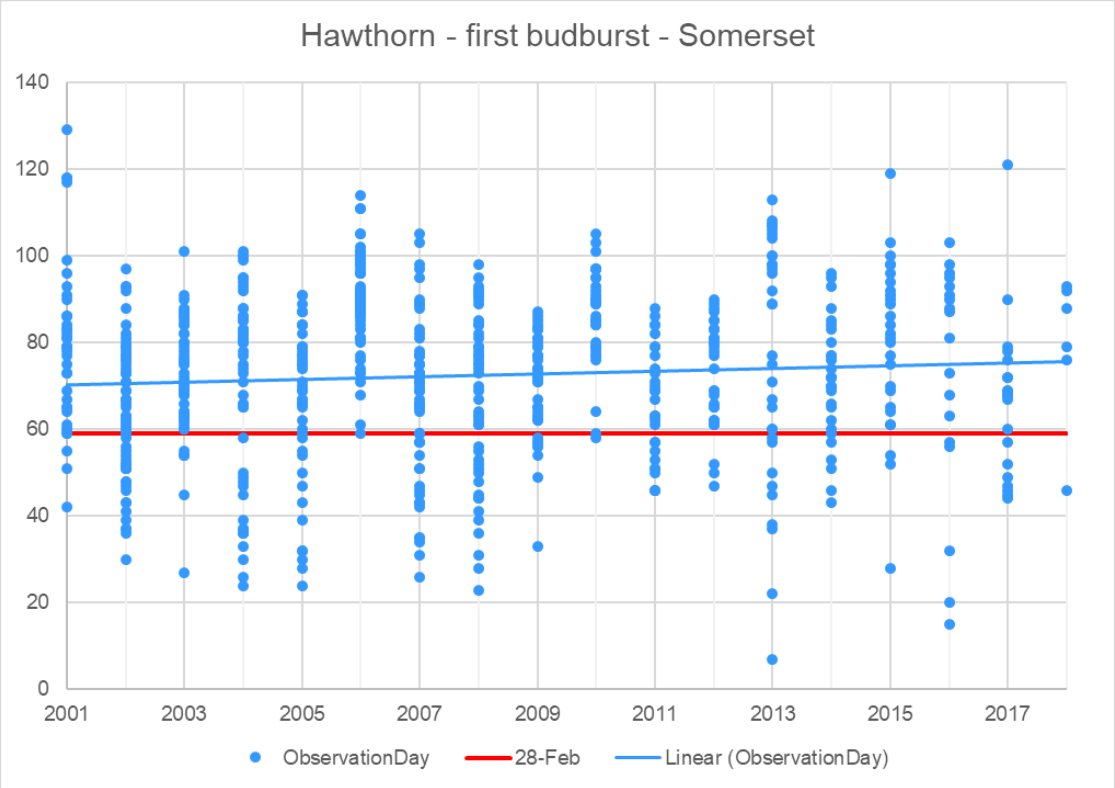
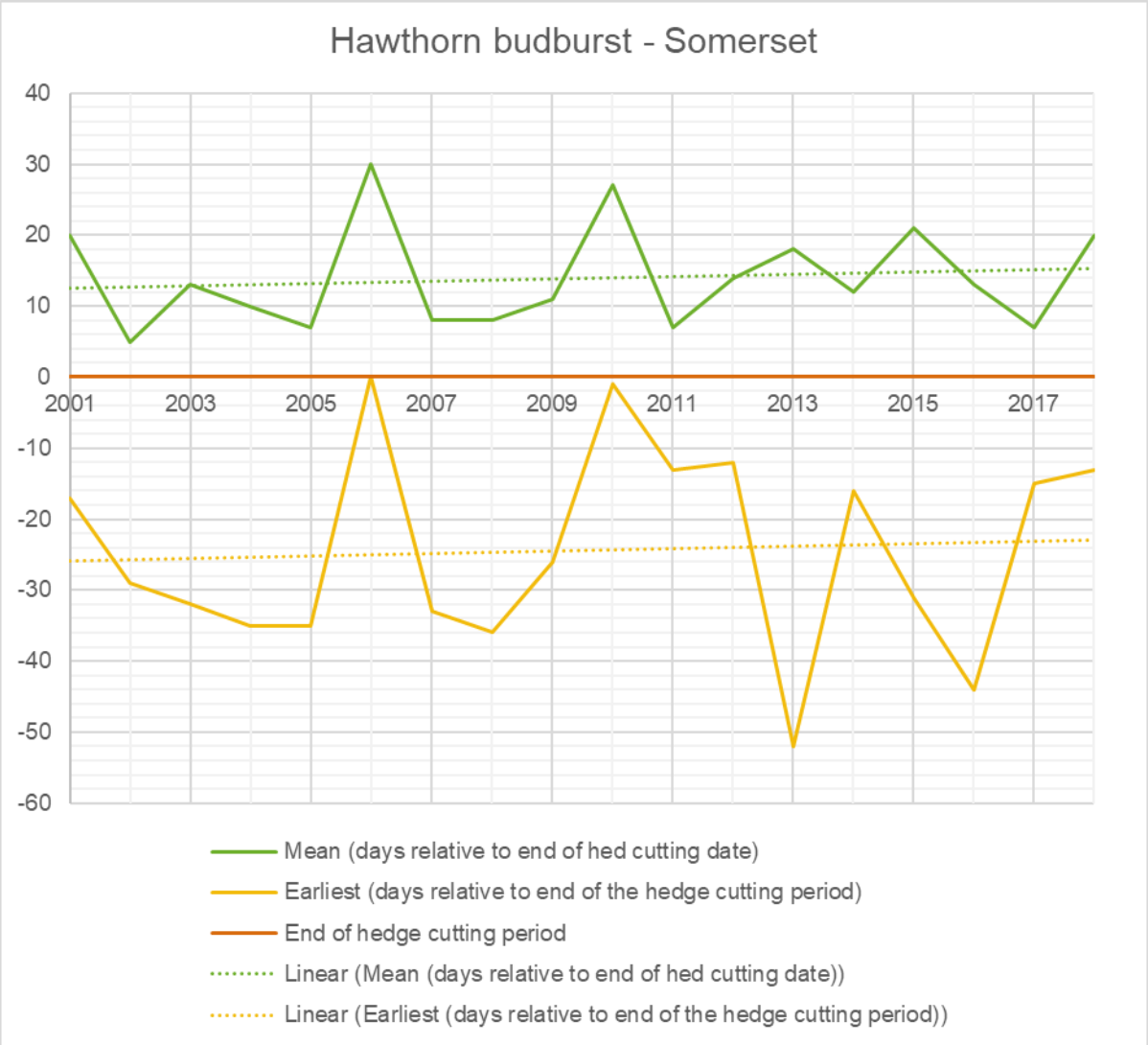


