# **Biodiversity Audit of the Norfolk Coast**

Phase 2 and 3 Report: Farmed landscapes and the Eastern coast

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## Acknowledgements

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Collated species lists and autecological information were validated by local experts to whom we are grateful for their generous gift of time and knowledge, including: Rob Coleman, Martin Collier, Tim Hodge, Steve Lane, Julia Masson, Nick Owens, Carl Sayer, Tim Strudwick, and Jim Wheeler

We are grateful to all site managers and workshop participants who shared their knowledge of land management outcomes

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#### Cover Images: Four priority species within the study area

Grey Partridge (*Perdix perdix*) are farmland birds that nest in farmland scrub or hedgerows. Numbers have declined due to habitat loss <sup>1</sup>, they benefit from the provision of floristically rich grass margins.

Ruderal Bumblebee (*Bombus ruderatus*) have been negatively affected by agricultural intensification and forestry development. Flower-rich grassland and well-managed farmland would be beneficial to this species <sup>2</sup>.

Garden Tiger moth (*Arctia caja*) were once common but have been in decline since the 1980s, potentially negatively impacted by warmer wetter winters <sup>3</sup>. Local experts recommend they can be supported by high quality farmland as well as semi-natural habitats.

Few-flowered Fumitory (*Fumaria vaillantii*) is an endangered and nationally scarce arable weed found in low-fertility arable land. It has been in decline since the 1950s due to agricultural intensification <sup>4</sup>.

<sup>1</sup>RSPB (2018) Grey Partridge. Available at https://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/grey-partridge/

<sup>2</sup> Buglife (2019) Species Management Sheet: Large garden bumblebee

(Bombus ruderatus). Available at

https://cdn.buglife.org.uk/2019/07/Bombus-ruderatus-species-management-sheet 0.pdf

<sup>3</sup> Conrad, K.F. et al (2002) Long-term decline in abundance and distribution of the garden tiger moth (Arctia caja) in Great Britain. *Biological Conservation* **106**, 3.

<sup>4</sup> BSBI Online Plant Atlas (2020) *Fumaria vaillantii*. Available at: https://plantatlas.brc.ac.uk/plant/fumaria-vaillantii

**Cover photo credits:** Chris [Geograph], Marek Szczepanek, Hectonichus, AfroBrazilian. Marie Portas.



Overall biodiversity

Hedges & scrub

Farmland

Ponds

Large habitats

Semi-natural sites

Methods

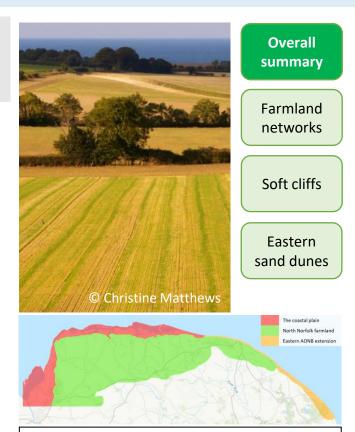
## Biodiversity Audit of North Norfolk Farmland to support evidence-based nature recovery:

**Fields** 

This Biodiversity Audit has identified land management priorities to achieve nature recovery across North Norfolk farmland and East Norfolk soft cliff and dunes, to protect, sustain and expand the full range of threatened and declining wildlife, as an exemplar of evidence-based conservation.

This **audit** collated and analysed **5.7 million species records**, working with expert taxonomists and site managers, farmers, conservation NGOs, Local Authorities and Natural England. In total, the audit revealed that **14,906 species** have been recorded across the study area from 1980. This includes **2,093 conservation priority species** (rare, scarce, threatened or designated) recorded since 1980.

- Semi-natural sites (e.g. fens, chalk grassland, heathland, ancient woodland) cover only 2% of the area, but together host the majority of priority species (73% of all terrestrial priorities), and are irreplaceable. Managing, buffering and expanding these semi-natural sites is a priority, as sources for wider nature recovery.
- The **farmed landscape** holds **significant numbers of priority species**, supporting ~27% of terrestrial (open and woodland) priority species and 25% of the highest priority species in the region.
- Within farmland, the greatest biodiversity uplift can be achieved by creating field-scale habitat blocks (e.g. woodland, scrub, semi-natural grassland, or wetland). Implementing these large habitat features to create high nature-value farmland can potentially support 4.5x the numbers of priority species found in conventional farmland.
- Biodiversity resilience can be maximised by restoring an ecological network of habitat features linked by cultivated
  margins, complemented by grass margins, sown mixes and well-managed hedgerows, facilitating dispersal, enhancing
  pollinator services, in-field crop yields, and amenity. Farmland supporting these mid-nature-value features alone can
  potentially hold up to 2.4x the numbers of priority species of conventional farmland, and when added to field-scale habitat
  blocks will maximise overall biodiversity.
- Across the landscape, restoring degraded and 'ghost' ponds, or where necessary creating new ponds, is also a high priority
  for nature recovery. In addition, river valley floodplains should be restored to a mosaic of wetland and wet woodland
  habitats, with grazing potentially a missing element relative to the coastal plain.



The 2022 Phase 1 Audit¹ considered the coastal plain. The current study reports on the Phase 2 Audit of North Norfolk farmland, and a Phase 3 Audit of the eastern part of the Norfolk Coast AONB, including important soft cliffs and sand dune systems of East Norfolk.

Overall biodiversity

Fields

Hedges & scrub

Farmland

Ponds

Large habitats

Semi-natural sites

Methods

## Large-scale habitat restoration within farmland and floodplains are key to nature recovery

**Bold landscape-scale actions** are needed to **restore biodiversity** in a resilient connected landscape, through adoption of the most relevant **large-scale** (below) and **finer-scale** (next page) agri-environment measures.

Key landscape-scale actions evidenced by the Audit, that would do most to enhance the full range of wildlife include:

- Creating nodes of restored semi-natural habitat within farmland, through targeted field-scale restoration of lower-productivity farmed areas to create contiguous habitat blocks. Priorities include restoring grass-scrub mosaics, pasture woodland, semi-natural grasslands, and floodplain wetland complexes. These should be placed in areas of low fertility and/or to buffer existing semi-natural sites, acting at scale to restore nature and soil condition. Mechanical ground disturbance during establishment will help create key microhabitat mosaics, followed by episodic or seasonal grazing to contribute the greatest biodiversity uplift.
- Restoring ponds across the wider landscape can very rapidly enhance biodiversity by providing essential resources, offering a low-cost 'easy-win' for nature.
- Within-channel river restoration actions can enhance rivers' natural function, benefiting 37 priority invertebrate species. A further 35 priority invertebrates need wet woodland, and approximately 3-times more need a range of wetland and wet-humid grasslands.
- Restoring large areas of **valley wetland complexes** has enormous potential **to support and recover biodiversity, water quality and amenity**. It is also essential to reduce diffuse agricultural pollution at catchment-scales to improve water quality, in-channel and at floodplain scale.
- A key message from the audit is that nature recovery strategies should revert any valley floodplain under arable or intensive (high-input) pasture to either wet (fluvial) woodland, wet grassland, grazing marsh, cut meadow, tall-herb fen or swamp, using a combination of incentives and market mechanisms, strategically to enhance catchment scale-heterogeneity.
- Adjacent to floodplains, areas that buffer rivers, streams and valley bottoms should be targets for restoration to scrub, wood pasture, permanent species-rich grassland or heathland. Enhancing protection of water quality and biodiversity and contributing to landscape-scale habitat connectivity.

Overall summary

Farmland networks

Soft cliffs

Eastern sand dunes



Landscape-scale partnerships are needed across upland landscapes, catchments and floodplains.

Overall biodiversity

Fields

Hedges & scrub

Farmland

Ponds

Large habitats

Semi-natural sites

Methods

## Creating a resilient wildlife-rich ecological network across farmland

Across the farmland landscape, an **ecological network** of **within-field prescriptions** can be developed to support large numbers of **priority plants and invertebrates**, building a **more resilient**, **permeable**, **nature-rich landscape** to buffer and connect semi-natural sites and restored habitat blocks.

Long-term **cultivated margins** should **form the core of a network**, as the audit indicates these deliver the **greatest biodiversity benefit** among field margin options, though they need time and care to establish.

These can be supplemented with:

- Sown flower and seed mixes (with high diversity alongside legumes) that provide pollinator services
- Grass margins (particularly with floral enhancement), that provide resources that complement cultivated margins. Higher-quality grassland habitats likely require large-scale (e.g. field or half-field) restoration, topographic placement (e,g. shallow soils, slopes) and initial soil amelioration.
- Appropriate hedgerow management, including retaining or growing-on of mature hedgerow trees, provides important resources for some additional tree-associated priority invertebrate species, as well as farmland birds.

These actions will replenish biodiversity in the wider landscape, and help the persistence of rare and threatened species currently hanging on in fragmented populations within SSSIs and other patches of ancient 'irreplaceable' semi-natural habitat.

In addition, wider uptake of **regenerative agricultural practices**, while unlikely to deliver new habitat resources for biodiversity by itself, could have **enormous indirect benefits** by reducing fertilizer usage - an essential step in **restoring wetland ecosystems**, and protecting our remnant semi-natural sites from diffuse pollution.

Similarly, wider uptake of zero-pesticide farming practices would also be transformative in delivering nature recovery, reducing chemical pollutants that are key drivers of landscape-scale declines in wildlife.



Overall summary

Farmland networks

Soft cliffs

Eastern sand dunes



Overall biodiversity

Fields

Hedges & scrub

**Farmland** 

Ponds

Large habitats

Semi-natural sites

Methods

## **Biodiversity of soft cliffs**



Left: *Evagetes pectinipes* a RedList Endangered wasp

Right: *Priocnemis hyalinata*,

a Notable wasp



**Eroding soft cliffs** and **associated seepages** of **East Norfolk** support **22 species not recorded elsewhere** in the study area, of which **six are priority species**. These soft cliff species depend on maintaining natural erosion processes.



Farmland networks

Soft cliffs

Eastern sand dunes







East Norfolk

Overall biodiversity

**Fields** 

Hedges & scrub

**Farmland** 

Ponds

Large habitats

Semi-natural sites

Methods

## **Biodiversity of East Norfolk sand dune landscapes**

Sand dunes landscapes of East Norfolk differ ecologically from North Norfolk dunes, and support 435 novel species not found in the Phase 1 study area. The audit revealed that East Norfolk's dunes support 117 priority plant and invertebrate species. Many of these species require maintenance of dynamic, mobile dunes with abundant earlysuccessional vegetation and bare sand, highlighting the key role of physical disturbance in supporting priority dune biodiversity.



Removing scrub from dune slack wetlands in East Norfolk, as well as restoring grazing to some dune slack areas, would support the majority of priority wetland species recorded in the East Norfolk dunes, including the flagship **Natterjack Toad**.

Overall summary

**Farmland** networks

Soft cliffs

Eastern sand dunes





Overall biodiversity

Fields

Hedges & scrub

**Farmland** 

Ponds

Large habitats

Semi-natural sites

Methods

#### Aims of the North Norfolk Farmland audit

#### The Audit approach:

- Gives a robust evidence-base for nature recovery across the farmland landscape
- Collates the first comprehensive list of the many thousands of species recorded in the region (since 1980)
- Presents management guidance quantifying how this can support hundreds of priority species (threatened, rare, or localized) across a wide range of taxonomic groups – based on analysis of their ecological, habitat and management need
- Quantifies biodiversity uplift achievable if land managers can best support and enhance the important biodiversity across the fullest range of priority species, to secure this important biodiversity and natural heritage for the future. See Methods pages for details of the audit process.

This Audit of North Norfolk farmland and the eastern coast area used ~5.7 million biological records and captured a wealth of knowledge from regional species experts and managers.

#### **Purpose of this report**

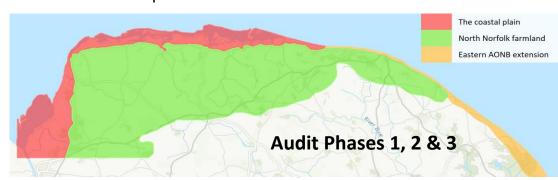
This Biodiversity Audit is intended to support Nature Recovery across the farmed landscape of North Norfolk.

A range of public and private funding, for Environmental Land Management Schemes (ELMS), Biodiversity Net Gain, Biodiversity Credits and Carbon Markets, has potential to transform landscape management. However, biodiversity recovery depends on carrying out the right management in the right place, and needs a regionally-tailored evidence base<sup>1</sup>.

To inform, support and catalyse Nature Recovery, this report quantifies, for the first time, the numbers of priority species that could be potentially supported by different farm management prescriptions.

This report shows which agri-environmental prescriptions will give the greatest benefit, and shows how a wide range of diverse field-margin prescriptions, hedgerow management and complementary field-scale habitat restoration can restore a resilient dynamic wildlife-rich farmscape.

This study extends the Phase 1
Audit <sup>2</sup> of the coastal plain,
reporting the Phase 2 Audit of
North Norfolk farmland, and
Phase 3 Audit of the eastern
part of the Norfolk Coast
AONB, including soft cliffs and
sand dunes of East Norfolk.



Aims

Quantifying biodiversity uplift

How to use this report

<sup>&</sup>lt;sup>1</sup> Crowther, L.P, et al. (2023) Harnessing biodiversity data to inform policy: rapid regional audits should underpin Local Nature Recovery Strategies. Biological Conservation, https://doi.org/10.1016/j.biocon.2023.110004

<sup>&</sup>lt;sup>2</sup> Crowther, L.P., et al. (2022) Biodiversity Audit of the Norfolk Coast – Phase 1. School of Environmental Sciences, UEA, Norwich. ISBN 978-0-9567812-8-4. Norfolk Coast Biodiversity Audit Phase 1 report.pdf (figshare.com)

Background & aims

Overall biodiversity

Fields

Hedges & scrub

**Farmland** 

Ponds

Large habitats

Semi-natural sites

Methods

## Assigning species to farmland versus semi-natural sites

To quantify the overall biodiversity value of different **landscape components**, we conducted a higher-level assessment of numbers of priority species potentially supported by farmland or restricted to semi-natural habitats, considering the following:

#### **FARMLAND**

- Farmed fields (arable and pastoral, including within-field features such as margins)
- Hedgerows, trees and scrub
- Ponds and wet features
- Larger **habitat blocks** within farmland (e.g. high-value grazing marshes, former agricultural fields restored to wildflower meadows, grass-scrub mosaics, heath)

#### **SEMI-NATURAL SITES**

- Lowland heathland
- Semi-natural grassland
- Wetlands (including fen and mire habitats)
- Soft cliffs and sand dunes
- Ancient woodland and mature native broadleaf woodland

An important aim of the audit was to quantify the numbers of priority species that currently **depend on semi-natural sites** within the region, being unable to persist on farmland or anthropogenic land uses in their current form.



#### Aims

Quantifying biodiversity uplift

How to use this report

#### **Semi-natural sites**

support fragments of ancient, ecologically-complex, irreplaceable semi-natural habitats. If lost these are impossible or extremely difficult to re-create or restore to their original condition. They host large numbers of priority species – 'source populations' with potential to colonize areas following nature recovery. Their protection and management is paramount, alongside measures to improve and restore biodiversity across the wider landscape.

Overall biodiversity

Fields

Hedges & scrub

Farmland

Ponds

Large habitats

Semi-natural sites

Methods

## Quantifying species uplift from high quality farmland management

Another core aim of the audit were to evaluate the potential for **farmed habitats** to support more priority plant and invertebrate specie by adopting the most **beneficial management options** (including agrienvironment prescriptions).

