Important Arable Plant Areas in Norfolk

a preliminary study

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Cover
Main image: cultivated field margin © Emily Swan);
Inset: corn marigold (© Henry Walker).

Abstract

Over the past 50 years, changes in agricultural practices have meant that many wild plants that once grew plentifully alongside crops have become very rare. It is now recognised how much these arable wild plants contribute to the overall health of the farmed environment, for example, by providing flowers for insect pollinators and food and shelter for a variety of small mammals and bird species.

In 2005, Plantlife International, a global plant conservation charity, devised a method for identifying areas of arable land of importance for arable plant species. The Important Arable Plant Areas (IAPA) criteria enable the selection of sites based on the presence of particular threatened species (Criterion A) or "exceptional plant assemblages" (Criterion B). Criterion B allows a comparison of the relative nature conservation value of different sites by totalling scores assigned to individual species. The technique has allowed the establishment of county, national and European thresholds and also recognises that groups of arable plants that grow together (plant "communities") on a particular geological substrate, may score more or less than an equally-ranked community on a different soil type.

The current study of Important Arable Plant Areas in Norfolk was commissioned by the Norfolk Biodiversity Partnership (NBP) and provides the first comprehensive report of this flora group in the county.

The study was managed by Farm Conservation Limited (FCL), and relied on information from a detailed botanical survey of Norfolk conducted between 1987 and 1999. Survey of over 900 arable margins between 2007 and 2010 by Norfolk's enthusiastic voluntary plant recorders generated more locality and habitat data.

Other local organisations provided advice and data for the report. NATMAP soilscapes produced by Cranfield University were used to identify the geological substrate categories for the tetrads studied.

Stewardship data were supplied by Natural England.

Plant records were digitised where necessary which allowed comprehensive analysis, contextualisation and presentation of all the information as a series of maps, using GIS technology.

The survey sought to establish the location of strongholds for arable plants in Norfolk, to provide a baseline for further study, and to inform conservation efforts and agri-environment scheme targeting.

- In total, 726 tetrads were identified as IAPAs in Norfolk, confirming the importance of the county for arable plants; of these, 12 tetrads were of European Importance for arable plant assemblages, 347 tetrads were of national importance and 367 were of county importance.
- The best aggregations (clusters) of important sites were concentrated in the following areas:
  - ◊ Sheringham to Wiveton (via Salthouse and Kelling);
  - ◊ Briston- Corpusty – Itteringham;
  - ◊ Narborough to Hockwold via Cockley Cley, Swaffham and Bodney;
  - ◊ Heacham (Snettisham) to Ringstead.
- All soil types were important for arable plants, with chalk tetrads exhibiting the highest percentage of national or European Importance scores (30.8% as opposed to 26.6% for sand and 24.4% for clay).
- Although agri-environment schemes are popular in Norfolk, uptake of options that benefit arable flora is generally poor. Entry Level Stewardship, although non-competitive, is very inflexible - with other options often proving more popular. This report highlights where Stewardship options could be used to benefit arable flora. Wider training for advisers in arable plant identification and potential arable plant sites will also help deliver action for this important and overlooked group of plants.

Contents

1. Introduction

1.1 Background

The arable flora of Britain has become our most threatened group of plants (Still and Byfield, 2007). Unlike the much publicised declines in farmland birds, the plight of our arable flora, at the base of the farmland food chain, has gone largely unnoticed. Modern agricultural techniques such as the widespread use of herbicides, efficient seed cleaning, increased nitrogen application and the development of densely-grown high-yield crops have brought many of these once common species to the verge of extinction.

Some 39 species of plant that occur primarily in arable fields are considered threatened in the current Red List for Great Britain (Cheffings & Farrell 2005) and 25 of these are known to occur in Norfolk.

The Plantlife International report *New Priorities for Arable Plant Conservation* (Still & Byfield, 2007) concludes that

"***there is an urgent need to focus attention on arable plants in the landscape, in part to reflect their continued rarity in Britain, but also to reflect the key role that they play towards the viability of rarer insects and birds, in their position at the base of the food chain***".

The national Arable Field Margin Habitat Action Plan (HAP) sought to expand the area of cultivated, unsprayed field margin in England by an additional 4,619 hectares to 15,000 hectares by 2010. The Norfolk HAP for cereal margins (not yet revised to the broader category of arable field margins) sought to "maintain, improve and restore by management" the biodiversity of some 750 hectares of cereal field margins in Norfolk by 2010.

Figure 1.

Utilisable Agricultural Area in Norfolk.

Norfolk is still very much an arable county – about 70% of the land use is arable, totalling a Utilisable Arable Area of 416,982 hectares (Natural England, 2011).

1.2 Conservation Measures for Arable Plants in Norfolk

Publicly-funded "agri-environment schemes" are the primary mechanism for delivering arable plant conservation in England.

Agri-environment schemes were initiated in the 1980s, and in 1987 the **Breckland Environmentally Sensitive Areas scheme (ESA; 1987 – 2014)** was introduced. Aside from arable reversion to grassland or heathland, the Breckland ESA scheme offered funding for three management options on arable land, all of which would benefit arable flora: Tier 4A - uncropped wildlife strips (cultivated margins); Tier 4B - conservation headlands and Tier 4D - winter stubbles. Due to the limited amount of choice in the Breckland ESA (and the absence of grass margins), the uptake of these options was relatively high.

The **Countryside Stewardship Scheme (CSS: 1991—2014)** was introduced in 1991 to cover the land outside the 22 ESAs. As this was a national scheme, it offered a wider range of management options to suit all land types. Through this scheme there were 11 arable options, of which six could create suitable conditions for spring or autumn germinating annual flora.

The ESA and CSS schemes are now closed to new applicants and they have been superseded by **Environmental Stewardship (ES: 2005 – present)**. There are two strands to this scheme: **Entry Level (ELS)** and **Higher Level Stewardship (HLS)**, both offering several options that are beneficial to, or designed for, arable plants (information can be found at http://www.naturalengland.org.uk/ourwork/farming/funding/es/default.aspx).

Although ES is proving popular (70% of Norfolk's utilisable arable area is "in" ELS), the uptake of the particular options that benefit arable plants has been poor (Table 1). The payment rate for these options is relatively low, whilst the management costs can be high compared to grass margins. The combination of these factors has lead to a low uptake to date.

Higher Level Stewardship offers more flexibility than the earlier schemes, and as existing CSS and ESA agreements expire, opportunities arise to reconsider management options, such as the historical placement of grass margins. Where grass margins have been ploughed up, we are starting to see some interesting seed banks unearthed, as these areas are returned to annual cultivation.

Organic farming also has obvious benefits but these have not been examined or quantified in this report.

Arable margin (© Henry Walker)

Table 1
Norfolk Agri-environmental uptake of arable options with potential benefits for arable plants. Data Source: Natural England, October 2010

Scheme	Tier	Tier Description	Option Area (ha)	Specified Tier Holding Count	Total All Norfolk Options (ha)	Total Norfolk Holding Count	% of all Norfolk Option Areas	% of Norfolk Holding Count
Breckland ESA	Tier 4A - BRECKS	Uncropped wildlife strips	152.29	13	3636.52	64	4.19	20.31
	Tier 4B - BRECKS	Conservation headlands	4.63	2			0.13	3.13
	Tier 4D	Over wintered stubble (OWS)	215.71	5			5.93	7.81
CSS	CH1	Conservation headlands	52.78	7	10162	404	0.52	1.73
	CH2	Conservation headlands with no fertiliser	291.31	59			2.87	14.60
	OS1	OWS	981.33	57			9.66	14.11
	OS2	OWS followed by a spring crop	50	5			0.49	1.24
	OS3	OWS followed by a spring/summer fallow	719.58	114			7.08	28.22
ES	EF10	Unharvested headlands	44.93	8	295462	1244	0.02	0.64
	EF11	Uncropped cultivated margins	57.36	33			0.02	2.65
	EF13	Uncropped cultivated areas (rotational)	7.5	2			0.00	0.16
	EF22	Extended OWS	39.26	9			0.01	0.72
	EF9	Unfertilised cereal headlands	77.43	9			0.03	0.72
	HF10	Unharvested headlands	34	5			0.01	0.40
	HF11	Uncropped cultivated margins	65.79	6			0.02	0.48
	HF13	Uncropped cultivated areas (rotational)	336.61	56			0.11	4.50
	HF13NR	Uncropped cultivated areas	10.92	4			0.00	0.32
	HF14	Unharvested unfertilised headlands	182.07	43			0.06	3.46
	HF14NR	Unharvested unfertilised headlands	0.6	1			0.00	0.08
	HF20	Cultivated fallow (rotational)	163.33	41			0.06	3.30
	HF20NR	Cultivated fallow (non rotational)	15.41	11			0.01	0.88
	HF9	Unfertilised cereal headland	5	1			0.00	0.08
	HG7	Low input cereal	199.15	21			0.07	1.69
		Total	3706.99	512		1712		29.91%
Utilisable Agricultural Area	416982.51	ES Coverage	295462	% ES coverage Norfolk	70.85			

1.3 Set - aside

This scheme, which takes land out of production for a period of time, carries benefits for rare arable plants in the farmed environment.

Set–aside was originally introduced in 1988 to control over-production. It provided a number of environmental benefits, some of which extended to arable plants. Rotational set-aside followed by spring fallow provided suitable germination conditions for some arable plants; during 2002-2004, approximately 50% of the total set-aside area in whole fields was rotational set-aside (Defra 2007). In 2007, set-aside was abolished and as a result the area of over-wintered stubble has declined dramatically.

In 2009, the two year Campaign for the Farmed Environment (CFE) was launched to compensate for this loss and avoid the return of compulsory set-aside. The CFE is a farmer-led voluntary initiative which aims to encourage targeted management that benefits the farmed environment to "re-capture" set-aside benefits. It can be delivered through either ELS or voluntary measures. Certain CFE targets are not being met e.g. the area of uncropped land decreased in 2011 (a result of high wheat prices), while areas of infield arable options under ELS and HLS are increasing. We have yet to see if the benefits of CFE will be sufficient to avoid compulsory set- aside. There is the possibility of the end date being extended and the added complication of the proposed Greening of the CAP from 2014 - 20.

Scientific evidence is supportive of the ability of agri-environment schemes to conserve arable flora, although it does suggest that some options are more effective than others (Walker et al., 2007a). For example, uncropped options, such as cultivated margins and spring fallows, have been found to benefit rare arable plants more than cropped options due to reduced competition from the crop (Walker et al. 2007b). In addition, location (aspect and distance from boundary) and environmental factors (soil properties and climate) are important in determining the abundance and diversity of rare arable plants. By choosing the most appropriate options to benefit rare arable plants, and using these in the 'hotspots' identified by this project, the future of these plants can be safeguarded in Norfolk.

Fine-leaved fumitory
Fumaria parviflora

1.4 Objectives

The current study aimed to redress gaps in our knowledge of Norfolk's arable flora.

The survey aimed to:

- Determine the number and location of important arable plant areas in Norfolk;
- Assess the importance of arable plant areas from a local, national and European perspective;
- Provide a foundation for more detailed arable plant surveys;
- Inform conservation efforts and agri-environment targeting in Norfolk;
- Inform potential new county targets for arable field margins and arable plants;
- Identify the precise local opportunities for arable field margin maintenance, enhancement, restoration and expansion;
- Identify precise local opportunities for population and range expansion of select arable plant species;
- Determine appropriate management regimes for arable plant "hot spots";
- Identify the most suitable locations for conservation action.

Weasel's snout
Misopates orontium

2. Methods

2.1 Field work methodology for arable plants

The area considered in this report is comprised of Watsonian vice-counties 27 (East Norfolk) and 28 (West Norfolk), between them covering some 4,939 square kilometres. The whole of Norfolk was systematically surveyed botanically on a tetrad (2km x 2km square) basis between 1987 and 1998, resulting in the publication of *A Flora of Norfolk* (Beckett et al 1999). Recording and the accumulation of botanical records by the Botanical Society of the British Isles vice-county recorders has continued in subsequent years, but less intensively and systematically.

© Emily Swan.

Prickly poppy
Papaver argemone

In the 1987-99 survey, almost all tetrads were visited on two or more occasions at different seasons. Even so, some of the scarcer arable species will have been somewhat under-recorded, partly because of their sporadic appearance from year to year and partly due to lack of access to parts of the tetrads. Furthermore, several of the target species for this report occur more often in non-arable habitats than arable ones and the survey only infrequently recorded such detail, nor were many records localised to a better resolution than the tetrad. That said, it is a very comprehensive dataset and supplemented by more recent recording, should form a comprehensive and relatively up-to-date basis for this preliminary study.

Aware of the absence in many instances of more precise locality and habitat data, the Norfolk Flora Group instigated a survey of stretches of arable margin in 2007. To date, **911** arable margin surveys have been completed and it is proposed that the project should continue with some emphasis on visiting land not otherwise accessible – in conjunction with the farming community, FCL and Natural England. Work in progress from this project has been included in this analysis.

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Venus's looking glass
Legousia hybrida

2.2 Methodology for identifying Important Arable Plant Areas (IAPA)

In 2005, Plantlife International devised a methodology for identifying IAPAs (Byfield and Wilson 2005). This underpins the approach taken in the report .

The methodology sets out two criteria:

- **One based on the presence (and abundance) of individual species (Criterion A) and;**
- **The second proposing a methodology to determine important assemblages of plants using a cumulative scoring system and threshold values for three broadly defined soil types (Criterion B).**

Criterion A - Threatened Species

This criterion allows for the selection of sites based solely on the occurrence of threatened arable species listed in recognised national, European or global Red Lists. At the present time, no British arable plant species are recognised as threatened at a European level. At UK level, Criterion A allows for the selection of key sites of threatened and/or protected species. For threatened species (i.e. Critically Endangered, Endangered and Vulnerable species), plus additional UK BAP priority species[1], up to 30 'best' arable sites should be selected. All additional populations of threatened species, plus county rarities, should be selected as being of county importance

Clearly, the designation of the 30 'best' arable sites for particular species needs to be considered on a national basis. This report simply attempts to identify which threatened species are present in Norfolk and to show their distribution.

Criterion B - Outstanding Assemblages

This criterion utilises the same methodology for identifying sites of county, UK and European importance, *viz.* a scoring system that tallies the weighted individual score of each of the species present according to their rarity and decline across Britain.

