Natural England Chief Scientist Report 2020: Developing our evidence base - research & collaboration

NATURAL ENGLAND

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Contents

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Thanks are especially due to the contributors to this report: Beth Brocket, Richard Caldow, Alistair Crowle, Rachel Jones, Jonathan Larwood, Jane Lusardi, Allison Potts, Colin Prosser, Nathan Shaw.

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Foreword

In July 2020, the Natural England Board approved a ground-breaking new strategy for science, evidence and evaluation (SEE). The new SEE Strategy makes clear the ambition for Natural England to be an evidence-led organisation and a leader in the application of environmental sciences from a across the breadth of natural and social scientific disciplines. The SEE Strategy kicks off a multi-year programme of work that will strengthen the critical role that science, evidence and evaluation play in underpinning Natural England's values; especially partnership working, inclusiveness, ambition and integrity.

As we progress towards our vision of "thriving nature for people and planet" and as the Board Member with responsibility for chairing Natural England's Science Advisory Committee (NESAC) I am more certain than ever that we are heading in the right direction and that the time is right for us to make these shifts. It must become second nature for us to follow the evidence, not relying on our hunches, our history or our prejudices. This will help us do what is right and help us do it in the right ways – even if this means confronting some 'inconvenient truths'. So, we need to be honest about whether our interventions work and have the courage to stop doing what the evidence tells us doesn't work.

I acknowledge that this is a huge challenge, but our new SEE Strategy maps out the routes ahead. Over the next few years we will ramp up our efforts to use science and evidence to identify strategic opportunities, priorities, and innovation, and act on them; to ensure that the best available evidence is central to all our decision making, delivery, advice and risk assessment; to be a learning organisation that evaluates the outcomes of our actions; and to be an organisation that invests in science, evidence and evaluation capability.

But as Chair of NESAC I am also privileged to work with many of our specialist staff and other technical experts who make this report possible, and whose contributions ensure our reputation. And NESAC is a living embodiment of a crucial aspect of the SEE Strategy, to work in close collaboration and partnership with experts from outside Natural England. NESAC members are drawn from academia and environmental practice and together, NEASC offers constructive challenge and steer and helps facilitate partnership working crucial to realising Natural England's vision for science.

This is why this third Chief Scientist Report is focusing on partnership working and the practical use of science and evidence. The SEE Strategy sets out eleven of Natural England's top science challenges, such as "How might changes in the natural environment affect people's health and wellbeing? What interventions can enhance the benefits and mitigate any negative impacts?" and "How can we most effectively implement nature-based solutions to address climate change and support progress to net zero carbon emission?" To address these (and other) questions, it is essential that Natural England builds and strengthens constructive partnerships with researchers and innovators in academia and elsewhere.

After the shocks and disruptions of 2020, we look forward to 2021 being a much more hopeful year, not just from society as a whole but for the environment too. Our appreciation for the value of nature has grown hugely in the last year and opportunities have opened up to build on this, to seek transformations to ways of living and working that enhance nature. Science and innovation should be at the centre of these transformations. Natural England's broader mission is "Building partnerships for nature's recovery" – and never before has there been such a great opportunity to do this than by advancing science and innovation in partnership with others.

Dr Andy Clements

Natural England Board Member,

Chair of Natural England Science Advisory Committee (NESAC)

Welcome and Introduction

Welcome to Natural England's third Chief Scientist Report. My first report shone a spotlight on the breadth and depth of the science & evidence work that we do and showed how it underpins and supports all of our work. In my second report, we focussed on monitoring and indicators; making clear how vital it is that we understand the changes in our environment and the effects of our actions.

As Andy Clements noted in his Foreword, this report focusses on our partnership working and the way that we use the science and evidence to deliver Natural England's vision to achieve **Thriving nature for people and planet**. Our science, evidence and evaluation (SEE) strategy underpins this vision by describing the importance of being evidence-led and in setting out our ambition to be strong leaders in the application of environmental science. We will only realise this ambition if we are able to enhance our scientific understanding in some key areas such as: our understanding of the nature of changes occurring to the natural environment; how to measure and improve the resilience of landscapes and ecosystems; and the importance of linkages between the natural environment and people's health and wellbeing.

Whilst we have a wide range of highly skilled and experienced specialist and technical staff, we cannot answer these questions alone. We need to build, maintain and strengthen a wider range of partnerships with academics, researchers and innovators from across society, in the public, private and civil sectors, both in the UK and (increasingly) internationally.

A sustainable future requires achieving nature's recovery while securing fairness for all and the UN Secretary General has said that "science is our great ally" in these efforts. Within Natural England, we draw on and contribute to natural and social science and economics; strengthening our understanding of how the natural environment is changing and of 'what works' for the natural environment.

Making the best use of robust, and often cutting-edge science and innovation, and the wide range of scientific and technical expertise among our colleagues and partners, means that Natural England can be more confident in its advice, decision-making and actions; increasing our impact on real-world outcomes.

Within this report you will see examples of the breadth and quality of our scientific work and the benefits of our partnership working. This is complemented by the impressive bibliography of peer reviewed papers, books and in-house reports published over the last couple of years, which paints a clear picture of the diversity of partnerships and collaboration that have become a central feature of our science and evidence work.

I continue to be enormously impressed by, and proud of, the breadth and depth of expertise we have in-house, and how my colleagues work brilliantly with a hugely diverse range of partners. This enables our scientific work to reach from local to global - participating across the country in local nature recovery partnerships, all the

way through to working on international collaborations such as the Intergovernmental Panel of Climate Change and the United Nations Global Environmental Outlook. Colleagues work in areas of basic science and ecology, right through to innovation of new practical on-the-ground solutions. They also work across the full spectrum of disciplines; increasingly bringing these together to provide unique insights and understanding of outcomes that cannot be achieved by focussing through the lens of a single discipline.

At the centre of this, the advice we receive from NESAC – our Science Advisory Committee – has been invaluable. Similarly, we work closely within other networks and groupings such as across the Defra group (e.g. with the Environment Agency, Forestry Commission and others) and with the UK's other Statutory Nature Conservation Bodies (SNCBs): Joint Nature Conservation Committee (JNCC), NatureScot, Natural Resources Wales (NRW) and the Northern Ireland Environment Agency (NIEA). Through such networks we build on each of our strengths and share our knowledge, experiences and resources which enhances the impact of what we all do, and how we work.

Also highlighted in this report are several vignettes highlighting how both the Chief Executive and members of staff first became aware of an environmental issue, giving a flavour of what their work within Natural England entails, and how science and scientific evidence underpin their work`

In my introduction to the second Chief Scientist Report, I highlighted the transformative change that was underway in Natural England as the importance of being an evidence-led organisation was being increasingly recognised and valued. The publication of our SEE strategy in July 2020 was something of a milestone as this became firmly cemented into Natural England's vision, values and ways of working. Working with partners to develop and use the best available science & evidence to: identify strategic opportunities; to underpin our advice, decisions and actions; and to evaluate and act on what works, and what doesn't, will be at the heart of our future success in achieving nature's recovery and improving people's connection with the environment.

I hope you find the material set out here as inspiring as I do and look forward to continuing to reinforce our partnerships even more in the coming years.

Dr Tim Hill MIEnvSc MIoD
Chief Scientist, Natural England
April 2021

To keep up to date with science and evidence developments in Natural England, you can follow me on Twitter @NEChiefSci.

People and Nature Survey: People and Nature in the COVID 19 pandemic.

Beth Brockett and Nathan Shaw

The People and Nature Survey, following on from the Monitoring Engagement in the Natural Environment Survey (MENE) was launched in April 2020 providing the continuation of the government's main source of data on how people experience and think about the environment; including a number of questions to understand people's physical and mental health.

As the country started dealing with COVID-19 earlier this year, questions were asked as to whether the survey launch should go ahead. It was successfully argued that the responses would create a unique dataset tracking the effect of COVID-19, and associated tightening and easing of social restrictions, on people's engagement with the natural environment. Indeed, the monthly and quarter one datasets have been used to inform Defra's COVID-19 Emergency advice on impacts of lockdown and easement on use of national parks and beaches. Findings have also been used to identify unequal effects of COVID-19 on mental health[1], the Cabinet Office's National Strategy for Disabled People, Greater London Authority's recovery plans in relation to children and levels of access to outdoor spaces, and to support our work on Connecting People with Nature[2].

To date, eight monthly and two quarterly reports have been published analysing a range of indicators (Fig 1, Fig 2) which have been viewed several thousand times. These releases have been publicised on social media (Fig 3, Fig 4), primarily using the @NEChiefSci Twitter account. The engagement rate of around 8% has been far above the government baseline.

[1] https://www.health.org.uk/news-and-comment/blogs/emerging-evidence-on-health-inequalities-and-covid-19-july-2020 and in submission to the UNECE on "COVID-19 & the benefits of contact with nature for mental health: Early findings".

[2] For example, https://naturalengland.blog.gov.uk/2020/07/20/tony-juniper-on-the-secretary-of-states-green-recovery-speech/ https://naturalengland.blog.gov.uk/2020/09/30/enhancing-englands-urban-green-spaces/ https://www.gov.uk/government/news/nationally-important-wildflower-grasslands-get-increased-protection

People and Nature in the Pandemic' (#PeopleNaturePandemic). Co-hosted by the University of Surrey and Natural England's People and Nature Survey Team

A User Hub has been developed as a focal point for everyone interested in the survey. It has been viewed over five thousand times and publishes guest blogs from partners. It also enables people to sign up to the survey (Fig 5) and log their interest areas, allowing us to notify them of latest developments and publications (367 signed up). It also provides a source of new members to the PANS Research User Group.

