Wetlands for Carbon Storage

Creating and managing saltmarshes to store blue carbon in the UK

A Route Map

WWT

The science is clear. Wetlands are the most effective carbon sinks on our planet.

Martha Rojas Urrego
Secretary General of the Ramsar Convention on Wetlands, January 2019.

Contents

Incredible things happen when land and water meet to create wetlands. These extraordinary places teem with biodiversity, providing homes for endangered and much-loved species. Wetlands are vital 'service stations' for millions of migratory birds, enabling them to rest and refuel. For us, they provide essential protection against the impacts of the climate crisis, floods, droughts and pollution. We also know that living near or visiting a wetland and its wildlife is good for our wellbeing.

Wetlands are the lifeblood of the planet, but they need our help: globally they are disappearing at a rate three times faster than forests[1].

The UK's wetlands need strong and effective laws to protect them from harm; they need careful and well-resourced approaches to manage them – and they also need restoring. Over the last 500 years England has lost approximately 90% of its wetlands[2,3], and in more recent times their continuing absence – coupled with further loss and degradation – has helped fuel some of the greatest challenges we face: the escalating climate crisis, plummeting levels of biodiversity and a rapid decline in our own wellbeing.

But there's hope: WWT are pioneers in wetland conservation. We use ground-breaking science to bring species and wetlands back from the brink and restore, protect and create wetlands around the world. In 2020, WWT joined calls for a green recovery to build back better out of the COVID-19 pandemic, and, crucially, for a 'blue recovery' to be at its heart.

We set out proposals for the creation and restoration of 100,000 hectares of wetlands in the UK – every single hectare will be filled with wildlife, providing a much-needed boost to biodiversity and to the Government's pledge to halt and reverse the decline of our natural world by 2030.

We are now setting out further details of how this blue recovery needs to happen, publishing four route maps for creating wetlands for carbon storage, urban wellbeing, water quality and flood protection.

Each route map sets out our proposals, the purpose the wetlands will serve, the potential they offer, the process involved and the partnerships and policy framework required to make these proposals happen.

I hope you enjoy reading our route maps; we look forward to working with you to create and restore wetlands that help protect our health and the health of our planet.

Sarah Fowler, Chief Executive
WWT (Wildfowl & Wetlands Trust)

Coastal wetlands provide valuable habitats for many migratory birds and fish.

A group of black-tailed godwits. WWT Steart Marshes.

Executive summary

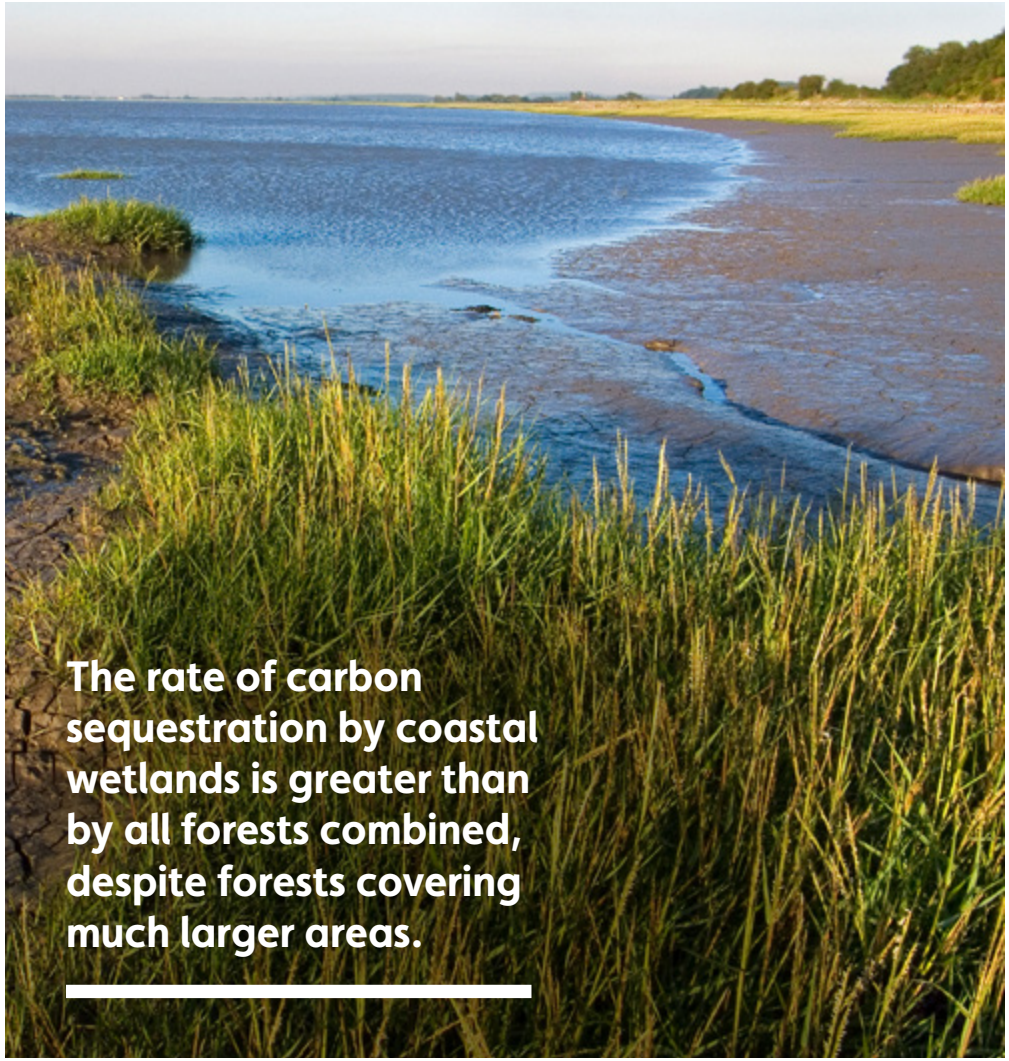
Wetlands play a vital role in limiting the amount of carbon in the atmosphere. Blue carbon (that stored in marine and coastal habitats) is one of the most important carbon stores in the UK.

Saltmarshes, in particular, are very efficient at locking away carbon, while also bringing a range of additional benefits for people and wildlife.

Damage and destruction of these habitats can result in the release of large amounts of greenhouse gases into the atmosphere. Therefore, protecting, restoring and creating saltmarshes is key to helping increase our ability to absorb and store carbon from the atmosphere, helping us tackle climate change. They should be a critical part of the UK's future 'blue infrastructure', but they are currently a significantly underused and overlooked nature-based solution.

We have the information and opportunity to achieve the scale and pace of delivery required, but some key components will need to be in place. Given the time it could take to deliver them, we must start planning restoration and creation projects immediately.

Nature-based solutions use the power of natural ecosystems to help tackle major challenges such as climate change.



Blue carbon is carbon that accumulates and is stored in marine and coastal habitats as a result of their high productivity and sediment-trapping ability. Saltmarshes, in particular, can be very efficient at locking away carbon. As they grow, carbon dioxide (CO_2) is drawn out of the atmosphere by the photosynthesis of saltmarsh plants and fixed as organic carbon. When saltmarsh plants die they become buried in the mud rather than decomposing and releasing their carbon into the atmosphere. As sea levels rise, more sediment layers get buried and more carbon is locked in.

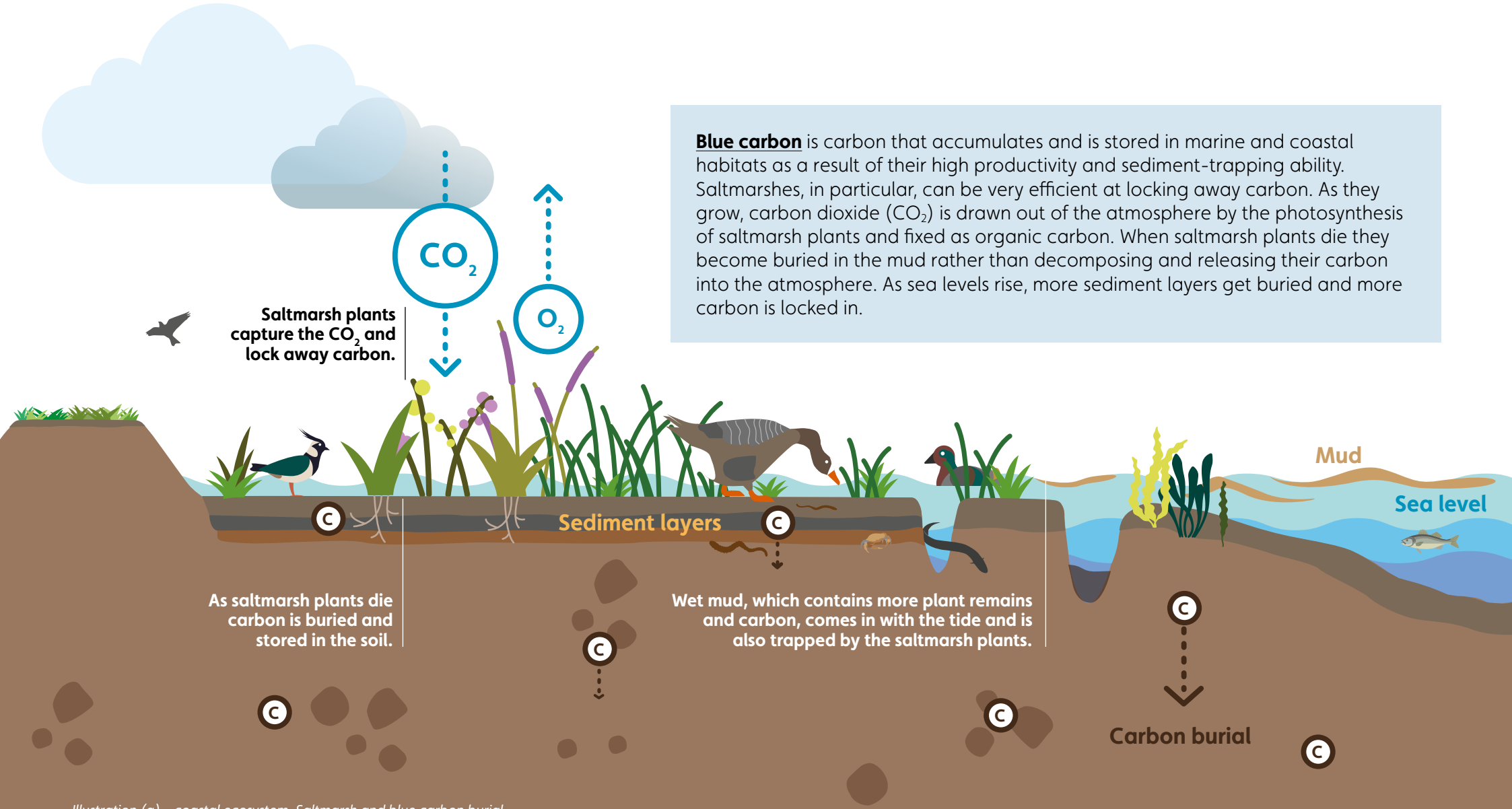


Illustration (a) – coastal ecosystem. Saltmarsh and blue carbon burial.

Proposal

A 2019 Government-commissioned report identified land around the English coast that could be restored to saltmarsh[4]. According to the estimated potential in this report, we propose that a minimum of 22,000 hectares is restored in the UK by 2050. This should be done alongside effective protection and management of the UK's existing 48,545 hectares of saltmarsh[5,6,7,8]. 22,000 hectares of restored saltmarsh could mean an extra 290,000 tonnes of carbon dioxide equivalent stored per year [57]. This is equivalent to taking roughly 150,000 cars off the road for one year.

Purpose

Coastal wetlands, such as WWT Steart Marshes, deliver a range of valuable services including: providing natural flood defenses to local communities; filtering out pollution to improve water quality; supporting local economies through food production and tourism; offering opportunities for outdoor access to boost wellbeing; and of course providing habitats for an incredible range of wildlife. Alongside an ability to bury carbon, WWT believes they are a cost-effective and land-efficient way to deliver multiple benefits.

Potential

We have an exciting opportunity to create saltmarshes to provide these benefits. WWT has developed indicative maps that identify the potential to create 306,688 hectares of new saltmarsh across the UK[9].

