Natural England Chief Scientist Report 2021: Using best available evidence to inform and update our conservation practice

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NATURAL ENGLAND

Contents

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Foreword

The mission for Natural England's Chief Scientist Directorate, is to 'develop evidence and provide scientific advice to drive decision-making for nature recovery'.

We want to continuously uphold a science and evidence infrastructure that is cross-cutting and accessible, providing services across the organisation and beyond that is capable of supporting innovative investigations and experimentation. Using the *best available evidence* enables everyone to integrate more science and evidence into their work and be confident to use the data available.

Action for nature's recovery needs to be evidence-led and the hugely impressive diversity of work described in this report illustrates the key role played by Natural England in environmental and conservation science.

This Chief Scientist Report describes just a few of the many examples where the best available evidence has been applied across the wide breadth and depth of science and evidence in Natural England. For example, the contribution of heathland mapping in defining Favourable Conservation Status of wet and dry heath within National Character Areas. This mapping project will help further refine our understanding of the distribution and relationship of these two habitats across England, and also how we manage and/or restore them to natural function.

I am extremely lucky in my role as Chair of Natural England's Science Advisory Committee (NESAC) that I get to see first-hand the high quality science and evidence that Natural England produces. NESAC is a formal committee of Natural England's Board, which involves highly respected, multi-disciplinary external academics that supports, challenges and oversees the quality of evidence produced within the Chief Scientist Directorate. I have been privileged to work with so many of our evidence and specialist staff over the years, who make all of this possible and whose contributions ensure our reputation.

Nature's recovery is dependent on knowing its current state, the trends that put it there, understanding pressures that are causing change and addressing them through *informed* action. That is why this fourth Chief Scientist Report is focussing on the use of the best available evidence to inform our options and priorities, direct our decisions and shape our delivery.

Dr Andy Clements

Natural England Board Member, Chair of Natural England Science Advisory Committee (NESAC)

Welcome and Introduction

Welcome to Natural England's fourth Chief Scientist Report. My first report shone a spotlight on the breadth and depth of our science & evidence work and showed how it underpins and supports all of our work. In my second report, I 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. My third report highlighted the research and collaboration we have been using – and continue to use - in developing our evidence base.

This, my fourth report, demonstrates the use of the *best available evidence* to inform and update our conservation practice.

The report celebrates our science and evidence, and highlights the science and evidence professionalism, the innovation and the expertise of our organisation. We have specialists in many fields, from environmental DNA to chemical and pesticide biomonitoring, and from social and economic science to earth observation, to name but a few. We are at the forefront of our field and are open and transparent about our science and evidence. This signals our maturity and confidence as an organisation that is building trust and making the right decisions for nature's recovery and people's enjoyment of it.

The introduction of our Science Evidence and Evaluation Strategy in 2020 indicated our determination to move Natural England from being evidence-based to one which is evidence-led – where we use evidence up front to inform our options and priorities, direct our decisions and shape our delivery. The quality of our advice and actions and the legality of our decisions, fundamentally depend upon our use and understanding of the evidence base – from understanding how and why the natural world is changing, to identifying and enhancing areas of high environmental value, to advising on the design of agri-environment schemes, and on creating opportunities for people and nature to thrive. Science and evidence are vital to the delivery of environmental outcomes.

Fostering a culture where the use of high quality science and evidence is celebrated and is at the heart of what we do and we do it, is key to the delivery of Natural England's vision of 'Thriving Nature for people and planet'.

I do hope you enjoy the report.

Dr Tim Hill MIEnvSc MIoD
Chief Scientist, Natural England March 2022

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

Mapping Heathland

Alistair Crowle, David Glaves, Frances McCullagh, Sally Mousley

Heathland is a habitat that is found across England often separated into upland and lowland types. This separation is an historical one based partly upon the perceived management issues that can prevail between the uplands and lowlands and also due to some differences in vegetation communities and associated species, especially at the altitude extremes, though there is much overlap. Upland heathland occurs above the level of agricultural enclosure typically above 250m AOD. In a European context, the UK holds slightly over 18% of the total heath resource, which is a habitat, in global terms, that is largely restricted to Europe. In England, there is approximately 2161 Km^2 of heathland which makes up around 0.11% of the European total.

The term “heathland” includes a range of acidic vegetation communities that are dominated by dwarf shrub heath species, particularly Heather *Calluna vulgaris*. Some of these communities are restricted by altitude, only occurring in England on some of the Lake District Fells and the North Pennines, whilst others only occur in the dry, warm, continental conditions of south-west and south-east of England. Some differences are driven by availability of water or numbers of frost days, but many of the differences in communities are driven by anthropogenic activity. Wet and dry heath type habitats are significantly different and are separate Annex 1 habitats under the European Habitats and Species Directive.

Heathland was one of the habitats selected for inclusion within the Defining Favourable Conservation Status project and this provided an obvious opportunity for re-visiting how we treat this habitat in terms of its geographic distribution. Initially, the approach was to continue with the separation of upland and lowland types whilst drawing up Favourable Conservation Status Definitions and some work was commissioned to investigate the occurrence and distribution of these habitats. The upland heath findings were significant, indicating that most of the habitat generally thought of as dry heath was actually on shallow peat and that the bulk of the resource of this habitat should be regarded as wet heath. Areas of heath-type vegetation on deeper peat should be regarded as degraded blanket bog. As we move out of the pandemic restrictions, we will be able to ground-truth some of this newly mapped data.