The basic listing of arable species has been drawn from *PLANTATT: Attributes of British and Irish Plants* (Hill *et al*. 2004), which provides the most comprehensive listing of species characteristic of arable land currently available. This has been supplemented with a selection of additional species considered to occur occasionally as characteristic members of the arable flora (although are often equally typical of non-arable habitats).

Individual species' scores - ranging between 1 (common) to 9 (rarest and most threatened) - have been assigned to arable plants based on:
(i) their current occurrence within 10-km squares; and/or

(ii) their recent decline (based on the information contained in *The New Atlas of the British Flora* (Preston *et al*., 2002)); and/or

(iii) their current species threat status (based on information contained in Cheffings & Farrell 2005, supplemented by that in Wigginton (1999) and Perring & Farrell (1983).

The scoring categories are detailed in Table 2.

[1] Since the publication of Byfield and Wilson (2005), the Biodiversity Action Plan priority list has been revised (2007) and additonal arable taxa have been included. However, all of these would already qualify under this criterion as threatened at UK level.

Table 2.
Plantlife IAPA scores

9	Critically Endangered
8	Endangered
7	Vulnerable
6	Near Threatened
5	Nationally Scarce: 16 to 50 10-km squares; or 51 – 100 10-km squares, change index less than - 1.0
4	Nationally Scarce: 51 to 100 10-km squares, change index greater than –1.0
3	Species of local concern:101 to 500 10-km squares
2	Species of local concern:501 to 1000 10-km squares
1	Species of local concern: 1001 to 1500 10-km squares, change index less than 0.0

The outstanding assemblage assessment methodology presented here is based on the cumulative total of the weighted scores of species present at each site, allowing the comparison of the relative nature conservation value of different sites. Provisional threshold scores have been proposed for sites of county, national and European importance (Table 3).

Table 3.
Provisional threshold scores for assessing the conservation importance of arable plant sites (Criterion B)

	Chalk and limestone-derived soils (excluding clays)	**Clays**	**Sands and freely draining acidic soils**
European Importance	90+	70+	70+
National Importance	45 – 89	30 – 69	35 – 69
County Importance	30 – 44	20 – 29	20 – 34

Conservation headland in arable landscape showing red of common poppies
(© Henry Walker)

In addition, the scoring system recognises that arable communities on a particular geological substrate may consistently score either more or less than equally valued communities on a different substrate. Accordingly, the thresholds are varied for three broad geological categories:

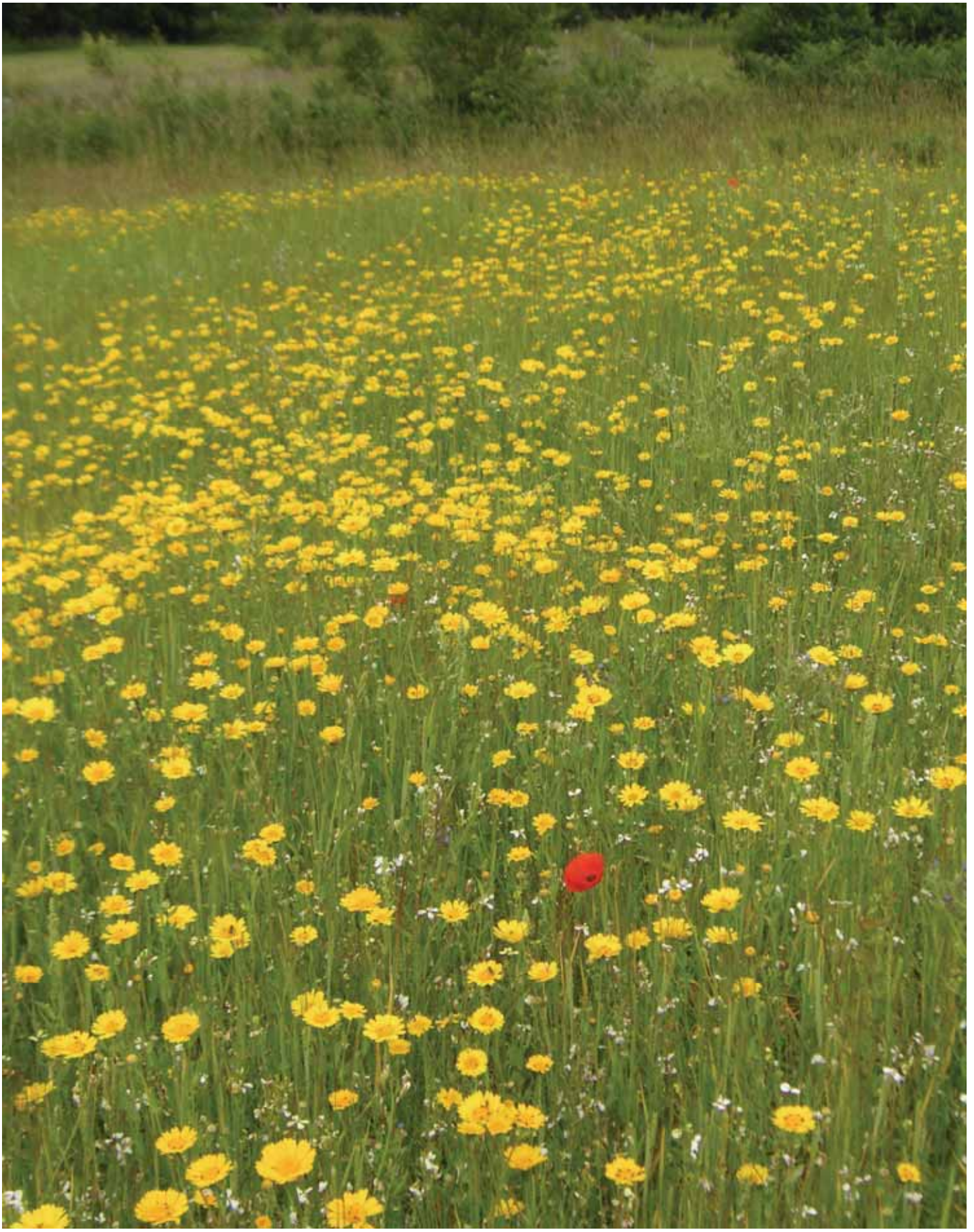
- sandy and other free draining non-calcareous soils (particularly in western and northern parts of the UK);
- heavier clay soils (particularly in the Midlands and East Anglia);
- dry calcareous soils on chalk and limestone (particularly southern and eastern England).

Known soil types occurring in Norfolk were assigned to one of the three broad substrate categories used by Plantlife to assign threshold scores for assessing the importance of arable plant sites (Table 4). Where multiple substrates were found within a single tetrad the tetrad was defined by the majority substrate (see Figure 2).

Table 4.
Soil types included in each Plantlife substrate category

Plantlife substrate category	"NATMAP Soilscapes" soil types
Chalk and limestone-derived soils (excl. clays)	Shallow lime-rich soils over chalk or limestone
Clays	Lime-rich loamy and clayey soils with impeded drainage
	Loamy and clayey floodplain soils of coastal flats with naturally high groundwater
	Slightly acid loamy and clayey soils with impeded drainage
	Slowly permeable seasonally wet acid loamy and clayey soils
	Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils
Sands and freely-draining acidic soils	Fen peat soils
	Freely-draining lime-rich loamy soils Freely draining sandy Breckland soils
	Freely-draining slightly acid but base-rich soils Freely-draining slightly acid loamy soils
	Freely-draining slightly acid sandy soils
	Loamy and sandy soils with naturally high groundwater and a peaty surface
	Naturally very wet acid sandy and loamy soils
	Saltmarsh soils
	Sand dune soils

A number of species were excluded because they are only known to occur in non arable conditions in Norfolk (see Appendix 1). The exclusion of these species makes comparison with previous studies indicative rather than absolute.



Corn marigold in cultivated margins on Pee-wit Farm, Briston.
(© Roger Gerry, NE)

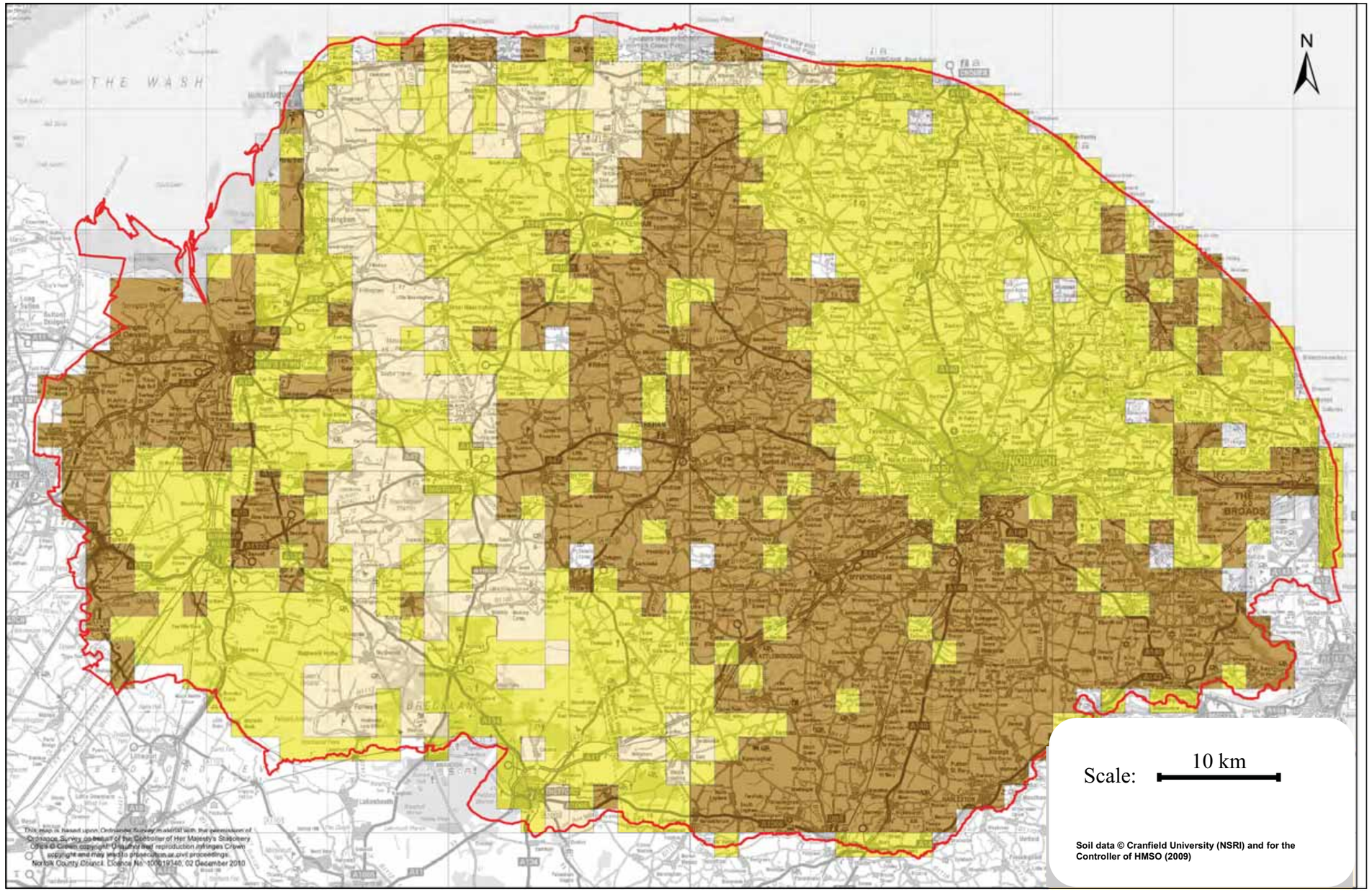


Figure 2. Soil type of Norfolk tetrads that were surveyed for arable flora

Legend

Tetrad grid showing the majority PlantLife substrate

CATEGORY

- Other
- Chalk
- Clayey
- Sandy

2.3 Mapping techniques

Mapping analysis was developed for the project

Plantlife methods (see 2.2) were used to collate and tabulate field data obtained during previous plant surveys of Norfolk (see 2.1). This generated:

- A list of Criterion A species in Norfolk (Table 5);
- A Plantlife IAPA score (Criterion B) for each tetrad.

A soilscapes map (NATMAP) was provided by Cranfield university.

Discussions were held to assign Plantlife substrate categories to each soil type.

Analysis of the data was undertaken using MapInfo and ArcGIS Geographical Information System packages. Information with clear visual impact was generated such as:

- thematic maps
- point data maps
- tetrad maps

The following GIS outputs were created for the project:

- A tetrad grid for Norfolk to show distribution results from Criterion A and Criterion B methods;
- A tetrad grid for Norfolk of Plantlife substrate categories (Figure 2);
- Distribution maps for individual Criterion A species over substrate category (Figures 4 - 9);
- Co-incidence distribution of all 20 potential Criterion A species in Norfolk to show 'hotspots' for arable flora on a tetrad basis (Figure 3);
- Distribution map of IAPAs in Norfolk were created using a calculation combining tetrad IAPA score and Plantlife broad substrate category, which assigns a conservation importance value to each tetrad. This map infers clusters and corridors of high conservation importance (Figure 10);
- Co-incidence of recent uptake of arable agri-environmental options with tetrads of conservation importance for arable flora (Figure 11).

Further details of the technical approaches used can be found in Appendix 2.

Narrow-fruited cornsalad
Valerianella dentata

3. Results

Results are presented as maps and tables.

3.1 Criterion A Species in Norfolk

- Of the 25 threatened arable species that occur in Norfolk, 15 occur primarily or frequently in arable margins, and five further species occasionally do so (see Table 5). Though present in the county, three species (red hemp-nettle, red-tipped cudweed and mousetail) are only currently known to occur in non-arable habitats – but given the right conditions they may re-occur in an arable context in the future.
- Criterion A species were recorded in 870 tetrads. The coincidence distribution of the 20 Criterion A species (Figure 3) shows that there are a number of hotspots where five or more of these species were recorded; over half of these tetrads are adjacent to at least one tetrad where Criterion A species were not recorded.
- The distribution of six Critically Endangered or Endangered rare arable plant species in Norfolk is shown in Figures 4 to 9. These distributions correspond with their known substrate preferences, with the exception of *Scleranthus annuus*.

