Greening the grey: improving the biodiversity value of sea wall flood defence embankments

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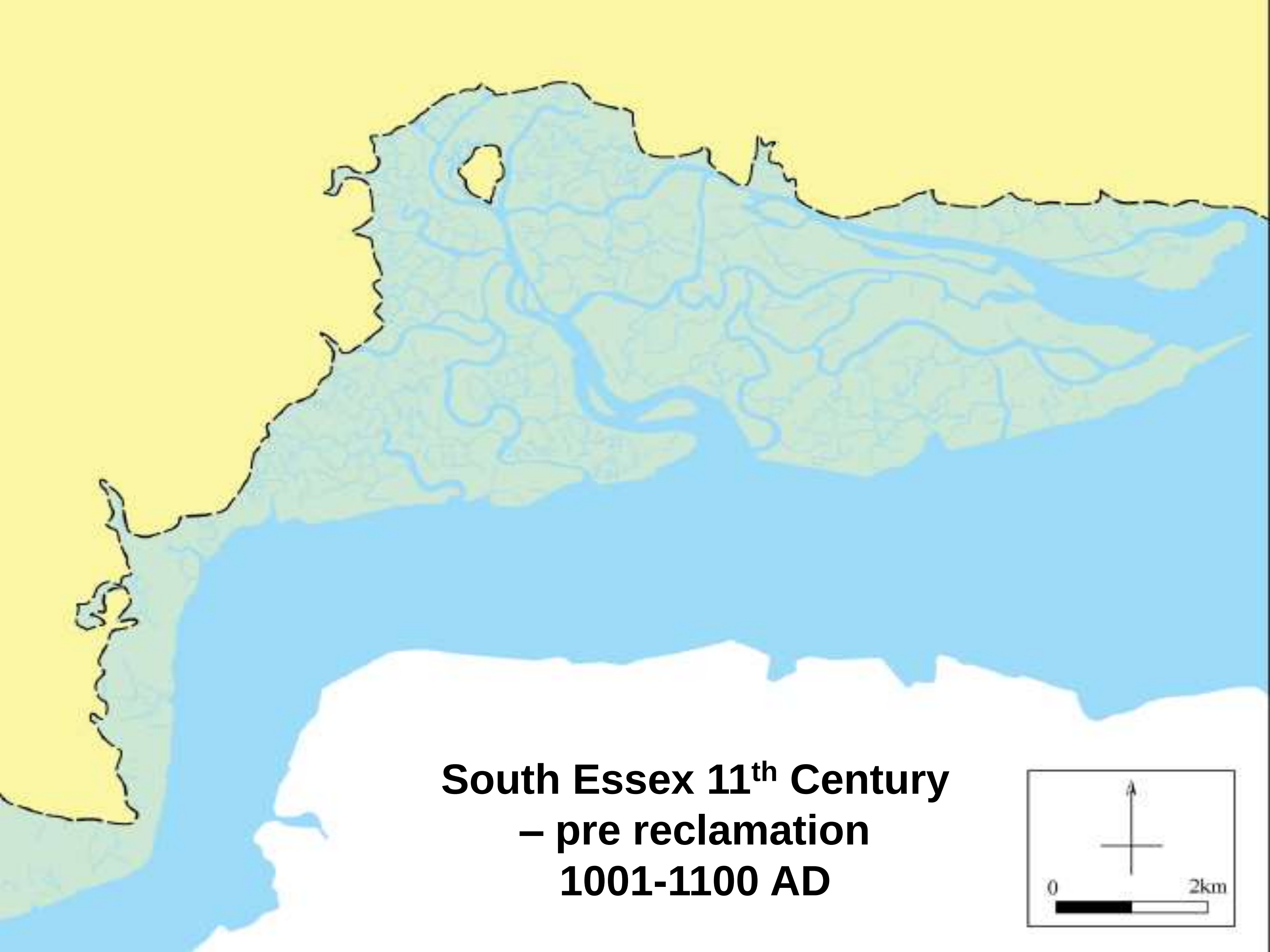
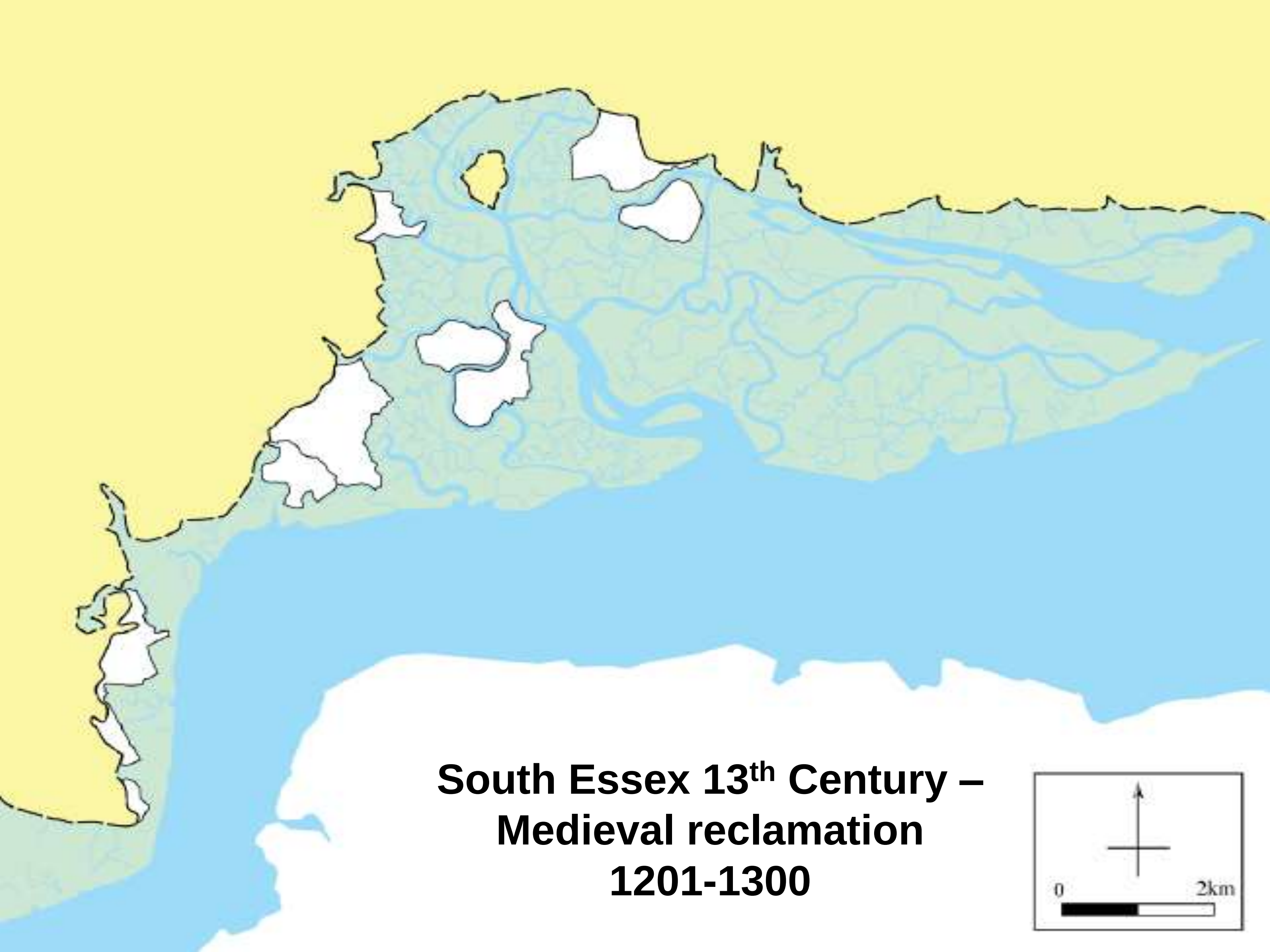
Environment Agency