To do this, we classified each priority species in terms of their likelihood of persisting across **three conceptual levels of biodiversity-friendly farming** (schematic below), spanning the underlying gradient of biodiversity-supporting habitat features seen across farms in the region. We classified species to these levels based on their management guilds, and whether the specific habitat features they require are likely to be present under different levels of environmentally-sensitive farm management practice.

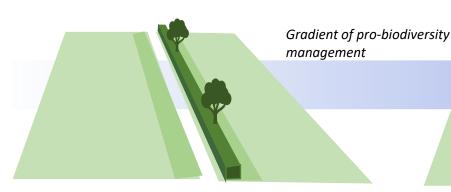
# High nature-value farmland with well managed hedgerows, sown pollinator strip and cultivated margin © Jake Fiennes

Aims

Quantifying biodiversity uplift

How to use this report

#### Our farmland biodiversity categorisation:



#### **Conventional farming**

Cropped area is maximised, agri-environment prescriptions limited in area and ambition (e.g. narrow grass strips), hedgerows absent or not managed sympathetically for wildlife



#### **Mid Nature Value**

A range of appropriate agri-environment prescriptions are present (e.g. cultivated margins, floristically-enhanced grass strips), hedgerows are well-managed, ponds restored



#### **High Nature Value**

Multiple complementary agri-environment prescriptions in each field, all managed with optimal practices, plus larger-scale blocks of restored natural habitat (e.g. scrub patches)

Farmland

Coarse

**Detailed** 

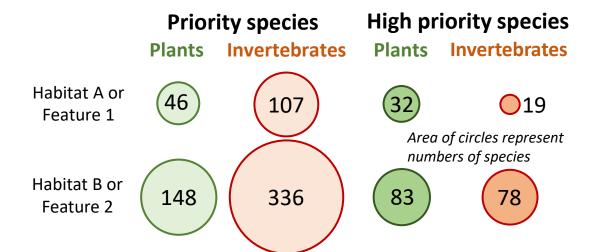
## How to use this report: Our measures of biodiversity importance



# We quantify the biodiversity importance of broad habitats and their features<sup>1</sup> using two metrics:

- the number of priority species supported by that habitat (or feature), defined as any that are: IUCN-GB or -ENG Threatened (CR, EN, VU) or Near-Threatened, NT, JNCC Nationally Rare or Scarce, Red Data Book, or designated (Section 41 species Countryside & Wildlife Act).
- o the **number of 'highest priority' species** defined narrowly as Threatened (CR, EN or VU *not NT*), Red Data Book, Nationally Rare *not Scarce*).

## Example: Visually comparing numbers of important species across habitats or features



# We analyse species' management needs at coarse and detailed scales:

**Landscape composition** in terms of **farmland** or **semi-natural sites**.

**Broad habitats** nested within these: **open-habitats**, **wetland**, **tree-associated** 

**Finer-scale habitats** (e.g. hedgerow, woodland, arable fields)

Ecological **features** (e.g. deadwood, cultivated soil) that relate to **management** options (e.g. retaining veteran trees, cultivated margins, pond restoration)

Priority species were assigned to relevant **management guilds**<sup>2</sup> based on their **ecological needs** and **habitat associations**, considering a hierarchy of farmland quality (intensive, basic agrienvironment, high nature value farming). For invertebrates we used the Pantheon database<sup>3</sup>, for plants information from previous Biodiversity Audits, the Online Atlas of the British and Irish Flora, and BSBI Plant Atlas 2020.

Wherever possible, species assessments were validated by local species experts (see acknowledgements). See full details in the <u>Methods section</u>.

Aims

Quantifying biodiversity uplift

How to use this report

**Background** & aims

Overall biodiversity

**Fields** 

Hedges & scrub

Farmland

**Ponds** 

**Plants** 

(2.684)

(2,636)

Crustaceans

& Arachnids

(707)

Large habitats

Semi-natural sites

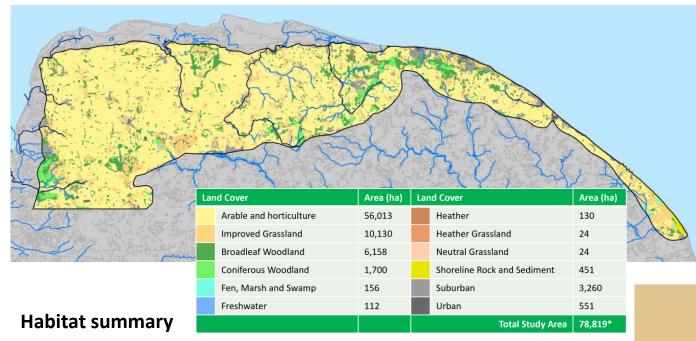
Methods

**Habitats** and species

Farmland vs.

semi-natural

## The region holds a wealth of biodiversity and large numbers of priority species, mostly plants or invertebrates



The Biodiversity Audit shows:

14,906 species have been recorded (across the study area since 1980).

Only 2% of the total species are vertebrates, despite these often being the focus of conservation

**62%** of recorded species are **invertebrates**<sup>1</sup>

18% of recorded species are plants. 2,093 are priority species

(rare, scarce, threatened or designated).

Insects

(8,010)

**84%** of land is under **intensive agriculture** (CEH arable + improved grassland).

**Deciduous woodland** covers **8%** of the study area.

But **ancient woodland** only covers **0.47%** (6% of all deciduous woodland).

Together, all semi-natural sites considered in this report cover only 2% of the landscape and are reduced to small fragments. Lowland heathland covers **0.5%**, and chalk grassland only **0.04%** of the study area.

Many of the actions detailed in this report can help buffer and increase these critical habitats through landscape-scale nature recovery.

Other Invertebrates (514)

Vertebrates

(355)

Fungi

<sup>\*</sup> Total area includes smaller habitats not shown on map;

<sup>&</sup>lt;sup>1</sup> Total invertebrate numbers may be inflated by some marine invertebrates, but numbers exclude the majority of these species, as well as marine fish and turtles.

Overall biodiversity

**Fields** 

Hedges & scrub

Farmland

**Ponds** 

Large habitats

Semi-natural sites

Methods

## Farmland is hugely important for biodiversity - but remaining semi-natural sites are critical

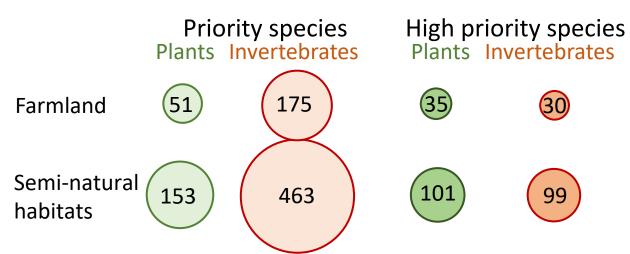
Given the extent to which it dominates the landscape, farmland must play a critical role in any efforts towards nature recovery.

**However** - despite potentially supporting a wealth of biodiversity, only a small proportion of the region's total priority species are ever likely to be supported by withinfield farmland habitats and agri-environment prescriptions.

For species inhabiting open areas and woodlands, the audit showed that **75%** of priority plants and **73%** of priority invertebrates are unlikely to ever occur in farmland, even with the highest-quality (within-field) agri-environment prescriptions.

Rather, this bulk of the priority species only persist in the irreplaceable remnants of semi-natural habitats in the region – found largely within the existing network of protected sites (SSSI's, nature reserves, CWS).

Creating new larger-scale blocks of semi-natural habitat, could potentially deliver suitable conditions for a large (but unknown) proportion of these rare and threatened species (see 'Large Habitats' within Farmland section of this report). Numbers of priority species that can potentially occur in farmland habitats *versus* those likely **restricted to** remaining **semi-natural sites**:



NB comparison includes all species inhabiting open and woodland habitats but not wetland



Bombus muscorum, the Moss carder bee (BAP, S41 Priority Species).

This species needs large flower-rich open habitats and is not expected to be found on even the best agricultural land. Mostly found on coastal dunes where there is sufficient forage over its long flight season, it has also been recorded in the study area on semi-natural sites. Bumble bees forage over hundreds of metres – so a sufficiently large new semi-natural site with a lowfertility, tussocky, flower-rich sward might be colonised.

Habitats and species

Farmland vs. semi-natural

Background & aims

Overall biodiversity

sity Fields

Hedges & scrub

Ponds

**Farmland** 

Large habitats

Semi-natural sites

Methods



Farmland components

Key findings

Background & aims

Overall biodiversity

Fields

Hedges & scrub

**Farmland** 

Ponds

Large habitats

Semi-natural sites

Methods

## Biodiversity is distributed across all components of farmland

The audit characterised each broad component of the landscape within farmland, in terms of the numbers of priority species they can potentially support. We then examine the relative importance of finer-scale features within each broad component, to identify key resources and management prescriptions needed to ensure each component delivers its full biodiversity potential.

Farmland components

**Key findings** 

#### **Fields**

This component includes field margin features (sown mixes, grass strips, cultivated margins), as well as smaller within-field plots such as skylark plots.

## **Hedges & Scrub**

Hedgerows, isolated trees and scrub patches have the potential to support important treeassociated species within active farm landscapes

#### **Ponds**

Farmland ponds, when maintained in good condition, are a hugely important and historically under-valued resource for biodiversity

## Large habitats

Larger blocks of semi-natural habitat within farmland have potential to support even more biodiversity. These features include field-scale grass-scrub mosaics, wildflower meadows and semi-natural grasslands, grazing marshes and naturally-regenerating woodlands.

Overall biodiversity

Fields

Hedges & scrub

**Farmland** 

Ponds

Large habitats

Semi-natural sites

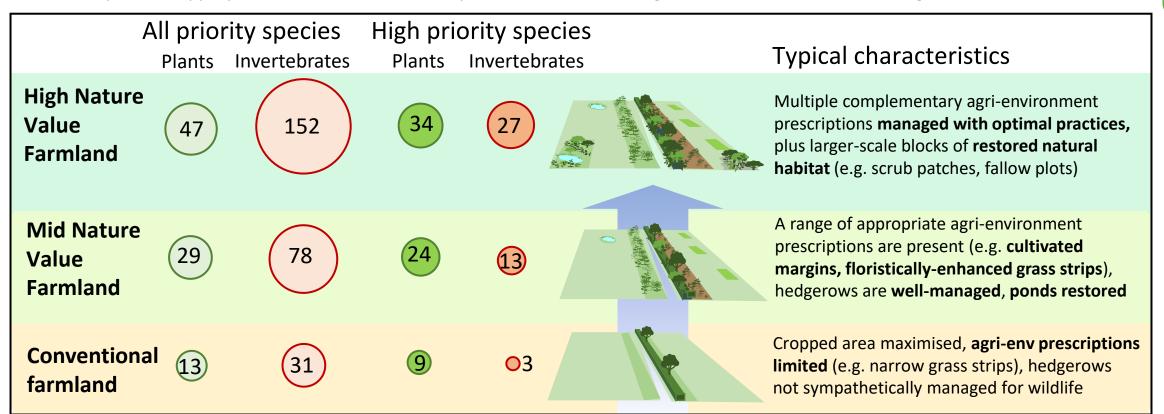
Methods

## Key findings: Significant benefits of High Nature Value farming practices

The audit revealed **huge variation in the extent to which farmland can support priority biodiversity**, depending on the amount, ambition and quality of nature-friendly management taking place. Conventional intensive farming practices with minimal agri-environment ambition support only a fraction (23%) of the priority plant and invertebrate species that could potentially occur **in high nature value farmed landscapes**. Such landscapes would have a large footprint of land under agri-env prescriptions, carefully sited and managed to ensure they deliver appropriate conditions (see subsequent sections), including some blocks of land where 'large habitats' are restored.

Farmland components

Key findings



Background & aims

Overall biodiversity

Fields

Hedges & scrub

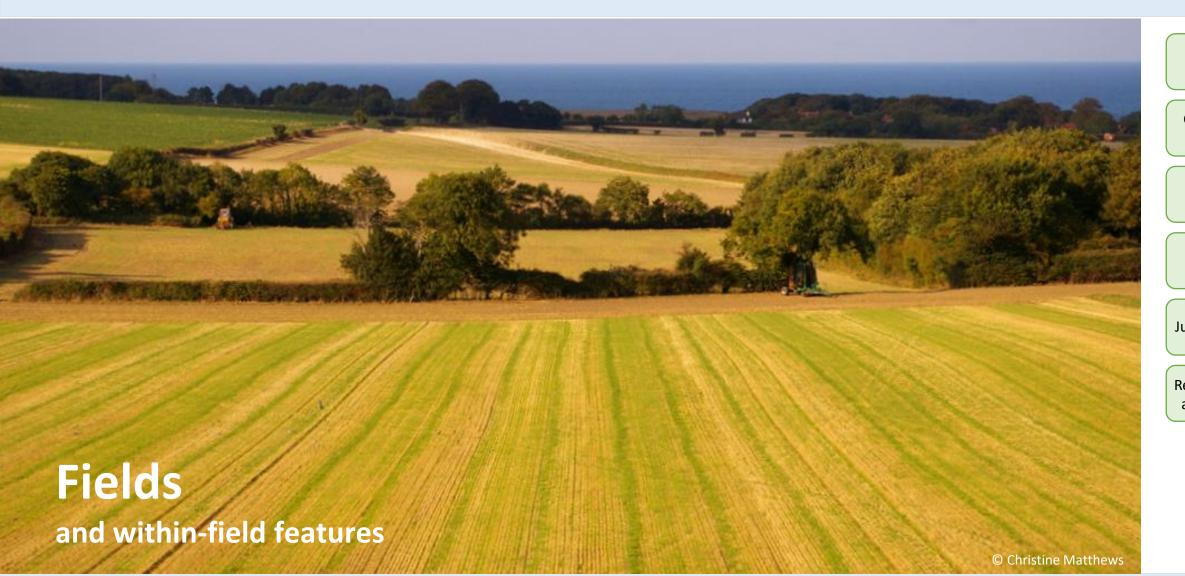
Farmland

Ponds

Large habitats

Semi-natural sites

Methods



Overview

Cultivated margins

Sown mix

Grass margins

Juxtaposition

Overall biodiversity

Fields

Hedges & scrub

Farmland

Ponds

Large habitats

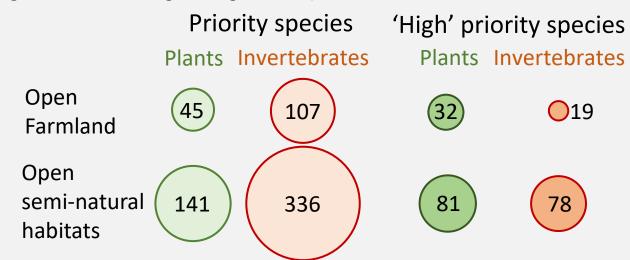
Semi-natural sites

Methods

## Key findings: Agricultural fields and within-field habitats have enormous potential to support biodiversity

The audit showed that highest quality open farmland habitats can support a significant subset of the priority open-habitat (not tree associated, excluding: scrub, hedges and woodland) plant and invertebrate species found in open semi-natural sites (e.g. lowland heaths, chalk grasslands). In-field management interventions can therefore make an important contribution to nature recovery for priority plants and invertebrates, as long as the most useful prescriptions are implemented in the right areas. The audit confirms that agri-environment interventions remain an essential complement to the protection of semi-natural habitats and restoring large sites in the region, with the potential to deliver significant gains for biodiversity.

Numbers of **open-habitat terrestrial species** supported by farmland, *relative to* **open semi-natural habitats** (lowland heath, semi-natural grassland including chalk grassland):



Economically productive farmland, incorporating pollen and nectar plots, beetle-banks, bird -seed plots, spinneys, copses and hedgerows. North Norfolk.