Sown cornfield annuals. (© Henry Walker)

Table 5.
Species known to occur in Norfolk that qualify under Criterion A

	Latin Name	Common Name	Designation	Recorded in Arable
Critically Endangered	*Galeopsis angustifolia*	Red hemp-nettle	BAP	No
	Ranunculus arvensis	Corn buttercup	BAP	Extinct
	Scandix pecten-veneris	Shepherd's-needle	BAP	Yes
Endangered	*Anthemis arvensis*	Corn chamomile		Yes
	Filago lutescens	Red-tipped cudweed	BAP	No
	Lithospermum arvense	Field gromwell		Yes
	Scleranthus annuus	Annual knawel	BAP	Occasionally
	Silene gallica	Small-flowered catchfly	BAP	Occasionally
	Valerianella dentata	Narrow-fruited cornsalad		Yes
	*Valerianella rimosa**	Broad-fruited cornsalad	BAP	Single site
	Veronica triphyllos	Fingered speedwell	BAP	No
	Veronica verna	Spring speedwell	BAP	Introduced
Vulnerable	*Anthemis cotula*	Stinking chamomile		Yes
	Bromus secalinus	Rye brome		Yes
	Chenopodium murale	Nettle-leaved goosefoot		Yes
	Chrysanthemum segetum	Corn marigold		Yes
	Fumaria parviflora	Fine-leaved fumitory		Yes
	Galeopsis speciosa	Large-flowered hemp-nettle		Yes
	Hyoscyamus niger	Henbane		Occasionally
	Hypochaeris glabra	Smooth cat's-ear		Occasionally
	Misopates orontium	Weasel's-snout		Yes
	Myosurus minimus	Mousetail		No
	Nepeta cataria	Cat-mint		Occasionally
	Papaver argemone	Prickly poppy		Yes
	Silene noctiflora	Night-flowering catchfly		Yes
	Spergula arvensis	Corn spurrey		Yes

*Note that this species was recorded outside of the survey period and has not been included in IAPA maps or calculations

Common cudweed *Filago vulgaris*
(© Emily Swan)

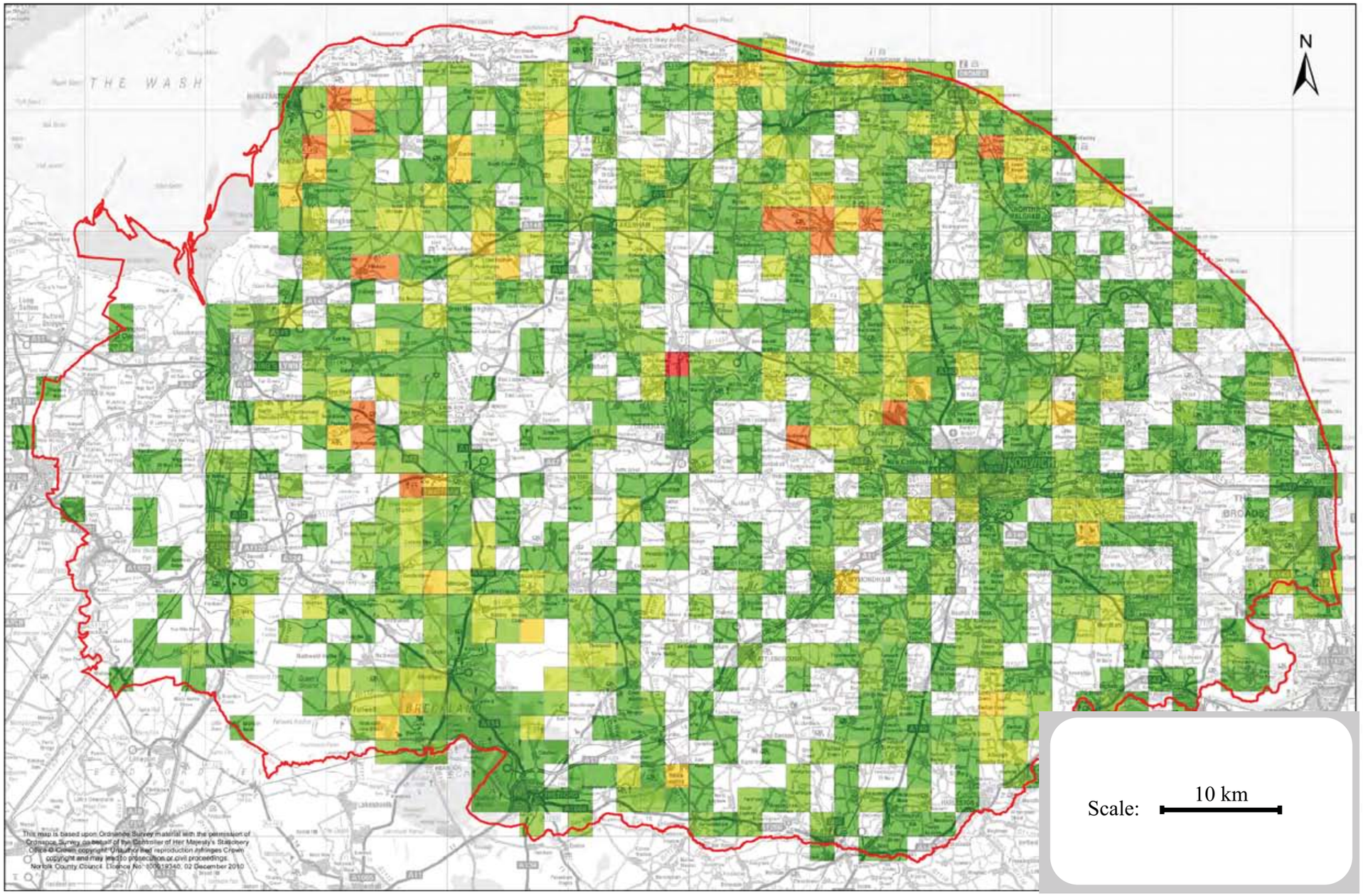


Figure 3. Co-incidence distribution of all 20 potential Criterion A species in Norfolk.

Legend

Criterion A Coincidence

Number of Species (Criterion A)

- 1
- 2
- 3
- 4
- 5
- 6

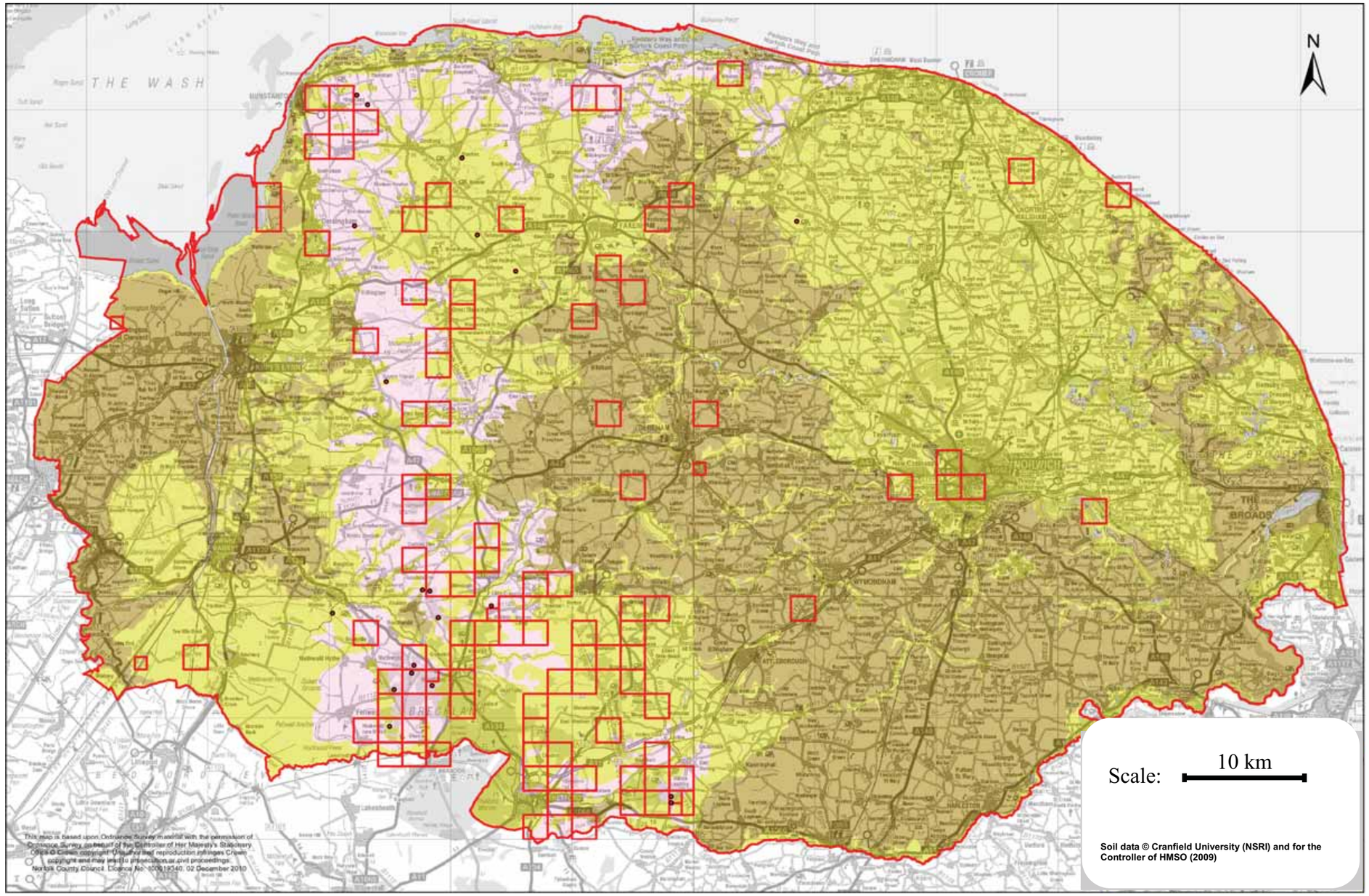


Figure 4. Distribution of corn chamomile (*Anthemis avensis*) over soil type)

This map shows that the distribution of this **Criterion A** endangered arable plant species corresponds with its known substrate preference.

Legend

- *Anthemis arvensis* point record (100m or 10m grid reference)
- *Anthemis arvensis* tetrad or 1km square record

NATMAP soilscapes - PlantLife substrate categories

CATEGORY

- Other
- Chalk
- Clayey
- Sandy

	Substrate preference in Norfolk	Soil type/substrate - as per field guide
Anthemis arvensis **Corn chamomile**	Chalk/sandy soils	Calcareous sands or chalky loams

Corn chamomile (*Anthemis arvensis*)

(c) Andrew Gagg-Plantlife

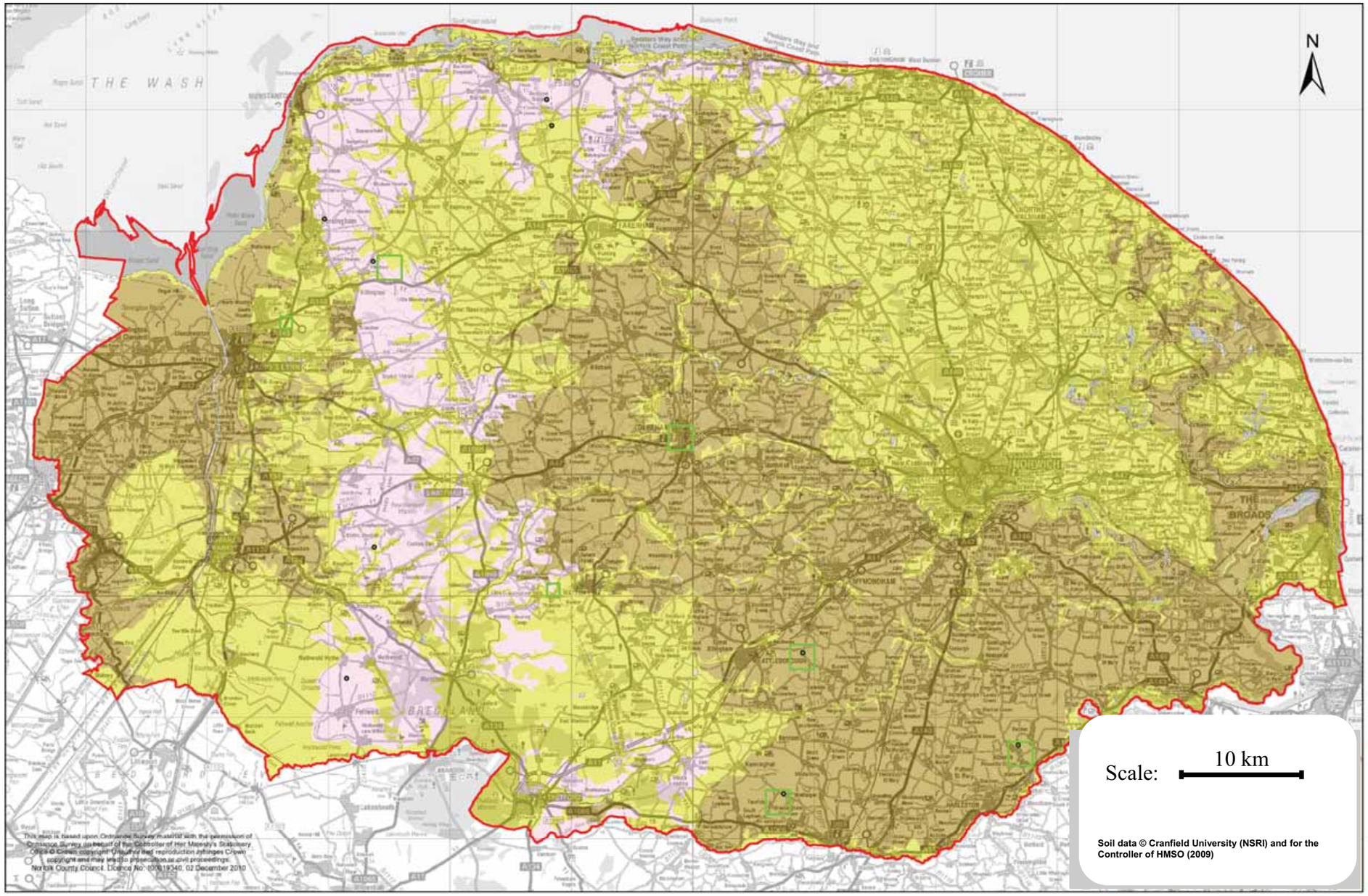


Figure 5. Distribution of field gromwell (*Lithospermum arvense*) over soil type

This map shows that the distribution of this **Criterion A** endangered arable plant species corresponds with its known substrate preference.