Figure A6.6, taking the same data, examines the relationship with the end of the cutting period in more detail. It plots the average date of first budburst over the period from 2001 to 2018 (blue dots) and tracks the trend in this date (solid blue line). It shows that the mean budburst date for Hawthorn in Somerset typically occurs at least 8 days after the end of the cutting period. Over these 17 years, the trend suggests that the mean date of budburst has fallen back by two days. The graph also plots the timing of the earliest single recorded budburst in Somerset over this period. This shows considerable variation from year to year, with budburst in all years starting before the end of during the cutting period. In 2013, the earliest recorded budburst occurred 50 days before the end of the hedge and tree cutting period. Over these 17 years, the trend suggests that the earliest recorded budburst each year has moved back by around two days, though the scale of year to year variation suggests this may not be a good representation of longer-term trends.

Figure A6.6 Nature Calendar budburst date for Hawthorn in Somerset, mean and earliest



Common Frog

Nature's Calendar data recording the first observed frogspawn were analysed for Somerset. Records are relatively sparse before 2001, so the analysis focused on the period between 2001 and 2018.

Figure A6.7 shows, for each year, the timing of the first observed frogspawn across Somerset. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (31 March) when land managers must ditch maintenance operations. The graph shows the majority of observations occurring within the ditch maintenance period, suggesting the potential for a clash with management activity. The blue dotted line shows a trend towards slightly later spawning in Somerset, though most spawning observations still occur before the end of the ditch maintenance period.

Figure A6.7 Nature Calendar spawning date for Common Frog in Somerset

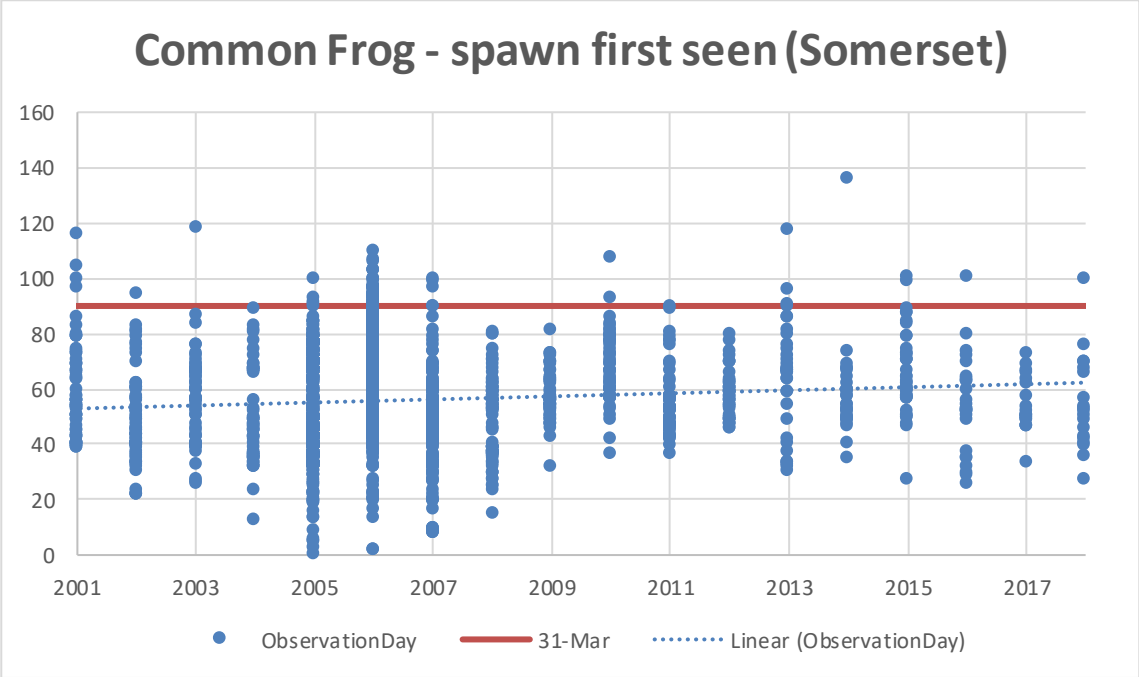
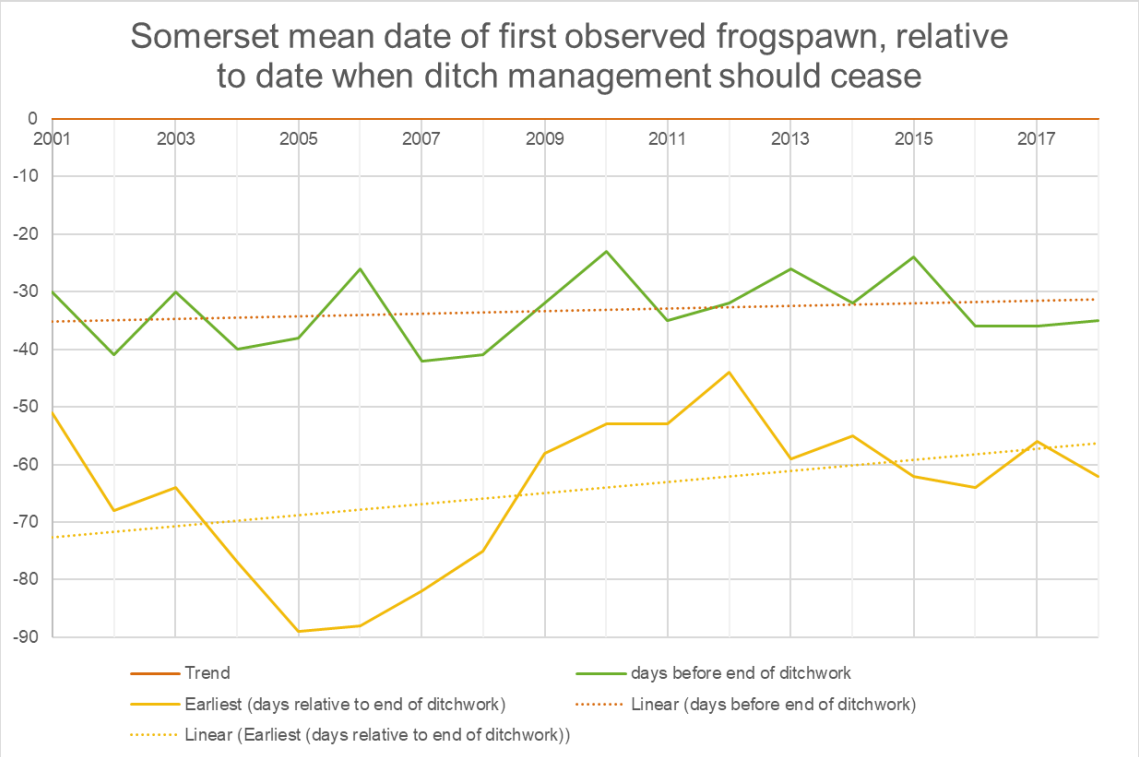


