



Breckland ground beetles project

A Buglife report produced for Natural England

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Summary

Buglife were contracted by Natural England to investigate potential conservation management tools for six scarce ground beetles which are associated with the disturbed habitats of the Brecks, as part of the 2014-15 Innovation Fund. The distributions of the Wormwood moonshiner (*Amara fusca*), Brush-thighed seed-eater (*Harpalus froelichii*), Set-aside downy-back (*Ophonus laticollis*), *Bradycellus csikii*, *Harpalus pumilus* and *Harpalus smaragdinus* were examined and key sites and features identified. Existing disturbance management undertaken for Breckland's nationally important wildlife has been reviewed, including the use of wide-scale rotovation, ploughing and topsoil stripping, the management of arable field margins under agri-environment schemes and the use of managed grazing exclosures for key species.

The report provides suggestions for research focusing on the frequency of disturbance management at large sites and in arable margins, to help identify the most beneficial regime for scarce ground beetles. The vast majority of known disturbance management areas have either been managed as a one off treatment or are managed annually, so research into diversifying management to include areas managed only every 2 or 3 years is recommended. Similarly researching the diversification of disturbance regimes within uncultivated, crop margins is recommended. Specific recommendations are made regarding encouraging the re-introduction of food plants for *A. fusca*, as well as mitigation and site safeguard to minimise the impacts of the Thetford Sustainable Urban Expansion (SUE) development on *O. laticollis* and *H. froelichii*.

This report includes an accompanying GIS layer of collated beetle records, an appendix containing the records and an A4 leaflet which has been produced to raise awareness of ground beetles of disturbed habitats to help engage landowners. Potential landowners for delivering new habitat management have also been identified in partnership with Norfolk Farming and Wildlife Advisory Group (FWAG) and have been provided to Natural England in a separate document for confidentiality purposes.

Introduction

The Brecks are home to a unique assemblage of ground beetles associated with disturbed habitats, notably the arable brecks. This includes a number of rare and endangered species, some listed as Priority species for conservation under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006. This report aims to inform the conservation of this unique assemblage at the landscape level, providing broad habitat management recommendations, identifying potential sites for targeted restoration and to provide potential mitigation measures to minimise the impact of urban development and agriculture on the assemblage.

This report focuses on six species known to be associated with disturbed brecks habitat:

- Wormwood moonshiner (*Amara fusca*)
- Brush-thighed seed-eater (*Harpalus froelichii*)
- Set-aside downy-back (*Ophonus laticollis*)
- *Bradycellus csikii*
- *Harpalus pumilus*
- *Harpalus smaragdinus*

A suite of eight species was originally proposed for investigation, however, it quickly became apparent that both the Necklace ground beetle (*Carabus monillis*) and *Harpalus melancholicus* had been included based on incorrect geographical data. A full datasearch and consultation with national and local experts has confirmed that the nearest record for *C. monillis* was from Bury St. Edmunds, which as well as being outside of the Brecks area, dated from 1946. It also became clear that there were no records for *H. melancholicus* for the region at all, with its initial inclusion based on a repeatedly reported erroneous grid record.

A number of aims and outputs for this work have been identified:

- Collate existing knowledge of the assemblage of the six ground beetles associated with disturbed arable brecks and produce a user friendly GIS layer.
- Map existing sites and highlight potential sites for habitat enhancement to support the assemblage, including references to the Thetford Sustainable Urban Expansion development (Thetford SUE).
- Produce an illustrated species sheet for the species represented in the assemblage to aid with identification of high quality arable brecks and to raise awareness to stimulate engagement with landowners.
- Identify potential agri-environment and mitigation appropriate habitat creation techniques, working with the Farming and Wildlife Advisory Group (FWAG) to identify potential landowners for trials.

It is important to note that it was beyond the scope and remit of this work to implement management techniques, but it aims to identify potential work and research areas to enhance the conservation of Breckland beetles.

This project was funded by Natural England's Innovation Fund 2014-2015.

Data collection

A central aim of the project was to collate records relating to the beetle assemblage, harnessing local and national expert knowledge. Approaches were made to leading organisations and individuals who have valuable records of Breckland ground beetles, including:

- Paul Dolman (University of East Anglia)
- Brian Eversham (Bedfordshire, Cambridgeshire and Northamptonshire Wildlife Trust)
- Paul Lee (Hymettus Ltd)
- Mark Telfer (National Carabid recorder)
- John Walters (Entomologist/Ecological consultant)
- Jon Webb and David Heaver (Natural England)
- Martin Collier (Norfolk Carabid recorder)
- Howard Mendell (Suffolk Carabid recorder)
- Steve Lane (Entomologist/Ecological consultant)
- Norfolk Biodiversity Information Service
- Suffolk Biological Records Centre
- Bev Nichols (Natural England)

Before collating the data, it was important that the Breckland study area be defined. It was considered appropriate to use the boundaries used for the Breckland Biodiversity Audit produced in 2010 (Dolman *et al.* 2010). This used the maximum extent of combining the Breckland Environmentally Sensitive Area (ESA) and the Breckland National Character Area (NCA) produced by Natural England (<http://publications.naturalengland.org.uk/publication/4282581>).

Efforts were made to prevent the duplication of records, however, many records for sites included both specific dates and dates only identified by the year of recording. For the sake of completion both records were included.

The names of recorders in the accompanying GIS layers have been removed for data protection purposes and to meet the requirements of some organisations which provided data. This data is available on request, however, still excluding the names of some recorders where the conditions of data provision dictated so. Only records with a minimum of a four figure grid reference have been included in the GIS layers, but coarser data has been included in the accompanying Excel spreadsheets for the sake of completion.

Disturbed Breckland ground beetles

Much of the historic biodiversity value of the brecks lies in the underlying chalk overlain by free-draining and low nutrient sandy soils, and a semi-continental climate leading to drought conditions. The Brecks is a mosaic of heathland and grasslands on soils ranging from acidic sands through to calcareous in nature often on the same sites, leading to a juxtaposition of contrasting characters.

The history of the Brecks is one of change, with changing intensity and patterns of agriculture over many centuries. This led to a very dynamic landscape that developed from low intensity agriculture, extensive grazing systems and widespread rabbit farming using enclosed warrens, producing early successional habitats across the landscape with periodic disturbance and abandonment. A suite of nationally rare and scarce ground beetles are associated with the early successional and disturbed brecks habitat, as was highlighted in “*Securing Biodiversity in Breckland*”, the first report of the Breckland Biodiversity Audit (Dolman *et al.* 2010). Suitable habitat for individual can be found on arable fields and margins, the remains of windblown calcareous sand dunes, brownfields, in grassland/heathland complexes and along trackways in some of the large heathland and forest complexes that now dominate some areas of the Brecks.

Disturbed habitats provide a diverse habitat for ground beetles, with regular creation of new bare ground, a good supply of annual flowering plant seed and with occasional or rotational disturbance, a mosaic of successional stages and degrees of vegetation. The historic land use patterns of the brecks, with periodic cultivation of heathland for a number of years followed by long periods of fallowing suited many of the annual plants which support seed-eating ground beetles (Dolman *et al.* 2010). This regime created weedy fallows without dominance by perennials as happens in closed swards free of disturbance, with regularly created bare areas for annuals to thrive and produce seed prolifically. However, modern agricultural advances have reduced the extent of this disturbed habitat type, with the cropping of previous arable field margins, use of herbicides reducing annuals, fertilisers encouraging vigorous grass growth, changes in crop types and changes in crop rotation patterns. The traditional movement of livestock across the landscape has also ceased, reducing regular disturbance of trackways, while post 1920s creation of conifer plantations accelerated after the Second World War, effectively reducing the resource of open habitats with one quarter of the region eventually afforested (Eycott *et al.*, 2006). This stabilisation of the landscape has led to the near disappearance of the windblown calcareous dune systems which once dominated large swathes of the region and provided regular new areas of bare sand for invertebrates and ruderal plants. Thankfully, localised disturbance along trackways through farmland, the forest landscape or as a result of quarrying activity has maintained and/or created stepping stones or connective habitat features suitable for scarce ground beetles across the region. The Forestry Commission’s current plan to manage 10% of Thetford Forest as open, disturbed trackways as part of their Open Habitat Plan (OHP), offers a new opportunity to enhance opportunities for ground beetles at the landscape scale.

The six study species have differing degrees of dependence on the Brecks to maintain their UK populations according to the Breckland Biodiversity Audit, with all species having Breckland described as a “primary stronghold”, with the exception of *O.laticollis* which has Breckland as a “secondary stronghold” (Dolman *et al.* 2010). Dolman *et al.* used the following definitions in identifying Brecks specialism:

- Primary stronghold = $\geq 50\%$ of 10 km squares in which a species have been recorded are, or $\geq 50\%$ of breeding population occur, within the Breckland 10km squares
- Secondary stronghold = $\geq 25\%$ of 10 km squares in which a species have been recorded are, or $\geq 25\%$ of breeding population occur, within the Breckland 10km squares

Species accounts

Wormwood moonshiner (*Amara fusca*)



A. fusca © John Walters

A. fusca is a Breckland specialist, with only one modern site from outside of the region and is classified as Endangered in the forthcoming Carabid status review (Telfer, 2015). This seed-eating beetle is associated with Field wormwood (*Artemisia campestris*), Mugwort (*Artemisia vulgaris*) and possibly Dune wormwood (*Artemisia crithmifolia*). It has been suggested that populations associated with the favoured Field wormwood are stronger than those associated with Mugwort (Walters, 2011). However, many of the sites supporting the favoured Field wormwood have been lost to agriculture, forestry and development, leaving it native at only three sites, although populations have been successfully established using native seeds, where rabbit grazing is excluded (Online Atlas of the British & Irish Flora, 2015). The theory that Field wormwood is preferred does, however, remain untested and the much commoner Mugwort is widespread in many disturbed, sandy habitats.

Artemisia campestris is a perennial plant (as presumably is *A. crithmifolia*) but requires disturbed soil in which to germinate, maintaining appropriate levels of disturbance at an appropriate spatial scale is important for maintaining large, healthy populations of the plant, and populations of the beetle. Mowing and deer grazing have both had detrimental effects on beetle populations in the past by removing seed-bearing parts of the *Artemisia* plants. *Amara fusca* is therefore threatened by inappropriate management

The beetle is best recorded in September and October, coinciding with the ripening of Field wormwood seeds. During this time it can be seen after dark climbing the plant to feed on seeds.

Brush-thighed seed-eater (*Harpalus froelichii*)



H. froelichii © John Walters

H. froelichii was previously considered to be a Breckland specialist in terms of its modern distribution and is classified as Near Threatened in the forthcoming Carabid status review (Telfer, 2015).

However, there have been recent records outside of its core range in Breckland which suggest that the species might be expanding its range or has previously been under-recorded, in addition to historic records from other areas of East Anglia and central south England (Walters, 2011). Historic records include a wider range of locations, but the species seems to have suffered from heathland fragmentation, development and the conversion of habitat into arable land or coniferous woodland. The beetle is strongly associated with Fat hen (*Chenopodium album*), a fast-growing annual associated with heavily disturbed ground, in sandy situations such as ploughed arable margins in Breckland, drought-stressed/dry sandy grasslands or coastal dunes. It is often recorded in August and September, during the Fat hen seed ripening period and appears to be very mobile, including being attracted to moth traps run overnight.