As well as a forum for connecting researchers with evidence users and maximising collaboration opportunities, this group of ~60 people provides opportunity to update researchers with NE's priority questions, thus expanding our analysis capacity. Since April we have developed funded partnerships with the University of Surrey on a series of projects looking at 'Nature Engagement and Wellbeing Pre-, During and Post Covid-19' (£400k UKRI) and with the University of York to undertake qualitative research to better understand the barriers to accessing greenspace. Natural England will co-author papers from all of these collaborations and disseminate the learning internally and externally.

We have identified 103 papers and reports which make use of MENE data and a number of reports already reference PANS[3], with a number of journal articles in development.

We also have three PhD studentships in the pipeline, with new collaborators, which will address the issue of 'quality' of green and blue natural spaces from an interdisciplinary perspective and the link between nature engagement and pro-environmental behaviours.

[3] For example, Engagement with Nature and Covid-19 Restrictions - Forest Research

NE Chief Scientist
@NEChiefSci

The People & Nature Survey for England first quarterly statistical release (data collected April-June) has been published, the release includes new analysis of how different groups experienced natural spaces.

Report gov.uk/government/sta...

#BetterWithNature #PeopleAndNature

12:36 PM · Sep 30, 2020 · Twitter Web App

28 Retweets **13** Quote Tweets **30** Likes

4.2 What types of natural spaces did people visit?

Table 1: Proportion of adults in England (weighted percentage) taking visits to different green and natural spaces between April and June 2020.

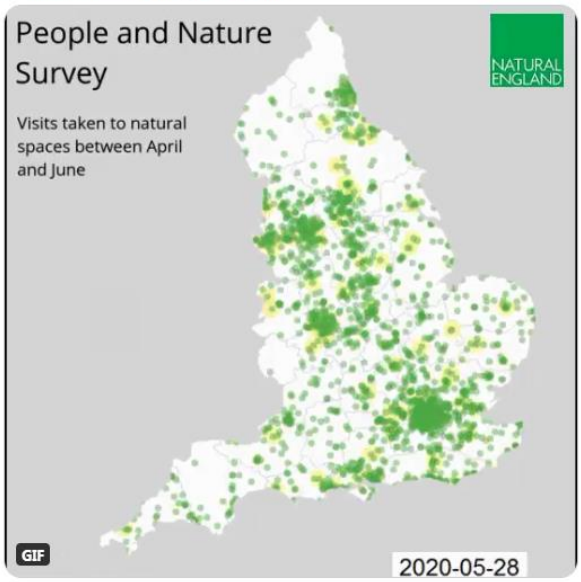
Types of place visited	Percentage	Confidence interval (%)
Urban greenspace (such as a park, field or playground)	45.3	1.4
Fields / farmland / countryside	28.4	1.2
Woodland / forest	27.4	1.2
River / lake / canal	24.3	1.2
Beach / other coastline / sea	16.9	1.0
Nature / wildlife reserve	13.6	0.9
Grounds of a historic property or country park	10.6	0.8
Hill / mountain / moorland	8.4	0.7
Allotment or community garden	6.7	0.7
No visits in the last month	**26.1**	**1.1**

Table notes Source: The People and Nature Survey: which of the following type(s) of green and natural spaces have you visited during the last month?
(1) Data collected in the period April 1st to June 30th (inclusive).
(2) The sample for this question was 6,033 respondents.
(3) This is a multi-select question so percentages will not total 100%.

NE Chief Scientist @NEChiefSci · Sep 30
Replying to @NEChiefSci
We know that over half of adults have been visiting natural spaces over the last 14 days during April–June, our 'visits taken' map shows where these visits have been reported.

Full report gov.uk/government/sta...

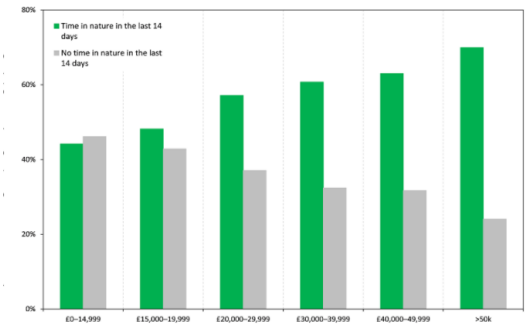
#BetterWithNature #PeopleAndNature



ucation: Adults with higher educational attainment are more likely to visit a natural ice: 66% of adults with a university degree (or above) made a visit in the last 14 days, npared to 57% of adults with any other qualifications (e.g. A Levels, O Levels, GCSEs, EC, Diplomas, Trade Apprenticeships), and compared to 37% of adults with no alifications.

ome: There is a positive relationship between income and visits; as you earn more are more likely to get outside in nature (Figure 1). For example, 44% of respondents ng in households earning £15,000 or less (below the poverty line) visited a natural ice in the **last 14 days**, compared to 70% of respondents living in households earning),000 or above[footnote 1].

ure 1: Proportion of adults in England (weighted percentage) making visits to green l natural spaces versus income. There is a positive relationship between income and ts - those earning more were more likely to have made a visit to a natural space in the 14 days; and vice versa.



People and Nature in the Pandemic' (#PeopleNaturePandemic). Co-hosted by the University of Surrey and Natural England's People and Nature Survey Team

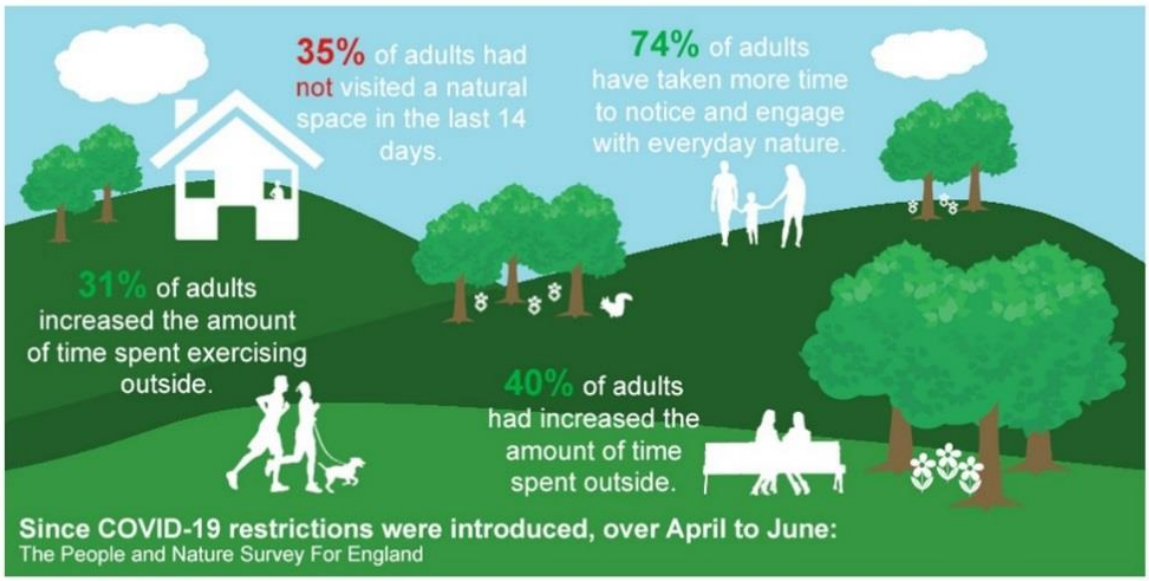
In December over sixty PANS users from academia, local authorities, Defra Group, the heritage sector, the outdoors sector, and conservation NGOs attended a 'sold-out' 2 day online event called 'People and Nature in the Pandemic' (#PeopleNaturePandemic). Co-hosted by the University of Surrey and Natural England's People and Nature Survey Team, the event linked up practitioners, policy makers and evidence specialists, and participants discussed the role nature has played in people's lives during Covid-19.

> *"I just wanted to say that I really got a lot out of the People and Nature event last week – it was great. Thanks for organising, I'm already looking forward to the next one."*
>
> *"I found the Natural England event the other week very insightful. So great to bring academia into the real world. We must do more of such."*
>
> *Participants of #PeopleNaturePandemic event*

All of the above has helped increase the impact of the survey, evident by the increasing number of requests from internal and external groups. The PANS team

recently completed its first commissioned piece of work for the Defra Marine Team. Evidence from the surveys have also been visible in the mainstream media[4].

There are lots of future projects in the pipeline for the team, including input into the development of a National Health Index with the ONS, a PANS for Wales, creating content for the Green Alliance, and we understand that PANS will be the first online panel survey to apply for National Statistic status[5] (process starting 2021). An exciting year ahead sharing evidence from this truly unique dataset.



[4] For example, https://www.vogue.co.uk/arts-and-lifestyle/article/english-countryside-racism https://www.theguardian.com/travel/2020/dec/02/the-bame-women-making-the-british-outdoors-more-inclusive

[5] It currently has Experimental Status as an Official Statistic

Spotlight on…

Amy Christie

What is your first memory of an environmental or conservation issue?