Agricultural fields and within-field habitats may support 32% of all open habitat-dependent invertebrate priority species in the study area (107/336), and 32% of open habitat priority plants (45/141). Of the highest priority species that depend on open habitats, farmland supports a slightly lower proportion (24%) of invertebrates (19/78), but a higher proportion (40%) of plants (32/81) – reflecting in particular the significant number of rare arable plants in the region that have high priority status.

Overview

Cultivated margins

Sown mix

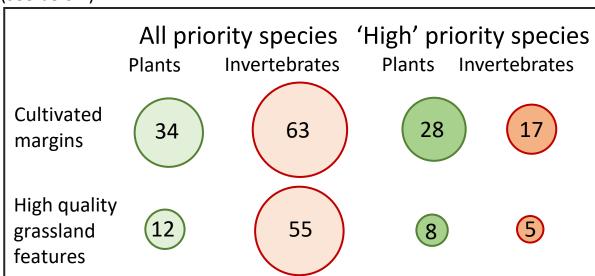
Grass margins

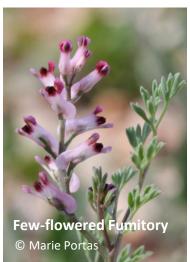
Juxtaposition

## Key findings: Cultivated margins have extremely high biodiversity value

The audit indicates that **annually cultivated margins** are **essential to successful biodiversity conservation** in the area.

Advocated for rare arable weeds, these wide, long-term fallow margins also support many priority invertebrates. The audit revealed cultivated margins can potentially support around 50% more priority species than other open farmland features (e.g. 96 priority species vs 66 in high quality farm grassland features). Among the highest priority plant and invertebrate species, cultivated margins support almost four-times as many of our rarest plants and invertebrates than grassland features (see below).





Farmland





Overview

Cultivated margins

Sown mix

Grass margins

The 'high quality grassland features' in this comparison relate to wide grass margins (particularly with floral enhancement), beetle banks, multi—year sown mixes, and larger areas of unimproved grassland.

Regenerative agriculture

Juxtaposition

Species supported by these habitats tend to be those associated with open, established perennial vegetation where the ground isn't regularly disturbed. While these features are clearly important, collectively they support fewer priority plants and invertebrates than cultivated margins, even when managed optimally in ideal soil conditions (see subsequent sections).

Overall biodiversity

Fields

Hedges & scrub

**Farmland** 

Ponds

Large habitats

Semi-natural sites

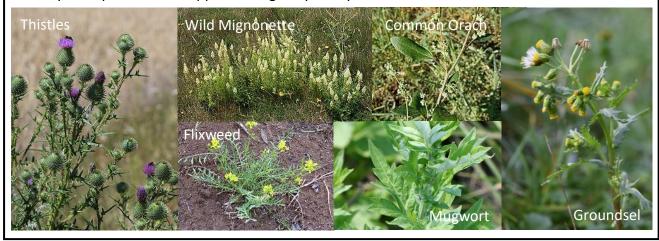
Methods

## Common 'weeds' in cultivated margins are key to many rare invertebrate species

Fourteen of the important invertebrate species that require cultivated margins have close associations with common arable weed species. These weeds are often abundant in cultivated margins, particularly in the early years after establishment. For example, the larvae of a Nationally Scarce hoverfly, *Triglyphus primus*, feed on galls created by aphids that are only found on **Mugwort**, while as an adult this species feeds on nectar from umbellifers such as **Wild Carrot**. Two priority beetles, *Rhinocyllus conicus* (Notable) and *Psylliodes chalcomera* (Nationally Scarce) both have larvae that feed on the young shoots of **Spear Thistle** and **Creeping Thistle**. Another beetle, *Cassida nebulosa* (Nationally Scarce) feeds on **Common Orache** leaves as both larvae and adult. Thus, although these weed species can sometimes be agricultural pests, **their presence in the landscape is critical** for many rare and threatened invertebrates.

#### Arable weed species that support important invertebrates:

Among the herbivorous priority invertebrate species that need cultivated margins, all those for which plant associations are known require widespread plants commonly found in cultivated margins, rather than rare arable weeds. This suggests that even in their early stages, before priority plants become well-established, cultivated margins with the following plant species already have potential to support a range of priority invertebrates:





Cassida nebulosa



Mugwort hoverfly, Triglyphus primus



Rhinocyllus conicus



© U Schmidt

Psylliodes chalcomera

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Cultivated margins

Sown mix

Grass margins

Juxtaposition

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## Management: How to make biodiversity-rich cultivated margins

#### **Establishing**

To give your cultivated margins the best chance of success, there are a few factors to consider at the creation stage:

- Select unshaded sites with a southerly, east or west aspect. Shady sites are more easily overtaken by brome, nettle, and other ruderal weeds.
- Avoid sites you know are particularly fertile or weedy, such as former muck heaps. Nutrient depletion will be quicker, and results will come faster.
- Make sure your margins are at least 3m wide, and aim for a fine seedbed following cultivation, as used for cereal crops. Leave the margin undrilled.
- Aim for a 50/50 split between autumn (October-November) or early-spring (February-March) cultivation across your cultivated margins. If possible fit in with cropping patterns and timings, but avoid earlier autumn cultivation before October that encourages Sterile Brome.
- To deliver their full biodiversity potential, cultivated margins should be seen as **long-term features** that are maintained in the same place over many years, allowing nutrient levels to reduce over time. Many priority species will not colonise the margin until the **underlying soil is low in nutrients**, which can take several years, but can then build up large populations.



#### Maintaining

Once created, cultivated margins need to be maintained to ensure their long-term success.

- Cultivate your margins annually, ideally in February/March for spring cultivation, or October/November for an autumn cultivation.
- Don't rotate margins. By keeping your margins in the same place each year, soil fertility declines, and margins become easier to manage over time as, fewer problems occur with dominant weeds.
- Depending on the starting nutrient level in the soil, a margin may initially be dominated by fastgrowing ruderal weeds. However, these ruderal weeds are an important resource for many herbivorous priority invertebrates (see previous page). It may take a few years to reduce fertility and for priority plant species to establish and build up populations. In that time, it is important to keep the margin in place to allow time for the more desirable plants to establish.
- If unwanted weeds become a major problem in your margins, they can be dealt with by high topping them (30cm minimum) before they set seed for the following year.

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## Sown mixes provide valuable resources - that complement but cannot substitute for cultivated margins

Margins prepared with **sown mixes** (pollinator or wildflower strips, wild bird seed mixes) are a popular way of increasing floral and seed resources within farmland. They can benefit many species, but are typically less floristically diverse than naturally regenerated cultivated margins, and provide **fewer distinct micro-habitats** (e.g. fewer bare patches, less variation in sward height and density). They **support fewer priority invertebrates and plants than cultivated margins**, but can provide important food resources for birds and other wildlife at key times of year.

A high proportion of priority invertebrates found in farmland feed on **nectar** from flowers in at least one life stage - both for species that require cultivated margins (59% of 63 sp) and those needing high quality grassland features (65% of 55 species). This highlights the value of flower-rich sown mixes as a **useful resource to lots of priority invertebrate species**, particularly if combined with other prescriptions at the farm-scale (e.g. cultivated margins).

To support the broadest taxonomic range of invertebrates, sown mixes must provide rich, diverse nectar resources for as long a season as possible. Sown pollinator mixes should ideally contain a range of legumes, together with multiple flowering herbs such as: burnets, knapweeds, Yarrow, Wild Carrot, Self-heal, Musk Mallow, Meadow Buttercup, Lady's Bedstraw, Field Scabious, or Red Campion (best suited to shady margins or wood edge; in contrast White Campion is annual and will not persist in perennial grass-strip). Avoid chicory that can become over-dominant.

Even enhanced sown mixes are unlikely to cover the full range of flower resources found in other habitats (especially **cultivated margins**), and many plants that eventually establish and give value to insects are unsown species from the seedbank. For this reason, sown mixes should be seen as an addition to, rather than a substitute for, other key options such as cultivated margins and floristically-enhanced grass strips.



Some nectivorous priority invertebrates may benefit from sown pollinator mixes, but others much less so. The **Checkered Heath**, *Chiasmia clathrate*, an S41 Priority moth, may benefit as it uses Alfalfa and Red clover as larval food plants, and as an adult visits a wide range of flowers for nectar. Conversely, *Hylaeus signatus*, a Notable solitary bee, relies heavily on Wild Mignonette pollen and nectar to provision its larvae; so likely benefits little from sown mixes, but could flourish with cultivated margins.





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## Adding flower strips can boost pollinator numbers and some crop yields – but this isn't nature recovery

Some mass-flowering-crops (MFCs, e.g. field beans, oil-seed rape) depend on insect pollinators to reach their best potential yields. **Creating high quality, flower-rich habitats on the poorest yielding parts** of arable fields has been shown to boost pollinator numbers and **increase per unit area yields** in these crops. Experiments in Buckinghamshire<sup>1</sup> showed that, **diverting up to 8% of cropped land into flower strips** resulted in **no net crop yield or financial loss** over a 5 year rotation (with three years of cereals and two of MFCs), through greater field-scale yields due to increased pollination.

The vast majority of crop pollination is performed by relatively few common and widespread insects important to pollination services, not the rare and threatened species that are the focus of conservation. Globally, as few as 20% of flower-visiting insect species provide up to 80% of crop pollination <sup>2</sup>. In the UK, a relatively small set of common species are responsible for the majority of pollination of oil-seed rape and field beans (*Honeybees and a few species of: bumble bees, solitary bees, hoverflies and other flies* <sup>3</sup> – none of which have priority status in the current analysis).

Supporting pollinators, while a practical aim for arable farmers, therefore **isn't a catch-all substitute for wider nature conservation** actions that can deliver for biodiversity as a whole.

**To recover nature requires a far wider range of habitat resources**, including looking for opportunities for flowering strips to also support rarer insect species, while also boosting MFC yields on cropped arable land:

- Creating flower-rich habitats with **diverse long-flowering native plant species** is most likely to support rare invertebrates as well as crop pollinators cultivated margins and well-managed floristically-enhanced grass strips are good ways to achieve this.
- Long-term (i.e. not annual) flower-rich habitats could be particularly beneficial when placed to buffer aquatic habitats (such as ponds), protecting them from nutrient-rich surface runoff
- Consider **juxtaposition of habitat types** locate flower-rich habitats in areas to complement existing habitats such as sympathetically-managed hedges, larger patches of semi-natural grassland, or scrub patches, as well as cultivated margins.



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#### Management: How to make good sown-mix strips

#### **Establishing**

Ideally choose **perennial native seed mixes**, which will be more resilient to any necessary cutting during maintenance, and are more likely to be used by priority invertebrates.

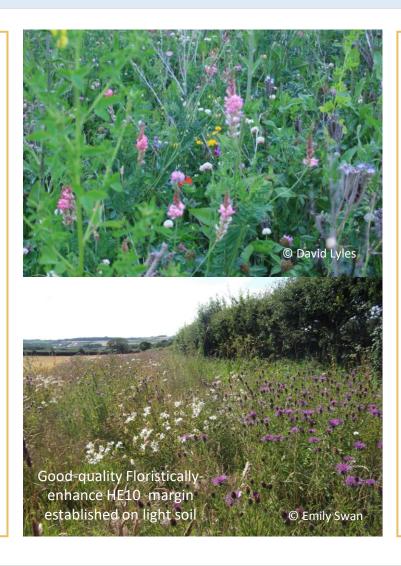
Most non-native plants in pollinator mixes are annuals included in mixes meant for short-lived (annual) strips that remain in place for one year. These often contain relatively few species — providing a **temporary** but **relatively low quality** boost of flower resources.

**Take advantage** of areas within the farmland where **native flowers** are already present in the seedbed. Consider establishing sown mixes in the less fertile areas of soil.

Uncompetitive **native grasses** can help exclude problematic weeds and make perennial strips last longer. An alternative to including grass seed is to add **inert organic material** such as sawdust or woodchip to spread floral seed mixes.

With precision farm equipment, spray drift (herbicide or pesticide) should be minimal, but if there is a risk consider sowing a wider margin.

Although commonly referred to as 'strips' any configuration can work, including field corners.



#### Maintaining

In **newly established** sown-mixes, it may be necessary to **regularly cut** to manage weeds and grasses. Although this will initially reduce the floral resource, it can then reduce the grass and weed burden in future. More fertile soil will require more frequent cutting. Try not to cut all your strips at once.

It is important to remove cuttings rather than leaving them in place – this helps deplete nutrient levels in the margin, and will reduce future weed growth. Leaving cut material in place also smothers smaller, less-competitive plants, encouraging rough grassland and coarser species. However, even large bulky species such as Umbellifers (e.g. Cow Parsley, Wild Parsnip) have huge value to pollinators.

Avoid cutting from Spring through to mid-Autumn, when the nectar resource is most needed and groundnesting birds are breeding.

Once established, gradual nitrogen depletion in the soil can mean cutting should only be necessary **once a year**.

**Try varying timing of cutting regimes** to increase variation in micro-habitats and resources. Alternatively, cut the crop-side half in autumn and leaving a hedge-side margin uncut until late winter.

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(5)

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## Key finding: Grass margins are less valuable than cultivated margins, but still provide important resources

Permanent grass margins can provide a range of **well-vegetated open habitats**, with the potential to support numerous priority invertebrates and some priority plants, as well as being valuable to mammals and some birds. Swards within grass strips can be particularly important as **overwintering sites for many invertebrate species**, which may be limited in areas lacking other permanent grassland features. Our analysis indicated that few, if any, priority predatory invertebrates rely on these habitats, however there is good evidence that common generalist predatory invertebrates use them and that this may have a significant impact on crop pests<sup>1</sup>.

Importantly, most (65%) of the 55 priority invertebrate species that can potentially occur within grass margins are **dependent on nectar** as a food resource for at least one life stage. In the absence of careful management, grass margins often have very limited floral diversity, particularly when established on more nutrient-rich soils. In the absence of rich floral nectar resources, grass strips are unlikely to support their full complement of potential species. Factors that can promote floral diversity of grass margins — including margin placement and surroundings — are discussed overleaf.

Establishing nearby **florally-enhanced grass margins** (using sown mixes that feature a diverse range of native wildflowers, see overleaf) or establishing **cultivated margins** helps ensure farmland provides the resources needed by these priority invertebrates.

All priority species High priority species Plants Invertebrates Plants Invertebrates

High quality grassland features

12

Farmland

55

8

Sown mix

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Regenerative agriculture

High quality: florally diverse nutrient limited grasslands that cover a range of conditions: wet, dry, woodland edge etc.



Grass margins that lack floral diversity support fewer priority invertebrates than those with native wildflowers.

However, they still have a valuable role in buffering hedgerows against spray drift, protect the roots of hedgerow trees from ploughing, and support small mammals (prey for Barn Owls)

<sup>25</sup> 

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# Key finding: Common grassland plants for priority invertebrates aren't necessarily found in grass margins, even with floristic enhancement....

....However, these important grassland plants can be found on **good quality grass margins** created in the right **landscape setting.** 

Of **21 herbivorous priority invertebrate** species potentially associated with grass margins, for which foodplants are known:

- only five priority invertebrate species depend on grasses
- four priority invertebrates are associated with herbs commonly found in sown mixes (clovers, Alfalfa, vetches, Common Bird's-foot-trefoil).
- another 12 priority invertebrates depend on common plants that are rarely included in sown mixes examples are shown on the lower right.

These plants may occur within grass margins, where conditions are appropriate. As these food plants vary in their ecology (damp *versus* dry grassland, shady edges *versus* open grassland) any individual margin is unlikely to host the full complement of priority invertebrates.