It appears to favour regular and intensive disturbance regimes, producing a diverse range of annual plants, but with a clear preference for Fat hen (Telfer, 2009a). As a result it is at risk within Breckland from reduction in disturbance management, tree planting and inappropriate management.

Set-aside downy-back (*Ophonus laticollis*)



O. laticollis © John Walters

O. laticollis was formerly more widespread but now has its national stronghold in the Breckland area, around a very small number of key sites, as its range has contracted significantly to a handful of southern counties in England. It is classified as Nationally Scarce in the forthcoming Carabid status review (Telfer, 2015). *O. laticollis* is found on sparsely vegetated ground such as those on arable field margins and disturbed calcareous soils, particularly favouring the interface between cultivated arable margins and grassland on chalky sandy soils (Telfer 2009b). It feeds on a range of seeds from annual plants, likely to include ripening, fallen and dead seed throughout the year (Telfer, 2009b). *O. laticollis* seems to require abundant arable seeds on friable preferably calcareous soils in sunny situations, adjacent to permanent shelter such as tussocky grassland or hedges (Buglife, 2013; Telfer 2009b).

Bradycellus csikii



B. csikii © John Walters

B.csikii can be found at a significant number of Breckland localities, making the region of high importance for the species, but with modern records showing the species to be found at localities throughout the south of England, as far north as Staffordshire (Steve Lane, 2014). The species is classified as Nationally Scarce in the forthcoming Carabid status review (Telfer, 2015). The species prefers well drained, disturbed sandy soils including brownfield sites and around arable field margins, where it appears to feed on the seed of a range of annual species.

Harpalus pumilus



H. pumilus © John Walters

H. pumilus is associated with open, disturbed areas on sandy sites, including within gaps in free-draining grasslands. Despite records showing a wide southern England distribution, the beetle demonstrates a strong affinity with the Brecks. It is classified as Near Threatened in the forthcoming Carabid status review (Telfer, 2015).

Harpalus smaragdinus



H. smaragdinus © John Walters

H. smaragdinus is perhaps the most widespread of the species studied, with records throughout the south as far north as the Midlands on sandy arable field margins, disturbed heathland and in sand pits, where it thrives on early successional habitats (Telfer & Eversham, 1995). It is classified as Nationally scarce in the forthcoming Carabid status review (Telfer, 2015).

Distribution of species and key sites

This report includes an accompanying Geographic Information System (GIS) layer, compatible with both ArcGIS and MapInfo, containing collated ground beetle records from a number of organisations and individuals. From this, a number of key sites for both the wider assemblage and specific species can clearly be identified. A key aim of this report is to identify potential sites to target the creation and management of suitable disturbed habitat, to create a more coherent network of habitat patches.

Sites were mapped where a boundary could be confirmed, such as for Nature Reserves, Airbases, camps or woods, or where a boundary had previously been mapped. Isolated records, irrespective of the accuracy of grid references were mapped only as records and not as key sites due to the difficulties of delineating sites.

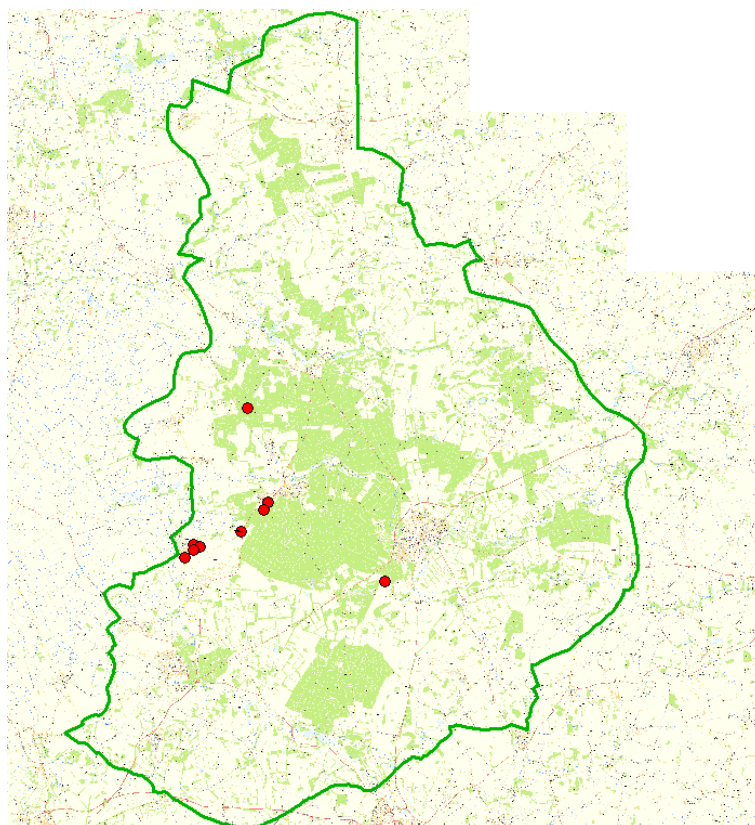
Species distributions

Wormwood moonshiner (*Amara fusca*)

Records for *A. fusca* are largely from three main sites in the Brecks, with the strongest population found on the Artemisia reserve which has been established in a Brandon industrial estate to conserve the last natural stand of Field wormwood. It has been recorded there on a number of occasions by national coleopteran experts, with records between 1994 and 2011 collated, with a peak number of 50 individuals observed in any visit.

The species was first recorded at the Wangford roadside in September 1993, having not been recorded in Britain since a 1942 record in Kent. It was subsequently recorded on visits to the site throughout the 1990s, generally in small numbers. The beetle has also been recorded over a number of years at Maidscross Hill Site of Special Scientific Interest (SSSI) with records from 1994 to 2003, with a maximum number of 18 observed on any individual visit. At both the Wangford Roadside and Maidscross Hill SSSI the beetle is strongly associated with Mugwort, as Field wormwood has either died out or is unknown from the site.

Two outlying records include one from 2010, when the county recorder identified a specimen from Weeting, taken from the disturbed forest rides, and in 2012 when an individual was pitfall trapped at Thetford Heath, again by the county recorder, in a rotovated plot.

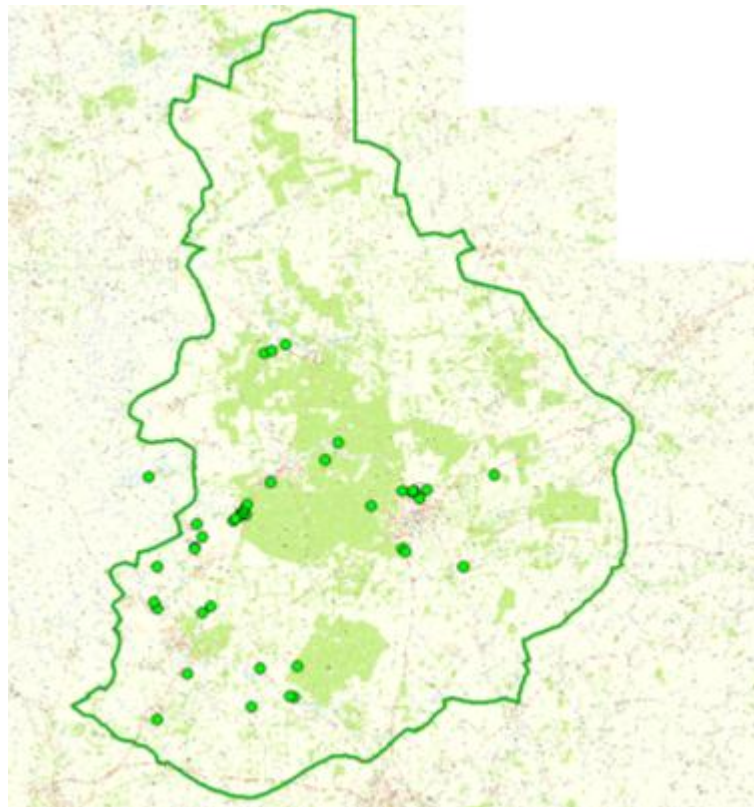


Map of records for *A. fusca* in the Brecks with at least a four figure grid reference. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Brush-thighed seed-eater (*Harpalus froelichii*)

H. froelichii has records throughout a number of sites in the central and southern-western parts of the study area, suggesting it to be more tolerant of a range of disturbed sandy conditions. It is clearly well established with records stretching back to 1905 in a Wangford conifer plantation.

Sites with a number of records include arable margins north of Thetford (including Gallows Hill and Blakeney Farm), while several sites around Thetford Forest have recorded the species on a number of occasions, with records within the forest itself in open trackways and paths. West of Thetford Forest, a strong population can be seen occupying the beetle-rich adjacent sites of RAF Lakenheath, Wangford Warren and Carr SSSI and Maidsclough Hill SSSI. However, its mobility and tolerance of a range of disturbed situations is reflected in it occupying sites as diverse as the Aspall Close Local Nature Reserve (LNR) (a site with woodland, grassland and scrub but new bare ground creation), cultivated arable margins around agricultural land in Thetford, and the urban *Artemisia* reserve. This willingness to occupy a range of regularly disturbed situations may be particularly important to the species' national conservation considering its strong dependence on the Brecklands region. A significant proportion of the records are also post-2000, with sixteen individual named sites holding records between 2000 and 2014.



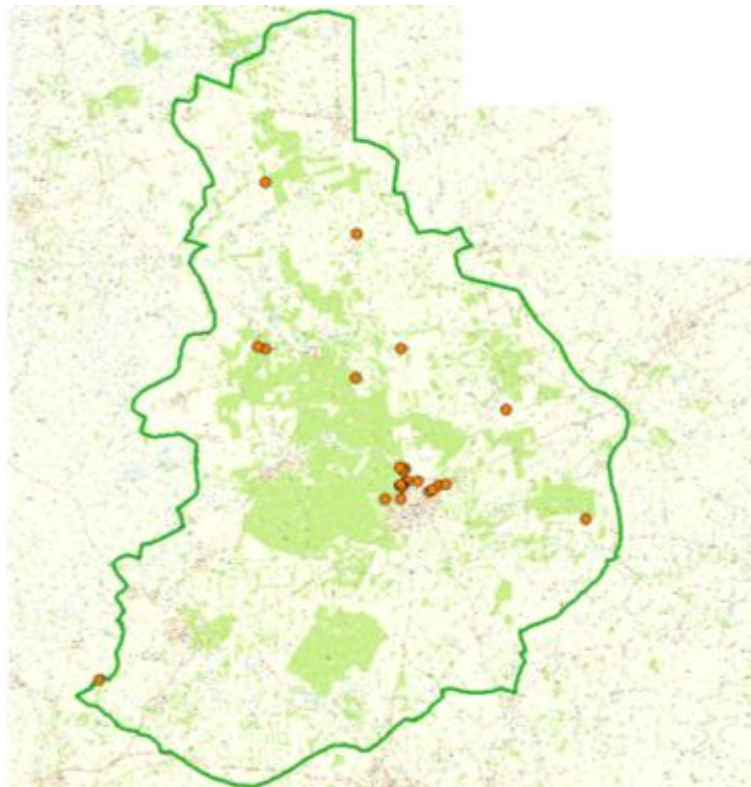
Map of records for *H. froelichii* in the Brecks with at least a four figure grid reference. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Set-aside downy-back (*Ophonus laticollis*)

O. laticollis populations and ecology have been examined in detail by Mark Telfer over a number of years on arable margins north of Thetford, reporting around half of the Brecks records in the process at Croxton Hall Farm, particularly in Gallows Hill. This heavily emphasises the value of the cluster of field margins with suitable habitat for the species. Records outside of this north Thetford core are scattered, however, post-2000 records are restricted to the expansive military Stanford Training Area (STANTA), which is only a few miles north of Thetford. This may be a result of under recording on sites with historic records, but it is more likely indicative of a very small modern range for a species which has the Brecks as a secondary stronghold (Dolman *et al.*, 2010).