Living in the Yorkshire Dales when I was a little kid in the 1970s; my dad was working as a farm hand and hay time was the best time of the year. Being allowed to properly help load-up the small, rectangular bales and stay up late in the evening sunshine; working in the fields and at the barn alongside the gruff farming blokes. But then came mutterings about the farm up the road cutting silage… it sounded modern but ominous…

What is your role in NE and what does it entail?

Lead Adviser in Northumbria Area Team. Working mainly in the uplands, on agri-environment agreements and on SSSIs. Negotiating burning and grazing regimes and trying to re-inject some 1970s life back into the meadows!

How does science and evidence inform what you do?

It underpins all my work. I use it to explain the burning and grazing regimes which we negotiate and to reason why that grouse butt shouldn't go there. Meadow restoration has benefited greatly from years of research e.g. use of yellow rattle.

Wildfire Review - working with practitioners to gather evidence

Alistair Crowle

In recent years, wildfires have featured heavily in the media, with events in California, Greece and Australia witnessing especially tragic scenes. In the UK, wildfires on peatland or heathland are relatively uncommon or localised but on occasion, they can be large and capture the attention of the media and public alike.

In order to unpick the various elements of wildfires and some of the myths associated with them, Specialists initiated an evidence review on the causes and prevention of wildfires on heathlands and peatlands.

Burning wet heath. Photo: Natural England/David Key

The approach taken saw the development of the review questions which were shared with a range of external audiences including: Moorland Association, Fire Rescue Services, Forestry Commission, NFU, RSPB, National Park staff and academic researchers. In response, the organisations and individuals submitted scientific papers, reports, and their collective experiences and opinions. The Moorland Association even undertook a survey of their members to gather their experiences. These inputs to the review, and in particular the practitioner evidence from people like the Fire Rescue Services, provided a rich context and important practical insight that would have been hard to glean from academic publications alone.

It can be difficult to take account of the people's experiences when carrying out a standard evidence review, and the challenge was how to make the best use of what people have learned so that it could be shared with others. To provide oversight of the work, we approached individuals with expertise on fire and wildfire from Forestry Commission, RSPB, Birmingham and Manchester Universities. These reviewers ensured the approach and conclusions of the report remained rigorous and balanced.

It was clear that certain themes were recurring: weather conditions and wildfire associations, flammability of certain vegetation types, ignition points of wildfires,

behaviour and spread of wildfires, wildfire planning and firebreaks, fire prediction and the importance of education. These were collated and included within an appendix so that they can be used to inform further research.

The assessment of the evidence following the literature review addressed both the specific review questions about causes and prevention, and the themes identified by practitioners. At the end of the review, the themes were also used to help shape the research recommendations around the gaps in the evidence base.

Following the release of the evidence review, Natural England specialists were invited to present the research recommendations to the UK Wildfire Research Group. This group is made up of amongst others, academics from eight different universities, Forestry Commission (England and Scotland), Fire Rescue Service, Environment Agency and water utilities. It is hoped that this will lead to research collaboration in the next few years that addresses some of the fundamental gaps for example, around wildfire preventative measures on individual sites and management of people to prevent ignitions.

Ovenden Moor, West Yorkshire in May 2011. Photo: Natural England/David Key

In the meantime, we continue to work with Forestry Commission to further analyse the Home Office wildfire data set (c.260,000 records from 2009 to the present) compiled from records submitted by the Fire Rescue Service following a wildfire event. We believe that these data will help identify patterns of wildfire occurrence that will inform how we engage with land managers and the wider public to reduce their incidence.

Link to wildfire report: http://publications.naturalengland.org.uk/publication/4741162353295360

The Black Country UNESCO Global Geopark – collaboration and application of evidence

Colin Prosser

In July 2020, after more than 10 years of planning and partnership work and a rigorous application and assessment process, UNESCO accepted the Black Country into its network of Global Geoparks, joining the North Pennines and English Riviera as England's UNESCO Global Geoparks, and the Jurassic Coast as a UNESCO World Heritage Site. Wonderful news as UNESCO designations elevate our geoheritage to an international stage generating new and exciting opportunities for conservation, research, education, tourism and international networking in the process.

The Wren's Nest NNR – Photo Natural England/Colin Prosser

Achieving Global Geopark status is not easy. Applicants must demonstrate that their geoheritage is internationally important, that it is being protected, and that there is an active local partnership working to promote and sustainably use this geoheritage to deliver social and economic benefit for local people. Applications to become a UNESCO Global Geopark must be 'bottom-up' and community driven but Natural England has an important part to play too. Collaboration and application of the evidence we hold has played, and continues to play, an important role in the establishment and management of England's Global Geoparks and the Jurassic Coast World Heritage Site.

In the case of the Black Country, membership of the Geopark Project Team and long-standing partnership and collaboration on the ground has undoubtedly helped to shape and underpin the successful application. For example, published evidence from Natural England's Geological Conservation Review provides scientifically rigorous and robust evidence as to the international and national importance of the area's geoheritage, whilst the designation of nine geological Sites of Special Scientific Interest and the declaration of two National Nature Reserves (NNRs) within

the area demonstrates that the geological highlights of the Geopark are being conserved and managed. Furthermore, collaboration on a series of projects including the recent declaration of Saltwells as a new NNR, and the trialling over many years of innovative approaches to geoconservation, management of fossil collecting, interpretation, use of drones and community engagement at Wren's Nest NNR, all in an urban setting, undoubtedly helped to strengthen the application and meet some key requirements of UNESCO. Collaboration works both ways and Natural England has learnt a great deal about how geoheritage can be used in education, community engagement and geotourism through our involvement with the Black Country Global Geopark project. Consequently, the Geopark has been, and continues to be, the location for many of our geoconservation training courses, both for our own staff and external groups from across the UK.

UNESCO Global Geoparks and the Jurassic Coast World Heritage site are undoubtedly a major success story in terms of raising the profile of geoconservation and the importance of geoheritage to local communities. Through targeted application of the evidence we hold and continued collaboration with the UK Committee for UNESCO Global Geoparks, individual geoparks and the Jurassic Coast World Heritage Site, we hope to help shape and deliver increased levels of geoconservation, nature recovery, and public engagement with England's rich geoheritage.

On site at the Black Country Global Geopark. Photo: Natural England/Colin Prosser

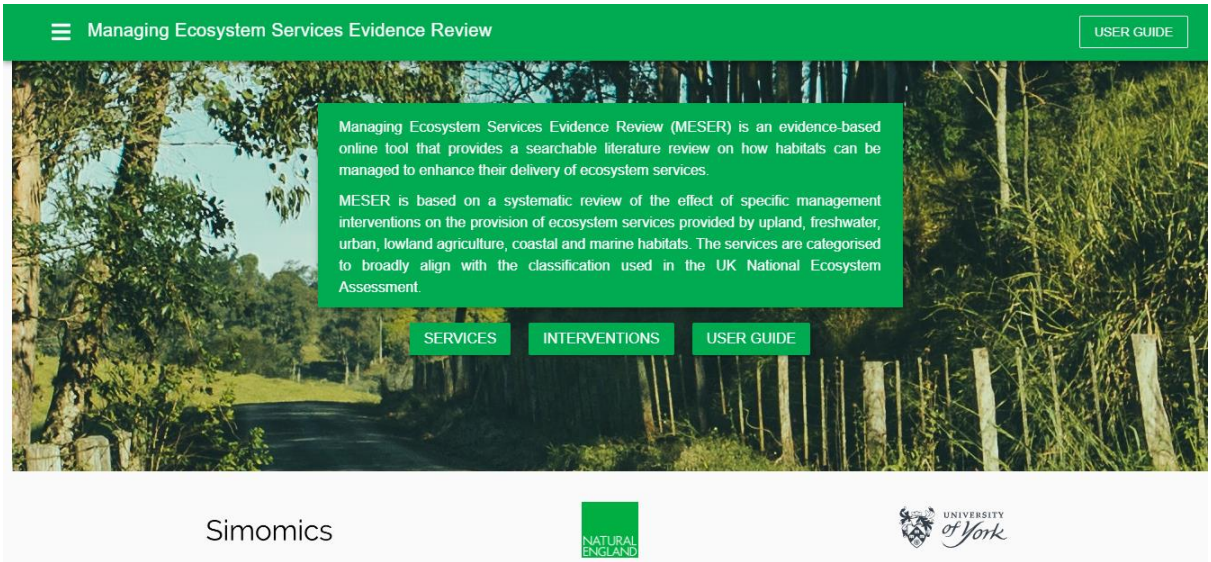
Co-developing natural capital evidence tools

Jane Lusardi

Making natural capital evidence easily accessible is essential if it is going to help to inform decisions on the ground. With this aim we have been working with University of York to develop two searchable literature review tools. The work has been jointly funded through a collaborative agreement. This has enabled the bringing together of expertise and understanding of the research, with the practical application. Co-development and design of the tools has ensured academic rigor and applied pragmatism in the creation of tools that are useful and ease to use for practitioners.

The tools cover terrestrial, freshwater, coastal and marine natural capital and the ecosystem services it provides. The Managing Ecosystem Services Evidence Review (Formally Ecosystem Services Transfer Toolkit NECR159) - JP033 (MESER) is a literature review of how management interventions affect the provision of ecosystem services, in different habitats. It is an update to our previous Ecosystem Services Transfer tool, with updated evidence and a new web-portal. This tool can be used to understand the available evidence on the effect of a range of management actions on ecosystem services.