#### Useful plants are more likely in margins

- established on **less fertile soils**, thinner soils or exposed slopes
- depleted of nutrients by annually removing cuttings after topping

Margins established **alongside woodland edges** are more likely to support some of these flowering plants, especially if a gradual transition from grass strip to woodland edge is allowed to develop. A range of priority invertebrates associated with **sunny and shaded wood edges**, may utilise floral resources in adjacent grass margins.

Grass placed adjacent to other natural habitats, increase the value of the margin itself but also **buffer other habitats** from nutrient or agrochemical drift. Grass buffers are particularly important for wet seepages, damp hollows or ponds.

**Important foodplants** for priority invertebrates often present in **native seed mixes and good quality grass strips**:









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## How to make good grass margins

#### **Establishing grass strips**

Whilst cultivated margins should be prioritised within the farm landscape, grass margins have an important complementary role in delivering for wildlife, especially with the following considerations:

- Choose the least fertile, nutrient poor areas when creating new grass margins. Whilst cultivated margins allow for nutrients to be leached by rain, grass swards lock in nutrients.
- Grass strips placed alongside hedgerows, or around key features like ponds, ditches and streams, can act as buffers from spray drift.





#### Floristic enhancement

Floristically enhancing a grass strip will improve the benefits of the margin, by adding flower and nectar resources. However, this is best done at the margin's creation as flowers struggle to establish into an existing dense grass margin.

Ensure a diverse range of native flowers are used in seed mixes, to provide the best support to wildlife. Annual mixes are more likely to include non-native species compared to perennial mixes.

Many seed mixes contain legumes (clovers, lucerne, etc.) which are good for bumblebees, but are not suitable for many other pollinators, such as hoverflies.

#### Maintaining

Grass strips should only need cutting once in the establishment year, with the **cuttings and mulch removed** to avoid nutrients returning to the soil. and help reduce weeds. Cut late in autumn or winter following establishment, and cut only 50% of the margin at a time to provide a variety of sward heights and micro-habitats.

Once established, the strip may only need cutting once every few years to manage scrub encroachment. Ensure this maintenance cutting is done above the base of tussocks to avoid damaging habitats for hibernating wildlife.

"Wiggling" in and out of the margin edge when cutting can provide a fine-scale mix of shorter and longer cover, producing ideal conditions for many birds and invertebrates.



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## Placing agri-environmental prescriptions next to each other supports additional priority species

Placing landscape elements, habitat creation actions, or agri-environment prescriptions next to each other supports more wildlife overall than if each is placed in isolation and buffers each element enhancing its quality.

Juxtaposing habitats in mosaics supports species that move between habitats to find the resources they need. Mosaics also buffer habitats against in-field operations.



Amphibians such as toads and newts over-winter in damp grassland, scrub or woodland near their breeding ponds — and thus benefit from ponds being buffered by other habitats.



**Farmland** 

**Priority invertebrates** in the study area that are predatory or parasitoid in one or more life stages use both short sward and bareground (30 species) as well as more vegetated open habitats (8 species). But of these we believe that only 7 priority species are found within farmland — these are all supported primarily by cultivated margins but may benefit from juxtaposition with grassland or scrub.



Cerceris quinquefasciata is an RDB2, S41 Priority wasp that nests in bare soil, while most of its adult food plants grow in scrub and woodland edge. It can potentially occur in high nature value farmland.

Complex mosaics of habitat patches close together help declining farmland birds that nest in scrub but feed in open seed-rich habitats.





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## Regenerative farming practices can deliver landscape-scale benefits, particularly if adopted widely



#### Farming without pesticides

Scientific evidence strongly points towards **pesticide use** (particularly Neonictinoids) **being a key driver of biodiversity loss**, both within farms and across wider landscapes.

Wider uptake of farming practices that reduce pesticide use is therefore an urgent priority. Many such practices fall under the banner of integrated pest management, which includes advanced pest surveillance technologies, non-pesticide solutions such as pheromone disruptors and parasitoid biocontrols, and mechanical weed management.

**Ecological intensification** combines these measures with targeted creation of **natural habitat patches** within and around fields, designed specifically to promote **natural pest control services**. This often involves sown wildflower mix strips, though **cultivated margins** can also be highly effective in supporting a diversity of natural pest controllers (e.g. predatory Carabid beetles).

Ultimately, any measures that decrease pesticide use are likely to have **enormous long-term benefits** for biodiversity, both on farms and across wider landscapes.

#### Regenerative farming for soil health

Most 'regenerative' practices focus on soil health, often targeting the storage of carbon within soils. Widespread regenerative measures include **cover cropping**, minimum/**zero tillage**, diversified **crop rotations**, **mixed-species cropping** and **livestock integration**. Interventions to reduce water- and wind-driven erosion such as **buffer habitats** and **agroforestry** are also increasingly implemented. The key aim of regenerative agriculture to decrease the requirement for fertilizer inputs whilst maintaining yields and long-term food production resilience.

#### **Direct benefits unclear?**

The direct impacts of regenerative measures for within-field biodiversity are difficult to quantify. Globally, previous studies have shown that below-ground organisms (soil macrofauna and microbial diversity) can increase dramatically with regenerative practices. More diverse crop rotations, together with livestock integration, have also been shown to increase the diversity of farmland birds and some insect groups. The potential benefits for priority biodiversity (i.e. rare, localised and declining species), however, remain unknown.

Further research is needed to understand how practices like minimum tillage influence the availability of key resources and microhabitats needed by priority species. While they might be directly beneficial for in-field biodiversity, they are unlikely to act as a substitute for habitat creation measures (e.g. margin features, restored habitat blocks) as a means of delivering nature recovery.

#### **Indirect benefits: Reduced nutrient pollution**

Importantly, any farming practices that **reduce the need for fertilizer input** will have significant **indirect** benefits for biodiversity, both within farms and throughout downstream catchments. **Nutrient pollution** from agricultural fertilizer is a **major driver of biodiversity loss** in rivers and wetlands, while diffuse airborne nutrient pollution can also damage biodiversity within dryland habitats such as woodlands, grassland and heathlands – including our irreplaceable ancient habitat sites. Regenerative practices that restore soil fertility and improve soil structure will actively reduce rates of nutrient loss through erosion, as well as reducing the need for future fertilizer inputs.



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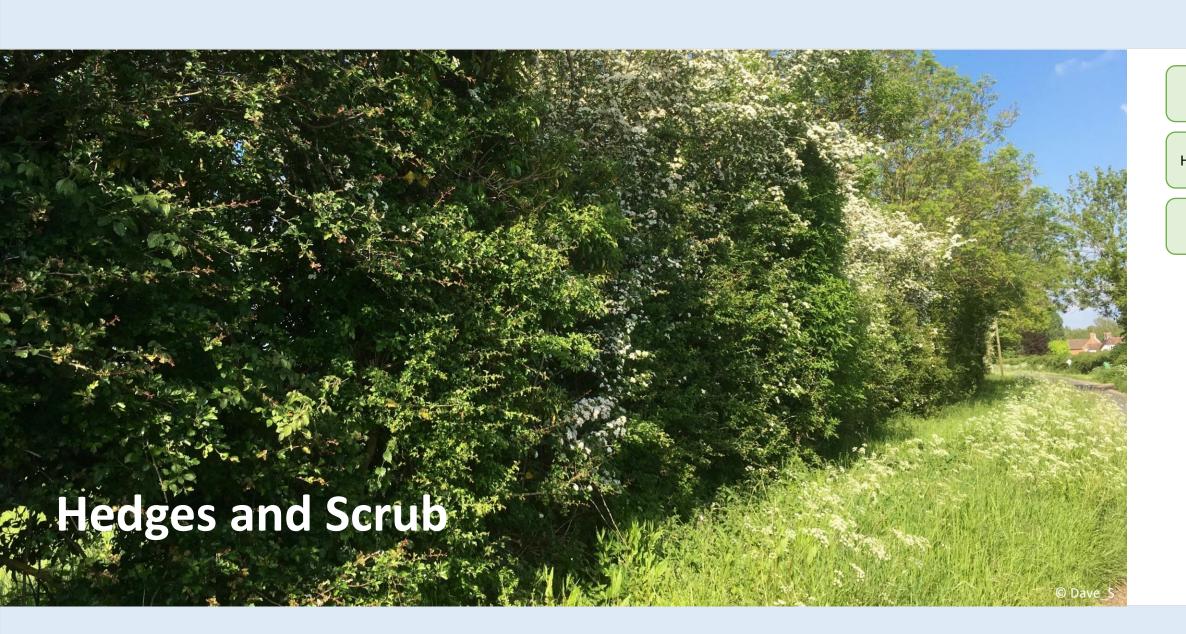
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Scrub

## Hedges and scrub support many important species but cannot replace established woodlands

**Fields** 

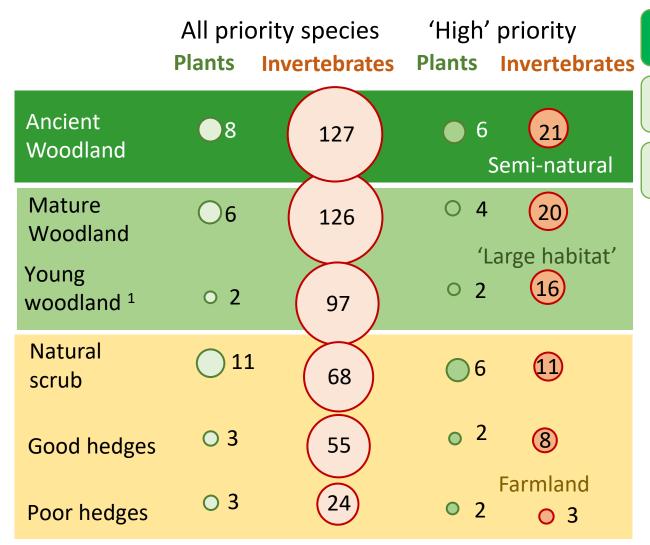
When managed sympathetically for wildlife, hedges and scrub can provide vital resources for farmland biodiversity, including food resources, shelter and nest sites for farmland birds, mammals and herpetofauna, as well as supporting significant invertebrate life.

However, these are a subset of the priority species found in the region's woodland habitats. The audit revealed that around 51% of all priority tree-associated species can potentially be supported in sympathetically-managed hedgerow and scrub features within high nature value farmland, with the remainder are only found in larger blocks of native woodland.



#### **Note on Methods:**

Species were considered to use hedges if they were recorded within farmland in the region, and were 'tree-associated' or utilise other microhabitats that are prevalent in hedges. The classification of these candidate species was then validated by local natural history experts.



Overall biodiversity

**Fields** 

**Hedges & scrub** 

Farmland

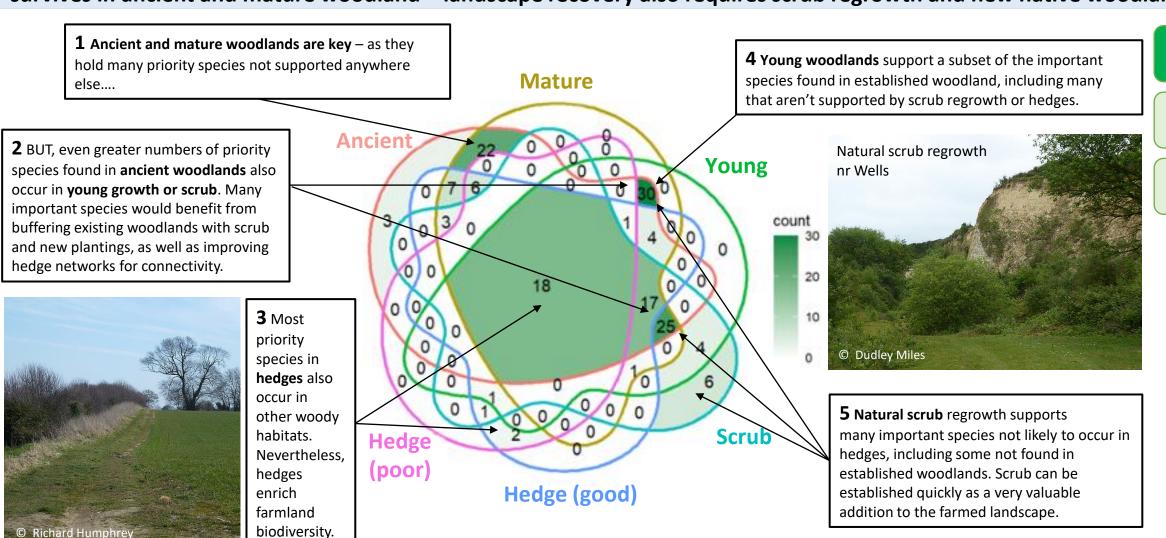
Ponds

Large habitats

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#### Well-managed hedges are valuable in farmland, but are not enough to support threatened woodland biodiversity that survives in ancient and mature woodland – landscape recovery also requires scrub regrowth and new native woodlands



Venn diagram classifies tree-associated priority plant and invertebrate species

**Overview** 

Hedgerows

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## Most of the invertebrate biodiversity in hedgerows is supported by large trees, especially dead trees

Features needed by tree-associated priority plant and invertebrate species found in

farmland: Heartrot Deadwood 30 Young growth Decayed sapwood Mature **Flowers** canopy

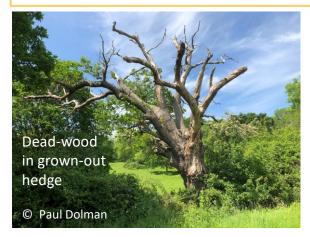
Fungal fruiting bodies

Shaded floor



Most of the important species supported by hedges within farmland need resources provided by large 'standard' trees, both living and dead (Mature canopy, Fungal fruiting bodies and deadwood - especially heartrot). Remaining important species are supported by resources (Young growth – including Flowers, and the Shaded floor) that that can be maximised through careful management.

Cutting hedges stimulates young growth and can lead to a bushier, tighter structure – offering nesting habitat for some farmland birds - and some more humid shaded condition at the hedge base. But most tree species in hedges do not produce the flowers (nectar sources) or berries (food for birds and small mammals) on one-year-old wood. Hence, for hedges to provide a full range of wildlife resources, a balance must be struck between stimulating growth and retaining fruiting branches and wood. Timing of cutting must also be planned to minimise disruption to breeding birds in accordance with the Wildlife and Countryside Act (1981). Breeding season varies with weather but the RSPB recommends avoiding hedge cutting between March and August, and to always check for nests1.





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## **Hedgerow management**

Most agri-environment directions instruct farmers to limit hedge cutting to once in every three years or similar, cutting hedges across a given farm on rotation (i.e. only a third cut in any year). This way, in any year some hedges should have plenty of two- and three-year-old wood to bear flowers and fruits as well as maintaining a tight structure for nesting birds. However some farmers find this unsatisfactory, because infrequent cuts tend to maintain a denser structure that requires deeper, harder cuts, while over time a hedge can lose its shape and integrity. Infrequent but harder cuts may also cause greater wear on machinery.

Some North Norfolk farmers successfully use an alternative approach to reach the same goals without the downsides, but this is not supported by agri-environment schemes. On these farms, all hedges are cut annually but leaving some of the current years growth, to ensure flower, nectar and fruiting wood for berries. This helps maintain both a dense structure and fruiting wood, but eventually requires restructuring / reduction once retained growth becomes too tall.





#### **Management Guidance**

**1** Always retain tall standard trees, including standing dead trees. In hedge sections without standard trees, consider allowing suitable trees to grow above the height of the hedge and remove limbs to raise the crown above the hedge to allow machinery access.