The presence of peat is significant as it tells us about how the heath formed and importantly, how it should be managed. Dry heath is often burned, cut or grazed to prevent succession to woodland whereas burning wet heath leads to a loss of the key plant species such as Cross-leaved Heath *Erica tetralix* and *Sphagnum* bog-mosses. Burning of vegetation on peat also leads to drying of peat and associated loss of function and carbon. Many of our lowland heaths including much of the New Forest, Dorset, Surrey and Cornwall also occur on shallow peats and there is concern that there will be an increasing tendency to rely on burning as a

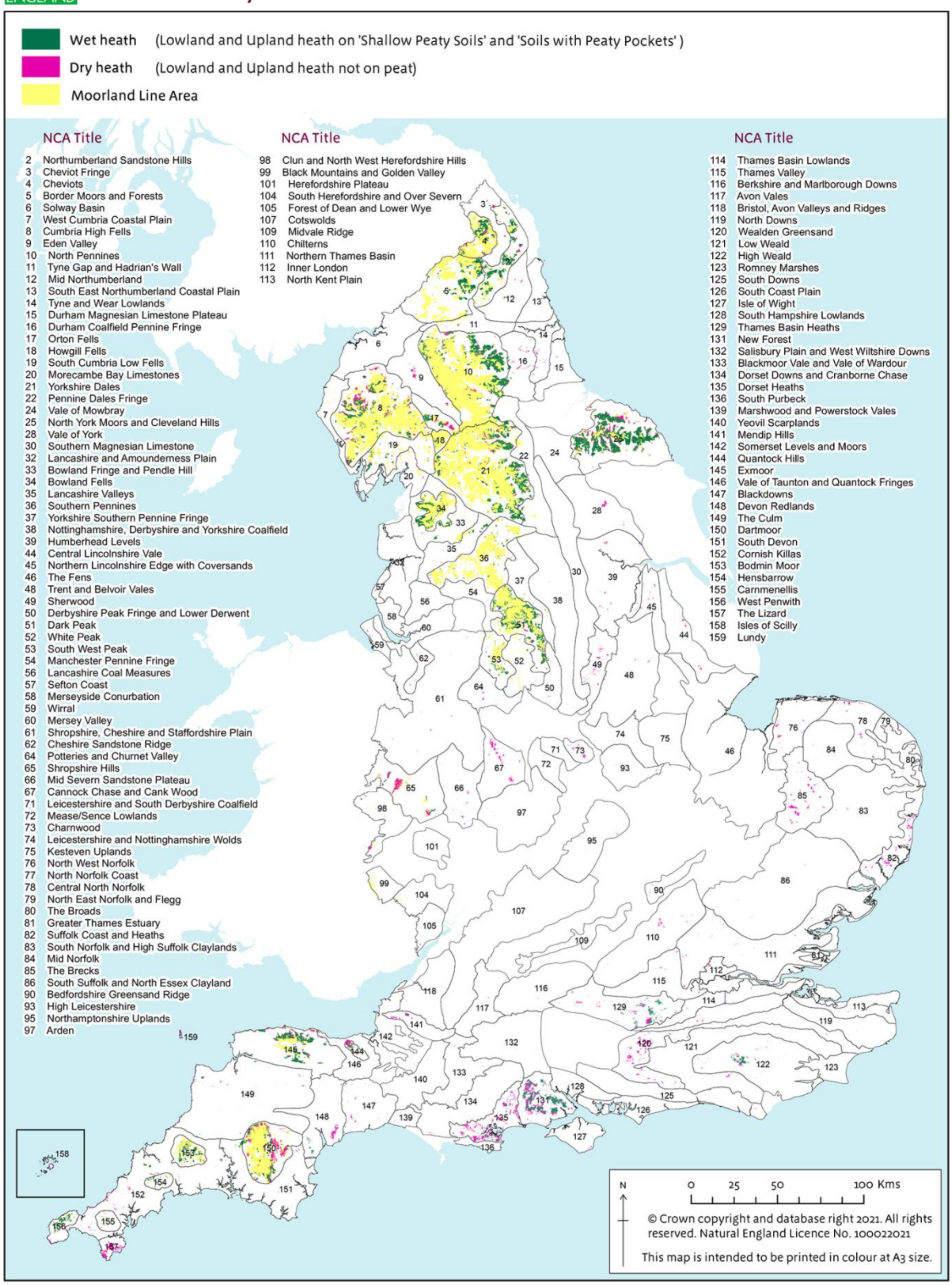
management tool, particularly where traditional grazing management becomes more difficult.

There is considerable overlap between the heath National Vegetation Communities with only a few relatively restricted communities occurring only in either the uplands or the lowlands. Similarly, the mapping of habitats within the upland and lowland Priority Habitat Inventory has led to a number of anomalies, such as different use of altitude to separate upland and lowland, with some sites sitting across the transition from lowland to upland. The new maps will help with delivering the objective of restoring natural function to degraded habitats on shallow peat soils.

Although we will now be viewing the heathland resource of England in its entirety there will still be a need to acknowledge that there can be differences in management between upland and lowland on a site or regional basis, so that restoration and management actions will need to be planned accordingly. Peat is a topical subject with major projects underway aimed at mapping and restoring this globally rare habitat. Wet heath is a peatland habitat which often occurs on the fringes of blanket bog and the peat mapping project will help further refine our understanding of the distribution and relationship of these two habitats across England.

Defining Favourable Conservation Status

Wet heath and dry heath within National Character Areas



Spotlight on…

Bob Middleton

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

My background is in the management of the Historic Environment, inspired by visits to Stonehenge and the monuments across the surrounding landscape. I was fascinated by the mixture of farming and archaeology, most of which wasn't at that stage explained, certainly to my 8-year old self. Later in life I was involved in a long-term project surveying the wetlands of NW England for their archaeological potential. A big part of this was identifying prehistoric sites emerging from remnant farmland peat, which led to discussions of how to preserve or at least improve their management from intensive arable. What was the answer? Agri-environment schemes which led to me joining FRCA (NE predecessor) as an Historic Environment adviser.

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

Principal Adviser, Catchment Sensitive Farming. My substantive role is to manage the Catchment Sensitive Farming programme, an NE-led partnership with Environment Agency and Defra delivering a wide range of 25-year plan outcomes through working with farmers and land managers. I work closely with teams across Natural England and with partners to make sure we deliver a service that encourages farmers to be ambitious to benefit the environment and their businesses.

How does science and evidence inform what you do?

