Natural Capital Evidence Compendium for Norfolk and Suffolk

October 2020

Norfolk County Council

Suffolk County Council

UEA University of East Anglia | SCHOOL OF ENVIRONMENTAL SCIENCES

Photos: Trudie Dockerty UEA unless otherwise stated.

About this compendium

The counties of Norfolk and Suffolk have stewardship of a wealth of natural assets. The purpose of this Evidence Compendium is to present information about these assets and the potential risks to them, to provide an element of the preparatory work that will feed into a Norfolk & Suffolk 25 Year Environment Plan. Where possible, data is provided by county and also for five important natural areas within them: the **Norfolk Coast Area of Outstanding Natural Beauty (AONB)** and **Suffolk Coasts & Heaths AONB**, plus **The Broads National Park**, **The Brecks** and the **Dedham Vale AONB.** (These are termed 'key natural areas' throughout this compendium). The ***Introduction*** section outlines the scope of the work and the approach taken. This is followed with background information regarding the environmental and socio-economic setting of the two counties to provide some ***Regional Context*.**

A key part of the work is a ***Natural Asset Inventory*** for Norfolk and Suffolk which is presented in six sections -

This is followed by an examination of the current and future risks to these assets, presented in a ***Risk Review*,** with a synthesis of the ***Implications*** and outline of ***Priorities*** and next steps for the proposed Norfolk & Suffolk 25 Year Environment Plan.

This research was conducted in the School of Environmental Sciences at the University of East Anglia, supported by a Steering Group of representatives from Norfolk and Suffolk County Councils, the New Anglia Local Enterprise Partnership, Natural England, the Broads Authority, the Norfolk Coastal Partnership, Suffolk Marine Pioneer and local Wildlife Trusts, plus a wider group of stakeholder organisations who have contributed to this work. This work is based on latest available data compiled over the period October 2019 to July 2020.

About this research

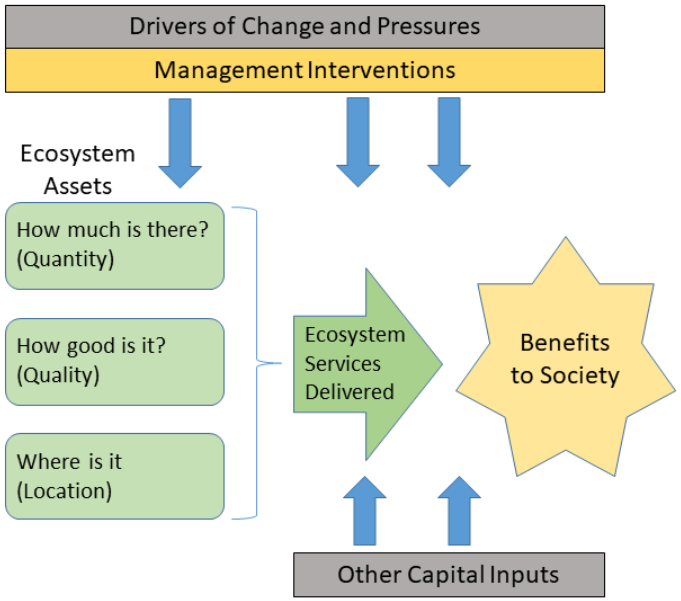
Understanding our '***natural assets***', the ***benefits*** that we derive from them and the ***pressures*** upon them, is a fundamental requirement if we are to ensure that we can maintain and enhance them into the future. Norfolk and Suffolk County Councils have commissioned this project which has taken a ***natural capital approach*** to compile a ***natural asset inventory*** and conducted an assessment of ***risks*** to these assets that will help inform the development of a local 25 Year Environment Plan.

The study uses nationally available datasets to identify natural assets in Norfolk and Suffolk and to highlight what is distinctive in our two counties compared to the rest of England. It also draws on the expertise of the many local organisations that play a part in protecting and managing these natural assets to help identify risks to them and their future sustainability, providing a baseline inventory from which priorities can be set and evaluated.

What is a natural capital approach?

"A natural capital approach is about thinking of nature as an asset, or set of assets that benefit people. The ability of natural capital assets to provide goods and services is determined by their quality, quantity and location. These in turn can be affected by background pressures, management practices and drivers of demand. For some services, additional inputs are required in order to realise benefits. In other cases, the benefit follows directly from the service without further capital or human inputs."

[Source: DEFRA (2020) *Enabling a Natural Capital Approach: Guidance*, p. 5]



[Source: DEFRA (2020) *The Natural Capital Framework, Fig. 1 (Source Natural England*]

Advantages of a natural capital approach

- Provides a common framework to bring together scientific, economic and social evidence and analysis for a particular subject or place
- Reduces the risk of the value of the natural environment being ignored in decision-making
- Facilitates a more innovative approach to identifying policy solutions
- Helps to identify priorities for investment
- Provides a basis for systematic accounting over time

[Source: DEFRA (2020) *Enabling a Natural Capital Approach: Guidance*, p. 6]

Next: Natural assets

What are 'natural assets' & 'ecosystem services'?

The terms '**natural assets**' and '**natural capital**' are often used interchangeably. They refer to stocks of both living and non-living aspects of ecosystems that have benefits to society. Examples include forests, fisheries, rivers and minerals. Benefits reflect a variety of values, including both aspects of use (e.g. consumption of a product) and non-use (e.g. knowledge of the continued existence of a rare species or beautiful landscape).

Types of natural assets can be defined in several ways. One approach is based on biophysical features as shown in the table below. Another recognises that assets often combine together to produce benefits (e.g. food is the product of assets such as land, soils and water, as well as additional inputs such as human expertise and equipment) and so uses categories of land use or habitat (e.g. farmland, woodland, urban areas) as an organising framework. Both of these approaches will be used in this study.

TYPES OF NATURAL ASSET	
Land (physical surface of the earth, landforms)	**Freshwaters** (rivers, lakes, wetlands, aquifers)
Soils (physical, chemical and biological elements) **& Sub-Surface** (rocks, minerals, fossil fuels)	**Coasts** (transition zone between land and ocean) **& Oceans** (saline bodies of water)
Species and Ecological Communities in **Habitats**	**Atmosphere** (gases, meteorological processes)
Source: Natural Capital Committee (2014) Second State of Natural Capital Report	

What are ecosystem services?

Stocks of natural capital provide flows of environmental or 'ecosystem' services over time. These services, often in combination with other forms of capital (human, produced and social) supply a wide range of benefits. Types of ecosystem service can be defined in several ways, but a common approach (originally proposed by the Millennium Ecosystem Assessment, 2005) is shown in the table below.

TYPES OF ECOSYSTEM SERVICE		
Type	Description	Examples
Provisioning Services	Tangible outputs that can be obtained from ecosystems that meet human needs	Food, timber, water supply, minerals, fossil fuels, solar, wind and tidal power
Regulating Services	Ecological processes that regulate and reduce pollution and other adverse effects	Air filtration, water regulation, carbon sequestration, noise mitigation
Cultural Services	Environmental settings that enable cultural interaction and activity	Recreation opportunities, tranquillity, landscape aesthetics
Supporting Services	Functions provided by ecosystems that underpin other services	Soil formation, nutrient cycling, biodiversity
Source: Millennium Ecosystem Assessment (2005) *Synthesis Report*		

Biodiversity within a natural capital approach

Biodiversity can be defined as "the variability among living organisms from all sources" (Convention on Biological Diversity, 1992). It is central to the resilience and quality of ecosystems, facilitating and enhancing the benefits they provide. Biodiversity therefore underpins many types of natural asset and represents an over-arching component of natural capital. This also means that gains or losses in biodiversity are likely to have implications for associated natural capital (Department for Environment, Food and Rural Affairs, 2020).

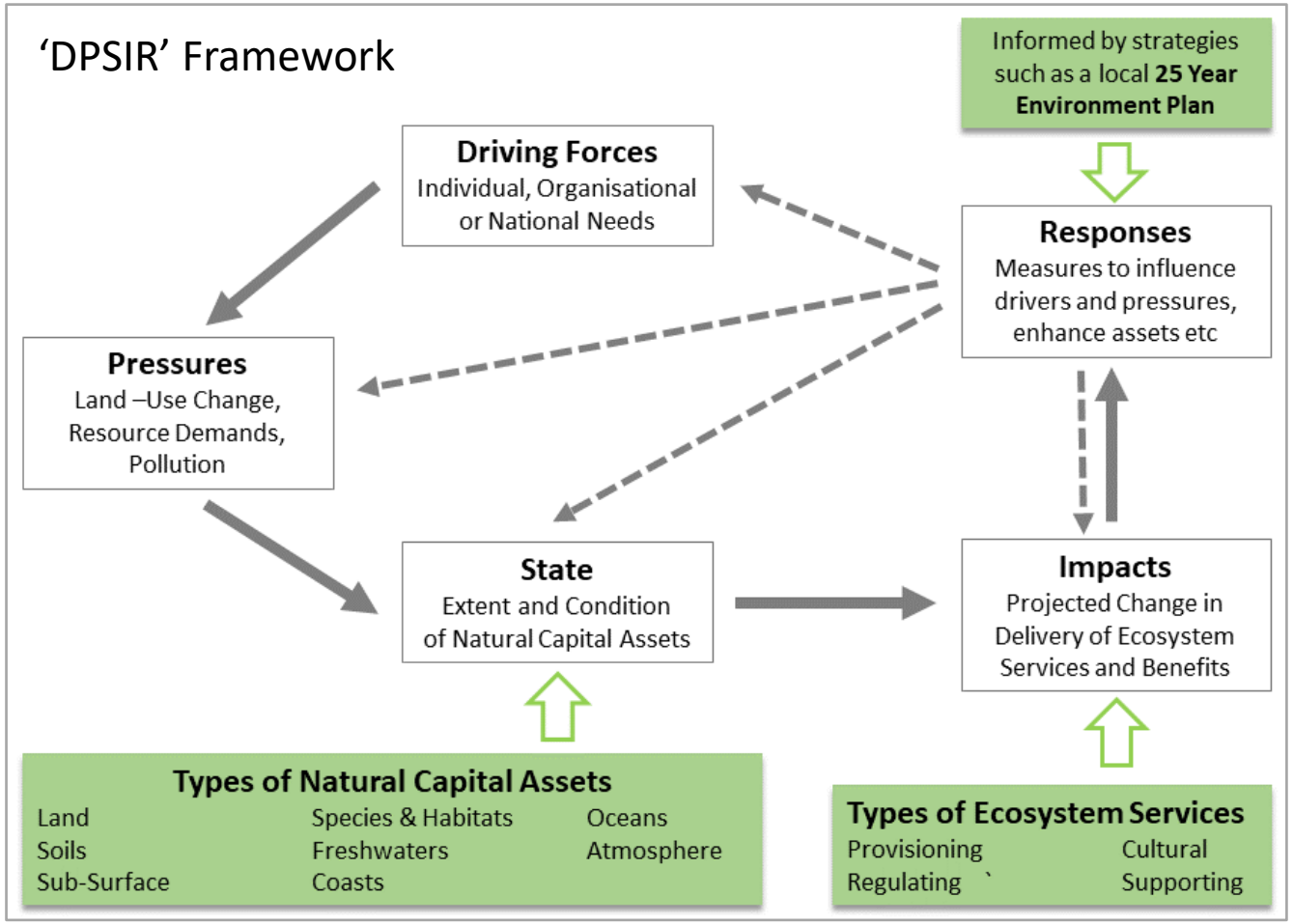
Next: Drivers and pressures

What are ‘drivers of change’ and ‘pressures’?

The impacts of environmental or socio-economic changes on human welfare can be assessed using a natural capital approach set within a wider DPSIR (Drivers-Pressures-State-Impact-Response) framework. This brings together information (in a causal chain) covering changes in environmental or socio-economic systems (drivers and pressures) with consequential alterations in the state of natural capital assets and impacts on the benefits to humans. As illustrated in the diagram to the right, the loop is completed by policy responses and feedback.”

Drivers of change can include population increase, economic growth, urban development, and lifestyle alterations. Pressures are more specific means by which drivers influence the condition of natural capital assets (e.g. changes in land use or discharge of pollutants). The combination of drivers and pressures represents risks to the future quantity and quality of natural capital assets.

The approach can help highlight the indicators needed to allow policy makers to monitor drivers and pressures, as well as resulting socio-economic impacts of current choices (policy responses), or those to be made in the future.



Source: Based on von Haaren *et al.* (2019) *Landscape Planning with Ecosystem Services*, p.25

Next: Implementation

How do we implement a natural capital approach?

A workbook published by the Natural Capital Committee (2017) suggests the five steps shown on the right to create a natural capital plan. The first involves establishing a vision and baseline starting position for planning and management. Insights from the scoping phase can then inform the development of an evidence base which typically encompasses three inter-related elements.

- The **asset statement** is an inventory of the natural assets in an area and their condition;
- The **risk register** identifies the likely source and scale of changes to the natural assets which could impact upon their delivery of benefits;
- **Natural capital accounts** help address the challenges of comparing assets by expressing their value in monetary terms

This compendium focuses on the first two of these elements, though with a shorter risk review than a full risk register as described by Mace et al. (2015). A discussion of the potential role of natural capital accounting and some selected asset valuations are included in the final section if this compendium.

1. Set out the vision
2. Understand where you are starting from

Scoping Strategy
Identify the baseline of existing assets and likely drivers and pressures

3. Build the evidence base

Compile an **Asset Statement, Risk Register** and **Natural Capital Accounts**

4. Identify and assess options
5. Implementation and evaluation

Plan Formulation
Scenario development, evaluation and implementation

Selecting Indicators

The assessment of changes in natural assets requires the definition of appropriate indicators. Ideally these should be transparent in rationale, meaningful in terms of capturing change, robust in measurement, scalable between national, regional and local levels and stable over time. In practice, data availability can be an issue, especially at more local geographical scales. Moreover, information on the extent and location of assets tends to be more widespread than that on their condition/quality or change over time. In this project, the definition of indicators has been informed by reports from Natural England (2018) *Natural Capital Indicators* and DEFRA (2019) *Outcome Indicator Framework for the 25 Year Environment Plan* and has used publically-available data wherever possible. However, the final selection of indicators has also reflected particular regional characteristics, advice from stakeholders and availability of relevant information from organisations in Norfolk and Suffolk.

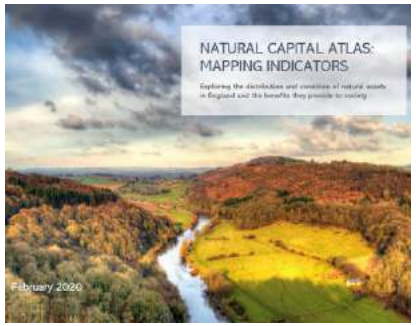
Next: Regional context

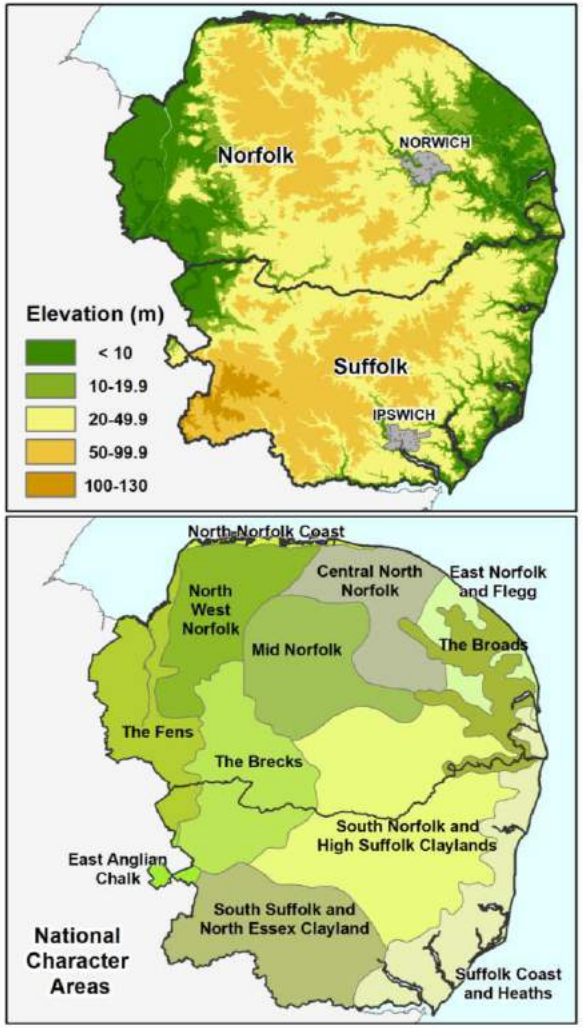
Regional Context

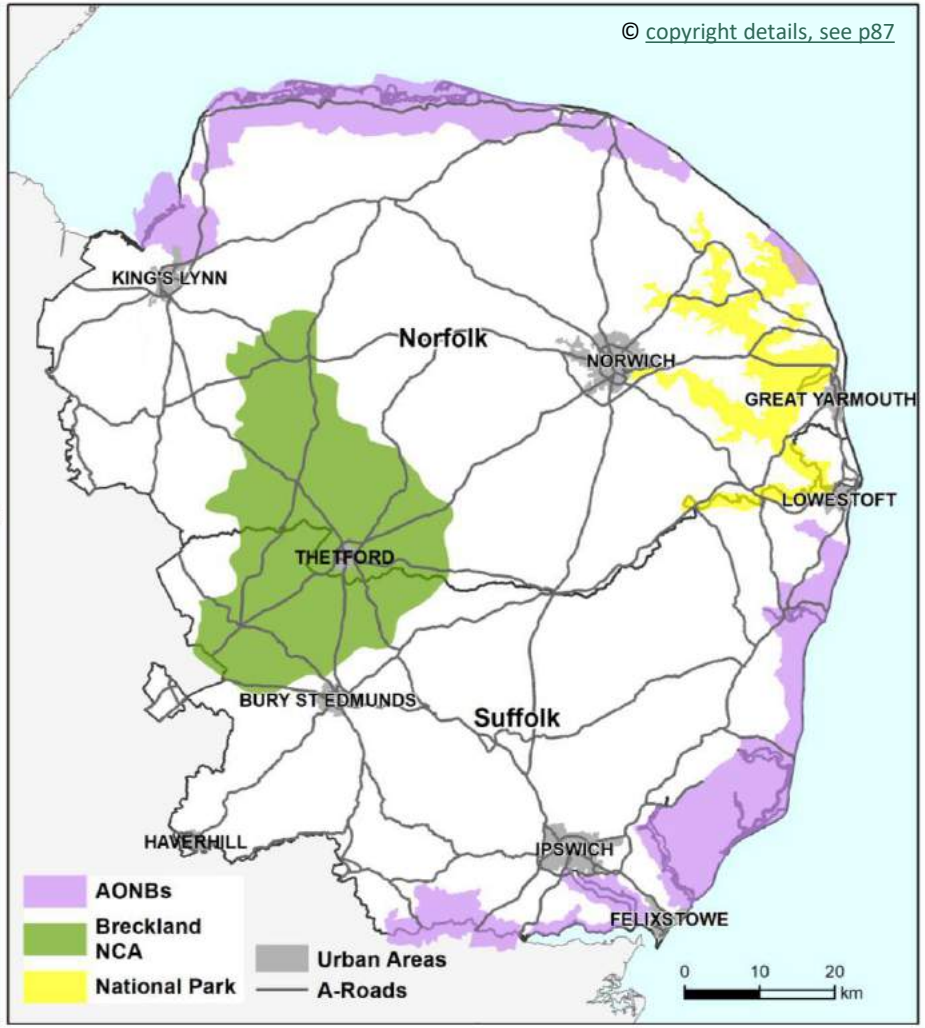
The counties of Norfolk and Suffolk have a combined coastline of over 220 km / 140 miles and a total land area of some 9,200 km^2 / 3,350 miles^2. Much of the land is low-lying, with an average elevation of 35 m and nearly a third of land below 20 m. The environmental conditions, combined with a history of human settlement dating back to at least the Stone Age, have created a variety of lowland landscapes, with 12 different character types being distinguished in a national classification (Natural England, 2014). Several of these are recognised as internationally important for wildlife, recreation and tourism, including Breckland, three Areas of Outstanding Natural Beauty (AONBs), and the Norfolk and Suffolk Broads National Park.

Other Natural Capital Initiatives

This compendium focuses on Norfolk and Suffolk but recent publications from Natural England (2020) review many similar indicators across England and the two counties. These Atlases complement the local detail in this review. Other ongoing studies which include natural capital assessments are the OxCam Arc project and the Broadland Futures Initiative.





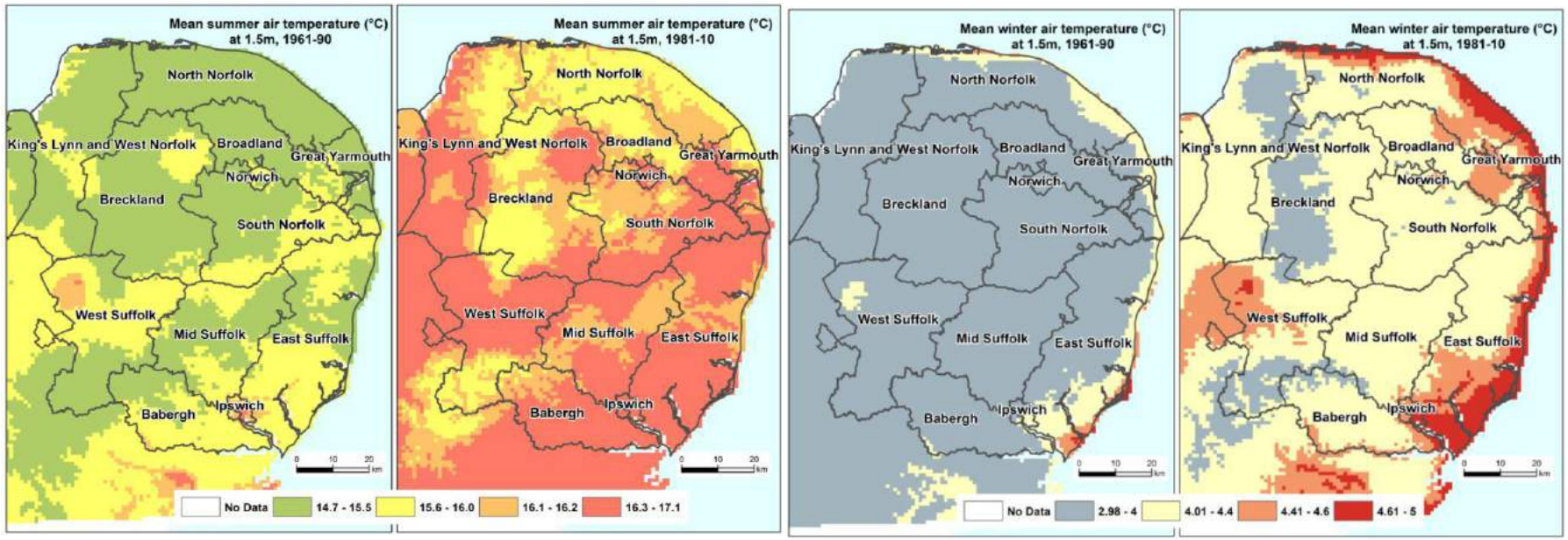


Note to maps: The southern boundary of the Suffolk Coast and Heaths AONB used throughout this Evidence Compendium predates the recently confirmed extension to south of the Stour.

Next: Drivers of change

Drivers and pressures – a changing climate

Drivers and pressures at the national scale
It is widely recognised that human influences have been responsible for a decline in both extent and condition of many natural assets in the UK. This is reflected in the findings of the UK National Ecosystem Assessment and the State of Nature reviews.



Source of observed climate data - HadUK-Grid https://www.metoffice.gov.uk/climate/uk/data/haduk-grid/haduk-grid

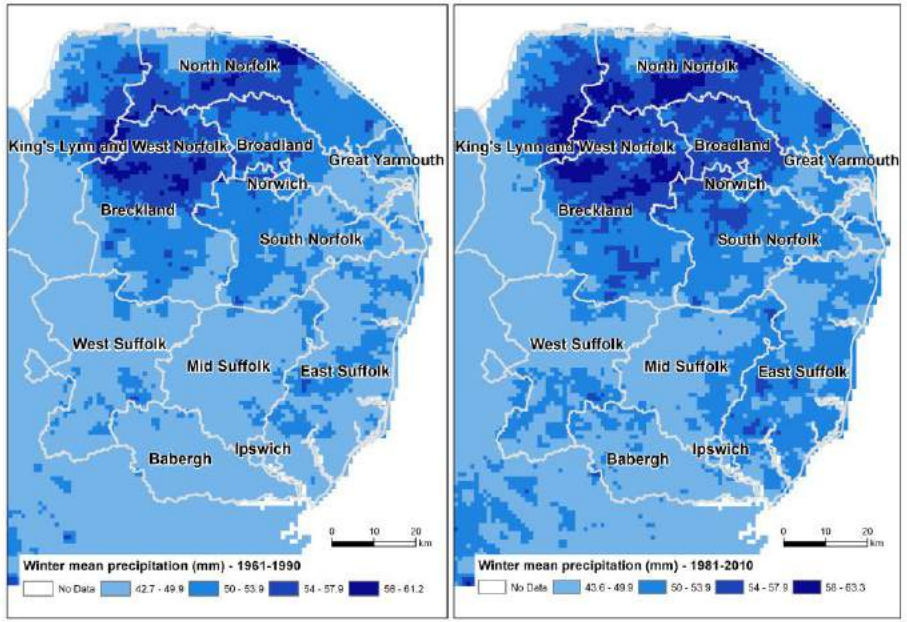
Indirect drivers include changes in population, culture and personal behaviours, economic growth and technological advances. These have influenced more direct pressures, such as alterations in land use, pollution of air, land and water, intensified agricultural land management, overexploitation of resources, and introductions of alien species, as well as changes in climate.

The regional situation The remainder of this section outlines environmental and socio-economic characteristics that represent important drivers of change at the regional level. **Climate change** represents a major societal challenge from the global to local scales and information from UK Climate Projections (UKCP18) is now sufficiently detailed to allow an assessment for Norfolk and Suffolk. The four maps above show the ***observed*** increase in mean Summer and mean Winter temperatures in East Anglia between 1961-90 and 1981-2010. As can be seen from the maps, mean temperatures have increased over time. Climate change projections suggest a further 1.2-1.6°C rise in mean summer temperature and a further 1-1.3°C rise in mean winter temperature by the 2040s.

Next: Precipitation and sea level rise

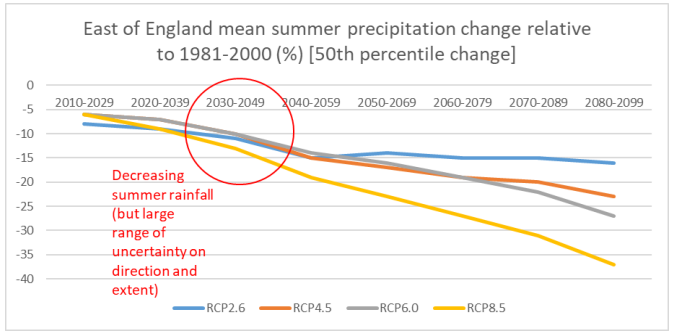
Environmental change – precipitation and sea level rise

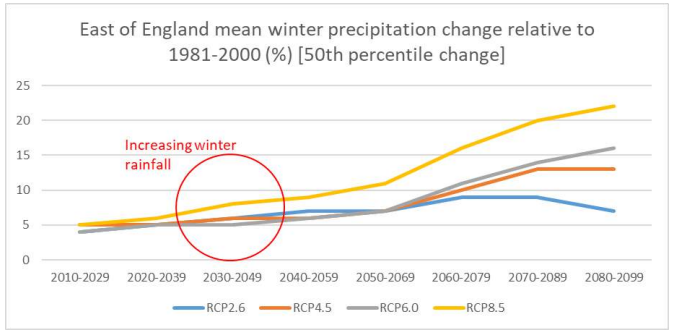
Precipitation Norfolk and Suffolk are amongst the driest counties in England. Differences in mean precipitation between 1961-90 and 1981-2010 were less pronounced than those for temperature, though the maps below show that winter averages increased more in the north and east compared to further inland.



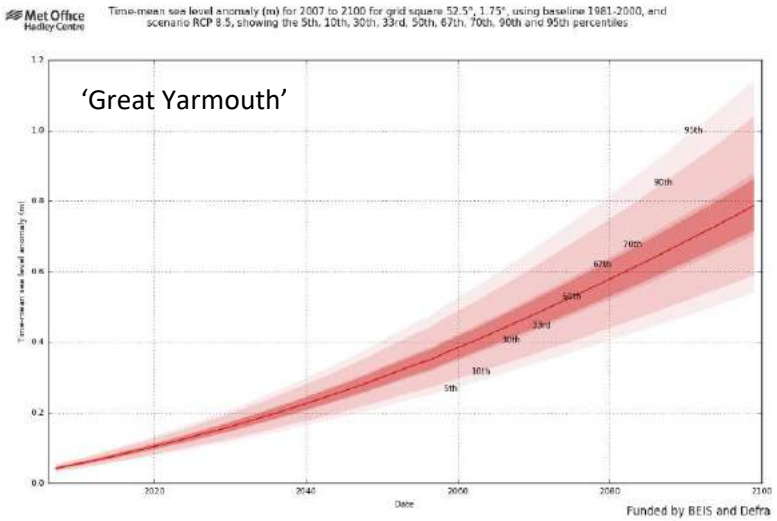
[Source for data download: https://catalogue.ceda.ac.uk/]

Future projections suggest a decrease in mean summer precipitation of 1% to 13% and an increase in mean winter precipitation of 5% to 8% by the 2040s. However, there is a considerable range of uncertainty around these mid-point estimates. Intensity of precipitation (e.g. concentration in several consecutive days) is also expected to increase and this will have implications for runoff and greater risk of surface water flooding.





Sea level rise Local sea level rise projections 2007 – 2100 relative to 1981-2000 baseline. E.g. Projections for 'Great Yarmouth' indicate 0.2-0.4m rise by mid-century and potentially 0.6-1m+ by 2100 (grid-ref approximation to nearest town). This is under UKCP18 RCP8.5 scenario climate change scenario which is the most extreme.



Next: Social change

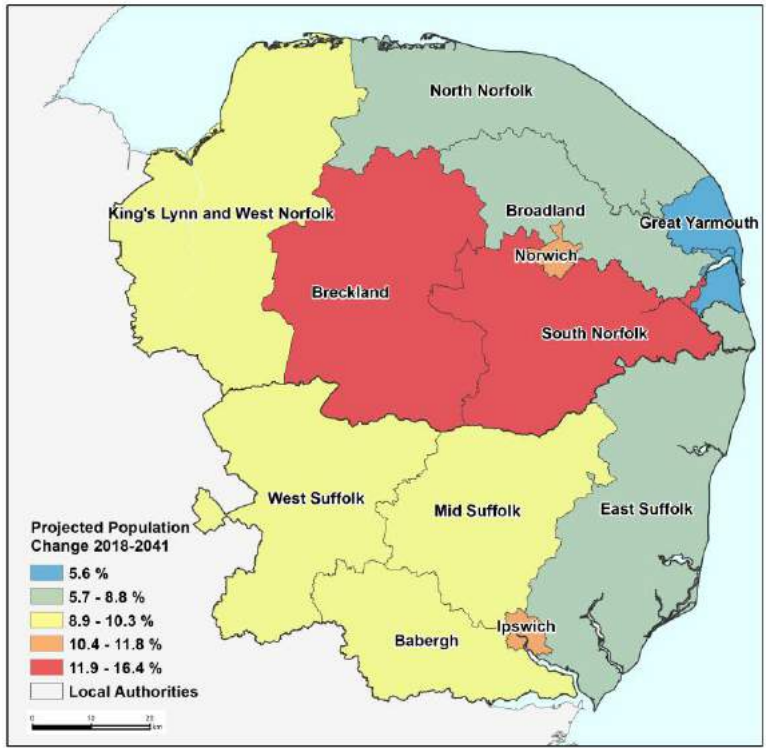
Social change

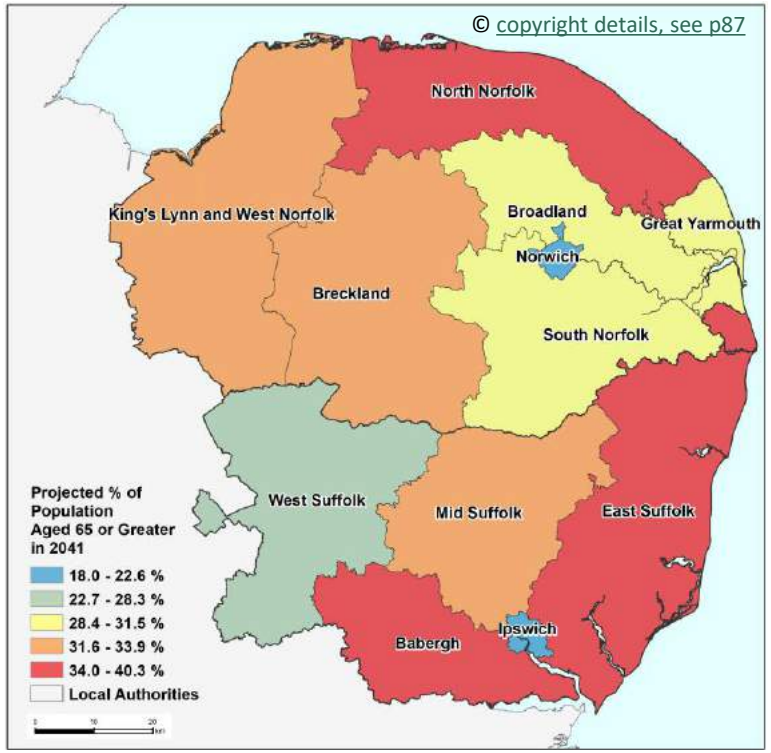
Current Situation Norfolk and Suffolk had a combined population of 1.66 million in mid-2018. Just over 20% of this total lived in the Norwich or Ipswich urban areas, and another 18% in a further seven centres with over 25,000 residents. A majority of the population therefore lives in smaller towns or rural settlements, with the overall population density being 181 persons per km^2, less than half the England average (430 persons per km^2).

Using the Index of Multiple Deprivation 2019, eight of the 12 local authorities in Norfolk and Suffolk are ranked in the middle 50% of all those in England. However, both Great Yarmouth and Norwich have over a fifth of their neighbourhoods classed as among the 10% most deprived nationally. There are also issues of deprivation in some small and isolated rural communities.

Future growth and change

The population of the two counties is projected to increase by an average of 10.3% to 1.83 million by 2041. This rate is similar to the English average. The left-hand map below shows higher average rates in Breckland and South Norfolk and there will be further local contrasts where new house building occurs. A second issue is the growing elderly population. At present, 24% of residents in Norfolk and Suffolk are aged 65 or more. This is projected to be 31% by 2041 but exceeding a third of residents in several authorities and reaching 40% in North Norfolk (see right-hand map below). This demographic change will have important implications for health and social services, as well as local economies more generally.

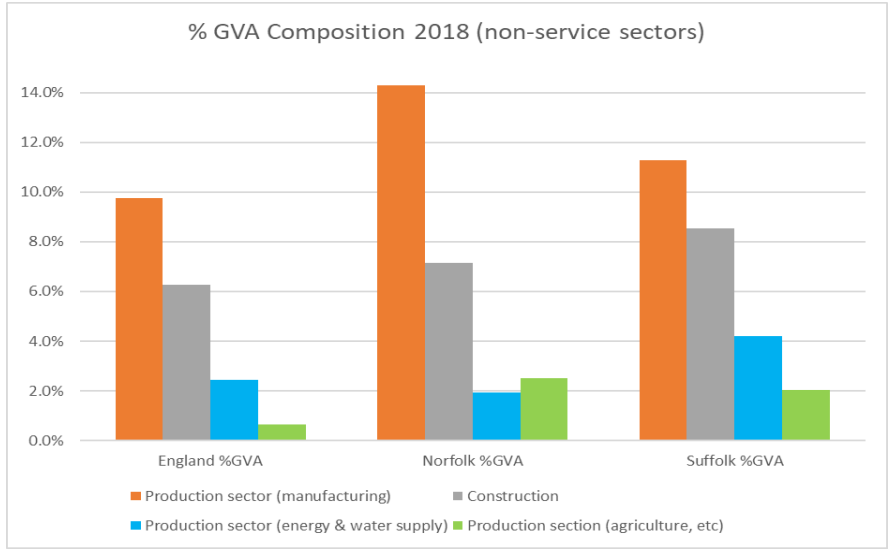




Next: Economic setting

Economic setting

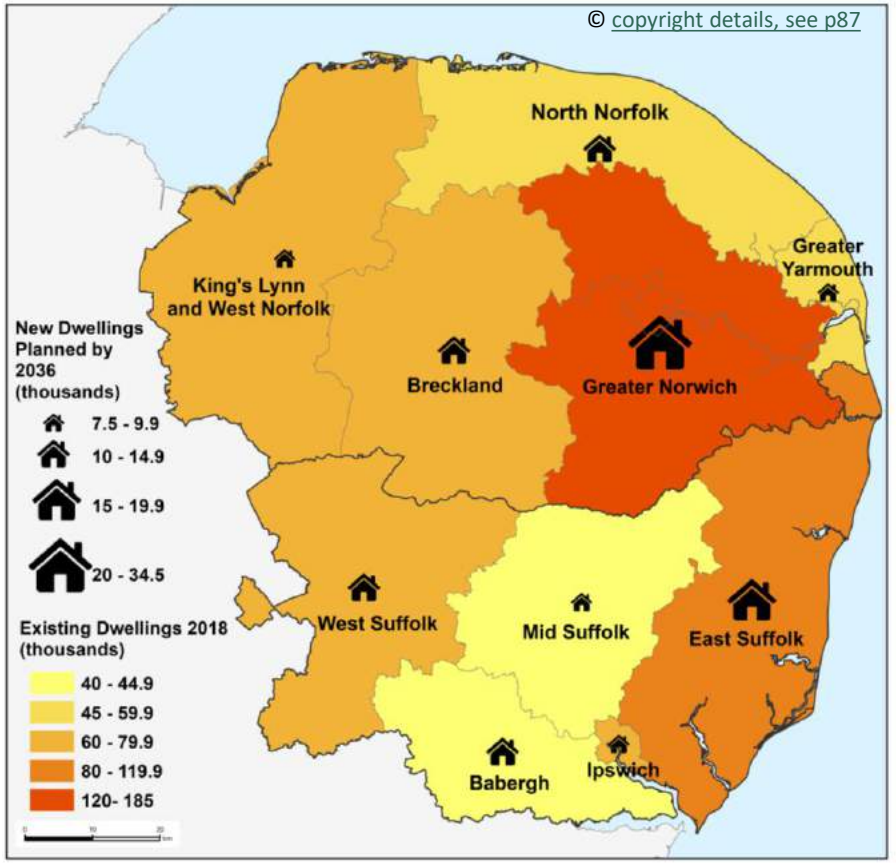
The value of goods and services produced in an area is measured by gross added value (GVA) and is an indicator of the health of the economy and economic growth (ONS, 2019a). Whilst Norfolk & Suffolk generally reflect the national situation where the greatest contribution to GVA comes from the services sector (England 80%; Norfolk & Suffolk 74%), the graph and table (below) shows the higher contribution of the two counties to national food/ fibre production, manufacturing, engineering and construction.