The Natural Capital Indicators and Metrics Evidence Review - JP034 is a literature review which uses our Natural Capital Indicators: for defining and measuring change in natural capital - NERR076 as search terms. This tool identifies evidence on environmental attributes which underpin the provision of ecosystem services, and metrics used to measure these.



Both tools are accessible through searchable on-line web portals (designed by Simomics in collaboration with University of York and Natural England). Users can search the literature for different habitats and ecosystem services. They can also

use it generate their own PDF summaries of the evidence for different management actions or indicators. These summaries include graphics showing the strength of the evidence in terms of the number of papers identified.

The tools are being used to generate evidence to support decisions in a wide range of topics. For example, they been used to: provide material for the rapid evidence review for Environmental Land Management; support the Green Infrastructure Standards literature review on how different aspects of Green Infrastructure affect the provision of ecosystem services. The gaps in evidence identified by the tools can also help to inform future research.

The strength of both of these tools has been in their co-development: Professor Piran White of the University of York said: “Working closely with Natural England on the look and functionality of these tools has meant that we can ensure they meet user demands and are fit-for-purpose. It is very satisfying that they are being used already to inform policy and practice around land use and green infrastructure.”

Spotlight on…

Marian Spain, Chief Executive

What is your first memory of an environmental or conservation issue?

There are a couple of things that come to mind. My mother was a 'countrywoman', she knew the names of the flowers and animals. Walking along quiet lanes back from school she would tell me the different common names of the flowers in different parts of the country, including what my farming grandmothers in Cheshire and Norfolk would call them. That really embedded for me nature as part of our heritage. Occasionally she might say 'of course you don't see them so often now', and that was my first sense, at the age of 5 or 6 years old, of nature changing and loss. Some years later I had a marvellous biology teacher who encouraged me to read Rachel Carson's 'Silent Spring'. The passionate way in which the book presented the evidence and told the story of loss and damage to nature has stayed with me, and also told me how important it is to communicate about the environment.

What is your role in NE and what does it entail?

A tough question! What does being Chief Executive entail? It is about setting the direction of Natural England: what are we here for, and where are we going. It is about ensuring that people can do their job to the best of their ability and providing them with the support and confidence to do that job. And it's about speaking up for the organisation externally, so our customers and partners- including Government- know what we do and why and trust us to do our job well and want to work with us.

How does science and evidence inform what you do?

Promoting science and evidence is more than 'just a good idea'. Science and evidence is at the heart of our organisational value of acting with integrity – being able to take the right decisions for nature and explaining clearly to people why. Acting on the evidence informs our priorities, and give me the confidence that we are doing in the right thing especially when things are challenging.

Developing social indicators for better delivery of Environmental Land Management

Beth Brockett

If we want agri-environment schemes, including the new Environmental Land Management schemes, to work it is essential that we consider their social outcomes. A motivated land manager will do a better job than a disillusioned one. Natural England has a strong record of monitoring the environmental outcomes from over 30 years of agri-environment schemes (AES) but there is less data on the social and psychological outcomes and how these relate to environmental outcomes.

To address this evidence gap, over a period of two years and by involving an array of people from within Natural England, including our farm advisers, as well as colleagues from Defra, the Environment Agency, the farming community, and external social science experts, we undertook research to develop a better understanding of land manager AES **engagement factors** and **social outcomes** and how these affect:

- Motivation to engage in AES and environmental land management in general,
- Environmental outcomes delivered,
- Decisions to participate in future schemes,
- The social sustainability of schemes.

Working with the Countryside and Community Research Institute and the University of Exeter we developed a conceptual framework of the inter-connections between engagements factors, social outcomes and environmental outcomes.

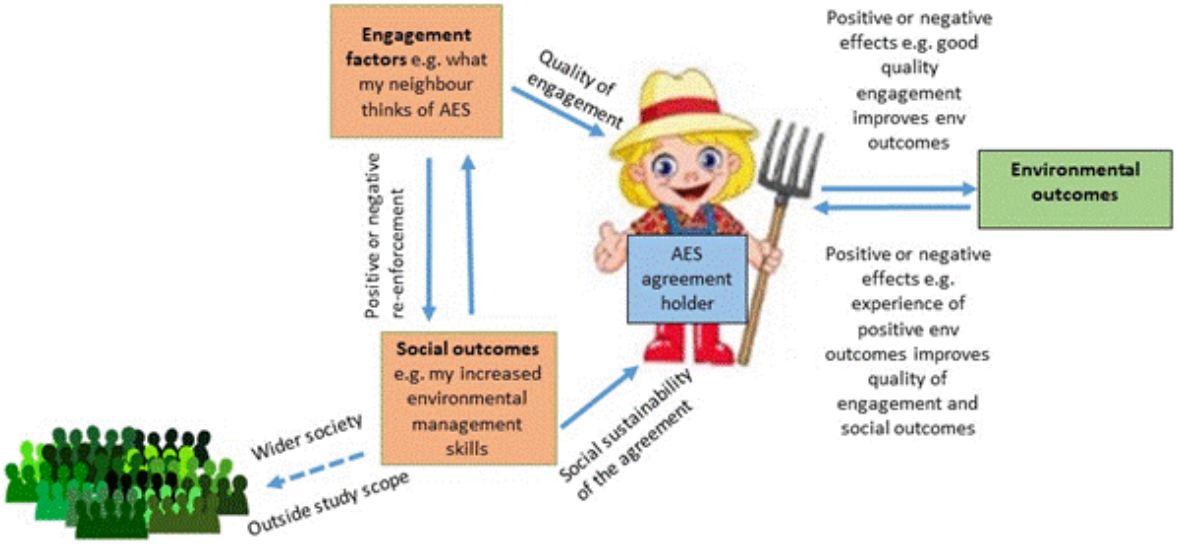


Diagram of conceptual framework showing links between AES engagement factors, social outcomes from AES and AES environmental outcomes and feedback loops

Engagement factors measure the nature and quality of land manager engagement with their agreement. For example, we can measure the agreement holder's level of interest in wildlife which evidence shows is likely to reflect their level of engagement with AES. Improved quality of engagement leads to long-term and long-lasting environmental behavioural changes, manifesting in, for example, land managers voluntarily undertaking unsubsidised environmental management practices.

Social outcomes measure outcomes, such, new skills, job satisfaction and mental health and wellbeing. These social outcomes can all contribute to the social sustainability of an AES. They can be positive (e.g. increased pride) or negative (e.g. increased stress).

An extensive literature search based on this framework identified a set of social indicators that are empirically and conceptually sound. This long list was refined by working with academic experts and our own farm adviser experts. A data collection method, focused on survey questions, was then developed to operationalise the monitoring and evaluation of this short list of indicators. Finally, small-scale testing of the proposed method was undertaken on 19 farms with agreement holders and their advisers, to provide a 'ground truth' of the questionnaire's practicality and validity.

For example, one of the indicators which has been shown to affect quality engagement with an AES agreement and delivery of environmental outcomes from that agreement is 'bridging social capital' - which refers to social connections between individuals who are dissimilar with respect to socio-economic and other characteristics (e.g. farming and non-farming communities). Bridging social capital has a positive effect on AES engagement. We can ask agreement holders about this via questions about:

- Extent of their involvement in non-agricultural networks;
- Extent of their engagement with general public;
- Whether they have received public recognition for their efforts in scheme.

There are lots of ways these indicators can be utilised in our work and the questionnaire has already been used within an ELM Test and Trial and the North Devon Pioneer project will be using it in 2021.

Other ways we think the indictors could be use include:

- Development of an index of indicators to provide a relative score for the social sustainability of a given scheme.

- To test the indicators': i) ability to predict agreement trajectory; ii) as proxies for environmental outcomes, and iii) as part of a wider monitoring and evaluation programme.
- Development of a suite of indicators which could be used by advisers to help them assess the quality of engagement an advisee has with their agreement and assess the trajectory of an agreement.
- As part of adviser training to help advisers understand the social world of agreement holders and how this influences the success of an agreement.
- As a basis for how to develop schemes to maximise and sustain positive social outcomes to increase pro-environmental behaviour.

The reports as well as a 2 page summary can be found here.

Measuring change in habitats and ecosystems – for biodiversity and natural capital

Jane Lusardi

Historically Natural England has measured the condition of Sites of Special Scientific Interest (SSSIs). However, the Lawton report focussed attention on the wider countryside and the need for "more, bigger, better and more joined"[6] habitats to address ongoing declines in biodiversity, for common species as well as rarities. Natural capital also provides many ecosystem services at a landscape scale. For the establishment of a Nature Recovery Network, benefiting wildlife and people, we need to be able to measure change in wider habitats and ecosystems, beyond SSSIs.

We have developed a suite of evidence relevant to understanding and measuring change in our ecosystems. Generating more integrated biodiversity objectives – rationale, principles and practice - NERR071 establishes the importance of natural processes in ecosystem restoration, whilst the Nature Networks Evidence Handbook - NERR081 sets out the evidence to support the delivery of Lawton's vision. Our work on defining Favourable Conservation Status (FCS) is identifying important attributes of structure and function for a range of habitats and species. We have also identified indicators of ecosystem quantity, quality and location, underpinning ecosystem services, in our report on Natural Capital Indicators: for defining and measuring change in natural capital - NERR076. Synergies between the Favourable Conservation Status attributes and the Natural Capital Indicators, demonstrate that what is good for biodiversity can also be good for providing multiple benefits to people.