Legend

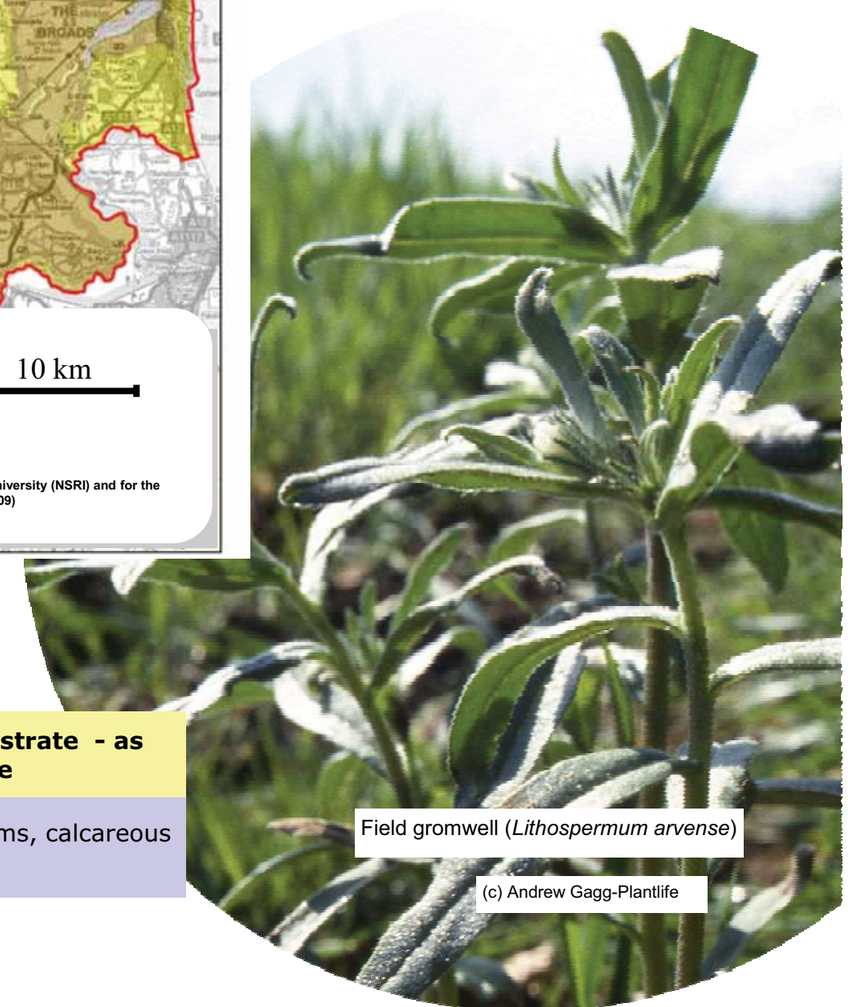
- *Lithospermum arvense* point record (100m or 10m grid reference)
- *Lithospermum arvense* tetrad or 1km square

NATMAP soilscapes - PlantLife substrate categories

CATEGORY

- Other
- Chalk
- Clayey
- Sandy

	Substrate preference in Norfolk	Soil type/substrate - as per field guide
***Lithospermum arvense* Field gromwell**	Chalk/clay soils	Calcareous loams, calcareous clay loams



Field gromwell (*Lithospermum arvense*)

(c) Andrew Gagg-Plantlife

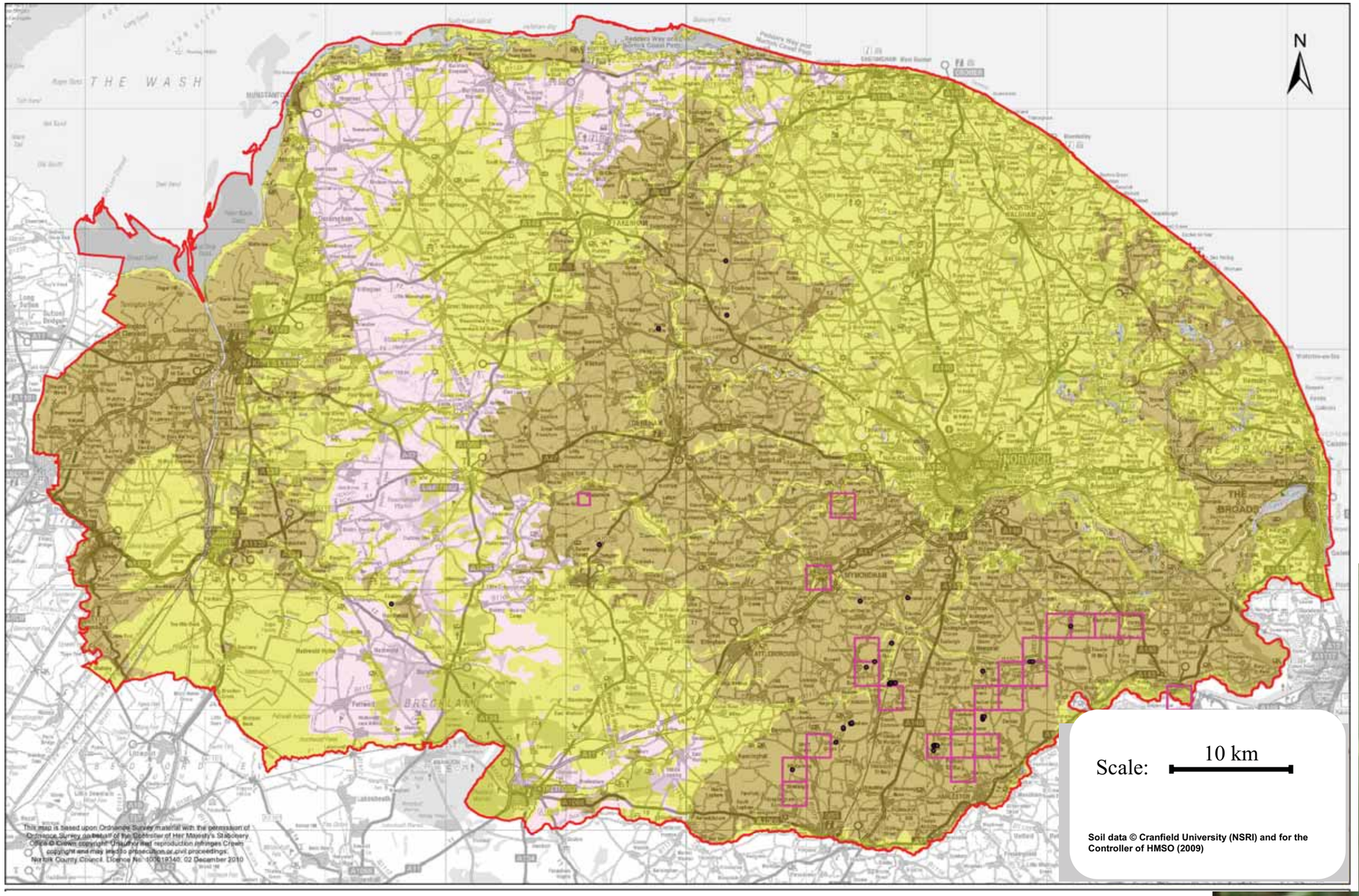


Figure 6. Distribution of shepherd's Needle (*Scandix pecten-veneris*) over soil type

This map shows that the distribution of this **Criterion A** endangered arable plant species corresponds with its known substrate preference.

Legend

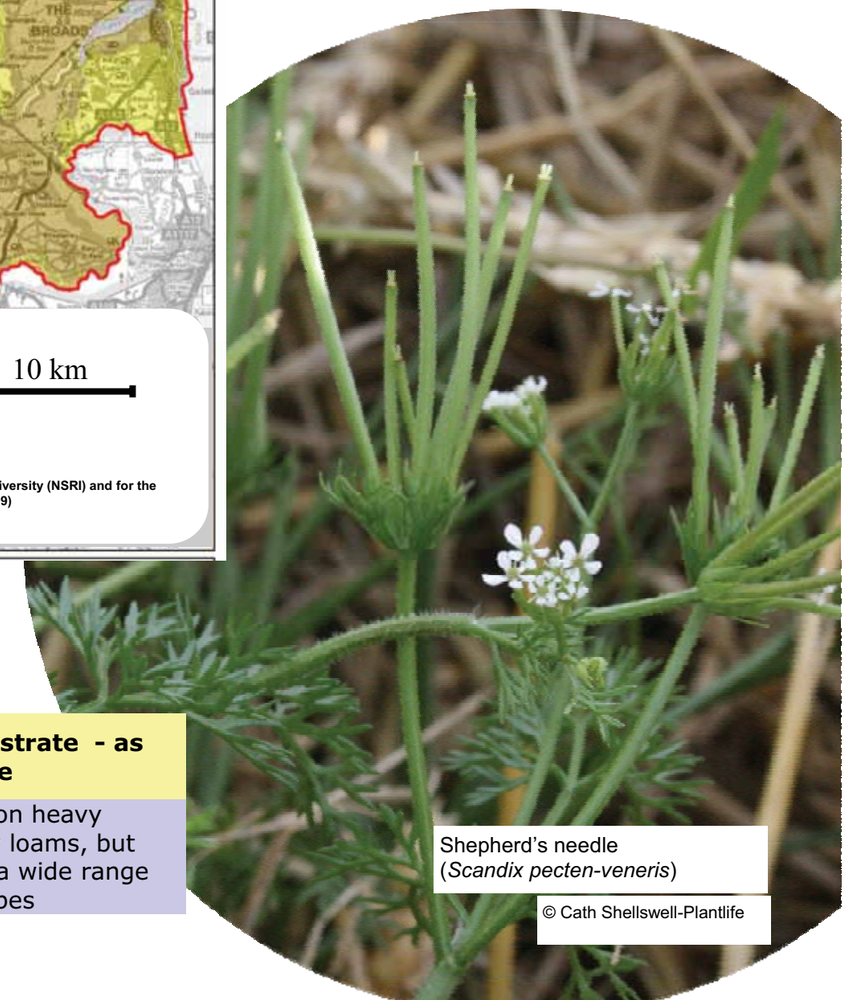
- *Scandix pecten-veneris* point record (100m or 10m grid reference)
- *Scandix pecten-veneris* tetrad or 1km square

NATMAP soilscapes - PlantLife substrate categories

CATEGORY

- Other
- Chalk
- Clayey
- Sandy

	Substrate preference in Norfolk	Soil type/substrate - as per field guide
Scandix pecten-veneris **Shepherd's needle**	Almost exclusively on clay soils	Most frequent on heavy calcareous clay loams, but sometimes on a wide range of other soil types



Shepherd's needle (*Scandix pecten-veneris*)

© Cath Shellswell-Plantlife

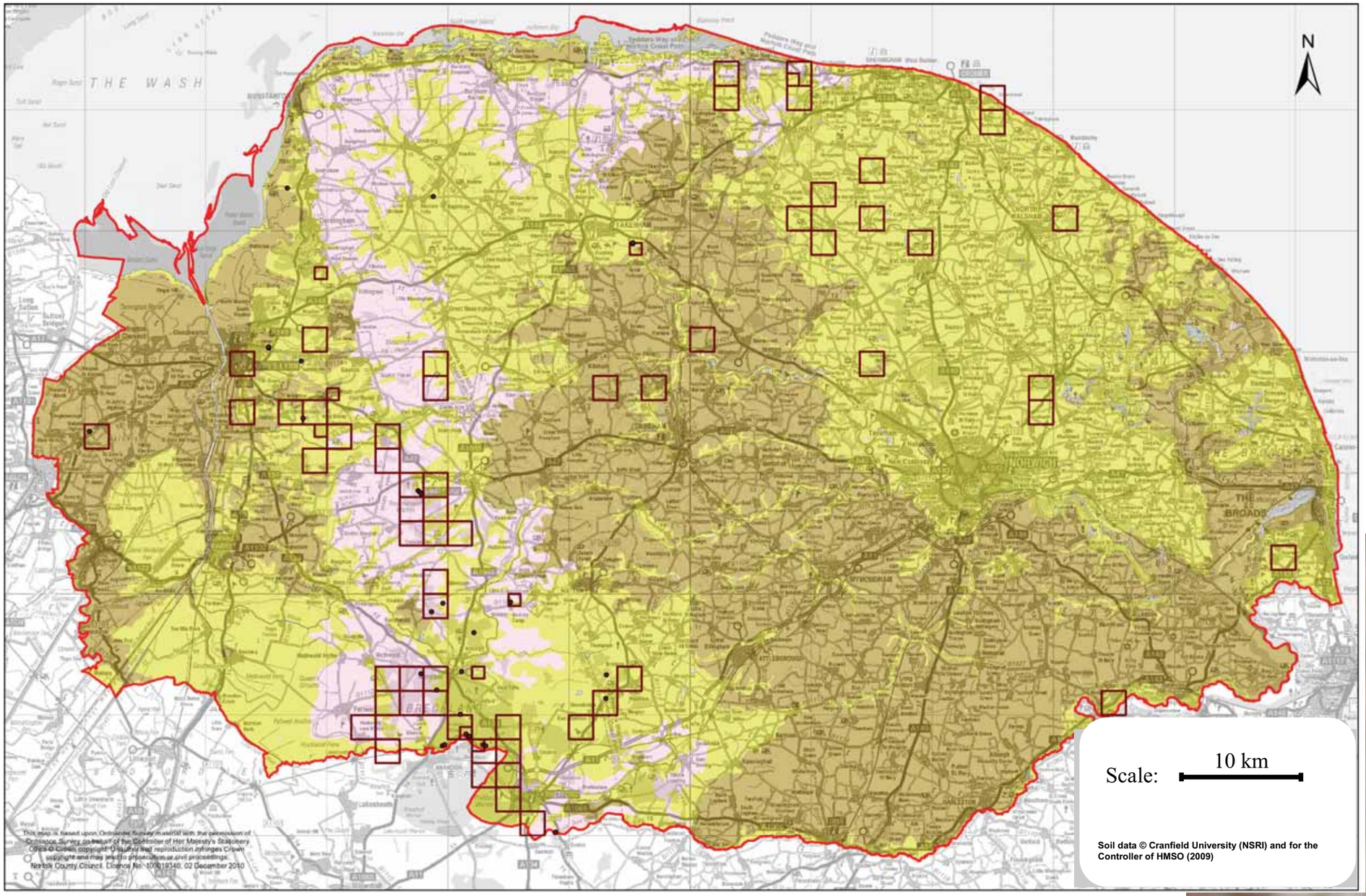


Figure 7. Distribution of annual knawel (*Scleranthus annus*) over soil type

This map shows that the distribution of this **Criterion A** endangered arable plant species in Norfolk does NOT completely correspond with its known substrate preference.