GVA Composition 2018 (£ millions)	England	Norfolk	Suffolk
Services sector (retail/financial etc)	1,284,152	13,556	13,388
Production sector (manufacturing)	154,778	2,613	2,039
Construction	99,364	1,308	1,545
Production sector (energy & water supply)	38,992	357	759
Production section (agriculture, etc)	10,514	459	368
	1,587,800	18,293	18,099

Key: Production sector (agriculture, forestry & fisheries; mining & quarrying); Services sector (retail/wholesale, financial & other services, education, health, arts)

The New Anglia LEP Local Industrial strategy values the Norfolk & Suffolk economy at £36b (NALEP, 2019) and highlights the agri-food industry, clean energy, information and digital technologies as future growth areas. As previously indicated, population is increasing with a net inflow of people to the region and employment levels higher than the UK average (NALEP, 2019).



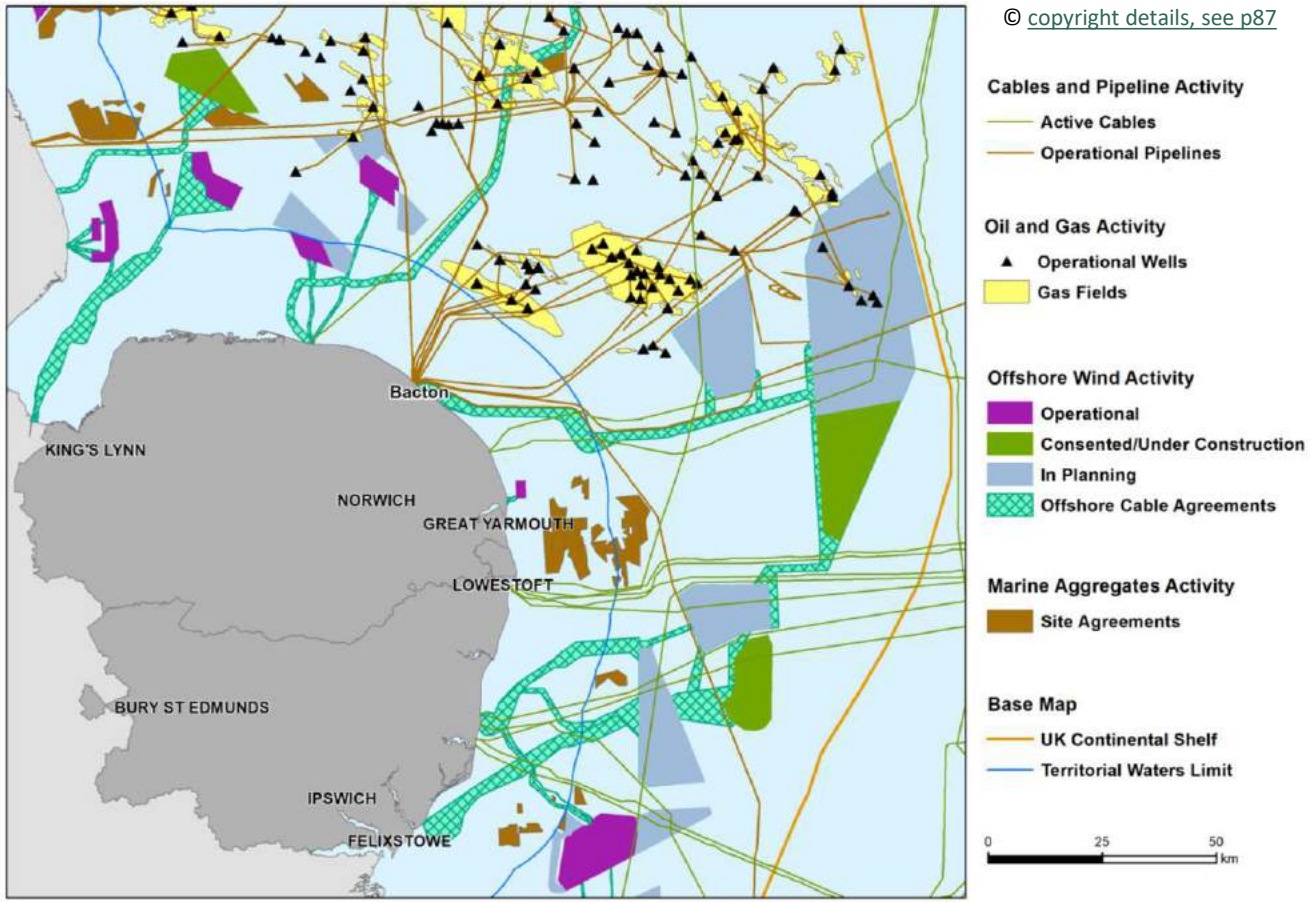
Nationally, housing demand exceeds supply (MHCLG, 2020) and the government is proposing reform to the planning system to ensure more land is available for development where it is needed. The map (shown above right) reflects new housing need already identified in Norfolk & Suffolk out to 2036. The new planning white paper promises 'radical reform' and it remains to be seen whether a balance can be achieved that meets housing need whilst safeguarding natural assets (particularly water availability).

Next: Offshore activity

Offshore activity

Norfolk and Suffolk are "*at the epicentre of the world's largest market for offshore wind energy, worth almost £1bn a year*" with the potential to benefit more than any other area in England from growth in this market (NALEP, 2019 p24). The ports of Great Yarmouth and Lowestoft have supported Southern North Sea gas operations for 50 years and are 1 of 6 areas awarded 'CORE' status recognising the port infrastructure, skills, supply chain and local Government support that will facilitate growth within the energy sector (NALEP, 2019). Wells on the North Norfolk Coast has also been important for the development of offshore wind farms.

The map shown right, from The Crown Estate dataset represents all current (23/04/20) agreements for offshore developments. NALEP foresee a huge energy market opportunity over the next 20 years, for offshore wind, oil and gas exploration and extraction, nuclear new build and decommissioning, gas storage and platform decommissioning within a 70 km radius of Great Yarmouth and Lowestoft.



NB: Marine Aggregates Activity: Marine dredged sand & gravel is mostly exported out of the region. There are licences for the dredging of up to 9 Mt of sand & gravel off the coast of the East Anglia on an annual basis. (Suffolk CC, 2020).

Sustainability

As the number of offshore developments increases there is a growing need to consider population level consequences on marine species (Bailey et al, 2014). Environmental impacts can be both negative and positive; with respect to offshore wind, most negative impacts occurring in the construction phase of developments (Dockerty et al, 2014). Concerns include increased noise levels, risk of collisions, changes to seabed and ocean habitats, alterations to food webs, pollution from increased vessel traffic or release of contaminants from seabed sediments but there are also potential benefits including shelter provided by the artificial reefs of turbine foundations (Bailey et al, 2014). In addition, offshore developments often have onshore impacts (e.g. offshore wind generation requiring onshore connection to the national grid).

Felixstowe is the busiest container port in the UK. With plans to further increase activity, monitoring of potential environmental impacts in this vicinity will be important. Greenhouse gas emissions from shipping are shown here.

Next: Asset Inventory

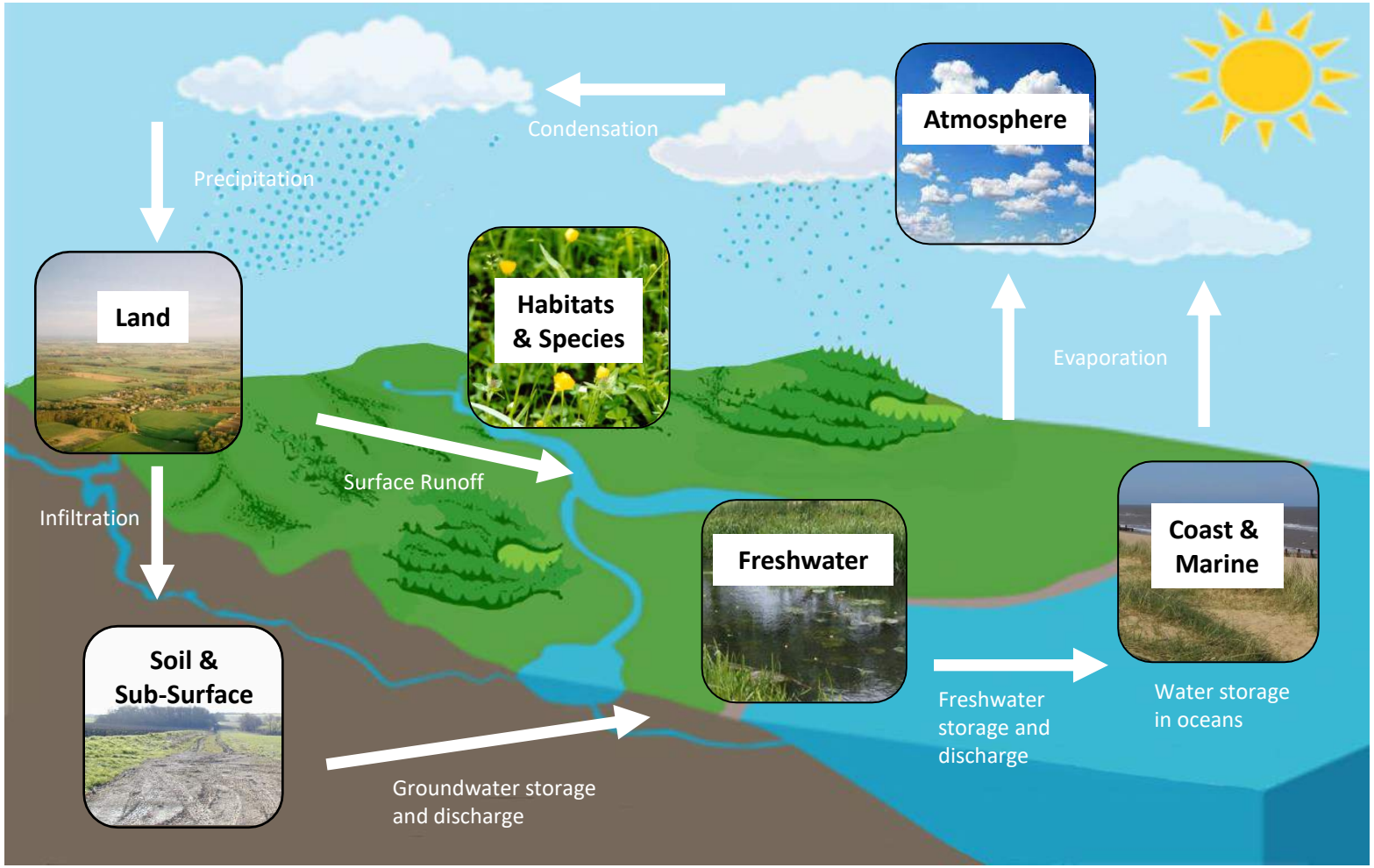
Asset Inventory: Introduction

What we have …

This **Asset Inventory** is divided into 6 sections – **land**, **soil & sub-surface assets**, **habitats & species**, **freshwater**, **coast & marine** and **atmosphere**. It presents data that provides ***indicators*** of the character of these assets (quantity, and in some cases, quality), highlights aspects of regional significance, and acts as a baseline measure for evaluating future change in their extent and condition.

While the assets are presented in separate sections, it is important to appreciate that there are connections and interactions between them. This occurs through a variety of physical, chemical and biological processes, such as the water cycle illustrated to the right, and means that change in one asset category is likely to have consequences elsewhere.

Further consideration of such interactions can be found in the risk review and implications sections.



Source: modified from https://www.sciencelearn.org.nz/resources/713-h-o-on-the-go-the-water-cycle-introduction

Land

Contents

Land is the physical surface of the Earth and a ***natural asset*** that provides ***ecosystem services*** across all four categories (***provisioning*** – e.g. food and fibre, ***regulating*** e.g. carbon sequestration, ***cultural*** – e.g. recreation opportunities, and ***supporting*** – e.g. soil formation and biodiversity). In this section we focus on first describing the broad land types as used in the National Ecosystem Assessment (2005) and then examine ***indicators*** of the status of *provisioning* land uses (food producing land and productive woodland) *regulating* land uses represented by carbon density in vegetation, *cultural* land uses i.e. land available for recreational use and finally, land under conservation management, (explored in more depth under the section on Habitats and Species), as an indicator of *supporting* ecosystem services.

Land: Key features

This page summarises key findings of significance for Norfolk & Suffolk selected from the data presented within this section and highlighting information gaps or needs revealed from this examination.

Land types

Our area has over 27% more arable farmland than the average for England but around 15% less grassland (clustered along river valleys, the Broads National Park and Dedham Vale AONB). Woodland cover is around the national average. Urban land is around 7% in Norfolk and 8.2% in Suffolk, well below the average for England (13.4%); indicating the rural nature of the two counties.

Food producing land

Our area has more of the best grades of food-producing land than the average for England (25.5% Grades 1&2 and 53.8% Grade 3 respectively, compared to 16.9% and 48.1% for England). In addition, Norfolk, all AONB areas and the Brecks exceed the England average (14.7%) for land in environmental stewardship schemes, potentially a positive indicator of the willingness to manage land sustainably.

Productive woodland

With 27.6% forest cover, The Brecks has over twice the England average (10%) in tree cover. Of this 18.3% is in the inferred productive woodland classes, and is focussed on the Forestry Commission's Thetford Forest which provides a valued recreation resource as well as providing timber and energy from waste wood.

Land under conservation management

Sites designated for nature conservation cover 10% of Norfolk & Suffolks' land. The five key natural areas have multiple designations recognizing their international importance. Equally important though, is the broad scatter of smaller sites that form island sanctuaries in the agricultural landscape, essential in a changing climate to enable species to migrate across the landscape.

Recreational use of land

Our area has 9,589 Km of Public Rights of Way but this area of land plus other open access land [CROW Act] is much lower than for England (0.08%), excepting in The Brecks, and Suffolk Coast & Heaths AONB. Similarly, there is less open green space within urban areas than the 2.4% average for England, though the Norfolk Coast AONB has nearly double this at 4.6%.

Carbon density in vegetation

This indicator helps reveal how future changes in land cover may influence aboveground carbon stores, as these play a vital role in climate regulation. In Norfolk & Suffolk woodland (24.6t/ha), heaths (11.7 t/ha) and freshwater margins (18.4 t/ha) have the highest rates of carbon storage, though due to the land area under agriculture, the total amount of carbon stored by farmland is greater than all other land uses combined.

Information Gaps

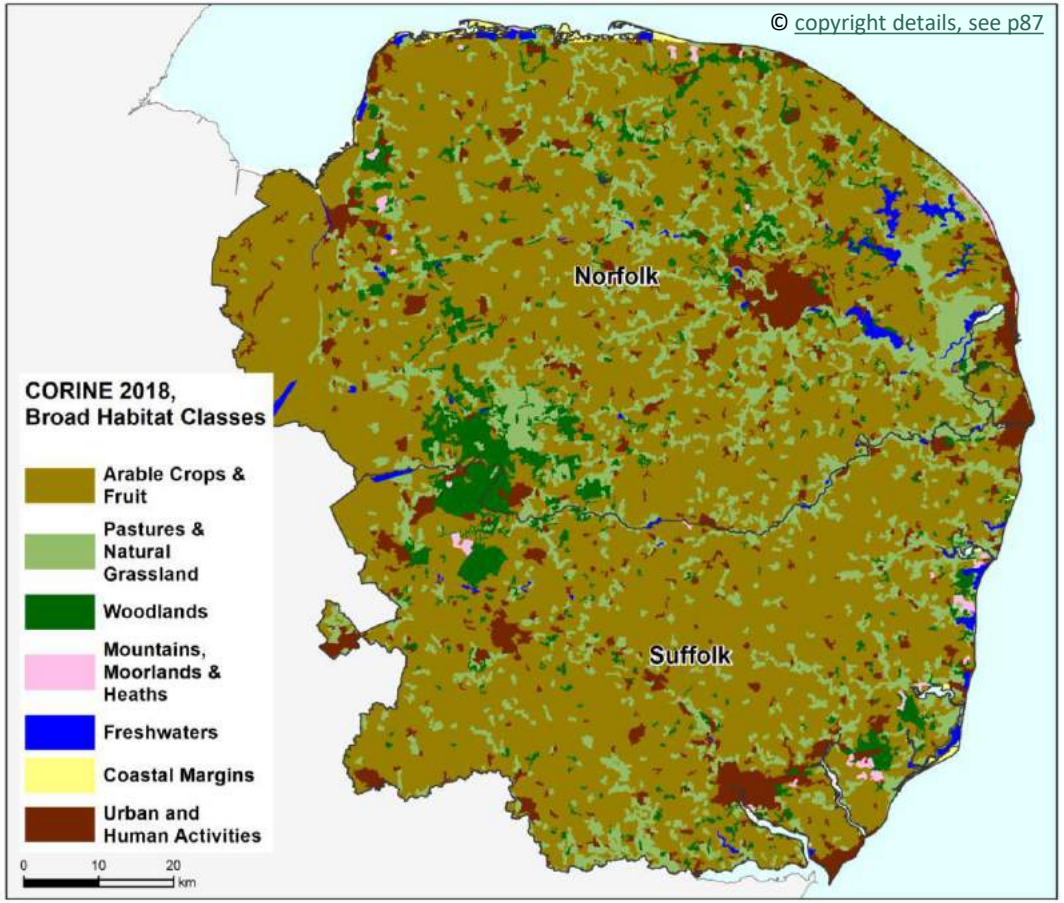
The datasets presented here are compiled nationally. Data for Norfolk & Suffolk have been selected from them. Many of these are updated periodically, providing both baseline data and the opportunity to assess change over time. However, for most, this is change in quantity. Indicators of change in quality are more elusive. Measures such as the amount of land in Environmental Stewardship schemes may help fill this gap.

Land types

Land cover data from the CORINE CLC2018 dataset, illustrated in the map, indicates the prevalence of arable farmland in the two counties, occupying 72% of the land area compared to the 44.1% average for England. Conversely, except within the Broads National Park and Dedham Vale AONB, there is over 15% less natural grassland than elsewhere in England, though the association between this and river valleys is quite striking. Woodland cover is around the national average, and is most prevalent in the Suffolk Coast & Heaths AONB and in The Brecks, where Thetford Forest is an important source of commercial timber.

The counties are also important with respect to the coastal habitats they are responsible for, particularly within the Norfolk and Suffolk coastal AONBs, as well as the freshwater and fen habitats of the Broads National Park. Although occupying a small overall area, the heathlands of The Brecks and Suffolk Coast AONB are of conservation significance. Priority habitats such as these are discussed further under Habitats and Species.

Land classified as urban /used for other human activities is around 7% in Norfolk and 8.2% in Suffolk, both well below the average for England (13.4%) and indicating the rural nature of the two counties.

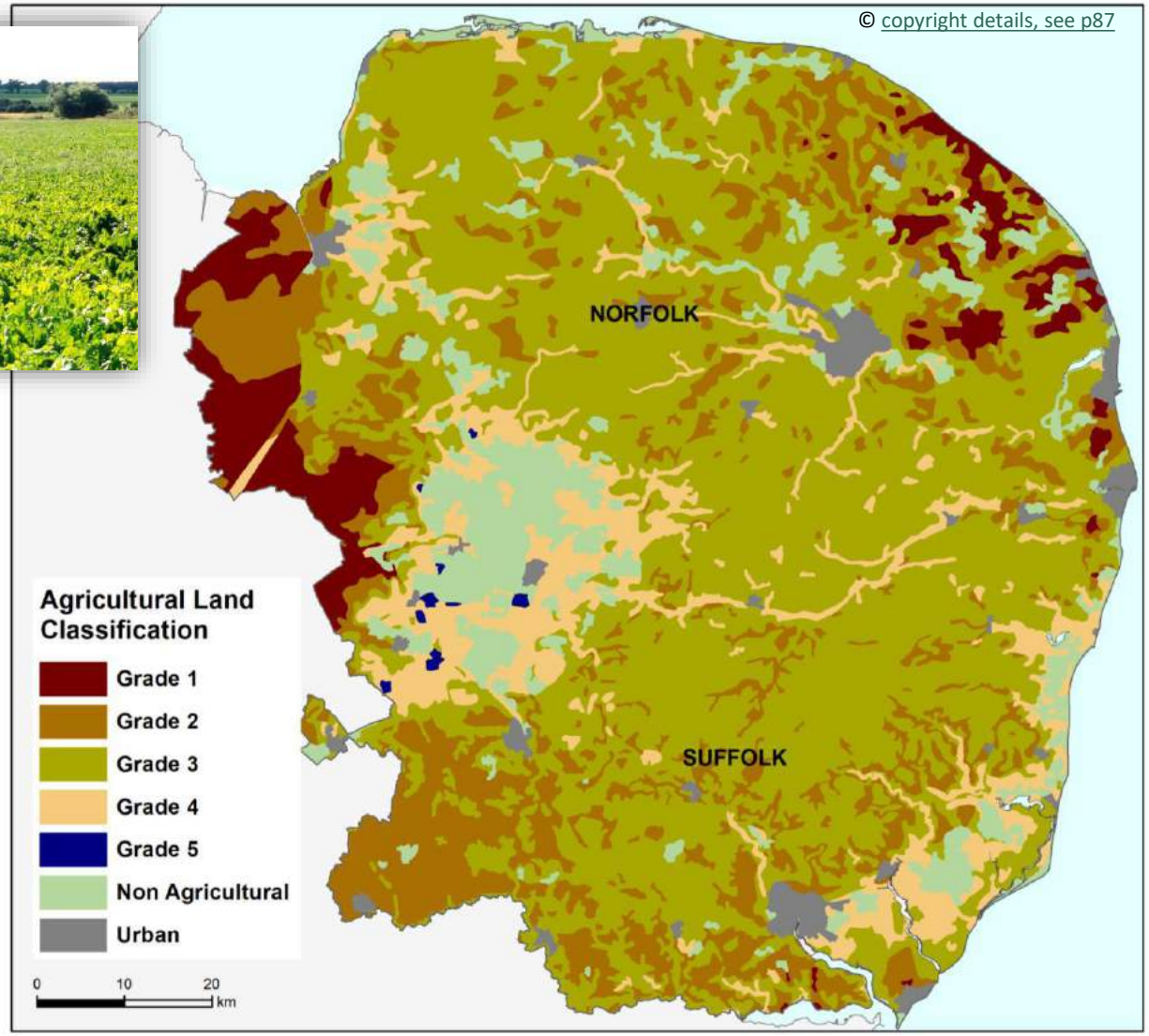


LAND TYPES BY AREA (Ha)	Norfolk	Suffolk	England TOTAL	The Brecks	Broads NP	N&S AONBs TOTAL
Arable crops and Fruit	380,622	280,916	5,759,358	55,206	6,623	45,954
Pastures and Natural Grassland	71,618	41,734	3,967,464	15,077	15,358	14,336
Heaths (Mountains, Moors & Heaths)	1,198	1,732	671,428	407	111	1,935
Woodlands	35,814	20,443	831,116	24,532	2,371	9,481
Freshwaters	7,445	2,677	77,755	240	4,640	2,634
Coastal Margins	3,674	1,587	49,046	0	501	14,460
Urban and Human Activities	37,477	31,020	1,696,614	6,465	547	5,019
Unclassified	164	60	1,679	0	-1	369
TOTAL AREA	538,011	380,169	13,054,460	101,926	30,151	94,187

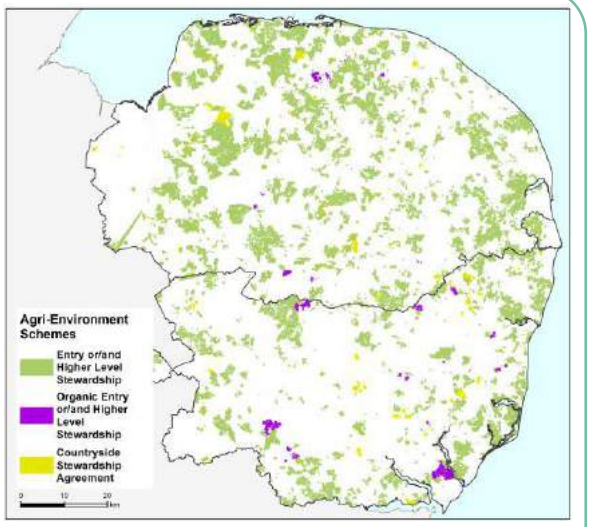
Food-producing land

The Agricultural Land Classification data set gives an indication of the quality of land for food production. It classifies agricultural land into categories based on a variety of criteria that assesses suitability for growing crops. Norfolk and Suffolk have a greater proportion of the best grades of food-producing land compared to the average for England (25.5% Grades 1&2 and 53.8% Grade 3 respectively, compared to 16.9% and 48.1% for England).

Farms across East Anglia are important for cereal & horticultural crops, produce 2/3 of England's sugar beet, 1/3 of the nation's potato crop, and are significant for pig, poultry and egg production. (DEFRA, 2010).



Environmental stewardship



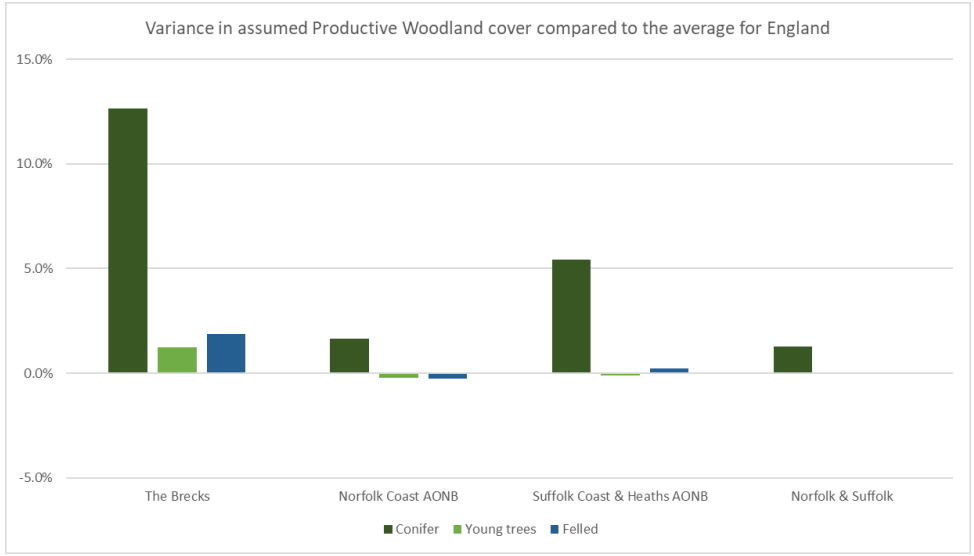
Over the last 40 years this region has been at the forefront of developing agri-environment measures. For example, the Broads Grazing Marshes Scheme led to the Environmentally Sensitive Areas (inc Broads, Brecks, Suffolk River Valleys) and the piloting of this approach in arable systems, which informed the broader spectrum Environmental Stewardship and Countryside Stewardship schemes funded through the EU Rural Development regulations. Norfolk, all AONB areas and the Brecks have more land in stewardship schemes than the England average (14.7%). The Dedham Vale AONB has 42.3% of land in environmental stewardship.

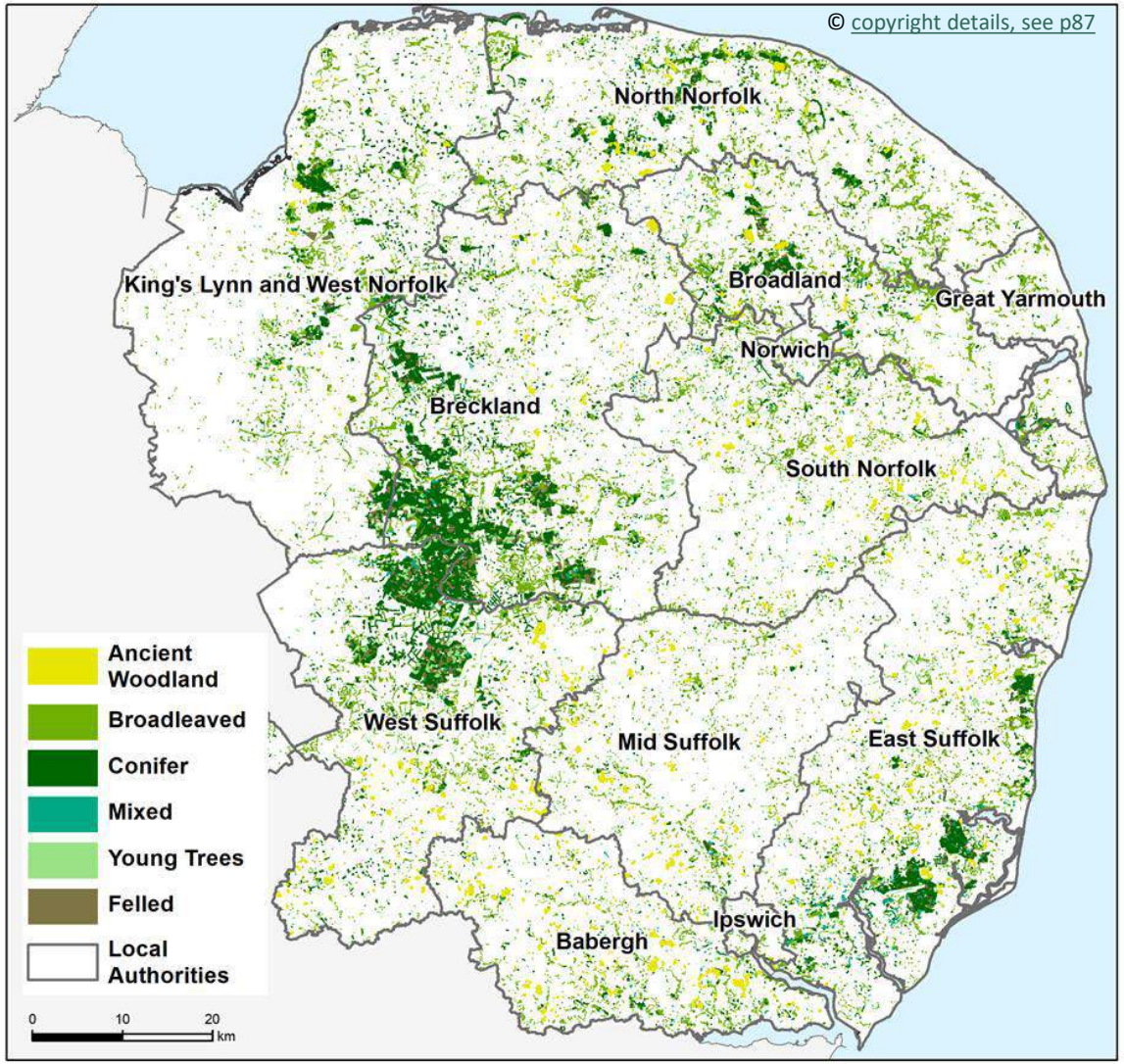
The NFU has set out it's ambition for 'net zero' greenhouse gas emissions from farming by 2040. Work will include the development of a 'sustainability metric' proposed by the Sustainable Farming Trust.

Productive woodland

The National Forest Inventory dataset produced by the Forestry Commission shows the extent of all woodland greater than 0.5 ha with a minimum of 20m width and 20% canopy cover, by interpreted forest type, based on field survey and remote sensing data. Although it does not specifically classify productive (i.e. timber-producing) woodland, it is the best dataset available and is inferred here from the following categories: **conifer, young trees, felled areas.**

With 27.6% forest cover, The Brecks has over twice the England average (10%) in tree cover. Of this 18.3% is in the inferred productive woodland classes and is focussed on the Forestry Commission's Thetford Forest which, as well as providing timber and energy from waste wood, provides a valued recreation resource (1.5 million visitors each year www.brecks.org). Risks to productivity include deer damage, other pests and disease and climate change.



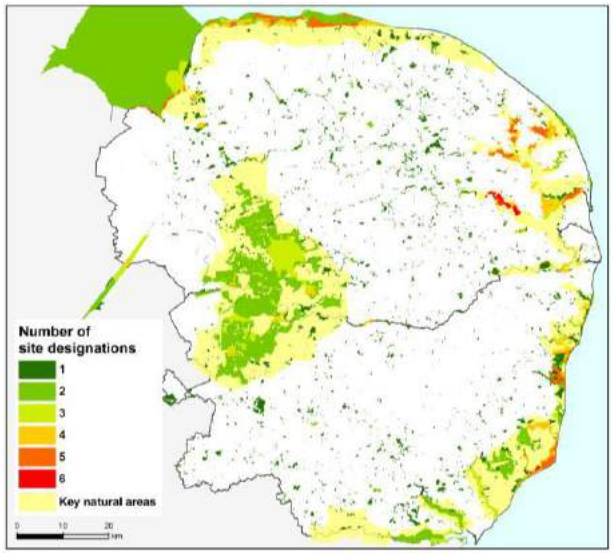


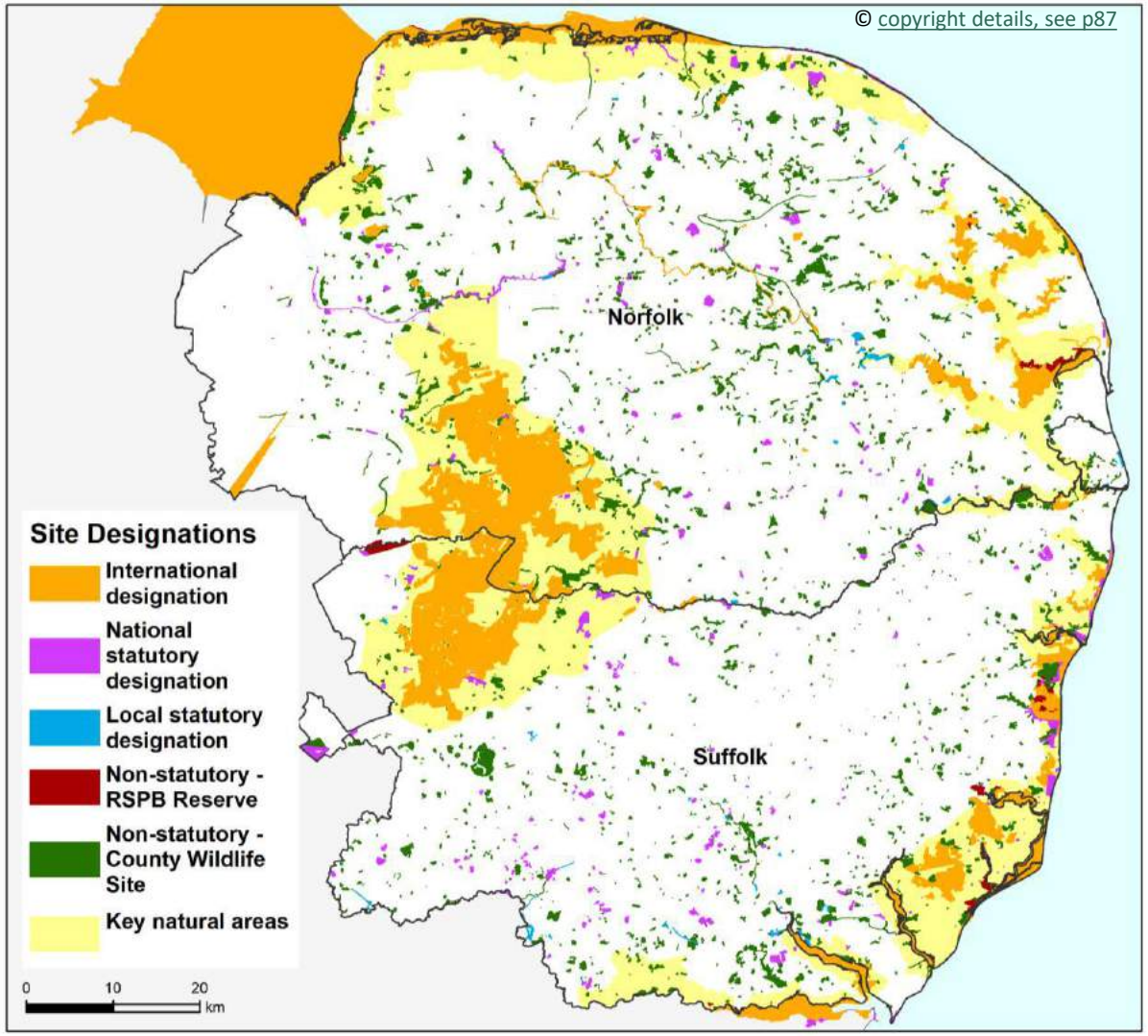
Land under conservation management

It is no coincidence that the five key natural areas of Norfolk and Suffolk are important for site-based nature conservation recognised through a number of designations indicating the international importance of habitats and/or species.