The existing evidence is persuasive, but we need more data. Restored saltmarshes in the UK have been estimated to store an average of 13.3 tonnes of carbon dioxide equivalent per hectare per year, compared to 8.2 tonnes in naturally occurring saltmarsh. However, the newly restored saltmarsh at WWT Steart Marshes saw much higher rates of around 70 tonnes of carbon dioxide equivalent per hectare per year. Given the high variability of carbon burial rates among restoration sites, it is important we continue to gather data so that we can derive a more precise average value for blue carbon storage and prioritise the most effective sites.

Process

Creating saltmarshes to store carbon involves the following three elements:

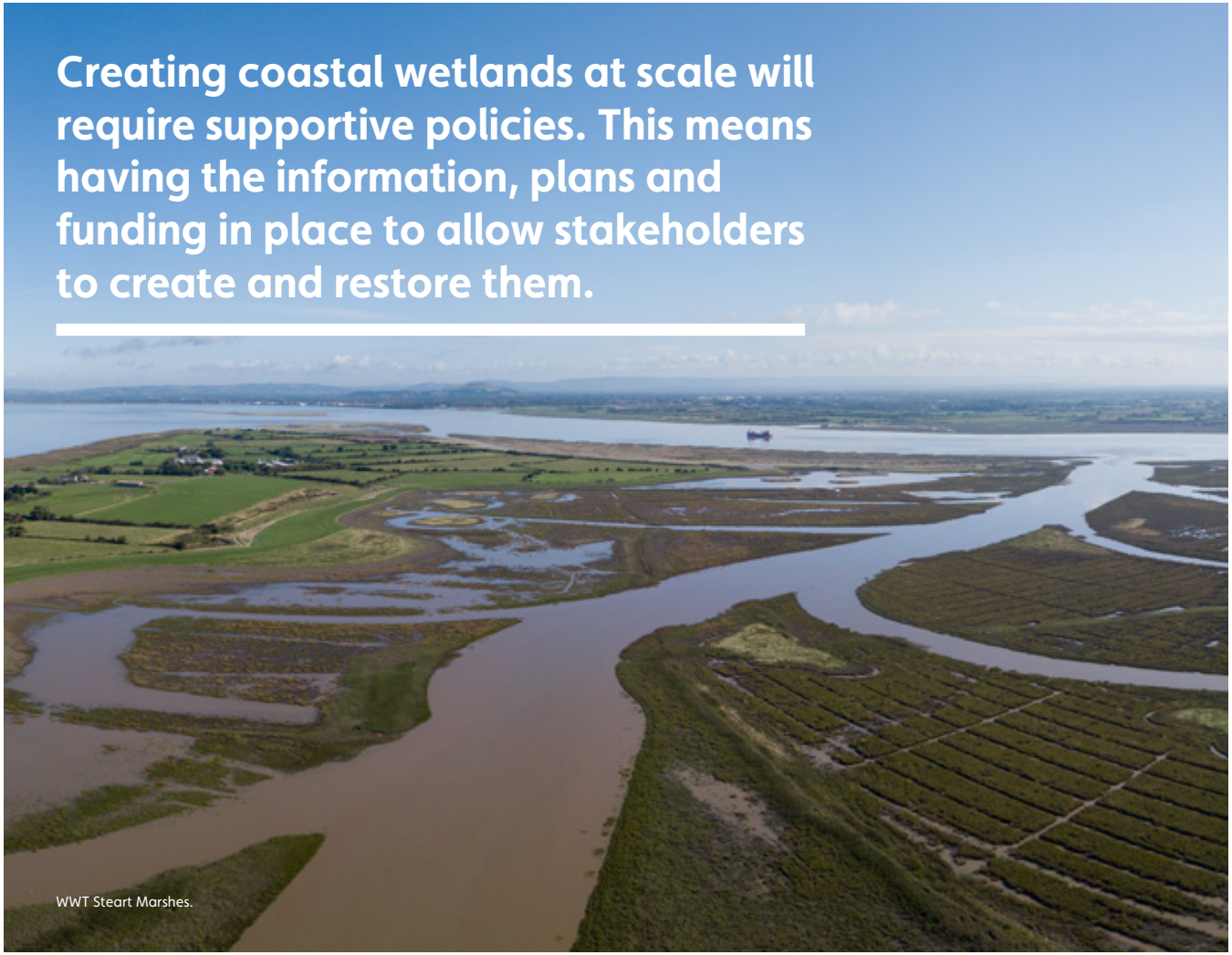
Delivery: Direct conservation action to create and manage saltmarshes to store blue carbon and provide co-benefits.

Capacity building: Providing advice and training to landowners and local councils, creating innovative financing approaches, and gathering and sharing further evidence on how to derive multiple benefits from saltmarshes.

Community engagement: Consulting and involving people in shaping their local community, from design and governance of saltmarsh creation projects through to completion and management of sites into the future. Such projects must serve the community rather than be imposed from outside.

Protection and management

This route map focuses on creating and restoring saltmarshes, but other existing wildlife-rich coastal habitats *(such as seagrass, bivalve reefs and kelp)* are also crucial to delivering blue carbon and co-benefits. These valuable resources deserve full protection and effective management.



WWT Steart Marshes.

Partnerships

Working in strong effective partnerships will be key to reaching the target of 22,000 hectares of saltmarsh. We need the involvement of national and local governments, the investment and know-how of businesses, and a process of co-creation with landowners and local communities.

Policy

Creating saltmarshes at scale will also require supportive policies. We need policies that provide the necessary information, plans and funding.

WWT is calling on the UK Government to adopt saltmarsh creation as an important part of its plans to meet its net zero commitment, to help unlock private sector investment in saltmarsh restoration.

Policy priorities

By 2025:

- UK Government to include coastal wetland creation as a nature-based solution in the UK's Nationally Determined Contribution (NDC)[10] and the UK Greenhouse Gas Inventory.
- UK Government and devolved administrations to support a nationally recognised Saltmarsh Carbon Code that sets clear standards for best practice in saltmarsh creation, restoration and maintenance.
- UK Government to put in place funding mechanisms to facilitate the creation and restoration of coastal wetlands for carbon sequestration, through public and private sector investment.

1.

Proposal

We propose the creation and restoration of a minimum of 22,000 hectares of nature-rich saltmarsh by 2050, and the protection of our existing saltmarsh resource, to maximise the opportunity for blue carbon and co-benefits.

Coastal wetlands such as WWT Steart Marshes are cost-effective and land-efficient because they bury more carbon per hectare than other habitats, including forests. They also deliver a range of other valuable services, such as providing habitats for many migratory birds and fish, improving water quality through filtering out pollution, acting as a natural flood defence and providing a wealth of benefits to human health and wellbeing.

What are wetlands?

Wetlands are unique ecosystems that are either permanently or seasonally inundated with water.

They include lakes, rivers, swamps and marshes, wet grasslands, estuaries, saltmarshes and human-made sites such as ponds and reservoirs. They range in size from garden ponds to the Pantanal in Brazil, Bolivia and Paraguay, which is three times the size of Ireland.

What do wetlands do?

Wetlands hold much of our natural capital.

They also provide some of the essential ecosystem services that make life on earth possible, providing nature-based solutions to many of our most pressing environmental and social problems.

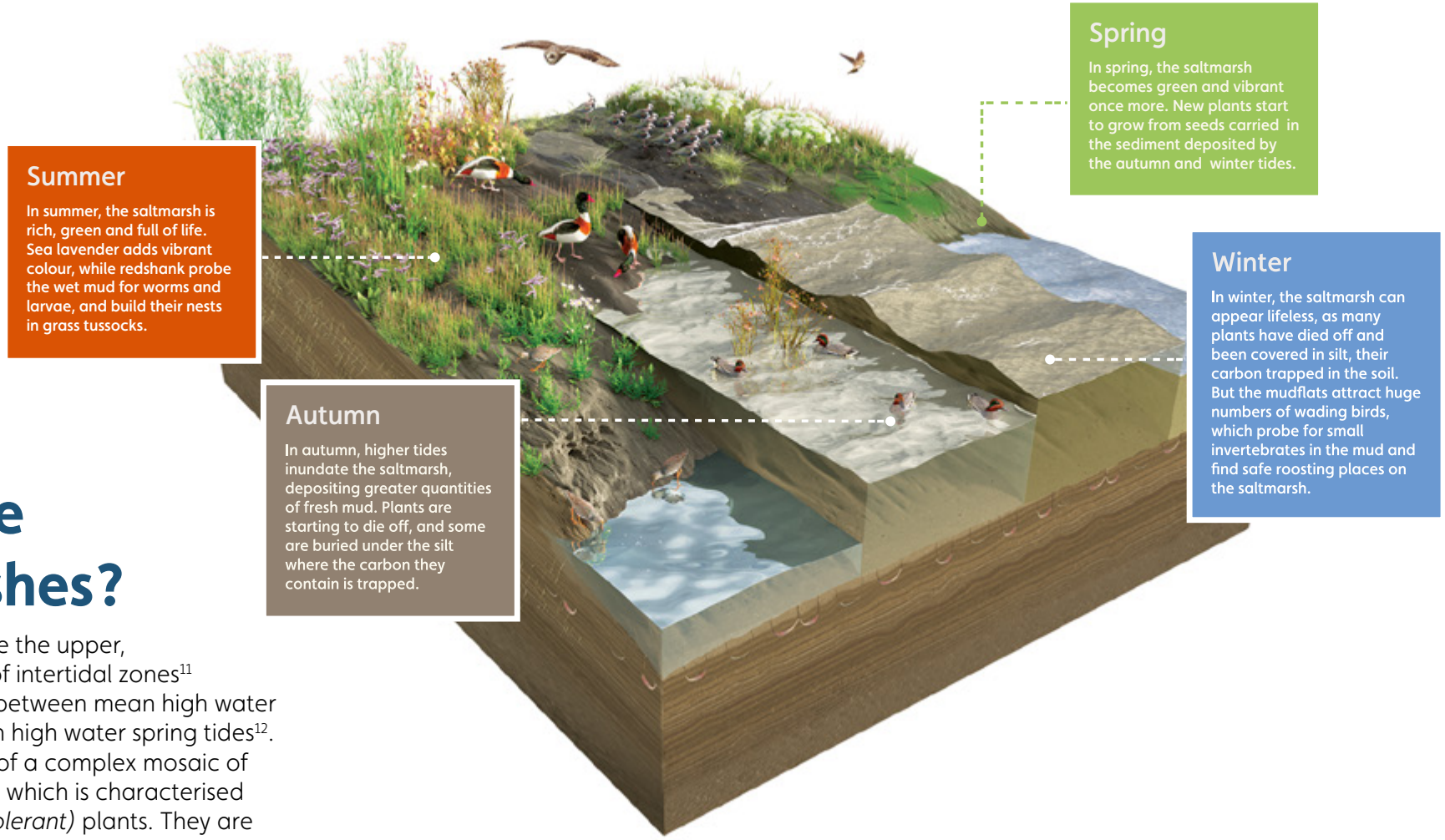
They give us relief from the stresses of modern life and improve the resilience of communities to the pressures of the climate crisis, pollution and the effects of urbanisation.

This document sets out how we can realise these benefits.

Natural capital

The world's stocks of natural assets that underpin our economy, including geology, soil, air, water and all living things.

Illustration (b) coastal ecosystem. How saltmarshes work.



What are saltmarshes?

Saltmarshes comprise the upper, vegetated portions of intertidal zones[11] lying approximately between mean high water neap tides and mean high water spring tides[12]. They are composed of a complex mosaic of intertidal vegetation, which is characterised by halophytic *(salt-tolerant)* plants. They are important habitats for many migratory species of bird and fish, and many areas are protected by national and international designations.

How do wetlands help us?

They help combat climate change by storing enormous amounts of carbon.

They support livelihoods by providing jobs, tourism and food.

They provide food and act as nurseries for many commercial fish species.

They provide freshwater for drinking, cooking and cleaning.

They protect us from flooding.

They are biodiverse habitats, providing a home for over 100,000 species of animal[13].

They prevent coastal erosion by providing a buffer to the sea.

They treat our polluted water without the use of chemicals.

WWT Steart Marshes.

Coastal wetlands like the saltmarshes at WWT Steart Marshes store more carbon per hectare than other habitats such as forests.