Earlier Norfolk records for the species include Cranwich Camp SSSI, an undated record from Cockleyclew Woods, and 1990s records from arable field margins in Hilborough, Southgate and Woodhouse. The exact location of the records is not explicitly stated in data sources, but the very accurate grid references (ten figure, or 1m by 1m) allows pinpointing, and further strengthens Mark Telfer's suggestions on the value of these margins.

Interestingly the only Suffolk record for the species was in Freckenham in 1920.

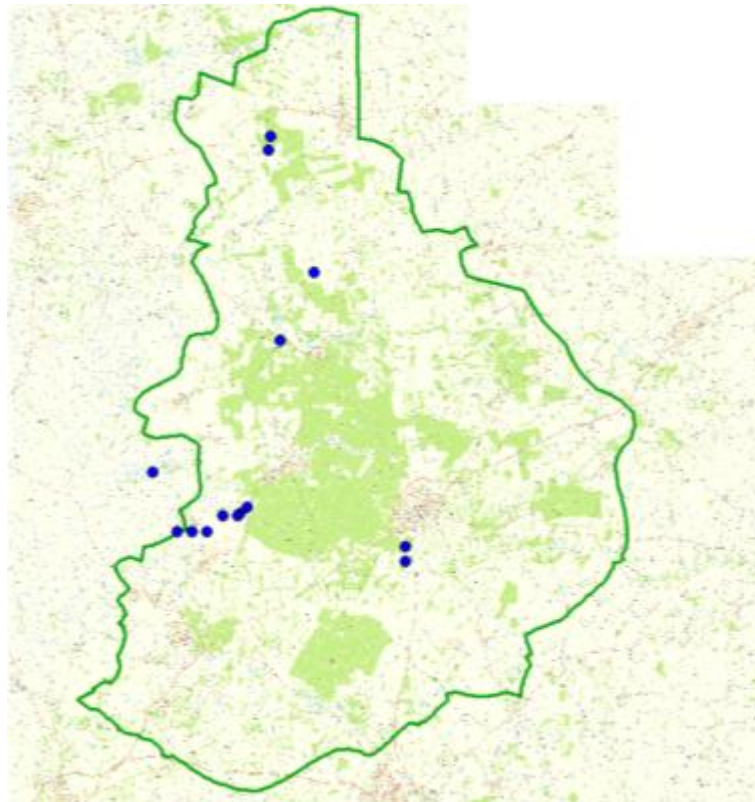


Map of records for *O. laticollis* in the Brecks with at least a four figure grid reference. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Bradycellus csikii

The area with the highest density of records for *B. csikii* appears to be west of Thetford Forest in RAF Lakenheath, the Wangford roadside and Maidscross Hill SSSI, as well as a record from the nearby Lakenheath Fen which is just outside of the study area but included for completion.

Post-2000 records are restricted to Maidscross Hill SSSI and the nearby Wangford roadside, as well as Barnhamcross Common SSSI south of Thetford, while there are records north of Thetford Forest from Hilborough, Cranwich and Swaffham Heath. Interestingly, all sites with pre-2000 records also have post-2000 records, suggesting the species is not being lost from sites.



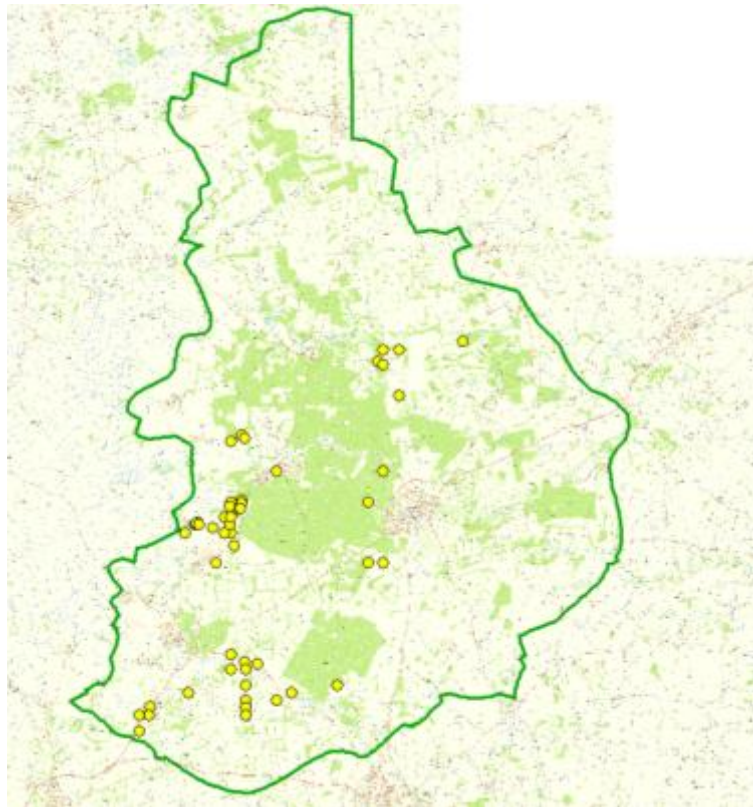
Map of records for *B. csikii* in the Brecks with at least a four figure grid reference. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Harpalus pumilus

There are extensive records for *H. pumilus* in the Brecks, with records stretching back to 1900 in Lakenheath, and 1908 in Wordwell and Brandon. Post-2000 records are scattered across at least ten locations, but with two clear clusters of records. The first post-2000 cluster is around the west of Thetford Forest, including Maidscross Hill SSSI, RAF Lakenheath SSSI, Wangford Warren and Carr SSSI. The second cluster is in the south around Cavenham and Icklingham, largely within the Cavenham-Icklingham Heaths SSSI but also adjacent sand pits.

There are also both historic and recent records on Weeting Heath and the east of Thetford Forest at Thetford Warren, Two Mile Bottom and Thetford Heath. Pre-2000 records include scattered records around STANTA, as well as further around the southern cluster of records around Cavenham-Icklingham Heath SSSI, extending both east to West Stow Heath SSSI and west towards Red Lodge Warren.

The species affinity for sandy disturbed sites is very clear from the list of sites with *H. pumilus* records.

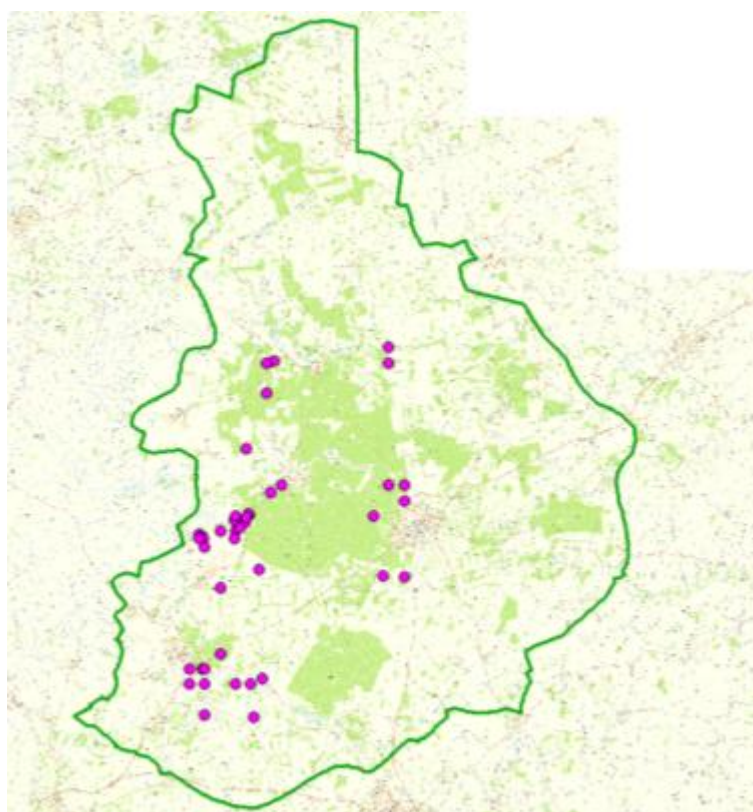


Map of records for *H. pumilus* in the Brecks with at least a four figure grid reference. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Harpalus smaragdinus

Historic records for the species stretch back to 1908 at Brandon, with scattered records across the Brecks. There is a good deal of post-2000 records, demonstrating a number of clusters, many of which are similar to *H. pumilus*, occupying a range of sites with disturbed sandy conditions.

A cluster to the west of Thetford Forest includes RAF Lakenheath SSSI and the Wangford roadside, Wangford Warren and Carr SSSI, Maidscross Hill SSSI and a small number of surrounding sites. A cluster in the south of the Brecks, is largely restricted to the Cavenham-Icklingham Heaths SSSI, but with historic records in nearby Mildenhall and Barton Mills. A cluster of records can also be seen around Thetford, including Thetford Heaths SSSI, Thetford Warren, Two Mile Bottom and agricultural fields north of Thetford. There are additional post-2000 records at the Brandon Artemisia reserve, Cranwich Camp SSSI, Weeting Heath and STANTA.



Map of records for *H. smaragdinus* in the Brecks with at least a four figure grid reference. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Key sites for ground beetles

Having examined the distribution of the target ground beetles, it quickly became clear that a number of sites hold either a significant proportion of the records for an individual species, or modern records for multiple species. The vast majority of these sites are under statutory protection as SSSIs or NNRs and support either extensive disturbed habitats or locally disturbed features of interest. These are often in clear clusters, forming a core area holding the vast majority of the local records. These clusters of sites are likely to be essential to maintaining Brecks populations, potentially acting as sources of beetles to exploit any new habitat opportunities that may crop up in the surrounding area. A brief description of the key sites and clusters of sites identified follows to better inform landscape level habitat enhancement proposals.

West of Thetford Forest

To the west of Thetford Forest, a number of ground beetle-rich SSSIs occupy an area formerly enclosed as part of the medieval rabbit warren of Lakenheath as well as the remnants of the large calcareous dune systems that previously dominated the area. Disturbed sands produced by the activities of rabbits produced a mosaic of successional stages, with regular areas of newly disturbed sand and closely cropped turf of fine grasses and grazing tolerant herbs. Much of this former area is still retained, albeit in isolated fragments thanks to development, roads, agriculture and forestry, allowing the cluster of sites to support five of the six study species, with only *O. laticollis* absent. The importance of these sites makes them worth considering individually.

RAF Lakenheath SSSI

The extensive RAF Lakenheath site includes large areas of species-rich Breckland grassland on well-drained sandy soils overlying chalk (Natural England, 1997). The activity of the airfield ensured that the site was protected from the agriculture and plantations that led to much habitat loss elsewhere. Current intensive mowing regimes are likely to go some way to mimicking the close grazing of rabbits, although there is likely to be less disturbance than the historic rabbit populations provided. The site contains numerous records for *H. froelichii*, *H. pumilus* and *H. smaragdinus* which are all species of disturbed sandy ground.