Figure A6.8, taking the same data, examines the relationship with the end of the ditch maintenance period in more detail. It plots the average date of first observed spawning over the period from 2001 to 2018 (blue dots) and tracks the trend in this date (solid blue line). It shows that the mean frog spawn date in Somerset consistently occurs at least 24 days before the end of the maintenance period. Over these 17 years, the trend suggests that the mean date of spawning has moved back by around three days. The graph also plots the timing of the earliest single recorded spawning in Somerset over this period. This shows considerable variation from year to year, with the earliest records in 2005 and 2006 occurring in very early January. Over these 17 years, the trend suggests that the earliest recorded spawning each year has moved back by around fifteen days, though the scale of year to year variation suggests this may not be a good representation of longer-term trends.

Figure A6.8 Nature Calendar spawning date for Common Frog in Somerset, mean and earliest



West Anglia (Bedfordshire, Cambridgeshire, Essex and Hertfordshire)

Hawthorn

Nature's Calendar data recording the first Hawthorn budburst were analysed for West Anglia. Records are relatively sparse before 2001, so the analysis focused on the period between 2001 and 2018.

Figure A6.9 shows, for each year, the timing of the first recorded hawthorn budburst across West Anglia. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (28 February) when land managers must end hedge cutting and tree cutting operations. The graph shows most budburst taking place after the end of the hedge and tree cutting period, though in several years (e.g. 2002, 2004, 2005, 2007, 2008 and 2016) there are a large number of records for the period before the end of February, suggesting the potential for a clash with management activity. The blue line shows a trend towards slightly later budburst occurring in West Anglia, suggesting risk of budburst occurring before the end of the cutting period has not increased over this relatively short period.