Legend

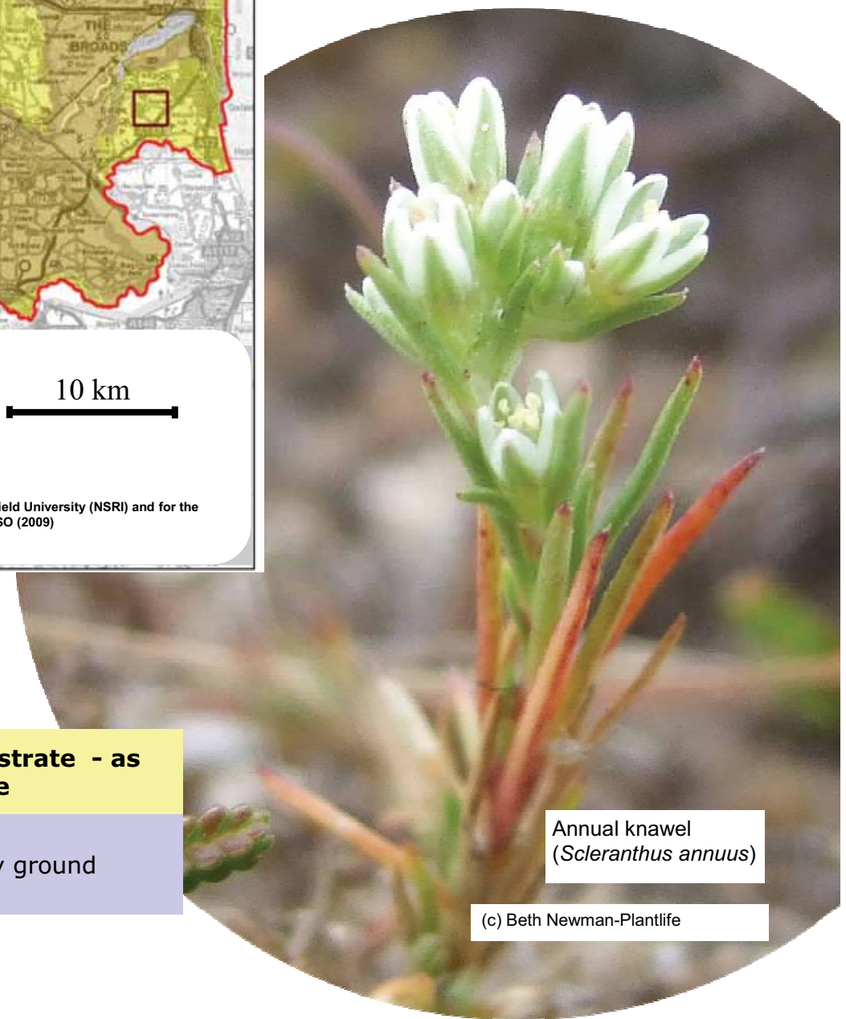
- ● ***Scleranthus annuus* point record (100m or 10m grid reference)**
- ▭ ***Scleranthus annuus* tetrad or 1km square record**

NATMAP soilscapes - PlantLife substrate categories

CATEGORY

- **Other**
- **Chalk**
- **Clayey**
- **Sandy**

	Substrate preference in Norfolk	Soil type/substrate - as per field guide
***Scleranthus annuus* Annual knawel**	Chalk/sandy, plus some clay soils	Dry open sandy ground



Annual knawel (*Scleranthus annuus*)

(c) Beth Newman-Plantlife

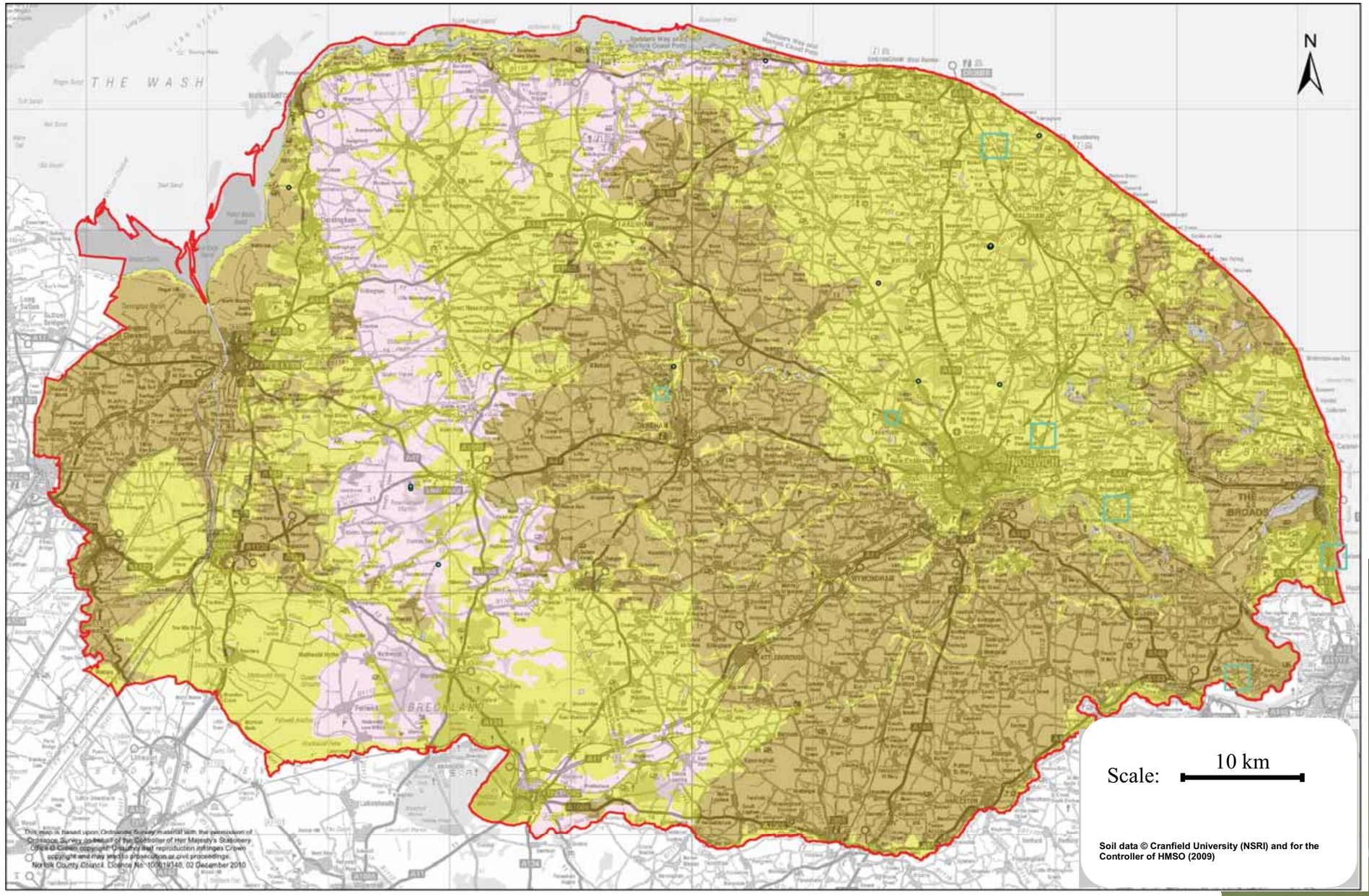


Figure 8. Distribution of small flowered catchfly (*Silene gallica*) over soil type

This map shows that the distribution of this **Criterion A** endangered arable plant species corresponds with its known substrate preference.

Legend

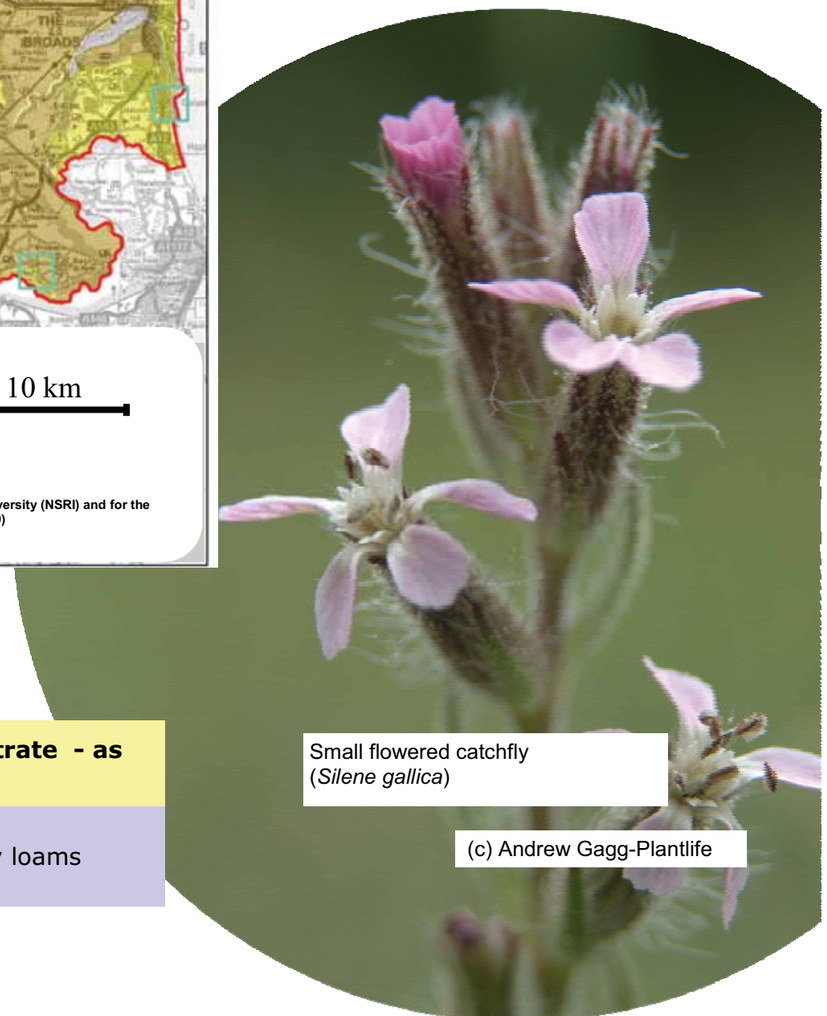
- *Silene gallica* point record (100m or 10m grid reference)
- *Silene gallica* tetrad or 1km square record

NATMAP soilscapes - PlantLife substrate categories

CATEGORY

- Other
- Chalk
- Clayey
- Sandy

	Substrate preference in Norfolk	Soil type/substrate - as per field guide
Silene gallica **Small flowered catchfly**	Mainly on sandy soils	Sands and sandy loams



Small flowered catchfly (*Silene gallica*)

(c) Andrew Gagg-Plantlife

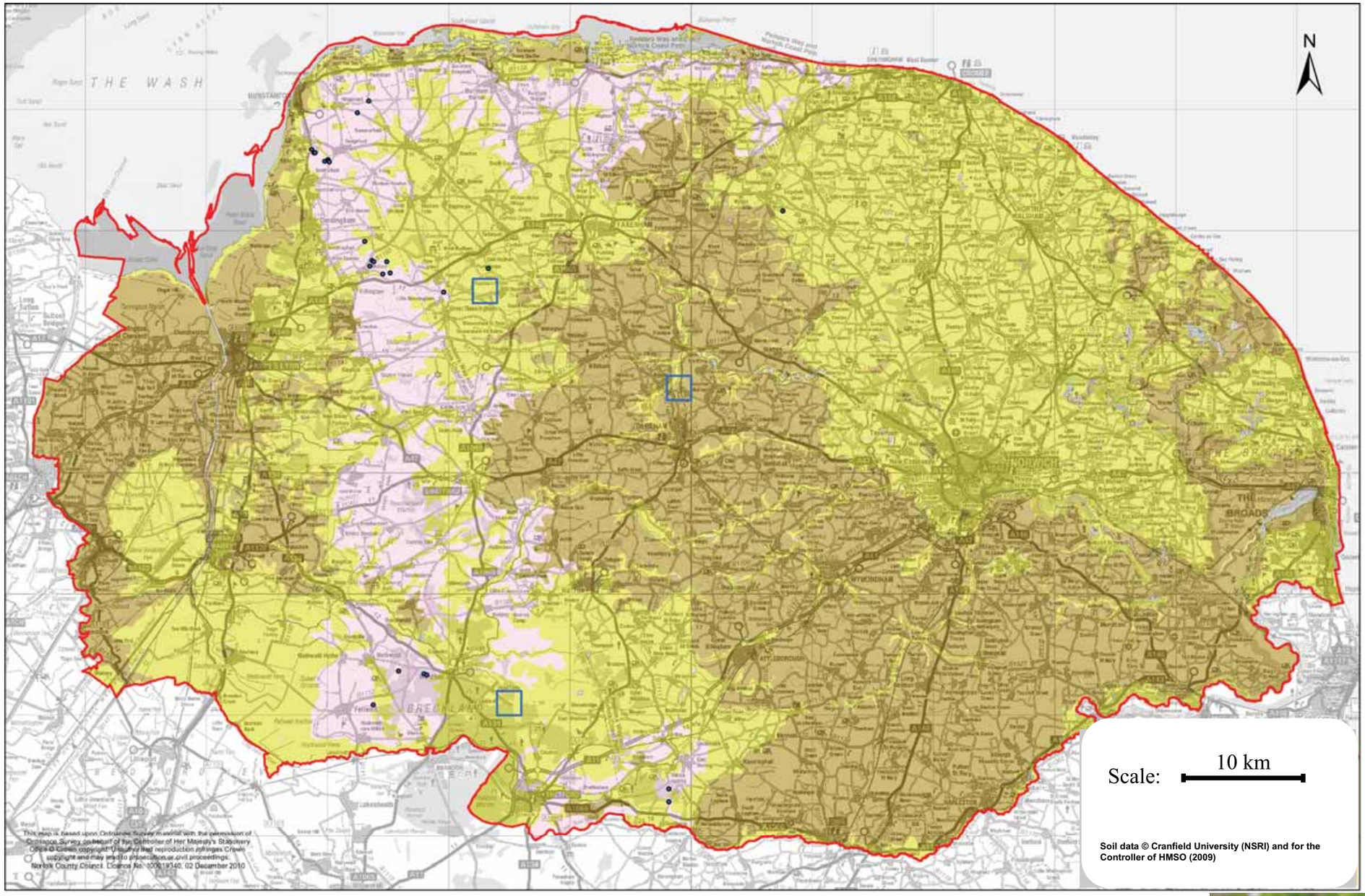


Figure 9. Distribution of narrow fruited corn salad (*Valerianella dentata*) over soil type

This map shows that the distribution of this **Criterion A** endangered arable plant species corresponds with its known substrate preference.