Our new evidence shows us that when assessing change in our ecosystems we need to understand this across the country. This includes the best areas, SSSIs and Priority Habitats, as well as other wildlife-rich ecosystems which may not fit neatly into traditional habitat categories, such as those driven by restoration of natural function or re-wilding. It has also emphasised the importance of natural ecosystem function and attributes of nature networks which need to be considered, such as dynamic mosaics, diversity of niches and a bit of "messiness". However, with much of our land area being agriculturally improved grassland or arable, we also need to

[6] Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J., & Wynne, G.R. (2010) Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra.

know about the state of those modified habitats which have some of the greatest potential for change, in terms of both losses and gains for wildlife.

So how are we going to assess this change?

To assess progress against the 25 Year Environment Plan (YEP), a framework of indicators has been established. Natural England is responsible for the development of a number of these indicators including those to assess habitat quantity, quality and connectivity (indicator D1) and the natural functioning of water and wetlands (indicator B6). These indicators apply across England, within and outside of SSSIs. Whilst we are a relatively biodiversity data-rich country, we have a relative paucity of data on the state of our ecosystems outside of SSSIs. Both of these 25 YEP indicators require substantial development before we can report on them, and work is ongoing under a Memorandum of Agreement between Centre for Ecology and Hydrology (CEH), Defra and Natural England.

The establishment of the Natural Capital and Ecosystem Assessment pilot this year, is enabling a vital shift in the collection, availability and accessibility of data on the state of ecosystems across England. Through partnership working of Natural England, the Environment Agency, Defra, Joint Nature Conservancy Council, Forest Research, the Marine Management Organisation, Cefas and others, this pilot will enable a fundamental step change in our understanding of the state of our terrestrial, freshwater and marine ecosystems. With the current biodiversity and climate crisis, understanding the state of our ecosystems is essential, for biodiversity, the vital societal benefits they provide and the contribution Nature-based Solutions can make to tackling climate change.

Spotlight on …

Richard Broadbent

What is your first memory of an environmental or conservation issue?

Growing up in Malaysia I remember seeing the timber trucks rolling past my home in Seremban. I also used to play in the 'orange places' near my home - areas cleared of forest earmarked for future housing developments. They were orange because the soil was tinted with iron oxide and cut into deep gullies by the tropical rain. We had monkeys and gibbons in the trees nearest to my house and my pet rabbits were eaten by the neighbourhood monitor lizard. When I returned to Malaysia when I was 17 I had more appreciation for the conservation issues that I could see around me where I lived in the Klang Vally. For example, a wooded hill next to my home was entirely demolished to make way for houses and the woods around my school were gradually removed as a new town was created, taking with them the gibbons we used to hear in the mornings. There are, of course, pressing development needs in Malaysia as well as a growing grassroots eNGO presence interested in nature conservation.

What is your role in NE and what does it entail?

I am Head of Natural England's Legal Services team. Together with the management of the Principal Solicitors and team budget etc, I tend to work on the larger litigation and enforcement cases. More recently I have been working with colleagues from across Natural England on a project looking into stakeholder engagement regarding our regulatory functions.

How does science and evidence inform what you do?

Science and evidence is hugely important in the practice of environmental law. At Natural England it is both our sword and shield. The rationality and clear thinking of the scientific method is key to my role defending our decision-making in accordance with public law principles against legal challenge. This is because public law demands, for example, clear reasons for decisions which are rationally defensible. In a public inquiry context science and evidence is crucial as the evidential basis for decision-making is forensically investigated under adversarial cross-examination. Linked to science and evidence is the importance of being able to operationalise and deliver our work. When science, the law and our operational capability work well together then Natural England can better achieve what it sets out to do as well as defend its actions from challenge.

Spotlight on:

Cara Courage

What is your first memory of an environmental or conservation issue?

Hard to say really! I come from a farming background so the countryside, nature and the environment are sort of in my blood. I think I have always been aware that there can be tensions over land use, different camps. But I did realise a long time ago that these problems can so often be resolved by getting the different players together, building trust and understanding. So often people want similar outcomes for people and the environment, but different language and preconceptions can get in the way.

What is your role in NE and what does it entail?

I am a manager in the Northumbria Area Team, covering sustainable development, marine, forestry and peats issues. What does this entail? Managing a great bunch of people and supporting them to navigate some quite challenging scenarios that also offer real opportunities such as the widening of the A1, forest design plans. Marine, is a work area I'm looking forward to finding out about particularly the Northern Gateway Container Terminal and Tees Net Zero.

How does science and evidence inform what you do?

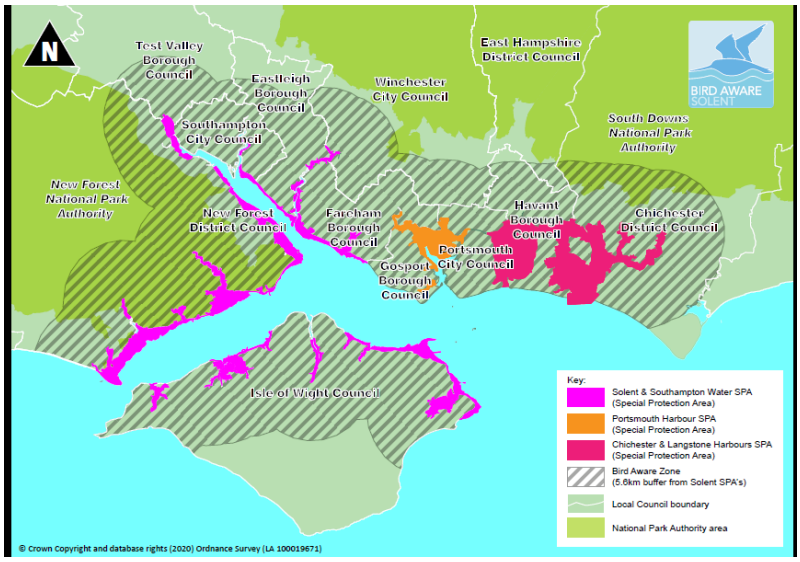
It provides input to our thinking and steers what me and the team do. Importantly, being evidence-led gives my advisers confidence to negotiate in difficult situations.

Bird Aware Solent: Recreation Mitigation

Richard Caldow, Allison Potts, Rachel Jones

Sanderling - Copyright Bird Aware www.birdaware.org

Upwards of 90,000 birds winter in the Solent. They must rest and feed to survive, migrate and breed successfully. But these birds are disturbed by human activities, depleting their energy. The South East Plan (2006-2026) Appropriate Assessment concluded that, without mitigation, the disturbance caused by recreational activity associated with 80,000 new homes in South Hampshire could adversely affect the integrity of several Solent coast Special Protection Areas. In 2009 the Solent Forum (comprising 12 local authorities, 10 harbour authorities, and many other organisations, including Natural England), initiated research into the problem and help identify mitigation measures to enable sustainable development.



First, existing evidence on the abundance and distribution of birds, housing and human activities around the Solent was collated. Then, new evidence was gathered, including field surveys of human activities and of their interactions with birds, household questionnaires to quantify recreational usage, and statistical modelling to predict future usage. This provided inputs to an individual's-based model which simulated Southampton Water within which individual model birds maximised net energy gain by deciding where, when and on what to feed each day depending upon the tidal exposure and distribution of food, the distribution of competitors and the disturbing effects of humans. Model birds gained or lost mass and "starved" if mass dropped below a threshold.

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Existing levels of recreational activity in Southampton Water were predicted to adversely affect survival of dunlin, ringed plover, oystercatcher and curlew, with 30 human visits/day/ha being a threshold above which such effects appeared. Statistical modelling predicted future visitation rates exceeding this threshold across much of the Solent, risking further reductions in birds' survival. Critically, the modelling predicted how effectively adverse effects could be reduced by various mitigation measures.

The Bird Aware Solent partnership (originally the Solent Recreation Mitigation Partnership) consists of 15 Local Planning Authorities and 4 conservation organisations, including Natural England (Thames Solent Team). Their adopted mitigation strategy is funded by financial contributions from developers of new homes within 5.6km of the Solent SPAs.

The principal measure is a team of rangers helping coastal visitors understand the birds' importance and the impacts of disturbance. This involves communications, marketing and education initiatives. Responsible dog walking is encouraged, as are visits to less sensitive coastal areas. Creation or enhancement of alternative local greenspaces is funded by £1.3m from the Solent Local Enterprise Partnership. Positive messages about sharing the coast with birds through responsible choices are key to the partnership's success.

This success has been recognised with a growing number of awards including winning: the 2020 Institute of Environmental Managers and Assessors' Sustainability Campaign, Public Sector Award; the 2019 Planning for the Natural Environment Award at the National Planning Awards, and the 2018 Award for Planning Excellence from the Royal Town Planning Institute South East Region.

Bird Aware Solent incorporates a successful brand, available to other partnerships e.g. the Bird Aware Essex Coast partnership of 12 Local Planning Authorities, Essex County Council and Natural England (West Anglia Team), further strengthening recognition of positive messages on recreation management.

We are proud of this partnership, which Natural England has nurtured and contributed to for many years. The positive messages and emphasis on helping people connect with nature align with our vision of creating resilient landscapes and seas while putting people at the heart of the environment.

Spotlight on …

Amanda Craig

What is your first memory of an environmental or conservation issue?