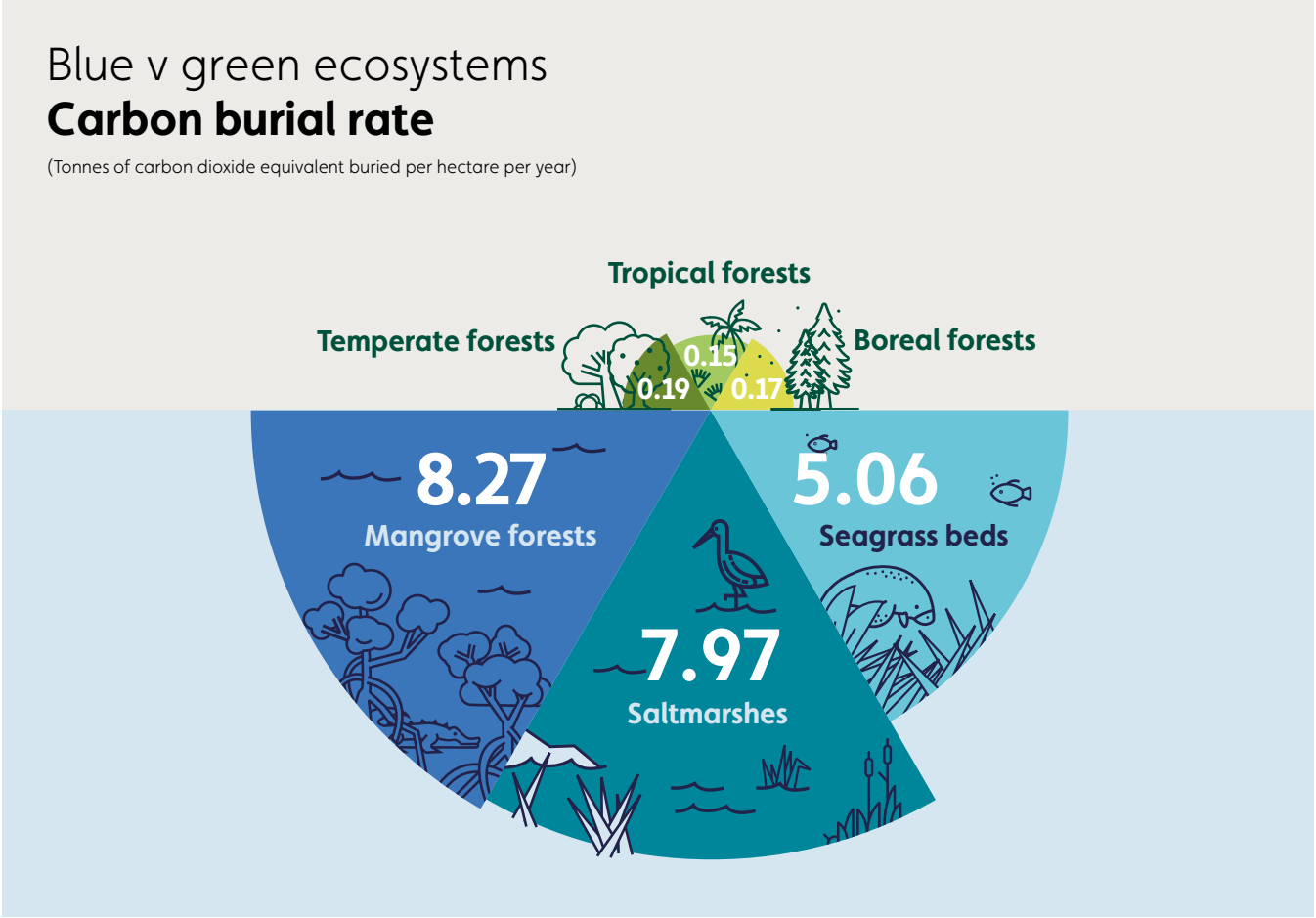
Steart Marshes is burying organic carbon at a rate of approximately:

70 **tonnes of carbon dioxide**[14]
(equivalent) per hectare (per year)

What role do wetlands play in tackling climate change?

Wetlands, primarily peatlands, store over a third of the world's terrestrial carbon[15].

Illustration (c) Carbon burial rates versus terrestrial forest ecosystems (t Cha^{-1})[16]



Damage and destruction of wetland habitats often leads to large releases of greenhouse gases to the atmosphere. Protecting and restoring coastal wetlands presents an important opportunity to mitigate carbon emissions, complementing the need for urgent measures to reduce greenhouse gas emissions. *For a full explanation of the role that carbon plays in climate change see Appendix 1.*

Recent research indicates that blue carbon habitats have extremely high carbon sequestration rates *(the rate at which they capture and store carbon)*. In saltmarshes, carbon is typically captured 40 times faster than temperate forests[17].

Coastal wetlands (mangrove forests, seagrass beds and saltmarshes) make up **less than 2%** of ocean area but are estimated to be responsible for **almost 50% of carbon burial** in marine sediments[18].

How do saltmarshes store carbon?

Every day on saltmarshes, carbon in the form of sediment is brought in on the tide. When it's buried in the wet mud decomposition is slowed down due to the mud's low-oxygen *(anaerobic)* conditions and the carbon gets locked in[19]. In addition, when saltmarsh plants die they become buried in the mud rather than decomposing and releasing their carbon into the atmosphere. As sea levels rise, more sediment layers are buried and more blue carbon is locked in the mud. Tidal wetlands are considered carbon sinks because they are able to store the buried carbon, stopping it being released into the atmosphere. *For more detail on carbon burial rates in saltmarshes compared to forests see Table (1) in the Appendix.*

Saltmarsh sediment accummulates vertically in response to sea-level rise. If the habitat is maintained, carbon can accumulate indefinitely in some situations[20], although the limits to this response as sea level rise accelerates are unclear.

Creation of this habitat also replaces high-emission land uses such as intensive agriculture, adding to the net carbon benefit of the approach. *For more details on carbon sequestration see illustration (a) coastal ecosystem pg 7.*

In saltmarshes, carbon is typically captured 40 times faster than temperate forests.

What are the challenges we face in restoring, maintaining and creating saltmarsh?

In the UK, saltmarsh covers approximately 50,000 hectares[21,22,23,24]. It is a relatively scarce wetland habitat that has been depleted historically.

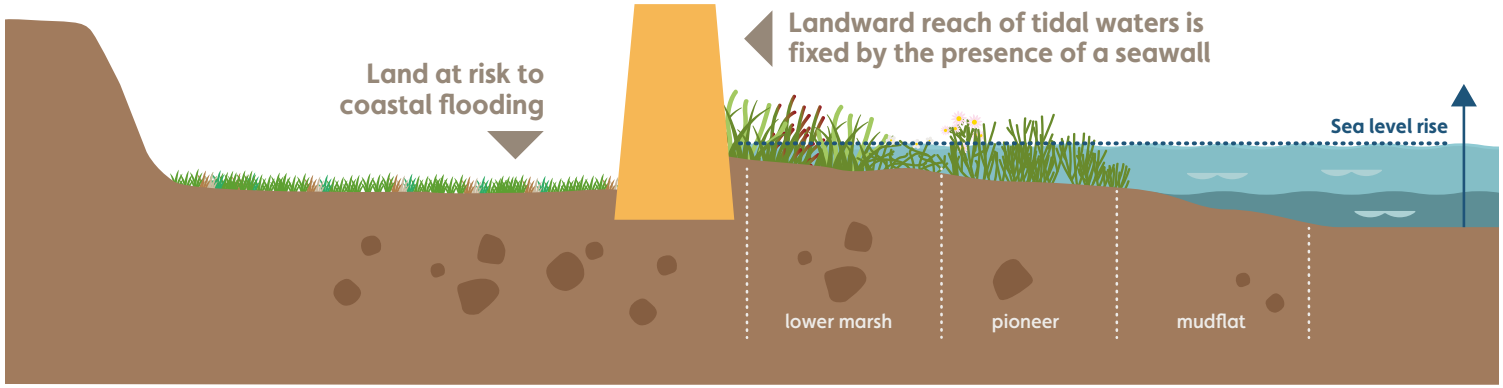
The existence of saltmarsh is dependent on being periodically flooded and drained by tides. However, the extent of the tidal reach around much of the UK coastline is restricted by flood defence embankments *(constructed to provide flood protection and in some instances as part of land reclamation schemes)*.

These embankments constrain the degree to which saltmarsh can extend inland, which it would naturally do in response to rising sea levels. Together with rising sea levels, this causes 'coastal squeeze' *(see illustration (d) pg20)*.

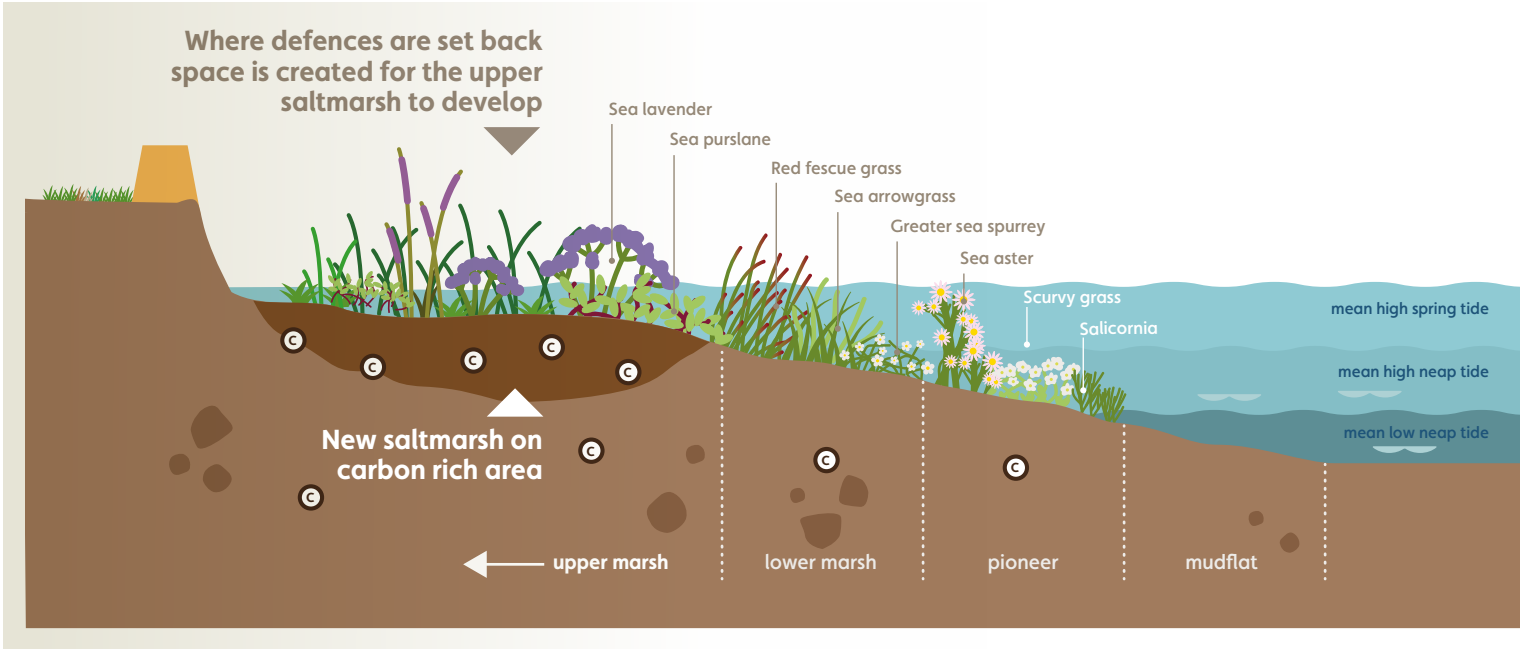
In the UK only 58% of existing protected saltmarsh sites are considered to be in a favourable condition[25].

Illustration (d) 'coastal squeeze'.

1. With **embankment constraints** and **sea-level rise** we are losing the upper saltmarsh habitat all around our coastline.



2. Removal or re-positioning of constraint **allows for coastal habitats to move further inland.**



Saltmarsh restoration and managed realignment:

Generally in the UK the requirement to restore habitat has been driven by biodiversity objectives, either as compensation for loss of habitat elsewhere or to provide feeding and roosting habitats for migratory or breeding waterbirds. Often this restoration is targeted at areas already under threat from tidal flooding through managed realignment.

Managed realignment is the process of setting back coastal protections, allowing a previously protected area to be flooded. Doing so promotes the creation of natural habitats such as saltmarshes. These natural defences help to absorb and dissipate the force of the waves.