**2** Aim to create and maintain hedges with a tight structure that also bear as many flowers and as much fruit as possible. Either follow the prescriptions of agri-environment schemes or an alternative approach such as that discussed here (left).

**3** Minimise impacts of agrochemicals, especially insecticides and herbicides but also fertilisers, consider siting other in-field conservation measures alongside the best hedges.

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## Scrub patches within farmland can provide vital habitats for many species

Natural scrub features on farmland can support up to 68 priority invertebrate species and 11 priority plants within the region, including 6 species found exclusively in scrub habitats.

**Scrub can regenerate quickly** on farmland, particularly in areas adjacent to established hedgerows, woodland edges, or other habitats that act as sources for seed dispersal of species like hawthorn, blackthorn, bramble and broom.

Scrub has highest value for biodiversity if it is patchy with varied height and density, with patches of grassland interspersed within the scrubby area. Targeting scrub growth towards nutrient-poor or lower-yielding areas may also be beneficial.

**Flower-rich habitats within scrub,** and areas of **disturbed bare ground**, further increase biodiversity. Management interventions such as partial cutting, episodic clearance, or extensive grazing by hardy livestock, can help create these conditions.

Marl pits are scattered across Norfolk fields – a legacy of historic soil improvement. These now form islands of scrub or mature trees, though they are often eutrophic and shaded. Opening up dense mature scrub, scraping some banks and buffering pits with grassland could turn these features into valuable habitat nodes across the landscape.







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# Ponds are of immense value in the landscape

### Resilient

Many freshwater habitats are challenging to restore. Rivers and lakes, for example, often face very challenging external pressures, chiefly water quality, and responses to restoration efforts may be limited by the presence of excess nutrient and pollutants. Ponds get around this limitation to some extent as their own water quality in many cases only depends on the local area which is often within a land manager's ability to control. Furthermore, there is some evidence that plants within ponds may be more resilient to excess nutrient levels, especially phosphorus, that would be very detrimental in rivers and lakes.

Lestes dryas,
the Scarce
Emerald
Damselfly,
once thought
extinct in
Britain, now
occurs in
restored
Norfolk ponds







### Rapid

Wildlife responds quickly to pond restoration. This is welcome, given the urgency of nature recovery; and may allow ponds to act as a refuge sustaining freshwater invertebrates until the longer-term goal of restoring degraded river valleys can be achieved. Many wetland invertebrate species are relatively mobile, and even scarce invertebrates may rapidly settle in restored ponds.



The Zircon Reed Beetle, Donacia aquatica, needs ponds within a landscape rich in wet grassland and fen. Once widespread, including in North Norfolk, it is now restricted to a few sites in England including in the nearby Bure Valley – an ambitious but possible nature recovery goal?

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# Pond water quality is key to maintaining biodiversity rich ponds



**Surface water** in agricultural landscapes, even where farming techniques are carefully chosen to benefit water quality, is likely to contain high levels of nutrients (Nitrogen, Phosphorus) and sediment during heavy rain events. While ponds can be relatively resilient to this pollution, compared to other water bodies, excess nutrient levels severely limit the level of biodiversity that persists in a restored pond. Pesticides, have well known adverse effects on non-target species, and aquatic invertebrates likely face rates of exposure in surface run-off that can be expected to have lasting effects on their populations <sup>1</sup>.

**Buffer** - Good quality ponds and all restored ponds (whether from ghost status or degradation) should be buffered from arable land by at least 10 m (more if possible) to help protect from agrochemicals and soil run-off after cultivation. When located in pasture they should be fenced (or partially fenced) to prevent the entire margin being trampled or grazed and to stop dung being deposited in the water.

**Break drains** - Where field drains carry surface water into (or out of) ponds these should be removed, not just the outlet – dig up the drain and refill to slow drainage.

**Careful siting** - For new ponds, where the location can be freely chosen, use drainage maps to choose sites that will naturally limit surface water run-off. As well as diffuse pollution from agricultural land, consider point sources of pollution or run-off from farmyards, roads, septic tanks, etc.

Right: A degraded pond, likely due to high nutrient levels - where there is enough light for herbaceous vegetation to grow on the banks only nettles grow and only duckweed is found in the water. This surface blanket of duckweed leads to low oxygen levels in the water. After restoration, this pond would need to be buffered to maximise its benefit to biodiversity.



Overview

Water quality

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Left: A restored shallow mid-field pond. Even though this pond is surrounded by arable land a small buffer helps protect the water quality resulting in clear low-nutrient water that stays oxygenated and can support many aquatic plants and invertebrates.

For more practical guidance on pond conservation – see Norfolk Pond Project website https://norfolkponds.org/

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# Restoring overgrown or lost farmland ponds is an excellent way to quickly recover nature

**Ponds** were once common across the farmed landscape, created as water sources for livestock, and sources for building materials and preindustrial fertiliser. Many have been filled or drained - so called 'ghost ponds', and surviving ponds are often overgrown, shaded or covered by scrub, or impacted by surface run-off with excess nutrients and sediment.

**If left unmanaged, ponds become overgrown** by scrub, and most plants and many specialist aquatic invertebrates cannot tolerate the shading and lack of oxygen due to decaying leaf litter.

**But degraded and lost ponds can be recovered**. As many aquatic plants have seed that remains dormant when buried for a very long time, restoring degraded ponds, or excavating 'ghost' ponds can help many rare and important plant species that were once widespread in the pre-industrial farmed landscape.

**Degraded ponds can be restored** close to the ecological condition of the best remaining ponds, by removing scrub, excess sediment and organic matter. Once located, **ghost ponds can be 'resurrected'**, by excavating the buried pond bed.

**Restored ponds can be kept in good condition** with occasional scrub and vegetation clearance and protection from poor quality surface water.

Farmland ponds represent a relatively cheap way to recover important species quickly and can be maintained in good condition with relatively little effort. Ponds can be targeted for restoration at a farm scale whereas other water bodies, or river valley wetlands require coordination across greater catchment scales.





**Degraded and ghost ponds** can be quickly restored to a very good condition (see above), offering a relatively 'easy win' for nature recovery.

### **Historic maps**

https://maps.nls.uk/os/6inch-england-and-wales/ are invaluable in finding ghost ponds with potential for restoration

### **Management:**

- Identify opportunities to restore degraded ponds and resurrect ghost ponds within fields—and contact <a href="https://norfolkponds.org/">https://norfolkponds.org/</a> for support and guidance
- Where ponds are already in good condition, plan for periodic scrub removal, and safeguard water quality by buffering with wide vegetated and/or unfertilised strips, particularly when ponds are embedded within cropped land.

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# Restoring degraded and 'ghost' ponds supports more important plants than creating new ponds

Note: with respect to different types of ponds we have only been able to consider responses of vascular plants not invertebrates



Long-established ponds in good condition support most priority species (17, 7 highest priority). Open water, and unshaded areas of pioneer vegetation are important. Once overgrown by sallow or trees, water plants are shaded, water has less oxygen, and silting occurs – a pond should be restored. Once restored, manage every few years to recreate open unshaded conditions.

Degraded ponds (shaded, silted) support very few priority species (only 2, 88% less than those in good condition).

**Restored ponds** support far more priority species than degraded ponds and can recover most species found in long-established ponds in good condition. Restoring from degraded conditions or from a 'ghost' pond gives similar chances for success.

New ponds can gradually accumulate priority species, but fewer than long-established ponds in good condition or restored ponds. Many water beetles are good at dispersing and colonising new habitats.

count

7.5

5.0

2.5

0.0

New



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### **Consider Distinctiveness**

Rather than creating the 'perfect' pond that supports all the species we aim to recover, we should bear in mind that ponds can be quite distinctive due to factors that we can't realistically control. Instead, to help recover more species restore more ponds. Since results can be unpredictable, it helps to maximise the 'rolls of the dice'.

Management: Wherever possible prioritise keeping ponds in good condition. Prioritise restoring degraded or ghost ponds; and create new ponds in areas with no existing ponds to restore.

Take chances, results are unpredictable, and new ponds serve as stepping stones for dispersal.

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# **Practicalities of pond restoration**



Guidance for restoring degraded ponds Clear scrub to minimise shading, especially on the south and west sides. Pull out stumps except where this would damage pond banks, in which case grind to surface level and treat with glyphosate. Remove most of the silt and litter from pond, exposing a little of the mineral substrate under the bottom of the pond. Leave some dead wood in the pond.

**Guidance for restoring ghost ponds** Locate ghost ponds using old maps and small-scale topography. Using an excavator dig an exploratory trench to locate the pond. Excavate carefully to the bed, leaving most of the dark silty seed bed in place. Dig up or block field drains that supply or drain water from the pond. Dispose of waste soils e.g. by spreading thinly over fields.

**Guidance for creating new ponds** Choose sites carefully to minimise drainage from and the flow of surface water into the pond. Allow plants and invertebrates to colonise the new pond naturally and do not introduce any species.



Management guidance for maintaining ponds Periodically clear scrub around ponds, more frequently (3 years) around smaller ponds and less frequently (up to 8 years) around the largest . Follow biosecurity precautions to avoid introducing invasive species, and avoid trampling sensitive vegetation.

Costs may be similar between restoring degraded ponds, ghost ponds or creating new ponds. New and ghost ponds require equipment to handle spoil and more excavator time but don't require the chainsaw teams needed to restore degraded ponds.

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Costs can vary more between sites than they do between ghost and degraded ponds, due to relative accessibility and spoil disposal options.

By far the cheapest option is maintaining ponds in good condition which just requires occasional clearance of encroaching scrub.

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# Translocating <u>any</u> plants into ponds erodes distinctiveness and risks introducing damaging invasives

Several attractive or interesting species are only found in new ponds because someone deliberately introduced them (translocation). This erodes the individual distinctiveness and variety among farmland ponds - each with it's own mix of plants. In restored degraded and ghost ponds species not seen in decades can appear from the seedbank; while translocation homogenises ponds. Even more importantly **translocation greatly increases the risk** of bringing in **invasive damaging species** that are hard to eradicate.



Crassula helmsii - one of the most damaging invasive aquatic plants in Norfolk. Guard against moving propagules on machinery, clothing, livestock or footwear. If Crassula is found in a pond under your management, act immediately as it will only get worse. With great effort it has been eradicated by hand picking from ponds in Norfolk.



### **Biosecurity for ponds**

- Never transplant between ponds
- Make sure machinery, clothes and footwear are not a vector for invasive species (Check, Clean, Dry).
- Restrict livestock from ponds that contain damaging invasive species, especially Crassula.

### Crassula management

- If found act immediately before it spreads
- Picking can eventually eradicate it but subsequently needs continual vigilance
- If it cannot be eradicated fence or fill in a pond so that it can't act as a source of spread to other ponds.

### Priority plants considered to have been translocated to newly created ponds in North Norfolk

These are important species, but their natural place is in the Broads, not beyond their natural range into north Norfolk – unpredictable natural colonisation is preferable to introducing these three.







# Other damaging invasive species, of aquatic and wet areas include:

- Himalayan balsam,
- Pennywort,
- · Parrot's feather
- Signal crayfish

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# Creating and restoring large habitat areas within farmland can greatly enhance nature recovery

**Fields** 

While small-scale habitat features within farms can benefit many priority species (e.g. cultivated margins, grass strips and hedgerows), nature recovery on farmland can be greatly enhanced by providing larger areas of semi-natural habitat within farms. We consider 'large habitats' to be field-scale or larger features, including areas of open habitat (e.g. semi-natural grassland, restored lowland heath, grass-scrub fallows), woodland (e.g. naturally regenerating broadleaf woodland, mixed native broadleaf plantations) and wetland (e.g. zero-input grazing marsh, wet woodland). In the following pages we consider the potential for managing and restoring these habitats to benefit on-farm biodiversity in the region.

Overview

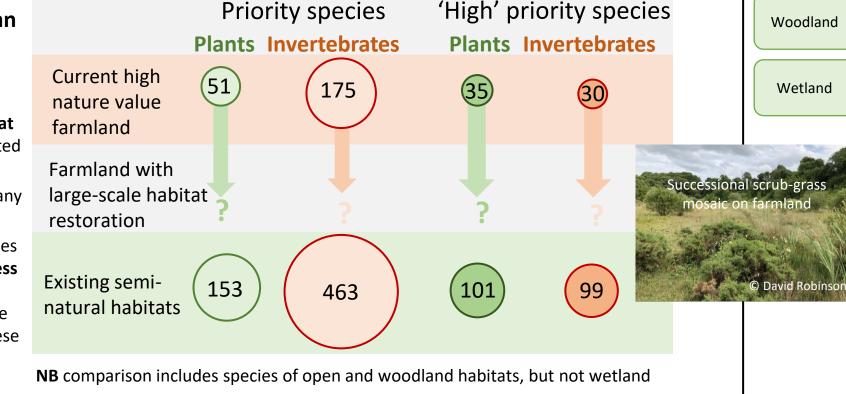
Open Habitats

# Large-scale habitat creation on farms can benefit many more priority species

Creating large blocks of semi-natural habitat has potential to create conditions for recolonisation of farmed landscapes by a range of priority species that currently only persist in reserves and other protected areas (right).

Most require **complex low-fertility habitats** and many have poor dispersal ability.

These species form the bulk of conservation priorities (73% of all priority species in the region) - the **success of wider nature recovery** depends in large part on actions to benefit them. Within farmland, field-scale or larger habitat creation may cater for many of these species, though the proportion that will be able to recolonise such sites remains unknown.



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# Potential benefits of field-scale open habitat creation within farms

A range of **open semi-natural habitats** can be restored on land that is currently farmed, even under intensive arable practices. Wider uptake of field-scale restoration options on farms across the landscape could potentially more than **double the number of open habitat priority species** utilising the region's farmland.

High nature value farmland can support up to 153 open habitat priority invertebrates and plants in the region. Importantly, the audit revealed that 331 additional open habitat priority species could plausibly be encouraged to recolonise farmland areas, by restoring large blocks of high-quality, semi-natural, open habitat. This would represents more than a twofold increase above even the highest-quality nature-friendly farm sites.

These 331 additional priority species all depend on open habitat features currently found only within remnant seminatural sites - primarily lowland heathland, chalk grasslands, grass heaths and grass-scrub mosaics. Similar habitats can be re-created on arable fields, though feasibility varies significantly with soil conditions. Successful habitat creation can require significant preparatory management (particularly for heathland), but the potential contribution of such initiatives to nature recovery is enormous – particularly if targeted towards the lowest-yielding areas of farms, where restoration potential is highest.

# Selecting optimal sites for open habitat restoration

Success depends heavily on careful selection of optimal sites, and as well as choosing the appropriate target habitats. The best sites will typically be areas that are most difficult to farm – poorer agricultural soils tend to be easiest to restore to semi-natural habitat. Other key considerations include the position of sites relative to other features – priority should be given to buffering existing semi-natural habitats, as well as streams, rivers and ponds, to create larger-scale natural habitat mosaics. Deciding which habitat to restore will depend largely on soil conditions:

- dry sites on calcareous soils (chalk) are ideal for open semi-natural grassland,
- dry sandy soils should be targeted for heathland, grass-heath or wood-pasture.
- on heavier clay-rich soils, grass-scrub mosaics are most feasible.



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# Achieving successful open habitat creation

### **Establishing**

The wildlife value of any restored open habitat will be limited by the residual fertility of soil.

To successfully recreate semi-natural habitats like heathland or chalk grassland, on former arable land will depend on reversing the impacts of nutrient enrichment in the soil. Long-term arable fertiliser inputs typically leave nutrient enriched soils that are unlikely to support species-rich plant communities typical of target semi-natural habitats.