Summary of talk

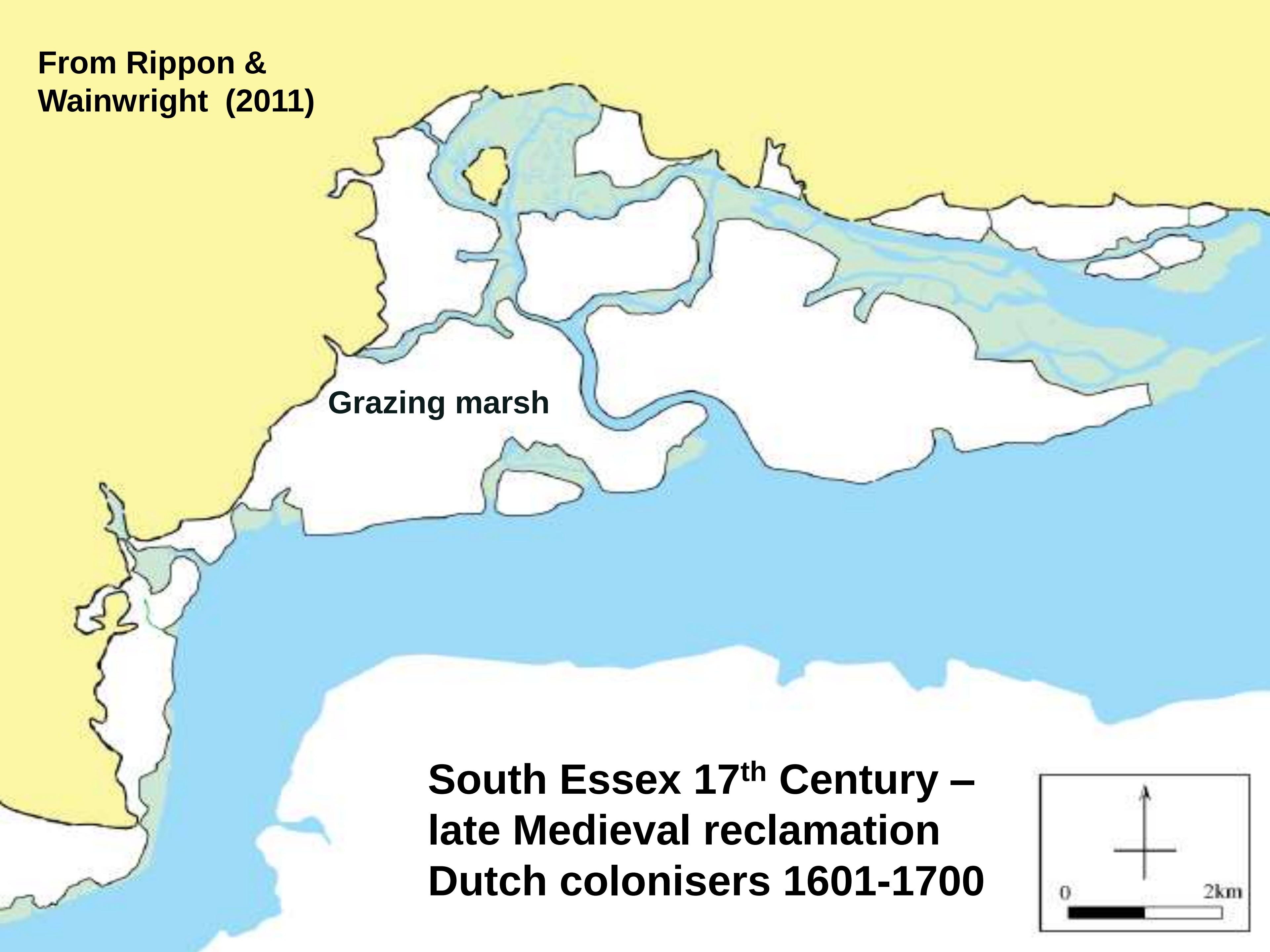
- Introduction to sea walls in UK, their function and wildlife interest
- Examination of wildlife of Tokyo Bay sea walls
- Engineering measures to ‘green the grey’
- Delivery of ecosystem services
- What can be done in Tokyo Bay
- Seawall nature reserves and handbook



South Essex 11th Century – pre reclamation 1001-1100 AD



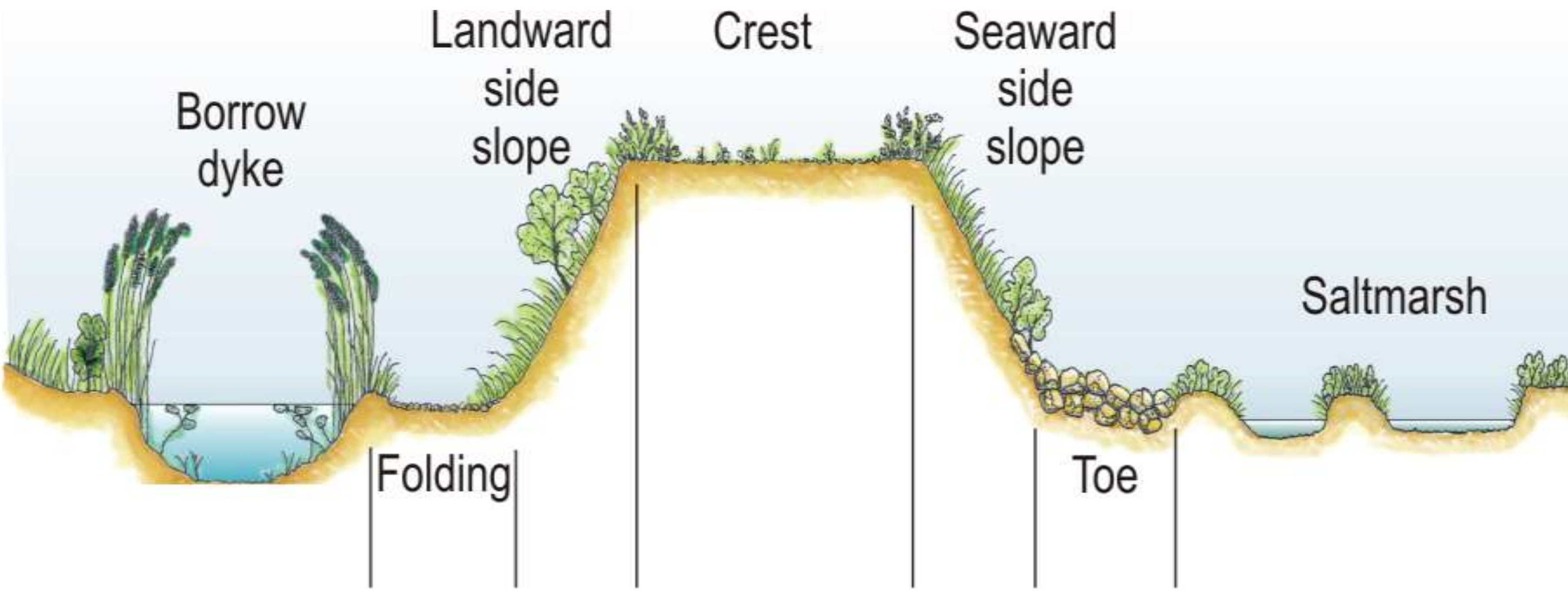
South Essex 13th Century – Medieval reclamation 1201-1300


From Rippon &
Wainwright (2011)
Grazing marsh
South Essex 17th Century –
late Medieval reclamation
Dutch colonisers 1601-1700
0
2km

2100 km

450 km in Essex

The perfect mosaic?