In the UK, managed realignment has predominantly been delivered in England by the Environment Agency and a small number of environmental non-governmental organisations (NGOs). Some examples of private saltmarsh restoration also exist.

A list of managed realignment schemes in the UK can be found at **omreg.net/query-database/**.

In the UK, saltmarsh restoration for biodiversity purposes usually takes place in the same estuarine system from which saltmarsh was lost.

2.

Purpose

Saltmarshes provide multiple benefits, including carbon capture, while boosting biodiversity.
We would like to see an increase in healthy saltmarsh in the UK.

What range of benefits do saltmarshes provide?

Carbon sequestration

The Government's Natural Capital Committee estimated a potential 22,000 hectares of land around the English coast that could be restored[27]. If this happened, it could mean an extra 290,000 tonnes of carbon dioxide equivalent stored per year[28]. This is equivalent to taking roughly 150,000 cars off the road for one year.

Restored saltmarshes in the UK have been estimated to store an average of 13.3 tonnes of carbon dioxide equivalent per hectare per year, compared to 8.2 tonnes in naturally occurring saltmarsh *(as shown in table 3)*. However, at our newly created saltmarshes at WWT Steart Marshes, the annual figure has been recorded as much higher at around 70 tonnes of carbon dioxide equivalent per hectare per year *(though this may be reduced when we adjust for various influencing factors)*.

Saltmarshes are natural assets that deliver a range of other valuable services. *A summary of the ecosystem services provided by saltmarshes in addition to carbon sequestration is provided in Table (2) pg 25.*

Water quality

Saltmarshes can play a key role in improving water quality through filtering out pollution. Studies have found that saltmarshes can absorb nutrient pollution, plus a range of other pollutants including pesticides, metals and hydrocarbons[29].

Creating habitats

Saltmarsh is considered a priority habitat in the UK. Around 40 species of plants grow only in saltmarshes, and of the 293 species of terrestrial invertebrates that use saltmarshes, 148 use them exclusively[30]. A wide variety of resident and migratory waterbirds such as redshanks, little egrets and brent geese use saltmarshes to breed and/or spend the winter months. Saltmarshes are also a vital habitat for birds like dunlin and egrets that are of conservation concern[31].

Saltmarshes are invaluable to several fish species of commercial importance. For many centuries they have been recognised as crucial feeding and nursery areas for them.

UK saltmarshes are conservatively estimated to be worth around £3 million annually to the commercial landings of European seabass, common sole and European plaice[32].

Around 40 species of plants grow only in saltmarshes.

Reducing flood risk

Coastal wetlands, such as saltmarshes, can provide natural flood management. They reduce the energy *(or wave power)* of incoming tides, which can cut flood defence costs and/or reduce the impacts of flooding. When saltmarsh is restored, new sea walls are set back from the coast. They are protected by the marsh, and therefore they are less costly to maintain. A recent study estimated that £33,000 was saved each year per kilometer of coast where managed realignment had taken place[33].

At WWT Steart Marshes, between £500,000 and £900,000 of net annual benefit is derived from the nature reserve[34]. This is based on five ecosystem services alone: food; climate regulation; recreation and tourism; education and provision of habitat. It is worth noting that this study did not take into account the current knowledge on carbon storage rates[35].

Wellbeing

Wetlands improve our mental wellbeing and combat mental illness. They do this by providing tranquil spaces in which to escape from the everyday stresses of our busy lives; they are a world away from our daily worries[36].

The benefits of time in nature are now being recognised by healthcare professionals.

These benefits include disease prevention and a reduction in the social burden of chronic disease. The NHS is currently championing the importance of healthy lifestyle choices and is looking at options such as social prescribing to help patients improve their health and wellbeing. WWT already has a successful 'blue prescribing' project at WWT Steart Marshes.

Table (2). A 2011 estimate of the monetary value of ecosystem services provided by worldwide coastal marshes (shown in hectares per year or $ha^{-1}yr^{-1}$)[37]

£15.27 $ha^{-1}yr^{-1}$

Raw materials (including food provisioning)

Generates biological productivity and diversity

£7,200 $ha^{-1}yr^{-1}$

Natural hazard regulation

Attenuates and/or dissipates waves

£1,700–32,200 ha^{-1}

Regulation of pollution and water purification

Provides nutrient and pollution uptake, as well as retention, particle deposition

£2,100–13,900 ha^{-1}

Maintenance of fisheries

Provides sustainable reproductive habitat and nursery grounds, sheltered living space

£26 $ha^{-1}yr^{-1}$

Organic matter accumulation

Generates biogeochemical activity, sedimentation, biological productivity

£32.80 $person^{-1}$

Recreation and aesthetics

Provides unique and aesthetic submerged vegetated landscape, suitable habitat for flora and fauna

Case study

WWT Steart Marshes

Overview

The Environment Agency and WWT in partnership have created a vast 477 hectare wetland in Somerset – one of the largest wetland creation projects in the UK. It helps mitigate climate change through carbon burial, while providing a home for wildlife and a special place for people to enjoy nature. It has also increased climate resilience locally by helping to protect nearby houses from flooding and by reducing the risks of coastal erosion.

WWT Steart Marshes was created in 2014 as a habitat creation scheme to compensate for the loss of saltmarsh in the Severn Estuary. The rate of loss is likely to increase due to rising sea levels.

Research is showing how effective the saltmarshes are in storing carbon. A team from Manchester Metropolitan University, studying sediments in the marsh, have calculated that WWT Steart Marshes is burying carbon at a rate of approximately 70 tonnes of carbon dioxide equivalent per hectare per year *(this figure will be reduced when various factors are accounted for)*. This evidence is why WWT is calling for saltmarsh to be included into a new saltmarsh carbon code, just as peatlands and woodlands are.

Over a four year period, over 18,000[38] tonnes of organic carbon was stored at WWT Steart Marshes.

1M+

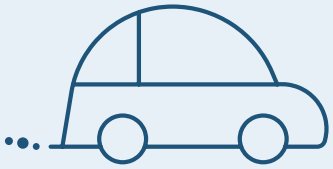
This is equivalent to the carbon stored by over one million new trees grown over a 10 year period.

77.9K

Or the greenhouse gas emissions from powering 77,930 UK homes for one year.

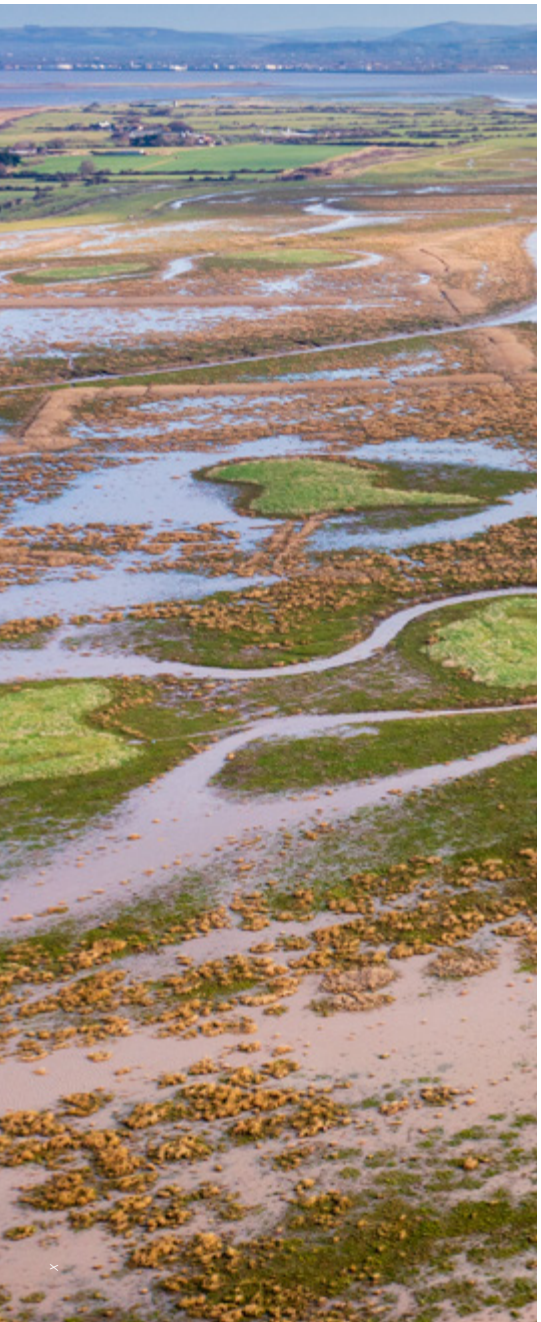
32.9K

Or taking 32,900 cars off the road for a year.



WWT Steart Marshes also brings other associated benefits. Once intensively managed farmland, the area is now used to rear saltmarsh beef and lamb that can be sold at a premium price.

The marshes are now home to a vast array of wildlife and support a range of breeding and wintering birds, as well as providing shelter for the fry of commercial fish such as seabass. Rare plants have also established themselves in the intertidal area.



3.

Potential

There is an exciting opportunity to create saltmarshes to provide the range of benefits outlined. WWT has developed indicative maps that identify the potential to create over 300,000 hectares of new saltmarsh across the UK.

The existing evidence is persuasive, but it is important we continue to gather data to prioritise the most effective sites and better understand the benefits they bring.

Low tide on the saltmarsh. WWT Steart Marshes

What are the specific opportunities for saltmarsh creation?

The Natural Capital Committee found a strong economic case for the creation of 22,000 hectares[39] of saltmarsh around the English coastline.

WWT have developed indicative maps for wetland creation and restoration *(Figure 1)* that include the potential for new saltmarshes.

For England, we used the 'Potential habitat-creation sites within the current floodplain' map, developed by the Marine Management Organisation *(MMO)*[40]. It shows where intertidal habitats *(mainly mudflats and saltmarshes)* could be created in existing coastal floodplains. It highlights areas where techniques such as managed realignment and/or regulated tidal exchange could be used to inundate land that is currently defended.

To create equivalent maps for Wales, Scotland and Northern Ireland we closely replicated the methods used to develop the MMO's map for England.

At this coarse scale, the map identifies 306,688 hectares (ha) of saltmarsh creation potential across the UK*(England: 258,013ha; Wales: 25,762ha; Scotland: 15,591ha; and Northern Ireland: 7,322ha)*. It does not account for the many constraints on managed realignment/ regulated tidal exchange that limit the potential for saltmarsh creation at a local scale, but emphasises those locations where the most opportunities are likely to be.

The map, together with technical guidance on the methodology, will be published after further refinement to remove obvious constraints to saltmarsh creation.

The location of existing coastal habitat-creation sites around the UK coastline is reasonably well documented and a wide range of research has been undertaken to determine their success, albeit usually framed around the delivery of habitat for wildlife to meet biodiversity objectives.

Table (3). Summary of estimated carbon burial by current and potential saltmarsh in the UK.

Resource	**Extent/opportunity** *hectares*	**Carbon burial rate** *$tCO_2e\ ha^{-1}yr^{-1}$*	**Annual value** *$tCO_2e\ ha^{-1}yr^{-1}$*
Existing UK saltmarsh extent	48,545[41,42,43,44]	8.2[46]	394,617
Existing UK coastal realignment	2,252[45]	13.3[46]	30,590
NCC ambition for saltmarsh creation	*22,000*	13.3	292,600
Total *(estimated)*			**717,807**

Figure (1). UK indicative Saltmarsh Potential map (see footnote for data sources used to develop map and associated licencing information)

Click on the map to view enlarged sections in the Appendix.

1. Northern Ireland[47]
2. Scotland[48]
3. Wales[49]
4. England[50]

(MM01135 Potential habitat creation sites within the current floodplain_mudflat/saltmarsh)

What is the evidence needed to accelerate saltmarsh creation?

Underpinning our ability to kickstart the creation and restoration of saltmarshes for carbon storage and to drive the adoption of a UK Saltmarsh Carbon Code, is the need for further evidence.

Given the high variability of sequestration rates among restoration sites, we urgently need more data from which to derive a more precise average value, and an understanding of the factors that cause the variation among sites. This will allow us to prioritise the best sites and unlock their potential.

The Blue Carbon Evidence Partnership was set up after COP26 to progress the evidence on blue carbon habitats. It presents an opportunity to fill these evidence gaps and support a science-led strategy to saltmarsh creation.