I grew up in Kent and had a really inspiring 'environmentally minded' primary school teacher (Mrs Worcester) who took our class to Woods Mill (Sussex Wildlife Trust) at the age of 9. Part of the work we did as a class was create a massive embroidery montage of British wildlife – I remember being simply overwhelmed by the array of wildlife that existed and realising how many I'd never heard of, and were rare and I'd probably never ever get to see them…

What is your role in NE and what does it entail?

I am Natural England's Director for People and Nature. I oversee one of our 4 delivery programmes - Connecting People with Nature Programme. As a programme team we have led the work to design the 5 year objectives for Natural England's work on Connecting People with Nature and developed the annual programme of work that is delivered across all Natural England teams. I also oversee the work Natural England does to influence Government policy in this work area to help deliver the 25 Year Environment Plan and meetings with partner organisations. Our connecting people with nature work covers three key areas: Health and Wellbeing, Community Engagement & Regeneration, and Social Inclusion.

How does science and evidence inform what you do?

I think there are three key elements of science and evidence that help with the work I do, firstly survey and data gathering: such as the People and Nature Survey (formally MENE), which has provided a wealth of up-to-date evidence supporting the link between people's mental health and well-being and nature – a really significant influencer for our work during the pandemic as it helped us provide the Government with a better understanding of the importance of nature and green spaces for local communities. Secondly around research – where we have really good links with the academic community that are helping us across all three of our key work areas for our programme, ranging from social media analytics/behavioural insights to development of the nature connection indicator. And finally around evaluation of the delivery of our work, not just process evaluation, but so that we can evaluate impact too, this is helping us to demonstrate when our delivery activities (*e.g.*: social prescribing) may have the potential to be mainstreamed through Government policy…

Geoconservation Gathering 2020: Conserving life - past, present and future

Jonathan Larwood

2020 was the Geological Society of London's 'Year of Life'. As part of this celebration in October Natural England collaborated with the Geological Society and the Black Country UNESCO Global Geopark to co-host a one-day conference 'Conserving life – past, present and future'. Speakers from across the UK, and participants from around the world, were virtually brought together to provide insights into how different aspects of our fossil heritage are conserved and used.

Underpinning much of what was discussed was the importance of conserving fossil sites. Whether eroding coastlines such as the Jurassic Coast World Heritage Site or the diversity of outcrops, man-made or natural, that you find in an area such as the Black Country, it is access to these sites that continues to enable our understanding of the evolution of life on Earth, and our ever changing environments, habitats and species. Equally important is what you do with your fossils once they are collected. Here museums provide long-term repositories, places where research continues and more than ever, places where people are inspired and awestruck by the past worlds of which fossils tell.

Pliosaurus kevani – Jurassic marine reptile found by an amateur from South Dorset SSSI, part of the Jurassic coast World Heritage Site. A spectacular near complete skull, new to science, and now display at Dorset County Museum. (photo copyright: Jurassic Coast)

Through conserving fossil sites, and looking after the collections that are made, in turn we have a resource not only for research and learning, to help us better understand the environment in which we live, but also a heritage to engage and inspire people, connecting them with the natural world. Here Natural England makes a significant contribution that shouldn't be underestimated. Through our work we help conserve over 1200 geological Sites of Special Scientific Interest many of which are protected for their fossils. These SSSIs in turn underpin a network of National Nature Reserves, UNESCO Global Geoparks, and England's only natural World Heritage Site, the Jurassic Coast – we are conserving life – past, present and future.

Bibliography

Dave Stone

This bibliography is organised by the Programmes our work follows. The bibliography covers material published in 2020 including Natural England authored peer-reviewed papers, book chapters and articles, as well as Natural England science and evidence reports.

Connecting people with nature:

De BELL, S., WHITE, M., GRIFFITHS, A., **DARLOW, A.**, TAYLOR, T., WHEELER, B., & LOVELL, R. 2020. Spending time in the garden is positively associated with health and wellbeing: Results from a national survey in England. *Landscape and Urban Planning* **200**, 2020, 103836, ISSN 0169-2046, https://doi.org/10.1016/j.landurbplan.2020.103836.

MARTIN, L., WHITE, M.P., HUNT, A., RICHARDSON, M., PAHL, S., & **BURT, J.** 2020. Nature contact, nature connectedness and associations with health, wellbeing and pro-environmental behaviours. *Journal of Environmental Psychology*, **68**, art. no. 101389, DOI: 10.1016/j.jenvp.2020.101389

WHITE, P.C.L., GUÉGAN, J.-F., KEUNE, H., De BELL, S., GEIJZENDORFFER, I.R., HERMANS, T., PRIEUR, RICHARD, A.-H., IROEGBU, C., **STONE, D.,** VANWAMBEKE, S., De VRIES, S., FORD, A., & GRAHAM, H. 2020. Integrative policy development for healthier people and ecosystems: A European case analysis. *Area*, **52(3)**, pp. 495-504. DOI: 10.1111/area.12618

Natural England Reports / Commissioned reports

LOVELL, R., WHITE, M.P., WHEELER, B., TAYLOR, T., & ELLIOTT, L. 2020. *A rapid scoping review of health and wellbeing evidence for the Green Infrastructure Standards*. European Centre for Environment and Human Health, University of Exeter Medical School. For: Natural England, Department for the Environment, Food and Rural Affairs, Public Health England, and Ministry for Housing, Communities and Local Government, England.

Monitor of Engagement with the Natural Environment. 2020. *A summary report on nature connectedness among adults and children in England: Analyses of relationships with wellbeing and pro-environmental behaviours*. JP32

The People and Nature Survey for England - Child Questionnaire (PANS002)

Sustainable Development:

ESSAH, E.A., RUSSELL, S.J., WARING, S.D., FERGUSON, J., WILLIAMS, C., **WALSH, K.,** DYER, S., & RAYNOR, R. 2020. Method for evaluating the snagging propensity of roofing membranes in buildings by roosting bats. *Building Research and Information*, **48(8)** pp. 886-898. DOI: 10.1080/09613218.2020.1763773

MULLINEUX, S., SPARKS, R.S.J., **MURPHY, M.D**., MACNIOCAILL, C., BARFOD, D., NAJORKA, J., SCHUMACHER, J.C. 2020. Erratum: Columnar-jointed bentonite below a Doleritic Sill, Tideswell Dale, Derbyshire, UK: Formation during prograde contact metamorphism. *Journal of Physical Chemistry*
DOI: 10.1017/S0016756820000163

MULLINEUX, S., SPARKS, R.S.J., **MURPHY, M.D**., MACNIOCAILL, C., BARFOD, D., NJORKA, J., & SCHUMACHER, J.C. 2020. Columnar-jointed bentonite below a Doleritic Sill, Tideswell Dale, Derbyshire, UK: Formation during prograde contact metamorphism. *Geological Magazine*, **157(7)** pp. 1181-1198.
DOI: 10.1017/S0016756819001535

Natural England Reports / Commissioned reports

SUNDERLAND, T., RICE, P., LORD, A. & TRAILL THOMSON, J.A. 2020. Natural Capital Strategy for North Devon, *Natural England Research Report* number NERR083

LEAR, R., WIGLEY, S., LORD, A., LUSARDI, J., & RICE, P. (2020) Natural Capital Atlases: Mapping Indicators for County and City Regions. *Natural England Commissioned Report* Number NECR318.

COASTAL MARINE APPLIED RESEARCH - UNIVERSITY OF PLYMOUTH. 2020. Westward Ho!: Geomorphological Assessment. *Natural England Commissioned Reports*, Number NECR317.

Resilient landscapes and seas:

ALLEN, S., BANKS, A.N., CALDOW, R.W.G., FRAYLING, T., KERSHAW, M., & ROWELL, H. 2020, Chapter 29 - Developments in understanding of red-throated diver responses to offshore wind farms in marine Special Protection Areas, Editor(s): John Humphreys, Robert W.E. Clark, *Marine Protected Areas*, Elsevier, Pages 573-586, ISBN 9780081026984, https://doi.org/10.1016/B978-0-08-102698-4.00029-0.

ARMBRUSTER, M., GOODALL, T., HIRSCH, P.R., OSTLE, N., PUISSANT, J., **FAGAN, K.C**., PYWELL, R.F., & GRIFFITHS, R.I. 2020. Bacterial and archaeal taxa are reliable indicators of soil restoration across distributed calcareous grasslands. *European Journal of Soil Science*, DOI: 10.1111/ejss.12977

BATEMAN, M.D., MCHALE, K., BAYNTUN, H.J., & **WILLIAMS, N**. 2020. Understanding historical coastal spit evolution: A case study from Spurn, East Yorkshire, UK. *Earth Surface Processes and Landforms*, **45(14)**, pp. 3670-3686. DOI: 10.1002/esp.4991

BUNTING, G., ENGLAND, J., GETHING, K., SYKES, T., **WEBB, J.,** & STUBBINGTON, R. 2020. Aquatic and terrestrial invertebrate community responses to drying in chalk streams. *Water and Environment Journal*, DOI: 10.1111/wej.12621

CREER, J., LITT, E., RATCLIFFE, J., **REES, S.,** THOMAS, N., & SMITH, P. 2020. A comment on some of the conclusions made by Delgado-Fernandez et al. (2019). "Is 'remobilisation' nature conservation or nature destruction? A commentary". *Journal of Coastal Conservation*, **24(3)**, art. no. 29
DOI: 10.1007/s11852-020-00745-9