Figure A6.9 Nature Calendar budburst date for Hawthorn in West Anglia

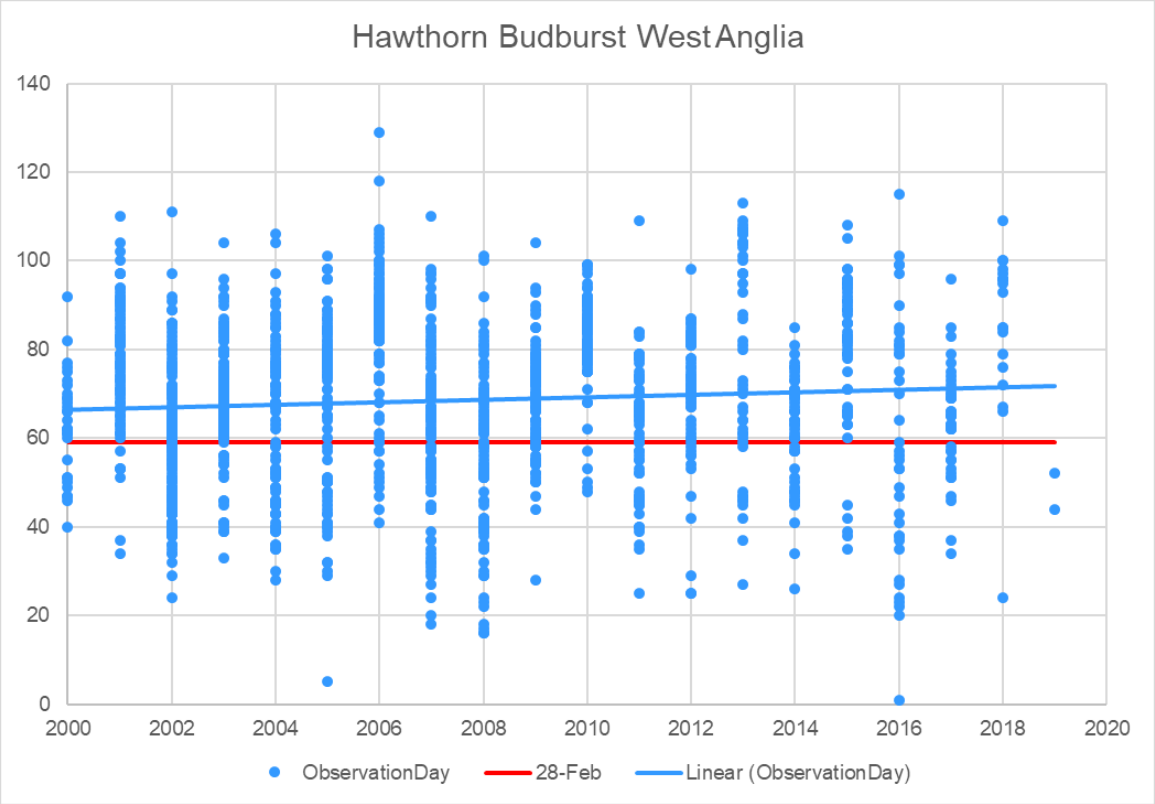
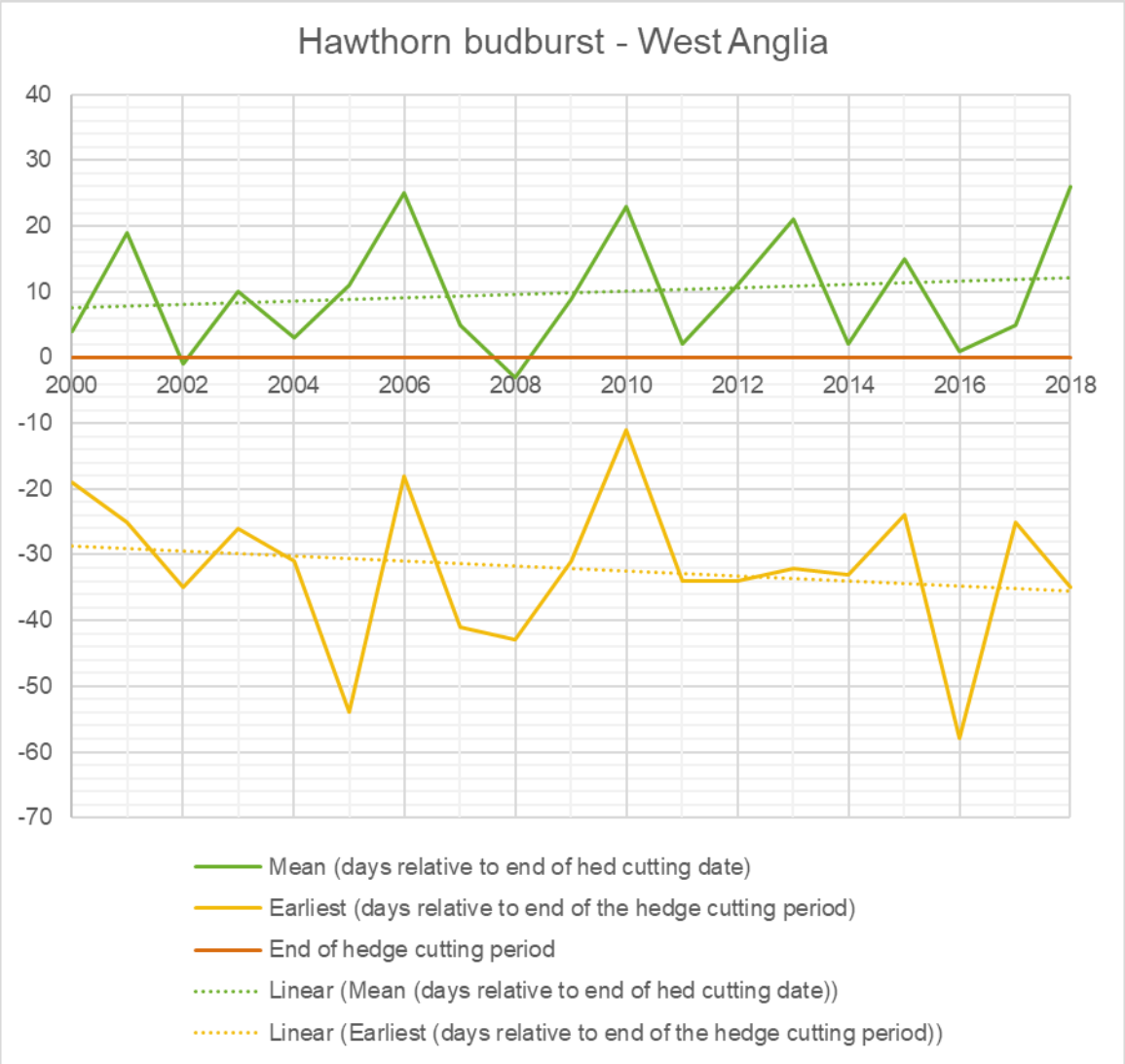