The evidence gaps that need to be addressed are:

Understanding how much 'additional' carbon is buried by restored saltmarshes

We know that saltmarshes vary in the rate of carbon sequestration, but we do not yet know exactly what factors cause this variation. This means that it is not yet possible to predict, with confidence, where we should restore sites for maximum climate mitigation value.

There are details in how we measure saltmarsh carbon burial, and account for how much of that carbon is new and additional, that we still need to determine and agree. For example, a proportion of the carbon that arrives on the tide and is buried would otherwise have been buried in some existing sediments, and therefore should not be accounted as additional sequestration, but how we measure and account for that needs resolving.

Understanding carbon sequestration rates and how they change over time

Similarly, the rate or carbon burial in restored saltmarshes is influenced by how they are designed and how they are managed, but again, these factors are not well understood. So, there is not yet a clear prescription of how to create saltmarshes for maximum carbon burial rate.

Newly restored saltmarshes often accumulate sediment – and so bury carbon – very rapidly. However, as the site fills with new sediment and starts to reach equilibrium with the tide, the sediment deposition will slow, and so the rate of carbon burial will slow accordingly. If carbon credits are sold with a lifespan of multiple decades, this slowing of the initial rate of burial needs to be accounted for, but we don't yet understand how to predict this.

Better understanding the associated benefits

While we know that saltmarshes bring multiple benefits and services, our understanding of this is still somewhat limited. We need research to better quantify and predict the pollution and flood regulation functions, the commercial fish nursery benefits, and the human cultural benefits.
We also need to create new markets, so that payments for these services can be used to support saltmarsh restoration. This needs environmental economics research.

Evidence to support community engagement

Creating new saltmarshes by moving sea defences inland is a major change for local communities. It can transform the landscape in which they live and affect their sense of place and feeling of security from coastal flooding. Therefore, there is a potential for communities to strongly oppose saltmarsh restoration, rather than welcoming it as an opportunity. Social science research is needed to understand how best to work with communities so that they feel agency in the decision-making process. (*For more information on evidence gaps, see Appendix 4*).

What additional skills are needed to unlock the potential to create more saltmarshes for carbon storage?

As the number of coastal managed realignment examples is relatively limited within the UK, the expertise and experience of delivering such schemes comes from a small professional pool. We need to build the number of practitioners who have the relevant expertise and skills to design and build them.

Additional sources of guidance:

The Saltmarsh Restoration Handbook[51] provides excellent practical guidance on restoring and creating saltmarsh habitat.

The Blue Carbon Forum offers the opportunity to bring together government departments, statutory agencies, non-governmental organisations, environmental economists, academics, coastal engineers, engagement specialists and site practitioners. They could be key in outlining the full extent of which environmental parameters and technical solutions could efficiently deliver carbon sequestration within coastal realignment schemes. This would ensure the full range of benefits of saltmarshes are realised.

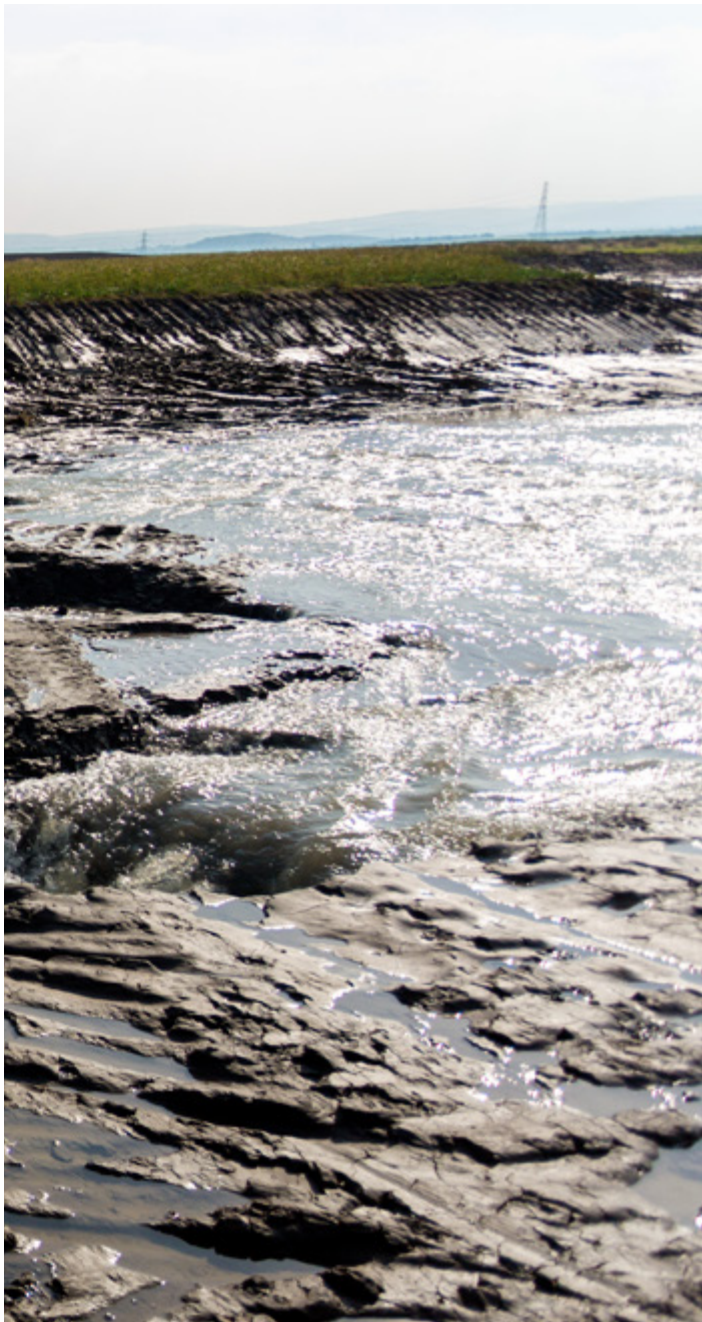
This Forum could advise on the places where realignment should be prioritised, identify evidence gaps and communicate best practice in delivery.

4.

Process

The process of delivering critical saltmarsh habitats at scale will require building capacity through developing evidence, advice and training, while engaging the community on project design and delivery. Protection and effective management of existing saltmarsh is also vital to ensure the carbon remains buried.

The process of establishing saltmarshes as a carbon offset will be key to reaching our 22,000 hectare target. However, to ensure this is done effectively it is important to create a transparent, credible and verifiable approach. Finalising the Saltmarsh Carbon Code will help achieve this.



Creating saltmarshes to store carbon involves the following three elements:

Delivery

Direct conservation action to create and manage saltmarshes to store blue carbon and provide other benefits.

Capacity building

Providing advice and training to landowners and local councils, creating innovative financing approaches, and gathering and sharing further evidence on how to derive multiple benefits from saltmarshes.

Community engagement

Consulting and involving people in shaping their local community, from design and governance of saltmarsh creation projects through to completion and management of sites into the future. Such projects must serve the community rather than be imposed from outside.

What are the priorities for the creation and restoration of saltmarshes for carbon storage?

Set out below are the priority actions that will kick-start the creation and restoration of saltmarshes for carbon storage.

Delivery

The following will demonstrate the benefits of saltmarsh creation and protection and create a model for further expansion:

Habitat creation at scale

Saltmarsh creation will need to accelerate rapidly in order to deliver 22,000 hectares of new habitat by 2050. These projects take time to deliver and planning has to start now, driven by government policy, public funding and market-driven initiatives.

There are opportunities to create saltmarsh through existing government-led initiatives, but these are unlikely to be sufficiently resourced without more designated funding and policy developments *(see Policy section for more detail)*.

Securing new private finance, initially linked to carbon and biodiversity offsetting but complemented by other natural capital markets in the future, appears to be the only way to scale up significantly and rapidly.

Blue carbon has not yet been the driver, the funder, or the realised benefit of managed realignment sites created in the UK. It will be necessary to use the existing expertise and evidence to develop early projects that demonstrate best practice and that deliver carbon sequestration rates that meet the demands of government and investors, while also delivering high-quality habitats for wildlife and the multiple co-benefits offered by these habitats.

The research and learning opportunities provided by these 'early adopter' sites will help fill evidence gaps and build the business case for new income streams associated with nutrient neutrality or flood management.

Capacity building

Advice and training

Planning, delivering and managing managed realignment sites requires specific skills, expertise and engineering capacity. There are currently relatively few organisations that are willing and able to deliver habitat creation and management at the scale proposed in this document.

It is therefore critically important that those who have existing skills, resources, capacity, knowledge, expertise and experience are involved in the early stage of a national restoration/creation programme.

Over time, other bodies will need to be engaged and supported to build their capacity to deliver and it will be necessary to increase the size of the workforce, so that we have the necessary skills to create saltmarshes effectively.

This should be a significant opportunity for job creation and the education sector should consider how it can scale up professional training in the different areas of expertise required to meet the coming demand.

Evidence

Filling evidence gaps to build confidence in the delivery of blue carbon and co-benefits of saltmarsh creation requires resourcing. Consistent monitoring of saltmarsh habitats that aligns with the needs of the Greenhouse Gas Inventory and the verification requirements of the Saltmarsh Carbon Code will also be necessary. Aligning methodological approaches will be critical to filling these evidence gaps and to ensure there are sufficient people to monitor and verify the success of projects.

Community engagement

Project development

The needs of local people and communities must be central to projects. This goes further than consultation, including them in the design, governance and management of projects. This ensures projects serve the community and are not imposed from outside.

Project delivery

Community members may be able to get involved in the delivery of saltmarsh management. This can be done through volunteering programmes and employment of local people. This helps to ensure saltmarshes are integrated into the lives of the community. It also means people can improve their wellbeing by working in these natural environments.

Use

Running and facilitating activities that remove barriers to accessing saltmarshes will ensure the benefits are widespread and equitable. This could include community activities, educational classes and walks, and schools outreach programmes based around projects.

Maintenance

Where appropriate, community involvement in the management of saltmarshes, including opportunities for sustainable grazing, should bring about better and longer-lasting wellbeing and biodiversity benefits for sites. Involvement in project design and delivery ensures this is made possible.

Protection and effective management of existing saltmarshes

Given the importance of saltmarsh for carbon storage, Sites of Special Scientific Interest (SSSI) notified for the importance of their saltmarsh should be an immediate priority for remedial action and improved management if they are in unfavourable condition.

We must not forget the benefits of existing saltmarshes in the drive to create new ones. The natural saltmarsh resource around our coastlines remains threatened by erosion, development and pollution. It is essential that the best sites, together with fragments outside protected area networks, continue to benefit from site-protection legislation. These areas must be managed effectively, have management plans and the resources to deliver them.

How will wetlands for carbon storage be financed?

Carbon markets

Carbon markets can be regulatory *(where governments set the limits on emissions)* or voluntary *(where businesses and others are not required to limit emissions but choose to do so)*. To develop blue carbon markets, policies and practices requires expertise in the following fields:

- habitat restoration planning, design and practice
- wetland management
- climate finance
- wetland greenhouse gas science
- carbon standards
- wetland policy
- community engagement and advocacy.

Creating saltmarshes can deliver carbon offsets. However, to ensure this is done effectively, teams of stakeholders with the right skills, knowledge and expertise will be required to build a transparent, credible and verifiable approach. This will support the delivery of government schemes while creating, restoring and managing carbon-rich saltmarshes.

Carbon markets is a term for a trading system through which countries may buy or sell units of greenhouse-gas emissions in an effort to meet their national limits on emissions.

Creating a UK Saltmarsh Carbon Code

There is currently no trading value for UK blue carbon. This needs to be established quickly through the UK Saltmarsh Carbon Code.

The UK Saltmarsh Carbon Code will generate carbon offsets through the creation and restoration of saltmarsh. The finalisation of this code will be an important step to monetising the carbon value of restored saltmarsh. Existing woodland and peatland carbon codes (which generate carbon offsets for woodland creation and peatland restoration) demonstrate the success of such codes.

This important code is being developed by the UK Centre For Ecology and Hydrology, WWT and other partners. The project to develop it is funded by the UK Government's Natural Environment Investment Readiness Fund. This project must be supported until it is completed.

Additional projects that develop tools to stimulate private investment in saltmarsh restoration will be needed. Through market testing we have established that sites with multiple benefits attract investors and could significantly improve their returns.