Primary function: **flood defence**
Secondary function: **nature conservation – many in protected sites SPAs, Ramsar and SSSIs**

Borrowdykes – clay dug for seawall building

Scarce Emerald Damselfly – RDB Vulnerable

Lagoon Sea Slug – RDB & Protected Species

Credit: Dennis R. Seward

Scrub on the folding – not on sea wall slopes or crest for engineering reasons

Sloe Carpet – Old Hall Marshes, Essex
UK BAP Priority Species

Credit: UK Butterflies website

Compensatory planting

Folding/berm –

mosaic of bare earth through to tall grass and scrub


Vehicle ruts
an important habitat
Sea Barley

Folding has much of the forage required for pollinators – combined with grazing marsh

Moss Carder-bee   UK BAP Priority Species

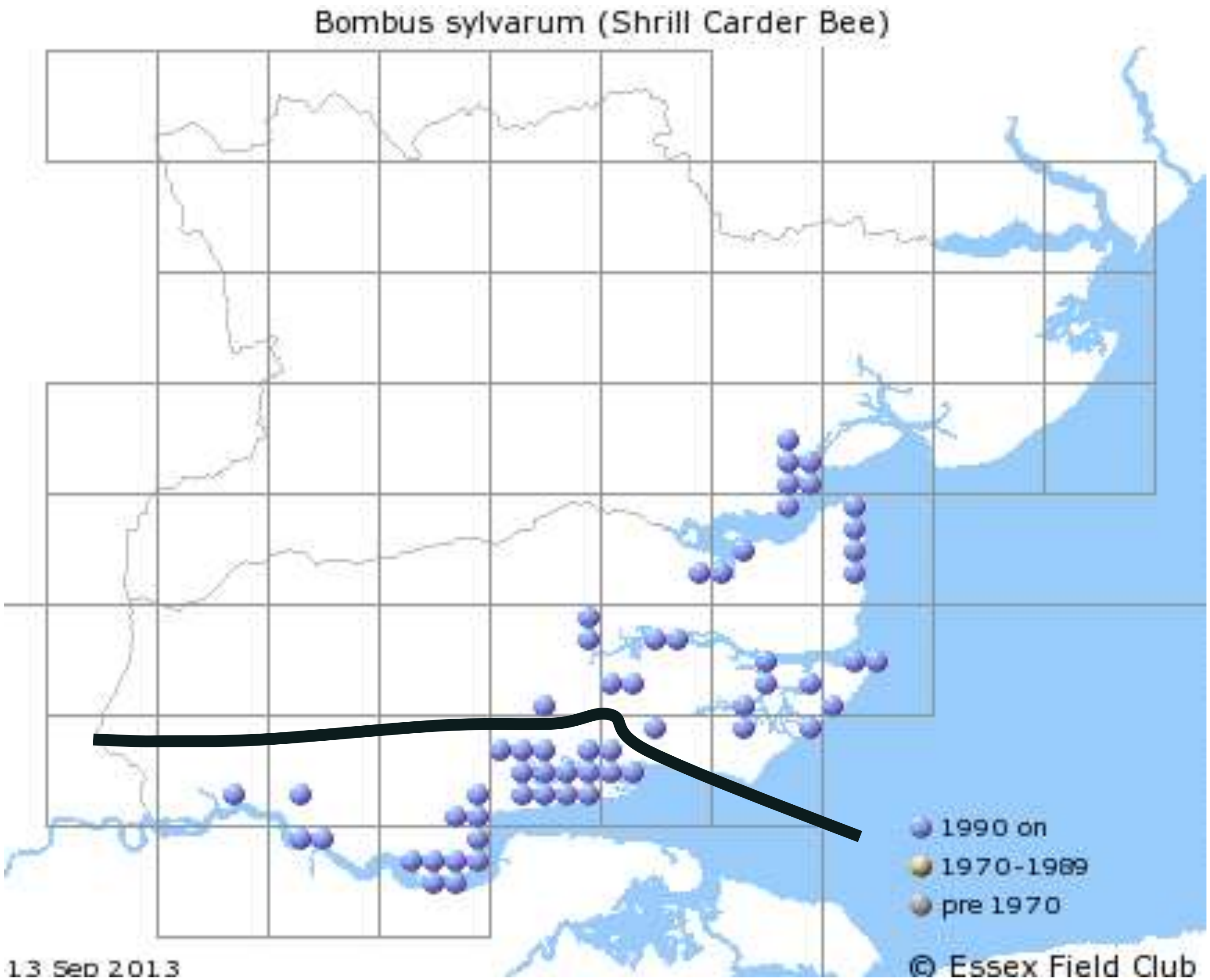
Credit: Ted Benton

Plus possibly provides nesting habitat for carder-bees

- buffering brownfield habitat

Shrill Carder-bee on the move

Credit: Ted Benton


Bombus sylvarum (Shrill Carder Bee)
1990 on
1970-1989
pre 1970
13 Sep 2013
© Essex Field Club

Saline ruts important – seepage zones

Photo: Peter Harvey

Saltmarsh shortspur ground beetle – saltpans, seasonally inundated areas near brackish water

Landward slope

- south facing slopes – warm microclimate
- tussocky grass in summer
- little bare earth from rutting

Critical flood defence function in overtopping event – no scrub and short grass overwinter

Crest

often trampled habitat and bare ground due to public footpath

Credit: Karen Brown

Seaward slope

Sea Aster Mining Bee

Credit: Laurie Campbell

Photos: Ray Reeves

Managing the mosaic

- annual flail cut – August-September
- cut delayed where invertebrate interest
- cuttings not collected

National Pollinator Strategy


ENERGREEN


No collection of arisings and
late cutting can lead to rank
grassland with few wildflowers


10 cm high cut
Normal cut


Credit: Kim Thirlby

Rotational mowing – cutting in blocks

Old Hall Marshes RSPB
Tollesbury Wick EWT
Wallasea Island RSPB

Sheep grazing

- where light creates sward structure
- summer grazing not good for pollinators
- winter grazing is better