However, equally important is the broad scatter of smaller sites that form island sanctuaries in the wider agricultural landscape providing homes for beneficial (pollinating) insects and other species. These sites will become both increasing vulnerable in a changing climate and more essential in enabling species to migrate across the landscape. Maintaining and enhancing habitat connectivity will be vital in the future. Currently around 10% of land in Norfolk and Suffolk has at least one designation (see map below) and there are additional undesignated areas managed by the Wildlife Trusts, National Trust etc.

Area under each individual classification (Ha)	Norfolk	Suffolk
RAMSAR	11,889	3,964
Special Area of Conservation	16,786	5,211
Special Protection Area	35,883	23,114
National Nature Reserve	6,471	2,224
Site of Special Scientific Interest	40,180	26,961
Local Nature Reserve	501	467
RSPB	2,185	2,467
County Wildlife Sites	15,642	10,772
Total Area Within Above Categories		
(i.e. adjusted for land under multiple designations) (Ha)		
TOTAL Area	**56,294**	**38,458**
County area	538,011	380,169
Total as % of County	**10.5%**	**10.1%**

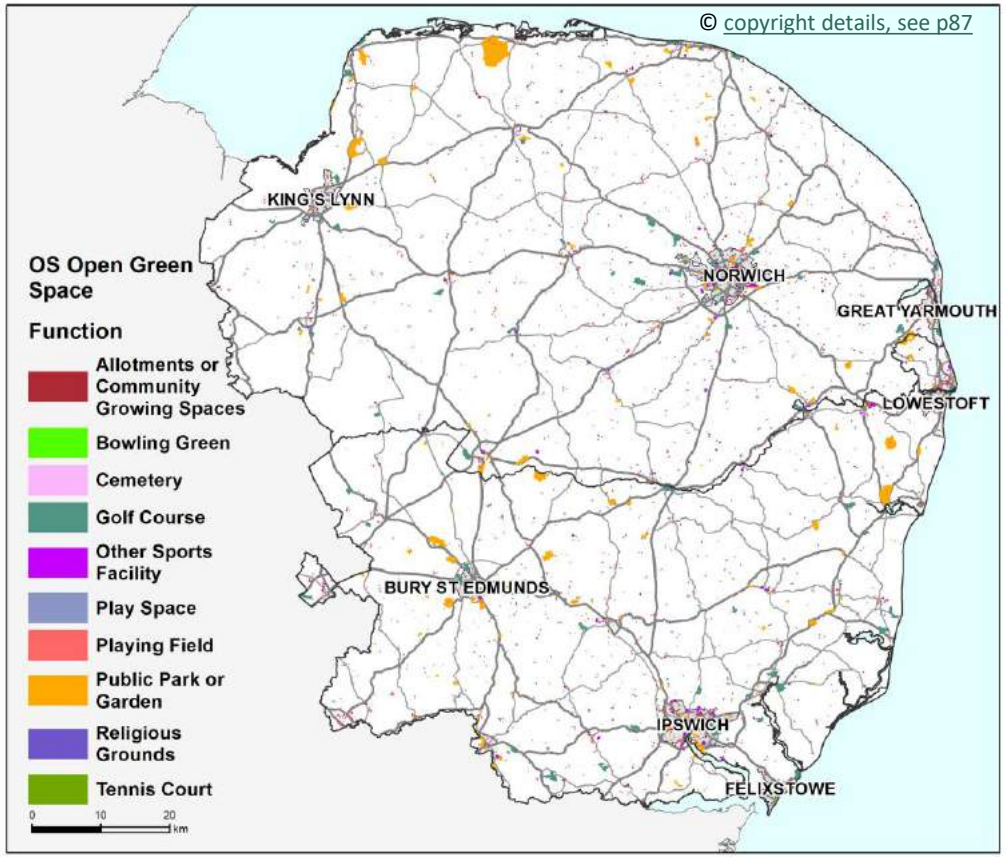




Recreational use of land

Land available for recreational use, for example with access designated under the Countryside and Rights of Way Act (2000), Public Rights of Way or other areas of Open Greenspace, provides an important cultural ecosystem service. Access land under the Countryside and Rights of Way Act (2000) represents 7.8% of the total land area of England. Due to the predominant agricultural land use, the average values for Norfolk (2.0%) and Suffolk (3.2%) are lower, though localities such as The Brecks (12.6%) and Suffolk Coast and Heaths AONB (10.3%) exceed the England average on this indicator. The total lengths of Public Rights of Way in Norfolk & Suffolk are shown in the table shown right.

Public Rights of Way	Length - Km
Norfolk	3856
Suffolk	5732
The Brecks	554
The Broads NP *	332
Norfolk Coast AONB	301
Suffolk Coast & Heaths AONB	665
Dedham Vale AONB	180



Open green space includes the many sites within urban areas used for recreational activities. Surprisingly perhaps, both Norfolk and Suffolk overall have less than the 2.4% open green space average for England, though the Norfolk Coast AONB has nearly double this at 4.6%.

OS Open Greenspace (Ha)	Norfolk	Suffolk	The Brecks	Broads NP *	Norfolk Coast AONB	Suffolk Coast & Heaths AONB	Dedham Vale AONB
TOTAL AREA OF OPEN GREENSPACE	7,253	6,352	1,212	270	2,055	946	145
Percentage of area in open greenspace	1.3%	1.7%	1.2%	0.9%	4.6%	2.3%	1.6%

* NB: As so much of the area of the Broads National Park is waterways, this value is not strictly comparable to the other areas.

Definitions

Public Right of Way: a specific route over land belonging to someone that permits the public to walk, ride, cycle and sometimes drive along.

Countryside and Rights of Way Act (2000): access land includes Open Country (e.g. mountains, moors & heaths where there is a public 'right to roam'.) and Registered Common Land.

Open Greenspace: Green space sites such as parks, playing fields, sports facilities in urban and rural areas available for public use.

Carbon density in vegetation

This dataset from the Centre for Hydrology and Ecology presents estimates of total carbon stored in vegetation based on land cover type (Land Cover Map of GB, 2007). Forests and other vegetation make up large proportions of the total carbon pool which acts as a sink and source for carbon dioxide. The importance of this indicator is to reveal how changes in land cover over time may influence the above ground carbon pool, as carbon stored in vegetation plays a vital role in climate regulation (Henrys et al 2016).

Above ground carbon in vegetation closely follows the geographic distribution of forests and woodland across England, hence Thetford Forest is an important above ground carbon store. Other vegetation types such as heathland and wetlands (freshwater margins) are also important stores. (Henrys et al. 2016). The table below shows data for Norfolk and Suffolk, with values for woodland of 24.6t/ha, freshwater margins (18.4 t/ha) and heathlands 11.7t/ha. These habitat groups are mapped on the Land types page.

CEH Above Ground Carbon Density in Vegetation in Norfolk & Suffolk			
Habitat Group	Hectares	C Tonnes	t/ha
Arable Crops & Fruit	661,138	2,944,924	4.5
Pastures & Natural Grassland	113,258	769,200	6.8
Heaths (Mountains, Moors & Heaths)	2,885	33,636	11.7
Woodlands	56,241	1,381,648	24.6
Freshwaters (marginal vegetation)	10,122	186,681	18.4
Coastal Margins	5,261	6,814	1.3
Urban and Human Activities	59,837	352,862	5.9
unclassified	9,434		
Norfolk & Suffolk Total	918,180		

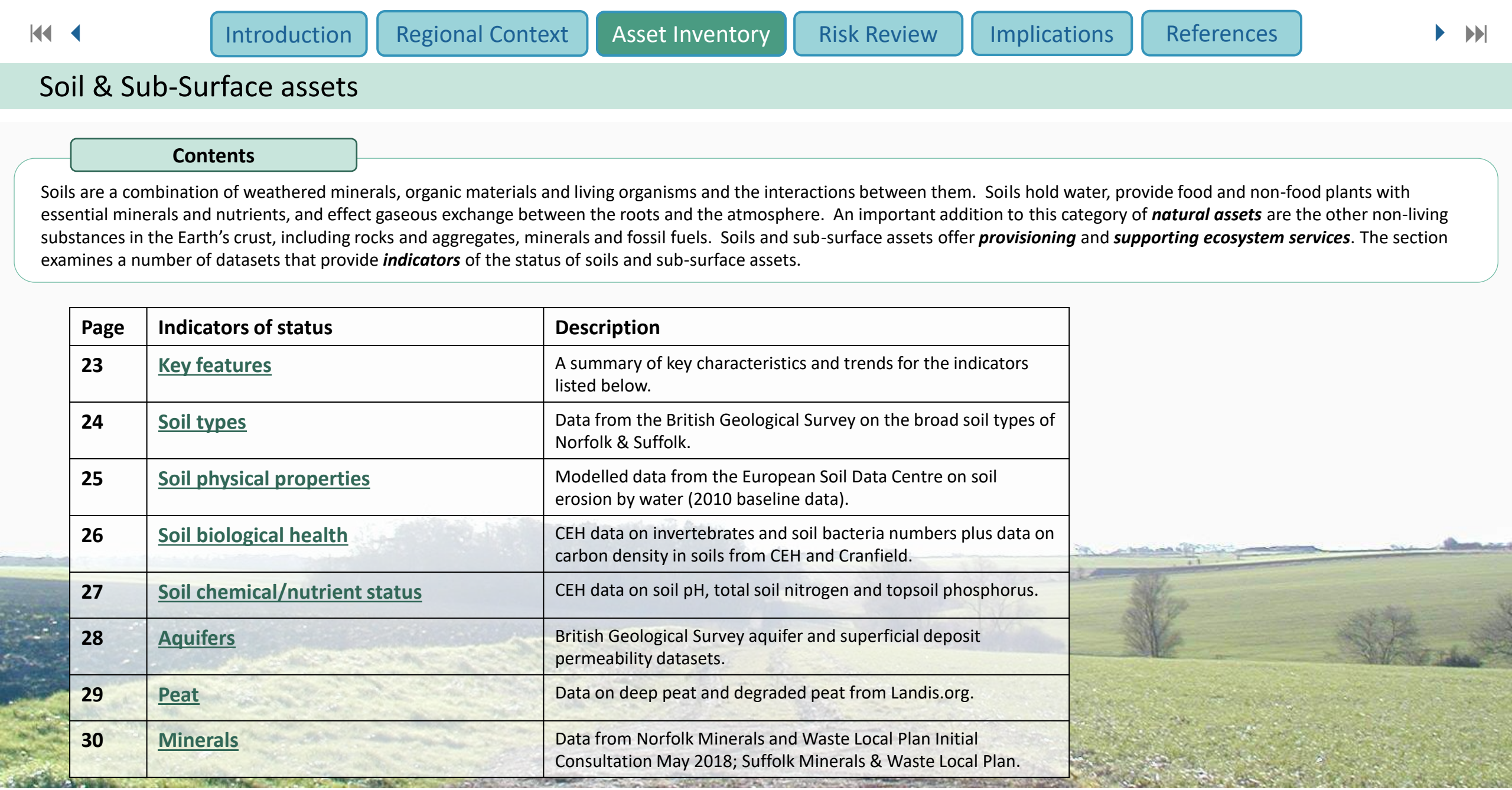
In total, approximately 5.7 million tonnes of carbon are stored in vegetation across Norfolk and Suffolk. This compares with 92.6 million tonnes using equivalent data for the whole of England, so the two counties represent some 6% of the national above-ground carbon store.

The total amount of carbon in vegetation is also relatively small compared to that in soil (e.g. 45.1 million tonnes in topsoil across Norfolk and Suffolk), though the proportion that vegetation represents of the total varies between habitat groups (e.g. an average of 28% for woodlands compared to 8% for arable land).

Soil & Sub-Surface assets

Contents

Soils are a combination of weathered minerals, organic materials and living organisms and the interactions between them. Soils hold water, provide food and non-food plants with essential minerals and nutrients, and effect gaseous exchange between the roots and the atmosphere. An important addition to this category of ***natural assets*** are the other non-living substances in the Earth's crust, including rocks and aggregates, minerals and fossil fuels. Soils and sub-surface assets offer ***provisioning*** and ***supporting ecosystem services***. The section examines a number of datasets that provide ***indicators*** of the status of soils and sub-surface assets.



Soil & Sub-Surface: Key features

This page summarises key findings of significance for Norfolk & Suffolk selected from the data presented within this section and highlighting information gaps or needs revealed from this examination.

Soil types

Chalk, gravel and sand deposits form the bedrock that underlie the soils of Norfolk & Suffolk. The most prevalent soils are 'medium to light (silty) to heavy', covering 43.8% of the two counties and another 14% are 'light-medium sandy soils'. Light soils can be subject to wind and water erosion, and be prone to drying. Hence soil condition will be an important environmental indicator to monitor in a changing environment.

Soil physical properties

Soil erosion can be accelerated by poor land management. Wind erosion is more limited in extent than water erosion but can be more severe. Modelled data showing soil loss by water erosion, indicates high soil loss (16 t/ha/yr) in North Norfolk and other smaller areas across the two counties. Flood alleviation and other schemes can have a positive impact on soil loss.

Soil biological health

Soil organic matter is an important indicator of long-term soil health and the peaty soils of heaths, freshwater margins, woods and grassland are important carbon stores. Modelled data indicate soil bacterial diversity is relatively uniform across natural habitats and cultivated land whilst soil invertebrate abundance is highest in freshwater margins and other less disturbed habitats.

Soil chemical/nutrient status

Improved control of emissions mean that soil acidification is now a reducing pressure. Oversupply of nitrogen and phosphorus from agricultural fertilisers and other sources are now a greater environmental problem causing eutrophication of waterways and risk to drinking water supply.

Aquifers

Around 90% of Norfolk and Suffolk is underlain by aquifers of high/medium productivity (31% for England). Aquifers overlain by permeable deposits are more vulnerable to surface leaching or pollution. In this area these are most prevalent in the Brecks and Suffolk Coast AONB. Aquifers provide >70% of the public water supply in the south and east of England.

Peat

Peat is found in river valleys, and in the broads and fens of Norfolk and Suffolk. Drainage for agricultural production has led to considerable shrinkage and loss. Peat restoration holds the potential for climate change mitigation through carbon sequestration. However, if neglected, climate change may exacerbate peat erosion risking a 'positive feedback' that could lead to further carbon release and add to global warming.

Minerals

Local authorities are required to provide a steady supply from locally available resources. Over the next 25 years (up to 2036) plans allow for 57.1 mt of sand and gravel extraction, carstone of 2mt and silica sand of 18.75 mt, from around 50 sites across the two counties. However, for sand and gravel, the long-term trend is for less (onshore) extraction locally.

Information Gaps

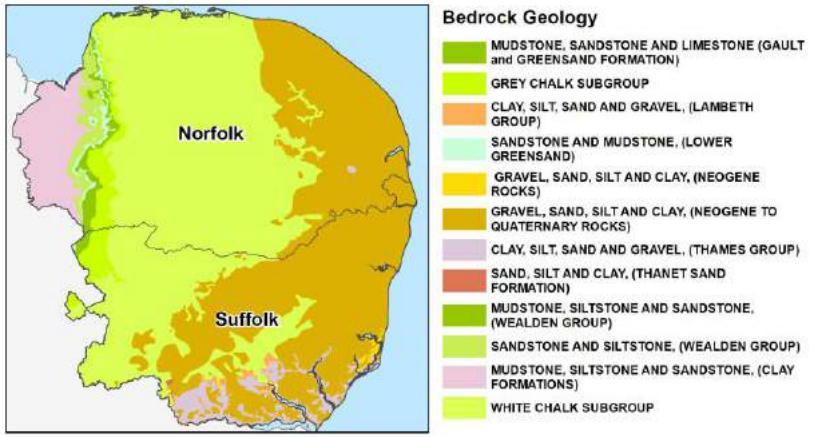
Many of the datasets relating to soil and sub-surface assets are created from modelled data, in some cases based on sample data, in others derived from other environmental parameters. The most sensitive data in relation to environmental degradation is possibly that related to ***soil nitrogen*** and ***phosphorus, soil loss*** and ***soil carbon***. In addition to these indicative datasets other methods need to be incorporated for more closely monitoring these.

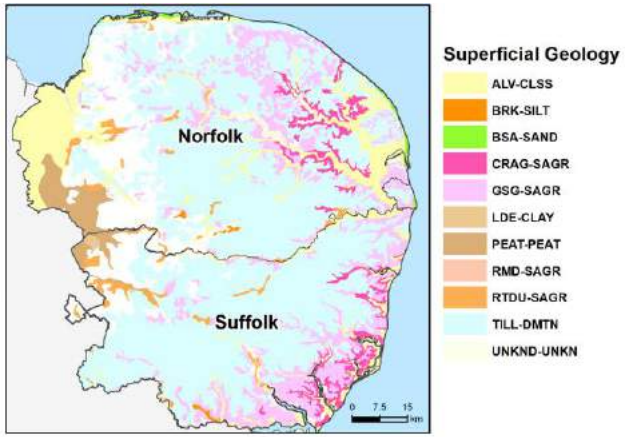
Soil types

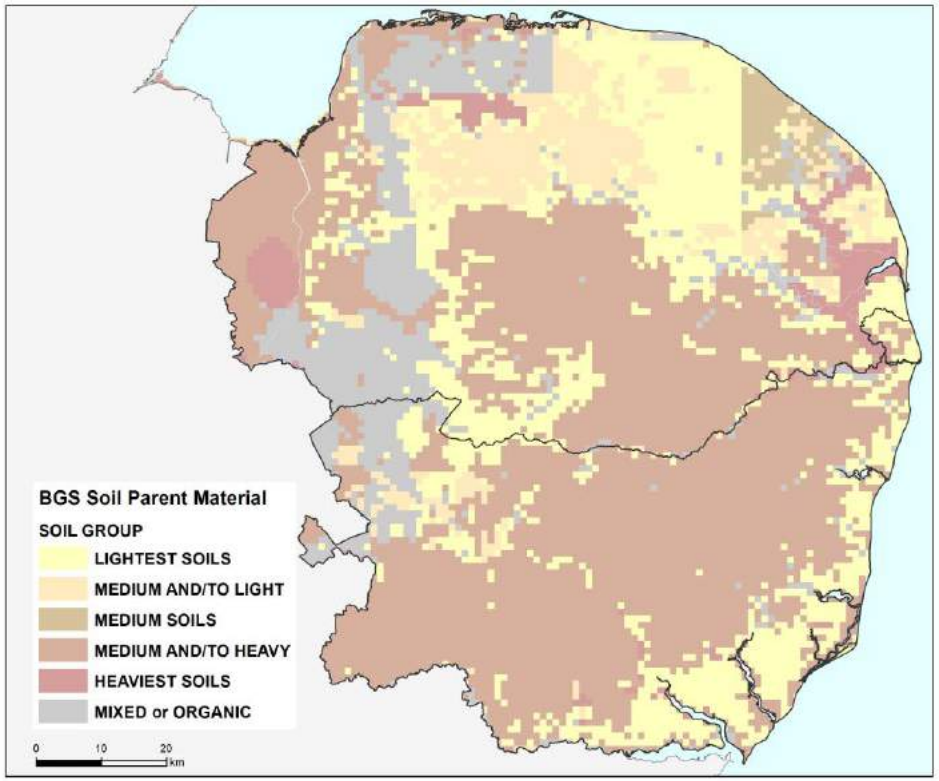
These datasets from the British Geological Survey show the chalk, gravel and sand deposits that underlie the soils of Norfolk & Suffolk. The permeable bedrock geology enables considerable groundwater storage in aquifers across virtually the whole area. The superficial geology (unconsolidated sediments of glacial drift, moraine, gravels and sands, floodplain deposits (tills) and peat) and bedrock provide the 'parent material' that forms soil.

There are a wide variety of classifications of soil type, from the very specific (soil series) to the very general (peaty, clay, loam etc). The map on the right classifies soil from light (e.g. sandy soils) to heavy (e.g. clay); these have particular relevance to farming.

The most prevalent soils are 'medium to light (silty) to heavy', covering 43.8% of the two counties and another 14% are 'light-medium sandy soils'. Light soils can be subject to wind and water erosion, and with low organic matter, can be prone to drying. Hence soil condition will be an important environmental indicator to monitor in a changing environment though this will need to be addressed through other surveillance means as these datasets are static.





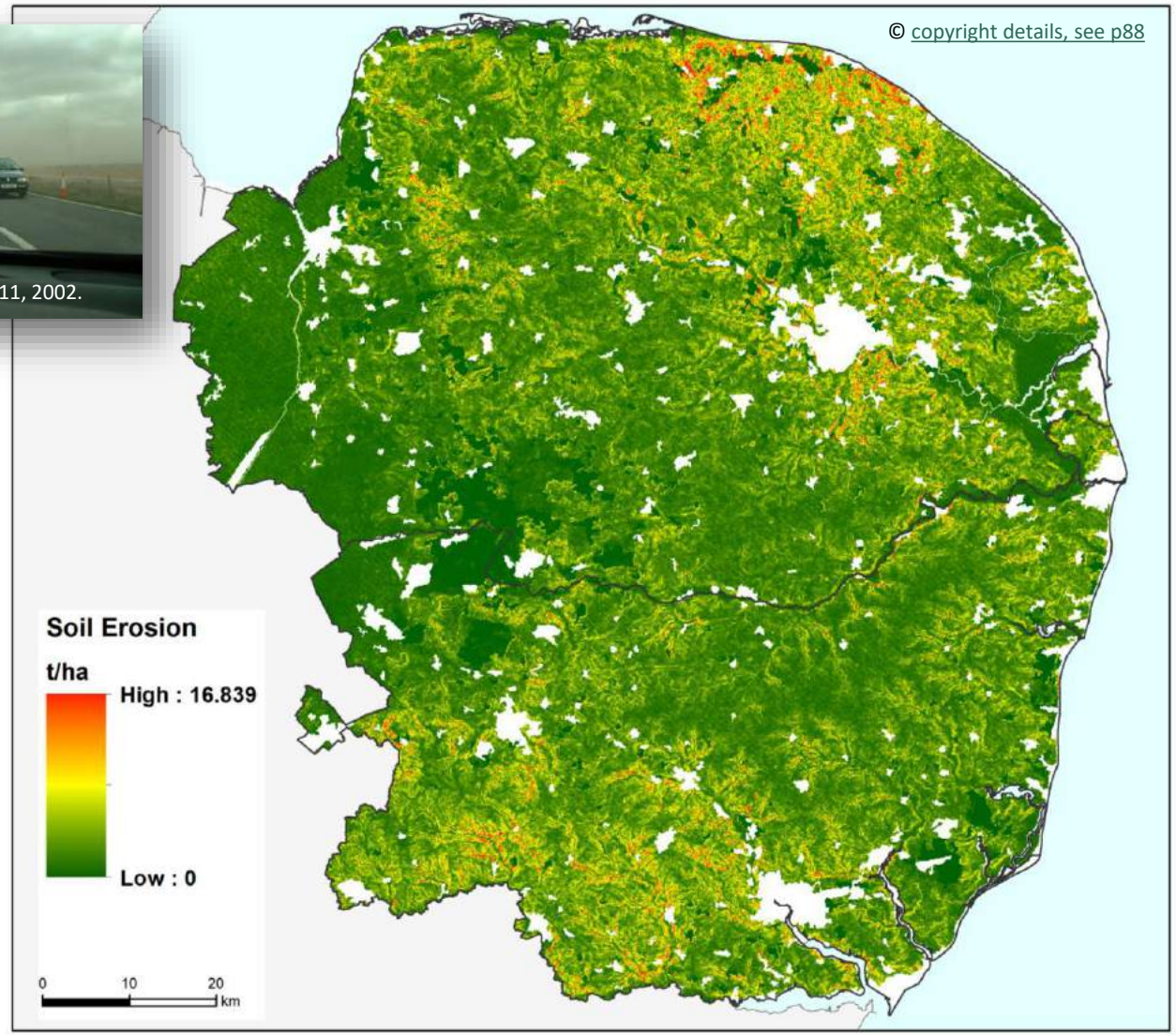


Soil physical properties

Soil health, according to the Environment Agency (2019), is defined as '*the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans*', and depends on a range of physical, biological and chemical factors. Physical factors include compaction, erosion and soil sealing (i.e. covering soil with an impermeable surface such as concrete).


Wind erosion of soil, A11, 2002.

Soil erosion is caused by wind or water and can be accelerated by poor land management. Although wind erosion is more limited in extent than water erosion, where it does occur, it can be more severe (POST, 2006) (see picture above). The rate of soil erosion by water in the UK has been estimated at 0.1–0.3 tonnes per hectare per year (POST, 2006). The mapped data shown right is extracted from a European Soil Data Centre dataset (Panagos et al, 2015). Potential soil loss by water erosion (t/ha) is modelled using rainfall, soil type, topography, and land use and management (from 2010) as inputs. This shows potential for high soil loss (16 t/ha/yr) in North Norfolk and other areas.



Soil loss from water erosion is being mediated through agri-environment and flood alleviation schemes, which provide a local indicator to monitor progress over time. For example sediment traps in Norfolk's river Wensum catchment funded through a 'Slow the Flow' programme captured over 7 tonnes of sediment in the first year (Cooper et al, 2019).

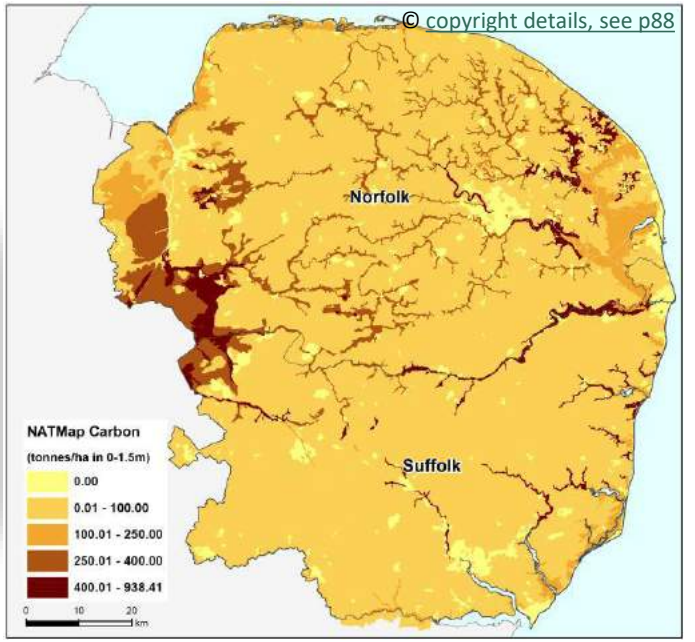

Photo: Sediment trap, Wensum DTC (R. Cooper)

Soil biological health

Soil organic matter is another important indicator of long-term soil health, important for soil structure, resilience and water retention and as a vital store of carbon (Environment Agency, 2019). Increasing rates of organic matter decomposition and leaching due to climate change is a threat to soil formation (UKNEA, 2011).

Data on topsoil carbon density (0-15cm depth) are available from the Centre for Ecology and Hydrology (CEH) and data on carbon down to 150cm is available from the National Soil Resources Institute, Cranfield University (map, right). The peaty soils of heaths, freshwater margins and under woodland provide the highest carbon densities per hectare in the top 15cm of soil, and freshwater margins and grassland is significant for deep carbon (0-150cm) (see Table, below right).

Photo: Worm survey, Wensum DTC (S.Dugdale)



Map (right): Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2020].

Soil Biota

Soil bacteria and invertebrates are additional key indicators of soil biological health. Mean estimates of bacterial and invertebrate diversity in topsoil per 1km^2 have been extrapolated from sets of sample locations by CEH (Henrys et al, 2014; 2012a). Bacterial diversity tends to be higher in lowland areas with agriculturally associated flora, less acidic soils and milder climate. In Norfolk & Suffolk diversity values are relatively uniform across natural habitats and cultivated land (Shannon-Weiner Index 3.65 – 3.83; [Index range 0-5 where 5 = high]). Topsoil invertebrates (0-8cm depth), on the other hand, tend to be in higher densities in semi-natural less-managed habitats and in lower quantities in more intensively managed habitats such as arable, improved and neutral grassland (Henrys et al 2012a). Invertebrate abundance values from the CEH data for Norfolk and Suffolk by habitat are shown right. A map of this data on a national scale is included as a soil quality indicator in the National Natural Capital Atlas (NE, 2020).

Mean Abundance of Invertebrates in Topsoil	CEH Topsoil Carbon Density in 0-15cm in Norfolk & Suffolk				NATMAP Carbon C Tonnes 0-150cm			Topsoil Carbon	Deep Carbon
	Habitat Group	Hectares	C Tonnes	t/ha	Hectares	C Tonnes	t/ha	Rank t/ha	Rank t/ha
60.51	Arable Crops & Fruit	656,851	31,985,573	48.7	660,972	115,775,515	175.2	7	6
47.87	Pastures & Natural Grassland	110,761	6,418,449	57.9	112,884	35,102,163	311.0	4	**2**
66.81	Heaths (Mountains, Moors & Heaths)	2,435	165,108	67.8	2,825	413,639	146.4	**1**	7
61.82	Woodlands	55,565	3,469,037	62.4	56,218	13,652,085	242.8	3	4
61.38	Freshwaters (margins)	8,972	593,579	66.2	9,702	6,753,722	696.2	**2**	**1**
43.13	Coastal Margins	1,567	92,873	59.3	4,479	1,042,676	232.8	4	5
46.25	Urban and Human Activities	41,999	2,383,441	56.8	67,901	5,636,247	253.7	6	3
		878,151	45,108,060		914,981	178,376,046			
	Unclassified (CEH -mostly urban)	40,029			3,199				
	Norfolk & Suffolk Total	918,180			918,180				

Soil chemical/nutrient status

Soil pH has a strong association with the underlying geology but in recent times has been impacted by deposition of atmospheric pollutants resulting in increased soil acidification. Improved controls of emissions mean that this is now a reducing pressure (EA 2019) with ongoing monitoring of soil pH providing a general indicator of environmental health. Soil pH is important in agriculture as pH affects concentrations of trace elements in the soil with higher availability to plants and microbes in neutral or slightly acidic soils. (Henrys et al 2012b).

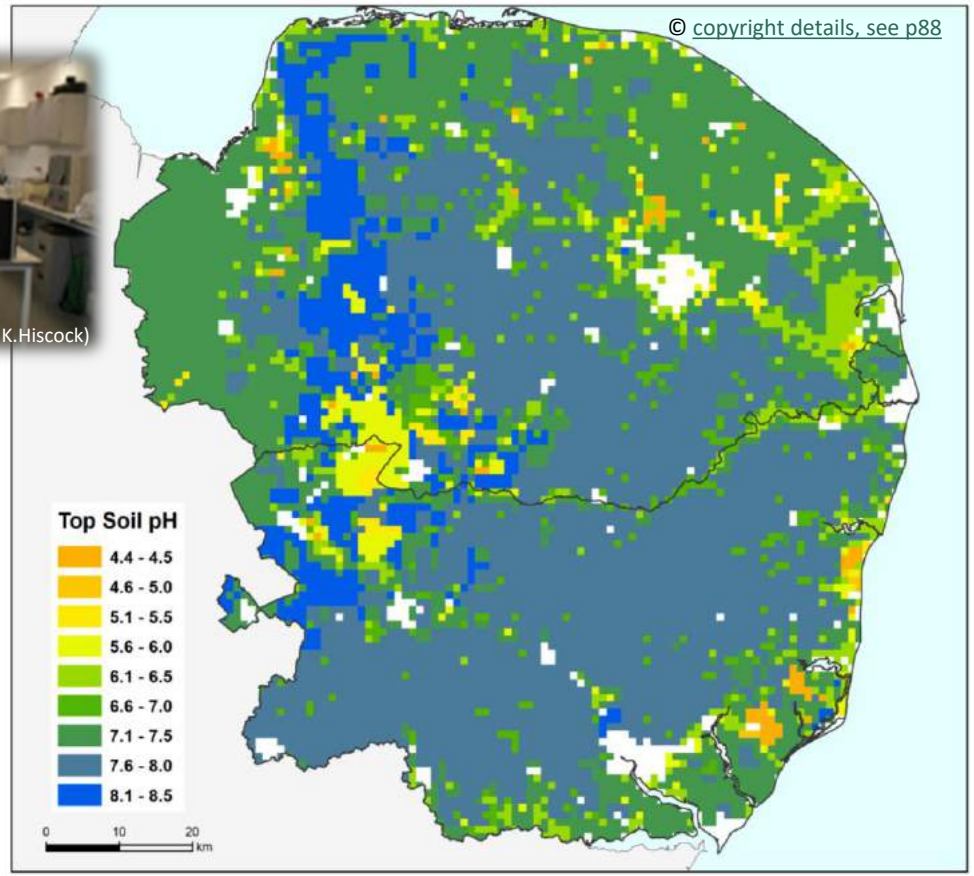
Photo: Lab analysis, Wensum DTC (K.Hiscock)

The key soil nutrients nitrogen and phosphorous (below) are also important in agriculture and are key influencers in the composition of plant communities.

Key soil nutrients

Nitrogen: "*Soil total nitrogen concentration is a basic measurement of soil fertility. Along with soil organic carbon, it plays a key role in the processes of soil formation. Not all of the nitrogen locked up in organic matter in soils, such as peat, is available for plant growth. However, soil nitrogen is important for agricultural productivity. Nitrogen leached from soils can also adversely affect water quality.*" (Henrys et al 2012c)

Phosphorous: "*Soil phosphorus is a key component for nutrient cycling, soil formation and plant growth. It particularly influences food production. However loss of phosphorus from soil can also result in nutrient enrichment of freshwaters. In semi-natural habitats high soil phosphorus can constrain the restoration of plant species diversity*." (Henrys et al 2012c)



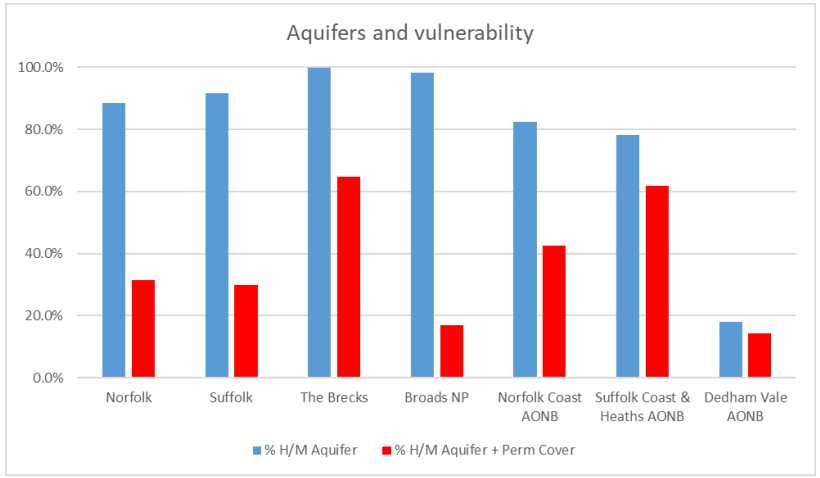
The map above shows mean estimates of topsoil pH (0-15cm depth) per 1km^2 extrapolated from sample locations (Henrys et al, 2012). In general, the soils of Norfolk and Suffolk are of neutral or higher pH. Heathland habitat areas are associated with the more acidic soils.

Regrettably, application of these nutrients to land as agricultural fertilisers, plus discharges from domestic industrial use of detergents etc., has given rise to excesses in the environment. The Broads NP has suffered extensive eutrophication, whilst increasing nitrate levels in ground-water are a potential threat to local drinking water supply. Further nitrogen deposition from animal husbandry, e.g. pig farms is a significant pressure on low nutrient habitats such as heathlands. However, the threats are well understood and there are now many measures in place to mitigate these risks.