Securing carbon financing for coastal habitat restoration in the UK can be based on proven approaches developed elsewhere. For example, the 'Bringing Wetlands to Market' project in the USA was instrumental in the development of the first methodology to enable coastal carbon projects to secure credits through verified carbon markets. The creation of this (VM0033) Methodology for Tidal Wetland and Seagrass Restoration *(the 'Verra approach')*[52] involved several partners. It was adopted in 2015 and is now available for application.

These methodologies were a significant achievement. They paved the way for project developers interested in supporting saltmarsh creation/restoration to advance the creation of a blue carbon market. They will be used to underpin the UK Saltmarsh Carbon Code.

5.

Partnerships

No single organisation alone will be able to create saltmarsh for blue carbon. To create saltmarsh at the scale required we need the involvement of national and local governments, the investment and know-how of businesses, and a process of co-creation with landowners and local communities.

We have identified key partners from across the UK to facilitate UK-wide saltmarsh creation.

Delivery

Government

As well as working to protect existing saltmarsh, the UK Government, must develop and implement policies that facilitate and scale up the restoration and creation of saltmarsh. WWT will encourage this by:

- **advocating for policies**, often in coalition with other organisations
- **meeting policymakers** to discuss barriers to change
- **working with the All-Party Parliamentary Group for Wetlands** to influence parliamentary processes and decision-makers.

Key departments:

- **The Department for Business, Energy and Industrial Strategy (BEIS)** delivers the Greenhouse Gas Inventory and the UK's Nationally Determined Contributions, and is therefore important from an evidence perspective, although delivery of the land-use aspects are part of Defra's remit.
- **The Department for Environment, Food and Rural Affairs (Defra)** as the department responsible for protecting and enhancing nature, including how people interact with nature
- **The Department for Levelling Up, Housing and Communities (DLUHC)** as the department responsible for planning law. Access to nature and natural spaces, including saltmarshes, could also be important to the levelling up agenda. Saltmarsh restoration is a significant engineering project that would create employment opportunities in deprived areas.

WWT will work also with statutory agencies that have a stake in the development and long-term management of restored and created saltmarsh, including **coastal flood authorities, statutory nature conservation bodies and coastal local authorities**.

Business

The creation and restoration of saltmarsh at scale will require the involvement of a wide range of businesses and companies, including:

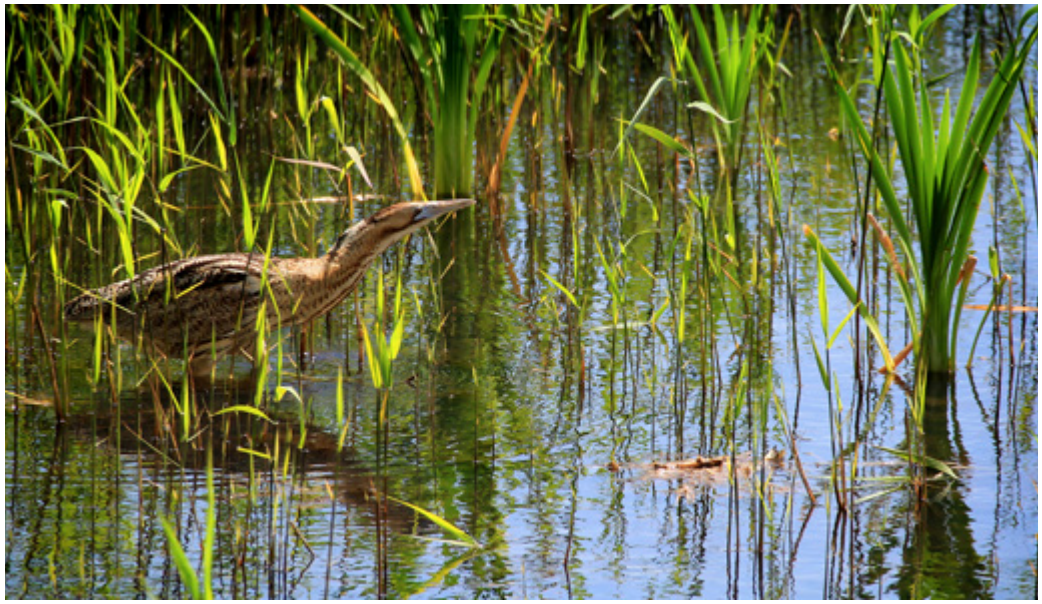
- ethical investment banks
- private entrepreneurial investors
- businesses with strong corporate social responsibility policies
- landowning organisations or businesses
- utility companies, particularly those in the water sector
- ethical pension investment companies
- developer contributions through existing planning obligations *(e.g. Section 106)* or Biodiversity Net Gain.

It will be important to develop the principle of an ethical investment model. Such a model would require a percentage of any carbon profits generated from the restoration or creation of saltmarsh sites to be invested in a fund. The fund would be managed and divided between the immediate local community and future wetland creation. Such a solution would ensure robust financial support for the local community far into the future.

Additionally, we will work with consultants who have experience of developing and delivering saltmarsh restoration for private investors.

Civil society

WWT will work with other local and national non-governmental organisations. We are stronger in coalition. Where our aims overlap with other organisations we will advocate and campaign together for policy changes that increase saltmarsh restoration and creation and underpin successful financing from the private sector, for example, the UK Saltmarsh Carbon Code.



Capacity building

Government

The Climate Change Committee (CCC) is an independent statutory body that advises the UK and devolved governments on mitigating climate change and adapting to its impacts. It reports to Parliament annually on the progress that has been made in reducing greenhouse gas emissions. The CCC will be an important influencer, applying pressure and critical evidence for ramping up investment and policy developments in blue carbon.

Business

Demand from business for validated, high-integrity carbon credits is at an all-time high. However, converting this into investment in blue carbon projects requires robust proof of concept to improve confidence and manage risk. In turn, this would substantially increase the supply of viable projects. Evidence should be shared with businesses on potential financial savings through investment in saltmarshes.

Civil Society

Funded partnerships with academic institutions to deliver the scientific expertise to fill evidence gaps will be essential to the success of our ambition.

Community engagement

Government

Local authorities have a responsibility for planning, flood prevention and public health. They will therefore be essential partners in ensuring that the multiple benefits of saltmarsh restoration are considered and that projects are delivered. We will seek to advise them on how to use the multiple benefits of restored saltmarsh to save money, improve wellbeing and increase resilience to climate change.

Members of the community should be involved as equal partners in making these changes.

Business

Projects involving developers and water companies should include community members as equal partners.

Civil Society

To seek the investment required to support the restoration and creation of saltmarsh we need to show decision-makers and key stakeholders that there is support for these wetlands; this means raising public awareness, and building meaningful and effective engagement to inspire action.

It will be essential to work alongside community groups and stakeholders that use coastal spaces. Community engagement at every stage is vital to ensure the restored saltmarsh meets local needs and becomes part of community life.

We will also work with community groups and local charities to increase the skills of their members, and build their capacity so that they can adopt and manage projects they helped to create and initiate blue carbon projects of their own.

Through our Wetlands Can! public campaign, calling for 100,000 hectares of wetlands to be created across the UK, we will continue to raise awareness of wetlands and their multiple benefits, and inspire people to support and take action for them.

6.

Policy

WWT wants to see saltmarsh restoration recognised as a valuable contribution to UK Government carbon targets that will unlock investment in saltmarsh restoration.

Restoring saltmarsh habitats for blue carbon requires a supportive policy framework. Stakeholders need the right information, plans and funding to make this happen.

Despite the benefits, coastal saltmarsh is not fully factored into any government climate change policies or initiatives and is not included in the Government's Net Zero Strategy. And while there are currently carbon offsetting codes for peatland and woodland, no such code exists for saltmarsh.

The UK Government must adopt the following policies to ensure we can make the very best use of saltmarshes[53].

Information

TOP PRIORITY

Evidence: By 2025, the UK Government needs to incorporate coastal wetland creation as a nature-based solution into the UK's Nationally Determined Contribution (NDC) and to include it in the UK Greenhouse Gas Inventory.

The Greenhouse Gas Inventory feeds into the UK's NDC required under the Paris Agreement. Country NDCs outline and communicate their post-2020 climate mitigation measures, which can include habitat creation and restoration for carbon storage. Currently, the UK Government states that it requires additional evidence before it can support the inclusion of saltmarshes within the inventory and the NDC. However, there is currently sufficient evidence to support its inclusion at least at Tier 1. The Government should not wait for more evidence, but should include saltmarshes in its NDC now, and then build in further evidence as it is produced. It is important that we understand the gaps in the data, facilitate opportunities to fill those gaps and ensure that these data gaps do not result in a lack of action.

The UK's carbon budget places a restriction on the total amount of greenhouse gases the UK can emit over a five-year period. The UK has legally binding carbon budgets, yet there is no budget for wetlands other than peatlands. This is despite the Intergovernmental Panel on Climate Change publishing guidance on including wetlands in national greenhouse gas inventories[54]. While these do not include coastal ecosystems, the UK does have the option to incorporate them where there is sufficient evidence to do so.

Sites: We are calling for The Environment Agency to use existing data to identify and promote geographical opportunities for saltmarsh restoration and creation around the English coast. This will establish a 'community of the willing' among the landowning community as opportunities for investment arise.

Existing data shows where saltmarshes could be restored and created around the UK. There are also planning processes that set out geographically discrete opportunities for action.

For instance, Shoreline Management Plans (SMPs) have created helpful ambition for coastal habitat creation in the UK yet it is clear that this ambition has not been realised, despite full implementation being the basis for the estimate of flood risk to properties[55]. Currently SMP policy is based on flood risk, but **WWT would like to see a review of SMP policies to take into account the opportunity for managed realignment to store carbon.**

There is a lot of variation in sequestration rates and carbon storage values, and, despite the efforts of WWT and partner academics, there is still work to be done to establish the factors that make particular sites better or worse for blue carbon.

A process of identifying landowners willing to offer land for coastal habitat restoration and creation, with associated clear incentives for doing so, needs to be developed. This will ensure a 'community of the willing' is established and that it can benefit from and be part of the delivery of the multiple benefits of restored and newly created saltmarsh outlined earlier in this report.

Guidance: The UK Government needs to provide clear advice and guidance to local planning authorities and landowners on saltmarsh protection, management, restoration and creation and the public and private financing mechanisms that will drive investment in these areas.

Creating a UK Saltmarsh Technical Advisory Group, made up of technical experts and practitioners, will be important in guiding the focus of managed realignment that maximises ecosystem services, including carbon sequestration and storage. This could unlock the potential to share and benefit from the fast-moving development of projects, new research on the benefits of saltmarshes and the funding that will be available to drive their restoration and creation. This may be best set up under the auspices of the existing Blue Carbon Forum.

There is also an urgent need for those advising landowners on future opportunities for funding land management to have a clear and consistent list of options, such as carbon offsetting, to end the current paralysis in decision-making.

Plans

TOP PRIORITY

Standards: By 2025, we need to see the UK Government and devolved administrations support a nationally recognised Saltmarsh Carbon Code that sets clear standards for best practice in saltmarsh creation, restoration and maintenance.

This code must be prioritised. WWT and partners have secured funding to develop a carbon code for saltmarsh but the costs of any additional work to support its finalisation must be provided immediately. Based on the Verra approach, the confidence created by the new UK Saltmarsh Carbon Code and its governance will help drive investment and reduce risk to investors.

A Saltmarsh Carbon Code will provide a rigorous and scientifically based voluntary certification standard for those seeking to market the climate benefits of saltmarsh restoration, and will give assurances to voluntary carbon market buyers that the climate benefits are quantifiable, additional and permanent. However, to be successful it will need a supportive policy framework that enables the establishment of an effective carbon market for saltmarsh maintenance, restoration and creation.

Existing carbon codes *(such as the Woodland Carbon Code and the IUCN's Peatland Carbon Code)* help ensure that habitat created for carbon storage is genuinely providing the intended benefits. Producing a saltmarsh code is critical to ensuring coastal wetlands meet recognised standards in storing carbon. It should facilitate the process of developing financing opportunities around the multiple benefits of coastal wetlands alongside private investment in saltmarsh creation. The latter will focus on monetising the value of blue carbon stores and helping businesses reach net zero targets and subsequently the UK Government's net zero target.

Standards: We are calling on the UK Government to ensure that protected area networks also protect blue carbon stored in saltmarshes, through effective management and restrictions on damaging activities.

To secure the benefits of the carbon stored in existing saltmarshes and those being restored and created in perpetuity, it is essential that the habitat remains intact and is managed to avoid any loss of greenhouse gases. Existing site-protection plans and policies should be used to do this.