DAVIES, P., BRITTON, R.J., NUNN, A.D., DODD, J.R., CRUNDWELL, C., **VELTEROP, R**., Ó'MAOILÉIDIGH, N., O'NEILL, R., SHEEHAN, E.V., STAMP, T., & BOLLAND, J.D. 2020. Novel insights into the marine phase and river fidelity of anadromous twaite shad *Alosa fallax* in the UK and Ireland. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **30(7)** pp. 1291-1298. DOI: 0.1002/aqc.3343

DUNN, J.C., MORRIS, A.J., **GRICE, P.V**., & PEACH, W.J. 2020. *Effects of seed-rich habitat provision on territory density, home range and breeding performance of European Turtle Doves* Streptopelia turtur. Bird Conservation International, DOI: 10.1017/S0959270920000635

FUENTES-MONTEMAYOR, E., FERRYMAN, M., WATTS, K., **MACGREGOR, N.A.,** HAMBLY, N., BRENNAN, S., COXON, R., LANGRIDGE, H., PARK, K.J. 2020. Small mammal responses to long-term large-scale woodland creation: the influence of local and landscape-level attributes. *Ecological Applications* **30(2)**, art. no. e02028, DOI: 10.1002/eap.2028

GREEN, B.C. & JOHNSON, C.L.E. 2020. Characterisation of microplastic contamination in sediment of England's inshore waters. *Marine Pollution Bulletin* **151**, art. no. 110788, DOI:10.1016/j.marpolbul.2019.110788

HAWKINS, S.J., O'SHAUGHNESSY, K.A., ADAMS, L.A., LANGSTON, W.J., BRAY, S., ALLEN, J.R., WILKINSON, S., **BOHN, K**., MIESZKOWSKA, N., & FIRTH, L.B. 2020. Recovery of an urbanised estuary: Clean-up, de-industrialisation and restoration of redundant dock-basins in the Mersey. *Marine Pollution Bulletin* **156**, art. no. 111150, DOI: 10.1016/j.marpolbul.2020.111150

LUSARDI, J., SUNDERLAND, T.J., CROWE, A., JACKSON, B.M., JONES, G. 2020. Can process-based modelling and economic valuation of ecosystem services

inform land management policy at a catchment scale? *Land Use Policy* **96** art. no. 104636, DOI: 10.1016/j.landusepol.2020.104636

LIGHTFOOT, P., **SCOTT, C**., & FITZSIMMONS, C. 2020. Using object-based image analysis with multi-temporal aerial imagery and LiDAR to detect change in temperate intertidal habitats. Aquatic Conservation: *Marine and Freshwater Ecosystems* **30(3)** pp. 514-531. DOI: 10.1002/aqc.

MASSIMINO, D., BEALE, C.M., SUGGITT, A.J., **CRICK, H.Q.P., MACGREGOR, N.A**., CARROLL, M.J., MACLEAN, I.M.D., & PEARCE-HIGGINS, J.W. 2020. Can microclimate offer refuge to an upland bird species under climate change? *Landscape Ecology* **35(9)** pp. 1907-1922. DOI: 10.1007/s10980-020-01069-7

MINTER, M., DASMAHAPATRA, K.K., THOMAS, C.D., **MORECROFT, M.D**., TONHASCA, A., SCHMITT, T., SIOZIOS, S., & HILL, J.K. 2020. Past, current, and potential future distributions of unique genetic diversity in a cold-adapted mountain butterfly. *Ecology and Evolution* **10(20)** pp. 11155-11168. DOI: 10.1002/ece3.6755

MITCHELL, L.J., **KOHLER, T**., WHITE, P.C.L., & ARNOLD, K.E. 2020. High interindividual variability in habitat selection and functional habitat relationships in European nightjars over a period of habitat change. *Ecology and Evolution* **10(12)** pp. 5932-5945. DOI: 10.1002/ece3.6331

NELMS, S.E., EYLES, L., GODLEY, B.J., RICHARDSON, P.B., **SELLEY, H**., SOLANDT, J.-L., & WITT, M.J. 2020. Investigating the distribution and regional occurrence of anthropogenic litter in English marine protected areas using 25 years of citizen-science beach clean data. *Environmental Pollution* **263** art. no. 114365 DOI: 10.1016/j.envpol.2020.114365

RADBOURNE, A.D., RYVES, D.B., **MADGWICK, G.,** ANDERSON, N.J. 2020. The Influence of Climate Change on the Restoration Trajectory of a Nutrient-Rich Deep Lake. 2020. *Ecosystem*s, **23(4)**, pp. 859-872. DOI: 10.1007/s10021-019-00442-1

RITSON, J.P., ALDERSON, D.M., ROBINSON, C.H., BURKITT, A.E., HEINEMEYER, A., STIMSON, A.G., GALLEGO-SALA, A., HARRIS, A., QUILLET, A., MALIK, A.A., COLE, B., ROBROEK, B.J.M., HEPPELL, C.M., RIVETT, D.W., CHANDLER, D.M., ELLIOTT, D.R., SHUTTLEWORTH, E.L., LILLESKOV, E., COX, F., CLAY, G.D., **DIACK, I.,** ROWSON, J., PRATSCHER, J., LLOYD, J.R., WALKER, J.S., BELYEA, L.R., DUMONT, M.G., LONGDEN, M., BELL, N.G.A., ARTZ, R.R.E., BARDGETT, R.D., GRIFFITHS, R.L., ANDERSEN, R., CHADBURN, S.E., HUTCHINSON, S.M., PAGE, S.E., THOM, T., BURN, W., & EVANS, M.G. 2020. Towards a microbial process-based understanding of the resilience of peatland ecosystem service provisioning – A research agenda. *Science of the Total Environment*, art. no. 143467..DOI: 10.1016/j.scitotenv.2020.143467

STEWART-SINCLAIR, P.J., LAST, K.S., **PAYNE, B.L**., & WILDING, T.A. 2020. A global assessment of the vulnerability of shellfish aquaculture to climate change and ocean acidification. *Ecology and Evolution* **10(7)** pp. 3518-3534 DOI: 10.1002/ece3.6149

VYE, S.R., DICKENS, S., ADAMS, L., **BOHN, K.,** CHENERY, J., DOBSON, N., DUNN, R.E., EARP, H.S., EVANS, M., FOSTER, C., GRIST, H., HOLT, B., HULL, S., JENKINS, S.R., LAMONT, P., LONG, S., MIESZKOWSKA, N., MILLARD, J., MORRALL, Z., PACK, K., PARRY-WILSON, H., POCKLINGTON, J., POTTAS, J., RICHARDSON, L., SCOTT, A., SUGDEN, H., WATSON, G., WEST, V., WINTON, D., DELANY, J., & BURROWS, M.T. 2020. Patterns of abundance across geographical ranges as a predictor for responses to climate change: Evidence from UK rocky shores. *Diversity and Distributions* **26(10)** pp. 1357-1365. DOI: 10.1111/ddi.13118

VAUGHAN. D. & AGARDY,T. 2020. Chapter 2 - Marine protected areas and marine spatial planning - allocation of resource use and environmental protection. Editor(s): John Humphreys, Robert W.E. Clark, *Marine Protected Areas*, Elsevier, Pages 13-35. https://doi.org/10.1016/B978-0-08-102698-4.00002-2.

WAGGITT, J.J., EVANS, P.G.H., ANDRADE, J., **BANKS, A.N**., BOISSEAU, O., BOLTON, M., BRADBURY, G., BRERETON, T., CAMPHUYSEN, C.J., DURINCK, J., FELCE, T., FIJN, R.C., GARCIA-BARON, I., GARTHE, S., GEELHOED, S.C.V., GILLES, A., GOODALL, M., HAELTERS, J., HAMILTON, S., HARTNY-MILLS, L., HODGINS, N., JAMES, K., JESSOPP, M., KAVANAGH, A.S., LEOPOLD, M., LOHRENGEL, K., LOUZAO, M., MARKONES, N., MARTÍNEZ-CEDEIRA, J., Ó CADHLA, O., PERRY, S.L., PIERCE, G.J., RIDOUX, V., ROBINSON, K.P., SANTOS, M.B., SAAVEDRA, C., SKOV, H., STIENEN, E.W.M., SVEEGAARD, S., THOMPSON, P., VANERMEN, N., WALL, D., WEBB, A., WILSON, J., WANLESS, S., & HIDDINK, J.G. 2020. Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology*, **57(2)**, pp. 253-269. DOI: 10.1111/1365-2664.13525

WILKES, M.A., EDWARDS, F., JONES, J.I., MURPHY, J.F., ENGLAND, J., FRIBERG, N., HERING, D., POFF, N.L., USSEGLIO-POLATERA, P., VERBERK, W.C.E.P., **WEBB, J.,** BROWN, L.E. 2020. Trait-based ecology at large scales: Assessing functional trait correlations, phylogenetic constraints and spatial variability using open data. *Global Change Biology*, **26(12)**, pp. 7255-7267

WILSON, L.J., RENDELL-READ, S., LOCK, L., **DREWITT, A.L**., BOLTON, M. 2020. Effectiveness of a five-year project of intensive, regional-scale, coordinated management for little terns *Sternula albifrons* across the major UK colonies. *Journal for Nature Conservation*, 53, art. no. 125779. DOI: 10.1016/j.jnc.2019.125779

WORRALL, F., BOOTHROYD, I.M., HOWDEN, N.J.K., BURT, T.P., **KOHLER, T., GREGG, R**. 2020. Are peatlands cool humid islands in a landscape? *Hydrological Processes*, **34(25)**, pp. 5013-5025.