Science and evidence are fundamental to the progress of CSF from a modest experimental project in 2006 to a national, established farm advice offer in 2021. This starts with evidence to inform the targeting of our work at national, catchment and farm level to ensure focus on the core issues across water and air quality and flood risk management. Secondly, CSF farm advisers have a wide range of evidence tools, pulled together into an Evidence Prospectus, which helps them plan catchment campaigns and to assess the issues on-farm to help shape the conversations with land managers about environmental priorities and what actions the farmer can take to address them.

Lastly, all CSF work is evaluated so we have a clear understanding of the benefits of our work. This is underpinned by a logic model that describes the complex links between activities and the resulting environmental improvements. This published work describes in detail how farmer engagement results in improvement in land management understanding of the issues and what they can do about them, which then leads to actions and outcomes. This work also allows us to understand what works to get the greatest outcomes and how we need to improve to maximise these opportunities. Science and evidence are therefore fundamental to the success of CSF's work.

Blue carbon: mapping risks and opportunities

Maija Marsh, Jess Elias and Ginny Swaile

Coastal and marine ecosystems play a crucial role in climate change and the global carbon cycle, with natural processes both removing and releasing carbon dioxide from or to the atmosphere. The term ‘blue carbon’ refers to the carbon accumulated in marine habitats and, if left undisturbed, it can be stored within the vegetative parts and sediments over long timescales.

The role of the marine environment in climate change mitigation and adaptation is gaining focus internationally and enhancement of blue carbon accumulation rates and stocks within marine habitats has become a priority alongside reduction of greenhouse gases. However, human activities can disturb and reduce the quality and extent of marine habitats, limiting their ability to accumulate and store carbon, and can even result in elevated carbon emissions. There has been significant loss of coastal habitats over the last century as a result of pollution, sea level rise, disease, urbanisation and industrial development around estuaries and the coastal hinterland, with only 10% of the historic extent remaining.

In January 2022, Natural England published a new report assessing the extent and distribution of blue carbon habitats in English waters, and the associated carbon stocks and accumulation rates, based on the best available evidence. The potential for recovery and restoration of coastal blue carbon habitats was also explored, alongside some key pressures that are driving habitat loss and inhibiting recovery, to identify opportunities for enhancing carbon storage. The work was funded by Defra and carried out by a team of marine staff across specialist and evidence services.

The report is now available here:

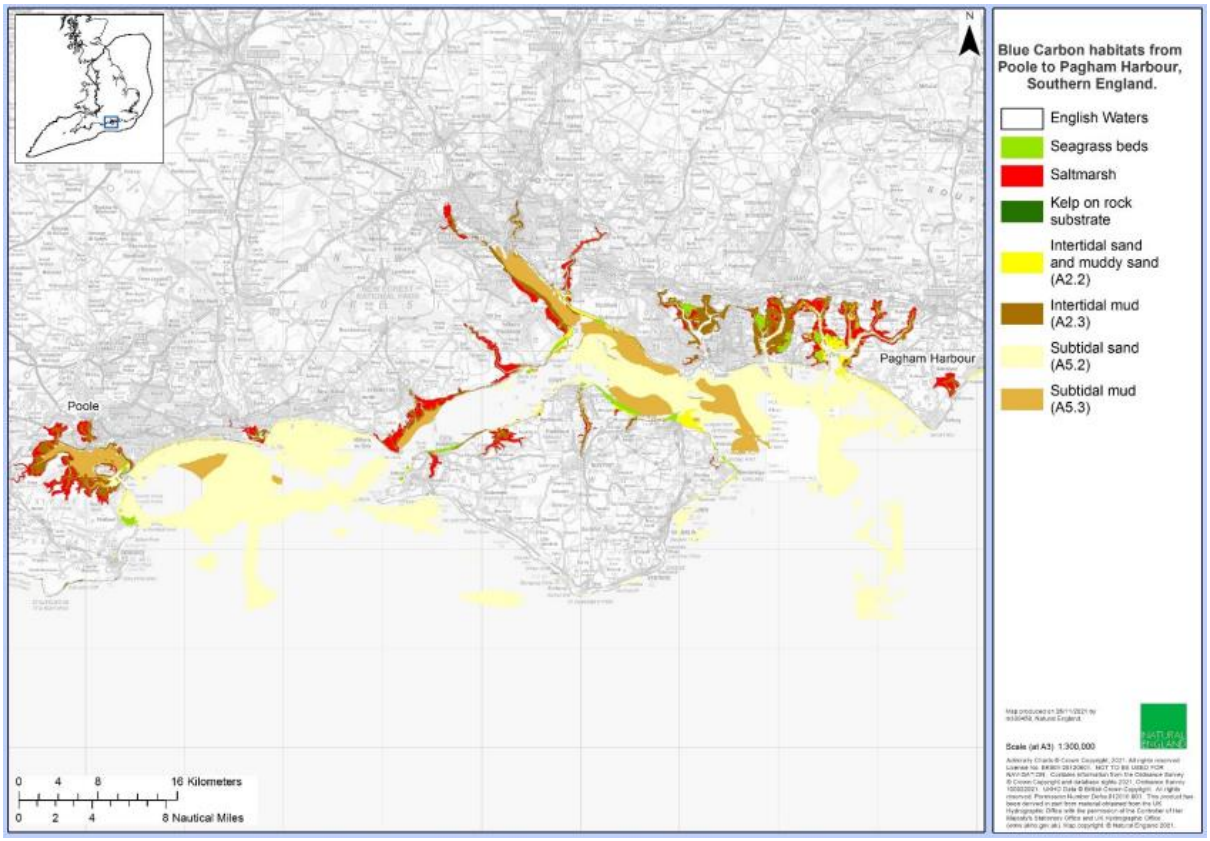
http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=20827