Wangford Warren and Carr SSSI

This site supports the best preserved dune system in the Brecks, including a range of stages of dune stabilisation. The system is now considered to be static with only a very small area of accreting dune, however, some of the features of active sand dune systems are mimicked by site management, with rotovation and rabbit activity creating bare ground (Bev Nichols, Natural England, pers. comm., 2015). The pattern of disturbance has maintained a range of successional stages from very sparsely vegetated bare sand areas, with intermediate areas colonised by mosses prior to a wider cover of mosses and lichens, followed by a closed turf of fine grasses (Natural England, 1985). The site also supports extensive lichen heath, dry heathy grasslands and calcareous grass heath as well as invading scrub and relict damp grassland, fen and carr. As with RAF Lakenheath, the site supports numerous records for *H. froelichii*, *H. pumilus* and *H. smaragdinus*.

Wangford Roadside

The Wangford roadside has been well studied over a number of years by coleopterists and is a 2m high unstable sandy embankment about 400m long between the SSSIs of RAF Lakenheath and Wangford Warren and Carr (Eversham & Telfer, 1993). The site is effectively a mobile dune formed by the annual clearing of windblown sand from the adjacent road, which prior to the construction of the airbase in 1942 was connected to the nearby dune systems at Lakenheath Warren SSSI (Crompton & Sheail, 1975; Eversham & Telfer, 1993). The site's sparsely vegetated sands include areas of bare sand, ruderal vegetation, stands of sedges and moss cover. It is likely to be at risk from any cessation of sand clearance and lack of disturbance leading to stabilisation.

The site has numerous 1990s records for *A. fusca* despite having lost the favoured Field wormwood food plant on site, thanks to a strong resource of Mugwort. Other recorded beetles are *H. froelichii*, *B. csikii*, *H. pumilus* and *H. smaragdinus*.



Indicative map of the location of the 2m high, 400m long area referred to as Wangford Roadside. Please note that the boundaries here are based on site descriptions from Eversham & Telfer, 1993. Edited aerial image © 2015 Google Earth, Infoterra Ltd & Bluesky.

Maidscross Hill SSSI

Maidscross Hill contains very dry grassland on a range of soil types as well as abandoned gravel workings at various stages of recolonisation. There are well developed areas of both calcareous grassland with short turf and more vigorous acid grassland, although other grassland areas have been invaded by more aggressive species such as Cleavers (*Galium aparine*) and Common nettle (*Urtica dioica*) (Natural England, 1986b). The former gravel workings provide a range of successional stages, including freely draining mounds with lichen and moss dominated heath vegetation. Rabbit grazing is essential to maintaining the site's interest, keeping the sward short and creating localised disturbance areas. Scrub management is ongoing in response to scrub and bracken (*Pteridium aquilinum*) invasion.

The site has records for *H. froelichii*, *B. csikii*, *H. pumilus* and *H. smaragdinus*, as well as *A. fusca* from Mugwort. The site does not support Field wormwood, with no known historic records or evidence for its presence.

Thetford area

A great deal of scarce ground beetle records can be seen from the area around Thetford, based on areas with distinctively different character. Thetford is dominated by agriculture to the north, Thetford Forest to the west and a complex of heathlands to the south.

North of Thetford

The north of Thetford is largely dominated by agriculture and bisected by the A11 carriageway, but includes a number of fields which are well studied by Mark Telfer and other coleopterists. This includes land around Croxton Hall Farm north of the A11 which includes Gallows Hill, and Lodge Farm and Blakeney Farm south of the A11.

Mark Telfer has shown that the arable field margins and adjacent cultivated field margins of Gallows Hill are nationally important for *O. laticollis*, which appears to thrive in the interface of the uncropped cultivated arable field margins and the unploughed grassy strip on the field boundaries (Telfer, 2009b). Other areas of Croxton Hall Farm also appear to be important, with records from sandy soils on the roadside edge of cultivated margins of *O. laticollis* as well as *H. smaragdinus*. South of the A11 is less studied, but within further land that is part of Gallows Hill, Lodge Farm and Blakeney Farm are records for *O. laticollis* and *H. froelichii*, effectively demonstrating a landscape where frequently disturbed uncropped cultivated arable margins are providing opportunities for scarce ground beetles.

Thetford Forest east

Although large areas of Thetford Forest have been afforested and lost their open habitat interest, some areas retained as open grassland or grass heath, and networks of disturbed trackways still provide habitat for scarce ground beetles.

Thetford Warren, west of Thetford, was once an extensive enclosed rabbit warren, creating regular disturbed conditions. Prior to large parts of the site being planted with conifers it supported an extensive area of heathland and grass heath maintained by rabbit activity. Although the site remains largely plantation, open areas in the north around Thetford Warren Lodge and the golf course continue to provide modern records for *H. froelichii*, *H. pumilus* and *H. smaragdinus*. The nearby Two Mile Bottom also supports records of *H. pumilus* and *H. smaragdinus*.

South of Thetford

South of Thetford is a collection of remnants of Breckland heaths, with a range of soil types producing a mosaic of calcareous and acid grasslands, heather heath, grass heaths and lichen/moss dominated heath. The broken turf and shallow soil is ideal for less competitive plants and rabbit activity creates regular disturbance areas.

This extensive heathland block includes Thetford Heaths SSSI (incorporating the Thetford Heath NNR and further land to the east) and Barnhamcross Common SSSI, with various management techniques currently used, including sheep grazing, rabbit activity and rotovation, with scrub cover well controlled (Bev Nichols, Natural England, pers. comm., 2015). Large areas of Thetford Heaths SSSI include extensive short sward calcareous grasslands, with some still maintained as the active military area of RAF Barnham (Natural England 1993).

The adjacent Barnhamcross Common is a public open space supporting extensive areas of calcareous and acidic grass heath (Natural England, 1986a). Acidic grass heath has developed on the uneven terrain produced by small scale gravel workings, while across the site scrub clearance and disturbance management are undertaken to maintain the site's character.

These sites support populations of *B. csikii*, *H. froelichii*, *H. pumilus*, *H. smaragdinus* and a recent single record of *A. fusca*.

South of Brecks near Cavenham

A number of scarce ground beetle records were recorded in the Cavenham area, largely in the Cavenham-Icklingham Heaths SSSI and sand and gravel pits to the south. Cavenham-Icklingham Heaths SSSI is a complex of heath, grassland, woodland and fen on largely acidic soils (Natural England, 1998). Grassland and heathland dominate, however, with localised lichen heath in acid grassland stands. The Icklingham Plains area includes the remnants of a fixed dune system that used to be more widespread in the area. The sand and gravel pits to the south regularly provide new disturbed areas in the local landscape, helping the Cavenham area to support numerous records for *H. froelichii*, *H. pumilus* and *H. smaragdinus*.

There are also modern records for *H. froelichii* east of Cavenham at West Stow Heath SSSI and numerous 1980s records for *H. smaragdinus* west of Cavenham around Mildenhall.

Brandon Artemisia reserve

The postage stamp sized Artemisia reserve was established in a Brandon industrial estate to conserve the last natural stand of Field wormwood. Across the Brecks the species has been lost from its ideal bare sand habitat due to a combination of overgrazing and lack of disturbance to create new sandy areas for germination. It appears that the plant is thriving on the small fenced off site measuring only 25m by 40m, which is periodically disturbed with an excavator to scrape the site's sand heaps into low, bare banks. The site is likely to be vital for *A. fusca* populations, with 50 recorded during 1994 surveys and 20 in 2003 during torchlight surveys.

Despite its small and isolated status, in addition to *A. fusca*, there have also been records for *H. froelichii* and *H. smaragdinus* thanks to management to retain open sandy areas.

Northwest of Thetford Forest

The northwest of Thetford is dominated by conifer plantations, but includes expansive areas of agricultural land and pockets of open grass heath maintained by rabbit activity, notably around

Weeting. Much of the surrounding landscape is part of either the Breckland Forest SSSI or the Breckland Farmland SSSI.

Weeting Heath SSSI

Weeting Heath SSSI is on the northwest edge of Thetford Forest, and is a classic example open rabbit grazed grass-heath in the region (Natural England, 1987). The site supports calcareous grassland which has developed on the site's dry calcareous sands, and lichen and moss-dominated heath which is maintained by the high levels of rabbit grazing. The site has several records of both *H. pumilus* and *H. smaragdinus*.

A highly significant record less than a mile north of Weeting Heath is a 2010 record of *A. fusca* in recently disturbed forest rides.

Cranwich Camp SSSI

Cranwich Camp SSSI is a former military training area with grassland and grass heath developing over sand and chalk. The site is largely managed by livestock grazing, with rabbit activity virtually absent, leading to a patchy sward height. However, management of some areas of the site by topsoil stripping and rotoation has helped to maintain early successional areas (Bev Nichols, Natural England, pers. comm., 2015). The site itself has several records for *H. froelichii*, *H. smaragdinus*, and interesting outlying records for *O. laticollis*. The surrounding areas support further records of *H. froelichii*, *H. smaragdinus* and *O. laticollis* as well as a record for *B. csikii*.

Cranwich Heath to the south also includes a record for *H. smaragdinus* from 1994, prior to the clearance of 65ha of conifer plantation which is now managed as heath, suggesting the species was most likely recorded in the network of disturbed trackways.

Stanford Training Area (STANTA)

STANTA occupies over 4,600ha of Breckland which supports extensive areas of Breckland grassland and heath with calcareous grass heath, heathland and a mosaic of acidic and calcareous communities, in addition to woodland, wetlands and internationally important groundwater fed fluctuating meres (Natural England, 1999). The mixed history of the site, which includes military activity and cultivation has produced a diverse set of areas with different historic levels of use and disturbance, but overall create one of the largest extents of Breckland heath. The very mixed grasslands include areas grazed by sheep and rabbits to produce a short turf, with locally disturbed areas from warrenning.

Perhaps unsurprisingly for a site of such size, there are plentiful records of both *H. pumilus* and *H. smaragdinus*, but also modern records for *O. laticollis* from 2003.

Principles of identifying areas for habitat management

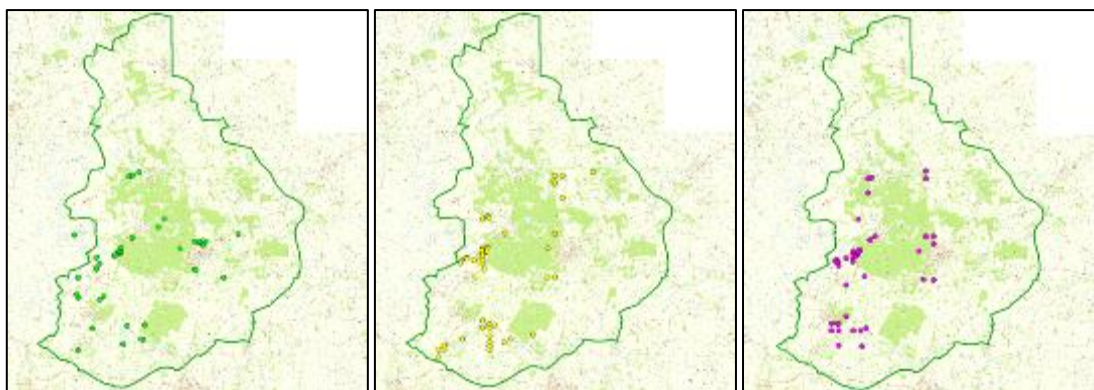
It is clear that there are a number of clusters of sites with multiple records of Brecks ground beetles and scattered sites of significantly raised value. Many of these are within a matrix of relatively inhospitable conifer plantations or intensive agriculture, or else separated from other sites by the larger urban areas or Brandon and Thetford. In addition, several sites are in relatively poor condition for ground beetles due to insufficient disturbance allowing swards to close and reducing the extent of bare sandy areas.