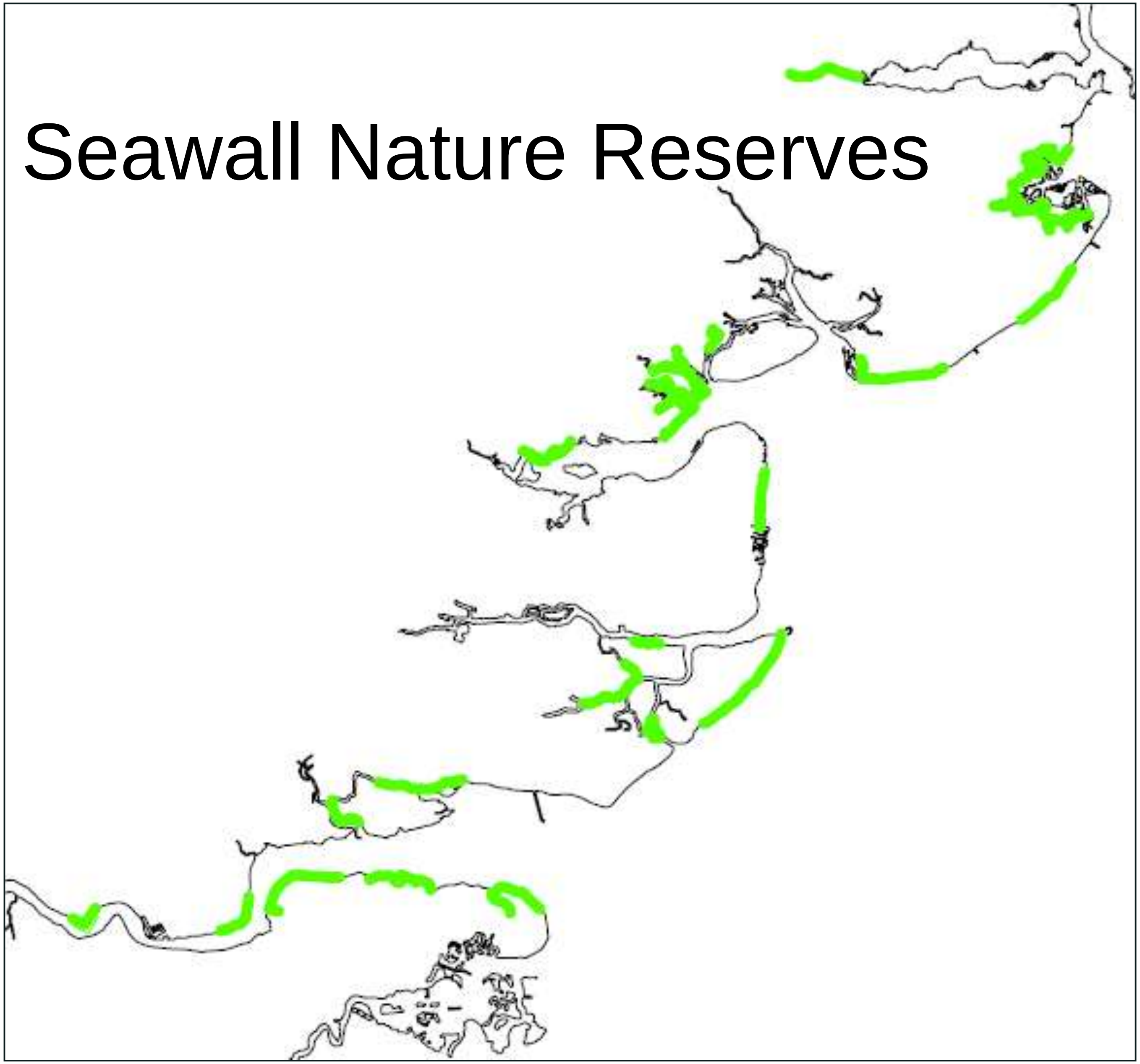

Sheep grazed
Not grazed


SHEEP GRAZIN
PLEASE
KEEP DOGS ON A L AD

Horse grazed
Not grazed


Cattle grazing can be good botanically but poaching often damages flood defence

Seawall Nature Reserves



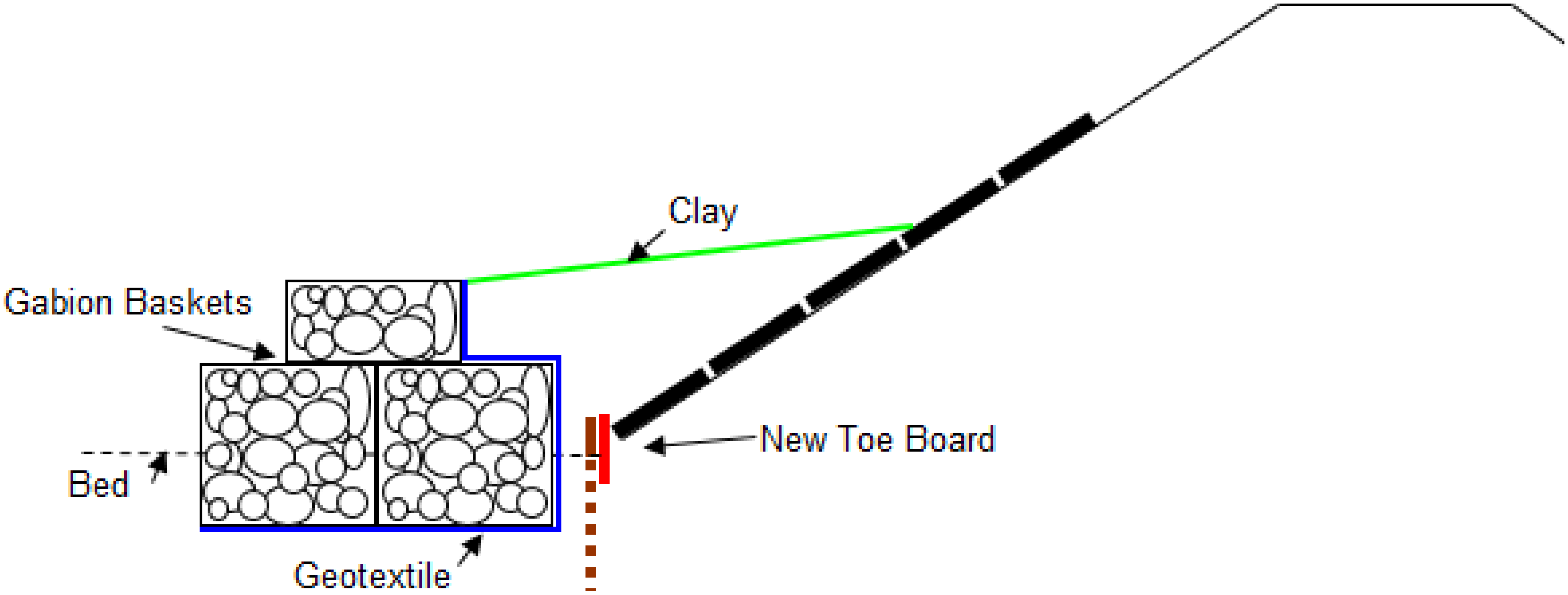
Salt marsh loss: 40 ha/year

6 m wide fringe of salt marsh can reduce costs by 70%

Wave attenuation as high as 60% even during storm surge conditions

Canewdon block replacement: £635 per m

Salt marsh terrace: £660 per m



Natural colonisation by salt marsh vegetation since installation in 2011

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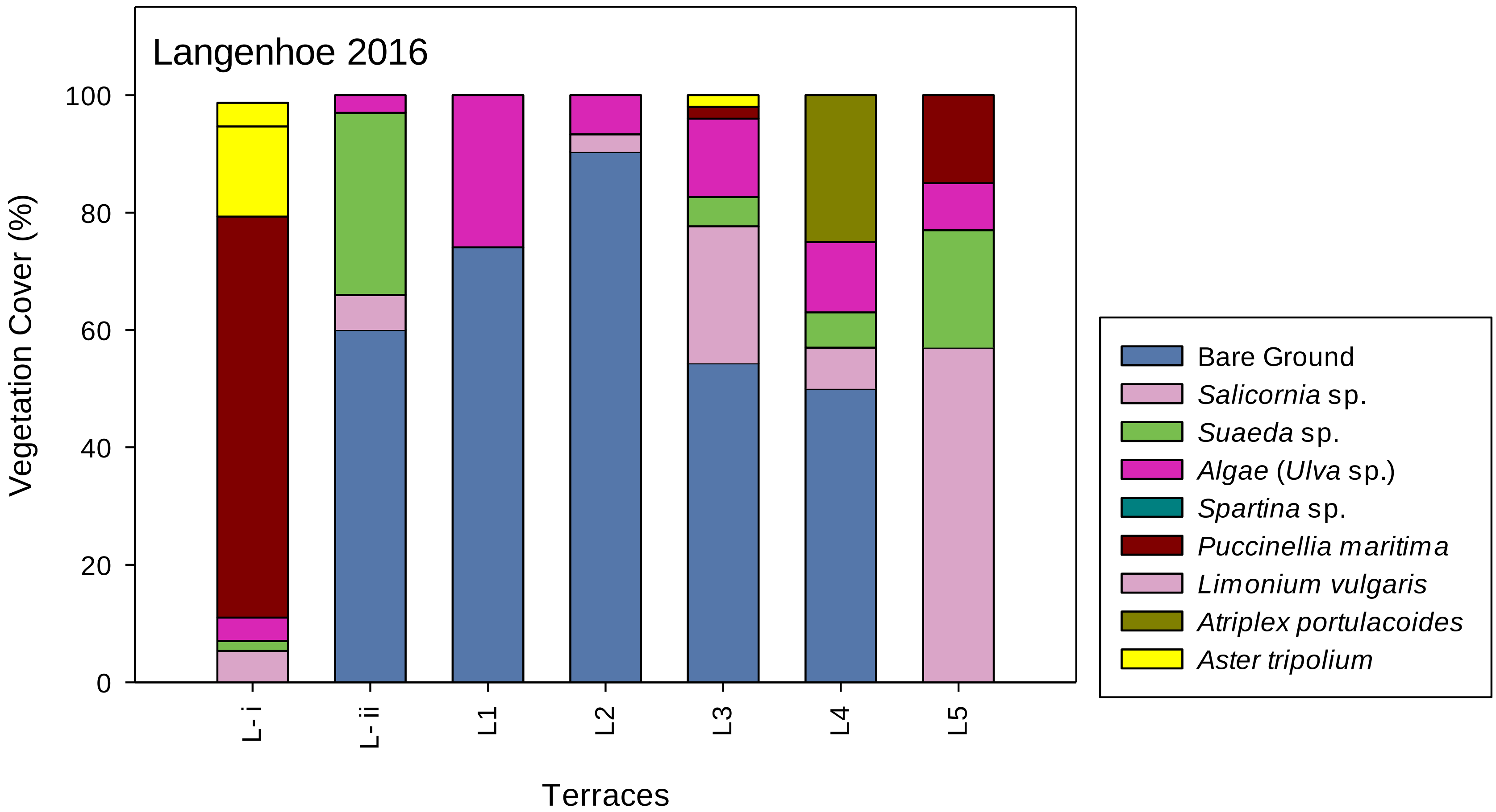
2013 – 2 years post construction