Legend

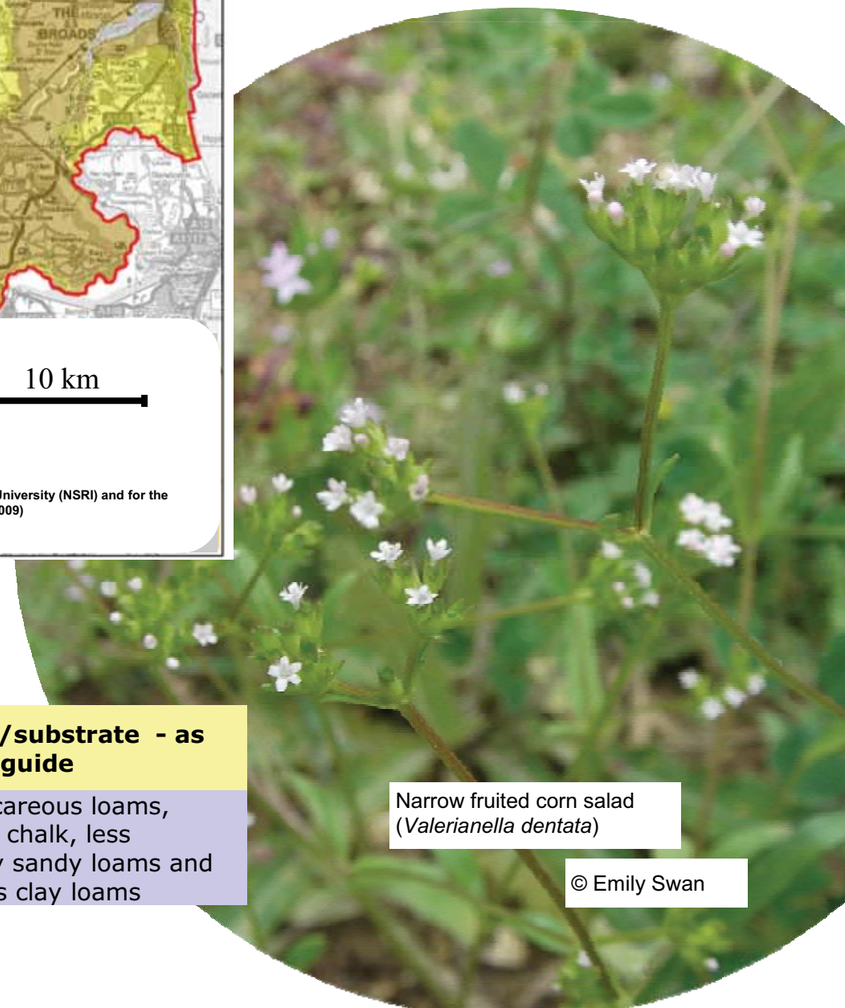
- *Valerianella dentata* point record (100m or 10m grid reference)
- *Valerianella dentata* tetrad or 1km square record

NATMAP soilscapes - PlantLife substrate categories

CATEGORY

- Other
- Chalk
- Clayey
- Sandy

	Substrate preference in Norfolk	Soil type/substrate - as per field guide
Valerianella dentata **Narrow fruited corn salad**	Mainly chalk, few on sandy soils	Light, calcareous loams, mainly on chalk, less commonly sandy loams and calcareous clay loams



Narrow fruited corn salad (*Valerianella dentata*)

© Emily Swan

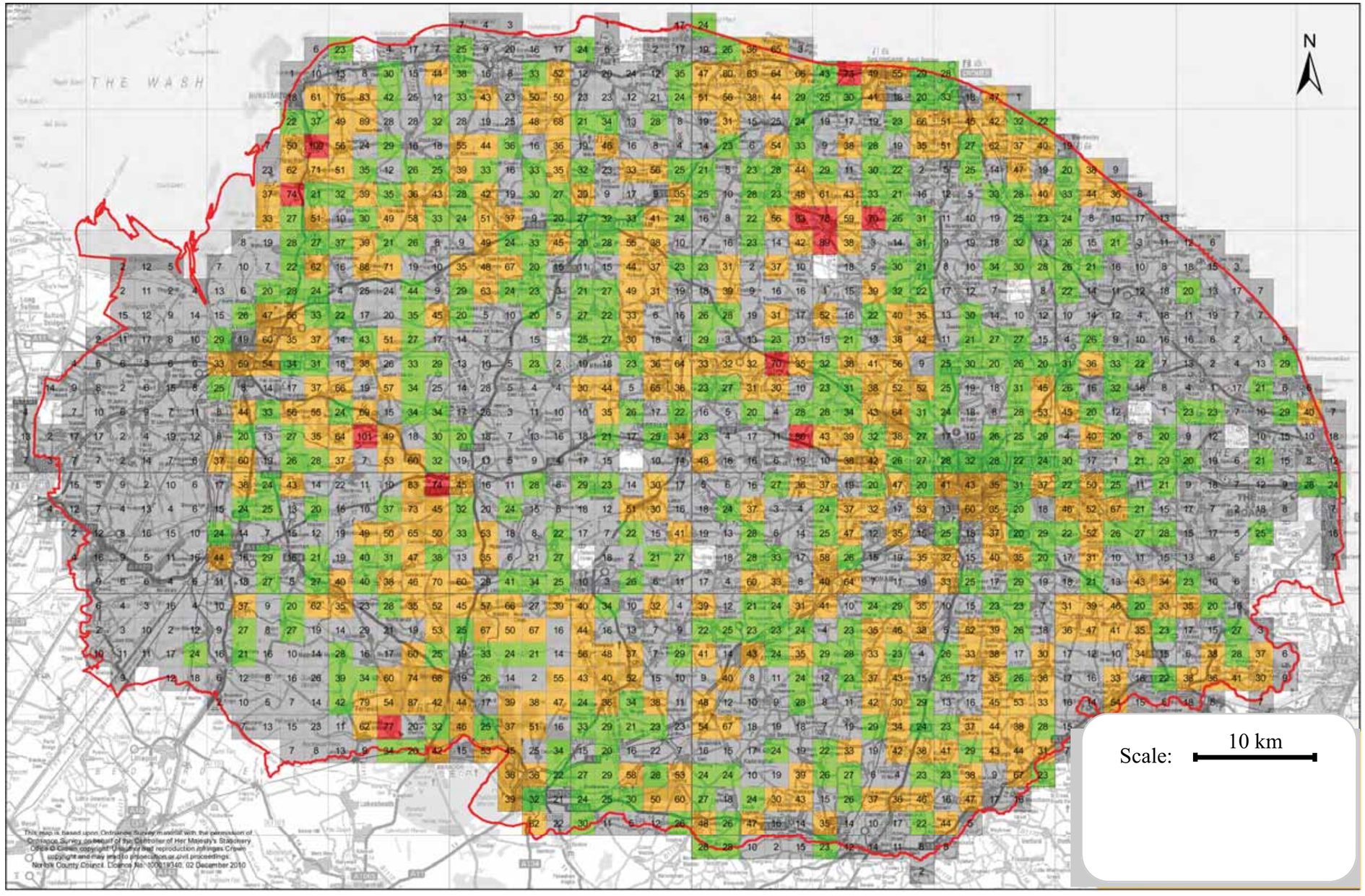
3.2 Criterion B species in Norfolk

- Of the 1418 tetrads surveyed, 726 were identified as Important Arable Plant Areas. The distribution of IAPAs shown in Figure 10 highlights that there are a number of hotspots, and they are notably absent from a large proportion of the Fens and the Broads.
- Soil type of Norfolk tetrads surveyed for arable flora was shown previously (Figure 2).
- The survey identified 12 tetrads of European importance for arable plant assemblages (see Table 6 & Figure 10). Over half of these are on sandy soils, mainly in the north of the county between Corpusty and Weybourne, and the remaining areas are scattered around the county, clearly excluding the Fens, the Broads and the south Norfolk clay lands. The European IAPAs had a mean score of 82 points
- The study identified 347 tetrads of National Importance for Arable Plant Assemblages (IAPA). The highest proportion of these occurred on sandy soils (Table 7), although chalk is the most important substrate for European and nationally-important assemblages (30.8% of all chalk tetrads were of European or national importance). The National IAPAs had a mean score of 45.8 points
- The study identified 367 tetrads of county importance for arable plant assemblages. As with the other important areas, the greatest number of sites of county importance occurred on sandy soils. The sites of county importance are more widely distributed than sites of European and national importance, and a number of these sites are within the Broads. The County IAPAs had a mean score of 26.7 points.

Table 6.
Location and IAPA score of sites of European Importance

Location	Score	Soil Type
Heacham	109	Chalk
Pentney	101	Chalk
Briston	83	Sandy
Corpusty (1)	89	Sandy
Corpusty (2)	78	Sandy
Hockwold cum Wilton	77	Sandy
Swaffham	74	Sandy
Weybourne	73	Sandy
Itteringham	70	Sandy
Hockering	86	Clay
Snettisham	74	Clay
Lyng	70	Clay

Common poppies in cultivated margin, Bracon Ash, Norfolk.
(© Henry Walker)



Legend

Conservation Importance (Criterion B)

IMPORTANCE

- Other value
- County
- European
- National

Figure 10. Distribution of IAPAs in Norfolk

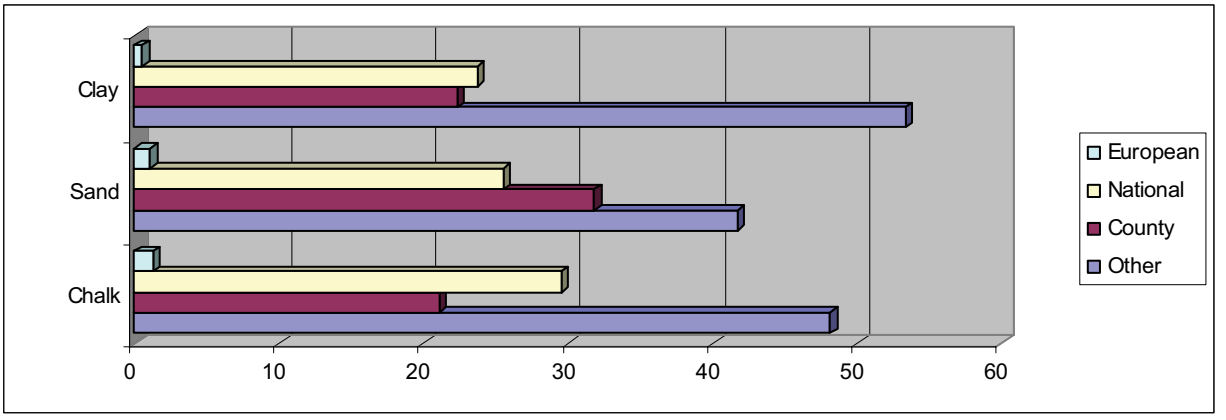
Of the 1418 tetrads surveyed, 726 were identified as Important Arable Plant Areas. The distribution of IAPAs highlights that there are a number of hotspots, and they are notably absent from a large proportion of the Fens and the Broads. Please note that squares which appear blank on this map were surveyed, but no Criterion B Plantlife-scoring species were found

Scandix pecten-veneris (Shepherd's needle) in winter wheat

© Henry Walker

Table 7.
Occurrence of Criterion B IAPAs of Conservation Importance on chalk, sand and clay.

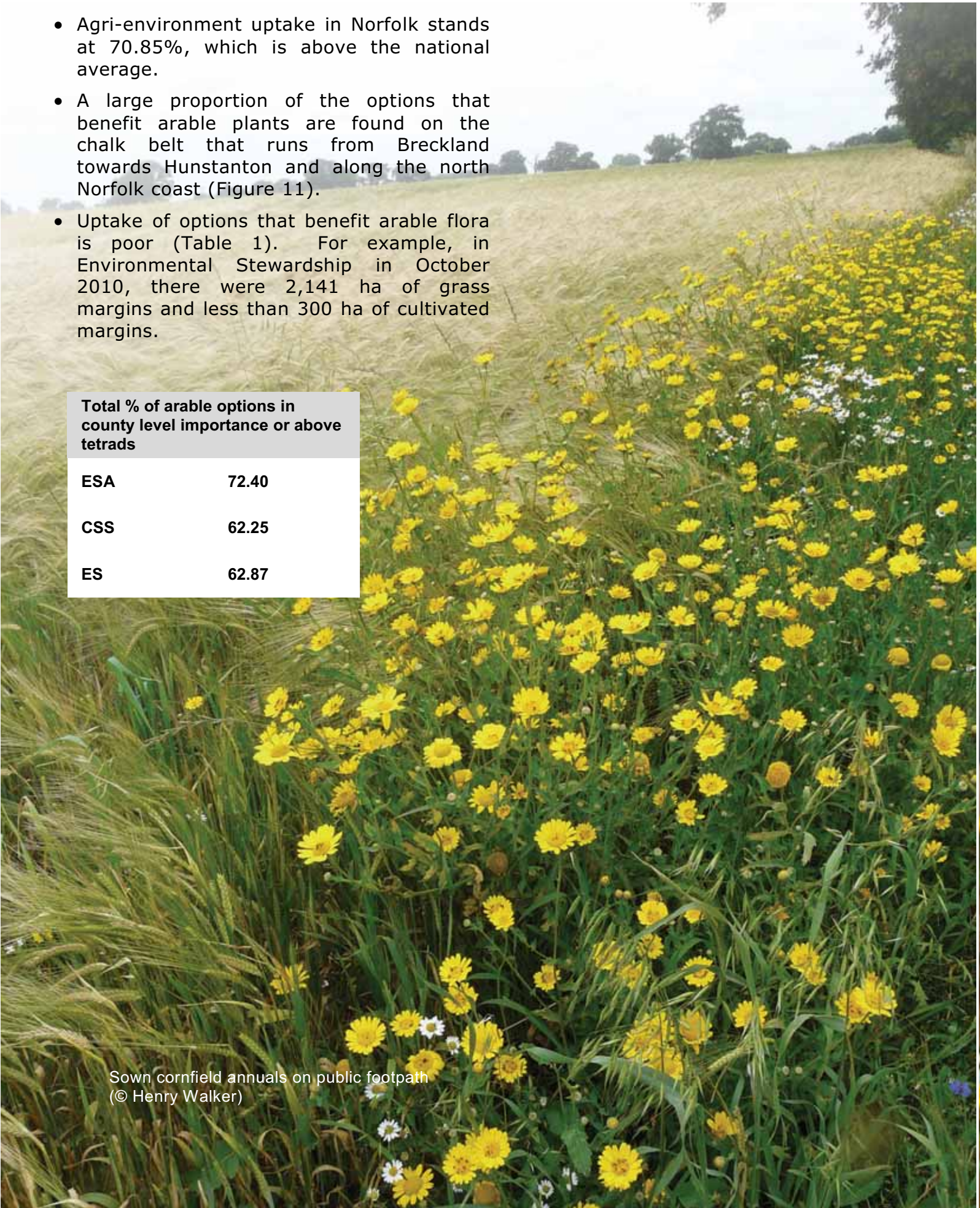
Plantlife Substrate	Total Number of Tetrads Surveyed	Conservation Importance	No of Tetrads of Conservation Importance	Percentage of Tetrads of Conservation Importance per Substrate
Chalk	156	County	33	21.1
		National	46	29.5
		European	2	1.3
		Total IAPA on chalk	**81**	**51.9**
Sand	648	County	206	31.8
		National	165	25.5
		European	7	1.1
		Total IAPA on sand	**378**	**58.3**
Clay	572	County	128	22.3
		National	136	23.7
		European	3	0.52
		Total IAPA on clay	**267**	**46.7**



3.3 Agri-environment schemes

- Agri-environment uptake in Norfolk stands at 70.85%, which is above the national average.
- A large proportion of the options that benefit arable plants are found on the chalk belt that runs from Breckland towards Hunstanton and along the north Norfolk coast (Figure 11).
- Uptake of options that benefit arable flora is poor (Table 1). For example, in Environmental Stewardship in October 2010, there were 2,141 ha of grass margins and less than 300 ha of cultivated margins.