Three different approaches to enhancing the landscape for Brecks ground beetles need to be considered:

- Enhancing existing sites by introducing more favourable management to increase the resource of useful disturbed habitats to help populations on site to be more resilient.
- Increasing opportunities on land neighbouring these key existing sites, as their close proximity increases the chances of colonisation and new populations being established.
- Creating new habitat stepping stones to connect isolated sites or clusters of sites, aiming to facilitate movement across the landscape to create more resilient populations that are able to more easily discover new opportunities as they are created.

Having reviewed the distributions of the six ground beetle species and their key sites, it is also essential to look at the different management approaches required for each species. Some species' needs are incompatible with others, requiring specific management approaches to be considered, whereas some species can be grouped together under more general management prescriptions.

- *A. fusca* may favour the now very restricted Field wormwood as a food plant over the more widespread Mugwort, although this remains untested (Walters, 2011). Approaches to enhance the Breckland resource of Field wormwood should clearly be an aim, alongside establishing if there is a real preference for the species over the more widespread Mugwort. Field wormwood, although a species of disturbed sandy ground which likely thrived in the historic system of windblown mobile sand dunes, is highly intolerant of grazing.
- *O. laticollis* on the other hand seems to favour the interface between regularly disturbed ground in uncropped cultivated arable margins and the permanent grassland of field edges, preferably in friable, calcareous and sunny situations (Telfer, 2009b).
- *H. froelichii*, *H. pumilus* and *H. smaragdinus* all seem to thrive in generally disturbed conditions, particularly in sand and calcareous sands. Their more similar requirements can be demonstrated well when viewing their Breckland distribution maps side by side. Although there are of course differences in their exact distributions, there is significant overlap, suggesting that general prescriptions at the landscape scale could produce results for all three of these species.



Map of records in the Brecks with at least a four figure grid reference, from left to right: *H. froelichii*, *H. pumilus* and *H. smaragdinus*.
Contains OS data © Crown copyright [and database right] 2015 (Licence information:
<http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

- Although also a species of generally disturbed habitats, *B. csikii* does not show as much overlap as the three *Harpalus* species. It does, however, show a similar cluster of records on the west of Thetford Forest and south of Thetford, while Mark Telfer National Carabid expert has suggested that there is a significant overlap between *B. csikii* and *H. froelichii* (Telfer, 2009a). Management for *B.csikii* can then be confidently combined with the three *Harpalus* species.

Review of habitat management

Different management prescriptions are clearly likely to be required to provide suitable habitat for the six study species due to differences in their preferences and historical records. This includes considering general Brecks-wide management principles, targeting arable margins and enhancing the resource of key food plants. The current literature in these areas will now be considered where there is relevance to the Brecks beetles, to provide background to the project's proposed management prescriptions.

Breckland disturbance studies

The preference for disturbed habitats of the scarce ground beetles and Breckland specialists has traditionally posed a challenge to conservation and land management. The management of entire units in a homogenous fashion, be it through cutting or constant grazing levels to maintain a stable site condition, is often an aim of traditional land management practices, but can fail to provide the necessary diversity for disturbance loving species. Management including episodic disturbance is the most efficient route to creating a more heterogeneous habitat for the rare invertebrates of the Brecks, as well as the many other taxonomic groups that have a stronghold in the region.

The wide ranging issues are well addressed by Dolman *et al.*'s Breckland Biodiversity Audit report, including the widespread use of heathland management by grazing livestock in response to the Myxomatosis outbreak among rabbits in the 1950s, which led to the progressive loss of localised disturbed features, and changes in agricultural farming systems. However, as Dolman *et al.* also

demonstrate, the biodiversity value of disturbance management has been known by ecologists and conservation workers in Breckland for a great many years. This has led to a history of small scale, piecemeal disturbance regimes, ranging from very small plots or strips through to a few hectares, and from one off actions through to regular rotations every three to five years (Dolman *et al.* 2010).

In one of the most comprehensive and modern reviews of Breckland disturbance methodologies, their success in enhancing landscape connectivity across Thetford Forest was examined, using a series of trackways that criss-cross the site (Pedley *et al.*, 2013). Pedley *et al.* looked at the responses of invertebrates to six different treatments on plots of 10m by 150m, including:

- Disc harrowing- mild disturbance, disrupting vegetation to a depth of 10-20cm
- Forest ploughing- moderate disturbance, inverting soil and litter, creating alternate strips of exposed bare ground in ploughed furrows and strips of intact vegetation
- Agricultural ploughing- heavy disturbance by inverting soil, leaving bare substrate exposed
- Turf stripping- removal of all soil and litter, exposing underlying mineral subsoil

Pedley *et al.* sampled invertebrates on a number of plots with undisturbed trackways, as well as at reference heathland sites in Breckland. The heavy disturbance methods did indeed enhance the habitat for ground beetles, including specialists such as *A. fusca* and *H. froelichii* which were recorded from turf stripped areas. Importantly the report revealed that low impact disturbance such as discing had only limited longevity in terms of sward height and exposed bare substrate, with the benefits of even some medium-heavy impact disturbance treatments very time limited. To maintain bare ground and the associated early successional habitats, Dolman *et al.* suggest that discing would need to be performed every 2-3 years and ploughing every 3-5 years. In contrast, turf stripping may last substantially longer (dependent on fertility) and will have less of an impact on less resilient species groups such as spiders which are often affected by the initial disturbance treatment. It is suggested that the targeted use of turf stripping both on sites currently of high value and on potentially suitable habitats within the proximity of high quality beetle sites has the potential to enhance the landscape connectivity of beetle populations, particularly as more mobile ground beetle species are able to quickly colonise and utilise suitable habitats.

It is important to note though, that the Pedley data is the result of only a single disturbance treatment. It is quite likely that if the medium and high disturbance treatments were continued, perhaps at differing intervals to allow a mosaic of successional stages to develop, that the value for biodiversity would be even greater. However, there are few sites where disturbance management has been undertaken in a long-term controlled manner and with sufficient monitoring data to provide prescriptive management advice. The situation is of course made more difficult by variations across sites in soils and prevailing site conditions, which can vary significantly across the Brecks even over short distances due to the underlying geology as well as land management history.

Butterfly Conservation has undertaken significant research into soil disturbance supporting some of the nationally scarce moths which are predominantly found in Breckland (Ellis *et al.*, 2012). As a result of insufficient disturbance of heathlands and the afforestation of many heathland for plantations, many of these species are now restricted to cultivated arable margins where disturbance is sufficiently regular to cater for their specific food plants. The Butterfly Conservation

work also involved using multiple disturbance techniques over 59 different plots over largely 3m by 150m plots. The techniques which were similar to those studied by Pedley *et al.*, were defined as:

- Rotovation- breaking up the turf to create a fine tilth, removing existing vegetation completely and breaking up the grass sward.
- Forest ploughing- two plough ridges are created either side of an undisturbed central sward, creating variable microtopography.
- Agricultural ploughing- creating ridges and furrows to provide varied microtopography.
- Disc harrowing – disc harrows cut through the existing vegetation to create bare ground but without completely destroying the sward.
- Turf stripping- a bulldozer was used to scrape off the turf and topsoil into a bank alongside the strip.

The work acknowledges the degree of unreliability of outcomes of creating bare ground for early successional communities due to variation in soil type, vegetation history, land management history and weather. This is coupled with locating the right areas within a site thanks to the fine mosaic of vegetation and soil types that can occur within individual Breckland sites. As with the Pedley *et al.* work, it demonstrated that harrowing and ploughing would require much more regular management, with many of the plots found to be grassy and often difficult to distinguish from untreated areas. Turf stripping was found to be an expensive, but successful method of creating disturbed areas alongside the bank of arisings, while ploughing offered great opportunity for ruderals and provided some diversity thanks to the ridges and furrows produced. They recommend that due to the dynamic nature of bare ground creation and the need for different successional stages to be present at all times, that a rotational approach should be adopted using multiple treatments.

The Breckland Biodiversity Audit comprehensively reviewed some of the disturbance methodologies used elsewhere across the Brecks on a variety of sites, including where known, the frequency of management and the extent of treatment. Disturbance management has been undertaken on a number of high profile sites of known biodiversity value, likely as a result of a number of well known naturalists in the area who noticed the effects that the Myxomatosis outbreak in rabbit populations had in reducing disturbance (Dolman *et al.*, 2010). However, few have been either repeatedly or extensively managed for any period. Two high profile sites which are exceptions and are highlighted by Dolman *et al.* are:

- Thetford Heath- Disturbance has been undertaken on the site as far back as 1956 when ten plots were rotovated in most years until 1977. A number of plots were managed through rotovation subsequently for a number of years, with some initiated in 1989 still being managed in this way. A more large scale disturbance regime started in 2005/6, with turf removal of three areas totalling 1 ha and annual rotovation of three areas totalling 2 ha.
- Weeting Heath- Rotovation was first used at Weeting Heath in 1959 until the 1970s, however, since the 1990s a number of different plots with replicates have been managed, with an area totalling 3ha. As at Thetford Heath, turf stripping was also undertaken in 2005.

Both Thetford Heath and Weeting Heath, sites with known populations of scarce ground beetles, have undergone turf stripping to remove organic soils material to expose the underlying chalk drifts

and create bare areas to develop into early successional mosaic (Dolman *et al*, 2010). The rotovated areas successfully produced species-rich calcareous lichen-rich grass-heath as well as indicating that such management techniques could help to reduce the impacts of nitrogen deposition, a significant long-term risk to low nutrient breck habitats (Dolman & Sutherland 1994; Dolman *et al*, 2010).



Hockwold Heath bare ground plots, immediately adjacent to Weeting © Hugh Venables (and licensed for reuse under [Creative Commons Licence](#))

Many sites, including those identified by Dolman *et al.*, are much less regularly or extensively managed, with the aim of acting as firebreaks, stone curlew nesting areas, or simply for very small localised diversifying features such as in the Brandon Artemisia reserve. At Little Heath and Deadman's Grave, trenches were excavated through the underlying chalk with the removed material used to create an adjacent bund. This has the effect of creating bare chalk slopes to be naturally colonised and develop sparsely vegetated habitats, while the adjacent, more nutrient rich but still highly calcareous arisings would develop more quickly with ruderals, creating a potentially high quality beetle bank. Other sites including Cavenham Heath and STANTA do not include confirmed details of size of frequency of disturbance.

There is also evidence that creating artificial dune ridges on sandy sites could produce suitable areas for ground beetles. An incidentally created sand ridge near excavations at Cavenham was found to support *H. froelichii*, leading to suggestions that scraping sandy areas and depositing the sand in a ridge could effectively mimic the historic dune habitats at a small scale (Thompson, 2007). There has been little research into this area, but with regular management such disturbance management

could complement the remaining resource of dune habitats in the Brecks and provide novel opportunities.