Key messages from the report

- Coastal blue carbon habitats (saltmarsh, intertidal mud and seagrass) are the richest in terms of carbon accumulation rates and storage per unit area, but the largest total stocks are held in the subtidal sediments, due to their vast habitat extents.
- Despite significant historic losses of all habitats, there is potential for restoration and recovery in terms of suitable areas based on physical parameters: up to twice the extent of saltmarsh and up to four times the extent of seagrass.
- Improving the quality of existing habitats to maximise their capacity for carbon accumulation and restoring mosaics of habitats together rather than singe habitats in isolation will optimise carbon storage and minimise loss, while creating greater resilience to climate change and other ecosystem benefits.
- Restoration efforts are only likely to succeed once the relevant pressures have been removed or reduced to a level where they no longer inhibit the recovery and functioning of the habitats. Whist a large proportion of the habitats assessed are already within protected areas, management measures to reduce or eliminate a range of pressures are required, both in the marine environment and on land.
- Dissolved inorganic nitrogen is elevated (categorised as ‘moderate classification status’) around large parts of the coast, particularly within the estuaries and shallow inlets and bays which coincides with the locations of many of the coastal blue carbon habitats. It is recommended that for catchments where nutrients have been identified as a significant pressure and cause of unfavourable condition in MPAs, plans to reduce nutrient loadings would have significant synergy with objectives to improve soil health and mitigate climate change on land and should be explored as strategic nature-based solutions.
- For blue carbon habitats that are subtidal and further away from the coast, physical intervention to create habitat becomes less viable and in the main,

and removing anthropogenic pressures is the key action required to allow natural processes to resume and the blue carbon habitats to recover naturally.

- The widespread nature and variability in the limited data available makes improving the evidence base around carbon stocks essential for evidence-led prioritisation of areas for protection.



Next steps

There is a need to continue this work, further refining the evidence base on carbon stocks and fluxes and understanding how and where habitat restoration and enhancement will have the most value, for carbon storage, climate change adaptation and biodiversity gain. Looking at the transport of carbon from land to sea and also within marine food webs is critical to understanding how wider marine restoration and more sustainable management of activities could impact on the overall carbon cycle.

Working in partnership with others in the Defra family and with academics, we will explore these areas via a suite of small independent projects and work within the marine Natural Capital and Ecosystem Assessment project. We have already begun looking at changes to embodied carbon within food chains using ecosystem modelling and a natural capital approach to valuing the benefits of different fisheries management scenarios in both monetary and non-monetary ways. This evidence will be used to inform a number of policy areas including marine protected area management, fisheries management, climate change adaptation and mitigation.

Spotlight on…

Katie Finkill-Coombs

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

Growing up I attended a small primary school in rural Leicestershire, I remember really enjoying learning about nature and the life cycles of animals. Part of the school playing field was being turned into a ‘nature area’ in which we helped to create a wildflower meadow and a small pond. One sunny day the class went out to do some pond dipping, I remember being amazed at seeing the number of tadpoles and biodiversity in the pond we’d created just the previous year. Since then, it’s stuck with me how important it is to provide new habitats, no matter the size or scale and our role in helping natures recovery. Of course, my role now focuses on restoring and creating new habitats across a landscape scale, but I think the seeds were sown at a very young age.

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

I’m a Senior Adviser working on Local Nature Recovery Strategies (LNRS) in the Cheshire to Lancashire Area Team. Over the years I’ve built strong relationships with a wide range of stakeholders and partners. Whilst building and developing these relationships I’ve managed to bring together a wide range of communities and partnerships to help establish a locally led, shared plan for nature recovery. It’s exciting to be working on something which will deliver new and ambitious opportunities to benefit biodiversity and the wider environment.

How does science and evidence inform what you do?

I’ve worked in several different roles at Natural England over the last decade, and science and evidence has been fundamental in all roles and enabled me to feel confident in my decision-making. Science and evidence will be the very foundation for the creation of LNRS which will need to be developed with an evidence-led approach. Whilst the challenges are many, I’m lucky enough to work for such an organisation where science and evidence is rightly held front and centre as the cornerstone on which we can rely.

A new national categorisation system for maerl bed habitats

Dr Magnus Axelsson

Maerl forms unique marine habitats that typically support highly diverse assemblages of species but also harbours rare and endemic taxa, analogous to coral reefs. Recent research has furthermore shown discrete maerl beds to be genetically unique, further illustrating the importance of these habitats.

What is maerl?

Maerl is the common and collective term used for several free-living, unattached coralline red algae species including: *Phymatolithon calcareum, Lithothamnion corallioides, Lithothamnion glaciale* and *Lithophyllum fasciculatum.*

Why is maerl important?

In addition to be being unique habitats, maerl beds create architecturally complex and heterogenous habitats, which typically exhibit high benthic biodiversity and biomass. These habitats harbour high densities of broodstock bivalves and act as nursery areas for the juvenile stages of many commercial species such as cod (*Gadus morhua*), brown crab (*Cancer pagurus*) and queen scallops (*Aequipecten opercularis*), which are attracted to the complex three-dimensional substratum structure. However, as all maerl habitat forming species are ecologically fragile due to slow growth and recovery rates, the loss of the maerl taxa would result in the concurrent loss of the habitat.

Need for a categorisation system

There is currently no standardised categorisation system for maerl bed habitats in England or indeed the United Kingdom. Maerl is included in the Marine Habitat Classification (MHC) system, but this does not encompass all aspects of the different UK maerl bed habitats.

Various maerl bed definitions have been developed over the years, but these are all site-specific and not applicable for use at a national level. The lack of a national system has furthermore resulted in challenges with field work, analysis, mapping and designations as not all actual or potential maerl habitats have been recorded. A new universal categorisation system would provide more detailed information, help the mapping of maerl as well as improve the underlying evidence for designations and ongoing protection. We have developed a standard, easy-to-use classification system in the hope that it will be adopted by partners and in the other UK agencies to promote consistency in identifying the different types of maerl habitat.

Factors to consider when developing a new system

In creating the new maerl bed habitat classification system (MBHCS), a number of parameters and factors have to be considered including habitat physical size, maerl percentage cover, architectural complexity (3D / 2D), percentages of live and dead maerl, and the type of dominant substratum, but the system also needs to be relatively simple to enable analysis, mapping and reporting.