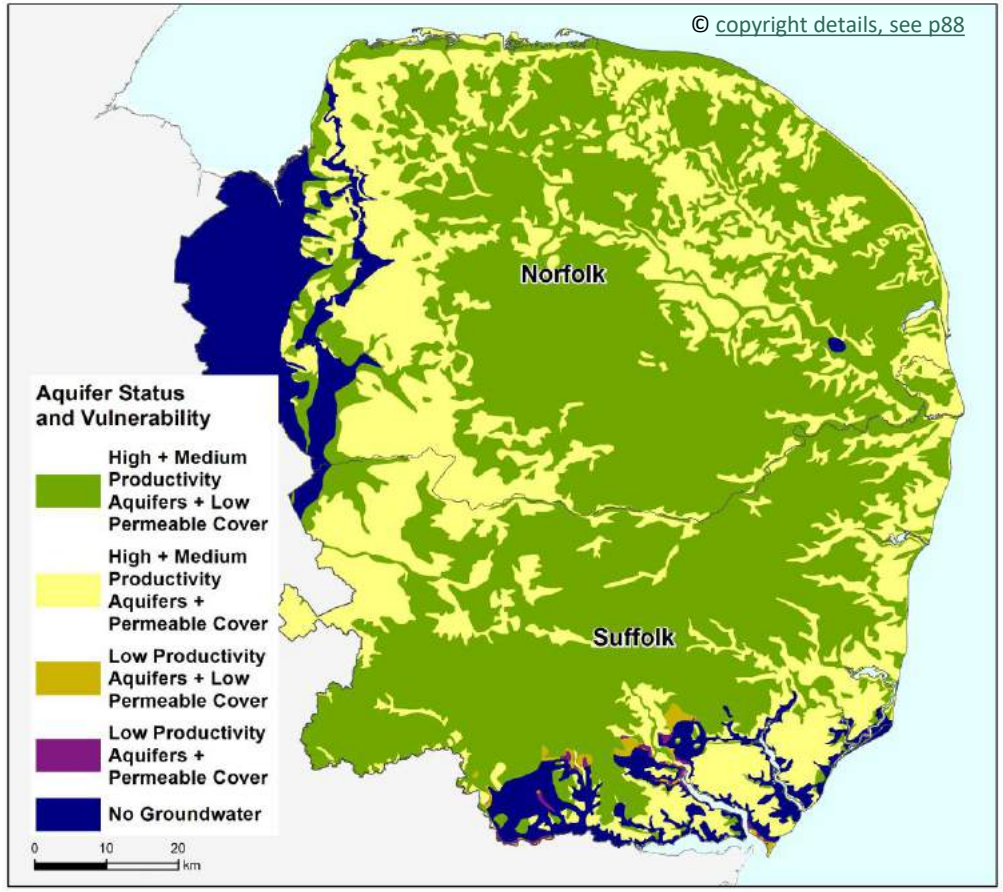
Aquifers

Aquifers are underground layers of water-bearing permeable rock or drift deposits from which groundwater can be extracted. Around 90% pf Norfolk and Suffolk is underlain by aquifers of high or medium productivity (compared to just 31% across the whole of England). The map (shown right) uses data from the British Geological Survey (BGS) on permeability which identifies areas of High, Medium and Low Productivity Aquifers or No Groundwater. This has been combined with further BGS data on the permeability of geological deposits overlying the aquifers, with two classes: 'low permeability cover' and 'permeable cover'.

Permeable deposits are more vulnerable to surface leaching or pollution. In the resulting map (shown right) those areas with High/Medium productivity and permeable cover (in yellow) represent the resource with greatest vulnerability. These 'vulnerable' aquifers are most prevalent in the Brecks and Suffolk Coast AONB (see graph below).



Across England and Wales around 35% of public water supply is provided by groundwater resources, however, in the south and east of England the figure exceeds 70% (Ander et al 2006). Aquifers are important not only as a water supply for drinking, irrigation and industry but also for their role in supporting surface-water flows and wetland ecosystems, including the Broads National Park (Ander et al 2006).

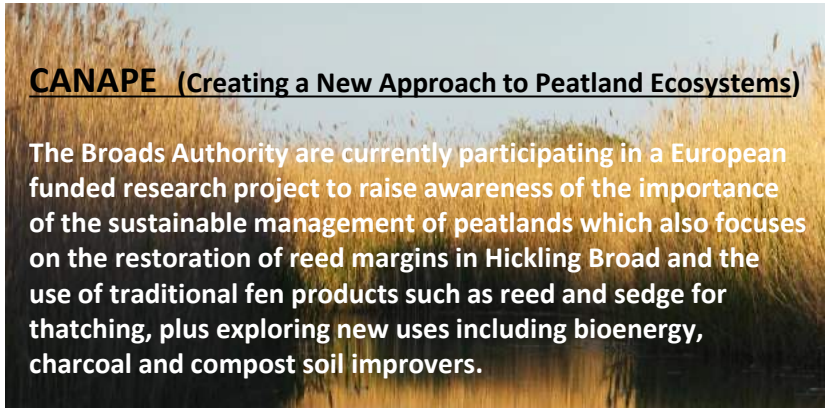


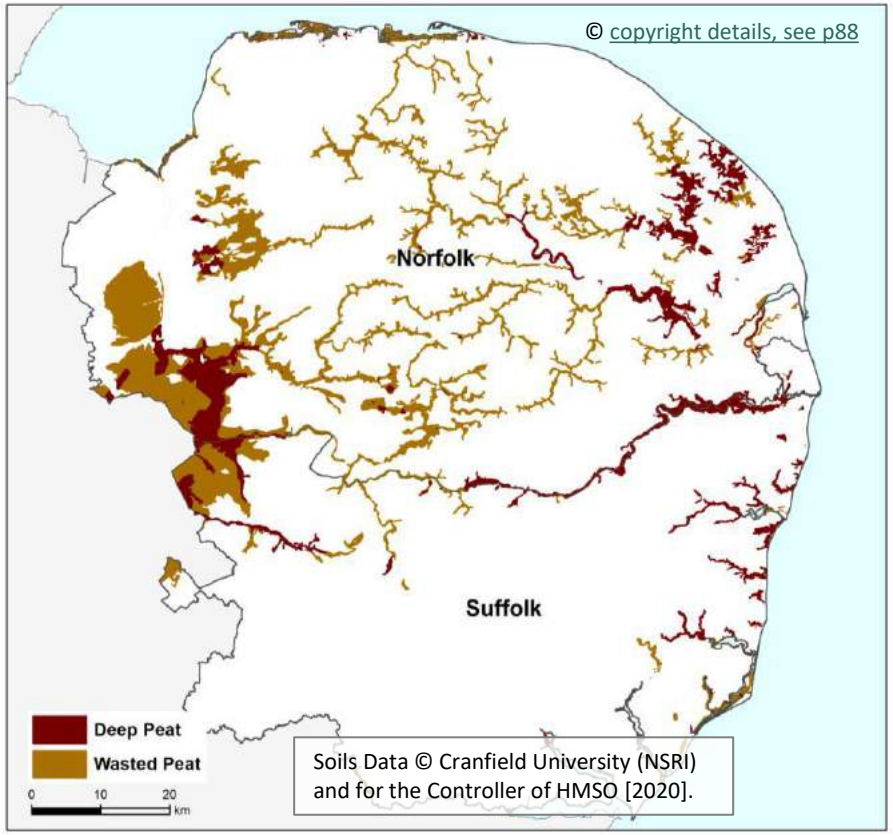
Threats to aquifers include over-abstraction, contamination e.g. infiltration from excess farm nutrients (e.g. nitrate) and pesticides (e.g. molluscicides) and saltwater intrusion in coastal areas.

Peat

Peat is an ancient soil, formed several thousands of years ago in bog or fen habitats. It is found in the Broadland area and fens of south-west Norfolk and north-west Suffolk where it can be several meters thick. It also occurs in river valleys. (Harrison *et al.* 2003; 2004). Peat was worked for fuel in Norfolk between the 12th and 15th centuries and the flooded workings now form the Broads National Park. Many of the peatland areas in the two counties have national or international conservation status, hence commercial peat extraction no longer takes place. However, artificial drainage to facilitate agricultural production over the past two centuries has led to considerable shrinkage and loss of peat soils, particularly in the fens (Holman and Kechavarzi 2011). Peat is also vulnerable to climate change through enhanced erosion from extreme events such as droughts and heavy rainfall (Bain *et al.* 2011).

Peatlands are the largest natural terrestrial carbon store sequestering 0.37 gigatonnes of carbon dioxide (CO_2) a year globally and according to the IUCN store more carbon than all other vegetation types in the world combined. However, the condition of peatlands is strongly related to land use and areas that have been cultivated or drained can be substantial GHG emitters (Evans *et al.* 2017, ONS, 2019b). In a recent report the Committee on Climate Change highlight the benefits of peatland restoration to bolster carbon sequestration amongst five priorities for post COVID-19 economic recovery (CCC, 2020a).





Mapping peatland extent and condition

Mapping peatlands is challenging because of the combination of soil and habitat properties that need to be considered. Natural England (2010) produced a widely-cited map and estimated that there were 495,858 ha of deep peat (e.g. in upland bogs) and 186,372 of wasted peat (where condition has been degraded through use) in England. Unfortunately, this map is not publicly available in digital form due to licensing issues. The map above uses a combination of the NATMap Carbon layer from the National Soil Resources Institute and details from the Priority Habitats Inventory to recreate the appearance of the Natural England (2010) map for Norfolk and Suffolk. This results in estimates of 27,356 ha of deep peat and 65,544 ha of wasted peat in the two counties, 14% of the national total (35% of the wasted peat). Better information on this local asset and initiatives to improve degraded condition would therefore be nationally significant.

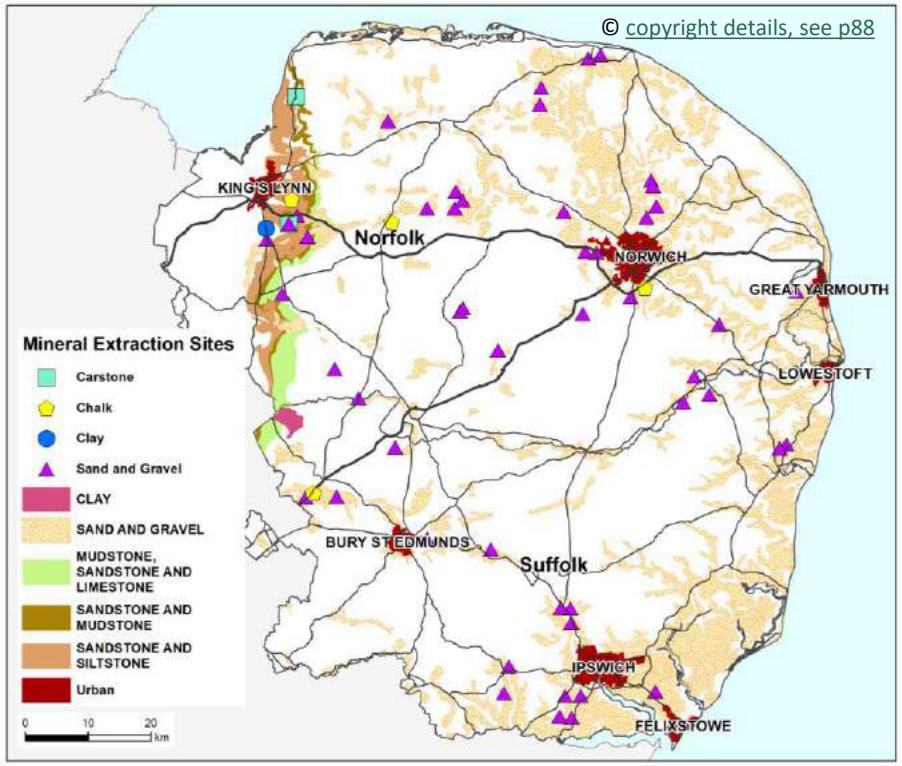
Minerals

The main quarried minerals in Norfolk and Suffolk are sand and gravel (aggregates); carstone (a sedimentary sandstone used as a building stone / crushed to make hoggin), and silica sand (which has a high silica content and has many industrial uses). Chalk is also extracted, on a relatively small scale, mainly for use in agriculture (agricultural lime) (Harrison et al 2004). The associated flints have historically provided a distinctive local building stone.

Local authorities are required by the government to plan for and provide a steady and adequate supply of aggregates from locally available resources. In East Anglia 9 Mt of marine dredged sand and gravel annually, is mostly exported out of the region (Suffolk CC, 2020). Due to diminishing resources and other factors such as increased aggregate recycling, the long-term trend is for less onshore sand & gravel extraction locally (Suffolk CC, 2020).

The Suffolk Mineral and waste local plan has allocated 9 sites for the extraction of sand and gravel sufficient to supply 9.3 Mt over the Plan period to the end of 2036 (Suffolk CC, 2020).

In Norfolk the forecast is for 1,868,000 tonnes per annum of sand & gravel), 121,400 tonnes per annum of Carstone and 750,000 tonnes per annum of silica sand over the same period. This includes 40 sites for sand and gravel extraction, one site for carstone extraction and three sites for silica sand extraction. (Norfolk CC, 2019).



Pressures

The requirement to keep searching for sites to exploit to meet future demand must be balanced against potential impacts such as loss of habitats / species, groundwater contamination, nuisance to residents from noise, dust, traffic and visual intrusion; post-extraction site restoration, etc.

Habitats & Species

Contents

Habitats and species are ***natural assets*** with an intrinsic value, adding to landscape aesthetics (***cultural ecosystem services***) and promoting biodiversity (***supporting ecosystem services***). Habitats provide living spaces for plants and animals, helping maintain genetic diversity, providing a gene-pool which may provide future beneficial plants, medicines and food sources (***provisioning ecosystem services***); provide for carbon storage and sequestration and specific functions, e.g. wetlands may improve water quality by filtration and serve as flood plains providing ***regulating ecosystem services***. This section examines Natural England data on the priority habitats present in Norfolk and Suffolk and additional ***indicators*** of the extent and condition of these and a selection of iconic species associated with the two counties.

See also Page 48 Chalk rivers under Freshwater.

Information Gaps

The datasets presented here are compiled nationally. Data for Norfolk & Suffolk have been selected from them. Many of these are updated periodically, providing both baseline data and the opportunity to assess change over time. As with other asset categories, for most, this is change in quantity. Indicators of change in quality are more elusive.

Habitats & Species: Key features

This page summarises key findings of significance for Norfolk & Suffolk selected from the data presented within this section and highlighting information gaps or needs revealed from this examination.

Priority habitats

This data maps habitats identified as being the most threatened and requiring conservation action. Across England priority habitats cover just under 11% of land area. In the key natural areas of Norfolk and Suffolk, this value is much higher especially in the Broads NP (60.2%), and coastal AONBs (>30%). Coastal saltmarsh, plus fen wetlands and heathland habitats highlight as regionally important.

Extent & condition of SSSIs

This dataset provides an indication of quality as well as extent. Norfolk (8.2%) and Suffolk (7.5%) have more land in SSSI than the England average (6.5%) with 39.6% of the Brecks, 23.8% of the Broads NP and > 25% of the coastal AONBs designated. SSSIs in these key natural areas have a much higher proportion in favourable or improving condition compared to the national average.

Habitat connectivity

More than 75% of the priority habitat in Norfolk and Suffolk is in patches under 10 ha in size and connectivity needs to be improved. Hedges and ponds are important features in this regard, estimates suggesting that the counties contain nearly 20% of all ponds in England. Better information on these natural assets will also help support wider environmental enhancements.

Natural woodlands

Woodland cover in England is 9.9%. Of this 2.8% is ancient woodland and 5.7% is broadleaf or mixed broadleaf and conifer. Norfolk and Suffolk have very little ancient woodland (0.8%) and slightly less broadleaf and mixed woodland (5.1%). Broadleaf woodland features most strongly in the Broads NP (10.9%), Dedham Vale AONB (8.7%) and in the Brecks (8.4%).

Lowland heath & dry acid grasslands

Norfolk & Suffolk have 4,711 ha of lowland heath, 8.4% of England's total holding of this habitat type. The majority is in The Brecks and Suffolk Coast & Heaths AONB. The two counties also have 4,203 ha of dry acid grasslands, 27.7% of England's holding of this rare habitat type. 22.5% is within The Brecks with a further 2.6% in the Suffolk Coast & Heaths AONB.

Saltmarsh & coastal habitats

Norfolk & Suffolk's coastline holds >12% of England's total for Saltmarshes, and >17% of the rare Vegetated Shingle habitat. Saltmarsh, mudflats and saline lagoons provide homes for native waterfowl, marshland birds and seabirds and important winter refuge for migrating birds, wild ducks and geese. All are threatened by coastal erosion and sea level rise.

Wetlands & grazing marsh

The grazing marsh, fens and reedbeds of Norfolk & Suffolk are of international conservation importance. Lowland fen within the two counties accounts for 19.4% of England's total holding of this habitat type, and reedbeds account for 45.8%. The Broads NP is important for all of these wetland habitats accounting for 9.4% of the nation's fens and 22.8% of its reedbeds, providing home to a wide range of rare species.

Priority/iconic species

Priority species are those requiring conservation based on international importance, rapid decline and high risk. Highest densities of priority species tend to coincide with key natural areas. For a 25 year plan, it may be beneficial to include indicators for 'priority' and 'iconic' flagship species for key habitats, plus e.g. pollinating insects that perform beneficial ecosystem services.

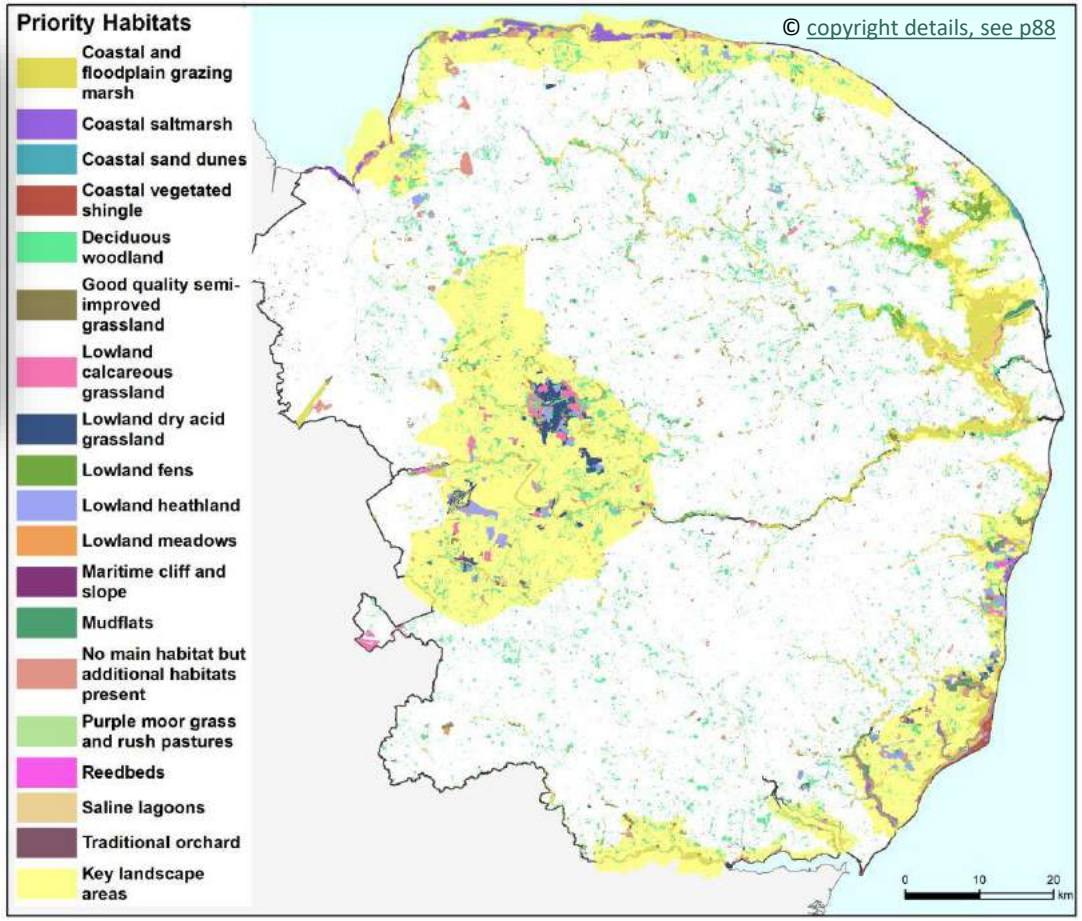
Priority habitats

At its most basic level, a habitat is a place where species' reside. It may be natural or semi-natural, terrestrial or aquatic, or one formed by humans (e.g. a garden). Priority habitats are natural/semi-natural habitats identified as being the most threatened and requiring conservation action. The Priority Habitat Inventory* maps these habitats (see map, right).

Priority Habitats	Norfolk	Suffolk	The Brecks	Broads NP	Norfolk Coast AONB	Suffolk Coast & Heaths AONB	Dedham Vale AONB
Area (Ha)	68,211	40,770	19,981	18,159	14,550	14,253	2,079
% of Total Area	12.7%	10.7%	19.6%	60.2%	32.6%	35.2%	23.0%

Across England priority habitats cover just under 11% of land area but, particularly in the key natural areas of Norfolk and Suffolk, this value is much higher (see Table top right) especially in the Broads (60.2%), and coastal AONBs (>30%).

Important priority habitats for the two counties are shown in the Table below, with the values indicating the variance from the average for England as a whole. Coastal saltmarsh, plus fen wetlands and heathland habitats highlight as regionally important. These are examined in more detail later in this section.



VARIANCE from England TOTAL	Values are percentage variance						
	Norfolk	Suffolk	The Brecks	Broads NP	Norfolk Coast AONB	Suffolk Coast & Heaths AONB	Dedham Vale AONB
Coastal and floodplain grazing marsh	1.5%	0.7%	0.5%	**34.4%**	1.5%	**6.4%**	**7.8%**
Coastal saltmarsh	0.2%	0.0%			**6.4%**	**2.4%**	
Deciduous woodland	-0.5%	-0.9%	**2.1%**	**4.2%**	0.8%	0.7%	**3.3%**
Lowland dry acid grassland	0.4%	0.3%	**3.2%**	0.0%	0.0%	0.9%	0.1%
Lowland fens	0.5%	0.0%	0.2%	**6.2%**	-0.1%	0.2%	-0.1%
Lowland heathland	-0.1%	0.3%	**1.5%**	-0.4%	0.4%	**2.8%**	-0.4%
Mudflats	0.0%	0.0%	0.0%	1.2%	**2.4%**	**3.9%**	0.0%

* Natural England. NB: Last update 2015, update frequency 'irregular'.

Extent and condition of SSSIs

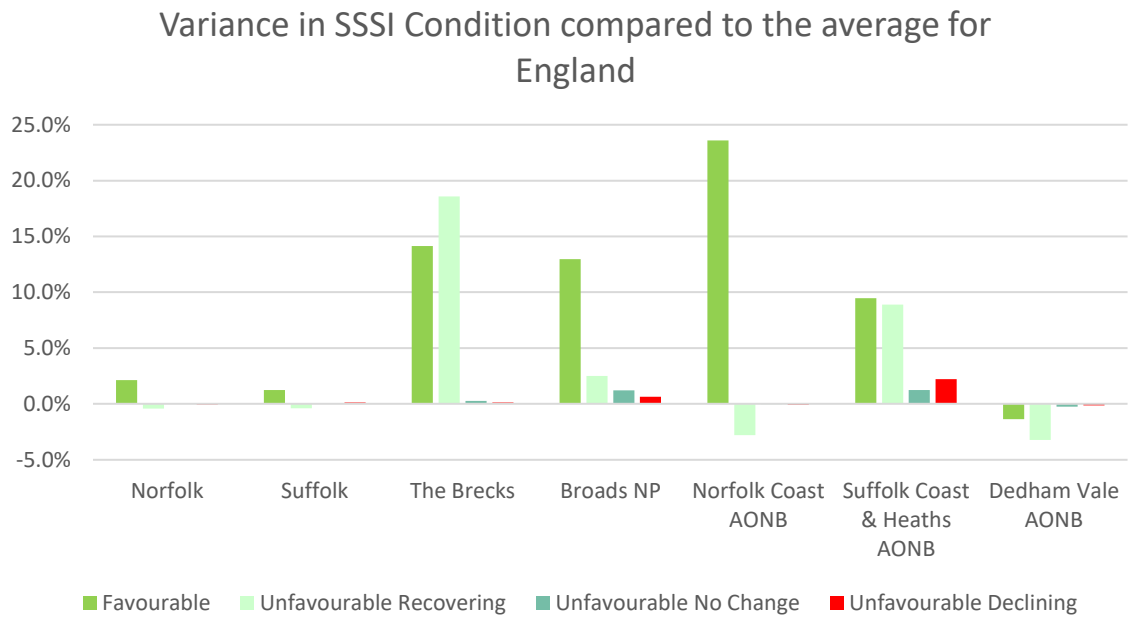
There are a limited number of datasets that give an indication of condition or quality as well as extent. However, Natural England's SSSI dataset (Sites of Special Scientific Interest) does just that.

Across England 6.5% of land is designated as an SSSI. The Table (below, centre) indicates that this is higher in Norfolk and Suffolk, and more so in the key natural areas (with the exception of the Dedham Vale AONB).

An SSSI designation denotes the presence of key features, habitats or species of conservation importance. National monitoring guidelines requires the condition of SSSIs to be assessed every 6 years (though this has not always happened in practice). Hence monitoring change between datasets can be a valuable indicator of pressures on these habitats and species.

The graph (above right) indicates the condition of SSSIs in these areas and shows that Norfolk & Suffolk have slightly more SSSIs in favourable condition than the national average, again with many of the key natural areas having more of their SSSIs in favourable or recovering condition. The table (right) gives and explanation of the condition classification.

Percentage of total area in SSSIs	
Norfolk	8.2%
Suffolk	7.5%
Brecks natural area	39.6%
Broads National Park	23.8%
Norfolk Coast AONB	27.2%
Suffolk Coast & Heaths AONB	28.3%
Dedham Vale AONB	1.5%



Definition of SSSI Condition Assessment Terms			
Favourable	SSSI is being adequately conserved and is meeting its 'conservation objectives', however there is scope for enhancement of these sites.	**Unfavourable declining**	SSSI unit is not being conserved and will not reach favourable condition unless there are changes to the site management or external pressures. The site condition is becoming progressively worse.
Unfavourable recovering	SSSI unites are not yet fully conserved but all the necessary management measures are in place. Provided that the recovery work is sustained, the SSSI will reach favourable condition in time.	**Part destroyed**	Part destroyed means that lasting damage has occurred to part of the special conservation interest of a SSSI unit such that it has been irretrievably lost and will never recover. Conservation work may needed on the residual interest of the land.
Unfavourable no change	SSSI unit is not being conserved and will not reach favourable condition unless there are changes to the site management or external pressures. The longer the SSSI unit remains in this poor condition, the more difficult it will be, in general, to achieve recovery.	**Destroyed**	Lasting damage has occurred to all the special conservation interest of the SSSI unit such that it has been irretrievably lost. This land will never recover. Source: https://www.pla.co.uk/Environment/Definition-of-SSSI-Condition-Assessment-Terms

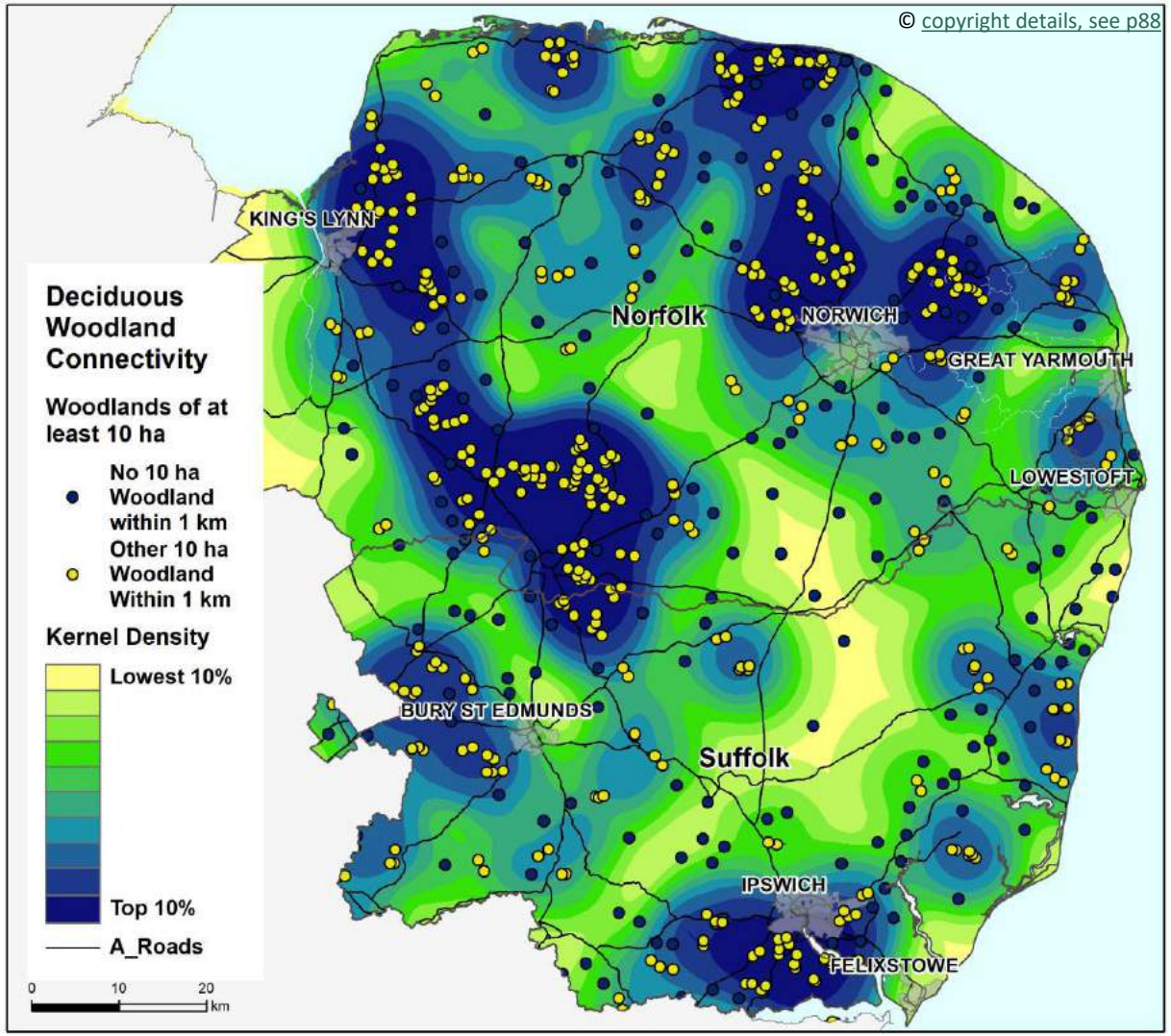
Habitat connectivity

The need to address habitat loss and declining quality by developing ecological networks was highlighted by the Making Space for Nature review in 2010 and also features in the objectives of the 25 Year Environment Plan. A recent review from Natural England (2020) presents a set of principles for the design of nature networks, including the need for larger and better connected habitat patches. While Priority Habitats represent over 20% of the key natural areas in Norfolk and Suffolk, more than three-quarters of this extent is in patches smaller than 10 hectares and for deciduous woodland the proportion is 91%. Only 5% of the Priority Habitat in Norfolk and Suffolk is in patches larger than the 40 hectare threshold advocated by Natural England.

Mapping habitat connectivity

Organisations such as Forest Research, Natural England and Local Nature Partnerships have developed and applied methods to map habitat connectivity. A common approach is to select habitat patches of a certain type and size, calculate their distances to the nearest similar patch, and then map the proportion where the distance is within a desired threshold (i.e. less than 2 km) as a density surface. This method has been used to produce the map to the right which shows the extent to which deciduous woodland Priority Habitat patches of at least 10 hectares size are within 1 km of another similar patch. The map highlights how such habitat varies across Norfolk and Suffolk, with regions where connectivity is relatively high and others where existing woodland patches are quite isolated. Such mapping can therefore provide insight into where new habitat creation would improve connectivity.

Some local connectivity studies have been conducted in Norfolk and Suffolk, but a systematic assessment across both counties does not exist. Undertaking such an analysis would provide an important baseline for planning initiatives and monitoring progress as part of a local 25 Year Environment Plan.



Habitat connectivity: Hedges and ponds

The national situation

Hedgerows, lines of trees and shrubs, ditches and ponds are important corridors and 'stepping stones' connecting habitats, especially in the types of agricultural landscapes that exist in many parts of Norfolk and Suffolk. Across England, data from the most recent Countryside Survey estimates that in 2007 the total length of woody linear features (i.e. hedgerows and lines of trees and shrubs) was 547,000 km, of which 402,000 km consisting of managed hedgerows. Between 1998 and 2007 the length of managed hedgerows decreased by 6.1%, many of these turning into lines of trees and relict hedges reflecting a reduction in management intensity (Carey *et al.,* 2009).

The Countryside Survey also provides data on pond numbers and condition, with an estimate for 2007 of 234,000 ponds in England (1.8 ponds per km^2). Around 80% of these were rated as poor or very poor quality. A high turnover was also highlighted, with an estimated 14,900 ponds lost and 48,300 new ponds created in England between 1998 and 2007 (Williams *et al.*, 2010).

Norfolk and Suffolk

The table below compares estimates of hedge and pond densities for England from the Countryside Survey 2007 with local estimates based on information from the county Biodiversity Information Services and Wildlife Trusts.

Region	Length of managed hedges (km)	Length of hedges (km) per km^2	Number of ponds	Ponds per km^2
England	402,000	3.1	234,000	1.8
Norfolk	16,500	3.1	23,000	4.3
Suffolk	13,800 to 14,200	3.6 to 3.7	22,600 to 23,000	6.0 to 6.1

It is important to caution that these estimates are spread across different years and some are over 10 years old. Nevertheless, they are the best that can be compiled from current information and suggest that the density of hedges and ponds in Norfolk and Suffolk is above the national average. This is clearly the case for ponds where the total for the two counties represents nearly 20% of that for England.

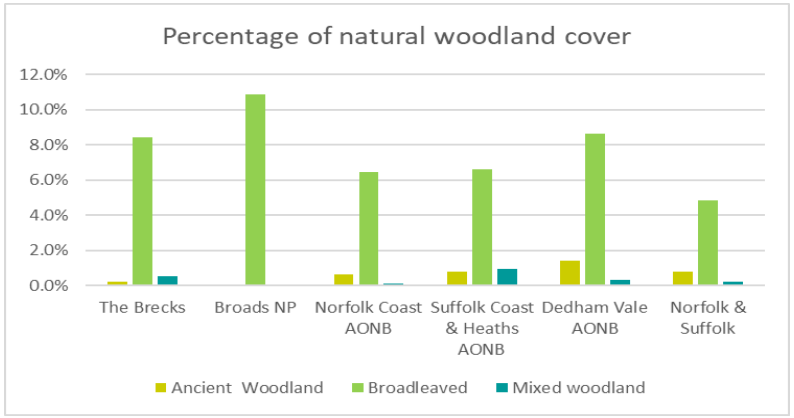
In addition to estimates of extent, several surveys have examined the condition of these habitat features. For instance, the Suffolk Hedgerow Survey covered two-thirds of Suffolk parishes between 1998-2012 and concluded that over 52% of the 38,295 hedgerow stretches examined were relatively species rich. The Norfolk Ponds Project estimates that Norfolk holds more ponds than any other English county. Pond surveys such as that conducted by University College London in North Norfolk have identified a series of threats (including eutrophication and invasive species) and several restoration programmes are now in progress. Suffolk Wildlife Trust state that up to 70% of Suffolk's ponds are neglected or abandoned. Better information on these natural assets across the two counties would be a valuable resource for future initiatives to improve overall environmental quality.

Natural woodlands

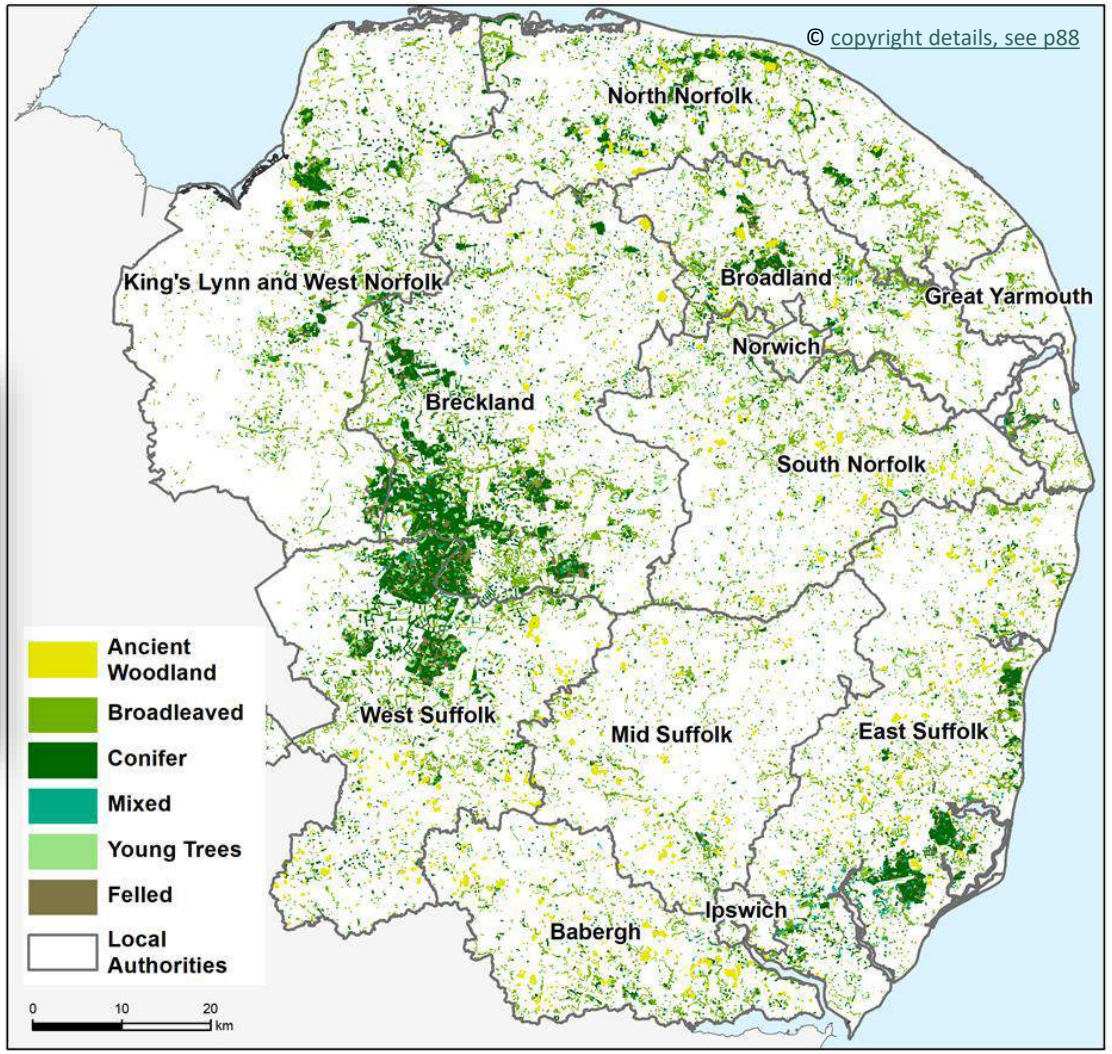
This data, also from the National Forest Inventory (as shown on page 18) focuses on natural woodland categories (i.e. ancient woodland, broadleaf and mixed woodland, assumed as non-timber producing /commercial forestry).