There has also been much work in recent decades examining the value of disturbance management in more traditional lowland heathland across the UK. Where sites are largely managed by cutting or grazing, there are well documented biodiversity benefits even from small scale ground disturbance to add structural and successional diversity, such as through rotovation (Kirby, 1992). Where rotovation is used to maintain regular bare ground areas on rotation, it is suggested that the rotation should not be more than five to six years, with overall disturbance in a single year not exceeding 10% of the site unless a small site in poor condition is being managed (Kirby, 1992). Firebreaks throughout large heathland and forest complexes have long served as valuable habitat for the scarce ground beetles of disturbed habitats, particularly where creation is by ploughing or harrowing to maintain a vegetation free strip. To maintain this interest, it is recommended that at least two plough widths be maintained, managing the halves alternately with a rotation of several years, so long as the vegetation-free status is sufficiently maintained (Kirby, 1992).

It is clear that although disturbance management is being recognised as a valuable tool, that it is still not as widespread a management tool as it should be to deliver biodiversity gains. The potential for more widespread use of disturbance through turf stripping and ploughing is now well known, but efforts need to be made to promote the uptake of work.

Arable margins

Cultivated uncropped arable field margins as part of agri-environment schemes have been shown to mimic some of the features of arable brecks, with annual disturbance allowing plentiful annual plants to colonise and produce valuable biodiversity gains. Such margins are generally managed as either 6m or 12m strips, and also in some instances as plots. Uptake of this management option has been very successful, with over 312ha managed in Environmental Stewardship agreements, equating to over 500km of linear habitat now managed in this fashion for the region's biodiversity (Bev Nichols, Natural England, pers. comm., 2015). The annual (or in some cases biennial) autumn or spring cultivation is intended to maintain open, disturbed conditions suitable for rare arable flora, invertebrates and their foodplants, and for farmland birds. This management has the potential to strongly benefit seed feeding ground beetles, particularly where key food plants thrive, such as Fat hen with which *H. froelichii* is strongly associated.

Arable margins managed in this manner have the potential to create significant areas of habitat for ground beetles, including making the inhospitable landscape between existing populations easier to disperse across. Populations may be able to establish in long managed margins scattered throughout the landscape, effectively connecting previously isolated populations. Where possible, margins should be created near to existing areas of remnant semi-natural habitat (Thompson, 2007).

The monitoring of *O. laticollis* at Gallows Hill has demonstrated the beetle's reliance on cultivated arable margins and its preference for the interface area between the cultivated uncropped margins and the unploughed grassy strip at the edge of the site (Telfer, 2009b). Telfer also describes the

beetle as using localised shelter within disturbed situations, such as scrub in disturbed calcareous sites and hedges around arable field margins. The underlying material and requirement for fine, dry litter is also important, with Telfer recording no *O. laticollis* from either hard, bare clay areas with grassy stolons, or in damper, shaded and north-facing situations with damp grass litter (Telfer, 2009b). It also appears essential that drier, light soils are preferred where there is a calcareous influence (Telfer, 2009b). The value of these margins for *H. froelichii* has also been well documented, with numerous records on cultivated margins around Thetford, although the species appears to be slightly less reliant on these than *O. laticollis* (Telfer, 2009a).

Grazing regimes

Grazing is the most frequently used management type in the Brecks, with the Breckland Biodiversity Audit's questionnaire responses revealing that of the 2,446ha of grass-heath referenced, all but 45ha was grazed, with 32% described as low intensity/light grazing (Dolman *et al.*, 2010). In addition, it was revealed that bare ground within grass-heath was very rare or rare on 52% of sites and occasional on 25% (Dolman *et al.*, 2010). Increasing sheep grazing regimes across the Brecks would enhance the resource of short, cropped grasslands, which in turn encourages rabbits whose warrening would likely enhance the bare ground resource (Ausden, 2007).

Grazing of sheep is most common in the Brecks, and historical movement and management of flocks was likely important in preventing the stabilisation of extensive sand dune systems, in combination with the prevailing drought conditions. The absence of this disturbance is a key factor in the stabilisation of many sandy features and reduction in disturbed features for invertebrates.

Rabbit activity regularly creates newly disturbed areas, heterogeneity in nutrient status and their grazing effectively maintains a short sward with bare ground gaps. The medieval warrening of large areas near Lakenheath and Thetford is thought to have made a significant contribution to the invertebrate value of the Brecks through creating an early successional mosaic and regular disturbance.

The Breckland Biodiversity Audit also noted that for grass heaths where information could be obtained, 57% were described as being virtually absent to low, a significant absence of a key disturbance type (Dolman *et al* 2010). In addition to increasing sheep grazing densities, studies have actually been undertaken on methods to enhance populations of rabbits within their native Mediterranean range where they are a key species and useful conservation tool, even stretching to translocation. There is evidence that removal of scrub and creating more open situations benefits rabbit populations, while retaining areas for shelter (Moreno & Villafuerte, 1995). It may be that encouraging rabbits in areas of the Brecks where there is only limited conflict with agricultural interests could provide significant biodiversity gains on key sites.

Habitat recommendations

To best conserve the populations of beetles associated with the disturbed breck habitats, along with other invertebrates associated with this unique habitat type, it is essential to integrate habitat creation and management recommendations into local land management schemes. This includes using agri-environment schemes and working with landowners to actively encourage the creation and maintenance of periodically ploughed but uncropped arable field margins. This approach has been adopted by Natural England's advisers for a number of years, with cultivated uncropped margins a key management tool proposed to landowners in the region. Buglife supports the emphasis placed by Natural England on maximising the area of cultivated arable margins in the Brecks as an action likely to lead to significant gains for ground beetles. It is hoped that over time the number of landowners opting to take up the management option will increase in response to the continued efforts of Natural England's advisers. Other recommendations have been made which may not fit into agri-environment schemes, but that have the potential to significantly benefit beetle populations across the Brecks.

It is important to note, that as already highlighted, the six study species have different management requirements, meaning a range of options are required. The requirements for *A. fusca* and *O. laticollis* are discussed individually, while those of *B. csikii*, *H. froelichii*, *H. pumilus* and *H. smaragdinus* are combined due to significant overlaps in requirements.

In addition, it is noted that reversing the historic trend for afforestation of land in Breckland is a method of significantly increasing the amount of disturbed open habitat in the region. Many areas of Breckland are notified as SSSIs, which in some instances may help support the future creation of open habitats, although this is dependent on the different notified features. Due to the complex issues of land ownership and site designation, the clearing of plantation areas has not been explored in depth in this report. However, there is currently a great deal of impetus in encouraging the creation of open habitat in plantation areas, with the Thetford Forest Open Habitat Plan demonstrating an ambitious plan to enhance the resource of disturbed trackways, and the extensive areas of heathland that have been re-created in Thetford Forest. In instances where open clearances can be managed through disturbance, the same management principles as discussed in the following sections would apply.

Extensive disturbance management within large sites (*B. csikii*, *H. froelichii*, *H. pumilus*, *H. smaragdinus*)

There is now clear evidence of the benefits that regular disturbance management can benefit many of the scarce beetles discussed, while also being compatible with the wider conservation interests of Breckland wildlife. The loss of traditional management has caused many grassland swards to become closed and sites to become increasingly homogenous.

Where general disturbance is to be introduced, it would be ideal to offer a range of different management prescription options, including ploughing and soil stripping, but also less severe

methods such as disc harrowing. This would help contribute to a landscape scale mosaic of different successional stages due to the different rates of sward recovery from treatment. It is important though that only a proportion of an entire site is managed through disturbance in this way in any one year, to provide sufficient continuation of habitats on site for the suite of species associated with it.

Areas for work within sites should be carefully selected, due to the variation in soil types across a very fine-scale on some breck sites. Butterfly Conservation have also acknowledged the importance of existing vegetation types when creating bare ground, with undesirable species such as Bracken, Sand sedge (*Carex arenaria*) and Wood small-reed (*Calamagrostis epigejos*) reappearing very quickly following treatments (Ellis *et al.*, 2012). For *B. csikii*, *H. froelichii*, *H. pumilus* and *H. smaragdinus* it would be ideal to target areas of acidic sand and calcareous sand, avoiding the larger calcareous drifts.

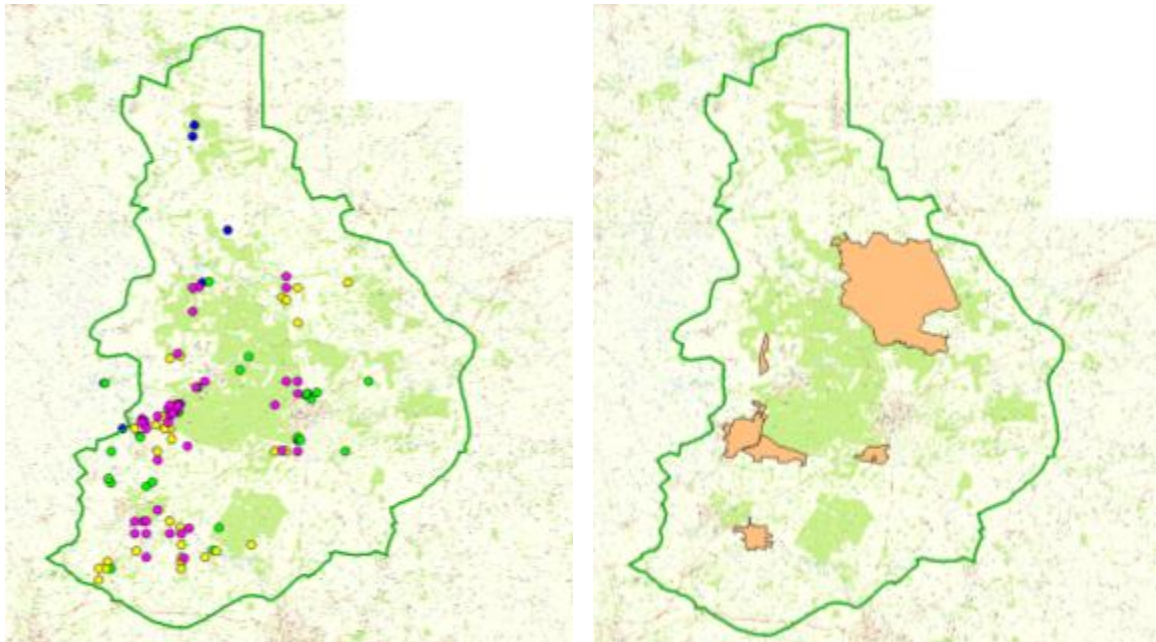
Rotovation has been the most commonly used disturbance techniques, undertaken with apparently positive results according to Natural England SSSI condition statements. Many in fact suggest the need for a greater level of disturbance. Rotovation creates a fine tilth which is easily colonised by the arable weeds needed to support seed-eating ground beetles. Rotovated plots should ideally be in large blocks of at least a few hundred square metres to reduce the impact of grasses rapidly invading edges, with blocks of 0.5-1ha preferable. Many rotovated areas are treated annually and there has been little research into the effects of reducing the frequency of management. Where space is limited within a site, it would be preferable to annually rotovate the same area, but it may be that further research identifies the greatest benefit is likely to be achieved from rotational management with some areas managed annually and others every 2 or 3 years.