2015 - 4 years post construction and post surge


2015 – 4 years post construction and post surge



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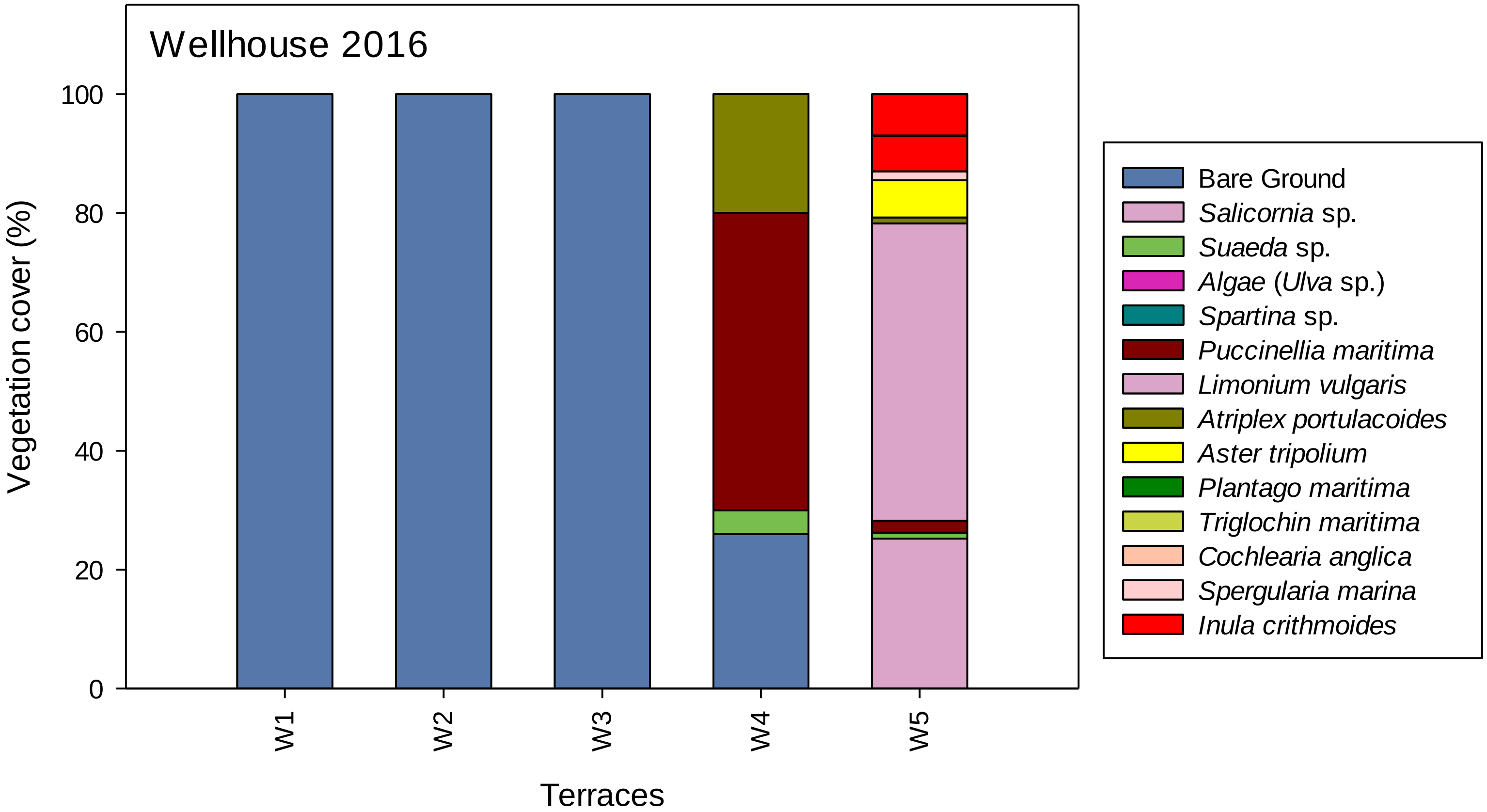
2015



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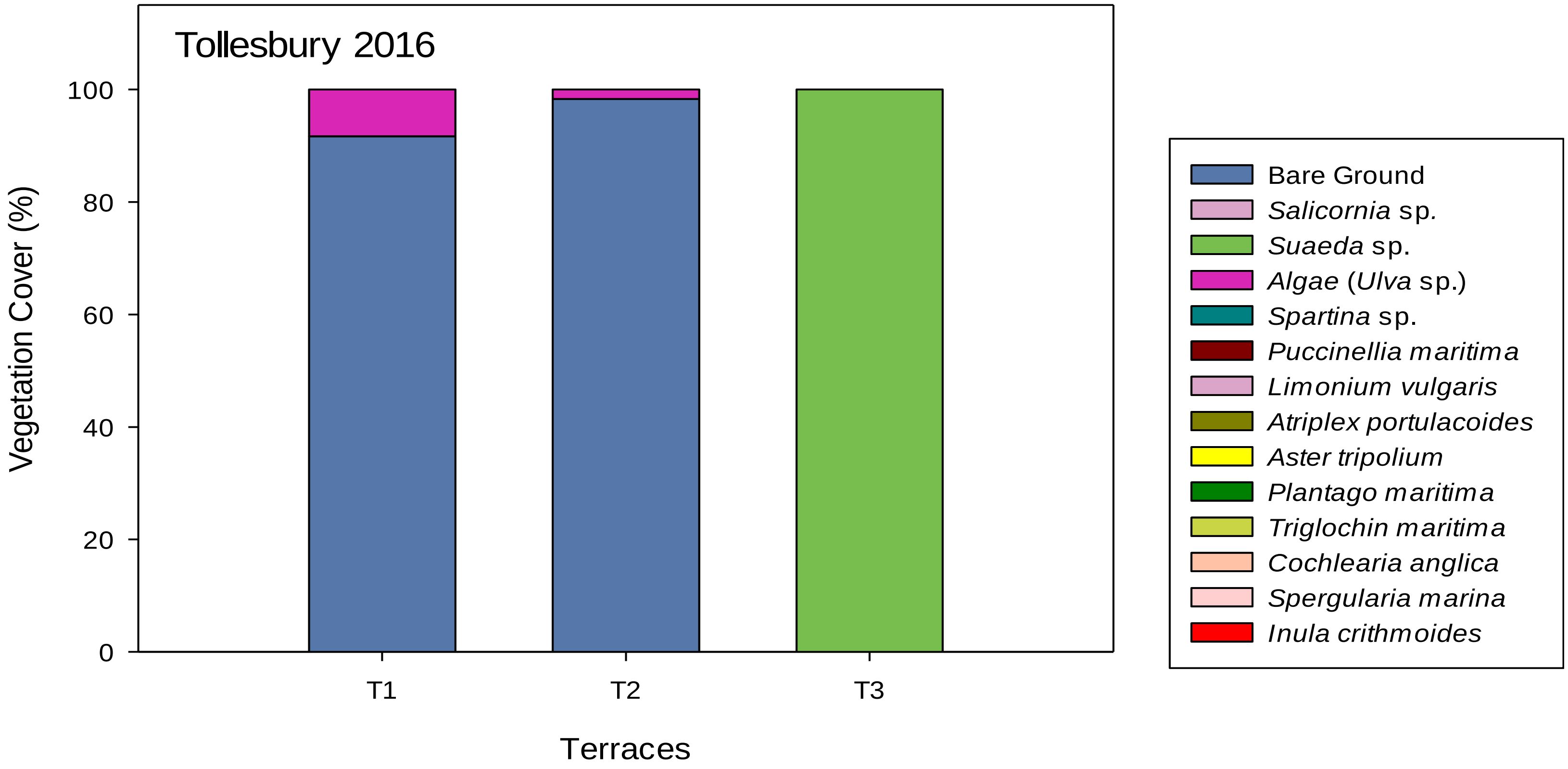
2015 – 4 years post construction and post surge