The England average for total woodland cover is 9.9% and of this natural woodland comprises ancient woodland (2.8%) and broadleaf or mixed broadleaf and conifer (5.7%). Norfolk and Suffolk have very little ancient woodland (0.8%) and slightly less broadleaf and mixed woodland (5.1%) though these values are higher within the key natural areas as shown in the graph below.

The total area of woodland (ha) and percentage woodland cover is shown in the Table (below, right).



Total area in woodland	Ha	%
Norfolk	53,826	10.0%
Suffolk	35,240	9.3%
Brecks natural area	28,101	27.6%
Broads National Park	3,526	11.7%
Norfolk Coast AONB	4,872	10.9%
Suffolk Coast & Heaths AONB	6,705	16.5%
Dedham Vale AONB	1,151	12.7%



Key pressures

Lack of management, deer and grey squirrel damage, pests & disease, with additional stresses from climate change particularly for 'colder climate' tree species at the southern edge of their natural range (including the Scots Pine that is characteristic of The Brecks area).

Lowland heath & dry acid grasslands

Lowland heath & dry acid grasslands are internationally important, scarce habitats, between them now accounting for only 0.5% of England's land area (one sixth of the area present in 1800) (NCC, 2011). Norfolk and Suffolk have double the amount of these priority habitats making them **regionally important** (see text box below).

Lowland heath (below 300m altitude) is found on nutrient poor, acidic, sandy soils and are characterised by various species of heather and other dwarf shrubs (Suffolk BIS, 2003). The UK BAP identifies heathland as consisting of "an ericaceous layer of varying heights and structures, some areas of scattered trees and scrub, areas of bare ground, gorse, wet heaths, bogs and open water" (NCC, 2011). Acid grasslands are often an integral part of lowland heath landscapes (JNCC, 2008) and are likewise found on soils with a low pH and comprise grasses, rushes and sedges, including e.g. sheep's sorrel, tormentil, heath bedstraw, wavy hair-grass and sheep's fescue.

Regionally important

Lowland heath: Norfolk & Suffolk have 4,711 ha of lowland heath, representing 8.4% of England's total holding of this habitat type. The majority of it is located within The Brecks and Suffolk Coast & Heaths AONB.

Lowland dry acid grasslands: Norfolk & Suffolk have 4,203 ha of dry acid grasslands and this forms 27.7% of England's holding of this rare habitat type. The majority of this - 22.5% of the national holding - is within The Brecks with a further 2.6% in the Suffolk Coast & Heaths AONB.

The Brecks: The heaths are a mosaic which include chalk grassland and relatively little heather (NCC, 2011). 'Brecks' were fields that were cultivated for a few years and then allowed to revert to heath when the soil was exhausted (www.brecks.org).

The Suffolk Sandlings, is a major area of conservation importance within the Suffolk Coast & Heaths AONB and includes 42 heaths ranging from 247 ha at Minsmere (the location of a flagship RSPB reserve) and Walberswick to small fragments of under 2 ha (Suffolk BIS, 2003). The area is important for species such as the Stone Curlew, Nightjar, Natterjack toad, Antlion and many other insect, animal and plant species.

Key pressures

- Encroachment of trees, shrubs & bracken
- Abandonment of grazing
- Declining water availability
- Uncontrolled fires
- Atmospheric deposition of nitrogen
- Inappropriate recreational use (recreation pressure)

Source: NCC (2011).

Saltmarsh and coastal habitats

Between them Norfolk & Suffolk have around 220 km / 140 miles of coastline much of which has international conservation importance for a variety of coastal habitats. This is a 'soft' coastline of saltmarsh & mudflats, sand dunes and shingle. These are priority habitats requiring conservation that are challenged by coastal erosion and sea level rise.

Saltmarshes comprise the upper, vegetated portions of intertidal mudflats, and those on the fine sediments of the east coast have different species and community composition than elsewhere in Britain (Maddock, 2008). Norfolk and Suffolk have over 12% of England's total of this habitat type. Saltmarshes form high-tide refuges for birds feeding on adjacent mudflats, and for migrating birds, supporting large flocks of wild ducks and geese in winter.

Mudflats are areas of high biological productivity providing habitat and food for many species but also reducing the risk of erosion to saltmarshes, coastal defences and flooding of low-lying land (Maddock, 2008b). **Lagoons** of brackish, or salt water are further important associated habitats supporting waterfowl, marshland birds and seabirds.

Sand dunes form in relatively exposed locations with onshore winds and are characterised by the marram grass *Ammophila arenaria*. Embyonic shifting dunes are found at only two sites in the east of England – the North Norfolk coast, and on the east coast at Winterton where Natterjack toads inhabit the acidic dune slacks. (JNCC 2015).

Key pressures

- Coastal erosion
- Sea level rise
- Invasive species
- Pollution (especially nutrient enrichment)
- Artificial control of water (sea and fresh)
- Coastal defence works
- Visitor pressure

Priority habitats	Hectares		Percentage of National Resource	
Saltmarsh and coastal habitats	Norfolk	Suffolk	Norfolk	Suffolk
Coastal saltmarsh *	2,225.1	883.9	9.0%	3.6%
Mudflats *	116.8	75.6	2.2%	1.5%
Saline lagoons	83.3	73.5	8.8%	7.8%
Coastal sand dunes	976.0	38.5	9.6%	0.4%
Coastal vegetated shingle	86.3	599.9	2.2%	15.6%

Vegetated shingle is a rare habitat of international importance. Examples are round at Snettisham in Norfolk, and Dunwich and Orfordness in Suffolk comprising over 17% of England's total of this habitat type. It is found above the high tide line, may be only a few metres wide and is susceptible to trampling.

** Note: Actual habitat areas may be considerably larger than indicated here as they extend out into the sea beyond the land-boundary of the coastal datasets.*

Wetlands & grazing marsh

The wetland habitats of Norfolk and Suffolk comprise a variety of priority habitats including grazing marsh, fens and reedbeds. Grazing marsh is pasture that is periodically inundated with fresh or brackish water, with ditches controlling the water level. There are over 26,000 ha of grazing marsh in the two counties, of which Halvergate marshes in Norfolk is the largest at 2,642 ha (English Nature 2005). Lowland fens & reedbeds are internationally important, scarce habitats, which between them now account for only 0.2% of England's land area. These wetland habitats are regionally important, with Norfolk & Suffolk holding nearly 20% of the nation's lowland fens and 45.8% of its reedbeds. The Broads NP encompasses a large proportion of these habitats, which support an abundance of rare species, such as the bittern, swallowtail butterfly and Norfolk hawker dragonfly.

Habitat area & % of National resource		Norfolk	Suffolk	Broads NP	Norfolk Coast AONB	Suffolk Coast & Heaths AONB
Coastal and floodplain grazing marsh	**Ha**	**17,010**	**9,057**	**10,877**	**1,398**	**3,256**
	%	7.8%	4.2%	5.0%	0.6%	1.5%
Lowland fens	**Ha**	**3,477**	**450**	**1908**	**40**	**159**
	%	17.2%	2.2%	9.4%	0.2%	0.8%
Reedbeds	**Ha**	**848**	**580**	**713**	**113**	**355**
	%	27.2%	18.6%	22.8%	3.6%	11.4%

Regionally important

Lowland fens: Norfolk & Suffolk have 3,927 ha of lowland fens, representing 19.4% of England's total holding of this habitat type, with 17.2% of that in Norfolk, of which 9.4% is in the Broads NP alone which includes 75% of the UK's base-rich or species-rich fen type.

Reedbeds: Norfolk & Suffolk have 1,428 ha of reedbeds but this relatively small area forms 45.8% of England's holding of this rare habitat type. The majority of this - 22.8% of the national holding - is within the Broads NP with a further 11.4% in the Suffolk Coast & Heaths AONB.

Key pressures

- Encroachment of scrub
- Maintenance of reed cutting regime
- Sensitivity to declining/fluctuating water levels
- Sensitivity to changes in rainfall pattern & extreme events e.g. droughts and floods
- Coastal areas sensitive to saline intrusion & loss to sea level rise / coastal erosion

Source: Natural England 2014

Priority/iconic species

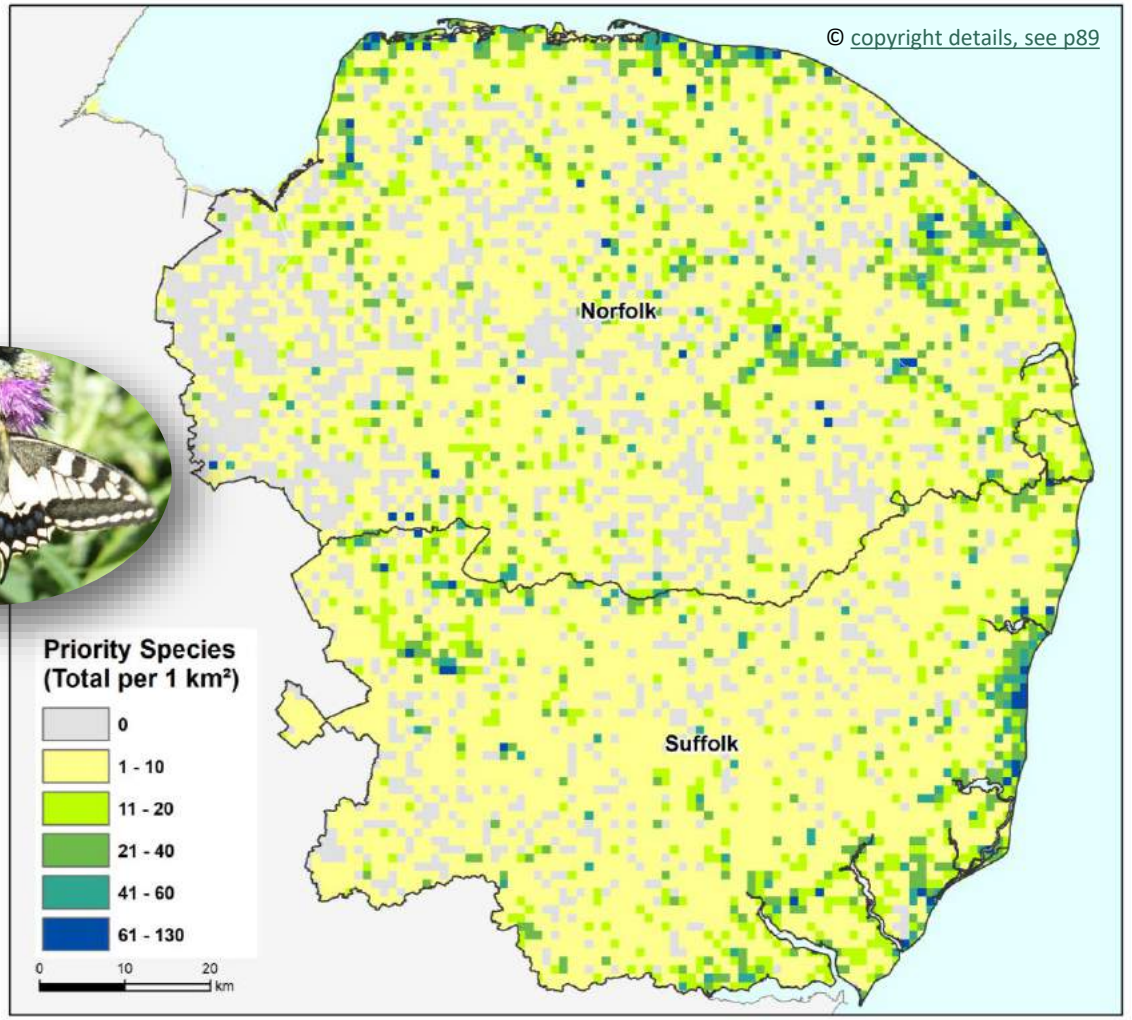
A list of species considered most threatened and requiring conservation action was originally compiled under the UK Biodiversity Action Plan (1995-1999) and has had a few subsequent revisions. Species were selected based on international importance, rapid decline and high risk, and cover all taxa of plants and animals (both land, freshwater and marine). The map (shown right) presents data held by the Norfolk & Suffolk Biodiversity Information Services and shows the density of priority species per 1 km^2 with highest densities tending to coincide with key natural areas.

The priority species list includes familiar species under threat such as the Hedgehog, House Sparrow, and Herring Gull. However, it does not include species that might be considered 'iconic' to the area such as the Little Tern, Avocet, Bittern, Marsh Harrier, Common Crane, Great Crested Newt or Swallowtail butterfly.

Risk and opportunity areas for bat species across Norfolk and parts of Suffolk have been identified by The Norfolk Bat Survey citizen science project (Border et al, 2017).

In terms of a 25 year environment plan, it may be beneficial to consider indicators for 'priority' and 'iconic' species which are flagship species for key priority habitats, plus animals such as pollinating insects (see below) that perform beneficial ecosystem services.

Pollinators: The ecosystem service provided by pollinating insects is significant both for wildflowers and for food production. Data from the Centre for Hydrology & Ecology indicates the distribution and abundance of nectar plants for bees, and shows all areas of Norfolk and Suffolk have fewer nectar plant species than the average for the rest of England.



Map note: The priority species data is based on observations submitted to the Biodiversity Information Service and may therefore have an element of bias due to uneven recorder effort.

Freshwater

Contents

Freshwater ***natural assets*** comprise rivers, lakes and ponds, ground-waters and wetlands, including the water, sediments, living organisms and their interactions. The availability and quality of freshwater for drinking, irrigation and life itself, is a fundamental ***provisioning ecosystem service***. The eastern counties have a dry climate compared to the rest of England and maintenance of water resources will be important as the climate is predicted to warm further over the coming century. Reduction in water availability may impact on ***regulating ecosystem services*** e.g. the ability of rivers and streams to mediate inflow of water or sediment borne pollutants. This section examines ***indicators*** of ground and surface water quality and availability, examines the risks posed by flooding, and examines the considerable ***cultural ecosystem services*** provided by on-water and waterside recreational opportunities.

See also Page 40 Wetlands and grazing marsh under Habitats & Species.

Photo: River Wensum (K.Hiscock)

Freshwater: Key features

This page summarises key findings of significance for Norfolk & Suffolk selected from the data presented within this section and highlighting information gaps or needs revealed from this examination.

Surface water quality

Very few water bodies in Norfolk or Suffolk currently meet 'good' status for surface water quality and this failure is largely due to ecological shortcomings. The majority are of 'moderate' status. Change in surface water status between assessment cycles shows a decline in status in 26 water bodies and an improvement in 28. For the majority there is 'no change'.

Groundwater quality

The Environment Agency Water Framework Directive Cycle 2 assessment shows overall 'poor' groundwater status for virtually the whole of the two counties. The main reasons for poor status are diffuse pollution from rural areas and also from towns, cities and transport; point source pollution (e.g. sewerage leachate, industrial discharge) and groundwater abstraction.

Water availability

East Anglia is the driest region in the UK, has the highest forecast growth outside London, is a leading agricultural producer, and has habitats (including wetlands) of international importance. Little surplus water is available; competing demands exist between water needs for public supply, irrigation and the environment. Projections indicate a regional net deficit of around -200Ml/d by 2050 (Water Resources East, 2020).

Flood risk

Several regions in Norfolk and Suffolk have experienced major flooding problems in the past. Over 11% of the two counties is rated by the Environment Agency (2020) as having at least a 1 in 100 flooding risk in any given year, with higher proportions in some key natural areas (e.g. the Broads NP) and certain habitats (e.g. coastal margins, freshwaters and pastures or grasslands).

Chalk rivers

Chalk rivers are globally rare. Many are located in the UK. Between them Norfolk & Suffolk have around 565 km/ 350 miles of chalk river, nearly 17% of England's total, and hosting many distinctive species. More chalk streams are in 'Poor or Bad' water body status categories than the average river. Threats include diffuse pollution, abstraction, sedimentation and invasive species.

Recreational use of waterways

Waterways offer opportunities for an array of recreational pursuits. Within the Broads NP and surrounding area, these generated over £600 million / 12.74 million visitor days in 2017. Boating (hire boat holidays, day boat hire, sailing, canoeing etc.,) are key activities. Managing visitor and wildlife needs, in an environmentally sensitive landscape, is an ongoing challenge.

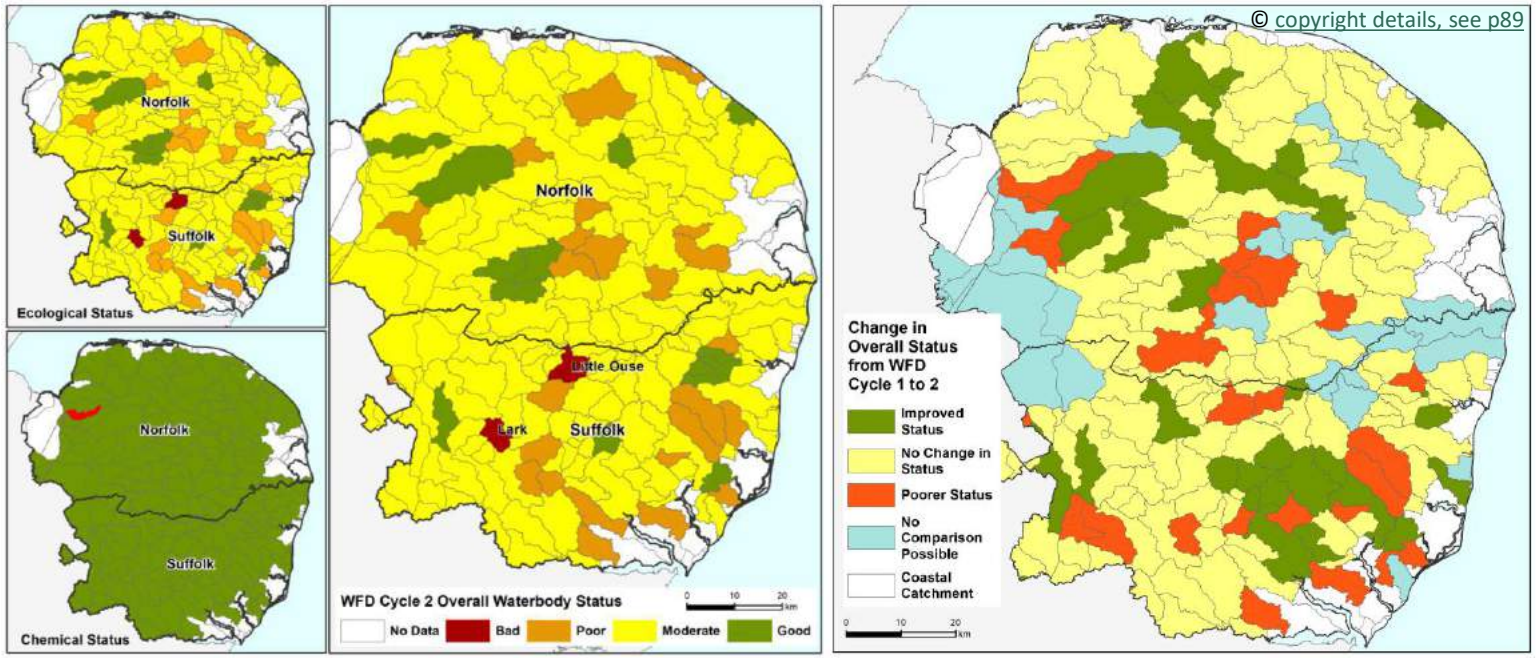
Information gaps

Due to the high importance of water resources for public supply, irrigation, energy and industrial uses, and strong regulation under the Water Framework Directive, data on water use and water quality is relatively well documented, updated with reasonable frequency, and are readily available.

Surface water quality

The Water Framework Directive includes a classification scheme for **water body status** which has five status classes – high, good, moderate, poor, bad. A 'water body' includes surface or groundwater in a 'coherent sub-unit in the river basin' (EC, 2003). 'High' status is the water quality benchmark, defined as the biological, chemical and hydromorphological conditions associated with no or very low human pressure. Overall status is based on periodic assessments of these factors by the Environment Agency. Grade is based on the lowest rating from a number of contributory indicators.

Two 'cycles' of assessments (2009-15 and 2016-21) have been carried out so far. The map (left) shows the current **surface water** assessment which combines a chemical evaluation with an ecological assessment. Very few water bodies in Norfolk or Suffolk currently meet 'good' status, largely due to ecological shortcomings. The majority (70%) are of 'moderate' status.



The second map (above, right) shows change in status between Cycle 1 and Cycle 2 assessments. This shows a decline in status in 26 water bodies representing over 98,000 ha of land (Table, below).

Water body ecological status assessment

- Biological assessment: measures communities of plants and animals (e.g., fish and rooted plants).
- Physico-chemical assessment: measures e.g. temperature and the level of nutrients.
- Hydromorphological assessment: measures water flow, sediment composition and movement, continuity (in rivers) and the structure of physical habitat.

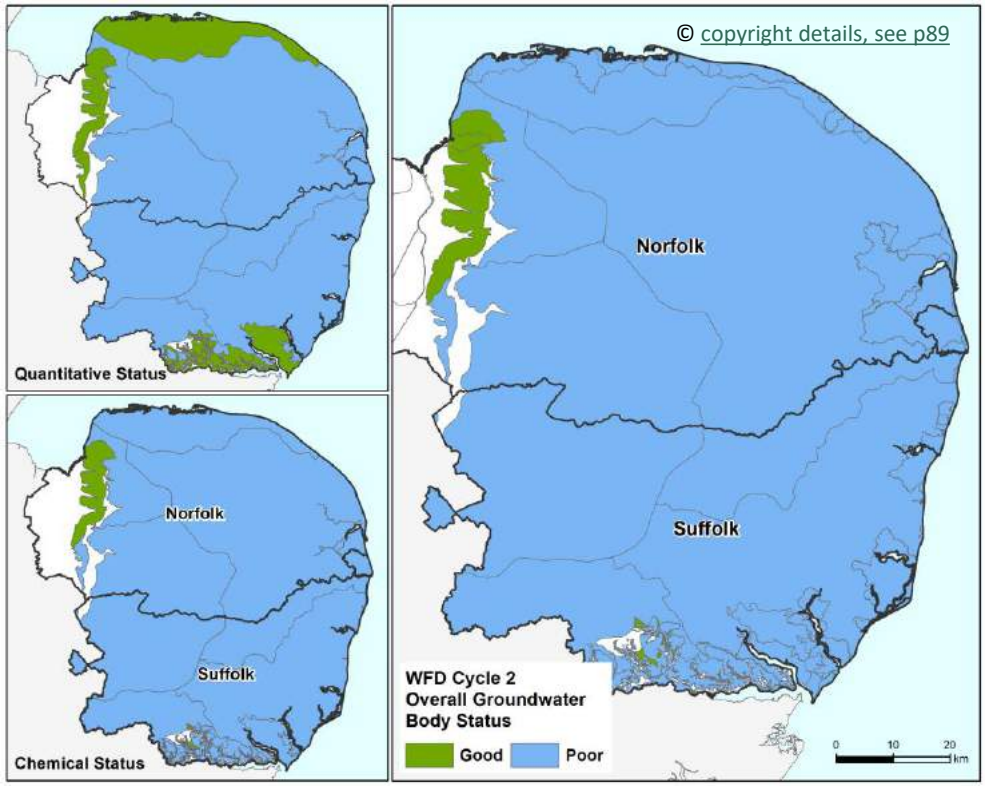
Source: EA (2010)

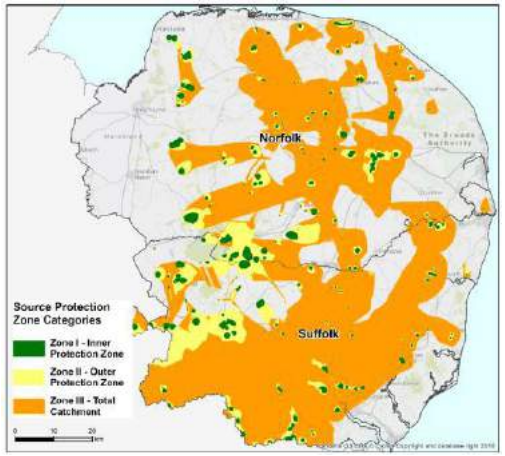
Change between C1 & C2	Number of WBs	% of Total	Hectares	% of Total
Improved Status	28	13.3%	143,681.4	13.5%
No Change in Status	107	50.7%	479,029.9	45.0%
Poorer Status	26	12.3%	98,676.2	9.3%
No Comparison Possible	21	10.0%	210,597.0	19.8%
Coastal Catchment	29	13.7%	132,179.9	12.4%
Total Water Bodies	211			

Groundwater quality

Groundwater provides one third of England's drinking water, but assumes greater importance in eastern England. Of the 15 Water Resource Zones serving Norfolk and Suffolk, ten rely entirely on groundwater sources and five a mixture of surface and groundwater abstractions (AW, 2019; NWG, 2019). This high reliance on groundwater reflects the porosity of the underlying soils and geology. The Base Flow Index (BFI) indicates the proportion of river flow that derives from groundwater and other stored sources. The BFI for a non-porous catchment (e.g. with clay soils) is around 0.15 whilst most chalk streams have a BFI > 0.9. Excluding The Fens, many river gauging stations in Norfolk and western Suffolk have BFI values between 0.6 and 0.9, while those in eastern and southern Suffolk typically range from 0.3 to 0.5 (UK Hydrometric Register, 2008).

The Environment Agency Cycle 2 assessment of groundwater body status (EA, 2016) for Norfolk & Suffolk (map right) shows overall 'poor' groundwater status for virtually the whole of the two counties. As with surface water, overall status is based on the lowest rating. The reasons for the failure to achieve 'good' status are shown below right.





Source protection zones

The Environment Agency is responsible for protecting and monitoring the quality of groundwater. Source Protection Zones (SPZs) indicate where potentially polluting activities might endanger wells, boreholes and springs used for public drinking water supply (see map lower left). The zones indicate different levels of risk; the closer to the source (i.e. inner zones), the greater the potential risk of contamination. Nearly 2% of Norfolk and Suffolk has Zone 1 status and 50% is in Zones 1 to 3.

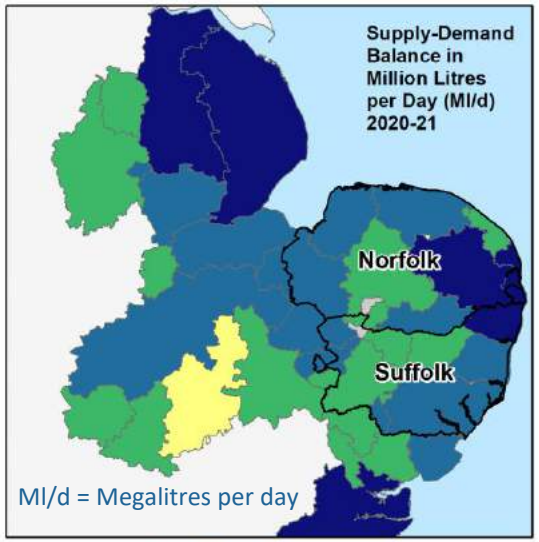
Photo: Boreholes, Wensum DTC (K.Hiscock)

Reasons for poor groundwater quality:-

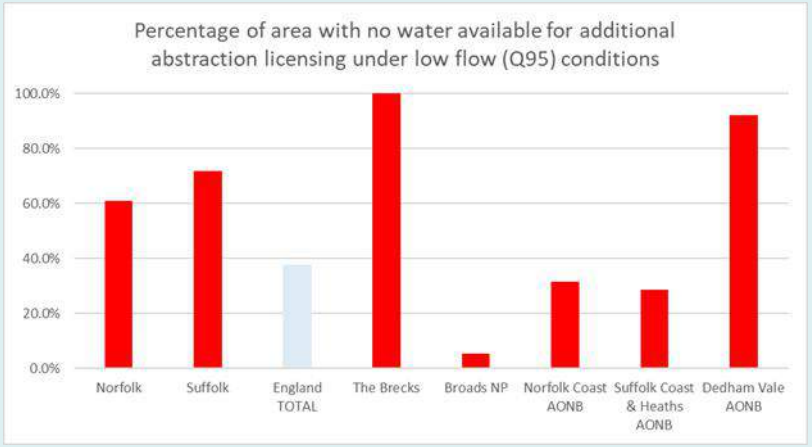
Most groundwater bodies in Norfolk and Suffolk fail to achieve good status on both quantitative resource and chemical grounds. The only one with good status on both is the North West Norfolk Sandringham Sands. Information from the Environment Agency (2015) database on reasons for not achieving good status (RNAG) for Cycle 2 indicates that the dominant cause of quantitative failures is over-abstraction of groundwater, while for chemical status it is most commonly diffuse pollution from agriculture, though industrial sources and sewage discharges also feature.

Water availability

Water Resources East (WRE) is the organisation tasked under the National Framework for Water Resources (EA, 2020) with producing an integrated water resource plan for eastern England. The WRE initial position statement (2020) includes an assessment of the current and future supply-demand balance based on water company Water Resource Management Plans, taking into consideration climate change impacts, abstraction reductions in environmentally-sensitive areas, and demand considerations based on forecasted economic growth and development. The maps on the right show the current supply-demand status and projections out to 2040. Across the whole region there is a **net projected deficit of around -200 Ml/d by 2050** (WRE, 2020).



Water Use: (Baseline 2020/21): "On an average day, in a dry year, the total consumptive demand for water in the WRE region is equivalent to 2,311 million litres (megalitres) per day. Most of this water **(85%) is used for public water supply** . Most of the rest is used for **spray irrigation (8%), power generation (3%)** and in the **manufacturing, food and drink sectors (2%)**. (WRE, 2020 p.9)



Water Resource Availability and Abstraction Reliability Cycle 2 data (EA, 2019), indicates the current demand stress on water for irrigation. Norfolk and Suffolk both have a greater area of land where additional water is not available for abstraction than the average for England. This is most critical for The Brecks and Dedham Vale AONB.

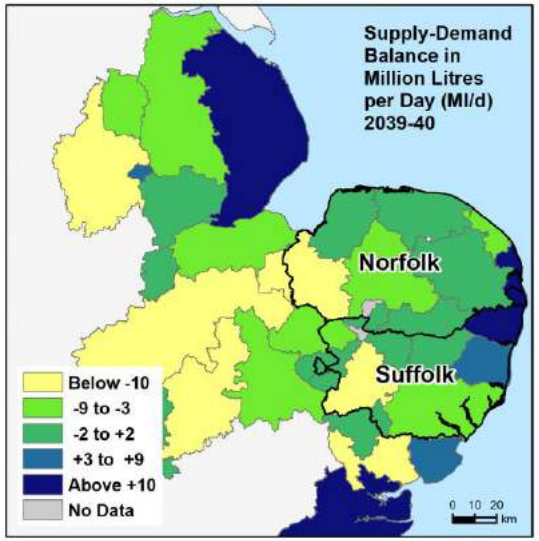
Pressures

- Driest region in the UK
- Highest forecast growth outside London
- Internationally important natural habitats
- Leading agricultural producer
- Tension between water needed for the environment, public supply and irrigation
- Little surplus water currently available

Source: WRE (2020)

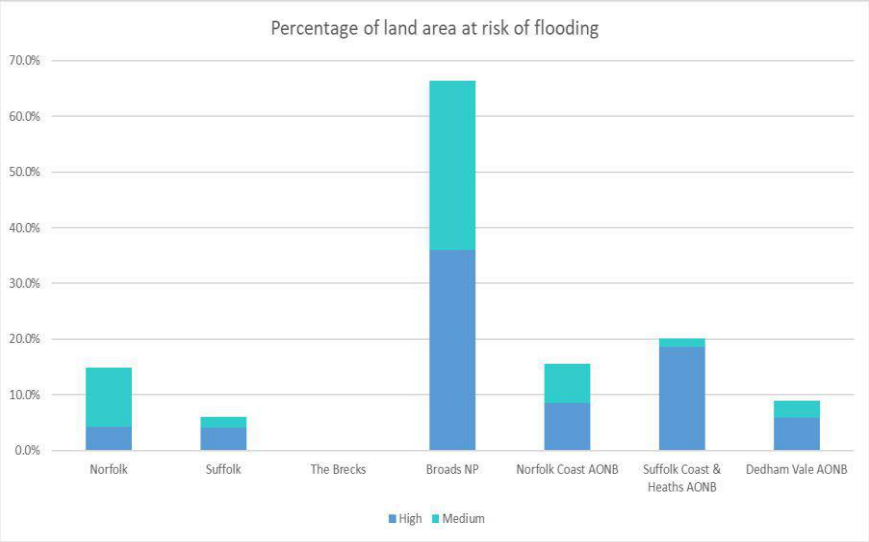
Responses

- Increase efficiency of all water users
- Promote need for additional water storage within the landscape through opportunities to link water scarcity with flood risk management solutions
- Transfer water from areas of surplus to areas of deficit, increasing connectivity and maximising open water channels
- Explore other technologies, e.g. water transfers, desalination and water re-use.



Flood Risk

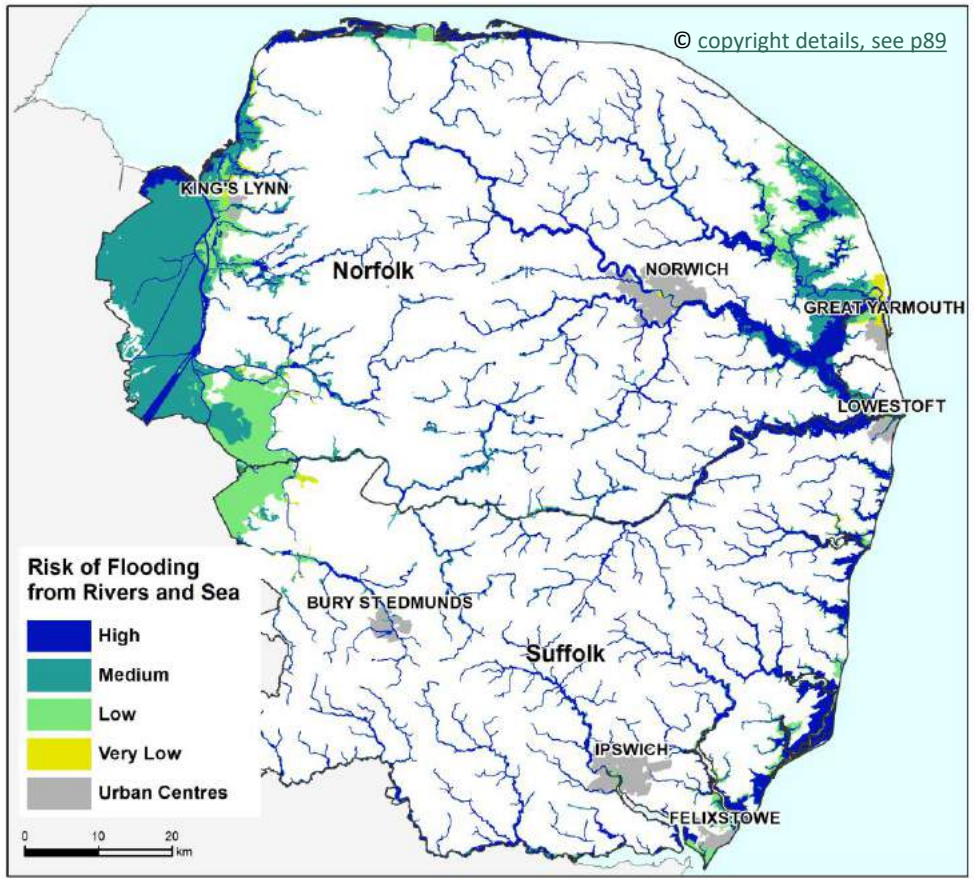
Norfolk and Suffolk have a history of flooding, including major events in 1953, 1978 and 2013. The map on the right is the latest update of an Environment Agency dataset produced using local expertise, showing the probability of land flooding from rivers and/or the sea. Each 50m cell is allocated one of four flood risk categories, taking into account flood defences and their condition. Overall, 11% of Norfolk and Suffolk is rated as having a 1 in 100 (1%) chance of flooding in any year, though as the graph shows the proportion for the Broads NP is over 60% and the map indicates that substantial parts of the Fens are at similar risk.