Unlike rotovation, ploughing can create extensive areas of newly disturbed ground free of vegetation, while also providing troughs and furrows to diversify topography. Ploughed areas should ideally be in large blocks of at least a few hundred square metres as many grass species can quickly invade edges where only strips are created, but ideally areas of 0.5-1ha should be considered. Where space is limited within a site, it would be preferable to annually plough the same area, but the greatest benefit is likely to be achieved from rotational management. Pedley *et al.* suggest that ploughing every 3-5 years in disturbed trackways is sufficient to maintain open conditions, suggesting that ideally at least three ploughed areas should be maintained on a rotation. This would ensure different successional stages are provided on the same site. These areas should ideally be within close proximity to allow beetle species to move across the landscape to exploit favoured successional stages and would aid the colonisation of newly created bare areas by annual plants which provide seed for feeding in abundance. Maintaining a maximum cycle of three years should ensure that no swards close sufficiently to lose their interest but is expected to be long enough to support a diverse range of weedy plant species.

However, where possible turf stripping should be considered preferable as there is much evidence of success in the Brecks of removing topsoil to expose underlying sands and chalk drifts, leaving a bare substrate to slowly develop into sparsely vegetated bare ground. Turf stripping can be accompanied by bank creation, with scraped material piled up alongside scrapes. The arisings may be of higher nutrient status and contain a seed bank so will recover much more quickly, providing a contrasting successional stage in only a short period as well as varied in topography and microclimate to benefit

a wider range of invertebrates. Turf stripping should ideally be undertaken in areas exceeding 5m by 5m and not in linear strips to slow down the speed of vegetation encroachment. Turf stripped areas should ideally be left to succeed through to closed grassland rather than managed, with new turf stripped areas created instead every few years, allowing a mosaic of successional stages to develop. Where sites are small or budgets limited, it may be preferable to create a number of turf stripped areas in a single year and then manage them on rotation with a plough. This will still ensure a range of successional stages are maintained but will be less effective at maintaining early successional resources than rotational clearance of new turf stripped areas.

The extensive disturbance works and establishing their success would be best undertaken on large designated sites of known value for the study species. This would help increase the chances of colonisation while also enhancing nationally important sites. These large designated sites are also of a sufficient size for a range of different techniques to be used at a large scale, indeed some of the sites have had plots of a few hectares managed annually for many years. Ideal sites would be the STANTA SSSI, Thetford Heaths SSSI, Cavenham-Icklingham Heath SSSI, Lakenheath Warren SSSI, RAF Lakenheath SSSI, Maidscomb Hill SSSI and Weeting Heath SSSI.



Left: Map showing all collated records for *B. csikii*, *H. froelichii*, *H. pumilus* and *H. smaragdinus*. Right: Large sites identified for large scale disturbance work, which strongly overlaps with the current distribution of the four species. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Small scale disturbance management (*B. csikii*, *H. froelichii*, *H. pumilus*, *H. smaragdinus*)

To truly maximise opportunities for ground beetles at the landscape level, it is important that even small-scale opportunities are created for ground beetles. Many of the large sites in the Brecks include locally disturbed areas of raised value, whether they are a result of land management, livestock grazing, rabbit activity, illegal off road biking or fires. Where it is not possible to initiate

large scale disturbance work, efforts should be made to encourage small scale disturbance work which would dramatically diversify habitats for invertebrates. The combined value of small disturbance within other sites could help to establish them as stepping stones within the landscape.

This could easily be accomplished by making general habitat recommendations to landowners including:

- Driving over sites in vehicles during wet weather to churn up soils and break up grass swards, creating localised areas of disturbance for annual plants to germinate
- Using ploughs intermittently when crossing fields to access other areas of a site
- Manually creating small disturbance areas with hand tools

A culture of encouraging small-scale disturbance on small sites could raise their ability to support scarce species significantly, particularly for more mobile species which are able to discover and take advantage of such opportunities.

Cultivated uncropped arable margins for *B. csikii*, *H. froelichii*, *H. pumilus*, *H. smaragdinus* and *O. laticollis*

The extensive network of cultivated field margins within Breckland provides many opportunities to create suitable habitat for ground beetles, with around 500km of margin. Much of this was created and maintained under the Breckland ESA which closed in 2004, Higher Level Stewardship (2005-2014) and will no continue under the new Countryside Stewardship, with the continued aim of prioritising cultivated arable margins. The primary aim being to create a network of brecks across the landscape to benefit plants, invertebrates and farmland birds associated with the habitat in the region. Buglife supports the prioritisation of cultivated arable margins to deliver multi-taxonomic benefits and efforts to retain landowners between agreements under the new Countryside Stewardship scheme.

The survey work undertaken by Mark Telfer and others, on arable field margins north of Thetford has confirmed that the margins in these areas support the most important national population of *O. laticollis* as well as numerous records for *H. froelichii* (Telfer 2009a, 2009b). Much of the value of these margins for *O. laticollis* seems to lie in the cultivated margins being adjacent to permanent grassland and hedge cover, providing overwintering sites and shelter from ploughing, as well as the calcareous nature of the soils in the area (Telfer, 2009b). When also considering the habits of the species across the UK and its affinity with calcareous grasslands, it seems highly likely that only arable margins in more calcareous conditions are likely to favour the species. Based on the success of the work on arable land north of Thetford, the main recommendation is for attempts to increase the uptake of similar field margin management by nearby landowners to build on the current success, as is recommended by Mark Telfer (2009b). Margins should be targeted in open, sunny locations and adjacent to areas of remaining semi-natural habitats, while dates for cultivation should be varied across the landscape between September and March (Dolman *et al.*, 2010).

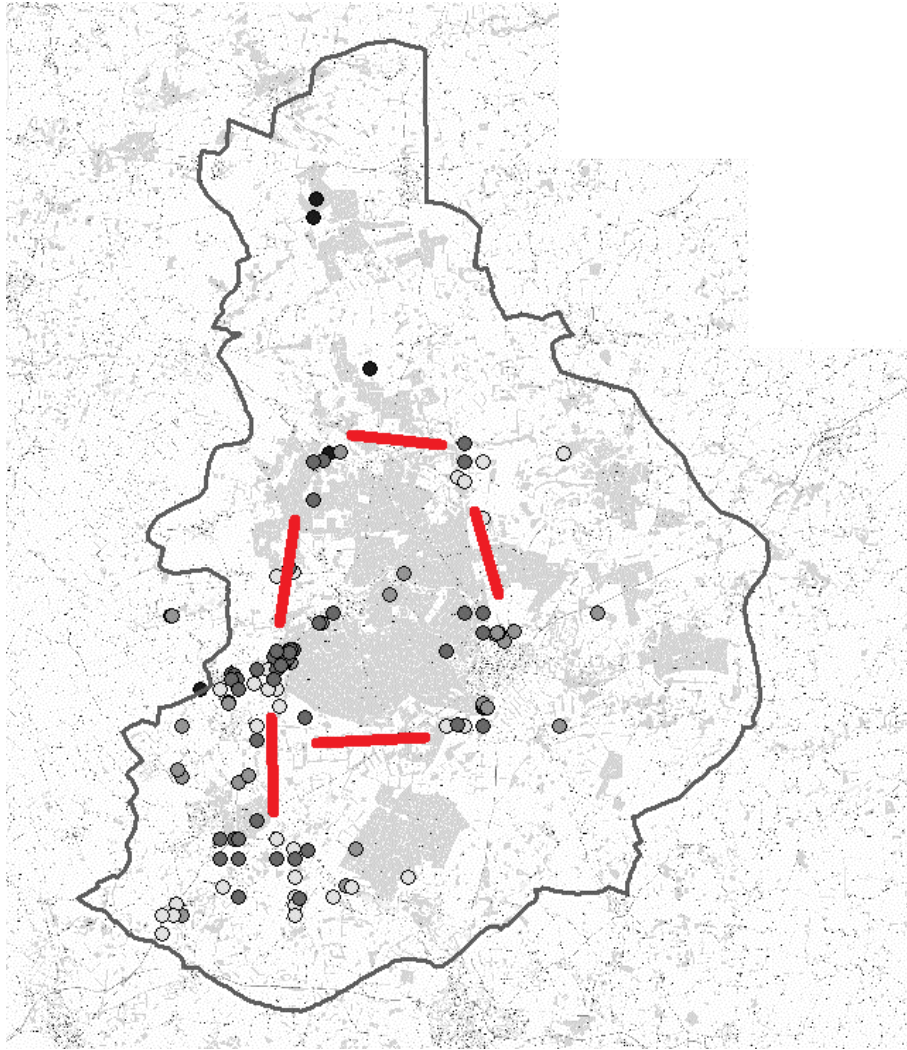
B. csikii and the three study *Harpalus* species are all more associated with sandier soils throughout much of the Brecks, suggesting the potential for much wider benefits across the landscape. Annual ploughing of uncropped arable field margins favours many of the rare arable plants of the region which alongside common arable plants, provide abundant seed for ground beetles. However, the annual treatment of all areas of margins in agri-environment schemes may limit opportunities for some species if there is insufficient shelter for them to avoid ploughing activity. To provide more diverse opportunities for ground beetles, it may be ideal to manage at least two small stretches of arable margin separately, instead managing them on a short two year rotation, alternately ploughing these separate units to ensure some areas of disturbed ground remain ploughed in every year as a refuge for beetles.

Habitat connectivity considerations

The high level of statutory designations within the Brecks and long history of study by naturalists suggests that the vast majority of the most valuable habitat areas have been included within statutory designations. This is supported by the very limited number of records for species recorded outside of designated sites, although both survey effort and difficulty in accessing private land must be acknowledged as limiting factors. It is interesting to note that many of the records from outside of designated sites are from private land in the form of arable field margins, but also from sand and gravel extraction sites and even moth traps.

However, to best enhance populations of scarce ground beetles at the landscape level, it is worth identifying opportunity areas where habitat creation or the introduction of new management could help to connect existing species hotspots. It must again be emphasised here that the Forestry Commission's imminent Open Habitat Plan for Thetford Forest is expected to significantly enhance the connectivity of isolated habitat fragments across the landscape while creating a significant additional resource of regularly disturbed habitat. This work should go some way to connecting the populations of scarce species which have the occasional record from within the Forest, and are currently separated by the vast extent of the plantation habitat.

To complement this work, efforts to enhance the connectivity around the Thetford Forest could also strengthen populations, by targeting the areas between current clusters of records. This could consist of clearing trackways through belts of plantation, introducing disturbance management to sites which currently lack sufficient levels (either large or small scale) or wider adoption of uncropped cultivated margins agri-environment schemes.