Tollesbury 2016
Vegetation Cover (%)
0
20
40
60
80
100
T1
T2
T3
Terraces
Bare Ground
Salicornia sp.
Suaeda sp.
Algae (Ulva sp.)
Spartina sp.
Puccinellia maritima
Limonium vulgaris
Atriplex portulacoides
Aster tripolium
Plantago maritima
Triglochin maritima
Cochlearia anglica
Spergularia marina
Inula crithmoides

Key factors for successful colonisation:

- Elevation
- Exposure
- Proximity to existing salt marsh

Planting in future?

Ecosystem Services

- The natural environment is essential for our survival and well-being
- It provides us with water, food and fuel; it also gives us vital space for recreation, relaxation and enjoyment
- Natural processes also play a critical role in the regulation of floods and droughts, and the purification of water and air

Collectively these benefits are often referred to as '**ecosystem services**'

Greening the Grey:

a framework for integrated green grey infrastructure (IGGI)

University of Glasgow

UNIVERSITY OF OXFORD

NERC SCIENCE OF THE ENVIRONMENT

Case Study CS-C1:

Salt marsh on engineered sea defence repair

Summary

The UK has an extensive network of sea defences already in place. Repair and maintenance work accounts for a little less than half the UK Governments planned spending here between 2016 and 2021 (£1bn of a £2.3bn total). Presuming repair costs per metre are significantly lower than new build, the potential for enhancement will be greater in retrofitting existing structures with innovations in green grey infrastructure than in applying them on wholesale replacement or new build scenarios. As an alternative to traditional engineering repairs, twelve experimental stone gabion and clay filled terraces (Fig. 1) were installed in Essex in 2012 by the Environment Agency. The purpose of the repair work was twofold; to protect the toe from wave action and to enhance habitat provision by re-establishing lost salt marsh habitat.

The clay was excavated locally and the borrow pits created additional saline lagoon and/or freshwater habitats.

How does it work?

Sea defences are relatively costly to install, maintain and repair. Climate change predictions describe significant increases in the future frequency and intensity of storm events, while much of the UKs 2100 km of earthen seawall raised after the 1953 North Sea flood event is approaching the end of its design life. The Environment Agency developed some pilot schemes to determine the potential to introduce naturally self-managing systems. Here the traditional repair was enhanced using an extended and raised gabion toe and locally extracted clay backfill to attempt to replace eroded salt marsh.

Where sea level rises inundate these areas within their design life these techniques will be relatively short-term solutions, particularly if the gabions fail and the height of the terrace lowers. However, the repair work is at a similar price to traditional repair, which in itself is not future proofed, and it produces habitat that can accrete material, reduce the impact of chronic and intense wave action (and so reduce the cost of future repair work) is useful in maintaining biodiversity that can improve climate change resilience and provides a source of propagules etc. to spread. It can also provide other valuable ecosystem services, fish nursery and amenity/aesthetic value.

Motivation

An on-site inspection showed that small areas of wall had deteriorated where salt marsh protection was limited or non-existent. In an attempt to regenerate the salt marsh protection, the repaired structure was designed to create habitat (between mid tide level and mean high water neap) that encouraged colonisation by salt marsh species.

Design innovation / Enhancement measure

Replacing traditional like-for-like sea wall revetment repair materials (e.g. Essex blocks or open stone asphalt) with gabion baskets and clay back fill in a toe design that helps re-establish salt marsh habitat in a sheltered estuarine setting.

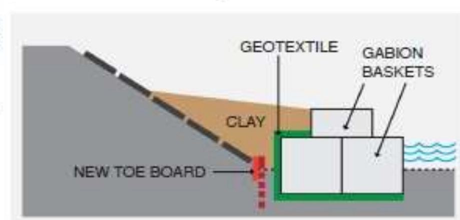


Figure 1. Example of repair work, new berm backfilled with clay behind stone gabions. The clay area provided habitat for saltmarsh plants.

Case Study CS-M1:

Embankment mowing for bees

Summary

The Environment Agency took an innovative approach to an established mowing regime in an attempt to improve pollinator habitats and reduce costs. A reduced mowing regime was tested compared to business-as-usual on an earth embankment flood defence on Canvey Island. The altered mowing regime has since been implemented across 120 km of earth embankments in Essex and Kent.

How does it work?

The embankments are engineered flood defences, where the landward side is terrestrial grassland habitat. If managed well these assets can provide important habitat for rich bumblebee assemblages, including UK Biodiversity Action Plan species, the Shrill Carder Bee (Bombus sylvarum) and Brown Banded Carder Bee (Bombus humilis). The business-as-usual model was to routinely cut the grassland (up to four times per year) but this trial showed that by leaving the grasses and flowers uncut until at least mid-September, significant biodiversity gains can be made.

Motivation

To improve habitat management to support declining bee populations (as is seen nationally), including UK BAP target species, and a drive to reduce maintenance costs.

Design Innovation / Enhancement measure

Change in management regime – altered or reduced intervention

Business-as-usual mowing practice

Changed mowing practice

- Over 100 km (20% of coast) in Essex of insect friendly mowing – more to come
- Working with Bumblebee Conservation Trust, MoD, RSPB, Essex Wildlife Trust and Buglife
- Seawall Biodiversity Handbook

Chapter 1: Introduction

Introduction

Sea walls are well known as vital engineered structures for the defence of our flat coastal areas such as along the Severn Estuary, around the Solent, the Pevensey Levels in Sussex, the North Kent Marshes and a significant part of the Essex coast. What is less well known is the importance of these structures for wildlife. Made up of a range of habitats, sea walls lie at the interface of the shoreline, be it of an estuary or the open sea with a marine influence and, on the landward side, usually grazing marshes and other agricultural habitats. They have strong linear characteristics, including their continuous nature and long length: 2,141 km in England (Figure 1.1; Table 1.1) with the county having the greatest length being Essex (450 km). This combination, not surprisingly, serves to support a wide range of flora and fauna, some of which are special to sea walls and move along sea walls and into the habitats on either side, use them as refuges at high tide or particular times of year, and as vital corridors between other habitats

Table 1.1: Length of sea wall flood defence (raised earth embankment) throughout England sorted by Environment Agency region (see Figure 1.1).

EA Region	Sea wall length (km)	% of national length
Anglian	1,202	56
Midlands	43	2
North-east	102	5
North-west	198	9
South-east	421	20
South-west	175	8
Total	2,141	100

This Sea Wall Vegetation Handbook draws together the growing body of knowledge about the wildlife value and management of vegetated sea walls found around our coasts and estuaries in England. This is used to present a synthesis of good practice guidance on how to manage the constituent habitats in a way that achieves the critical flood risk management requirements relating to the condition of sea walls whilst at the same time optimising their nature conservation value.