The categorisation system

The new national categorisation system has been organised in such a way that new categories and groups can easily be added to expand the system, as our understanding of maerl bed grows. There are currently five categories with a number of different subgroups in each (see summary table 1). The system was developed with reference to the OSPAR, MHC and other national and international definitions of maerl beds in terms of physical size and percentage cover but it was also based on two decades of working with maerl (e.g., analysing seabed footage, scuba-diving surveys) and developing several site-specific definitions to describe particular beds.

Summary table 1. A categorisation system for maerl bed habitats in England (from Axelsson, in prep).

Category	Group	Maerl bed habitat	Physical size	Structure	% cover	Live/dead	Substratum
A	1	**Dense Maerl** 'live & dead'	≥25m^2	3D; raised; ≥10cm depth	≥20%	≥5% live	Maerl
	2	**Dense Maerl** 'dead'	≥25m^2	3D; raised; ≥10cm depth	≥20%	0% live ≥20% dead	Maerl
	3	**Dense Maerl** 'live & dead'	<25m^2	3D; raised; ≥10cm depth	≥20%	≥5% live	Maerl
B	1	**Maerl Sediment** 'live and dead'	≥25m^2	3D / 2D	≥5% ≤20%	5% Live and dead	Gravel, sand, mud, mixed
	2	**Maerl Sediment** 'dead'	≥25m^2	2D	≥5% ≤20%	Dead	Gravel, sand, mud, mixed
	3	**Maerl Sediment** 'live and dead'	Patchy	2D	≥5% ≤20%	5% Live and dead	Gravel, sand, mud, mixed
C	1	**Sparse Maerl** 'live and dead'	Sparse	2D	<5% ≥1%	Live and/or dead	Gravel, sand, mud, mixed
	2	**Scattered Maerl** 'live and dead'	Scattered	2D	<1%	Live and/or dead	Gravel, sand, mud, mixed
D	1	**Maerl Veneer** Live and dead, static	≥25m^2	2D	≥20%	≥5% live	Rock
	2	**Maerl Veneer** Live and dead, mobile	≥25m^2	2D	≥20%	≥5% live	Rock
	3	**Maerl Veneer** 'live and dead, static'	Patchy	2D	≥5% ≤20%	≥5% live	Rock

E	1	**Potential Maerl**	Lacking detail		Lacking detail	Live and/or dead	Any suitable, near horizontal

The future

The vision with the new maerl bed habitat classification system (MBHCS) is for it to be used in parallel with the MHC rather than replace the current maerl biotopes. We hope that MBHCS can be coordinated at the UK level, sitting alongside the definitions of *Sabellaria* and stony reef.

Spotlight on…

Naomi Oakley

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

I moved to a new rural school at six years old and my most vivid memory was of the 'Village Nature Table', which consisted of an assortment of amazing bits and pieces from our parish brought together for the pupils. Our teachers were keen naturalists, and my favourite lesson was story time when a child would choose an object and the teacher would tell us about it - from bird distributions to the lifecycles of fungi. I loved the sense of wonder about the place where I lived and its connectedness into the wider natural world.

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

I am a Principal Adviser in the Peatland Team in Strategy and Government Advice. My particular work areas are uplands, common land, livestock farming and peatlands. My work currently focuses on the implementation of the England Peat Action Plan. I contribute to the development of new agri-environment schemes for the uplands and common land. I am also involved in the Horizon 2020 WaterLANDS Project which is looking at best practice in wetland management across Europe.

Out of work, my husband and I run an organic, regenerative upland farm on Dartmoor where we use hardy breeds to graze our archaeology and wetlands.

How does science and evidence inform what you do?

Our science and evidence sits at the very core of my work, it justifies investment of public money on the achievement of environmental outcomes. Most importantly for me it allows me to make hard decisions based on peer reviewed evidence that I can share and explain to others. I have a growing interest in social science and this more qualitative side is really helpful when I think about achieving sticky outcomes, so not just for today but for the future too.

I use evidence in my home life too, adjusting our farm business model to have many less, but better suited, livestock, reducing our costs and adding value at every opportunity.

Taking an evidence-led approach to delivery of Government's tree target

Clare Pinches

The ambition to increase tree and woodland cover in England from 14% to 17% by 2050, and to more than treble planting rates within the next few years represents a prominent component of Government's net zero plan. As well as enhancing carbon storage and sequestration new woodlands and trees have a pivotal role to play in supporting the recovery of nature, injecting much needed structural complexity into our landscapes. However, where and how we establish these new wooded habitats and trees profoundly influences their value for carbon, nature and the delivery of the wide range of other public benefits sought from so significant a land use change.

Using the best available evidence is fundamental to ensuring the development of effective policy and regulation, to integrate many more trees into our landscapes, and to the design of appropriate incentive measures and guidance. Natural England have taken a proactive and fully evidence led approach in all our work in this area. By doing so, and working with Defra, Forestry Commission (FC), Forest Research (FR) and other partners, we are helping to ensure we realise the ambition of right tree, right place, established in the right way and for the right reason.

An important strand of this work is improving the reliability and accessibility of environmental data to inform decision making. This recognises the need to be clear sighted on where existing nature-rich habitat and important populations of rare and declining species are within our landscapes. In partnership with the Botanical Society of Britain and Ireland (BSBI) we have developed botanical heatmaps. These use the high-quality citizen science plant records collected by BSBI volunteers to identify areas of high botanical value which may not be captured on our Priority Habitat Inventories, so ensuring these can be considered when assessing the suitability of sites for tree planting and other land management activities. These heatmaps will have relevance for all other strands of the 25 Year Environment Plan. We are also working with Local Environmental Records Centres to update the Ancient Woodland Inventory to incorporate sub-2ha woodlands. Collectively these and other evidence projects help us identify where increasing tree and woodland cover can enhance biodiversity and where it should be avoided to protect and restore open habitat elements of the Nature Recovery Network.