Probability of flooding:-

Very Low: Less than 1 in 1000 (0.1%) chance in any given year
Low: Less than 1 in 100 (1%) but greater than or equal to 1 in 1000 (0.1%) chance in any given year
Medium: Less than 1 in 30 (3.3%) but greater than or equal to 1 in 100 (1%) chance in any given year
High: Greater than or equal to 1 in 30 (3.3%) chance in any given year

Source: Environment Agency (2020)



The impacts of flooding are also likely to vary between habitats. Unsurprisingly, the table shows that coastal and freshwater habitats are most likely to flood, with over a quarter of pasture / grassland also in the 1 in 100 category. These floodplain habitats provide an important ecosystem service benefit in alleviating flooding in other areas.

Habitat Category	% of Area at 1 in 100 Flood Risk
Arable Crops & Fruit	8.3%
Coastal Margins	82.4%
Freshwaters	76.4%
Heaths (Mountains Moors & Heaths)	3.9%
Pastures & Natural Grassland	25.9%
Urban & Human Activities	4.8%
Woodlands	5.5%

Surface water flooding

Other data from the Environment Agency assess the risk of flooding from surface water. These often highlight quite local variations (linked to topography) which are difficult to depict at the scale of Norfolk and Suffolk and so have not been mapped here.

Chalk rivers

Of the 210 chalk streams in the world, 160 are in the UK, and most of the lowland ones are found in Norfolk (VN website, 2020). Between them Norfolk & Suffolk have around 565 km/350 miles of chalk rivers, accounting for nearly 17% of England's total (see table). This rare habitat is home to many distinctive species, e.g. Bullhead and Brook Lamprey (fish), White-clawed crayfish, Desmoulin's Whorl Snail and Water Crowfoot and Water Starwort vegetation (Ranunculus habitat).

Threats to chalk river habitats come from modification of the water course, abstraction, influx of sediments, invasive species, and diffuse water pollution e.g. phosphate and nitrate input from runoff from agricultural fertilisers and discharges from septic tanks.

The condition of chalk streams is monitored by the EA within the assessment of surface water body status. In a study in 2014, more chalk streams were likely to be in 'Poor or Bad' categories than the average river in England and Wales (O'Neill & Hughes, 2014).

Key facts

"Chalk streams in Norfolk include the Rivers Mun, Glaven, Stiffkey, Burn, Heacham, Ingol, Hun, Babingley and Gaywood, but the longest, biggest and most significant is the River Wensum, the most protected river in Europe – it has Site of Special Scientific Interest and Special Area of Conservation status for its entire length. " (VN website, 2020).

Length of Chalk Rivers	Km	% of England
England	3,343.3	
Norfolk	463.4	13.9%
Suffolk	101.6	3.0%
Norfolk Coast AONB	19.5	0.6%
The Brecks	220.9	6.6%

Recreational use of waterways

Waterways offer opportunities for an array of recreational pursuits: walking, fishing, wildlife-watching, boating, canoeing, paddle-boarding etc. These are available along many of the two counties' rivers and, in particular, within the Broads NP which includes 7 rivers and 63 broads, attracting more than 7.6 million visitors a year (BA, 2018). Land and water-based tourism within the Broads National Park (NP) and the immediate surrounding area, generated over £600 million within the local economy and accounted for 12.74 million visitor days in 2017 (BA, 2018). A Broads Authority survey in 2015 shows the activities undertaken by visitors to the Broads NP (table, far right).

Boating is a popular activity both in the Broads NP and elsewhere. There are 200km/ 120 miles of waterways and 13 broads open to navigation. Across the two counties boat moorings account for around 450,000 visitor nights annually (see table, below left) generating revenue (from the moorings alone) in excess of £20m. In 2015 there were 885 registered cabin hire boats on the Broads and privately owned boats are around 7 times this number. Additionally there are day hire boats, sailing boats, tourist passenger boats, plus a range of non-powered canoes, row boats etc. (TTC, 2016). The Broads NP has 8 canoe trails.

Boat Moorings		2017	2018
Spend (£ on boat moorings)	Norfolk	£22,005,000	£14,134,000
	Suffolk	£6,773,000	£6,294,000
% of accommodation spend	Norfolk	3%	2%
	Suffolk	2%	2%
Number of visitor nights	Norfolk	313,000	297,000
	Suffolk	152,000	149,000
% of visitor nights	Norfolk	3%	3%
	Suffolk	3%	3%

Source: Economic Impact of Tourism reports; Visit Norfolk / Visit Suffolk

Visitor Survey 2015: Activities in the Broads (% visitors to Broads)		
Have undertaken in	Past 5 years	Plan to undertake
Walking	69%	68%
Heritage site visit	35%	49%
Day boat hire	33%	45%
Bird-watching	27%	33%
Hire boat holiday	26%	41%
Cycling	22%	30%
Fishing	18%	21%
Sailing	12%	17%
Canoeing	11%	17%

Source: TCC (2016)

Pressures

The Broads NP has multiple conservation designations (see Habitats & Species section) and is set within a working agricultural landscape. Consequently, balancing pressures from surrounding land uses (e.g. diffuse pollution), whilst managing visitor and wildlife needs in an environmentally sensitive landscape, is an ongoing challenge.

Coast & Marine

Contents

Our oceans and coastal zone ***natural assets*** provide a wealth of ***ecosystem services***, from ***provisioning*** of food to ***supporting*** biodiversity, plus ***cultural*** benefits in the form of recreational opportunities, and landscape aesthetics, but additionally ***regulating services*** as they sadly endure misuse as a repository of human-produced pollutants. Our region is particularly vulnerable to the impact of global warming induced sea level rise, exacerbating the threat to human settlements and sensitive habitats on an already eroding coastline. This section includes data on marine habitats and protected areas and ***indicators*** of the status of fish, shellfish and marine mammals and coastal water quality.

See also Page 39 Saltmarsh and coastal habitats under Habitats & Species.

Coast & Marine: Key features

This page summarises key findings of significance for Norfolk & Suffolk selected from the data presented within this section and highlighting information gaps or needs revealed from this examination.

Marine habitats & protected areas

Over 90% of the inshore marine environment of Norfolk & Suffolk falls within Marine Protected Areas. This includes two Marine Conservation Zones (the Cromer Shoal Chalk Beds and Orford Inshore), as well as internationally designated Special Areas of Conservation and Special Protection Areas.

Fish stocks

Economic uncertainty exists regarding the future of commercial fishing in this region due to both current regulatory regimes and sustainability of fish stocks from environmental pressures (e.g. warmer water temperatures) and local/foreign fishing effort. The ICES 2018 stock assessment highlighted several species in an undesirable situation.

Shellfish stocks

Controls of the shellfish fishery exist but knowledge of stock trends is less robust than for fish stocks. The East Marine Plan area accounts for around 40% of English shellfish production (via aquaculture) including over half of English mussel production. These fisheries are vulnerable to threats from disease, invasive species, increasing sea temperatures and ocean acidification.

Marine mammals

Our coast supports around 70% of England's breeding populations of Grey seals and over 90% of Harbour seals. Increase in the local population is slowing, potentially indicating a limit in carrying capacity. Seals can be impacted by disturbance, changes in prey distribution, conflicts with fishing operations, entanglement in marine debris, etc. There is no evidence of long term impact from wind farms.

Seabirds and migratory birds

The prevalence of seabird SPAs indicates the significance of the Norfolk & Suffolk coast for these birds. North Norfolk is especially important for migration and provides winter refuge for large flocks of waders/wildfowl. Summer breeding colonies of terns and other seabirds, wildfowl and waders are found all along the coast. Good Ecological Status (GES) is not being achieved for most seabirds, this is thought to be due to climate change and other human impacts.

Recreational use of coasts

The coast attracts nearly 12 million day-visits and a total visitor spend of around £330m. In 2019 the north Norfolk beaches of Sheringham, Cromer, Mundesley, Sea Palling, East Runton and West Runton were awarded Blue Flags, with a Seaside Award for Wells-next-the-Sea. Sea level rise and coastal erosion are future threats alongside the need for ongoing visitor management to avoid damage to sensitive habitats.

Information Gaps

With a vulnerable coastline of sand and shingle beaches and ageing coastal defences, the rate of coastal erosion will be an important future indicator in its own right of the status of coast as a natural asset. A National Coastal Erosion interactive map and Shoreline Management Plans are available from the Environment Agency. The detailed scale of these datasets make them inappropriate to include in this Evidence Compendium but their content will be an important consideration for the Norfolk & Suffolk 25 year Environment Plan.

Marine habitats and protected areas

Conservation of the inshore marine environment of Norfolk & Suffolk in conjunction with fisheries management and enforcement duties is the jurisdiction of the Eastern Inshore Fisheries and Conservation Authority (IFCA) (Eastern IFCA, 2020).

Marine Protected Areas account for around 96% of the Eastern IFCA area. The Table (right) lists SACs which protect habitats and species and SPAs which protect birds and their habitats. In 2016 the ecologically sensitive Cromer Shoal Chalk Beds was designated as a MCZ (DEFRA, 2016), and in 2019 a new MCZ was designated off the Suffolk Coast (DEFRA, 2019) (see below).

Cromer Shoals MCZ
Seaweed-dominated, shallow-water infralittoral rocks, an important habitat for a variety of juvenile species as well as being important for the fish, tompot blenny and the small-spotted catshark. The chalk beds are home to lobsters and crabs and vital for the small-scale crab and lobster fishery that characterises the economy of the area.
Source: DEFRA (2016)

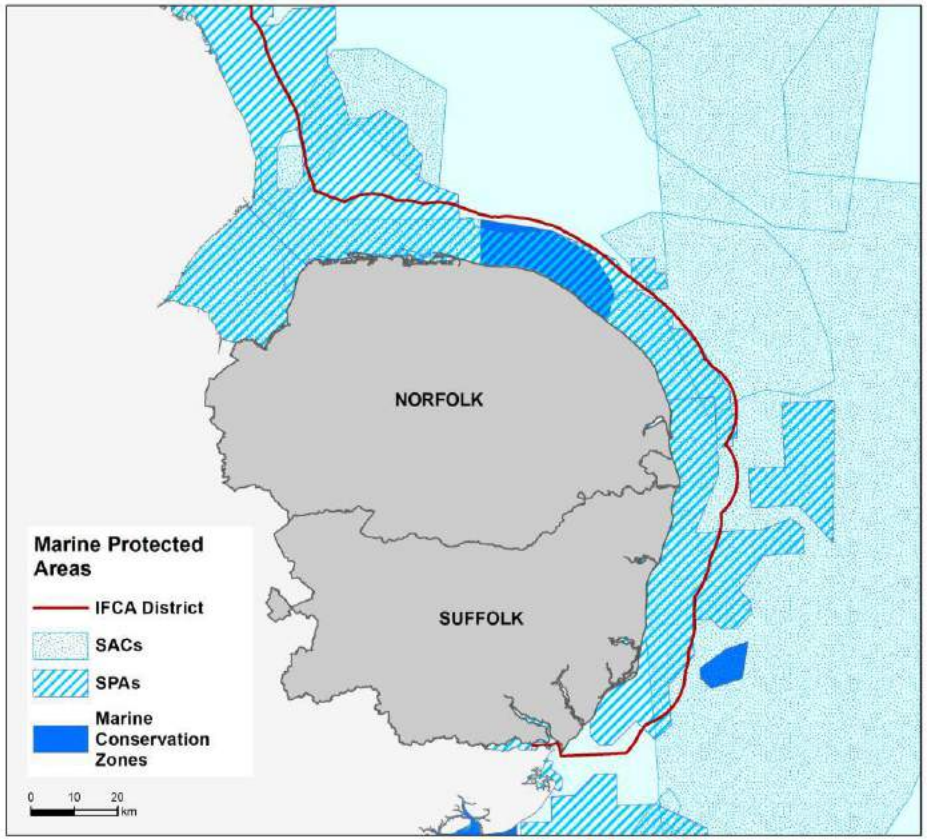
Orford Inshore MCZ
Subtidal mixed sediments important as nursery and spawning grounds for many fish species, including Dover sole, lemon sole, sand eels and the small-spotted catshark. Burrowing anemones can be found within the sediment, alongside sea cucumbers, urchins and starfish. Important area for foraging seabirds and harbour porpoise are often spotted.
Source: DEFRA (2019)

Photo: Bing Creative Commons

See link for a national classification of sea floor marine habitats

NORFOLK & SUFFOLK MARINE PROTECTED AREAS	Size (km2)
MCZ: Marine Conservation Zone	
Cromer Shoal Chalk Beds	321.0
Orford Inshore	72.0
SAC: Special Area of Conservation (protecting a range of internationally important habitats and species)	
Southern North Sea	36,951.0
The Wash & North Norfolk Coast	1,077.2
North Norfolk Coast	31.5
Inner Dowsing, Race Bank & North Ridge (1)	845.1
Haisborough, Hammond & Winterton (2)	1,467.6
Alde, Ore & Butley Estuaries	16.3
Orfordness to Shingle Street	8.9
SPA: Special Protection Area (protecting birds; supporting habitats)	
Greater Wash	3,536.0
Outer Thames Estuary (2)	3,793.0
The Wash	620.4
North Norfolk Coast	78.6
Great Yarmouth & North Denes	1.6
Breydon Water	12.0
Outer Thames Estuary extension (2)	121.7
Alde & Ore Estuaries	24.0
Deben Estuary	9.8
Stour & Orwell Estuaries (2)	36.7

NOTES (1) Offshore (non-coastal) site, partially within Eastern IFCA district (2) Majority of this site is in Eastern IFCA district, but part of it falls within the Kent & Essex IFCA district. Source: Eastern IFCA (2020).



Marine Protected Area

A term that covers several types of designation that offers an area some form of legal protection. It can be described as "*any area of intertidal or subtidal terrain, together with its overlaying water and associated fauna, flora, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment*" (Kelleher & Kenchington, 1992).

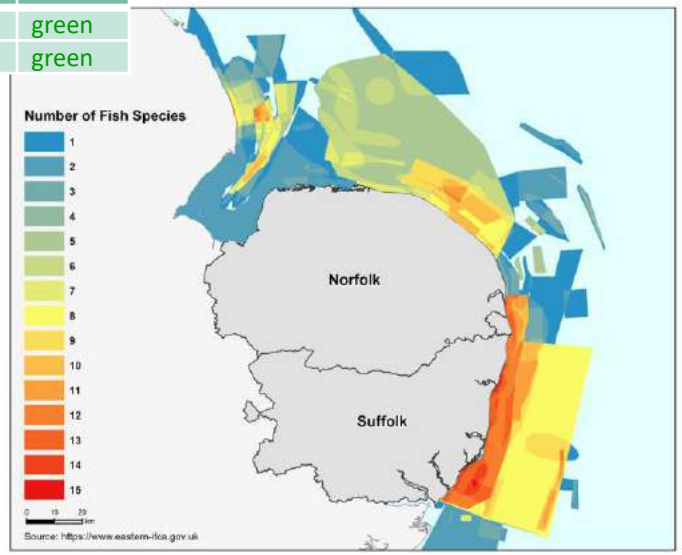
Fish stocks

Economic uncertainty exists regarding the future of commercial fishing in this region due to both current regulatory regimes and sustainability of fish stocks from environmental pressures and local/foreign fishing effort (DEFRA, 2014; REAF, 2019). Local fishing vessels are launched from ports, harbours and shingle beaches all around the coast catching mostly sole or bass plus skates, rays and shellfish. Offshore fleets are mostly foreign owned and land their catch outside of the UK (REAF, 2019).

A survey undertaken with fishermen by Eastern IFCA in 2009-10 resulted in the identification of historically important fishing grounds (mapped right) (Eastern IFCA, 2010). The map below indicates key areas where a higher diversity of fish species are found. The table below shows a recent assessment of the health of finfish and flatfish stocks in the North Sea.

Health of finfish and flatfish stocks in the North Sea	Sole	Plaice	Cod	Bass	Herring
Fishing pressure	red	green	red	green	green
Stock size	green	green	red	red	green

Key: ICES 2018 stock assessment: Red = undesirable situation, e.g. fishing pressure is above the relevant reference point or stock size is below the relevant reference point. Source: REAF, 2019.



"The East Anglian coast spans estuaries, shingle beaches, harbours and the fairly shallow North Sea, with its banks and hollows and varied substrates, creating a variety of local ecosystems in which shellfish grounds, demersal fish spawning grounds and other areas are found. It is home to significant stocks of sole, brown shrimp and plaice, as well as herring, mackerel, skate, bass, crab, lobster, cockles and whelks." (REAF, 2019, p9).

Shellfish stocks

The map (right) of historically important shellfish zones was derived from a survey undertaken with fishermen by Eastern IFCA in 2009-10 (Eastern IFCA, 2010).

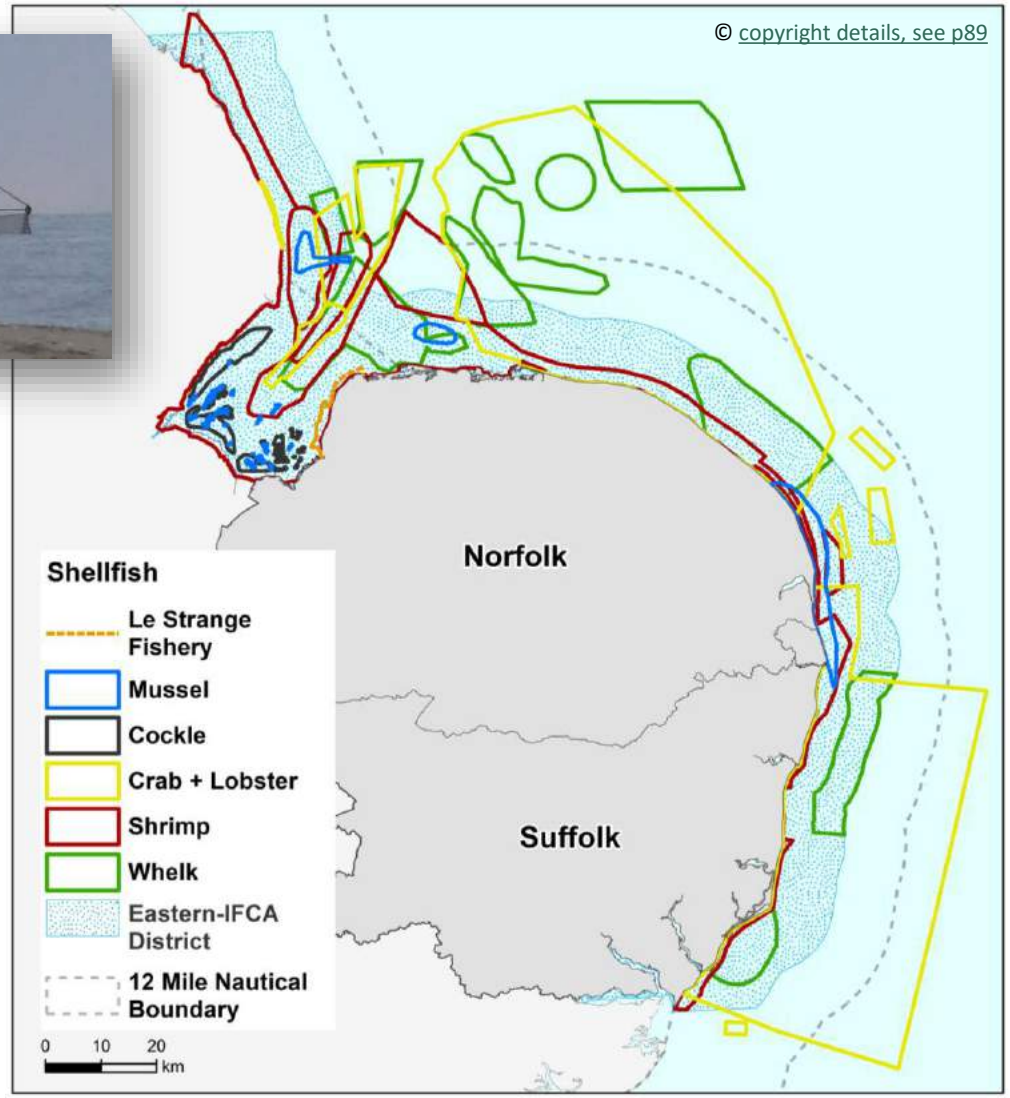
A fleet of over 70 shellfish vessels operates off the East Anglian coast, targeting cockles, whelks, brown shrimps, lobsters and crabs (REAF, 2019). As with fish, minimum landing size and other controls of this fishery exist but are not as well established as for fin and flatfish.

REAF (2019, p10) reports that *"crab stocks appear to be stable but, while catches have been high and fishers report that the catch rate remains good in most areas, the trends in whelk stocks are not known and there is some concern that a large transfer of effort in recent years from other stocks into whelk fishing may be depleting the stock. On the other hand, the absence of cod, a predator of whelks, might partly explain the abundance of whelks".*

Aquaculture: Cockles, mussels, and oysters are grown within The Wash and at sites on the North Norfolk coast and at Orford in Suffolk (Eastern IFCA, Pers. Com.) The East Marine Plan area accounts for approximately 40% of English shellfish production including over half of English mussel production, via aquaculture (DEFRA, 2014). These fisheries are vulnerable to threats from disease and invasive species and are subject to control by Eastern IFCA.

Key pressures to shellfish and fish stocks

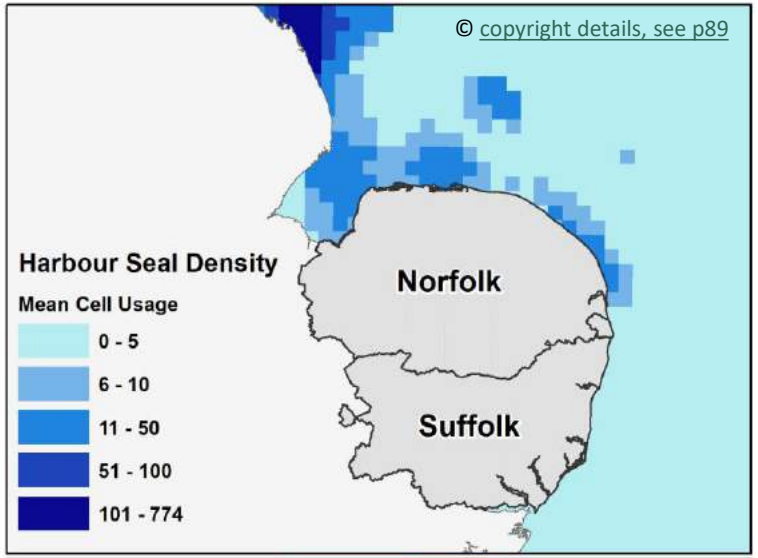
- Climate change and increasing sea temperatures
- Ocean acidification
- Invasive species (shellfish)

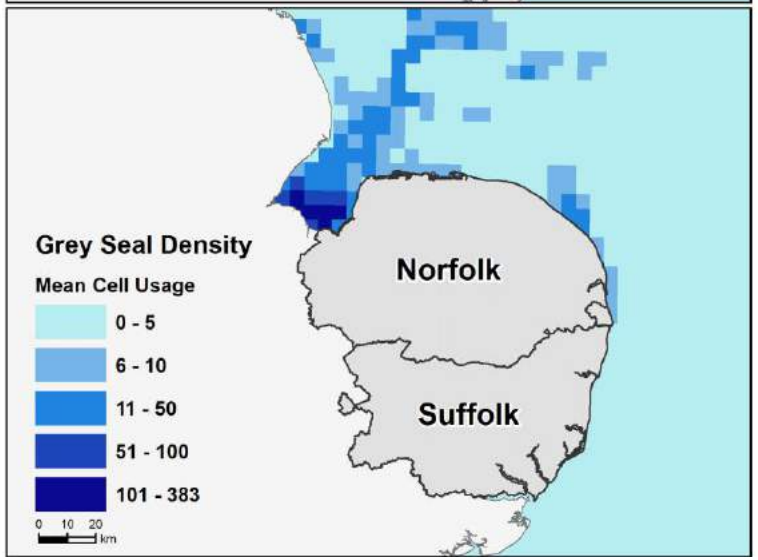


Marine mammals

Although they are infrequently seen, there are various species of whale, porpoise and dolphin that pass along our shores. In fact a Special Area of Conservation (SAC) encompassing most of the east coast, exists for the harbour porpoise (*Phocoena phocoena*) (JNCC and NE, 2019). Our coasts also support breeding populations of both the Grey seal *(Halichoerus grypus)* and Harbour seal (*Phoca vitulina)* (also known as Common seal). The UK is home to around 150,000 Grey Seals (2017 estimate), 38% of the world population and around 45,000 Harbour seals (2017 estimate), 30% of Europe's population (SCOS, 2018). The majority (over 80%) of the populations of both seal species are found in Scotland but Norfolk is home to around 70% of England's Grey seals and over 90% of England's Harbour (SCOS, 2018).

There are breeding colonies of Grey seals along the Norfolk coast at Blakeney Point and at Horsey. Unlike elsewhere in the UK these have been expanding in recent years but the rate of increase is now slowing, potentially indicating the population is reaching carrying capacity (SCOS, 2018). Harbour seals are less numerous and the population is mostly centred in The Wash and North Norfolk. They too have been increasing in number along the east coast in recent years. The maps (right) show estimates (based on telemetry data) of seal density (usage/occupancy) along the coast (SMRU, 2017).





Key pressures

There are a number of environmental pressures on seal populations. Whilst they are considered adaptable to climate change (SCOS, 2018), they may be impacted by changes in prey distribution, conflicts with fishing operations, entanglement in marine debris, disturbance etc. Evidence to date indicates no long-term impact from wind farms (apart from temporary disturbance during construction phase) (SCOS, 2018).

Crowds drawn to view seal colony during pupping season

Seabirds and migratory birds

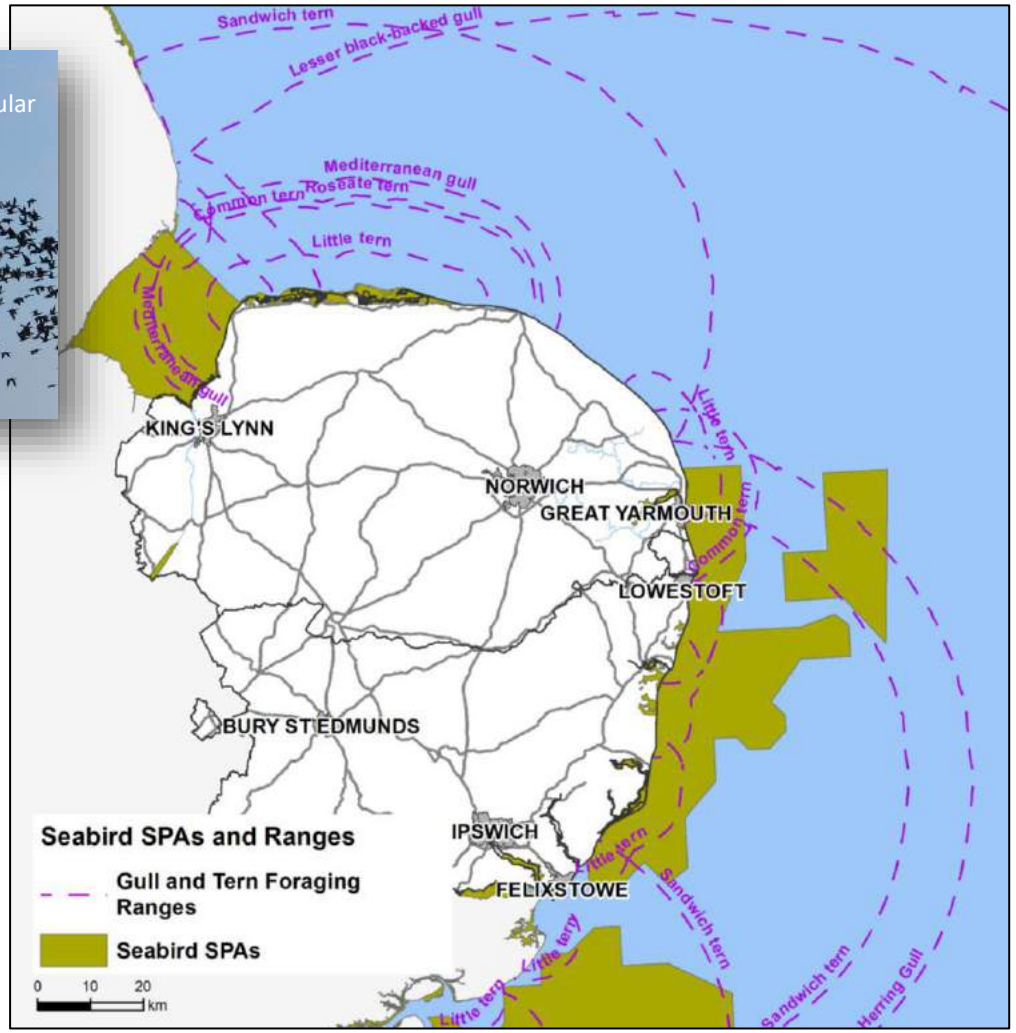
Internationally important numbers of seabirds, waterfowl and waders are found around the seas and coasts of the UK, which provides nesting sites for around 7 million seabirds, 25% of Europe's breeding seabirds (DEFRA, 2019, DEFRA, 2020). The large extent of seabird SPAs (see map) is testament to the importance of our coastline for these birds. The north Norfolk coast, in particular, is important during spring and autumn migration for a wide range of bird species, and provides winter refuge for large flocks of waders and waterfowl. In summer the coasts, estuaries and nature reserve sites are important for breeding colonies of Terns and a variety of wildfowl and waders such as Avocet, Ruff, and Godwits.

Around 80,000 Pink Footed Geese – 22% of the Greenland and Icelandic population are spectacular winter visitors to the Norfolk coast.

The map (right) shows use of sea areas by seabirds and inshore waterbirds compiled from boat and aerial observer surveys to provide evidence to assess impacts on seabirds from offshore wind farm developments. Although seabirds do collide with turbines, there is currently no evidence of population-scale impacts on seabird numbers, though this will need to be kept under review as the number of offshore developments increases (Bailey et al, 2014).

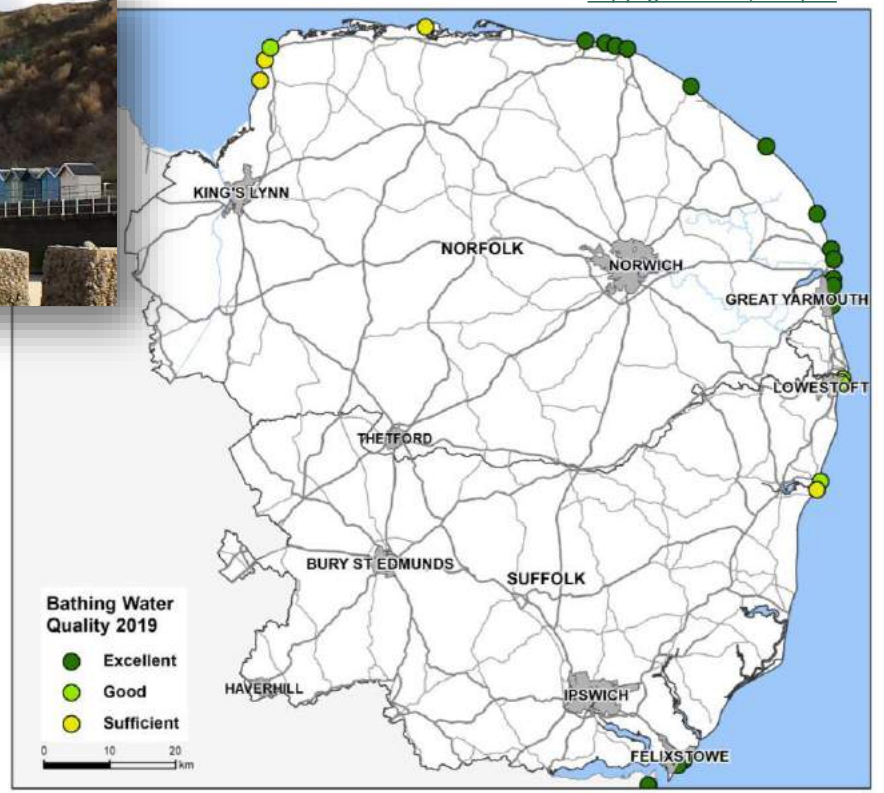
Key pressures

The latest UK Marine Strategy update (DEFRA, 2019) finds most UK marine bird populations are not achieving Good Ecological Status (GES). The reasons are not well understood but climate change is implicated, with milder winters affecting where waterbirds forage and reduced numbers of small fish affecting condition and breeding success. Other human related impacts may also be implicated. (DEFRA, 2019). A new national Seabird Conservation Strategy will be published in December 2020 (DEFRA 2020a).



Source: Natural England's SeaMaST data

Recreational use of coasts



Norfolk and Suffolk's 220 km / 140 miles of coastline offer a variety of seascapes and a wealth of recreational opportunities. With quaint coastal villages in Areas of Outstanding Natural Beauty, miles of beaches, long coastal footpaths and traditional sea-side resorts, offering opportunities for walking, wildlife watching, and beach activities such as swimming and angling. In 2018 the two counties saw nearly 12 million day visits to the coast (see Table below) producing a total visitor spend of around £330m.

Bathing water quality (map, right) is assessed annually by the Environment Agency. Annual ratings classify each site as excellent, good, sufficient or poor based on measurements taken over a period of up to four years. The international ***Blue Flag*** award (determined annually) is only given to beaches which have excellent water quality and are well managed. ***Seaside Awards*** reflect the diversity of the coastline and are awarded to the best beaches.

In 2019 the north Norfolk beaches of Sheringham, Cromer, Mundesley, Sea Palling, East Runton and West Runton were awarded Blue Flags, with a Seaside Award for Wells-next-the-Sea.

Coastal Day Visits								
	No. of visits (millions)		Spend (£m)		% of All visits		% Total spend	
Year	Norfolk	Suffolk	Norfolk	Suffolk	Norfolk	Suffolk	Norfolk	Suffolk
2014	5.8	no data	£148	no data	14.5%	no data	10.9%	no data
2015	5.7	no data	£155	no data	14.5%	no data	10.9%	no data
2016	5.9	no data	£181	no data	14.3%	no data	12.2%	no data
2017	6.2	4.6	£187	£130	14.4%	12.5%	12.2%	12.5%
2018	6.9	4.8	£195	£135	14.5%	12.4%	12.2%	12.4%

Source: Economic impact of tourism reports; Visit Norfolk; Visit Suffolk

Highlighting the issue of beach litter

Key pressures

- Visitor pressure (litter, footpath erosion and habitat & wildlife disturbance)
- Sea level rise and **coastal erosion** (loss of caravan parks and other visitor accommodation; loss or degradation of beaches)

A major 'sandscaping' scheme to restore the beach from Bacton to Walcott in Norfolk has recently been completed at a cost of £22m, using 1.8 million m^3 of sand, adding around 7m height to the beach and protecting the coastline for the next 25 years. (NNDC website).

Atmosphere

Contents

The atmosphere is a ***natural asset*** that is essential to life on this planet and protects us from solar radiation. Gases within our atmosphere (including oxygen, carbon dioxide and nitrogen) are vital for life and ecosystem function and the composition of those gases is also important in relation to climate regulation and global warming. The weather we experience represents the state of the atmosphere. Clean air, free of chemical and particulate pollution is important for human, animal and plant health. The atmosphere, as with the oceans, is too often the recipient of pollution from human activities. Atmospheric processes regulate and reduce pollution and other adverse effects and are known as ***regulating ecosystem services***. The impact of human activities on the atmosphere can be monitored by measuring any number of the pollutants those activities produce and these act as ***indicators*** of the state of the atmosphere. This section examines indicators relating to air quality and greenhouse gas emissions in Norfolk and Suffolk highlighting issues of regional importance.

Atmosphere: Key features

This page summarises key findings of significance for Norfolk & Suffolk selected from the data presented within this section and highlighting information gaps or needs revealed from this examination.

Air quality: particulates

Particulates are an important indicator of air quality. PM2.5 particles have been implicated in many chronic human diseases, e.g. respiratory disease, vascular inflammation etc. Air pollution background concentration data are produced by DEFRA and are predicted values modelled from road emissions. The data indicate PM2.5 levels in much of Norfolk and Suffolk to be above the average for England.

Greenhouse gas emissions

It is widely accepted that greenhouse gas emissions from human activity is leading to climate change, and that this is one of the greatest challenges at this time. Although there is an overall downward trend in GHG emissions for Norfolk and Suffolk, emissions from road transport remain reasonably static, making up an increasing proportion of the overall total. Both counties now have higher per capita emissions (5.6 t/pp/yr) than the England average (5.0 t/pp/yr). Per capita emissions need to reduce to -0.4 – 1.7 t/pp/yr to meet the Paris Agreement and limit global mean temperature rise to below 1.5°C.

Point source emissions

Data from the National Atmospheric Emissions inventory shows that point-source emitters produce approximately one quarter of CO_2 emissions in Norfolk & Suffolk equivalent to 2,088,303 tonnes of CO_2. There are 37 point-sources in total, the largest four being the Great Yarmouth power station, the British Sugar factories at Bury St Edmunds and Wissington, and the Suez recycling plant near Ipswich. Assisting businesses that are large point-source emitters (particularly in food processing) transition to a low carbon economy could be an important consideration in a 25 year environment plan for the region.