Total % of arable options in county level importance or above tetrads	
ESA	72.40
CSS	62.25
ES	62.87



Sown cornfield annuals on public footpath
(© Henry Walker)

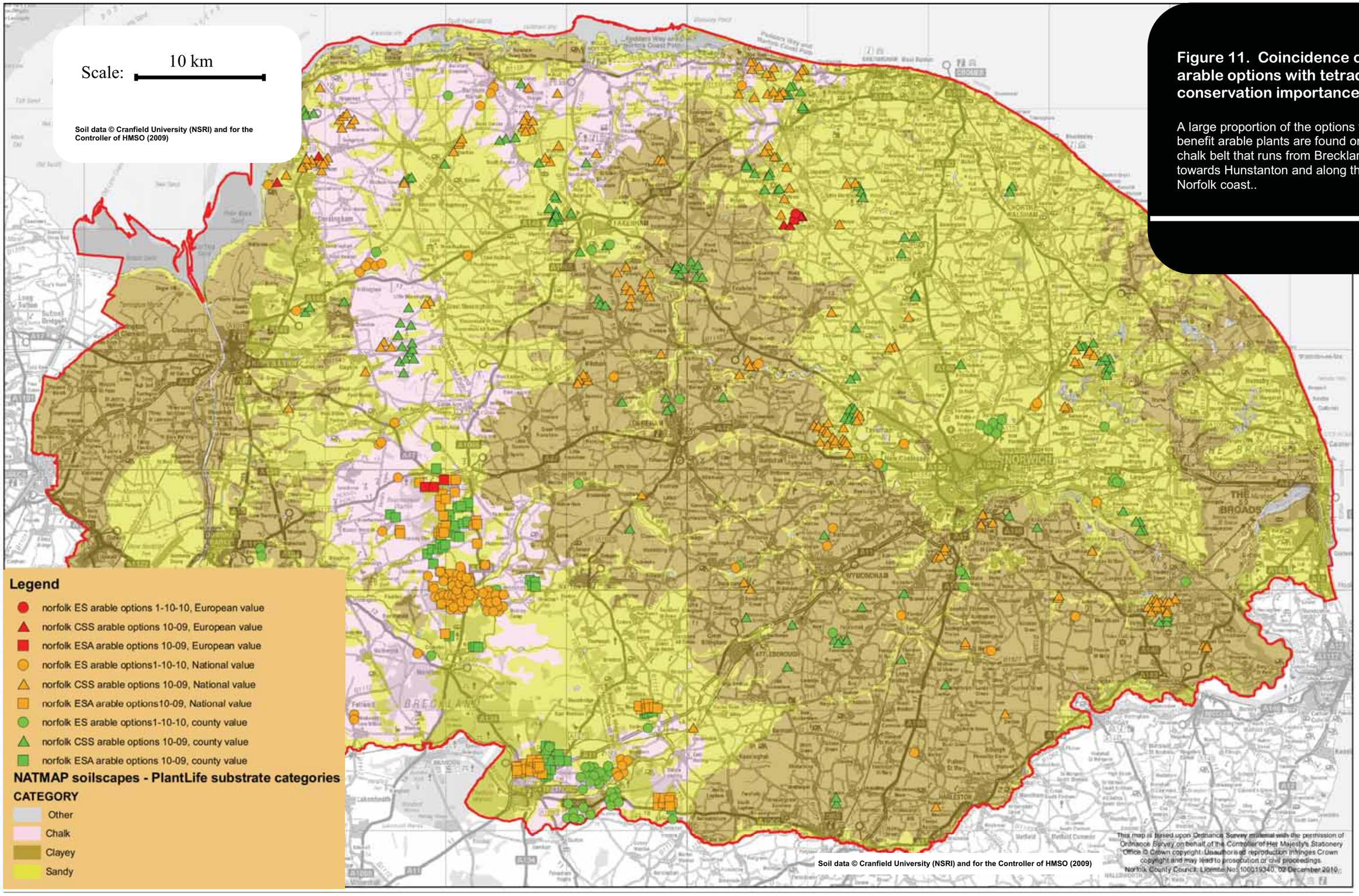


Figure 11. Coincidence of arable options with tetrads of conservation importance

A large proportion of the options that benefit arable plants are found on the chalk belt that runs from Breckland towards Hunstanton and along the north Norfolk coast..

4. Discussion

This is the first comprehensive study of arable plants in Norfolk to identify IAPAs at county, national and European level. IAPAs have been found in most parts of the county, including the Broads which has never been associated with rare arable flora. Clear clusters of IAPAs can be seen, with high scoring tetrads concentrated in the following areas:

- **Sheringham to Wiveton (via Salthouse and Kelling)**
- **Briston- Corpusty - Itteringham and surrounding areas**
- **Narborough to Hockwold via Cockley Cley, Swaffham and Bodney**
- **Heacham (Snettisham) to Ringstead**

and the isolated small pockets of high conservation importance:

- **Around Flitcham**
- **East of Hockering**
- **North of Lyng.**

These offer an indication as to where appropriate agri-environment and conservation efforts could be targeted. However, the methodology used is not without some weaknesses that are outlined later.

Our findings support the idea of the importance of the chalk substrate for arable plants, with 30.8% of all chalk tetrads being of European or national importance. Although the incidence on sand (26.6%) and clay (24.2%) was also significant, and indicates that the **importance of these soil types cannot be disregarded.** Furthermore, the distribution of the critically endangered shepherd's needle (*Scandix pecten-veneris)* highlights the importance of the south Norfolk boulder clay for this species in particular. The distribution maps also show that it is important to carry out these surveys at a local level, as annual knawel (*Scleranthus annuus*) was found on substrates that are not listed as suitable for this species in national field guides. The maps produced through this study should help to ensure that field workers are aware of where plants have been recorded locally, and should help to boost records in the future.

Arable margin, Roper Farm, Briston
(© Emily Swan)

Agri-environment

The uptake rates of options that benefit arable flora varies between schemes. One of the key features of the Breckland ESA was that it operated at a landscape scale and offered a concise selection of locally suitable options. Indeed, the Brecks ESA, unlike CSS and ES, did not contain a 'grass margin' option. Therefore, those wishing to harness the financial benefits of removing less productive headlands from cropping had no choice but to use the 'uncropped wildlife strip' option. In contrast, where people had the option of using grass buffers instead this was often chosen as a preferred, more straightforward alternative.

This is often because landowners are averse to building up weed seed banks in arable areas in order to reduce potential problems in future crops. In CSS landowners could opt for 6 m grass margins (R3), and this option was substantially more popular than options designed to benefit arable plants. There is a slight anomaly here, as there was the opportunity to cultivate R3 margins as a CSS option, **but because these were never coded differently, the statistics do not reflect this.** Anecdotal evidence does strongly indicate that cultivated R3s were rare.

Options for arable plants under ES have evolved as the schemes developed. Originally under ELS, land managers were allowed to convert cultivated margins into grass strips if the weed burden became unmanageable. There was no requirement to notify Natural England of this change; potentially the first five years of figures on un-cropped, cultivated margins in ELS were distorted, as many people are thought to have taken advantage of this opportunity. Recognising this as a problem, this element of the prescription was removed in 2008. In terms of recording, all options now have individual codes pertaining to their purpose and this should allow for more accurate monitoring in future statistics.

There are over 40 management options available through ES, and therefore the potential for the selection of options perceived to be more desirable agronomically remains. Over-wintered stubbles are found to be one of the most popular agri-environment options that benefit arable flora. This is largely because this option fits well in cropping rotations that include spring crops (such as spring

E Swan of Natural England demonstrating arable flora conservation on a FWAG walk at Herbert Kittle's Peewit Farm (© Henry Walker)

barley and sugar beet) and often does not involve taking land out of production.

In order to increase the attractiveness of other options, there is a greater need for flexibility within ELS. ELS, unlike HLS, is non-competitive and therefore offers wider delivery and greater potential for arable flora. However there is no flexibility within ELS and all holdings must abide by national prescriptions, whereas HLS agreements are tailored on a site-by-site basis by advisers. For example, in ELS, the use of graminicides is forbidden in a number of arable options and this means that the land owner is unable to control for sterile brome. In contrast, landowners in HLS can control for sterile brome, whilst still delivering appropriate management for arable plants. Additionally, the payment rates in ELS are often lower than the equivalent HLS payment options. Furthermore, ELS applications are often drawn up by landowners without guidance from advisers and so there is no encouragement for them to adopt options that benefit arable plants. These three reasons may go some way to explain why the uptake rate of certain HLS options specifically designed to benefit arable plants are nearly four times higher than their ELS equivalents.

Through local knowledge and expertise, agri-environment has been fairly successful in delivering options that benefit arable plants in some of the most important areas for arable flora (Figure 11). However, the Natural England targeting maps do not make reference to rare arable plants outside the Brecks see http://www.naturalengland.org.uk/ourwork/farming/funding/es/agents/elsoptions/farm-wildlife-ee.aspx#arable. This is a real concern for arable flora conservation in Norfolk and highlights an obvious need for increased awareness of this group amongst key national-level decision makers.

In the first round of ELS agreements (2005—2010), boundary management and management plans were the most popular options. In an attempt to steer farmer decision-making as well as renewals of the five year scheme, Natural England has recently funded a farmer advice training initiative, with one-to-one on farm advice encouraging the uptake of infield options. Targets to increase a high priority option uptake have also been set. However, ELS is still a farmer-led scheme: in spite of the best advice, farmers will always avoid taking land out of production with high cost options where possible. Only in combined ELS/HLS schemes is there the opportunity for advisers to ensure priority options are used through negotiation with farmers.

As Natural England sets land management targets, measures should be put in place to maintain the options beneficial to arable plants. In the Brecks, as Breckland ESA

agreements are superseded by ELS and HLS by setting high targets locally and even dictating option choice. The draft Breckland script has gone part of the way there, recommending that "cultivated margins should comprise 50—80% of all HLS margin options in agreements, with a preference towards the upper figure (Nichols, 2011). It is hoped that these will be raised to something nearer 80—100% of all ES margins in the Brecks.

Although the methodology used in this study provided a rapid and coarse technique for determining important arable plant assemblages, it is not without weaknesses. Firstly, soil substrate in each tetrad was determined by the majority substrate rather than the actual substrate, and this may have distorted the figures in Table 1. This may also be partly responsible for annual knawel being recorded on clay substrate, but as species were only recorded at the tetrad level rather than exact location, it is impossible to decipher a more accurate soil type for any given record. As this study has identified a number of important arable plant assemblages of national or European importance, it is recommended that these areas be re-surveyed to greater detail to allow more targeted action to conserve these plants in the future. Some of the tetrads of European importance are adjacent to other tetrads that do not even reach county importance, e.g Itteringham scored 70, and the tetrad directly south scored 3, yet the tetrads' soil types were the same. This could be due to a range of reasons, including land management, current cropping year, date of survey, access or soil type. More detailed study which takes into consideration current land management may help clarify this.

Due to their nature and ability to lie dormant in seed beds for many years, these species have often been under-recorded. Since collecting the data for this study, broad-fruited cornsalad has been recorded in Norfolk, on a holding that has been surveyed annually for the last five years. This is one of only 18 records for this species in the UK at present, and a first for Norfolk (in recent years). This emphasises the importance of continued efforts in surveying these elusive and often inconspicuous species.

5. Conclusions and Recommendations

- **This study identified 359 tetrads of European or national level importance for arable plant assemblages, which represents more than 25% of tetrads surveyed.** This highlights the importance of the arable landscape in Norfolk for the conservation of this threatened group. Future conservation efforts should be focussed within the European and national IAPAs and include a two km radius adjacent to these areas over similar soil types.
- **Agri-environment schemes are contributing towards the conservation of arable flora, although benefits could be increased (see box).**
- **The Norfolk Habitat Action Plan for cereal margins target to "maintain, improve and restore by management" the biodiversity of some 750ha of cereal field margins in Norfolk by 2010 has been easily met.** Norfolk had well over a quarter of the national HAP target for cereal field margins in 2010 without counting ES grass buffer strips. More ambitious and specific targets should be set for the future.
- **The Plantlife criteria of selecting IAPA have been honed to exclude species known only to occur in non-arable locations.** It is felt that this gives a truer representation of site scores although it makes comparison with previous studies indicative rather than absolute.
- **The 2km tetrad system used in the study provided a quick and coarse method for identifying IAPA, although the location of arable flora within tetrads has not been identified.** More work is therefore required to determine the distribution of species within tetrads and to generate more refined hotspots.
- **Byfield & Wilson (2005) suggested formal designation of IAPA as SSSI or CWS. It is thought that this would be difficult to implement given the rotational nature of options, and that designation would not be well received by the farming community.** Instead, targeting conservation efforts in known hotspots through agri-environment and other funding schemes is more likely to maximise the benefits for these important plant communities.