We have worked closely with Forestry Commission and Forest Research to develop and co-author an evidence-based decision support framework which helps guide landowners and regulators on where to establish trees and where to restore peat. Deploying the best available evidence means that this guidance marks a significant step forward protecting far more of our peatlands with associated benefits for carbon, nature and much else. Our habitat and species specialists have also helped FC develop a suite of new survey standards. These help staff from both organisations confidently determine the likely environmental impact of new woodland proposals

Abundant blossom in 25-year-old naturally-colonising woodland at Monks Wood, Cambridgeshire. Photo: Richard K Broughton, UKCEH.

and reach a view on their appropriateness. Here, our evidence-led input led to a substantive change in the breeding bird survey, with survey now required not only on the footprint of the proposed woodland but on a buffer of 1km around it. This important change ensures that the offsite impacts arising from the increased predation pressure associated with increased woodland cover on ground nesting birds such as Curlew, Lapwing and Golden plover are properly understood and accounted for.

The design of new woody habitats, and how they are established also substantively influences their value for nature. Here too NE have deployed evidence to good effect, successfully advocating for inclusion of a funded option for natural colonisation within the Forestry Commission's flagship England Woodland Creation Offer (EWCO) scheme, to complement planting options. Recent studies such as those at the long-established Monks Wood wilderness sites have shown that natural colonisation offers considerable benefits for nature, especially on sites close to existing native woodland or alongside old hedgerows which can provide a ready source of seed or suckers. Structurally complex mosaic habitats of scrub, open habitat and young trees, provide plenty of edge habitat and a diverse array of niches and food and nesting resources for invertebrates and birds. Moreover, these conditions are maintained for longer as canopy closure is slower than in a planted woodland, providing vital habitat for species such as Turtle Dove, enroute to establishing native woodland.

Finally, Natural England is working with Forest Research and the Forestry Commission to address critical gaps in the evidence base. We have helped influence the scope and focus of a significant number of research projects funded under Defra's England Tree Planting Programme. These include work to better understand the carbon value of Trees outside Woods, of natural colonisation compared to planting and to provide insights into the socio-cultural factors which enhance or constrain integrating more trees within farmed landscapes.

Peatland Restoration

Deborah Land, Emma Craig & Kat Hopwood-Lewis

Peatlands cover 3% of Earth's land surface but are the largest terrestrial carbon store. They cover 10.9% of England but only an estimated 13% are in a near natural functioning state. The restoration of our peatlands to a near natural state has become a priority driven by the need to address both climate and biodiversity crises. Given its importance, there is surprisingly little scientific literature on the effectiveness of peatland restoration interventions. What is available though is a robust body of evidence around the ecology, hydrology and functioning of peatlands, alongside a wealth of practitioner evidence and experiences from restoring sites. Bringing these two bodies of evidence together in an applied sense gives us the best available evidence to tackle carbon and biodiversity challenges on our peatlands.

Peat contains very little solid matter and is approximately 90% water by volume when saturated. The most damaging activities to bogs are those that cause direct or indirect changes to the hydrology. Peatlands are drained for land uses such as agriculture, forestry or peat extraction for horticulture or energy, resulting in the loss of peat forming conditions in the active layer of the peatland (acrotelm) and an interruption in their ability to form new peat. Subsequently, stored peat (catotelm) collapses and compresses causing the bog to subside speeding up decomposition and leading to the loss of stored carbon making it a net source of greenhouse gases (GHG).

Peatland can be split into two broad hydrological classes of peatland. Ombrogenous mires (bogs) are typically water shedding systems that receive their water from rainfall, while Minerogenous mires (fens and transition mires) are typically water receiving system.

Fens and transition mires receive water from several locations including rainfall, ground water, surface water and overland flow and are intrinsically linked to the surrounding geology. They can be heavily influenced by the surrounding land type and its use, becoming degraded through eutrophication from diffuse or point source pollution as well as inappropriate grazing. Fen restoration plans must be tailored to specific sites taking account of the nature and extent of negative influences, water chemistry and water supply mechanisms.

Most peatland restoration has been undertaken on ombrogenous bogs in both upland and lowland locations. Whilst they differ in their community and species composition, the approach to restoration is largely similar. The principal consideration for restoration is to restore the hydrological continuity through the repair of erosion features. While water moves through intact peat very slowly, artificial drainage and erosion features lower the water table, drying the peat, and speed up of the rate of transmission of water through the bog. This leads to a change in the vegetation away from sphagnum dominance to woody or shrubby plants, further exacerbating drying and erosion.

Over the years, conservationists and contractors have developed restoration techniques to include a range of novel approaches. The construction of dams in drains/grips not only slows the movement of water but raises the water levels,

preventing further degradation of the peat and facilitating the recovery of the vegetation.

Methods of dam construction using solid materials such as timber or plastic piling have been tried, but these materials have a different hydrological conductivity to the surrounding peat and can lead to scouring or erosion around the dam coursing or create too much water pressure behind the dam which could lead to bog burst. The most common material for dam construction is now peat. The design has evolved over the years through shared learning between projects and practitioners and the innovation of skilled contractors.

The fluctuating water levels in drained peat leads to oxidisation, causing it to become hydrophobic. Past projects have found that even when water levels are elevated through blocking drains, the impact is limited since water can continue to flow preferentially through the degraded layer of peat between drains. This practitioner experience led to the development of trench bunding, first used in the lowlands but is now being implemented on upland sites. Projects have demonstrated a wealth of different designs from long linear contour and perimeter bunds, networks of cell bunds to discrete horseshoe bunds. All aim to slow the passage of water through the peatland, therefore maintaining high water levels and reducing the transit of water through the peat.

Historic features are themselves threatened by peatland erosion hence in such settings ‘doing nothing’ is a direct threat to the preservation of peatlands’ historic environment features and deposits, resulting in loss of the historic environment resource. Historic features and palaeoecological records are vulnerable to ground disturbance, compression from machinery, and to changes in ground water which may alter the pH or oxygen levels within the burial environment leading to accelerated decay. Advance scoping to avoid historic features and adjusting restoration techniques to minimise impact can help limit this damage.