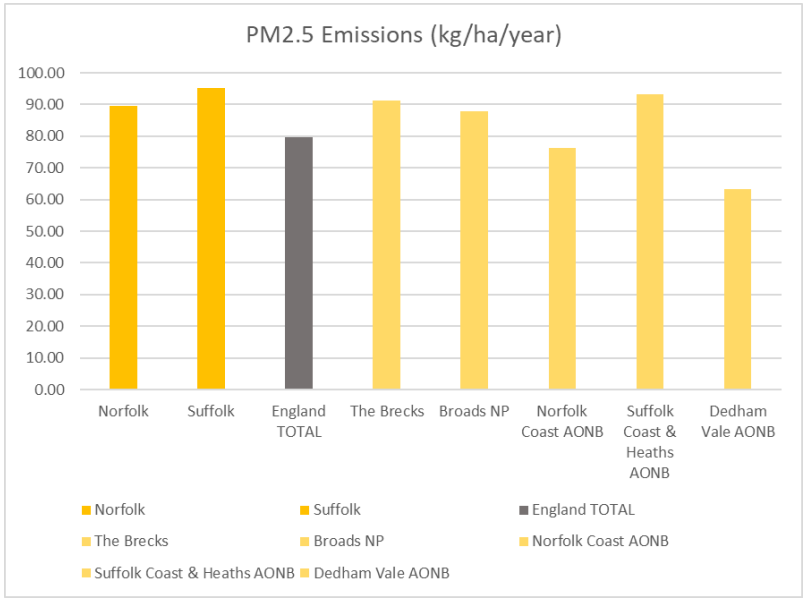
Information Gaps

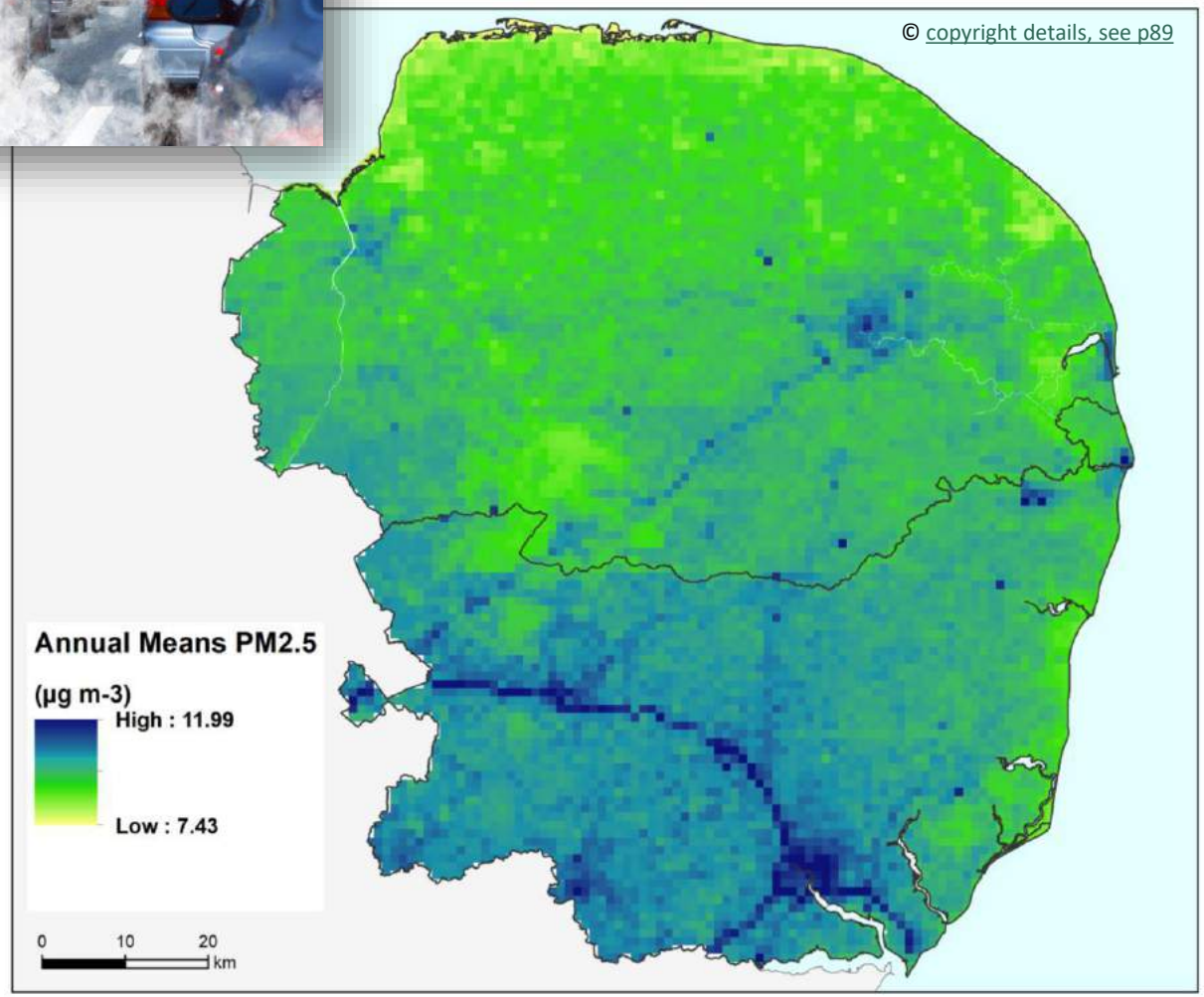
The information presented here is for a small selection of the data available on air pollutants drawn from nationally available datasets. However, many of these rely on monitoring data provided by local authorities, so more specific local data may be available to include as indicators in the Norfolk & Suffolk 25 year environment plan.

Air quality - particulates

Particulates are an important indicator of air quality. PM2.5 refers to atmospheric particulate matter with a diameter of less than 2.5 micrometers, detectable only with an electron microscope. The particles arise from combustion processes and sources include power plants, motor vehicles and planes, forest fires etc. Due to their size they stay in the atmosphere longer than larger heavier particles and have been implicated in many chronic human diseases, e.g. respiratory disease, vascular inflammation etc.

Air pollution background concentration data are produced by DEFRA and are predicted values modelled from road emissions. The map shown here is the 2017 reference year background map. The values for Norfolk & Suffolk are well below regulatory limits (20 µg m-3 to be achieved by 1st Jan 2020) though as the map illustrates, emissions are higher close to major roads and some combustion sources (DEFRA, 2018). Estimates of total particulates in kg/ha/year are shown in the graph (right). These indicate PM2.5 levels in much of Norfolk and Suffolk to be around the average for England.



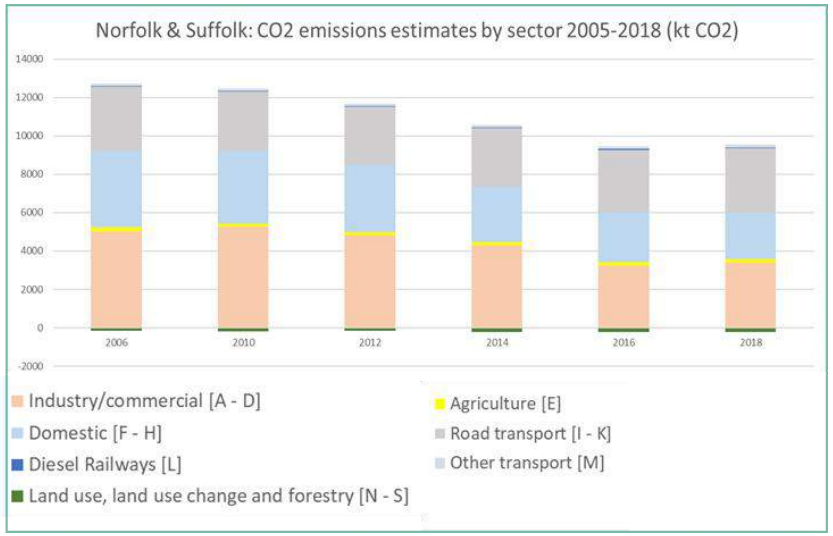


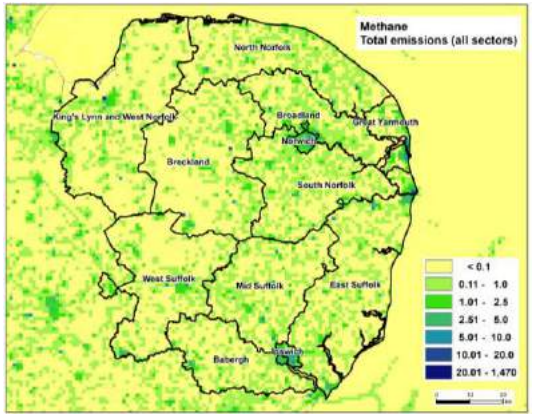
Greenhouse gas emissions

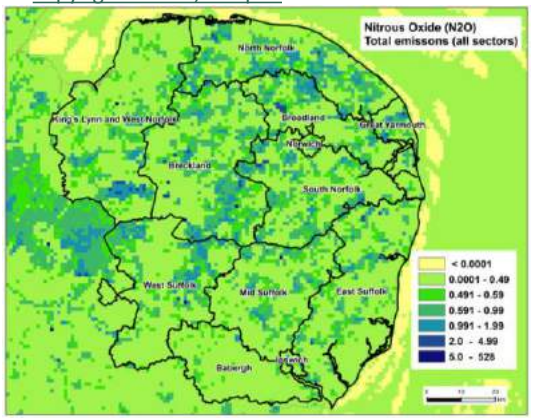
It is widely accepted that global warming, due to greenhouse gas emissions from human activity, is leading to climate change, and that this is one of the greatest challenges for governments and communities to address at this time. The Inter-govermental Panel on Climate Change (IPCC) states -

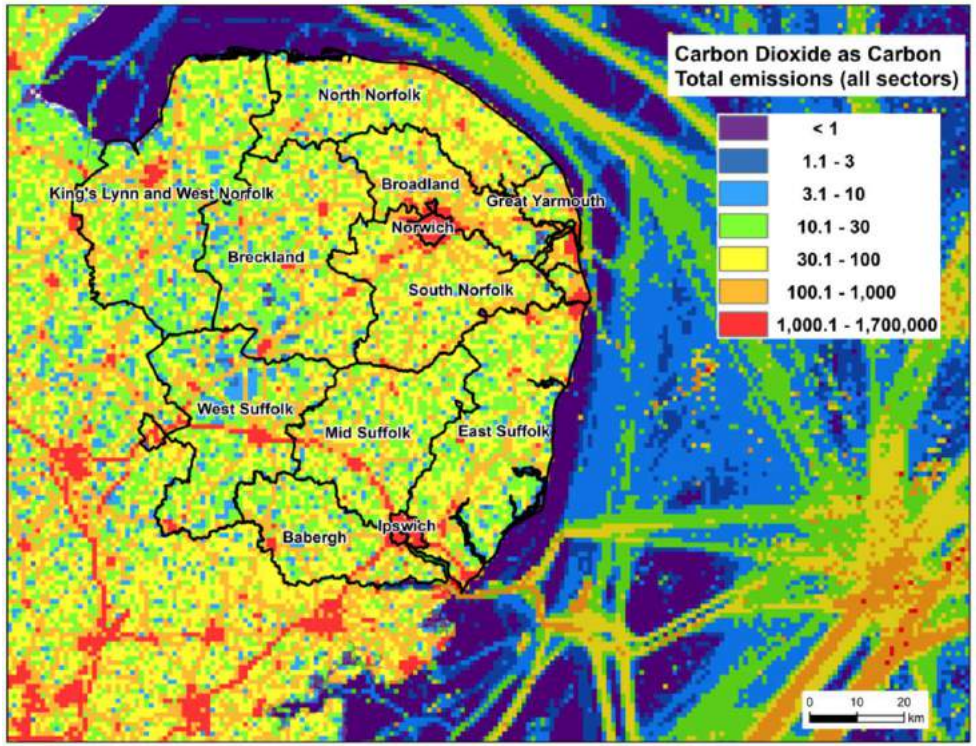
"Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems." IPCC's Fifth Assessment Report (AR5). A 6th Assessment report is due in 2022.

Maps showing emissions of carbon dioxide, plus the more potent gases, methane and nitrous oxide are shown on the right. Although National Atmospheric Emissions Inventory statistics show an overall downward trend in total GHG emissions for Norfolk and Suffolk, emissions from road transport remain reasonably static, making up an increasing proportion of the overall total (see graph below).









Per capita emissions

Progress has been made on reducing emissions but both counties now have higher per capita emissions than the England average (see table right). Per capita emissions need to reduce to -0.4 – 1.7 tonnes/per person /per year to meet the Paris Agreement and limit global mean temperature rise to below 1.5°C.

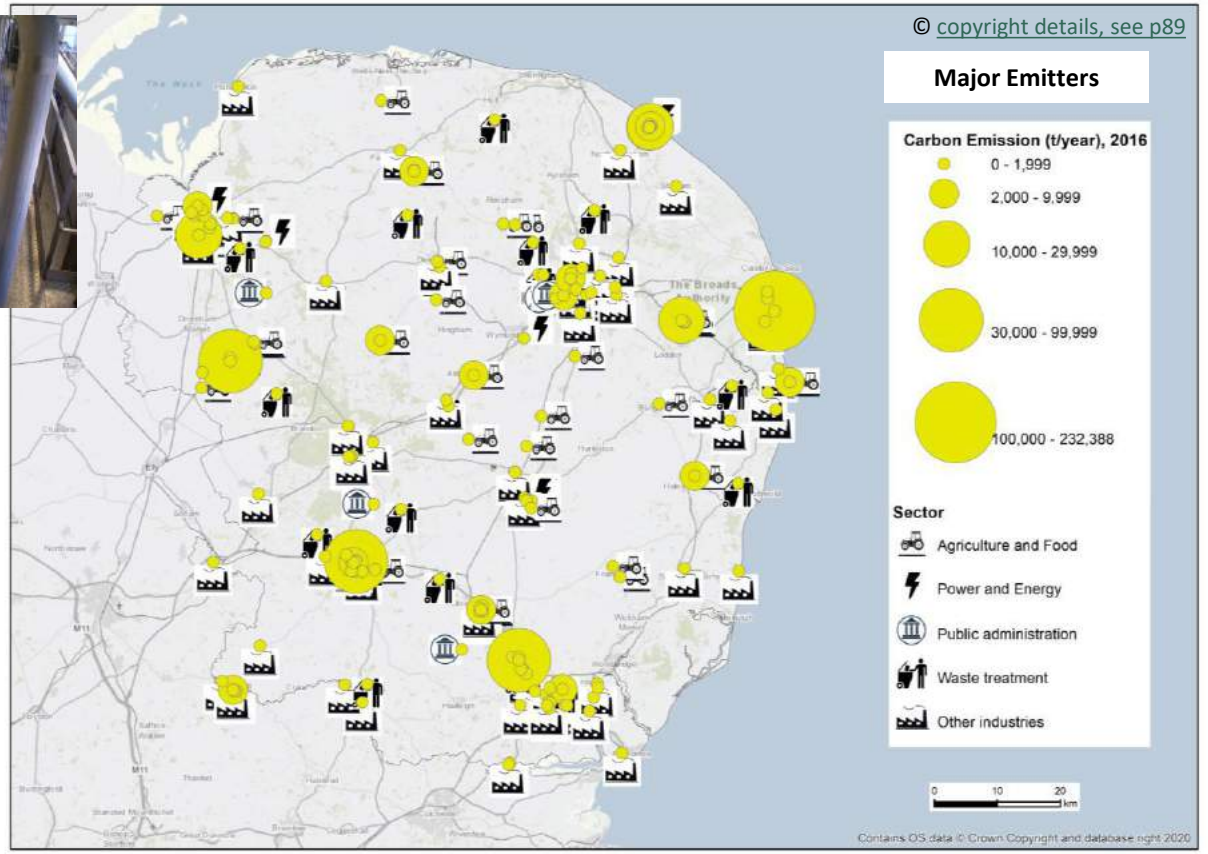
Per Capita (tonnes, CO2 pp/year)			
Year	England	Norfolk	Suffolk
2005	8.5	8.3	8.1
2018	5.0	5.6	5.6

Point source emissions

Data from the National Atmospheric Emissions inventory shows that point-source emitters produce approximately one quarter of CO_2 emissions in Norfolk & Suffolk (map, right). Each point-source on the map is represented by a circle for the amount of emissions and a symbol for the sector involved. There are 37 sources in total, the largest four being the Great Yarmouth power station, the British Sugar factories at Bury St Edmunds and Wissington, and the Suez recycling plant near Ipswich.

The emissions data are reported as tonnes of carbon rather than CO_2 but the total 568,019 tonnes of carbon (in 2016) is equivalent to 2,088,303 tonnes of CO_2. The BEIS emission estimates total 9,232,700 tonnes of CO_2 for Norfolk and Suffolk in 2016 so the 37 point sources account for 22.6% of total CO_2 emissions.

GHG Emissions in Norfolk & Suffolk - major emitters						
NAEI Emissions from Point Sources, (as carbon) tonnes / % share, 2016						
Greenhouse gas	Human-related sources	Agriculture, forestry & fishing	Food, drink & tobacco industry	Power / energy producers	Others	TOTAL CO2e (tonnes)
Carbon dioxide	Fossil fuel combustion/use. Land use changes. Industrial processes.	3,309	302,853	303,248	59,610	568,019
		1%	36%	53%	10%	
Methane	Fossil fuel production, distribution and use. Livestock farming. Landfills and waste. Biomass burning. Rice agriculture.	0.2	24.2	2,348.1	6.2	2,379
		0%	1%	99%	0%	
Nitrous oxide	Agriculture, fossil fuel combustion, industrial processes	0.02	3.18	41.52	0.43	45
		0%	7%	92%	1%	
TOTAL CO2e						570,443



Source: National Atmospheric Emissions Inventory http://naei.beis.gov.uk/data/map-large-source

Assisting businesses that are large point-source emitters (particularly in food processing) transition to a low carbon economy could be an important consideration in a 25 year environment plan for the region.

Risk Review: Introduction

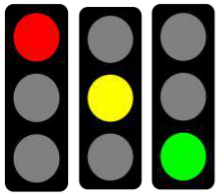
Challenges ahead…

This section reviews ***risks*** to natural assets as gathered from the published literature, regional and national reports. The literature at this time is not well developed with regard to specific local risk; very few local studies have been identified, so differentiation of risk to local assets from the national level is not always possible to assess.

To help address the lack of published information on local risks, two stakeholder workshops were held in Diss and Lowestoft in November 2019 as part of this project. The expert insights and feedback from those who work in organisations locally that have responsibility for the management of the natural assets of Norfolk and Suffolk were invaluable, and are also reflected in this review (see Local insights).

The key objective of this review was to highlight risks to assets that exist now and are likely to exist within the next 25 years. It should be noted that unless specifically stated in the literature, the attribution of 'high' 'medium/ growing' 'low' risk or 'positive' improvement is subjective/ based on the judgement of the participants and reviewer(s) and is therefore open to further interpretation.

Risk review: Key findings



Local insights

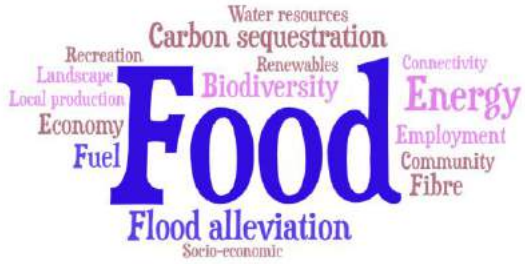
Stakeholder workshops

Stakeholder workshops were held in Diss and Lowestoft in November 2019 as part of this project, to gain expert insights from representatives of a range of local organisations who have an interest in feeding in to the development of the 25 year Environment Plan. Discussion focussed on the four natural asset categories shown below. A number of specific pressures, and risk to particular assets were indicated, along with the additional cross-cutting pressures of climate change, population growth and urban expansion and development. Highlighted ecosystem services most thought at risk were food, water, wildlife and flood alleviation.

Pressures on natural assets identified by local experts (shown as word clouds where the size of the word or phrase indicates relative importance)

Land

ES benefits at risk



Habitats & species

Freshwater

Coast & Marine

Source: Local expert opinion from workshops held in November 2019.

Risk Review: Key findings

Risks at a glance: The literature and expert opinions from the workshops have been synthesised to identify the most vulnerable indicators within the natural asset groups using a 'traffic light' system to identify high risk, medium or growing risk or low risk to the assets.

Pressures and risks:

There are a number of key issues that have a bearing on all asset categories:

- Climate change (the stand-out pressure across all asset categories)
- Population growth / Urban expansion

(See Regional Context section).

The risks resulting from these (e.g. loss of land to other uses, impact on quality of assets) are included in the risk review.

In addition, for each asset type there may be more specific associated threats (e.g. invasive species, sea level rise). These are also included in the review.

	Land	Soil & Sub-Surface	Habitats & Species	Freshwater	Coast & Marine	Atmosphere
High risk *Mentions/ suggestion of 'high risk' from the literature or workshops*		Aquifers Peat	Saltmarsh & coastal habitats Wetlands & grazing marsh Priority/iconic species Priority habitats	Water availability Surface water quality		Greenhouse gas emissions Point source emissions
Growing or medium risk *Mentions/ suggestion of 'medium risk' or 'growing risk' from the literature or workshops*	Food producing land Productive woodland Carbon density in vegetation Land under conservation management Land types	Soil physical properties Soil biological properties	Habitat connectivity Natural woodlands Extent & condition of SSSIs Lowland heath & dry acid grasslands	Groundwater quality Chalk rivers Flood risk Recreational use of waterways	Marine habitats & protected areas Seabirds & migrating birds Fish stocks Shellfish stocks Recreational use of coasts	Air quality: particulates
Low or reducing risk *Mentions/ suggestion of 'low risk', 'no risk' or 'reducing risk' from the literature or workshops*	Recreational use of land	Soil chemical/ nutrient status Minerals			Marine mammals	

Risks to Land

Recent reports on climate change and land (IPCC, 2019; CCC, 2020b) examine the role of land in GHG emissions and sequestration, and risks from a warming climate to ecosystem services (net primary production, food, feed, fibre, timber and energy). Sustainable land management will be critical to reducing impacts on ecosystems and society. Measures needed include sustainable food production and forest management, soil organic carbon management, ecosystem conservation and land restoration, dietary changes and reduced food loss and waste (IPCC, 2019; CCC, 2020b). The NFU have set out how they will work with the farming community and are aiming for net zero emissions from agriculture by 2040 (NFU, 2019); a Forestry Climate Change Adaptation Action Plan has been drawn up by a consortium of organisations to determine a strategy for woodland management to mitigate climate change (FCCWG, 2018); and the Wildlife Trusts are responding to the climate emergency with habitat restoration projects and supporting the national Nature Recovery Network proposed in the UK 25 Year Environment Plan (https://www.wildlifetrusts.org/climate-emergency 1/07/20; DEFRA, 2018).

Local organisations, farm businesses and others will be participating in these and other nationally-led initiatives (e.g. the GB non-native species strategy) to reduce the impacts of a range of identified risks across the land attributes highlighted in this asset section.

To complement these initiatives, further local studies would be valuable in setting the benchmark for tackling locally significant risks. Those risks identified from the general literature plus issues raised during the stakeholder workshops are shown right. A full list of literature consulted is given in the References section.

Land Risk Review Key Messages

Land types

Growing risk All land types at risk of degradation due to **climate change** and at risk of loss due to **urbanisation** and **sea level rise**.

Food producing land

Growing risk from **limited water availability** impacting on food production. Risks to productivity from **climate change**, **poor management** impacting soils, biodiversity; **diffuse pollution** impacting surface / groundwater. Some potential for new crop types due to climate change.

Productive woodland

Growing risk from **pests, pathogens and invasive species** and from **climate change** induced wildfires and storm/ drought extreme weather events.

Land under conservation management

Growing risk to species and habitats from direct impacts of **climate change** and **sea level rise**.

Recreational use of land

Low risk Some risk from **urban development** and potential loss of greenfield sites but with the possibility of increased urban green infrastructure.

Carbon density in vegetation

Growing risk Carbon stored in vegetation plays a vital role in climate regulation. Fire risk and drought (enhanced by **climate change**) could impact the amount of carbon stored.

Risks to Soil & Sub-Surface

Soils are the second largest carbon sink after the oceans. Rising temperatures and precipitation changes due to global warming exacerbate soil erosion and fertility but positive management of soils provides an opportunity for climate change mitigation. Soil carbon management measures are potentially applicable across many land-uses and peatlands can continue to sequester carbon for centuries (IPCC, 2019). However poor management of peatlands poses a risk of 'positive feedback' where release of carbon from eroding peat further enhances global warming (POST, 2006). The Environment Agency's 'State of the Environment Soil report' states -

"Soil carbon loss is an act of economic and environmental self-harm. If we are serious about the Committee on Climate Change's target of net zero by 2050, then we need investment, regulation, better management of our bogs and peatlands, and collaboration with, and between, farmers." (State of the Environment Soil Report; EA, 2019)

The Environment Agency point to insufficient data on the health of soils with investment needed in soil monitoring. In England and Wales over 2 million Ha of soil are at risk of erosion and almost 4 million Ha are at risk of compaction, affecting soil fertility and water resources and increasing risks from flooding. Soil biodiversity and the processes and functions it supports are potentially at risk with intensive agriculture causing arable soils to lose 40 - 60% of their organic carbon and further research needed to assess the effects of microplastics in soils entering the food chain (EA, 2019).

Diffuse pollution, largely from agriculture is a continuing issue for surface and groundwater quality (EA, 2019). This and over-abstraction are a significant problem for the region's aquifers.

As with other asset categories, data that could help characterise risks to soil and sub-surface assets in specific locations within Norfolk & Suffolk is not readily available.

Soil / Sub-Surface Risk Review Key Messages

Soil physical properties

Growing risk **Climate change** – drier summers increasing wind erosion, soil shrinkage and subsistence risk; loss of soil carbon; wetter winters water-bourne soil loss.

Soil biological health

Growing risk Intensive agriculture has caused arable soils to lose organic carbon & **climate change** could exacerbate organic matter decomposition. Implications of soil **microplastic contaminants** currently unknown.

Soil chemical / nutrient status

Low risk Potentially decreasing risk due to better controls: **Nutrient overload** from over-application of agricultural products and from atmospheric deposition.

Aquifers

High risk Due to increasing demand and **over abstraction**, increasing risk from **saline intrusion**.

Peat

High risk from **climate change** causing oxidisation of peat soils in fen habitats reducing habitat extent and quality, risking natural carbon stores / with accelerated peat erosion & risking increased carbon emissions.

Minerals

Low risk Risk of **soil and water/groundwater contamination** and **flooding** arising from extraction/ landfill activities. (Controls exist).

Risks to Habitats & Species

Risks to habitats and species are well documented and include habitat loss, fragmentation and loss of habitat quality resulting from pressures including climate change, land use change, intensive agriculture, nutrient enrichment, pollution, disturbance, pests & diseases and invasive species. The creation of a 'Nature Recovery Network' to provide a 'resilient and coherent ecological network' forms part of the government's 25 Year Environment Plan (DEFRA, 2018) and response to these pressures. This aims to provide an additional 500,000 hectares of wildlife habitat, more effectively linking current protected sites and landscapes, urban green spaces and waterways. Guidance for the development of Nature Recovery Networks has been published by Natural England (Crick *et al.,* 2020). This will be facilitated through the planning system and delivered locally by a partnership of organisations and land owners supported by the new Environmental Land Management Scheme.

The impacts of coastal erosion compounded by projected rise in sea level will bring significant risks to coastal habitats. These are highlighted below:-

- Projected rises in sea level will have significant impacts by accelerating the natural erosion of coastal and intertidal habitats, and by changing the pace and nature of natural geomorphological processes. Soft cliffs and the vegetation communities that grow on them will be particularly affected, especially in the south and east of England, where the land is sinking slightly. ***High confidence***
- Rising sea levels will result in conflict between (i) the need to maintain intertidal and coastal habitats (e.g. dune systems) by allowing the natural movement of coastlines and through managed realignment and (ii) the need to protect valuable inland coastal habitats (e.g. grazing marsh, saline lagoons and freshwater coastal lakes). ***High confidence***
- Coastal species and habitats will be subject to further coastal squeeze where coastal defences are maintained or enhanced or where hard infrastructure exists, preventing natural habitats rolling back inland. ***High confidence***
- Projected future losses in the extent of saltmarshes and mudflats will have significant impacts on overwintering bird populations and the invertebrates that they support. ***High confidence***
- Coastal grazing marshes, raised bogs and saline lagoons are all threatened by increases in salinity due to increased percolation and inundation of sea water during storm tides and flooding. This will ultimately cause their transformation into saltmarsh or other intertidal habitat. ***Medium confidence***
- Increased winter rainfall could lead to the softening of the surfaces of cliffs and, when coupled with potentially higher water tables, could result in higher rates of cliff erosion. Increased winter rainfall may also lead to more frequent summer landslips as a result of groundwater movement. ***Medium confidence***

(Morecroft et al, 2015. LWEC Programme)

Habitats & Species Risk Review Key Messages

Priority habitats

High risk to due to **climate change**, loss of habitat to **sea level rise**, **coastal erosion**, **flooding,** increased incidence of **pests & diseases, invasive species, urbanisation**.

Extent & condition of SSSIs

Medium risk of degradation through lack/ reduced frequency of monitoring/ **appropriate management**.

Habitat connectivity

Growing risk due to **increasing development** / urbanisation in an already fragmented landscape.

Natural woodlands

Growing risk potential for enhanced carbon storage via increased woodland planting. **Climate change** may impact e.g. beech woodland; frequency of droughts and storm events, pressures from **pests & pathogens** may increase due to climate change. Deer/squirrel damage.

Lowland heath & dry acid grasslands

Growing risk risks from **pollution** (nitrogen deposition) and **climate change,** particularly risk of **seasonal fires** and change in precipitation levels leading to change in species composition.

Saltmarsh & coastal habitats

High risk due **to coastal erosion/ sea level rise, invasive species, nutrient enrichment.**

Wetlands & grazing marsh

High risk due to **climate change** – wetlands drying out; **eutrophication, oxidisation of peat**, reducing habitat extent and quality.

Priority/iconic species

High risk due to **climate change** impacting habitat, food availability, phenology; risks from **pests, diseases and invasive / colonising species** due to range changes.

Risks to Freshwater

In the National Risk Register for Natural Capital, Mace *et al.* (2015) identify freshwater as a natural asset category with 'most benefits at risk'. Despite many improvements and initiatives, freshwaters continue to be affected by other land uses. In Norfolk & Suffolk the high area of agricultural land use, anticipated urban expansion, and the implications of climate change in a relatively dry part of the country heighten these risks (ASC, 2016).

An evaluation and summary of the risks drawn from the literature and stakeholder workshops is shown right and the table below shows the types of ecosystem services at risk. A full list of literature consulted is shown in the References section.

A stand-out risk both now and into the future is regarding water availability. WRE (2020) are predicting **net projected deficit of around -200Ml/d by 2050.** With little surplus water currently available a wide range of measures will need to be implemented to avoid the realisation of this projection. If the water availability question is not addressed, this will impact negatively on other freshwater indicators (surface and groundwater quality and chalk rivers in particular) that are also directly influenced by these pressures.

Photo: River Wensum (K.Hiscock)

Indicator	Ecosystem services impacted by change			
	Supporting	Provisioning	Regulating	Cultural
Surface water quality		Y		Y
Groundwater quality		Y		
Water availability	Y	Y	Y	
Flood risk		Y	Y	
Chalk rivers	Y	Y		Y
Recreational use of waterways				Y

Freshwater Risk Review Key Messages

Surface water quality

High risk to clean water provision due to **increasing demand** and **pollution** from agriculture and urban areas leading to further stress on water body status. Many of the areas targeted for **urban expansion** coincide with those where pressures on water resources already exist.

Groundwater quality

Growing risk to groundwater quality due to **over-abstraction, diffuse pollution** and potential for **saline intrusion** due to **sea level rise** with implications for drinking water supplies.

Water availability

High risk: Norfolk & Suffolk catchments are in Irrigation abstraction 'hotspots' where catchments are already water stressed and where **abstraction** for irrigation is most intense. There is a projected deficit in future supply over demand. **Climate change** may further impact water availability.

Flood risk

Medium risk due to **urban expansion** and surface water flooding from **impermeable surfaces** but with the potential to mitigate flood risk through floodplain and wetland management. More intense rainfall due to **climate change** may exacerbate flooding.

Chalk rivers

Growing risk to biodiversity due to **pollution** (nitrates/ algal blooms) and **invasive species**.

Recreational use of waterways

Medium risk because freshwaters play a critical role for tourism in the region. Deterioration of **water quality** could have major implications for recreation opportunities and tourism.

Risks to Coast & Marine

The UK Marine Strategy sets out a framework for assessing, monitoring and setting targets for achieving 'Good Ecological Status' (GES) for 60 indicators relating to the marine environment and reports that GES has largely been achieved for eutrophication, hydrographical conditions, contaminants and contaminants in seafood (DEFRA, 2019). However, issues remain relating to some marine mammals, fish populations, food webs and marine habitats. The report stresses that vigilance is required regarding emerging chemical threats and major offshore infrastructure projects that may impact marine life (DEFRA, 2019).

The latest report on the associated regional East Marine Plans (DEFRA, 2020b) points to progress in designating Marine Protected Areas and in work towards a healthy marine ecosystem. However, it also points to risks associated with expansion of the wind energy sector (see offshore activity) which suggests that cumulative impacts are increasing pressure on bird species and cetaceans and that policies on potential interactions need updating (DEFRA, 2020). There is no clear indication of impact from the removal of marine aggregates. No coastal priority habitats were shown to decline between 2014 – 2019.

The stand out risk, for this section of natural assets, is with respect to the coastline. Norfolk & Suffolk have one of the fastest eroding coasts in Europe (Sustainability East 2012), the risks of which will be heightened by global warming induced sea level rise (see environmental change). Shoreline Management Plans outline defence strategies for each stretch of coastline which may include maintaining current defence structures, building new ones (e.g. 'sandscaping' project at Bacton, Norfolk), or realignment to enable the coastline to move (within limitations) to minimise negative impacts (e.g. Titchwell Marsh, Norfolk).

Coast & Marine Risk Review Key Messages

Marine habitats & protected areas

Growing risk issues identified as 'gaps' in East Marine Plan – **invasive species, marine litter, underwater noise, water quality**. Also risks from **offshore infrastructure** to benthic and pelagic habitats, **pollution risks** but potential benefits from artificial reefs. **Increase in ocean temperatures and acidification** due to **global warming**.

Fish stocks

Medium risk Fish stocks are managed but many are still in an 'undesirable' state. Impact of Brexit fisheries policy will need monitoring. **Increase in ocean temperatures** due to **global warming** may alter fish distribution.

Shellfish stocks

Growing risk from **climate change** and **increasing sea temperatures; ocean acidification** and **invasive species** and **diseases**.

Marine mammals

Low risk – seal populations are growing; seals are highly adaptable but may be impacted by **disturbance** from visitors and **offshore infrastructure** developments.

Seabirds & migrating birds

Medium risk Most Greater North Sea breeding seabird populations are not achieving good ecological status; reasons need more investigation. **Wind turbine collisions** need monitoring as such developments expand.

Recreational use of coasts

Medium risk from **sea level rise** and loss of natural assets e.g. beaches; change in public attitudes to offshore developments as views impacted.

Risks to Atmosphere

Maintaining an 'equable climate' delivered by atmospheric processes, requires a major and urgent global and local effort to address greenhouse gas induced global warming and climate change, which will impact many dimensions of future sustainable development. The seriousness of this problem is reflected in the decision of the UK government to adopt a target of net zero greenhouse gas (GHG) emissions by 2050 and declarations of a 'Climate Emergency' by many local government bodies.

A climate emergency

https://www.climateemergency.uk/

'Suffolk county councillors vote to declare a 'climate emergency' … Overwhelming agreement to work towards cutting greenhouse gas emissions with the aim of the council becoming carbon neutral by 2030'. PUBLISHED: 07:30 22 March 2019
https://www.eadt.co.uk/business/councillors-in-suffolk-vote-to-become-carbon-neutral-1-5952434

North Norfolk – 'Council the first in county to declare climate emergency… councillors were applauded after they unanimously agreed to declare a Climate Emergency and recognise "the devastating impacts" of global temperature change.'
PUBLISHED: 23:14 24 April 2019
https://www.northnorfolknews.co.uk/news/north-norfolk-district-council-declare-climate-change-emergency-1-6014754

Local priorities for climate change mitigation and adaptation were proposed in a report for the New Anglia LEP (Lovett et al, 2019) and are reflected in the Local Industrial Strategy (NALEP, 2019). These include:-

- **The Domestic Sector** – Adapting building stock and evaluating alternative means of heating provision to meet decarbonisation targets and reduce reliance on oil.
- **The Transport Sector** – Decarbonising transport by increased use of public transport and electric vehicles.
- **The Agricultural Sector** – Prioritise improved water management, both in terms of increased storage capacity and greater use efficiency (e.g. reservoirs and transfer schemes). Enhance carbon sequestration through improved cultivation and soil management.
- **The Food Processing Sector** – Support local business in reducing point source GHG emissions.
- **The Energy Sector** – Renewable energy generation will need to further increase to meet a growing demand for electricity, particularly from domestic and transport sectors. Present constraints on the capacity of the electricity transmission and distribution network in many parts of Norfolk and Suffolk will need to be addressed.