The benefits of agri-environment schemes for arable plants could be increased by:

- Using IAPA hotspots and clusters to assist with the targeting of options that benefit arable flora.
- Training advisers in the identification of arable plants and potential arable plant sites. This is particularly important during the early stages of environmental stewardship applications.
- Increasing the awareness of the importance of arable plants in Norfolk. Producing a concise pocket ID guide of key arable plants in Norfolk, which could be distributed amongst advisers and the farming community, could assist in this.
- Making historical records more readily available. As many arable plants are able to persist in the seed bank for numerous years, historical records are particularly valuable when conducting surveys on these taxa.
- Introducing a comprehensive monitoring system to record successes of options that benefit arable flora. This would also help to promote these options.
- Increasing the flexibility and payment rates in ELS, so that options that benefit arable flora in ELS are as attractive as the options in HLS.

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7. Appendices

Appendix 1.
Plantlife "scoring" arable plants known to occur in Norfolk

Species	Vernacular Name	Plantlife Score	Conservation Status	Notes	Inc
Alopecurus myosuroides	Black-grass	2		Quite widespread; locally abundant particularly on clay & peat soils. Usually arable. Can be a problem weed.	Y
Anagallis arvensis subsp. foemina	Blue pimpernel	5		Rare; Arable.	Y
Anchusa arvensis	Bugloss	1		Widespread; particularly on lighter soils. Usually arable.	Y
Anthemis arvensis	Corn chamomile	8	Endangered	Uncommon; particularly on light chalky soils. Usually arable.	Y
Anthemis cotula	Stinking chamomile	7	Vulnerable	Uncommon; particularly on heavy clay; Usually arable.	Y
Anthriscus caucalis	Bur chervil	3		Occasional; sometimes arable, sometimes hedgebanks etc.	Y
Apera interrupta	Dense silky-bent	4		Rare; sporadic; usually on lighter soils; often arable but also forest rides etc.	Y
Apera spica-venti	Loose cilky-bent	6	Near Threatened	Uncommon, sporadic; mainly on lighter soils; often arable but also other disturbed ground.	Y
Aphanes australis	Slender parsley-piert	1		Widespread, occasional; lighter more acid soils; possibly under-recorded. Occasionally arable.	Y
Brassica nigra	Black mustard	2		Locally frequent. Occasionally arable, but more often roadsides etc.	Y
Bromus secalinus	Rye brome	7	Vulnerable	Uncommon, sometimes casual. Probably increasing. Usually arable (particularly cereals) but occasionally other disturbed ground.	Y
Camelina sativa	Gold-of-pleasure	5		Rare. Now deliberately introduced in conservation and game cover crops.	N
Chaenorhinum minus	Small toadflax	1		Widespread but infrequent; more often on lighter more calcareous soils. Usually arable or other cultivated ground	Y
Chenopodium ficifolium	Fig-leaved goosefoot	2		Widespread and frequent. Possibly increasing. Usually arable; maybe associated with game cover crops.	Y
Chenopodium hybridum	Maple-leaved goosefoot	3		Scarce. Usually arable, perhaps most often in root crops.	Y
Chenopodium murale	Nettle-leaved goosefoot	7	Vulnerable	Rare. Usually arable.	Y
Chenopodium polyspermum	Many-seeded goosefoot	2		Widespread but infrequent; more often on clay. Usually arable	Y
Chrysanthemum segetum	Corn marigold	7	Vulnerable	Widespread, locally frequent, but mostly absent from clay. Usually arable. Sometime introduced in "wild" flower mixes.	Y

Species	Vernacular Name	Plantlife Score	Conservation Status	Notes	Inc
Descurainia sophia	Flixweed	3		Widespread in the west of the county on lighter soils; occasional in the east. Often arable but also other disturbed ground.	Y
Erodium cicutarium	Common stork's-bill	1		Widespread and quite common on light soils. Sometimes arable but probably more often in other habitats.	Y
Erodium moschatum	Musk stork's-bill	3		Uncommon. Rarely arable in Norfolk (if at all).	N
Erysimum cheiranthoides	Treacle-mustard	2		Widespread but only locally frequent. Usually arable.	Y
Euphorbia exigua	Dwarf spurge	6	Near Threatened	Locally frequent; particularly on clay. Usually arable. Possibly increasing.	Y
Filago lutescens	Red-tipped cudweed	8	Endangered; BAP; Sched. 8	Rare. Not currently known on arable land.	N
Filago vulgaris	Common cudweed	6	Near Threatened	Widespread on lighter soils. Often arable but perhaps more often in other disturbed habitats.	Y
Fumaria densiflora	Dense-flowered fumitory	3		Rare. Usually arable.	Y
Fumaria parviflora	Fine-leaved fumitory	7	Vulnerable	Rare. Confined to light chalky soils in the west of the county.	Y
Galeopsis angustifolia	Red hemp-nettle	9	Critically Endangered; BAP	Currently only on coastal shingle	N
Galeopsis speciosa	Large-flowered hemp-nettle	7	Vulnerable	Scarce. Mostly in the SW of the county. Often arable.	Y
Geranium columbinum	Long-stalked crane's-bill	2		Scarce. Mostly on light chalky soils. Occasionally arable.	Y
Geranium pusillum	Small-flowered crane's-bill	2		Widespread; common. Arable and a variety of other habitats.	Y
Hyoscyamus niger	Henbane	7	Vulnerable	Scarce; sporadic. Arable and other disturbed ground.	Y
Hypochaeris glabra	Smooth cat's-ear	7	Vulnerable	Occasional & local. Light soils. Only occasionally arable.	Y
Kickxia elatine	Sharp-leaved fluellen	2		Locally common. Mainly on the boulder clay but also on other, often calcareous soils. Almost always arable. Possibly spreading.	Y
Kickxia spuria	Round-leaved fluellen	3		Local. Scarce. Mostly on the southernmost part on the boulder clay. Almost always arable.	Y
Lamium amplexicaule	Henbit dead-nettle	1		Rather uncommon. Usually on well-drained soils. Usually arable.	Y
Legousia hybrida	Venus's-looking-glass	3		Widespread but uncommon and decreasing. Mostly lighter calcareous soils. Usually arable.	Y

Species	Vernacular Name	Plantlife Score	Conservation Status	Notes	Inc
Lithospermum arvense	Field gromwell	8	Endangered	Very rare now. Calcareous soils (light and heavy). Usually arable	Y
Malva neglecta	Dwarf mallow	2		Widespread, usually associated with villages.	N
Mentha arvensis	Corn mint	1		Widespread. Occasional. Often arable but in a variety of other habitats. Easily confused with *M* x *verticillata*.	Y
Mercurialis annua	Annual mercury	2		Widespread but absent from many areas. Occasionally arable – perhaps most often as a garden weed or general ruderal.	Y
Misopates orontium	Weasel's-snout	7	Vulnerable	Scattered. Scarce. Usually arable.	Y
Myosurus minimus	Mousetail	7	Vulnerable	Rare. Rarely arable in Norfolk (if at all).	N
Nepeta cataria	Cat-mint	7	Vulnerable	Local. Scarce. Usually on lighter calcareous soils. Sometimes arable. Very occasionally as a garden escape.	Y
Orobanche minor	Common broomrape	2		Widespread. Occasional. Rarely arable in Norfolk (if at all).	N
Papaver argemone	Prickly poppy	7	Vulnerable	Scattered. Scarce. Often arable.	Y
Papaver dubium subsp. lecoqii	Yellow-juiced poppy	2		Local. Scarce. Possibly most often as a garden weed.	Y
Papaver hybridum	Rough poppy	3		Local. Mostly on light chalky soils in the west of the county. Often arable.	Y
Petroselinum segetum	Corn parsley	3		Scarce. Scattered.	Y
Polygonum rurivagum	Cornfield knotgrass	3		Uncommon. Scattered.	Y
Ranunculus arvensis	Corn buttercup	9	Critically Endangered; BAP	Rare. Probably extinct.	Y
Ranunculus sardous	Hairy buttercup	3		Frequent on costal grazing marshes. Scarce elsewhere. Very rarely in arable.	N
Raphanus raphanistrum	Radish	1		Widespread. Common. Usually arable.	Y
Scandix pecten-veneris	Shepherd's-needle	9	Critically Endangered; BAP	Very local. Mostly on the south-east Norfolk clay.	Y
Scleranthus annuus	Annual knawel	8	Endangered; BAP	Local on lighter soils. Much decreased. More often on tracksides and old pits than in arable.	Y
Sherardia arvensis	Field madder	1		Widespread. Locally frequent. Usually arable but also in other habitats.	Y
Silene gallica	Small-flowered Catchfly	8	Endangered; BAP	Rare. Much decreased and now rarely arable.	Y
Silene noctiflora	Night-flowering catchfly	7	Vulnerable	Widespread. Usually on lighter more calcareous soils. Usually arable.	Y

Species	Vernacular Name	Plantlife Score	Conservation Status	Notes	Inc
Sinapis alba	White mustard	2		Scattered. Now deliberately introduced in conservation and game cover crops.	N
Spergula arvensis	Corn spurrey	7	Vulnerable	Widespread. Usually on lighter soils. Often arable.	Y
Stachys arvensis	Field woundwort	6	Near Threatened	Widespread but not common. On a variety of soils. Almost always arable.	Y
Torilis nodosa	Knotted hedge-parsley	3		Occasional. Rarely arable	N
Valerianella dentata	Narrow-fruited cornsalad	8	Endangered	Rare; chalky soils. Usually arable.	Y
Veronica agrestis	Green field-speedwell	1		Widespread but occasional. Usually arable.	Y
Veronica polita	Grey field-speedwell	2		Widespread but occasional. Usually arable.	Y
Veronica praecox	Breckland speedwell	8		Very rare, Breckland only. Arable and other disturbed ground	Y
Veronica triphyllos	Fingered speedwell	8	Endangered; BAP; Sched. 8	Very rare, Breckland only. Arable (introduced) and other disturbed ground	Y
Veronica verna	Spring speedwell	8	Endangered; BAP	Very rare, Breckland only. Arable – the only remaining population is introduced	Y
Vicia tetrasperma	Smooth tare	2		Widespread. Only occasionally arable.	N
Viola tricolor subsp. tricolor	Wild pansy	6	Near Threatened	Widespread but uncommon. Usually arable. Possibly over-recorded for *V.* x *contempta*.	Y

Appendix 2
Data analysis

Preparation of survey data
Field data obtained during previous plant surveys of Norfolk (described in 2.1) were collated and tabulated so to be consistent with the Plantlife methodologies outlined in 2.2.
The total number of species known to occur in Norfolk, qualifying under Criterion A, was identified and listed for each tetrad (this information is presented table 5).
The outstanding assemblage assessment methodology (Criterion B), described in Table 2, was used to assign a Plantlife IAPA score for each tetrad.
The results of this were several Excel spreadsheets; these were then used within MapInfo and ArcGIS GIS packages, as part of the analysis below.

GIS analysis
Pre-analysis work involved:

- Creation of a tetrad grid for Norfolk using a grid reference mapping tool in MapInfo GIS – this grid was used to display the distribution results from both criterion A and B methods;
- Creation of a layer showing the Plantlife broad substrate categories – this was used to display criterion A individual species distributions (figures 4-9) and arable option coincidences (figure 11) on. To prepare this layer, the NATMAP soilscapes map from Cranfield University, which has soil types as a vector polygon layer, was used. Discussions were held to agree which soil types should be assigned to each Plantlife broad substrate category (as per table 4). Each polygon was then assigned a broad substrate category, based on these agreed associations;
- Creation of a tetrad grid showing the Plantlife broad substrate categories (figure 2) – this grid was used in the analysis within criterion B;
- Using a tool in the Spatial Analyst ArcGIS extension to prepare a raster tetrad grid for the Plantlife broad substrate categories, using the previously created (above) vector broad substrate category layer. Where multiple substrates were found within a single tetrad the tetrad was defined by the majority substrate. The raster was converted to a vector layer to be used within the criterion B analysis.

Criterion A:
Using the tetrad grid (above), the co-incidence distribution of all 20 potential Criterion A species in Norfolk were symbolised by the number of species per tetrad (figure 3). This was achieved through thematically mapping the co-incidence spreadsheet data, now in the form of a tetrad grid, within MapInfo GIS.

Individual species distribution maps (figures 4-9) were created by plotting point and grid square records over Plantlife broad substrate categories. The grid reference mapping tool in MapInfo GIS was used to map the species records based on resolution of grid reference (i.e. point records are of better resolution than grid square records)

Criterion B:
The spreadsheet data created using the outstanding assemblages methodology (IAPA scores), was imported into MapInfo GIS as a tetrad grid. The tetrad grid showing Plantlife broad substrate categories (described above) was then spatially joined to this criterion B tetrad grid to result in a layer where each tetrad has both a IAPA score and Plantlife broad substrate category attribute. Each tetrad was then assigned a conservation importance value (county, national or European) based on the thresholds set in table 3 - For example if a tetrad is chalk substrate and the IAPA score is above 90, then it is European importance. If it is clay, the IAPA needs to be only 70 for it to be of European importance.
The resultant grid was thematically mapped, based on the conservation importance of each tetrad (figure 10). Table 6 lists the sites where one or more tetrads of European

importance have been identified.
Following this analysis, clear clusters and corridors of high scoring IAPA tetrads (national or European importance) were identified; these are listed, along with isolated pockets of high conservation importance, in section 4.

Table 7 shows the occurrence of criterion B IAPA tetrads of conservation importance on the Plantlife broad substrate categories (chalk, sand and clay). Some quick analysis of the data used in figure 10, shows the relative importance of the three substrates for IAPAs. The final column is a simple calculation to show the percentage of tetrads of each conservation importance category for each substrate.

Some final analysis using the criterion B data was undertaken, this was intended to show the co-incidence of recent arable agri-environment options (HLS, ELS, ESA and CSS) with tetrads of conservation importance (county, national and European).
Natural England provided a list of arable agreement options currently 'live'. GIS point layers of these arable option locations were created in MapInfo GIS. All options that intersected with tetrads of county importance or above were plotted and thematically mapped. The resultant map has been included as figure 11.

Corn marigold in cultivated margins on Pee-wit Farm, Briston.
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