This will be especially important for saltmarshes created to deliver carbon credits that only retain value if the carbon remains locked in the substrate.

Targets: The UK Government should introduce targets for saltmarsh creation and restoration in the national Flood and Coastal Erosion Risk Management (FCERM) Strategy for England.

Concern about flooding continues to focus attention on coastal management. The National Coastal Erosion Risk Map (NCERM) currently indicates that by 2060 about 2,000 properties will be at risk of being lost to coastal erosion[56]. In 2023, the Environment Agency will update the NCERM to ensure it reflects the latest evidence on coastal erosion and sea level rise.

The Environment Agency's Restoring Meadow, Marsh and Reef initiative is looking at ways to restore saltmarsh and other estuarine and coastal habitats beyond what is needed to compensate for habitat losses. This is invaluable work but the need to establish targets for saltmarsh restoration and creation should not be ignored. WWT is collating evidence for the FCERM to demonstrate the need for saltmarsh restoration and creation for natural flood management. In the future, the FCERM should include and drive the delivery of the 22,000 hectare target for saltmarsh.

National Flood and Coastal Erosion Risk Management (FCERM) can sometimes cause the loss of saltmarsh. When building and maintaining FCERM assets, the Environment Agency currently compensates for designated habitats impacted negatively by any activity.

Funding

TOP PRIORITY

Public funding: We are calling on the UK Government to put the funding mechanisms in place to facilitate the creation and restoration of coastal wetlands for carbon sequestration through government and private investment by 2025 *(using existing initiatives that are well placed to do so)*.

The scale of saltmarsh creation and restoration that WWT is calling for will need public and private funding. The current challenge around delivering an effective private market in saltmarsh creation and restoration relates to corporate risk and uncertainty. There is a need to bridge the gap between corporate funding of pilot schemes and scaled-up wetland restoration projects. Government could provide a range of financial mechanisms such as guarantees or seed funding to help bridge this gap and reduce risk and uncertainty.

There are a range of Government funds that could deliver coastal wetland restoration, creation and management. These include the Environmental Land Management Schemes (ELMs), which are based on the principle of 'public money for public goods' and the UK Infrastructure Bank, which has been allocated £22 billion to deliver objectives including addressing climate change.

The Government is open to reviewing the case for broadening the UK Infrastructure Bank environmental objectives *(for example, improving the UK's natural capital)*. If this is achieved it could leverage financing options such as seed funding and guarantees for investors to facilitate pilots to assess their commercial viability. There is also an opportunity to direct existing and relevant funds, such as from the Nature for Climate Fund, Biodiversity Net Gain, FCERM funding, to finance saltmarsh restoration and creation.

Private funding: We are calling for a bespoke fund to support the development of an investment case that drives saltmarsh restoration and creation projects so that carbon buyers can provide the finance for these projects while securing a return. Project development costs at this early stage of market development need to be met before investors will be attracted to the proposition.

We need to be in a position whereby the development, delivery and long-term maintenance of saltmarsh restoration projects are partially funded by the carbon offsetting opportunities that they provide *(Table 2 pg25)*. In the early stages, funds will be needed to cover the upfront costs of project development phases. These projects will ultimately deliver private investment streams and de-risk early investments.

Unsplash.

Conclusion

WWT proposes the creation and restoration of a minimum of 22,000 hectares of nature-rich saltmarsh by 2050, and the protection of our existing saltmarsh resource, to maximise this habitat's significant blue carbon storage potential and co-benefits.

We need urgent action to plan and establish projects that create and restore saltmarsh, to deliver blue carbon and a range of co-benefits.

This will require public and private investment, and a blend of the two, to deliver at the scale required. We need to build the capacity of stakeholders to create these habitats, primarily through managed realignment. Engaging with communities to co-create projects at all stages will be crucial to the creation of saltmarshes for carbon and co-benefits that sit at the heart of community life.

By restoring and creating saltmarsh at scale we can increase resilience to climate change, boost biodiversity, reduce flood risks, improve water quality and improve the wellbeing of people who access coastal wetlands.

These are WWT's proposals to restore, create and manage saltmarshes to store blue carbon and deliver so many co-benefits in the UK. We are already leading the way, protecting and managing existing and new saltmarshes while building the evidence base, pressing for further government support and policy changes, and inspiring new financing mechanisms to deliver at scale with the private sector.

However, we know there is huge potential to do a lot more. Unlocking this requires determined efforts by local and national governments, businesses and communities across the country.

The opportunity is now. With partnerships, funding and policy change we can do so much more to build a network of multi-benefit saltmarsh habitats that help address the climate emergency. The summer droughts of 2022, heatwaves and increased flooding have shown us that there is no time to waste. We need to act now to mitigate and adapt to the impacts of climate change. Please join us so that together we can make a blue recovery happen.

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Appendix

Appendix 1:

What is carbon's role in climate change?

Global atmospheric carbon dioxide levels are now consistently above 400 ppm, well beyond levels occurring in the last 800,000 years[1]. This rise has been driven by human activity with fossil fuel emissions becoming the dominant source of carbon dioxide from the 1920s onwards. Reducing greenhouse gas emissions by transitioning away from fossil fuels is necessary to stabilise our climate. To avoid the worst effects of climate change, science tells us that we must limit global temperature rise to 1.5 degrees Celsius, or a maximum of 2 degrees Celsius, above pre-industrial levels, also the central goal of the 2015 Paris Agreement . Whilst the reduction in emissions is critical, we also need to do more to improve the management of our biosphere, recovering terrestrial and ocean sinks as a form of natural climate mitigation.

The UK is legally committed to reaching net zero emissions of greenhouse gases by 2050[2], with an interim commitment to a 78% reduction from 1990 levels by 2035[3]. Meeting this target will require not just emission reduction, but also the active removal of greenhouse gases from the atmosphere, particularly carbon dioxide, as determined by the UK Climate Change Committee[4]. While new and untested technological solutions are being developed, we know natural systems already remove carbon dioxide from the atmosphere[5].

Appendix 2:

How newly restored saltmarsh stores carbon

Newly restored saltmarshes created by breaching a sea wall (managed realignment) are often lower in elevation than natural saltmarsh. Consequently, the accumulation of sediment tends to be very rapid in the early years after restoration as the tidal patterns stabilise. This means that restored saltmarshes tend to have unusually high initial rates of carbon sequestration. It is currently unclear how long these high rates are sustained for; this is likely to depend on how far away the saltmarsh is from stabilising. Typically, saltmarsh restoration takes place on land previously used for intensive farming that was a net source of greenhouse gases, enhancing the change in net carbon emissions upon restoration.

Appendix 3:

How saltmarsh carbon sequestration is calculated and credited

Saltmarsh creation stimulates new carbon sequestration. Some of the buried carbon arrives as dead organic matter on the ride, rather than being produced by photosynthesis on site. If the carbon that is buried in the saltmarsh would have been permanently buried elsewhere, it should not be credited to the new saltmarsh. Various approaches to this have been suggested and the issue is not resolved for UK saltmarsh carbon. However, a preliminary estimate of the deduction for Steart is that it would bring the carbon that could be credited down to approximately 22 tonnes of carbon dioxide equivalent hectares per year. This calculation is made using the Verra code, which is the most applicable carbon code method for the UK market due to its robustness.

A further area of uncertainty relates to the timescales of rapid carbon burial in restored saltmarshes. Ultimately, the rate of carbon burial at such sites will fall back towards those of natural sites, but it is not yet clear whether that takes place over years, decades or centuries. This is important for carbon accounting.

A remaining priority for research through to policy is to determine additionality[6] (to within reasonable confidence levels) to guide availability for emerging offsetting markets. Standardising the sampling methodology used by researchers at different sites is another.

Appendix 4:

Research gaps for saltmarshes

There is much to be learned about the benefits of saltmarsh and there is a great need for scientific research to fill the evidence gaps that prevent more saltmarshes from being created.

However, to provide some of the answers needed to drive the adoption of a UK Saltmarsh Carbon Code and for saltmarshes to be included in the UK Greenhouse Inventory, new research, and government funding for this research, should focus on:

- estimating carbon sediments to a depth of 1m so that accurate carbon stock estimates can be produced for UK saltmarshes, and make these values comparable with each other
- recording environmental variables such as salinity, sediment type and elevation for both natural and restored marshes where carbon and greenhouse gas fluxes are being measured, so that major drivers of variation in these processes can be identified
- obtaining before and after data for natural and restored marshes (where possible) and more data on restored marshes generally and over time, to fully compare the responses of restored marshes with their natural 'equivalents'
- assessing the additional ecosystem benefits of restoration projects, including the value of the natural capital secured by new sites.

Appendix 5:

Existing Government initiatives that could help build saltmarsh (as mentioned in the Policy section of this report)

Shoreline Management Plans (SMPs)

The UK Government is working with coastal authorities to review the SMPs developed between 2006 and 2012[7]. The Environment Agency is coordinating the work with support from the Coastal Groups.

This review should ensure that SMPs are up to date and use the best available evidence for their recommendations. It is hoped this will support planning and investment at the coast, including the creation of saltmarsh at scale.

The SMP process varies across the UK. In England and Wales it is overseen by the Environment Agency, in Scotland by local authorities and in Northern Ireland by the Department for Infrastructure Rivers (which has yet to create any).

There is a need for further strategic alignment across the UK to ensure SMPs are consistently and successfully implemented in all areas.

Habitat Compensation Programme

Most future saltmarsh losses are expected to arise from coastal squeeze. Compensation in these cases normally involves creating new habitat. The Environment Agency produces long-term forecasts for how much habitat it expects will be lost to coastal squeeze[8].

Since the early 2000s, the Environment Agency has had a Habitat Compensation Programme. This programme plays an important role in monitoring habitat gains and losses. Since its creation, the Environment Agency has created over 900 hectares of intertidal habitat (saltmarsh and mudflats)[9]. Despite this progress, the Environment Agency expects to see an overall net loss of coastal habitat as a result of sea level rise over time. The Environment Agency is leading the Restoring Meadows, Marsh and Reef initiative. This project is looking at ways to restore saltmarsh and other estuarine and coastal habitats beyond what is needed to compensate for habitat losses. It shares experience on facilitating funding, guidance and regulatory issues when undertaking estuarine and coastal restoration projects.

National Flood and Coastal Erosion Risk Management (FCERM)

In October 2020 the Environment Agency provided a 'health check' report for each SMP to the relevant Coastal Groups[10]. The report highlighted areas of concern in realising the management objectives in the SMPs. The Agency also shared guidance to highlight developments in government policy that might influence the plans. The new guidance sets out how to make SMPs clearer for those using them to make decisions, and the Coastal Groups have used the guidance to clarify management approaches in each SMP.

In January 2021, the FCERM Research and Development Programme published new research on the causes of coastal squeeze and how it can be measured and predicted[11]. As part of the SMP review, the Environment Agency has updated the understanding of coastal saltmarsh losses or gains over the last ten years . We want to see these projects improving the consistency and reliability of the Habitat Compensation Programme and driving more saltmarsh creation.