Case Studies

Type	Aim of the IGGI	Label	Title
Vegetated	Salt marsh creation on failing defences	CS-C1	Salt marsh on sea defence repairs
Vegetated	Urban re-alignment creating salt marsh habitat	CS-C2	Urban salt marsh creation
Vegetated	Reed beds added in front of sheet piling defence	CS-C3	Intertidal vegetated terraces
Vegetated	Altered mowing on earth embankment defences	CS-M1	Bee Banks
Armour	Use of more ecologically favourable armour	CS-C4	Enhancing armour
Sea walls	Pocket rock pools retrofitted onto vertical sea defences	CS-C5	Seawalls: Vertipools, artificial seashore habitats
Sea walls	Habitat features added under and around a new urban coastal waterfront	CS-C6	Seawalls: habitat enhancement of replacement wall
Sea walls	Niche habitat in stone cladded sea wall repair in a historic conservation area	CS-C7	Seawalls: habitat enhancement of historic wall
Other	Large scale development incorporating enhanced habitat features	CS-C8	Other: Intertidal habitat created around a new development

Ledges


actively textured wall panel
passively enhanced rock armour

Artificial rock pools

Rock pools

Environment Agency

Concrete rock pools

What is the measure?

Artificial concrete rock pools were created on a causeway in Galway Bay, Ireland (made of precast concrete hollow-core Shepherd Hill energy dissipation (SHED) units). The water-retaining features were made by pouring quick-drying concrete around buckets in the base of the SHED units. The buckets were removed when the concrete set, leaving 10-14 cm diameter and 10-12 cm deep depressions (~1250 cm^3 volume). In total, 80 pools were created: 20 in the upper (0.4 m above MHWS) and 20 in the lower (1.9 m below MHWS) shore on both the eastern (sheltered) and western (exposed) sides of the causeway.

Primary driver

To test efficacy of artificial concrete rock pools/water-retaining features in improving ecosystem enhancement

Ecosystem services

After the initial 12 months the lower and exposed pools supported greater diversity than the upper and sheltered pools respectively. However, after 24 months, all sheltered pools became inundated with sediment, creating muddy habitats, while the lower exposed pools became colonised with greater total diversity than the upper exposed pools; showing that <20 exposed pools can improve biodiversity outcomes. For rare species, more pools would be required.

Reputation

Galway City Council provided advice and permission for the work and this research helps the city understand and promote their rich biodiversity (see: https://www.irishtimes.com/

Art of the Possible

Bioblock

COASTA

AP-C2

What is the measure?

Precast habitat-enhancement unit comprising multiple habitat types that can be used as part of intertidal rock armour coastal defence structure. One 5.4 tonne BIOBLOCK (1.5 m × 1.5 m × 1.1 m or 2.48 m^3) was deployed as part of a new rock groyne.

It was tested on a moderately exposed coast at Colwyn Bay, West Wales, UK, 2012.

Primary driver

To improve the habitat and ecological potential of hard engineered structures.

Engineering

Expert judgement by engineers assumed no impact on engineering function of the groyne rock revetment. A BIOBLOCK can replace any rock armour unit on a defence structure and should last >10 years.

Ecosystem services

The BIOBLOCK supported greater biodiversity than the surrounding rock revetment. The range of habitat types (rock pools, ledges, overhangs, pits) rather than any one particular habitat type drove this pattern.

Armour drill-cored rock pools

What is the measure?

A technique for increasing water-retaining features on horizontal or gently sloping substrates; it was tested by retrofitting sets of four 150 mm diameter holes at either 50 mm or 120 mm deep per rock armour unit using a core drill, between MLWS and MHWS, on a granite rock armoured breakwater in Tywyn, Wales.

Primary driver

To test efficacy of retrofitted water-retaining features in improving ecosystem enhancement.

Benefit

Ecosystem services

The pools supported higher biodiversity than surrounding surfaces without water-retaining features where the unaltered, exposed areas of the structure reached species saturation after 6 months. In comparison, after 30 months, more species were still arriving in the rock pools and saturation had not been reached. When compared to natural rock pools, the artificial pools supported a similar number of species; however, community structure differed.

Reputation

Armour pits and grooves

What is the measure?

Granite and limestone rock armour were retrofitted with habitat features by drilling (arrays of 4 holes, 16 mm diameter x 20 mm deep) and scoring the rock armour with petrol saw/angle grinder (to mimic mining artefacts). Score marks were 2 mm x 600 mm x 10 mm deep above and below a central 1 mm x 600 mm long by 20 mm deep groove. The coarser middle grooves were chiselled out to create rough surface texture on the base and sides.

The created habitat features were tested at Runswick Bay, N. Yorks and Boscombe, Poole Bay, Dorset (both moderately exposed sandy shores).

Primary driver

To test the efficacy of increased surface heterogeneity and retrofitted water retaining features in improving ecosystem enhancements of rock armour.

drilling costs. For limestone these costs would be lower, adding between 15-40% to the cost of business as usual rock armour, thus costing between £84-£150/m^3.

Engineering

No discernible negative impact. The size and density of the holes were too small to adversely impact on the engineering performance of rock armour.

Ecosystem services

Both sites were monitored for 12 months where
Both sites were monitored for 12 months where
limestone had higher overall species richness and diversity than the granite rock armour. For both rock types (granite and limestone), there was a significant increase in species richness and species diversity in the holes and grooved treatments compared to the business as usual unenhanced control. The increase in species

Textured concrete for biodiversity

What is the measure?

Millimetre-scale grooves applied manually using a wire brush to concrete during casting/curing designed to improve the rate of settlement and abundance of barnacles and associated species.

Tests were carried out on wave exposed, open coasts in Cornwall.

Primary driver

To test if we can improve the ecological potential of marine concrete infrastructure for early colonists (barnacles), compared with business as usual plain-cast concrete.

Benefit

Simple inexpensive additions (mm-scale grooves) to the manufacture process led to a

Asset resilience

Increased cover of barnacles has also been found to improve concrete and rock resilience to weathering-related deterioration in field and laboratory trials (AP-C9).

Ecosystem services

Only supporting ecosystem services were measured by this study. Results show that more than double the number of barnacles was found on grooved concrete than plain-cast concrete in < 6 months. Increasing barnacle abundance (via texturing) also increased invertebrate species richness (a 7:1 ratio) after 2 to 3 years.

Social

Textured concrete is often more aesthetically pleasing than smooth alternatives. Facilitating

Textured concrete for sea walls



What is the measure?

Testing mm to cm scale surface texture designs to ecologically enhance vertical coastal structures (e.g. defences, walls, piers, pilings) compared with industry standard smooth plain-cast concrete. Eight different tile designs (184 tiles, 150 x 150 x 40 mm) were placed at mid to upper tidal level on north facing vertical seawalls at Saltcoats harbour, Scotland (sheltered), Blackness pier, Scotland (muddy, semi-exposed estuary) and on a sea wall on the Isle of Wight, England (moderately exposed). Tiles were cast in two material types: marine concrete and natural cement-based concrete.

Primary Driver

To establish the largest trial of ecologically enhanced text panel designs across the UK to determine which surface textures are optimal for enhancing species richness and diversity.

design would not affect performance, inspection and/or maintenance.

Asset Resilience

Many of the tile designs attracted high abundances of barnacles in as little as 6 months post-installation (over one settlement season for barnacles). High barnacle abundance has been found to reduce weathering-related deterioration in field and laboratory trials (AP-C9); there is potential to use some of these designs in future formwork to improve asset resilience.

Ecosystem Services

Only supporting services were measured in this study. Ecologically enhanced tiles with greater habitat complexity hosted higher abundance and species richness than plain-cast counterparts after six months.