Through Natural England’s Peatland Grant Scheme, we are seeing possibly the most extensive programme of peatland restoration undertaken in England. There is considerable collaboration between Peat Partnerships with new collaborations forming such as the Great North Bog, The Northern Lowland Peat Partnership and the Somerset Peat Partnership. The project aims to restore 35,000ha peatland by 2025 and secure 9 megatons of carbon by 2050.

Drawing on the accumulated experiential evidence the grant scheme builds on previous restoration schemes to incorporate previously un-funded aspects such as the needs of the historic environment, and encourages innovative approaches too.

Monitoring and evaluation is built into the grant scheme design, with funding available for projects to collect evidence on the impact of their restoration activities. Working with project partners, Natural England is aiming to build on the rich body of practitioner evidence with empirical data that will help everyone understand what restoration intervention work and where.

Newly constructed horseshoe bund on upland blanket bog, above Shap, Cumbria. Photo: Deborah Land, Natural England

Spotlight on…

Brad Tooze

What is your first memory of an environmental or conservation issue

When I was in Junior School, big global issues were getting media coverage and I was struck by the plight of the panda. No doubt I was influenced by the animal's beauty, but I became conscious of its dependence on its environment and how this was under threat because of human activity. I entered the school's annual charity poster competition (with a panda poster) and my poster got the most votes! Proceeds from the competition and our local summer fete were donated to WWF for their panda conservation work. I remember feeling better for doing something, even if it was a very small thing.

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

I currently manage our Strategy Team. I have worked in a rich variety of roles in recent years centred around influencing government policies and legislation to bring about large-scale nature recovery. It is a challenging work area that has, in no small way, been driven by improvements to our knowledge of the impacts of land management practices. Last year we used our evidence to demonstrate to government the need to phase out rotational burning on blanket bogs, to make licensing arrangements for the control of wild birds much more fit-for-purpose, to bring in regulations to prevent negative effects from gamebird release on protected sites. We also used our evidence to secure £58m and design a grant scheme to restore peatlands across England because of the contribution this will make towards our Net Zero targets, as well as for nature and for people.

How does science and evidence inform what you do?

Most of my work focusses on contentious topics where views can be polarised. The advice we give to government on these matters must be founded on science and evidence. This is key to our credibility and ultimately to our ability to achieve positive environmental outcomes. Our experts never fail to impress me with their up-to-date and comprehensive knowledge of the science and evidence. A clear and communicable environmental imperative is key to persuading decision-makers, and especially when broader social, individual or economic considerations are also factors that influence those decisions.

WTFutures?

Marcela Capaja

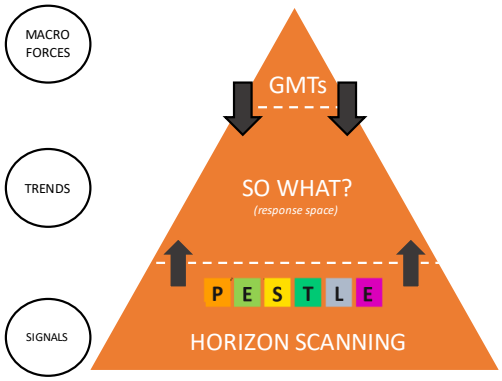
As the world continually undergoes dynamic change, with events such as the global pandemic, and continued wildfires amongst others, it is becoming increasingly important to think about the future to take stock of drivers of change, opportunities and threats, as well as what they might mean for Natural England. Now more than ever, preparing for the future and understanding the implications of different, multiple futures is proving critical. Nonetheless, for many 'futures thinking', is merely a buzz phrase and a source of confusion, so **WTFutures?** What does it entail? What is Natural England doing about it?

Myth busting

Contrary to some thinking, futures is NOT about predicting the future nor is it about forecasting based on historic trends with a degree of certainty. So rather than seeking to 'future-proof' the world around us, futures thinking is a valuable approach that helps us to anticipate; to take into consideration that the future is not linear, and to focus on future '**possibilities'**. Futures thinking looks at various alternatives because, well, the world is constantly changing and the futures toolkit provides the tools and methods to help us to be adaptable and agile in the face of such unpredictable change.

Jargon busting

Common, but often confusing terms used when thinking about the future include **megatrends** and **signals**.



Megatrends or macro forces are the broad, long-term sweeping drivers of change that can happen at various levels globally.

Signals of change (captured through horizon scanning) are the subtle signs that suggest a change may be happening. These signals can point to something emerging, even if it is not known what that *something* is yet.

The PESTLE framework is used to help make sense of these signals and ensure that a range of insights are collected across the political, economic, social, technological, legal and environmental framings, ultimately helping to cover potential blind spots. When thinking about the future in Natural England, it is not enough to

capture only the changes happening in the environmental sector. No organisation operates in a vacuum but as one element in a wider system. So, it's critical to understand all elements of emerging change across the PESTLE framework, their interactions, and how they might affect NE and our partners and stakeholders. Where megatrends and signals come together, that is the space in which one can begin to make sense of what this means for individuals, teams in an organisation, as well as an organisations leadership and our interactions with others.

Futures thinking often include strong elements of systems thinking and, together, these help to see the bigger picture: where megatrends and emerging signals combine, asking the 'so what?' and 'what if?' questions. This helps us to understand what is happening and to begin to identify strategic actions that need to be taken to remain effective in the potential future operating environment.

Futures thinking helps us to move away from an unhealthy short-termism, and instead embed long-term strategic thinking. But many are unaccustomed to thinking long term, reinforced by external and internal pressures such as how technologies move in fast product cycles, or business and political cycles that allow short-term needs to be put ahead of long-term resilience building.

FOOD FOR THOUGHT – Feeling change:

However, futures thinking is not easy. It is often the case that we overestimate what we can achieve in a year but underestimate what we can achieve in a decade. Without a time machine it can be difficult to grasp the level of change that can happen over a period. Consider two dates, one further into the past and one in the more recent past, i.e., 1980 and 2010 and think about a day in the life of a person from each of these timelines.