Natural England Reports/Commissioned reports

2020. The Economic Benefits Supported by Land Management – A Case Study of Shapwick Heath National Nature Reserve. *Natural England Research Report* NERR084.

HILLMAN, R. 2020. Habitat mapping and monitoring of Allis shad (*Alosa alosa*) on the River Tamar. *Natural England Research Report* NERR1947.

Natural England Evidence Statement Regarding Kittiwake Count Data Used to Classify the Flamborough Head & Bempton Cliffs SPA. *Natural England Evidence Information Note E*IN050 First edition 3 November 2020

MACLEAN IMD, SUGGITT AJ, GREENWOOD O, WILSON RJ, DUFFY JP, HOPKINS JJ, LAWSON CCR AND BENNIE JJ. 2020. Recent evidence from the Lizard Peninsula for the existence of microrefugia. *Natural England Commissioned Report* NECR279

WIGLEY, S., PALING, N., RICE, P., LORD, A., & LUSARDI, J. 2020. National Natural Capital Atlas, *Natural England Commissioned Report* Number 285.

LANE, S.A. 2020. A review of the status of the beetles of Great Britain – The Silphidae (Carrion Beetles). *Natural England Commissioned Reports* NECR316

Greener farming and fisheries

ASHBY, M.A., WHYATT, J.D., **ROGERS, K**., MARRS, R.H., STEVENS, C.J. 2020. Quantifying the recent expansion of native invasive rush species in a UK upland environment. *Annals of Applied Biology* **177(2)**, pp. 243-255. DOI: 10.1111/aab.12602

BABATUNDE, D., POMEROY, S., LEPPER, P., CLARK, B., **WALKER, R**. 2020. Autonomous deployment of underwater acoustic monitoring devices using an unmanned aerial vehicle: The flying hydrophone. *Sensors (Switzerland)*, **20(21)**, art. no. 6064, pp. 1-21.

BOND, S., KIRKBY, M.J., **JOHNSTON, J., CROWLE**, A., HOLDEN, J. 2020. Seasonal vegetation and management influence overland flow velocity and roughness in upland grasslands. *Hydrological Processes* **34(18)**, pp. 3777-3791. DOI: 10.1002/hyp.13842

BURTON, S. 2020. Chapter 24 - Marine protected areas - the importance of positive partnerships and stakeholder engagement for delivering environmental outcomes in an estuary, Editor(s): John Humphreys, Robert W.E. Clark, *Marine Protected Areas,* Elsevier, Pages 475-488. https://doi.org/10.1016/B978-0-08-102698-4.00024-1.

CALDOW, R.W.G, MARTIN R. PERROW. M.R., ALLEN, D., BLACK, J., BOND, I., HARWOOD, A., LILEY, D., MCCULLOCH, N., MURPHY, M., WIN, I., YATES, L. 2020. Chapter 28 - Verifying predictions of statistical models to define the size and shape of marine Special Protection Areas for foraging seabirds (terns), Editor(s): John Humphreys, Robert W.E. Clark, *Marine Protected Areas*, Elsevier, Pages 543-572, https://doi.org/10.1016/B978-0-08-102698-4.00028-9.

GRIFFIN, R.A., JONES, R.E., LOUGH, N.E.L., LINDENBAUM, C.P., **ALVAREZ, M.C.,** CLARK, K.A.J., GRIFFITHS, J.D., CLABBURN, P.A.T. 2020. Effectiveness of acoustic cameras as tools for assessing biogenic structures formed by Sabellaria in highly turbid environments. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **30(6)**, pp. 1121-1136. DOI: 10.1002/aqc.3313

MORECROFT, M.D., DUFFIELD, S., HARLEY, M., PEARCE HIGGINS, J.W., STEVENS, N., WATTS, O., WHITAKER, J. 2020. Agricultural lands key to mitigation and adaptation - Response. *Science*, **367(6477)**, p. 518. DOI: 10.1126/science.aba7577

Natural England Reports / Commissioned reports

BROWN, E. 2020. Agri-Environment Evidence Annual Report 2018/19: A summary of findings from recently published projects. *Natural England Research Reports* Number 085.

TIBBITT, F., LOVE, J., WRIGHT, J., & CHAMBERLAIN, J. 2020. Human Impacts on Cromer Shoal Chalk Beds MCZ: Chalk complexity and population dynamics of commercial crustaceans. *Natural England Research Report* NERR04412.

Assessment of the Condition of Features in Marine Protected Areas. *Natural England Technical Information Note* Date: December 2020 Version: TIN178

GLAVES, D.J., CROWLE, A.J.W., BRUEMMER, C. & LENAGHAN, S.A. 2020. The causes and prevention of wildfire on heathlands and peatlands in England. *Natural England Evidence Review* NEER014.

MADDEN J.R. & SAGE, R.B. 2020. Ecological Consequences of Gamebird Releasing and Management on Lowland Shoots in England: A Review by Rapid Evidence Assessment for Natural England and the British Association of Shooting and Conservation. *Natural England Evidence Review* NEER016.

CHISWELL, H., REED, M., LEWIS, N., SKAALSVEEN, K., CUSWORTH, G., SHORT, C. & LEAKE, B. 2020. ELM guidance digital media research: Literature review and behavioural analysis. *Natural England Commissioned Report* NECR288

SAYER, S; MILLWARD, S. & WITT, M. 2020. Monitoring grey seal (*Halichoerus grypus*) pupping sites in Cornwall 2019/2020. *Natural England Commissioned Report* NECR322

Science and evidence:

EVERARD, M., **KASS**, G., LONGHURST, J., ZU ERMGASSEN, S., GIRARDET, H., STEWART-EVANS, J., WENTWORTH, J., AUSTIN, K., DWYER, C., FISH, R., JOHNSTON P., MANTLEK, G., STADDON, C., TICKNERL, D., SPODE, S., VALE, J., JARVIS, R., DIGBY, M., WREN, G., **SUNDERLAND, T., & CRAIG, A.** 2020, Reconnecting society with its ecological roots Environmental Science and Policy 116 (2021) 8–19

FORLIN, V., **SCHOLZ, E.-M.** 2020. Strategic take-back programs when consumers have heterogeneous environmental preferences. *Resource and Energy Economics* **60** Art. Nº 101150. DOI: 10.1016/j.reseneeco.2020.101150

SCHULTZ, C.L., **ADAMS, J**., JURKSCHAT, K., LOFTS, S., & SPURGEON, D.J. 2020. Chemical transformation and surface functionalisation affect the potential to group nanoparticles for risk assessment. *Environmental Science: Nano* **7(10)** pp. 3100-3107. DOI: 10.1039/d0en00578a

HILL, T., STONE, D., & STEVENSON, N.M. (Eds) 2020. *Natural England Chief Scientist Report 2019: Monitoring and indicators.* Natural England Report NE759.

SUTHERLAND, W.J., DIAS, M.P., DICKS, L.V., **DORAN, H**., ENTWISTLE, A.C., FLEISHMAN, E., GIBBONS, D.W., HAILS, R., HUGHES, A.C., HUGHES, J., KELMAN, R., LE ROUX, X., LEANSTEY, B., LICKORISH, F.A., MAGGS, L., PEARCE-HIGGINS, J.W., PECK, L.S., PETTORELLI, N., PRETTY, J., SPALDING, M.D., TONNEIJCK, F.H., WENTWORTH, J., & THORNTON, A. 2020. A Horizon Scan of Emerging Global Biological Conservation Issues for 2020*. Trends in Ecology and Evolution* **35(1)** pp. 81-90. DOI: 10.1016/j.tree.2019.10.010

WATTS, K., WHYTOCK, R.C., PARK, K.J., FUENTES-MONTEMAYOR, E., **MACGREGOR, N.A., DUFFIELD, S.,** & MCGOWAN, P.J.K. 2020. Ecological time lags and the journey towards conservation success. *Nature Ecology and Evolution* **4(3)** pp. 304-311. DOI: 10.1038/s41559-019-1087-8

Natural England Reports/Commissioned reports

CLUTTERBUCK, B., LINDSAY, R, CHICO, G., & CLOUGH, J. 2020. Hard Hill experimental plots on Moor House – Upper Teesdale National Nature Reserve. A review of the experimental set up. *Natural England Commissioned Report* NECR321.

TROTH, C. 2020. Field testing of eDNA technologies to detect populations of non-native crayfish in Cumbria rivers. *Natural England Commissioned Report* NECR326.

MACADAM, C., ROBINS, J. & THOMSON, T. 2020. 2020 Gap Analysis of the BOLD Database for Key English Invertebrates, *Natural England Commissioned Report* NECR324

MYNOTT, S., & MARSH, M. 2020. Development of a novel (DNA-based) method for monitoring inshore fish communities using a programmable large-volume marine eDNA sampler. *Natural England Commissioned Report* NECR330

SELLERS., G.S. & HÄNFLING, B. 2020. Meta-analysis of eDNA metabarcoding data from UK lakes: optimising species detection probability and sampling effort. *Natural England Commissioned Report* NECR 325

PRICE, B., BRISCOE, A., MISRA, R., & BROAD, G. 2020. DEFRA Centre of Excellence for DNA Methods: Evaluation of DNA barcode libraries used in the UK and developing an action plan to fill priority gaps. *Natural England Joint Publication* JP035

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