Prior to any restoration to heathland or semi-natural grassland, a key aim is to **reduce topsoil nutrient loads**. Mechanical interventions including topsoil stripping or inversion are highly effective, but costly. Multiple rotations of **no-input farming**, with crop or other biomass removal, can be effective in removing nutrients but have low or no economic yield. On lighter soils repeated (annual) **cultivation can reduce soil organic matter and residual fertility**. For heathland restoration, soil acidification can promote typical heathland species.

Ground-preparation including **excavating banks and exposed mineral soil** enhances the biodiversity value of recreated open habitat, providing variation in topography, moisture and exposed nesting micro-habitats (e.g. for solitary bees).

Careful selection of sites is paramount — restoration should target sites with appropriate soil conditions, ideally close to existing areas of the target habitat in order to increase the likelihood of colonisation by priority species.







In grassland on lighter soils, repeated annual late-winter rotovation (above-left), or occasional ploughing (above-right), can deplete soil nutrients as well as creating valuable ruderal open habitat for specialist species.



### Maintaining

**Farmland** 

Without ongoing management, open semi-natural open habitats such as heathland, semi-natural grassland and grass-scrub will develop to closed scrub and woodland with the loss of open habitat species. Scarce and rare species depend on manager to hold back this natural process of succession on open habitat sites.

Grazing can be a key management tool to maintain optimal conditions on restored open habitat sites. Well-managed intermittent or paddock grazing can be used to promote and maintain desired habitat structures, with livestock types and grazing intensities carefully selected to deliver the target habitat conditions. The timing of grazing should also be carefully tailored to most effectively control scrub encroachment, and avoid impacting flowering plants. Cutting can be used if grazing is impractical, ideally using varied cutting heights and timings to avoid uniform swards and always removing cut material.

Tree and scrub removal may be necessary to maintain open conditions. Mechanical scraping, scarification or digging can be used to promote the disturbed conditions needed by many priority species. Succession is slower after turf stripping or mineral soil exposure. Targeted removal of dominant or invasive species may be necessary (e.g. rhododendron and bracken on heathland, thistles and ragwort on grassland), though these can usually be controlled by effective grazing.

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Ditch and bank created alongside restored species-rich chalk grassland provides nesting sites for rare specialist insects.



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# **Enhancing existing farm woodlands**

**Diversifying age-structure** by selectively harvesting small groups or individual trees, can develop a complex multi-layered canopy, allowing growth of selected high value stems, increasing light transmission to suppressed saplings, and promoting a richer understorey.

Widening rides and creating glades can allow valuable semi-shaded and sunny open-herb habitats to develop, as well as making deer management easier. Rides and verges can be cut in sections in late summer.

Cutting back woody ride margins on a long rotation can maintain complex young growth structures alongside tall herb vegetation, creating a mosaic of varied habitat features to support a wide range of woodland species.

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Woodland



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Semi-natural sites

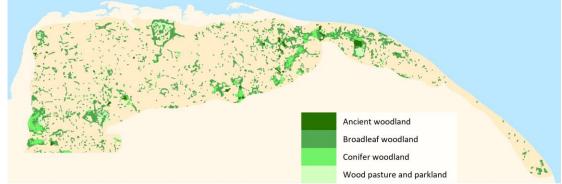
Methods

# Re-creating native woodland and wood pasture within farms

**Natural regeneration** of native woodland on former agricultural fields can potentially benefit many priority **species.** Low-diversity forestry plantations, by contrast, are unlikely to support such high biodiversity, even if they include native broadleaf

species.

Allowing some farmland to regenerate woodland gives multiple ecosystem benefits, sequestering large amounts of CO<sub>2</sub>. Although they cannot support all the species of ancient woodland, mature naturally regenerated native woodlands support up to 135 priority plant and invertebrate species. Planting accelerates establishment, but natural regeneration is likely to create more diverse woodlands with complex structure and composition, and greater resilience to climate shocks or pathogens.



Woodland regeneration sites must be carefully selected, avoiding sites with potential to be restored to higherpriority habitats such as lowland heath or chalk grassland. Woodland regeneration can be targeted towards heavier and more nutrient-rich soils where restoration to other high-biodiversity habitats is less feasible. Natural regeneration can be managed to maximise biodiversity by **promoting canopy variability** – maintaining open areas and mixed age structures. Rotational timber extraction can help promote this canopy heterogeneity, as can extensive grazing, particularly during early establishment.

**Wood pasture** Extensive grazing is also a key tool to establish and maintain wood pasture, which can be an extremely valuable habitat for biodiversity. Well-managed mature wood pastures potentially deliver for both woodland and open-habitat priority species simultaneously, making them a high priority option for restoration efforts. To maximise benefits for open-habitat species, consider nutrient stripping and bank creation (previous slide).



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# Coniferous plantations support few priority species - other land uses are far superior for nature recovery

**Relatively few priority species** within the region **depend on coniferous woodland** - fewer still can utilise plantations or scattered conifers in farmland

Only six priority species are associated with conifers across the whole study area, including non-farmland).

Analysis of the spatial location of records, showed only one conifer-associated priority species, *Didea intermedia*, was apparently recorded from farmland landscape. However, the hoverfly larvae depends on rot hollows in coniferous trees on heathland and was probably, therefore, recorded on farmland as an adult.

Other priority species potentially associated with conifer plantations - rather than small stands of conifers within farmland — are one nationally scarce beetle *Drominus angustus* and a Nationally Rare moth, *Eupithecia abietaria*, the Cloaked Pug. *E. abietaria* that uses spruce cones as a larval habitat (likely to be primarily found in plantations) — but is thought to be a scarce, and likely a non-breeding, migrant in Norfolk.

Where plantations have replaced heathland, priority should be to remove conifers and restore high quality heathland.



Grimston Warren a conifer plantation for ~ 40 years, was successfully restored to heathland by litter-stripping and stump removal after trees were harvested.

© Dudley Miles

Overview

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Woodland

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### Landscape management implications

- Tree-planting initiatives are increasingly considered through carbon finance, but plantations are unlikely to deliver for biodiversity, and could be harmful if they replace opportunities for natural habitat restoration.
- If trees are to be planted, favour mixed native broadleaf species. Conifer
  plantations in the region are unlikely to provide for many, if any, priority
  species.
- Popular non-native tree species such as *Paulownia*, while fast-growing, are also unlikely to provide an value for priority biodiversity
- As conifers readily colonise high-value semi-natural sites, such as heathland, they should ideally be targeted for removal and replacement with semi-natural habitats that can also sequester significant CO<sub>2</sub>, such as lowland heath.

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Hedges

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# Re-creating large wetland habitat areas to restore and protect catchments

**Eight rivers drain into the coastal plain**. Most are chalk streams or chalk-fed, with diverse habitats at least in their upper reaches. However, lower reaches tend to be canalised and nutrient enriched, reducing water quality and biodiversity. Within floodplain and valley farmland, recreating large-scale wetland habitats will support important biodiversity, and can enhance water quality down-stream to the coastal plain.

Overview

### **River Hun**

Short chalk stream with outfall at Holme Dunes NNR

### **River Burn**

Chalk-fed highly-modified river, outfall at Burnham Overy, Holkham NNR

### **River Stiffkey**

Longer river flowing over sand gravel and chalk bedrock, outfall via Stiffkey Fen SSSI.

### **River Glaven**

Flows through arable, plantations meadows and wetlands with outfall into Blakeney Marshes

### **River Mun**

Draining intensive farmland, feeding lakes and wet woodland, outfall at Mundsley Open Habitats

Woodland

Wetland

### **River Heacham**

Chalk-fed river potentially affected by abstraction in the upper catchment

### **River Ingol**

Chalk stream, lower reaches impacted by intensive arable, outfall near Snettisham RSPB reserve

### **River Babingley**

Chalk river, lower reaches are embanked and affected by sediment, enters Great Ouse at Wootton Marsh

**Restoring within-channel features** can enhance natural function of rivers, but it is also essential to **reduce diffuse agricultural pollution** at the catchment-scale to improve water quality. Re-meandering can only give optimal results with good water quality – unless pollutants are tackled at source then restoration will just create a meandering polluted river.

Restoring wet grassland, marshland complexes, and wet woodland in valley floodplains, buffered by reverting valley slopes to grassland or semi-natural terrestrial habitat to intercept and reduce sediment and nutrient runoff, together has enormous potential to recover wetland biodiversity. Restoring river wetlands can increase biodiversity resilience to coastal sea level rise.

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# Maximising wetland biodiversity requires complex and varied vegetation structures in river valley habitats

Larger-scale wetland features within farmland can support many priority freshwater invertebrate species — these features include **river and stream channels, ditches** and pools within **grazing marshes, swamps**, and wet features within **wet woodlands**. Importantly, the audit revealed that priority species are associated with a **varied range of vegetative conditions** within these features, highlighting the importance of restoring a mix of both **open, disturbed areas** and **well-vegetated areas** (ungrazed, lightly grazed), particularly at margins of ditches and wet features.

Running water
(includes margins, sediments, riffles, banks, seepages)

A fallen tree and complex vegetation structure on the banks create varied conditions on this reach of the river Wissey.

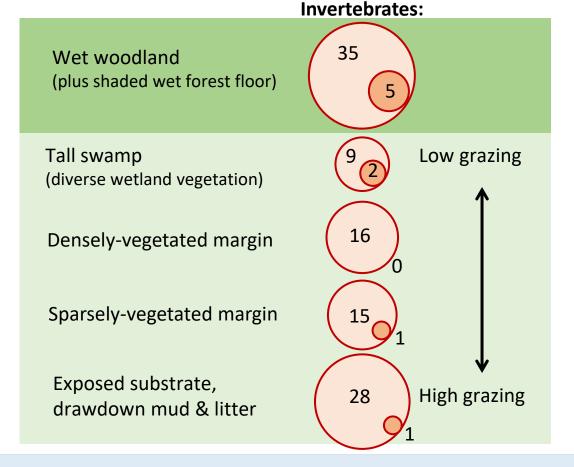
© Carl Sayer

Overview

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**Management.** In their natural state these rivers may not have followed meandering channels, but multiple shallow stream channels and slow-flows of water percolating through swamps and ponds. Wet habitats need a range of vegetation structures. Careful grazing, or mechanical vegetation clearance, will also be necessary to create and maintain early successional habitats. Whatever the mix of desired habitat conditions, reintroductions and developing grazing plans will need careful planning and monitoring as well as plans for coexistence with existing land uses that are retained in the river valleys and people that live there.

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# Currently, river valleys aren't a viable substitute for the coastal grazing marshes in the case of sea level rise

River valleys in the region have lost most of their historic wetland habitats to intensive farmland. Many important species have survived in remaining valley wetlands, but the number of priority species found in these habitats is far smaller than those found on grazing marshes in the coastal plain. There, the Phase 1 audit showed that hard-grazed humid grasslands support high numbers of important species, but that pattern is not replicated in the river valleys, though priority species still require a range of short and tall sward conditions across both saturated and drier marsh conditions. Restoring low-input grazing marshes on floodplain farmland could deliver conditions to allow more coastal plain freshwater species to spread inland, improving 'sea to source' connectivity in the face of sea level rise. But this shouldn't be at the expense of existing good wetland habitats, such as wet woodlands and species-rich, tall-herb fen.

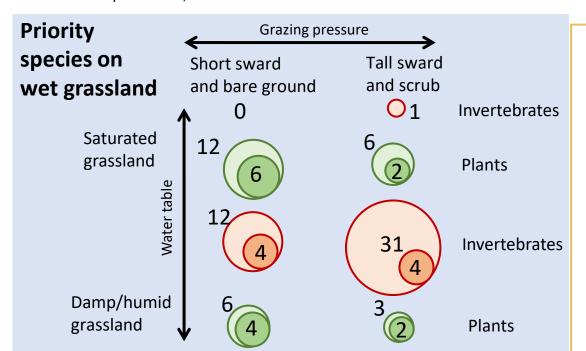


Overview

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### Management of floodplain farmland

In order for river valleys of North Norfolk to support priority biodiversity, as well as provide refugia for wetland species that are threatened by sea-level rise on the coastal plain, large-scale restoration of semi-natural wetland habitats. Further research is needed, but the following should be considered:

- Replace floodplain arable with low-input wet grassland, rich in wet features and ditches, as well as naturally regenerating wet woodland
- Improve water quality by restoring natural habitats on adjacent downslope fields
- Restore flooded forest, retaining deadwood and particularly dead trees falling into rivers – these create valuable riverine habitats
- Reintroduction of beavers may help to create wetland channels and pools as well as retaining water within river valley woodlands.
- Extensively grazing some wetlands and fens (e.g. by cattle or ponies) can increase heterogeneity, as can cutting and harvest within fens
- Increased sward heterogeneity on grazing marsh through varied stocking densities
- Prioritise remaining valley peatlands for wetland restoration

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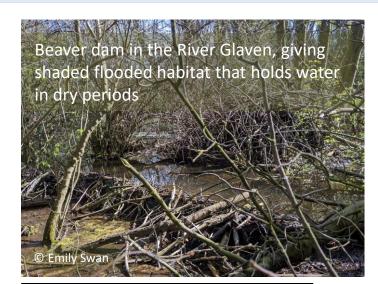
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# Beavers as wetland restoration engineers



Reintroducing Eurasian beavers, Castor fiber, provides an effective way to raise water levels and expand resilient wetlands. There is considerable experience of managing beavers in large enclosures and river catchments both locally and across the country. While they may have some negative impacts, e.g. by felling trees in unfavourable places, or damaging crops or gardens – there is growing evidence that conflicts between beavers and human land use can be minimised, and demonstrating the socio-economic benefits<sup>2</sup> of their reintroduction.



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Beavers can improve water quality, trapping silt and nutrients in their pools and channels<sup>1</sup>. They are generally seen as flow attenuators - holding water in shady vegetated habitats to be slowly released during summer droughts so may reduce critical shortages. Although beyond the scope of this work a careful hydrological investigation is needed as part of any plan for the river valleys.



Aerial view of beaver pools in flooded forest near Bamberg, Germany. Beavers were first reintroduced to this catchment in 1970 and have transformed many habitats at landscapescale. Across Europe, but especially in Germany, there are now a wealth of examples of the longer-term effects of beavers in varied landscapes that supplement what we can learn from recent introductions in

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# Irreplaceable semi-natural sites support vital source populations

Early Marsh-orchid

in fen





Lowland heathland at Roydon Common SSSI, vital for many rare invertebrates

© Kim Fyson

Overview

Ancient Woodlands

Wetlands

Heath & chalk grasslands

Dunes



Soft cliffs

Unimproved fen meadow

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# Ancient Woodlands – must be protected, managed and buffered

Ancient woodland is irreplaceable and cannot be recreated.

Ancient woodland is scarce in North Norfolk, with only 150ha of this vital habitat remaining, though some larger wood fragments (Swanton Novers, Foxley) lie to the south.

**Semi-natural woodlands support rare species** that depend on veteran trees, mature woodland, or young growth, as well as being a refuge for some species of heath, grassland or wet meadow. Woodlands on ancient, undisturbed soils are essential for many of these species.

The audit suggests mature woodlands can support similar numbers of priority species to ancient woodland, but new woodlands may take hundreds of years to reach this potential.



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Ancient Woodlands

Wetlands

Heath & chalk grasslands

Dunes

Soft cliffs







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# High-quality semi-natural wetlands support 348 priority species across a range of habitats









Lowland Fens

Reedbeds

Lowland Meadows

Farmland

Wetlands hold unique biodiversity, but are fragmented and often degraded.

Restoration of valley floodplain wetland complexes would transform nature recovery. The biodiversity audit suggests a mosaic of wet woodland, tall-herb marsh, grazed wet grassland with scrapes, pools and ditch complexes would support the greatest numbers of priority species.