Figure A6.10, taking the same data, examines the relationship with the end of the cutting period in more detail. It plots the average date of first budburst over the period from 2001 to 2018 (blue dots) and tracks the trend in this date (solid blue line). It shows that in around one in three years, the mean budburst date for Hawthorn in West Anglia occurs close to, or slightly before the end of the cutting period. Over these 17 years, the trend suggests that the mean date of budburst has fallen back by four days. The graph also plots the timing of the earliest single recorded budburst in West Anglia over this period. This shows considerable variation from year to year, with budburst in all years starting before the end of during the cutting period. In 2005, the earliest recorded budburst occurred more than 50 days before the end of the hedge and tree cutting period. Over these 17 years, the trend suggests that the earliest recorded budburst each year has moved forward by around a week, though the scale of year to year variation suggests this may not be a good representation of longer-term trends.

Figure A6.10 Nature Calendar budburst date for Hawthorn in West Anglia, mean and earliest



Common Frog

Nature's Calendar data recording the first observed frogspawn were analysed for West Anglia. Records are relatively sparse before 2001, so the analysis focused on the period between 2001 and 2018.

Figure A6.11 shows, for each year, the timing of the first observed frogspawn across West Anglia. The left-hand axis shows the day number (January 1 = day 1) and the red line shows the date (31 March) when land managers must ditch maintenance operations. The graph shows the majority of observations occurring within the ditch maintenance period, suggesting the potential for a clash with management activity. The blue dotted line shows a trend towards slightly earlier spawning in West Anglia, though most spawning observations still occur before the end of the ditch maintenance period.

Figure A6.11 Nature Calendar spawning date for Common Frog in West Anglia

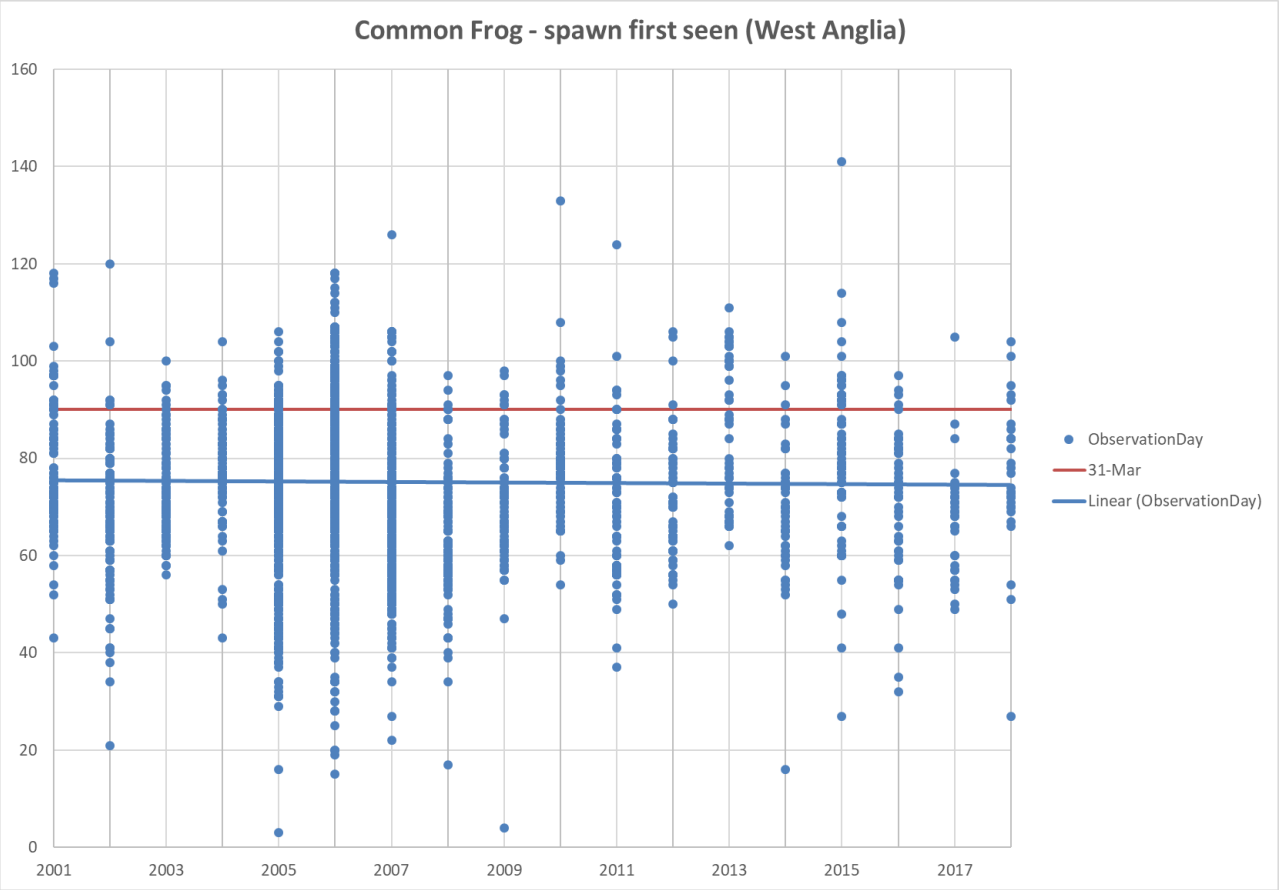
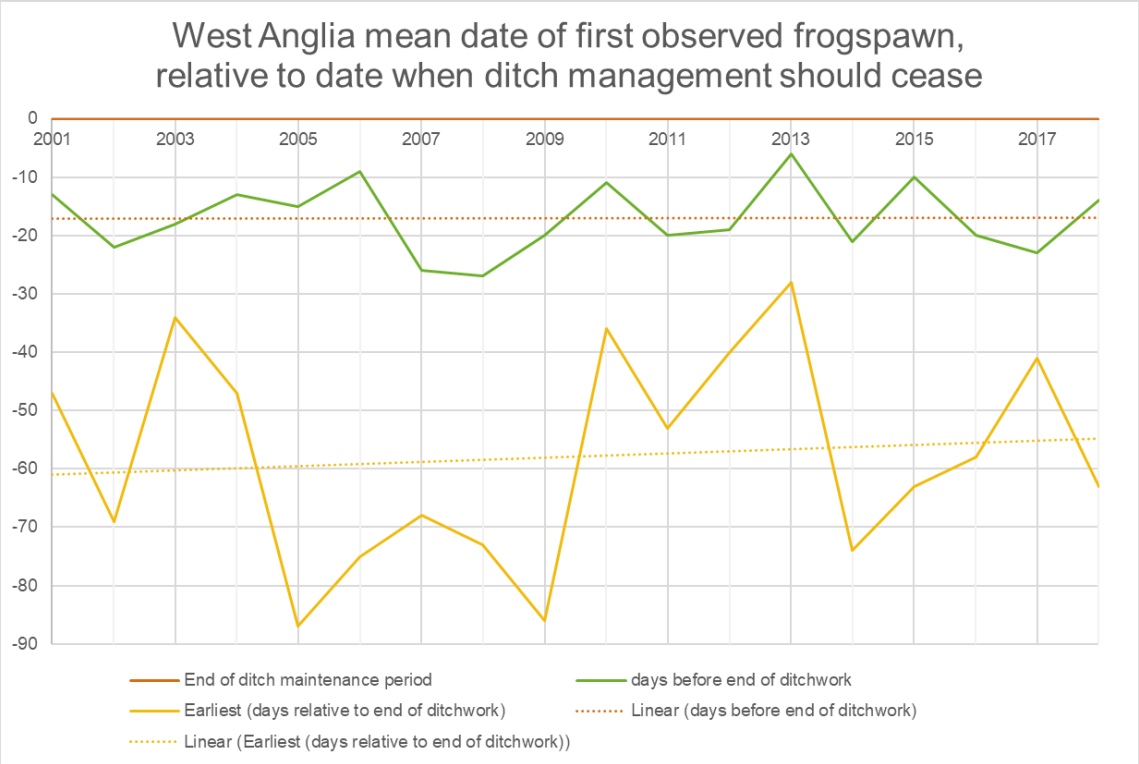


Figure A6.12, taking the same data, examines the relationship with the end of the ditch maintenance period in more detail. It plots the average date of first observed spawning over the period from 2001 to 2018 (blue dots) and tracks the trend in this date (solid blue line). It shows that in most years, the mean frog spawning date in West Anglia occurs at least 10 days before the end of the maintenance period. Over these 17 years, the trend suggests that the mean date of spawning has changed very little. The graph also plots the timing of the earliest single recorded spawning in West Anglia each year over this period. This shows considerable variation from year to year, with the earliest records in 2005 and 2009 occurring in very early January. Over these 17 years, the trend suggests that the earliest recorded spawning has moved back by around six days, though the scale of year to year variation suggests this may not be a good representation of longer-term trends.

Figure A6.12 Nature Calendar spawning date for Common Frog in West Anglia, mean and earliest



A COLLABORATION BETWEEN

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