Atmosphere Risk Review Key Messages

Air quality: particulates

Medium risk of health and environmental impacts from particulates with increasing **urbanisation**. However, the transition to electric vehicles should herald a decline in particulate emissions in the future.

Greenhouse gas emissions

High Risk from greenhouse gas induced **global warming**. Per capita emissions of CO_2 in 2018 were 5.6 tonnes in Norfolk and Suffolk; higher than the England average of 5.0 tonnes. Per-capita emissions compatible with the Paris Agreement to limit global warming to 1.5°C would require emissions to reduce to -0.4 to 1.7 t/yr. Emissions from the transport sector make a significant contribution to total emissions. Agriculture makes a significant contribution to Methane and Nitrous oxide. Population growth and economic development mean meeting the current government 'net zero' target will require determined and imaginative policy development and implementation.

Point source emissions

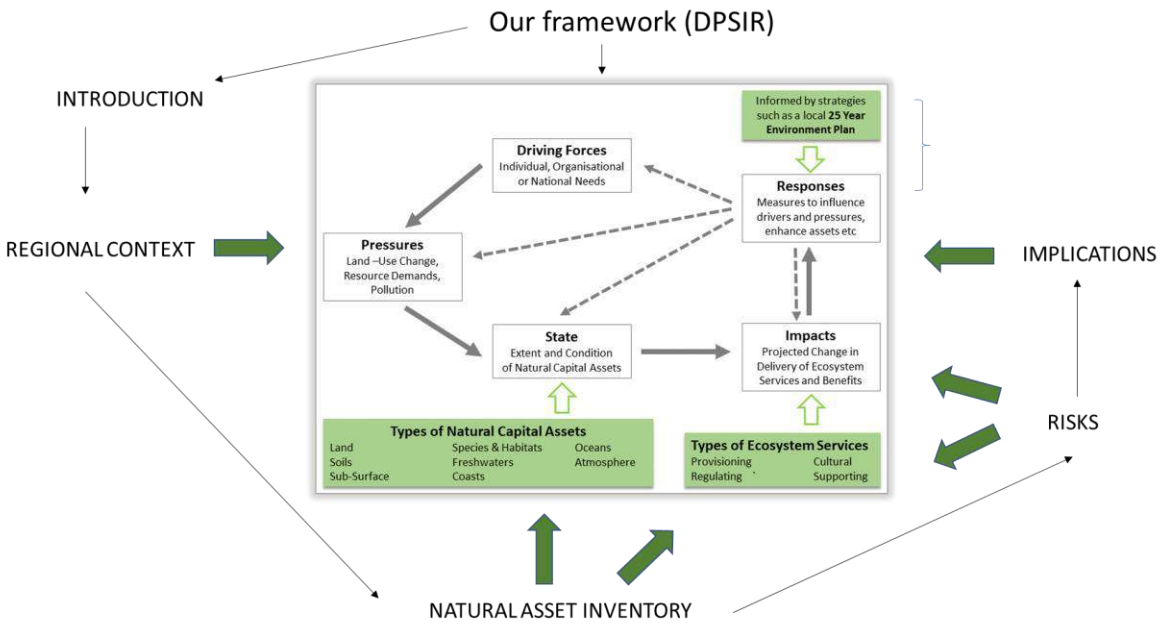
High risk from greenhouse gas induced **global warming**. Point source emissions account for around 25% of Norfolk & Suffolk's greenhouse gas emissions. These sources could be beneficial to target as emitters and options for reductions are known.

Implications: Introduction

Closing the circle…

In this Evidence Compendium we have used the DPSIR framework (as shown right, and introduced on page 5) to examine ***driving forces*** and ***pressures*** in the information presented under Regional Context, discussed data on the ***state*** (extent and condition) of key natural assets in the Asset Inventory, and looked at the ***impacts*** on these assets in the Risk Review.

In this section we aim to synthesise the Implications from this evidence base and outline *priorities* and *next steps* for consideration in the development of ***responses*** for inclusion in the local Norfolk & Suffolk 25 year Environment Plan.



STATE

IMPACTS

RESPONSES

Implications: Key findings

Nationally important assets

Norfolk and Suffolk represents 7% of England's land area, and in 2018, supported 3% of its population. However, the counties are important for a larger proportion, over 10%, of a variety of England's natural assets. These span provisioning, regulating and cultural ecosystem services, plus significant biodiversity, terrestrial and marine designations. The land, coast and sea of Norfolk and Suffolk therefore make a substantial contribution to the nation's natural assets.

Locally significant assets

The five key natural areas of Norfolk and Suffolk, in particular, offer protection for priority habitats and species. However, increasing risks from climate change, sea level rise and limited State: Locally significant assets water availability, could impact the quality or extent of these areas. Improving habitat connectivity across the whole area will enhance wider landscape resilience. The development of natural capital accounts also highlights the role of natural assets in carbon sequestration, facilitating recreation and nature-based tourism.

Vulnerable ES & Benefits

Four of the ten examples of nationally important assets are also classed at high risk and therefore require particular attention in any plan to maintain and enhance natural capital. However, important assets are not simply concentrated in the key natural areas and are widely dispersed across Norfolk and Suffolk. This needs to be recognised in future initiatives, with efforts made to enhance local environmental features on a wider landscape scale.

Identified Needs

Working with local organisations to implement monitoring programmes that could provide locally relevant or specific indicators for inclusion in the Norfolk and Suffolk Plan would assist development of the programmes needed to enhance specific natural assets or locations in the two counties. An additional requirement is specific assessments that can help to evaluate where risk to local natural assets may vary from the national picture.

Priorities

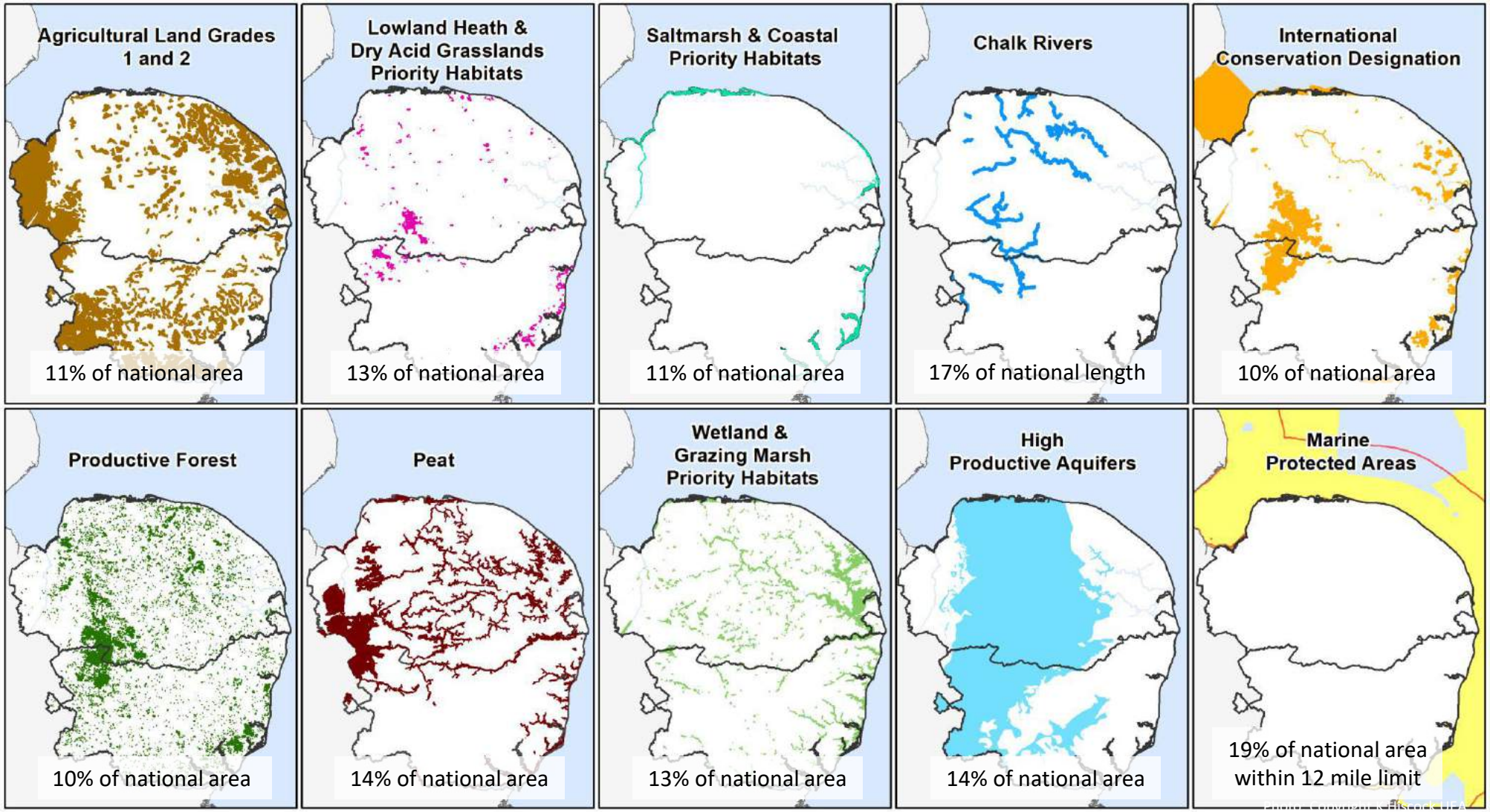
Seven priority areas relating to key risks to the natural assets of Norfolk and Suffolk have been identified from this work. Within the process of accommodating urban expansion and supporting economic prosperity, the implementation of measures to conserve water, reverse habitat fragmentation and create new habitat areas will be vital. Additionally, measures to support soil protection and carbon sequestration, and to work with point source GHG emitters, provide opportunities for climate change mitigation. Measures to ensure vigilance in relation to sustainability and biosecurity on land, and in the freshwater and marine environments, as well as extreme climatic events such as storms and wildfires will also be important considerations in a local 25 year plan.

Next steps

Next steps include dissemination of the findings of this work; identification of monitoring needs and more locally specific or relevant indicators of the state of natural assets in the two counties; creating of new monitoring programmes to address these data gaps and establishment of a stakeholder-driven process feeding into the development of the Norfolk and Suffolk 25 Year Environment Plan.

State: Nationally important assets

Norfolk and Suffolk constitute 7% of the land area of England and in 2018, supported 3% of its population. As the maps to the right show, the counties include over 10% of a variety of natural assets and protected areas. These examples span provisioning, regulating and cultural ecosystem services, as well as aspects of biodiversity and terrestrial and marine designations. The land, coast and sea of Norfolk and Suffolk therefore make a substantial contribution to the total stock of England's natural assets.



State: Locally significant assets

Alongside the key, nationally significant, natural areas of Norfolk and Suffolk it is also important to appreciate the role of locally significant assets such as woodland patches, hedgerows and ponds. This is particularly true when thinking on a 25 year horizon, since the risks from climate change, sea level rise and limited water availability, are likely to adversely impact the quality of certain existing habitats (e.g. wetlands & heathlands) or their extent (e.g. salt marsh). More initiatives are therefore needed to develop partnership working between conservation groups, farmers and landowners to enhance local assets and increase resilience within the wider landscape and coastal zone. Facilitating schemes to enable habitats to extend and link, providing 'stepping stones' to facilitate the mobility of species, will allow them to respond to changing conditions rather than be restricted in unsuitable habitat 'islands'. Achieving this objective will also require better information on the extent and quality of assets such as hedgerows and ponds, as well as monitoring and accounting frameworks to document progress in improving environmental assets and benefits.

Natural Capital Accounting

Natural capital accounting aims to provide a standardised framework for assessing change in natural capital and ecosystem services provided, whether these have a market value or not, helping to communicate the state of natural assets within a given area (DEFRA, 2020). At present, such accounting is in its infancy and methodologies are under extensive discussion (e.g. Turner *et al.*, 2019). This is due, in part, to the data requirements involved, but also reflects debates regarding both the feasibility and desirability of placing monetary values on environmental assets (Lovett, 2019).

The Office for National Statistics has produced a series of estimates working towards a UK natural capital account. Valuations from the latest report (ONS, 2019c) are shown on the upper table to the right. In total the assets are valued at just under £950 billion, though this is a partial assessment and does not include biodiversity or many types of cultural services. Provisioning services are generally the most straightforward to value because they often have a market price associated with the benefits and others such as carbon sequestration or recreation are where there has been the greatest development of techniques for non-market valuation. It would be unwise to interpret the values in the table too precisely, but what should be noted is their relative magnitude. In particular, recreation is by far the largest component (41% of the total) and the valuation of carbon sequestration is nearly equivalent to that of all agricultural production.

Recent research at UEA (Badura *et al.*, 2020) has developed a Complementary Accounts Network approach for natural capital decisions in the context of a wider project for the European Commission and demonstrated it with an application to Norfolk and Suffolk. Results for two example ecosystem service accounts are shown in the lower table to the right. That for nature-motivated tourism reflects the share of economic activity (i.e. GDP) generated through visits to the region arising from its natural landscapes and coastlines. The increase between 2012-18 is a manifestation of the increasing economic importance of natural assets in the two counties. Carbon sequestration is another important consideration in the region, though the results in the table illustrate that much depends on the basis of valuation (i.e. damage cost avoided or market exchange). As experiences with valuation methods evolve and the underlying databases improve so the scope for natural capital accounts to complement and inform a 25 Year Environment Plan will improve.

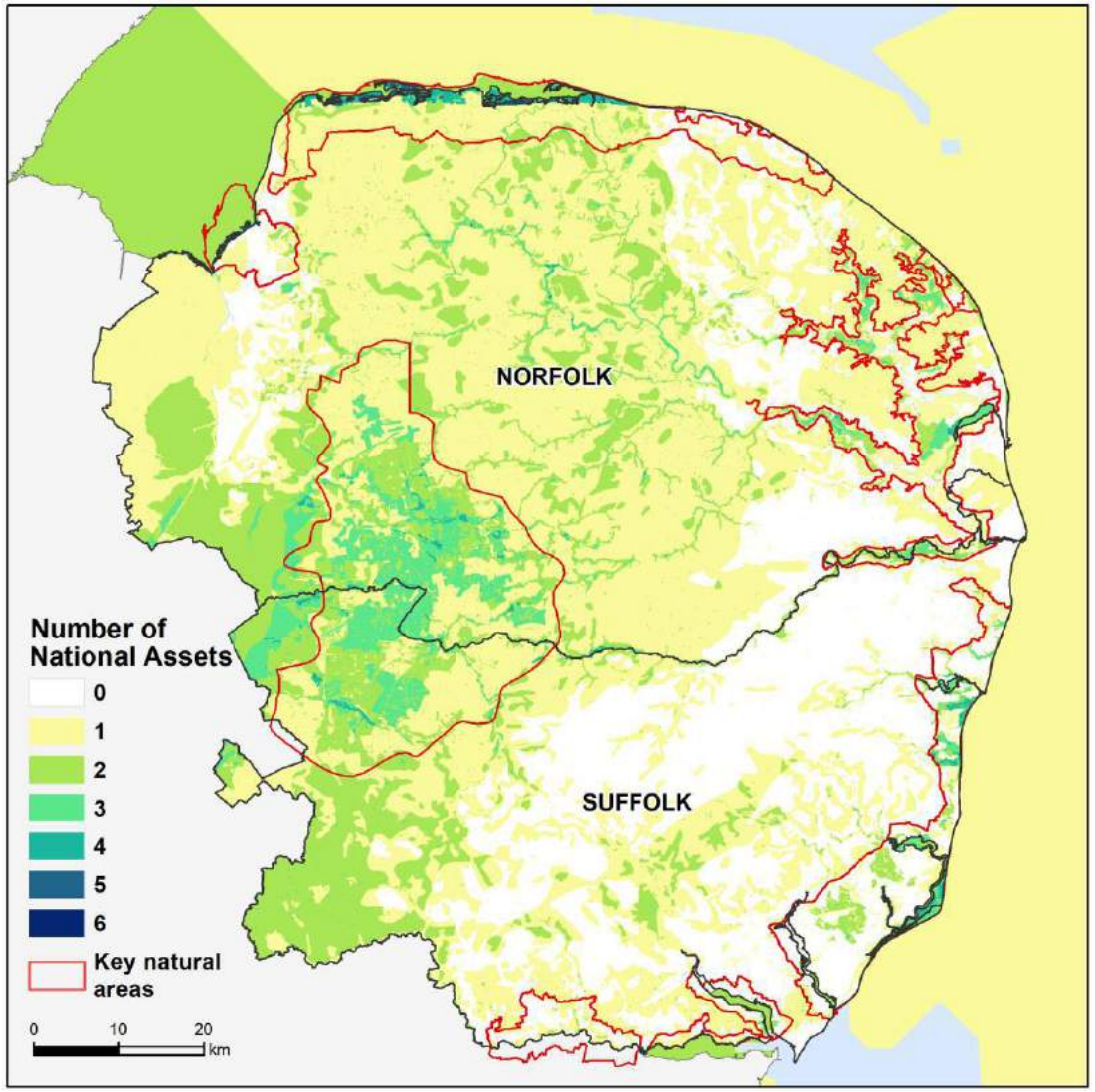
UK Ecosystem Services Assets	£ Million
Provisioning Services	£319,552
of which agricultural biomass	£118,426
Regulating Services	£158,497
of which carbon sequestration	£103,947
Cultural Services	£471,687
of which recreation	£393,707
Total	£949,736

Norfolk & Suffolk Accounts		£ Million
Nature-motivated tourism	2012	£87
	2018	£117
Carbon sequestration in 2018	Social Cost	£334
	EU ETS	£26

Impact: Vulnerable Ecosystem Services and Benefits

The table below shows the outcome of comparing the ten nationally important assets against the key findings of the Risk Review.

Risk Category	Nationally Important Assets
High	High productive aquifers
	Peat
	Saltmarsh & coastal habitats
	Wetlands & grazing marsh
Medium	Grade 1 & 2 agricultural land
	Productive forest
	Chalk rivers
	Marine Protected Areas
	International conservation designations
Low	Lowland heath & dry acid grasslands



Four assets are in the high category and several of these are also in environments which are important for recreation and nature-motivated tourism. These features therefore clearly require particular attention in any plan to maintain and enhance natural capital. However, it is essential to also recognise that key natural assets are widely dispersed across Norfolk and Suffolk. The map to the right shows the result of overlaying the 10 nationally important assets. Only 28% of the land area in the two counties has no such asset present, 67% has one or two and just 5% three or more. Key natural areas such as Breckland, the Broads and the coastal AONBs all have higher proportions of their area (at least 10%) with three or more assets, but much important natural capital occurs outside them. It is also important to recognise that there are wider functional connections across landscapes (e.g. via water flows in river catchments). As a consequence, initiatives in areas currently without such assets (the 'white space' on the map) might well improve quality further afield and indeed may be places where the greatest benefits could be achieved from investments in the local environment.

Response: Identified needs

Local indicators

As previously indicated, the majority of the datasets presented in this work are national in extent and granularity can be an issue in terms of local interpretation. This is also true for several, apparently more specific datasets (e.g. on soil microbes, pollinating insects, etc.) that are extrapolated nationally from a relatively small number of samples.

Working with local organisations to identify monitoring programmes that could provide locally relevant or specific indicators for inclusion in the Norfolk & Suffolk 25 Year Environment Plan would assist development of the programmes needed to enhance specific natural assets or locations in the two counties.

For example, improving habitat connectivity has been highlighted as important, but better data is needed on features such as hedgerows and ponds. Improved details of peat resources, indicators for 'iconic' species in key habitats, and pollinating insects that perform beneficial ecosystem services are other examples that would help determine locally important needs and ensure these are addressed.

Local risk analysis

Alongside the need for local indicators are specific assessments that can help to evaluate where risk to local natural assets may vary from the national picture. For example, with a vulnerable coastline of sand and shingle beaches and ageing coastal defences, the rate of coastal erosion will be an important future indicator of the status of coast as a natural asset in its own right. A National Coastal Erosion interactive map and Shoreline Management Plans are available from the Environment Agency. The detailed scale of these datasets make them inappropriate to include in this Evidence Compendium, but their content will be an important consideration for the Norfolk & Suffolk 25 Year Environment Plan. A means of 'upscaling' this information is needed to establish appropriate responses that can be incorporated into such a plan.

Information gaps

- Datasets to indicate change in asset *quality*.
- Local monitoring data representing *locally significant* assets that has *regular updates*.
- Impact of post-Brexit policy change e.g. replacement fisheries policy.
- A *systematic assessment* of habitat connectivity potential, ponds, hedgerows & peatlands across the two counties.
- *Local assessment of risk* to locally important assets (e.g. developing a coastal erosion indicator).

Response: Priorities & next steps (1)

Drawing on the information gathered in this work regarding the ***state*** of natural assets and ***risks*** identified, the following **seven priority areas** are suggested for consideration in the development of a local 25 year environment plan.

	Priority	Rationale & Evidence
A	**Develop a policy framework & programmes to safeguard water availability within planning control and other spheres of influence.**	***Rationale:*** *Safeguarding water availability is vital to ensuring protection of natural assets and meeting environmental and economic goals.* ***Evidence:*** p46, p65, p69
B	**Support policy and programmes for sustainable land management across whole landscapes to safeguard biodiversity, soil & water quality, food production and access that benefits health and wellbeing.**	***Rationale:*** *Provides the foundation for nature recovery, supports a wide range of ecosystems services and associated benefits.* ***Evidence:*** p17, p18, p20, p25, p26, p27, p28, p29, p44, p45, p49, p57, p66
C	**Develop a policy framework & programmes to reduce greenhouse gas emissions though planning control, to ensure energy efficiency & sustainability in new build, support retrofit in older buildings, decarbonise heating prioritising off-gas areas & by working with & targeting support at large point-source emitters.**	***Rationale:*** *Climate change is one of the greatest threats to natural assets and economic goals. Action to reduce GHG emissions is urgent.* ***Evidence:*** p61, p62, p65, p71
D	**Develop a policy framework & programmes to support carbon sequestration initiatives (e.g. through peatland restoration & measures to enhance soils & their organic content).**	***Rationale:*** *Carbon sequestration offsets GHG emissions and produces a wide range of benefits to natural assets.* ***Evidence:*** p21, p26, p29, p65, p66, p67
E	**Develop policy & programmes for partnership working to increase species richness, abundance and ecological resilience by managing existing habitats, improving habitat connectivity and enabling habitat & species migration (especially in coastal areas).**	***Rationale:*** *Supports nature recovery and mitigates the risks from sea level rise, climate change, pests & diseases and development pressures.* ***Evidence:*** p19, p33-41, p48, p52-56; p68, p70
F	**Support policy and programmes to improve biosecurity (e.g. raise awareness of, and provide early alert to, invasive species, pests and diseases).**	***Rationale:*** *Mitigation of risks to ecosystem services such as food production (both on land and sea) and fibre production.* ***Evidence:*** p18, p33, p37, p39, p41, p66, p69, p70
G	**Assess natural asset vulnerability & develop contingency planning in preparation for increasing likelihood of extreme climate events e.g. droughts & wildfires, floods, extreme storms and associated amplified coastal erosion.**	***Rationale:*** *Mitigation of risks to new developments, coasts, priority habitats & food producing land from climatic events.* ***Evidence:*** p47, p61, p65, p71

Response: Priorities & next steps (2)

The **seven priority areas** identified for Norfolk and Suffolk, map to natural capital elements within the UK 25 Year Environment Plan (DEFRA, 2018; see Box, lower left) and will align with national programmes outlined within it e.g. Nature Recovery Networks (Crick et al., 2020) and the new post-Brexit Environmental Land Management (ELM) scheme. Existing policies and programmes that support natural assets e.g. the Regional Invasive Species Management Plan for the Eastern region (Kenworthy *et al.*, undated); local waste management strategies (UK 25 YP policy area 4, see below) and the East Marine Plan (DEFRA, 2014) (UK 25 YP policy area 5) will also need to be linked to the Norfolk & Suffolk 25 Year Environment Plan, as will the inclusion of better data on locally important indicators and risk appraisal. Additionally, the learning experiences of the recently concluded Suffolk Marine Pioneer project (SMP 2020) regarding approaches to and processes for partnership working, provide a good blueprint for furthering the natural capital approach in the development of the Norfolk & Suffolk 25 Year Plan.

UK 25 Year Environment Plan:
Six key policy areas

1. Using and managing land sustainably [B], [C], [D], [E], [G]
2. Recovering nature and enhancing the beauty of landscapes [A], [B], [E], [F]
3. Connecting people with the environment to improve health & wellbeing [B], [E]
4. Increasing resource efficiency, and reducing pollution and waste [A], [C]
5. Securing clean, productive and biologically diverse seas and oceans [F]
6. Protecting and improving the global environment [C], [G]

(DEFRA, 2018)

Alignment of the **seven priority areas** for Norfolk & Suffolk [in brackets] to the UK 25 year Plan.

Next steps

This Evidence Compendium has highlighted the diversity of natural assets in Norfolk and Suffolk, as well as their importance for multiple benefits at national and regional scales. It is also apparent that there are risks that a number of key assets may decline or deteriorate in future and that, in some cases, gaps exist in the information base needed to enhance their functioning or resilience. Addressing these issues and improving collaboration between local organisations through a Norfolk and Suffolk 25 Year Environment Plan will help improve capacity to respond to the environmental and societal challenges ahead.

Next steps include dissemination of the findings of this work (including creation of an online resource to provide access to digital maps and associated statistics); identification of monitoring needs and more locally-specific or relevant indicators of the state of natural assets in the two counties; creation of new monitoring programmes to address these data gaps, and establishment of a stakeholder driven process to feed into the development of the Norfolk and Suffolk 25 Year Environment Plan.

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		AONBs	© copyright 2020 Natural England	https://naturalengland-defra.opendata.arcgis.com/datasets/6f2ad07d91304ad79cdecd52489d5046_0
		National Character Areas	© copyright 2020 Natural England	https://naturalengland-defra.opendata.arcgis.com/datasets/9185e7efe65f4e47b4a722446c061e62_0?geometry=-4.357%2C52.357%2C6.097%2C53.516
		OS Terrain® 50:	Open Government Licence (OGL)	https://www.ordnancesurvey.co.uk/opendatadownload/products.html
		National Parks	Open Government Licence (OGL)	https://data.gov.uk/dataset/334e1b27-e193-4ef5-b14e-696b58bb7e95/national-parks-england
8		Observed Climate Data, HadUK-Grid	© Crown Copyright	https://www.metoffice.gov.uk/research/climate/maps-and-data/data/haduk-grid/haduk-grid
9		Precipitation	Open Government Licence (OGL)	https://catalogue.ceda.ac.uk/
10	Map2_Population_Age_2040	ONS Statistics	Open Government Licence (OGL)	https://www.ons.gov.uk/searchdata
10	Map2_Population_Projections_2016_2041	ONS Statistics	Open Government Licence (OGL)	https://www.ons.gov.uk/searchdata
11	Map40_Housing_Projections	Norfolk & Suffolk County Councils		
12	Map13_Oil_and_Gas_Authority_Data	Cables and Pipelines, Oil and Gas Activity, Offshore Wind Activity, Marine Aggregates Activity	©The Crown Estate Open Data Licence (GIS) version 1.1	https://opendata-thecrownestate.opendata.arcgis.com/search?collection=Dataset
16	Map5_New_BroadHab8	Broad habitat Classes (CORINE 2018)		https://land.copernicus.eu/pan-european/corine-land-cover
17	Map24_ALC	Agriculture Land Classification	Open Government Licence (OGL), © Crown Copyright 2020	https://environment.data.gov.uk/DefraDataDownload/?mapService=NE/AgriculturalLandClassificationProvisionalEngland&Mode=spatial
17	Map26_Agri_Env_Schemes	Agri-Environmental Schemes	Open Government Licence (OGL)	https://naturalengland-defra.opendata.arcgis.com/datasets/ca68c90958c342a285d6370ddd7edd66_0
18	Map4_Forest	Forestry Commission's Open Data	Open Government Licence 3.0	http://data-forestry.opendata.arcgis.com/
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19	Map25_Land_under_Conservation	Designations	©Copyright Copernicus Programme	https://magic.defra.gov.uk/MagicMap.aspx
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20	Map11_OS_OpenGreenSpace	OS Open Greenspace	Open Government Licence (OGL)	https://www.ordnancesurvey.co.uk/business-government/products/open-map-greenspace

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24	Map6_Soil_Data	National Soil-Parent Material	Open Government Licence 3.0	https://data.gov.uk/dataset/b5ceb96b-2828-4cca-a410-ad516ccc3fb3/national-soil-parent-material
25	Map9_Erosion_Risk	Soil erosion by water (RUSLE2015)	©European Soil Data Centre (ESDAC), esdac.jrc.ec.europa.eu, European Commission, Joint Research Centre	https://esdac.jrc.ec.europa.eu/content/soil-erosion-water-rusle2015
26	Map3_LANDIS_SoilCarbon	NATMAP Carbon, Soil Organic Carbon Map	Soil data © Cranfield University (NSRI) and for the Controller of HMSO 2019	http://www.landis.org.uk/data/nmcarbon.cfm
27	Map15_CEH_pH	Soil pH, Mean estimates of topsoil pH	©UKCEH. All rights reserved.	https://eip.ceh.ac.uk/naturalengland-ncmaps/reportsData
28	Map10_Permeability_Aquifer_Zones	BGS permeability	"Contains British Geological Survey materials © UKRI [2020]".	https://www.bgs.ac.uk/products/hydrogeology/permeability.html
29	Map28_DEEP_Peat	Lowland Peat in England & Wales	Soil data © Cranfield University (NSRI) and for the Controller of HMSO 2019	
30	Map32_Mining_and_Geology	BGS Geology: Bedrock and Superficial	© NERC 2016. All rights reserved	https://www.bgs.ac.uk/products/digitalmaps/DiGMapGB.html
		Norfolk Minerals and Waste Local Plan	© 2015-2020 Norfolk County Council	https://www.norfolk.gov.uk/what-we-do-and-how-we-work/policy-performance-and-partnerships/policies-and-strategies/minerals-and-waste-planning-policies/norfolk-minerals-and-waste-local-plan-review
		Norfolk Minerals and Waste Development Framework	© 2015-2020 Norfolk County Council	https://www.norfolk.gov.uk/what-we-do-and-how-we-work/policy-performance-and-partnerships/policies-and-strategies/minerals-and-waste-planning-policies/minerals-and-waste-development-scheme
		Suffolk Local Aggregates Assessment (2017 data) April 2018	© Suffolk County Council	https://www.suffolk.gov.uk/assets/planning-waste-and-environment/Minerals-and-Waste-Policy/Minerals-and-Waste-SMWLP-Adopted/Local-Aggregates-Assessment-2018-data.pdf
33	Map23_Priority_Habitats	Priority Habitat Inventory	Contains public sector information licensed under the Open Government Licence v2.0.	https://data.gov.uk/dataset/4b6ddab7-6c0f-4407-946e-d6499f19fcde/priority-habitat-inventory-england
35	Map30_Connectivity			
37	Map4_Forest	Ancient Woodland (England)	Open Government Licence (OGL)	https://naturalengland-defra.opendata.arcgis.com/datasets/a14064ca50e242c4a92d020764a6d9df_0
37		National Forest Inventory Woodland GB 2017	Open Government Licence (OGL) Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2018 Ordnance Survey [100021242].	http://data-forestry.opendata.arcgis.com/datasets/bcd6742a2add4b68962aec073ab44138_0

References: Maps (3 of 3 pages)

Page	Map No. / Name (abbreviated)	Data	Copyright	Source link
41	Map20_Priority_Iconic_Species			Data from Martin Horlock, Norfolk Biodiversity Information Service.
44	Map8_3in1_WFD_C2_Overall_Waterbody_Status	Overall Water Body Status	Open Government Licence (OGL)	https://data.gov.uk/dataset/4d28e5c2-dc05-4945-9574-002fa71db22f/wfd-cycle-2-overall-classification
44	Map35_WFD_C1_and_C2	Changes in Surface Water Status between Cycle 1 and Cycle 2		Statistical calculations A. Lovett
45	Map34_Groundwater_Source_Protection_Zones	Source Protection Zones	Open Government Licence (OGL)	https://data.gov.uk/dataset/09889a48-0439-4bbe-8f2a-87bba26fbbf5/source-protection-zones-merged
	Map36_3in1_WFD_C2_Ground_Water_Status	WFD Groundwater Bodies Cycle 2	Open Government Licence (OGL)	https://data.gov.uk/dataset/2a74cf2e-560a-4408-a762-cad0e06c9d3f/wfd-groundwater-bodies-cycle-2
46	Map31_2in1_Water_Resource_Zones	Water Resource Availability and Abstraction Reliability Cycle 2	Open Government Licence (OGL)	https://data.gov.uk/dataset/b1f5c467-ed41-4e8f-89d7-f79a76645fd6/water-resource-availability-and-abstraction-reliability-cycle-2
47	Map36_Flood_Risk_from_Rivers_and_Sea	Risk of Flooding from Rivers and Sea	Open Government Licence (OGL)	https://data.gov.uk/dataset/bad20199-6d39-4aad-8564-26a46778fd94/risk-of-flooding-from-rivers-and-sea
48	Map12_Chalk_Rivers	Chalk Rivers	Open Government Licence (OGL)	https://data.gov.uk/dataset/f478556e-9eb5-4d4a-a0c6-78654860ebda/chalk-rivers
			Open Government Licence © Natural England	Norton, L.; Dunbar, M.; Greene, S.; Scholefield, P. (2016). Headwater stream quality for Britain. NERC Environmental Information Data Centre. http://doi.org/10.5285/85e7beb6-e031-4397-a090-841b8c907d1b
52	Map16_Marine_Protected_Areas	UK Marine Protected Area	© Joint Nature Conservation Committee	https://jncc.gov.uk/our-work/uk-marine-protected-area-datasets-for-download/
53	Map18_Fish_Species_Eastern_IFCA	Fish Species in Eastern IFCA Region		Source: Eastern IFCA
53	Map18_FinFish_Types	Finfish and Flatfish		Source: Eastern IFCA
54	Map17_Fish_Shellfish_Types	Shellfish Stocks		Source: Eastern IFCA
55	Map19_2in1_Mammal_Seals	Harbour Seal and Grey Seal Density	Open Government Licence (OGL)	https://data.marine.gov.scot/dataset/estimated-sea-distribution-grey-and-harbour-seals-updated-maps-2017
57	Map27_Bathing_Water_Quality	Bathing Waters Monitoring Locations	Open Government Licence (OGL)	https://data.gov.uk/dataset/dcb8bd46-c4cf-4749-bad0-7663da96845c/bathing-waters-monitoring-locations
60	Map7_AirQuality_PM2p5	Background Mapping data for local authorities	© Crown copyright	https://uk-air.defra.gov.uk/data/laqm-background-home
61	Map50_Emission_CO2; Map51_Emission_Methane; Map52_Emission_N2O	Greenhouse gas emissions	© Crown 2020 copyright Defra & BEIS via naei.beis.gov.uk, licenced under the Open Government Licence (OGL).	http://naei.beis.gov.uk/data/map-uk-das
62	Sector_Landscape_CCP_12062019	Point source emissions	© Crown 2020 copyright Defra & BEIS via naei.beis.gov.uk, licenced under the Open Government Licence (OGL).	http://naei.beis.gov.uk/data/map-large-source

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Supplementary Documents

1. Natural Capital Statistics Compendium for Norfolk and Suffolk

(spreadsheet of statistics compiled in support of this Evidence Compendium)

2. Risk Review

(documentation of statements of risks to natural assets from the literature reviewed for this study)

Data Acknowledgement

The individual sources and copyright related to the datasets presented in this work are shown in the Map References section. Some of the datasets have specific copyright attached though many are available under Open Government Licence. The specific references relating to CEH datasets are given on the relevant pages and in the References section. Housing projections were kindly supplied by Norfolk and Suffolk County Councils, and fisheries data were provided by Eastern IFCA for which we are extremely grateful.

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Stephen Thomson, Eastern IFCA
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Acknowledgements

This work was commissioned by John Jones on behalf of Norfolk County Council and Tim De-Keyzer for Suffolk County Council.

The research was conducted in the School of Environmental Sciences at the University of East Anglia, supported by a Steering Group consisting of representatives from Norfolk and Suffolk County Councils, the New Anglia Local Enterprise Partnership, Natural England, the Broads Authority, the Norfolk Coastal Partnership, Suffolk Marine Pioneer, Norfolk Wildlife Trust, Suffolk Wildlife Trust the National Farmers Union and the Norfolk Farming and Wildlife Advisory Group. Representatives of these and other interested organisations participated in workshops held in Diss and Lowestoft in November 2019. A full list of workshop participants can be found here. We are extremely grateful for all contributions to this work.

Additional thanks are due to the following people who provided access to data or commented on draft versions of this Evidence Compendium: Vittoria Danino and Phillip Stephens, Anglian Water; Stephen Thompson, Sandra Cowper, Judith Stoutt and Ron Jessop, Eastern Inshore Fisheries & Conservation Authority (Eastern-IFCA); Georgie Sutton, Marine Management Organisation; Nick Johnson, David White and Catherine Dew, Norfolk County Council; Martin Sandford, Suffolk Biodiversity Information Service; Matt Hullis and Cameron Clow, Suffolk County Council; Adele Powell, The Wash and North Norfolk Marine Partnership.

This document represents an evolving evidence base that will feed into a local 25 year Environment Plan; further comment and suggestions for inclusion are welcome. Please contact Professor Andrew Lovett in the first instance.

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