Table (1). Carbon burial rates and global area of saltmarsh and terrestrial forest ecosystems (tCha-1)[12]

ECOSYSTEM	Carbon burial rate *(mean $tCO_2e\ ha^{-1}yr^{-1}$)*	Global area *(km^2)*	Global carbon burial *(mean Tg C yr^{-1})*
Saltmarsh	7.97 ± 0.88	22,000-400,000	5– 87
Mangrove	8.27 ± 1.43	137,760-152,361	31– 34
Seagrass	5.06 ± 1.39	177,000-600,000	48-112
Temperate forest	0.19 ± 0.037	10,400,000	53
Tropical forest	0.15 ± 0.018	19,622,846	79
Boreal forest	0.17 ± 0.077	13,700,000	49

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Figure (1). UK indicative Saltmarsh Potential map (see footnote for data sources used to develop map and associated licencing information)

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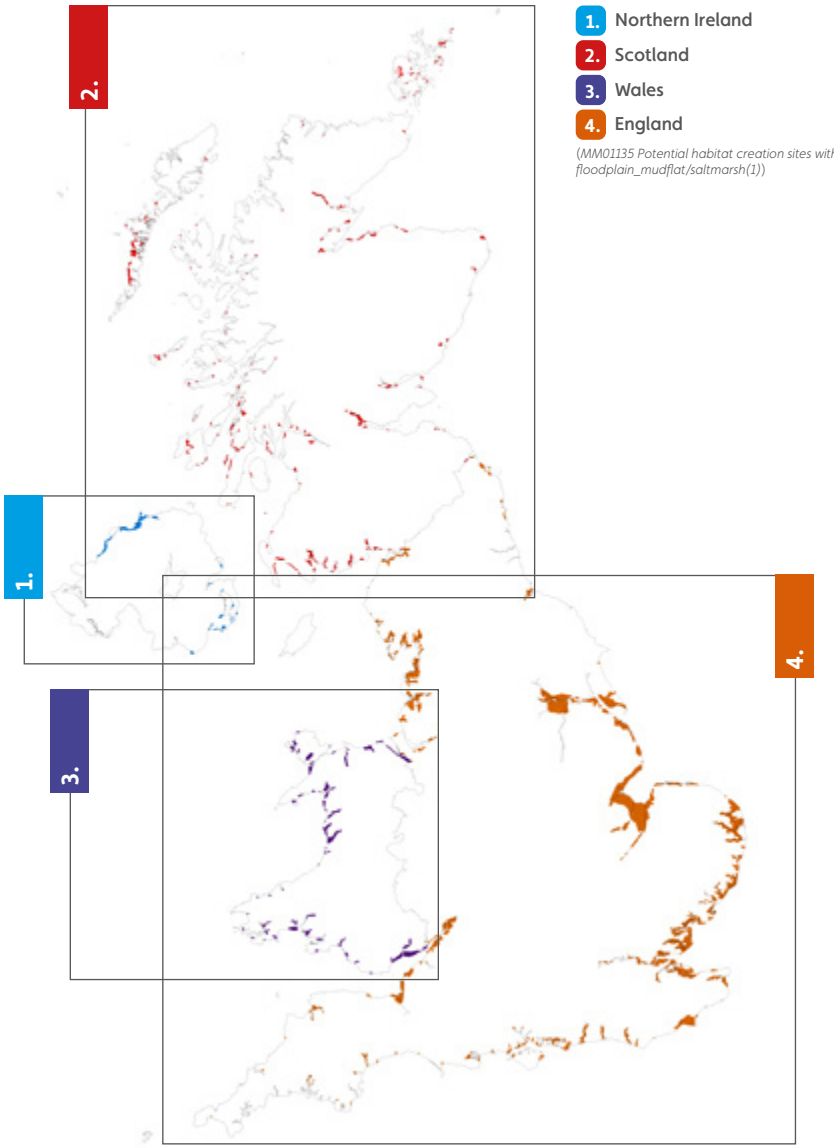
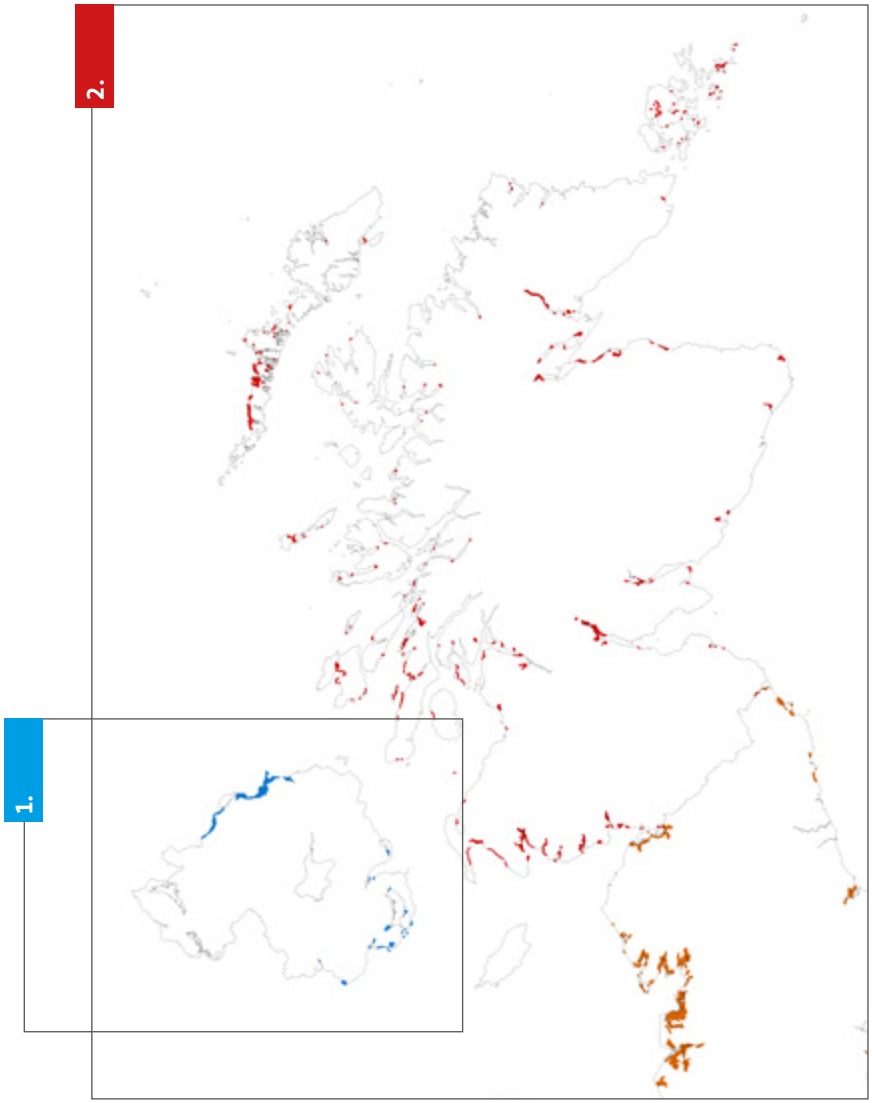


1. Northern Ireland
2. Scotland
3. Wales
4. England

(*MM01135 Potential habitat creation sites within the current floodplain_mudflat/saltmarsh(1)*)



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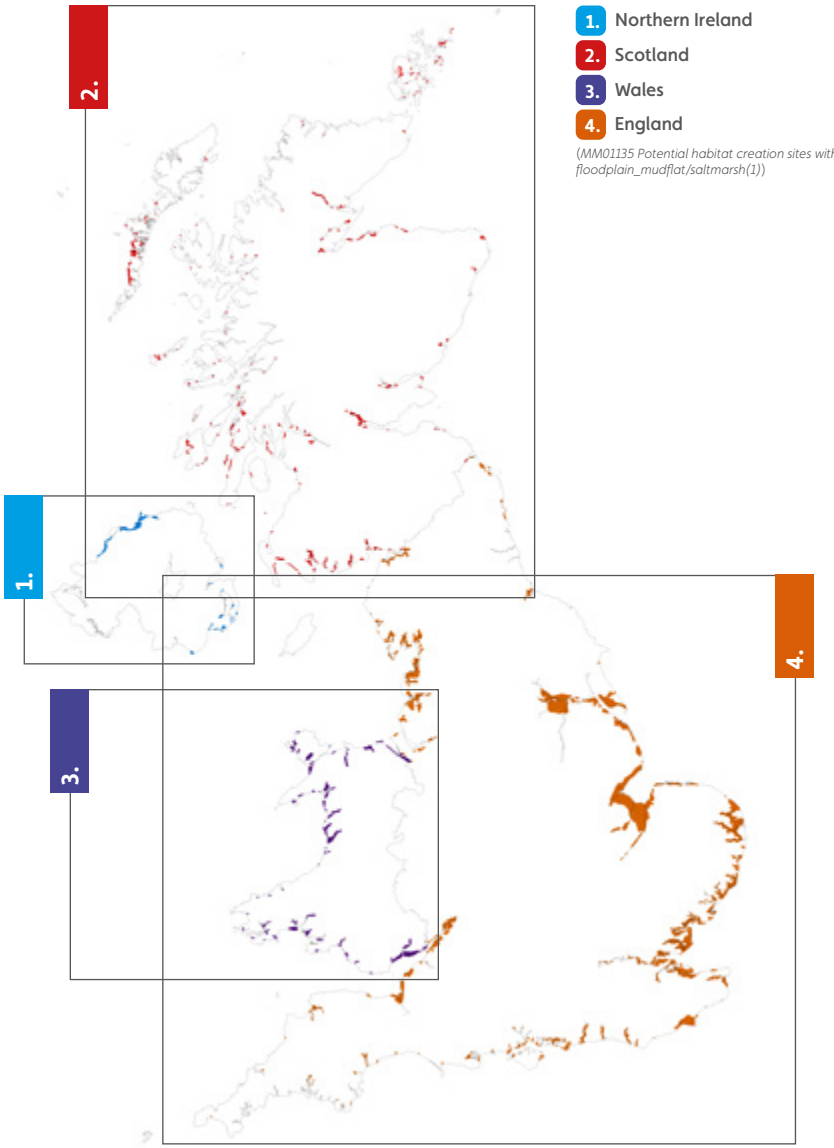

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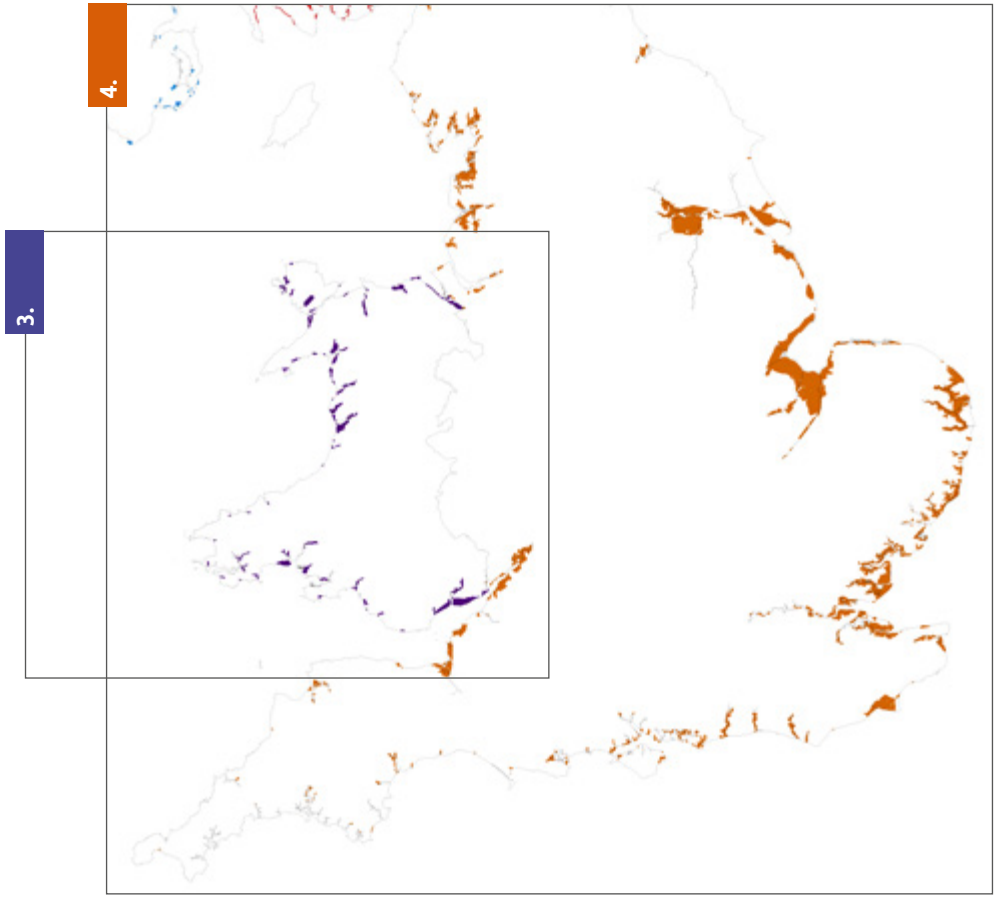

There are many exciting opportunities to accelerate the creation of wildlife-rich saltmarsh. Whether you're interested in working with WWT on a project, assisting others in building the capacity of stakeholders to create coastal wetlands, or helping us put in place the policies needed to do so, we'd love to hear from you.

Together we can help secure a future where healthy wetland nature thrives and enriches lives.

To find out more and read the full report on wetlands for carbon storage visit **wwt.org.uk/blue-recovery**

WWT

Tom Fewins
Head of Policy & Advocacy
tom.fewins@wwt.org.uk

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