- How different was life in those two timelines?
- What are some of the key changes that enabled life to be different in those two timelines?
- If you were living in 1980, what would you want to know about life in the future of 2010? And vice versa?
- How different was travel or communication, bearing in mind that the world wide web was invented in 1989 and the first generation iPhone was released in 2007 – how would you explain these and their impacts on society to someone living in each of the timelines?

It can be surprising how much or indeed how little things can change in 30 years, so what does that mean for thinking about organisational strategy? The first point, as Douglas Adams reminds us on the front cover of the Hitchhiker's Guide to the Galaxy is "Don't Panic!". While the future is inherently unpredictable, and the world we live in is increasingly complex, we have a range of aids to navigation.

Futures thinking in Natural England

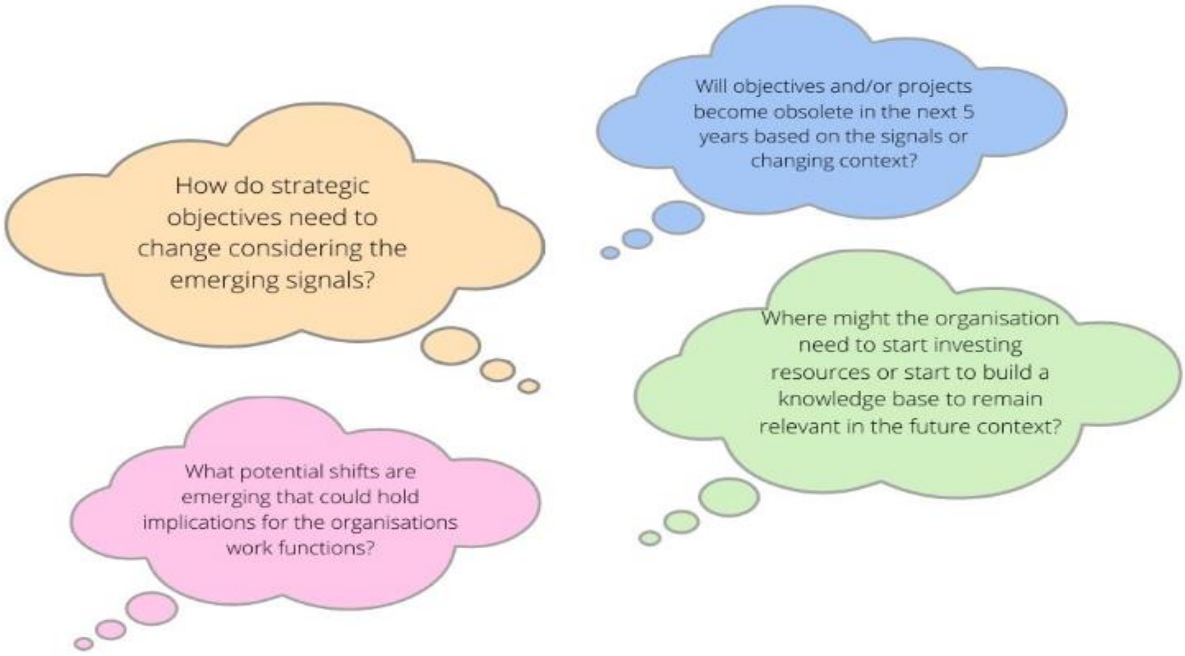
To help capture change, understand, and utilise thinking for future strategy, Natural England is engaging with futures thinking in several ways including:

- Global Megatrends: This is a set of global mega trends initially prepared in 2016 and part of an on-going update with Defra group that continues to be monitored and more importantly will be explored analytically to understand their meaning for the UK context and for Natural England specifically with respect to the organisations ways of working and the objectives it seeks to deliver.

- Horizon Scanning: Natural England continues its horizon scanning work to capture signals of change and make sense of them through three periodic scans throughout the year, complemented with an annual synthesis to help understand the changing landscape, emerging issues, and implications for Natural England colleagues. Deep dive scanning is also being undertaken to look more specifically into topical issues of interest to explore critical questions pertinent to work areas, from new developments in gene modification to the emerging new ways of working.

- Futures Cycle: There is ongoing work to embed a futures cycle into decision making at Natural England through workshops with the Executive Committee and Directors to open thinking about the future, contextualise the future operating environment for Natural England, and identify strategic actions to take forward as an organisation.

These activities help to explore questions such as:



It's important to remember that you don't have to be a futurist to think about the future. We encourage our colleagues to join this futures journey, whether through focus groups, scenario building or collective scanning.

Spotlight on…

Clare Warburton

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

Growing up on the outskirts of Birmingham with few hills, climbing 'Old Man Coniston' in the Lakes in my teens with school friends was a sore but exciting new experience for me! It was a sunny day and the first half of the climb was a breeze. It was the second half, as the mountain top teased with false summits, that I had to dig into my reserves. Head down, hot and weary, I scrambled to the summit, but all pain was forgotten as I lifted my head to gaze across the landscape - I was totally hooked! The experience inspired my love of nature, landscape and all things green, and gave me a passion for bringing nature close to people, particularly in urban places.

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

As the Green Infrastructure Principal Adviser in Strategy and Government Advice, it is my job to support the delivery of more good quality green infrastructure close to where people live and work. The pandemic showed how important nature is for our health and wellbeing, but also how many people don't have access to high quality green space close to home. It's brought to the fore the opportunities for greening of our towns and cities where over 80% of people live, so that more people can connect with nature close to home.

How does science and evidence inform what you do?

My role involves providing support and advice that can feed into policy development and delivery across government, and I have found that having facts and evidence at my fingertips can really help to make the case for change. Being curious helps, as evidence often starts with a question!

Evidence helps me to understand the scale and nature of an issue. For example, our green infrastructure mapping work has shed light on '*Who has access to good quality green space close to home, and who doesn't*?'. This can help to target interventions where they are most needed.

Over the years I have learned that we often have to work with incomplete evidence. It's important to be transparent about the evidence underpinning our work, setting out the caveats and limitations, but also not letting the perfect be the enemy of the good, and using the best available evidence to help us innovate and test new and novel ways of doing things.

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Dave Stone

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