Timber groynes


Uncut river fringes –
sea aster

Textured tiles


Uncut grassland important
refuge for invertebrates


Mowing large area leaves
no refuges for invertebrates

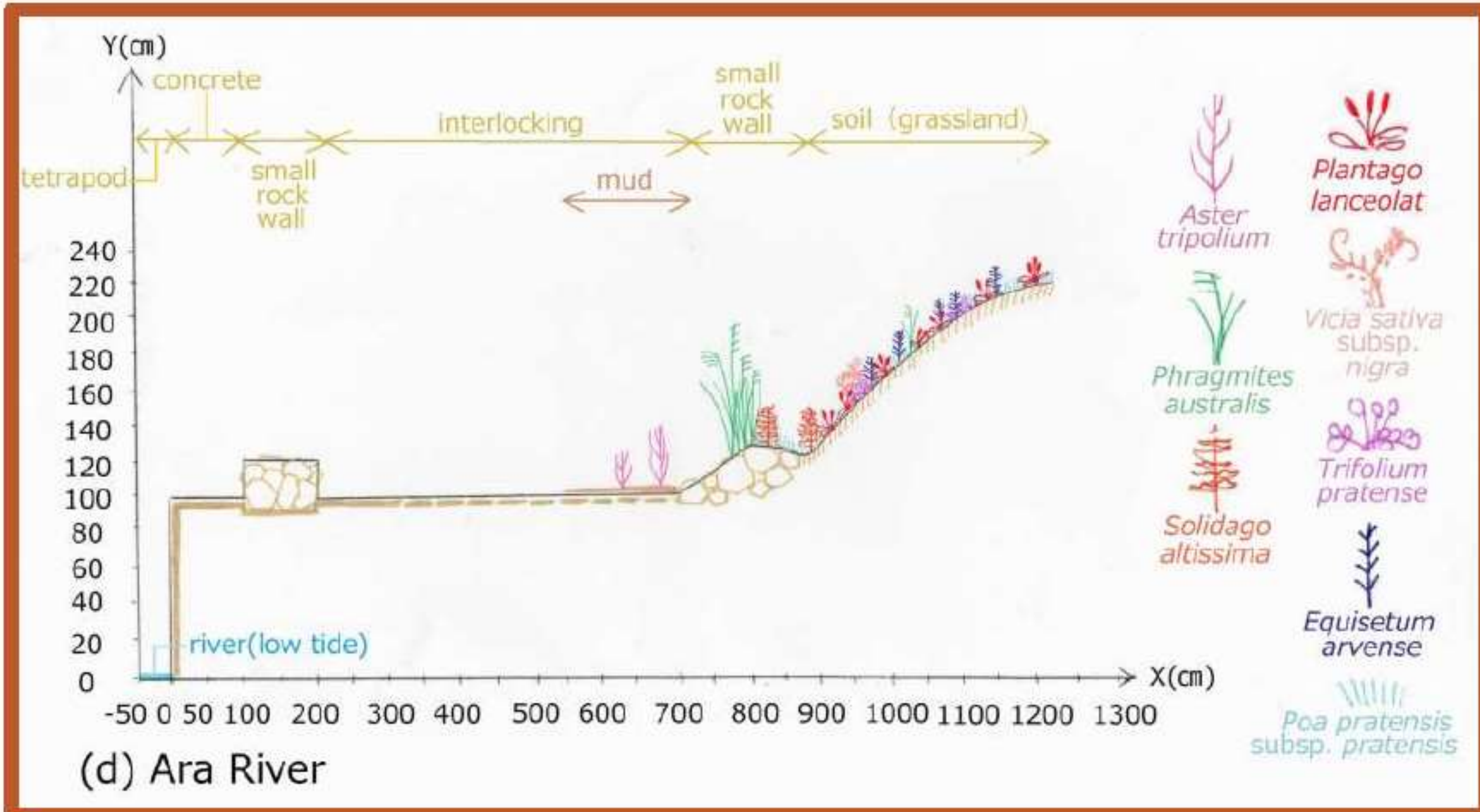

Rocks can provide habitat
for sea aster behind


Beaches important
intertidal habitat

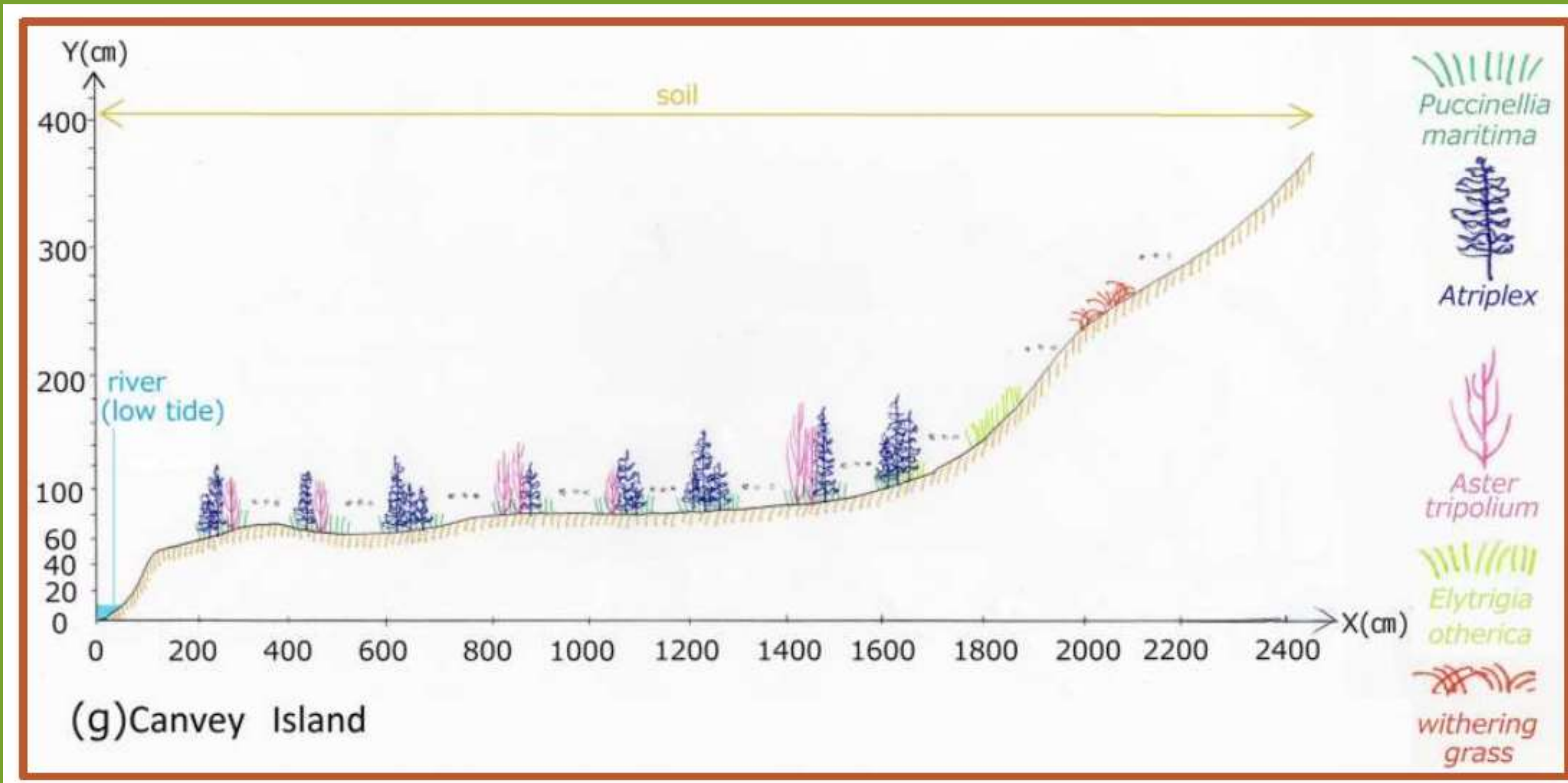
Cracks between concrete blocks good for plants


Collecting grass and collecting cuttings to increase butterfly populations

Butterfly gardens



Y(cm)
concrete
tetrapod
small
rock
wall
interlocking
mud
small
rock
wall
soil (grassland)
240
220
200
180
160
140
120
100
80
60
40
20
0
river(low tide)
X(cm)
-50 0 50 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300
(d) Ara River
Aster
tripolium
Plantago
lanceolat
Vicia sativa
subsp.
nigra
Phragmites
australis
Trifolium
pratense
Solidago
altissima
Equisetum
arvense
Poa pratensis
subsp. pratensis


Y(cm)
soil
400
300
200
100
60
40
20
0
river
(low tide)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
X(cm)
(g)Canvey Island
Puccinellia maritima
Atriplex
Aster tripolium
Elytrigia otherica
withering grass


Cut year 1
Cut year 2
Cut year 3


Control of reeds
where sea aster
grows