Overview

Ancient Woodlands

Wetlands

Heath & chalk grasslands

Dunes

Soft cliffs

Acidic valley mire at Dersingham Bog, buffered by low input landuse, supports rare specialists

© Dean Allison

Valuable wetlands develop where seepage is buffered by seminatural habitat (unimproved pasture, heathland, grassland or scrub), deliver unpolluted low-nutrient water.

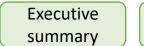
Complex mire-fen transitions between leached acid damp grassland or heath and calcareous (flush) seepages support specialists of open, low nutrient wetlands.

**Management** through biomass removal, long-rotation disturbance, biomass removal and appropriate grazing and buffering of hydrology.

Catchment-scale restoration, reducing agricultural fertilizer use and other diffuse and point-source pollution would improve water quality, habitat quality and sea to source connectivity.



Left: Eristalinae hoverfly larvae - six priority species use pools in mires



Overall biodiversity

Fields

Hedges & scrub

**Farmland** 

Ponds

Large habitats

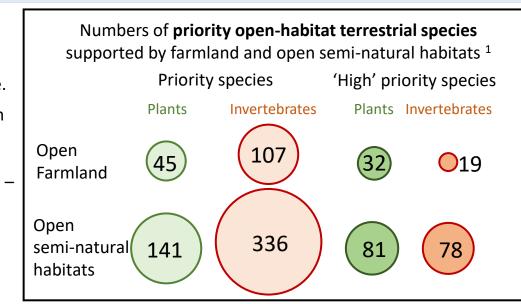
Semi-natural sites

Methods

# Heathland, acid grassland or wood-pasture, and chalk grassland support specialist species

Unimproved commons, pastures heaths and chalk grasslands are scattered across areas of lighter soils and the Cromer Ridge.

Open fields were enclosed piecemeal from the 15<sup>th</sup> century and **many remaining commons were enclosed, improved and converted to arable** from the 18<sup>th</sup> Century – ancient grassland and heathland are very now scarce, but support important many priority species.



# Ancient chalk grassland at Ringstead Downs SSSI © Evelyn Simak Ground disturbance management at Kelling Heath © Ashley Dace

**Historic commons** 

of NW Norfolk on

Fadens 1797 map

ath P cha

Overview

Ancient

Woodlands

Wetlands

Heath & chalk grasslands

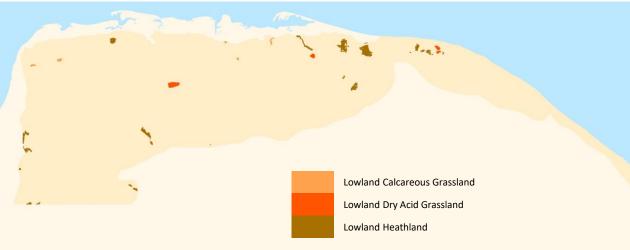
Dunes

Soft cliffs

### Management:

Biomass and nutrient removal, periodic physical disturbance (turf stripping, scrub removal), and appropriate grazing are essential for heathland biodiversity<sup>2</sup>.

Re-creating adjacent seminatural habitats can buffer remaining sites.



<sup>&</sup>lt;sup>1</sup> lowland heath, semi-natural grasslands; <sup>2</sup> see Fuller, et al. (2017) Human activites and biodiversity opportunities in pre-industrial cultural landscapes: relevance to conservation. *Journal of Applied Ecology*, **54**, 459-469. https://doi.org/10.1111/1365-2664.12762

**Background** & aims

Overall biodiversity

**Fields** 

Hedges & scrub

**Farmland** 

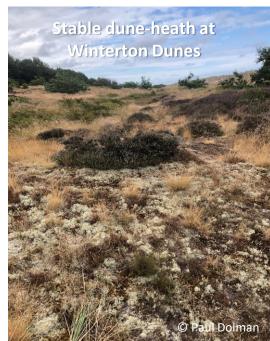
**Ponds** 

Large habitats

Semi-natural sites

Methods

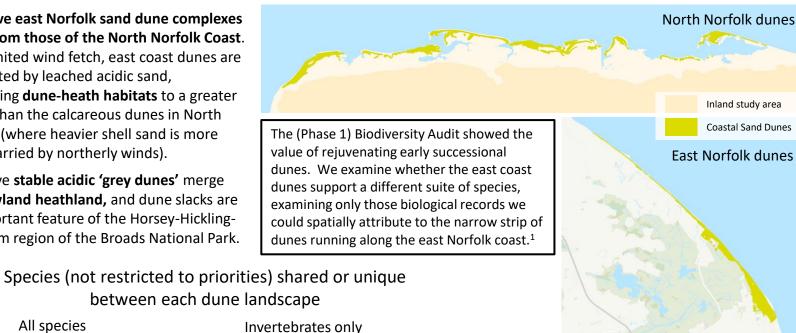
# East Norfolk Sand dunes contribute regionally unique biodiversity



Grey Hair-grass Corynephorus canescens (NT) is characteristic of east Norfolk dunes and the Wadden Sea, but also occurs in North Nor

**Extensive east Norfolk sand dune complexes** differ from those of the North Norfolk Coast. With limited wind fetch, east coast dunes are dominated by leached acidic sand, supporting dune-heath habitats to a greater extent than the calcareous dunes in North Norfolk (where heavier shell sand is more easily carried by northerly winds).

Extensive stable acidic 'grey dunes' merge into lowland heathland, and dune slacks are an important feature of the Horsey-Hickling-Martham region of the Broads National Park.



All species 1477 615 1038 532 435 North coast dunes East coast dunes

East coast dunes contributed 3,681 records, comprising 1,050 species (882 invertebrates; 121 plants) including 117 priority species. North coast dunes contributed 28,967 records,

comprising 2,092 species, (1,568 invertebrates; 267 plants), including 420 priority species. Despite nearly 10-fold less recording effort producing approximately half as many species, a large proportion of species recorded from the East coast dunes differ from those found on the North coast.

Overview

Ancient Woodlands

Wetlands

Heath & chalk grasslands

**Dunes** 

Soft cliffs

<sup>&</sup>lt;sup>1</sup> Records fitting all of the following criteria were attributed to the east coast dune complexes:

**Background** & aims

Overall biodiversity

**Fields** 

Hedges & scrub

**Farmland** 

**Ponds** 

Large habitats

Semi-natural sites

Methods

# Dune biodiversity needs early successional habitat that is lost without ground disturbance

Considering the invertebrate species known only from the East coast systems (not recorded in North Coast dunes), we find that many dune invertebrates require tall sward and scrub within dunes (51 species), but a larger number require short swards and bare ground (62 species), with a significant number also associated with exposed sand:

The audit thus confirmed that conditions associated with mobile, dynamic dunes with open shorter vegetation with exposed mineral sand are essential for dune biodiversity.in East Norfolk. Despite the differences in community composition, this echoes the findings of Phase 1 of the audit for the North Coast dunes – suggesting management priorities on the East Coast should be similar.

Overview

Ancient Woodlands

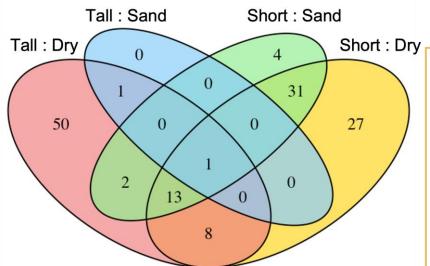
Wetlands

Heath & chalk

grasslands

**Dunes** 

Soft cliffs



Venn diagram showing microhabitat features within dunes required by invertebrate species from East Coast dunes

In the absence of regular disturbance (e.g. from livestock grazing), mobile biodiverse dune systems are likely to be degraded through succession to established swards and scrub.

Mechanical disturbance of such dunes can be a key intervention, creating notches and scrapes to restore mobile early-successional features, mirroring approaches that have been successful elsewhere.





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Methods

# Managers should remove scrub encroachment and restore dune slacks to open wetland

**Fields** 

### **Invertebrates**

Wet woodland
(incl. shaded wet forest floor)

Tall swamp wetland

As Key 1

Total species

Priority species

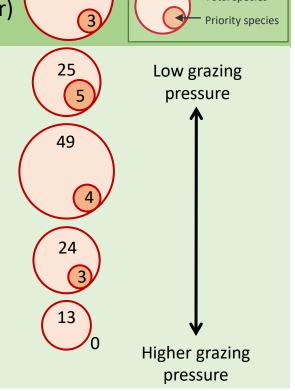
Low grazing

vegetation

Densely-vegetated wetland margin

Sparsely-vegetated wetland margin

Exposed drawdown mud & litter



The majority of wetland invertebrates recorded in the East Norfolk coastal dunes (103 of all 142 wetland invertebrates and 12 of 24 priority species) are associated with open habitat, rather than woodland-enclosed wet features (i.e. wet wood or sallow scrub).

Removing a large proportion of the extensive dune slack scrub in East Norfolk would support the recovery of priority biodiversity in this coastal system, restoring open wetland conditions that would benefit species like Natterjack Toads (see overleaf).

Restoring livestock grazing to some East Coast dune slack systems would also benefit priority species requiring sparsely vegetation or poached wetland margins.



Scrub encroachment (dark green) on the landward margin of the Horsey-Winterton dunes (grey).

Overview

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Dunes

Soft cliffs

<sup>&</sup>lt;sup>1</sup> On this page only, due to the low overall count of wetland priority species, the larger circle represents the total number of species, and the smaller circle represents priority species. Analysis considers all wetland species and all priority wetland species, recorded from the East Norfolk dunes, including those also recorded in North Norfolk.

Overall biodiversity

Fields

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Farmland

Ponds

Large habitats

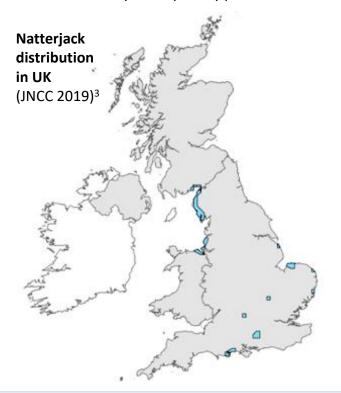
Semi-natural sites

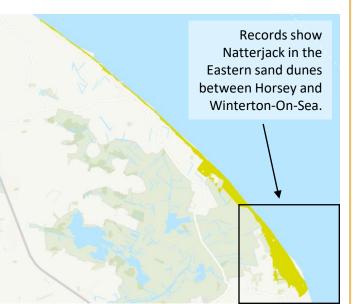
Methods

# A Norfolk stronghold for Natterjack Toads

### Norfolk holds some of the few remaining viable UK Natterjack Toad populations 1.

The native Natterjack Toad Epidalea calamita population at Winterton-Horsey provided the source for successful translocations to Holme and Minsmere<sup>2</sup>. A further large native North Norfolk coastal population occurs in dune slack-grazing marsh complex at occurs at Burnham Overy, Holkham NNR. An inland heathland-mire population at Syderstone Common (NWT reserve), provided the source for translocations to restored heathland in Bedfordshire. Natterjack are a Flagship Umbrella Species — as their management can support conditions for many other priority plant and invertebrates of dune slack and wetlands.





### **Dune slack requirements of Natterjack**

Ephemeral dune slack pools provide breeding grounds that dry out in late summer reducing competition with common toad. Ecological requirements include:

- Multiple shallow pools that dry out in late summer
- Bare, open sand with large tussocks
- Physical disturbance (pony grazing, rabbits)

### Management should:

Prevent scrub encroachment, create early successional habitat, and excavate pools to a variety of depths – providing successful conditions in years that differ in ranfall.



Overview

Ancient Woodlands

Wetlands

Heath & chalk grasslands

**Dunes** 

Soft cliffs

<sup>&</sup>lt;sup>1</sup> McGrath, A.L. & Lorenzen, K. (2010), Management history and climate as key factors driving natterjack toad population trends in Britain. Animal Conservation, 13: 483-494.

<sup>&</sup>lt;sup>2</sup> Rowe, G., et al. (1998), Phylogeography of the natterjack toad *Bufo calamita* in Britain: genetic differentiation of native and translocated populations. *Molecular Ecology*, 7: 751-760

<sup>&</sup>lt;sup>3</sup> JNCC (2019) European Community Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) Fourth Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2013 to December 2018 Supporting documentation for the conservation status assessment for the species: \$6284 - Natteriack toad (Epidalea calamita).

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### Soft cliffs



Previous intensive invertebrate surveys of sites around Overstrand, West Runton and Trimingham detected 374 invertebrate species <sup>1</sup> including 17 Red Data Book species and six invertebrates classed as being entirely dependent on soft cliff habitats in the UK. Key microhabitat features within the soft cliff environment include areas of **bare and disturbed ground**, early pioneer vegetation and **freshwater seepages**, particularly where each of these habitats form a contiguous mosaic.

The value of soft cliffs for biodiversity is **strongly dependent on erosive forces**, as most priority species that depend on cliffs require the open habitats, bare substrates and pioneer plant communities that follow erosion events.

**Soft cliff biodiversity** is **threatened by processes that inhibit dynamic erosion** - particularly human defences put in place to reduce or prevent cliff erosion.

Soft cliff biodiversity depends on areas where **coastal erosion processes are allowed to proceed in a natural way**. Identification and protection of existing zones is therefore a key priority. Areas where cliff stabilisation has occurred can potentially be restored through removal of stabilising defences, combined with careful removal of late-successional scrub.

Overview

Ancient Woodlands

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Soft cliffs



Management of cliff-top habitats can also influence soft-cliff biodiversity; some rare invertebrates require the **juxtaposition of dynamic soft cliff habitats** and **cliff-top flower-rich grasslands** 

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# The soft cliffs support important species, their varied hydrology and dynamic processes need to be preserved



Evagetes pectinipes, is a RedList Endangered wasp that hunts spiders to provision its young, it is associated with dry disturbed ground and feeds on nectar as an adult.

Priocnemis hyalinata, is a Notable wasp associated with damp conditions that likely occur around seepages.

Psychoides verhuellay, is a moth usually associated with woodland streams, but rather than representing a dependence on closed woodland, this is likely more because of its larval food plant Hart's-tongue Fern Asplenium scolopendrium which may be found in damp pockets within soft cliffs.



Dyschirius aeneus, is a predatory beetle seepages.

As candidate soft cliff specialists, our analysis selected species that were only recorded at hectare or finer resolution within 250 metres of the high water mark for the length of the soft cliff and were not recorded elsewhere in the study area.

This restrictive criterion highlighted **22 species** that are highly dependent on cliffs, of which six are priority species. Of these six, 3 are associated with dry, disturbed, open habitats (such as bare sand, e.g. Evagetes pectinipes) and 3 with wet habitats, such as seepages (see opposite).

Two further non-priority soft cliff species are shown, to illustrate that the assemblage also includes species usually found in scrubby sites, that in soft cliff sites may instead be found in open wet habitats around seepages.

Overall this confirms the guidance to allow dynamic erosion processes to take place and remove scrub where necessary.

### Management

- Wherever possible, remove stabilisation infrastructure and allow natural erosion processes to occur.
- Make sure a selection of wet (due to seepages) and dry areas are represented in the areas left to erosion.
- Remove scrub to keep habitats open and/or wet and prevent stabilisation.
- Restore semi-natural grassland habitats to cliff-top areas, particularly where cliffs currently abut arable fields, as these will act to buffer cliff communities from agricultural nutrient enrichment

Overview

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Dunes

**Soft cliffs** 



usually associated with shaded riparian mud – in the context of the soft cliff this probably means areas saturated by

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# Methods summary: How does 'biodiversity auditing' work?

The Biodiversity Audit is a framework to guide conservation management developed by researchers at the University of East Anglia. The process involves collating already-available species records — each with the place and date where a particular species was observed — to develop a comprehensive list of the many thousands of species that occur in that region. Cross-referencing this with information on species conservation status allows us to identify the regional and national significance of each species and thus which should be considered priorities for conservation.

The Biodiversity Audit then synthesises available information on the ecological, habitat and management needs of these species, using species attributes available in public databases, supplemented by consulting expert taxonomists. Auditing serves to input, collate, analyse and synthesise this information in a form that is easy for managers to interpret and apply. Crucially, the audit process also integrates this evidence with the local expert knowledge of naturalists and land managers via a series of workshops, allowing outputs to be refined and information gaps to be identified. Further explanation of the methodology is available in a technical annex to this report.

The aim is to provide clear guidance for management that can sustain, support and enhance the full complement of priority species, to secure the biodiversity and natural heritage for the future.

Biodiversity audits

Species data

Management guilds

Glossary of terms

Dataset references

### **Journal of Applied Ecology**

Journal of Applied Ecology 2012

doi: 10.1111/j.1365-2664.2012.02174.x

The biodiversity audit approach challenges regional priorities and identifies a mismatch in conservation

Paul M. Dolman\*, Christopher J. Panter and Hannah L. Mossman

School of Environmental Sciences, University of East Anglia, Norwich, UK









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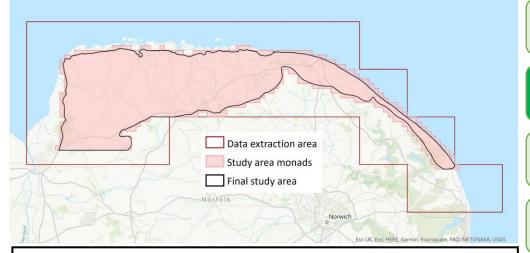
# Species data: collating and validating the species list

**Data acquisition and validation workflow**. The study area was defined as the area between the A149 and A148 roads, additions to include the upper catchments of the rivers Babingley, Stiffkey and Glaven, plus land east of Cromer that is part of Norfolk Coast Area of Outstanding Natural Beauty. Species records were obtained from a wide range of databases including NBIS, NBN, i-record, national recording societies, NGOs and individual recorders (see acknowledgements for list of sources).

Biological records (each comprising species name, location, date) were accepted at hectad (10 km x10 km) or finer resolution, and records at monad (1x1 km²) or finer resolution were extracted when within any monad that intersected the study area. Coarser resolution records (i.e. hectad or tetrad, 2x2 km²) were extracted if a study area monad occurred within them. All species were validated (as genuinely occurring in the study area) by a local natural history expert (usually the county recorder for that taxon) and the spatial resolution of the most precise record was supplied to help judge whether species actually occur within the study area.

Only records from 1980 or later were considered in analysis.

**Conservation status** was determined from the JNCC master list, considering Global, Great Britain and English Red lists (IUCN nationally Near Threatened, Vulnerable, Endangered or Critically Endangered, RDB lists, nationally rare or scarce, S41, Spider Amber list). In addition to birds, reptiles and amphibians, conservation status has been reviewed across a very wide range of other taxonomic groups (including vascular plants, bryophytes, spiders, millipedes, centipedes, aquatic hemiptera, shieldbugs, many beetle families, grasshoppers and crickets, dragonflies and damselflies, butterflies, mayflies, stoneflies, some Diptera families incl. hoverflies, and non-marine molluscs). Groups not yet thoroughly assessed for their national conservation status include fungi, lichens, earthworms, nematodes and aquatic worms, marine molluscs, and parasitic wasps <sup>1</sup>.



### **Excluded species:**

- For **mammals**, we excluded livestock, domestic/domestic escapes, and invasive non-native species (e.g. *Muntiacus reevesi*).
- For **birds**, we excluded vagrant or exotic species, and species only found at sea.
- For **reptiles and amphibians**, domestic escapes were excluded, as well as species not found in East Anglia and marine species (i.e turtles).
- For **fish**, marine-only species were excluded.
- For vascular plants, priority species that are native in some parts of the UK, but only occur in Norfolk where they have been introduced (including garden escapes and cultivated varieties) are excluded from the lists of priority species, as introduced populations can be of markedly different genetic origin and ecotype<sup>2</sup>.

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<sup>&</sup>lt;sup>1</sup> Webb & Brown (2016) The conservation status of British invertebrates. *British Wildlife*, August 2016, 410-421.

<sup>&</sup>lt;sup>2</sup> Adiantum capillus-veneris, Allium schoenoprasum, Brassica oleracea, Buxus sempervirens, Colchicum autumnale, Cyperus longus, Draba muralis, Erica vagans, Juniperus communis, Maianthemum bifolium,

Mecanopsis cambrica, Mentha sugueolens, Pyrola rotundifolia, subsp. rotundifolia, Ranunculus rentans, Ruscus aculeatus, Sedum forsterianum, Silene Viscaria, Tilia platyphyllos

Overall biodiversity

l sity

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## Guilds: assigning species to habitats and management choices

# Analysis of species ecological (and management) needs

- Although Pantheon classifies invertebrate species irrespective of conservation status, our guilding of plants and invertebrates was restricted to priority species (with a conservation status).
- For management guilds, Pantheon species attributes for invertebrate species include habitat niches and resource. Earlier Biodiversity Audits of Breckland and the Fens also coded landuse/habitat types and ecological processes – including distinguishing grazing from physical disturbance – helping link species' autecology to their management requirements.
- Using Pantheon it was possible to associate invertebrate species of 'open', 'wetland' and 'treeassociated' habitat complexes. Using Pantheon's categories for fine-scale resources, species were then assigned to management guilds within these complexes. Saturated and humid grassland species were reassigned to the wetland habitat complex as within the study area wet grasslands mostly occur in the river valleys alongside other wetland habitats.
- To guild important plants, we used management guilds from previous Biodiversity Audits<sup>1</sup>, Red Data Book statements, ecological accounts in BSBI Atlas 2020.

### Classifying responses to agri-environmental and management interventions

Farmland

- Priority species were assigned to guilds along a gradient of land-use intensity, using a combination of: spatial analysis of records (relative frequency of records from within farmland-dominated landscapes)<sup>2</sup>, autecological algorithms (e.g. based on Ellenberg plant nitrogen values or Pantheon associations) and local expert knowledge (e.g. to judge whether species occur in a hierarchy of agri-environment prescriptions). This separated:
  - o **open-habitat species** between: conventional farms, basic AES farms, high nature value farms, and restored large-scale semi-natural habitats
  - tree-associated species between: poor hedges, good hedges, natural scrub regrowth, young native woodland, mature woodland and ancient woodland. We assume hedges can provide dead sapwood but not heart rot or shaded litter.
- For each habitat complex the process described above was used to create a preliminary assignment which was then validated by a local taxon expert this resulted in reassignment of a minority of priority species, but enough to be potentially significant with respect to the results (e.g. Moths, 14 of 47 species; Beetles, 13 of 60 species).
- Our analysis of responses to pond restoration only considered priority plants as many are dispersallimited regenerating from a buried seed bank; although many wetland invertebrates are potentially mobile and capable of colonisation, detailed understanding of which invertebrate species require what pond conditions was not available.
- For wetland and aquatic priority plants in ponds: first we selected all priority plant species listed in the UK Checklist for Freshwater Species<sup>2</sup>, these were then guilded with respect to the restoration status of farm ponds in the study area by Carl Sayer, a recognised expert in pond restoration and survey. Categories were: longstanding good condition, degraded (i.e. shaded, silted, overgrown), restored (from degradation), restored (from dried-out 'ghost' pond) and new pond. Plants were included in a guild only if they were known to be found in that category of pond in the study area as a result of natural colonisation or persistence, but not if considered to only occur through deliberate translocation.

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<sup>&</sup>lt;sup>1</sup> Dolman, et al. (2010). Securing Biodiversity in Breckland: Guidance for Conservation and Research. First Report of the Breckland Biodiversity Audit. UEA, Norwich; Mossman, et al. (2012) Fens Biodiversity Audit: Part 1 & 2 - Methodology and Results. UEA, Norwich. <sup>2</sup>, i.e. farmland-dominated has >94% CEH arable or improved grassland across 100 m x 100 m pixel

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# **Glossary**

**AONB:** Area of Outstanding Natural Beauty – areas of countryside identified for conservation by Natural England and protected by the Countryside and Rights of Way Act (2000).

**Ancient Woodland:** Protected sites that have been continuously wooded since at least 1600 CE.

**Autecology:** The study of the detailed ecology, traits and characteristic of a specific taxon (usually a species).

**Conservation status**: species classified as being near threatened or threatened.

**Damp [soils]:** Soils that are moist but not so wet that water is free to pool at the surface, except under pressure (such as underfoot).

Sand dunes, and Heathland: Are open (unwooded) dry terrestrial habitats formed, structured and maintained by disturbance, typically deposition and erosion of wind-blown sand (mobile and grey dune), heavy grazing, physical disturbance biomass removal and `nutrient poor conditions.

**Dune slack:** A depression formed where wind erosion has stripped part of a sand dune down to the water table, creating pools or damp conditions.

**Fens/Fenland:** A species-rich, calcareous, peat-forming wetland. Fens take thousands of years to establish.

Guild: A group of species that share a given trait or characteristic.

**Habitat:** Distinctive land-cover, vegetation structure or hydrological condition. Most habitats are semi-natural (influenced and structured by humans) or anthropogenic (entirely human-created).

Heterogeneity: A mix of contrasting conditions. Nested heterogeneity is key – with heterogeneity at nested spatial scales, in terms of landscape composition (land-cover uses or land-cover types, e.g. woodland, arable, grassland), configuration (patch size, shape, juxtaposition), and within-patch structure (edges, glades, ecotones and mosaics), and microhabitat structure (e.g. in woodland: small group selection or coppice panel, or in grassland:

mosaics of exposed mineral soil – scattered tussocks - tall-herb vegetation – scattered scrub).

**Management guild:** A cross-taxa (e.g. cutting across plants, invertebrates) group of species associated with a particular set of fine scale conditions created when a habitat is managed in a certain way (e.g. densely vegetated pool margins *versus* sparsely vegetated and poached pool margins; or short-swards with exposed soil *versus* tall swards with scattered scrub).

**Mosaic:** an arrangement of different habitat conditions so that contrasting patches are arranged next to each other (juxtaposed) in a mixed or random pattern. Can be important to invertebrates with complex requirements.

**Priority species**: important species that have a **Conservation status** (IUCN-GB or -ENG threatened, CR, EN, VU; or near-threatened, NT; JNCC Nationally Rare or Scarce; Red Data Book) or are **designated** (Section 41 species, Countryside & Wildlife Act); not to be confused with S41 Priority Species, a specific designation. We also quantify numbers of **'Highest Priority'** that are threatened ( IUCN-GB or -ENG CR, EN or VU *but not NT*), Red Data Book, or Nationally Rare (not Scarce).

**Running water:** Fresh water that is flowing; e.g.: rivers, spring lines, seepages, flowing ditches.

**Saturated** [soils]: Soils that are so wet that water is free to pool at the surface.

**SSSI:** Site of Special Scientific Interest – areas protected by Natural England and the Wildlife and Countryside Act (1981) due to their biological or geological importance.

**Succession:** A pattern of ecological change where more and different vegetation takes hold resulting in fewer resources for what was there before (the early-successional community).

**Terrestrial:** In this report we use terrestrial to refer to **dry open** or **woodland** habitats, and not **wetlands**.

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Management guilds

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Farmland **Background** Semi-natural Executive Overall Hedges & scrub **Fields** Ponds Large habitats & aims biodiversity summary

Data sources

The following online ecology databases and publications were used in data processing and analysis: **Biodiversity auditing approach:** 

Dolman, P.M., Panter, C.J., Mossman, H.L. (2010) Securing Biodiversity in Breckland: Guidance for Conservation and Research. First Report of the Breckland Biodiversity Audit. University of East Anglia, Norwich. ISBN: 978-0-9567812-0-8

### Taxonomy:

National Biodiversity Network (NBN) Trust (2022). The National Biodiversity Network (NBN) Atlas. https://ror.org/00mcxye41.

### **Guilding:**

Cheffings, C.M. & Farrell, L. (eds), Dines, T.D., Jones, R.A., Leach, S.J., McKean, D.R., Pearman, D.A., Preston, C.D., Rumsey, F.J., Taylor, I. (2005). The Vascular Plant Red Data List for Great Britain. Species Status No. 7. JNCC, Peterborough, ISSN 1473-0154. https://hub.incc.gov.uk/assets/cc1e96f8-b105-4dd0-bd87-4a4f60449907

Fitter, A. H. and Peat, H. J., (1994). The Ecological Flora Database, J. Ecol. 82, 415-425. http://www.ecoflora.org.uk

Guiry, M.D. & Guiry, G.M. (2023). AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. https://www.algaebase.org

Gunn, I.D.M.; Carvalho, L.; Davies, C.E.; Edwards, F.K.; Furse, M.T.; Maitland, P.S.; Raper, C.; Siriwardena, G.M.; Winfield, I.J. (2018). UK Checklist of Freshwater Species. NERC Environmental Information Data Centre. https://doi.org/10.5285/57653719-434b-4b11-9f0d-3bd76054d8bd

Hill, M.O., Preston, C.D., Bosanquet, S.D.S., Roy, D.B. (2007, updated 2017). BRYOATT – Attributes of British and Irish Mosses, Liverworts and Hornwort. https://www.britishbryologicalsociety.org.uk/

Stace, C. (1997) New Flora of the British Isles, second edition. Cambridge University Press

Webb, J., Heaver, D., Lott, D., Dean, H.J., van Breda, J., Curson, J., Harvey, M.C., Gurney, M., Roy, D.B., van Breda, A., Drake, M., Alexander, K.N.A. and Foster, G. (2018). Pantheon - database version 3.7.6.

Botanical Society of Britain and Ireland (2020) Online Plant Atlas. https://plantatlas2020.org

Wigginton, M.J. (Ed). 1999. British Red Data Books: 1. Vascular plants (3rd edition), JNCC, Peterborough, ISBN 1861074514.

Various datasets were used to produce maps for the report:

CityofRoseville (2017) Topographic Basemap - No Labeling.

https://www.arcgis.com/home/item.html?id=9ca30f4623064920a6b6ea08 6cb20b27

sites

ESRI UK (2019) GB Topographic style with the GB Hillshade.

https://www.arcgis.com/home/item.html?id=cc027e3f61364983a5cf08dea 5dce4a5

Lehner, B., Verdin, K., Jarvis, A. (2008) New global hydrography derived from spaceborne elevation data. Eos, Transactions, 89(10): 93-94. https://www.hydrosheds.org

Morton, R.D.; Marston, C.G.; O'Neil, A.W.; Rowland, C.S. (2020). Land Cover Map 2019 (land parcels, GB). NERC Environmental Information Data Centre. https://doi.org/10.5285/44c23778-4a73-4a8f-875f-89b23b91ecf8

Natural England (2022) Priority Habitats Inventory (England). https://www.data.gov.uk/dataset/4b6ddab7-6c0f-4407-946e-

Natural England (2023) Ancient Woodland (England). https://www.data.gov.uk/dataset/9461f463-c363-4309-ae77-

d6499f19fcde/priority-habitats-inventory-england

fdcd7e9df7d3/ancient-woodland-england#licence-info

Natural England (2021) Wood Pasture and Parkland (England).

https://www.data.gov.uk/dataset/bac6feb6-8222-4665-8abe-8774829ea623/wood-pasture-and-parkland-england

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