Map showing potential connective corridors for habitat enhancement, to connect existing clusters of records for *B. csikii*, *H. froelichii*, *H. pumilus* and *H. smaragdinus*. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

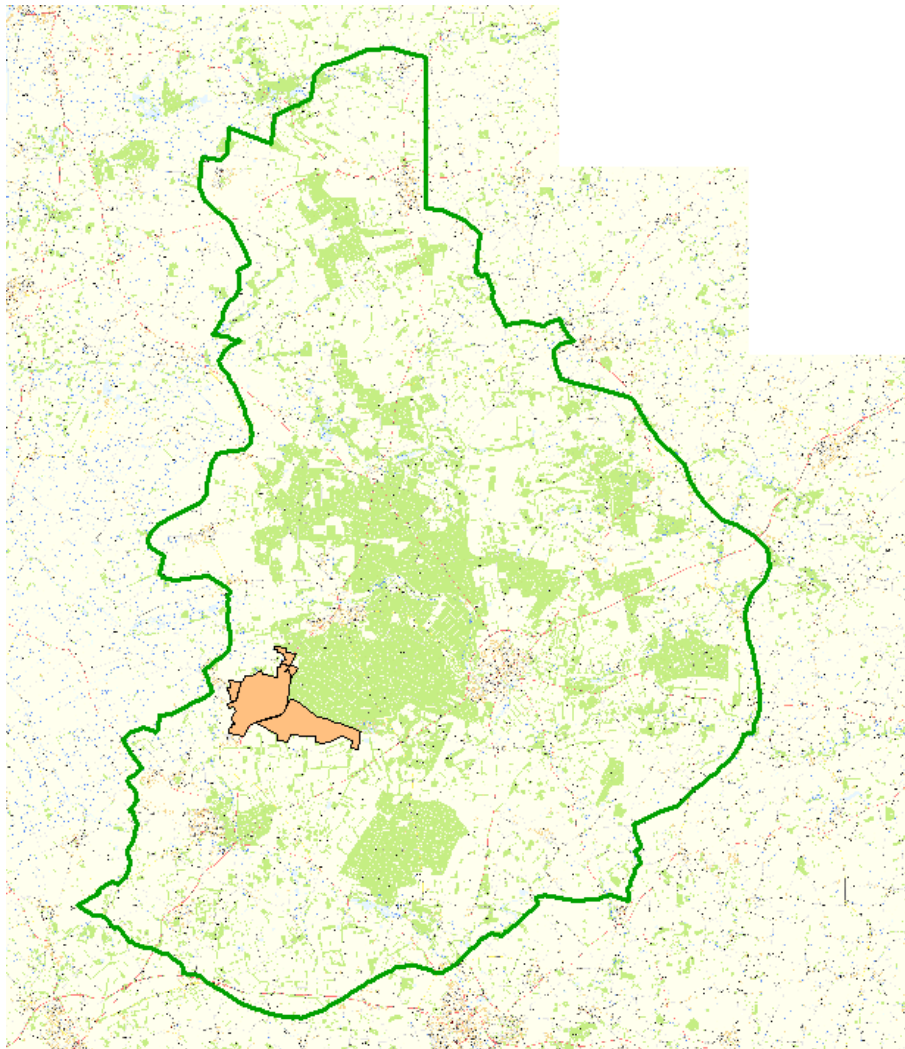
The proposed connective corridors appear to skirt the Thetford Forest, however, they connect up the current population clusters which would not be connected through the Forestry Commission's Open Habitat Plan for Thetford Forest as they lie largely outside of their land ownership. Any such connective features would ideally be extensively managed disturbed areas as already described, but could also consist of the small scale disturbance approach which may effectively act as habitat stepping stones.

Disturbed grazing exclosures (*A. fusca*)

Specific recommendations for *A. fusca* should aim to enhance the cover of native Field wormwood on suitable sites, a suggestion from John Walter's 2011 studies of the beetle. This could involve hand collecting seed from the Artemisia reserve in Brandon which appears to have a thriving population, or alternatively planting native seedlings grown from seeds from in situ collections. Due to the need for Artemisia to have disturbed sand for germination of new plants and an absence of grazing, it

would be desirable to have annually managed grazing exclosures of c. 20m by 20m. Any such enclosure would need to be rabbit-proofed to allow seedlings the opportunity to mature successfully. However, work to encourage Field wormwood needs to be considered alongside research into the relative success of Mugwort in supporting *A. fusca* populations.

Such work would be best trialled at sites with recent records, most obviously Maidscross Hill due to its extensive size. The Wangford roadside would likely be too small and as it is already suffering from stabilisation any attempts to reduce grazing pressure would be at the expense of the site's other significant beetle interest, while the Brandon Artemisia reserve is surrounded by industry. Should the introduction of Field wormwood on sites such as Maidscross Hill be successful, they could then be considered in nearby sites with sandy soil and of a sufficient size for small areas to be managed without impinging on wider site interest. Appropriate sites may include Wangford Warren and Carr SSSI, RAF Lakenheath SSSI and Lakenheath Warren SSSI. Annual management in such small areas could easily be undertaken using hand tools, to simply scrape off vegetation and expose underlying sands.



Map showing the location of potential areas to encourage Field wormwood and *A. fusca*, focusing on Maidscross Hill SSSI as the primary location, followed by the surrounding network of extensive SSSIs. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

Such small scale grazing exclosures with regular disturbance could also provide significant opportunities for other study species, most notably *H. froelichii*. *H. froelichii* favours seed of Fat hen, which although common in arable situations, tends to be preferentially grazed so cannot persist in many heathland and sandy grassland sites. Establishing small disturbed areas within grazing exclosures could be a potentially valuable tool within large sites for other study species. Such an approach may be viable as the success of the small Artemisia reserve in Brandon has demonstrated, as it produced not only records for *A. fusca*, but for *H. froelichii* and *H. smaragdinus* showing how even small scale disturbance work could produce habitat stepping stones for the two Harpalus species and potentially enhance populations at the landscape level.

Suggestions for further work

- Natural England advisers to continue their prioritisation of cultivated arable margins in recommendations to landowners across Breckland, to enhance the resource of disturbed habitats across the landscape.
- Arable field margin management should be trialled where two small stretches are managed separately on a short two year rotation within a wider annually managed strip. Monitoring of these strips when compared to similar strips managed homogenously on an annual cycle should be undertaken to assess whether the extended cycle is providing refuge areas for beetles. This would ideally be undertaken on at least three sites, each with a references site and comparable area nearby which would be managed with these additional longer rotation areas. To determine the effectiveness, at least two survey seasons would be required, with annual surveys undertaken in evenings in August by an experienced entomologist to coincide with the peak survey period for many of the study species.
- Further research into cultivated uncropped margins should be undertaken to assess if an extended disturbance cycle produces better results for ground beetles. This is particularly relevant in margins which are already known to support important populations. Trials comparing management every 1, 2 and 3 years would be ideal. This work has identified a clear knowledge gap in this area and has the potential to refine management for ground beetles across a number of nationally significant sites.
- Disturbed grazing exclosures, where trialled, would require a couple of years for introduced Field wormwood to establish. Subsequently, surveys should be undertaken in the evenings between September and October when records for the species peak to coincide with the ripening of Field wormwood seed.
- Research into the lifecycle of *A. fusca* could prove invaluable, with little about their habitat preferences understood beyond feeding on the seed of Artemisia species. It may be, for example that even if Mugwort is sub-optimal as a foodplant, that its more widespread distribution makes it more able to support beetle populations. Much of the evidence for Field wormwood being favoured seems to relate to the success of the population at the small Artemisia reserve, however this is a highly concentrated and well managed resource, in stark contrast to the wider landscape. It may also be useful to elucidate other areas of *A.*

fusca's lifecycle, for example its overwintering requirements, which may explain its currently limited distribution, despite the widespread nature of Mugwort.

- Comparable studies of altering the frequency of rotovation would be highly beneficial. Many rotovated plots are managed annually, but it is likely that combining annually managed plots with plots managed only every 2 or 3 years would provide a greater diversity of disturbed conditions.
- Comparable studies of altering the frequency of rotovation and ploughing would be beneficial to define the preferred management strategy within large sites for ground beetles. Sites with existing beetle populations would be ideal and that are large enough for a number of techniques to be trialled, with a number of plots managed, including both rotovated and ploughed, with some managed annually and others every 2 and 3 years. The ideal location would likely be a sandy site to the west of Thetford Forest near the cluster of sites at Wangford Warren and Carr SSSI, Maidscross Hill SSSI and RAF Lakenheath SSSI. This would require monitoring of both key food plants such as Fat hen for *H. froelichii*, as well as of beetles to clearly identify the rotation which provides the most suitable habitat for the range of relevant species. This work would require annual monitoring over at least three survey seasons, involving survey work in August by an experienced entomologist.
- All proposed survey work would require regular monitoring of both vegetation regenerations and beetle populations.

Thetford Sustainable Urban Extension (SUE)

Influencing the wider management of the Brecks offers the greatest potential to encourage populations of the scarce beetles of disturbed ground that are characteristic of brecks. However, working with the planning system also provides opportunities to help conserve the assemblage by protecting existing hot spots or creating new opportunities as part of mitigation packages. The timing of this work has the potential to help minimise the impacts of the Thetford Sustainable Urban Extension (SUE) project, which is likely to lead to the loss of some well known scarce ground beetle sites, as well as potentially unknown ones.

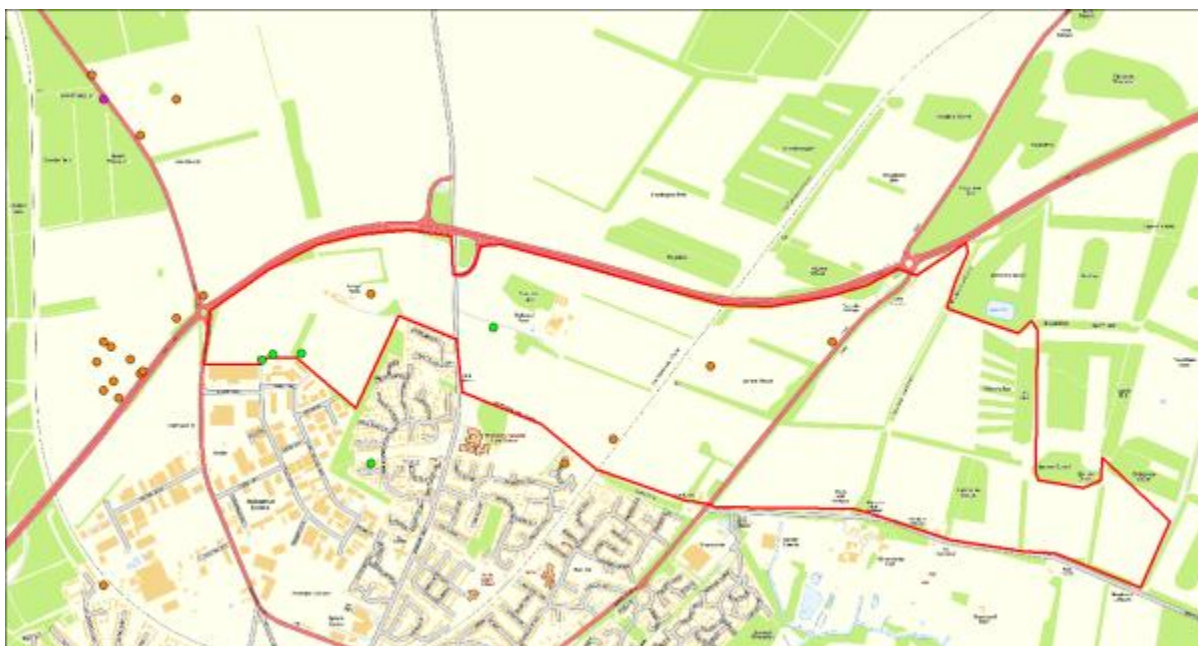
The Thetford SUE project aims to extend the urban centre of Thetford northwards, creating 5,000 residential units as well as employment, infrastructure and community resources. The final development will involve the conversion of 270ha of arable land within a 285ha site, which includes land at Gallows Hill, Lodge Farm and Blakeney Farm, which supports valuable records for *O. laticollis* and *H. froelichii*. These sites are of particular importance for *O. laticollis*, as the agricultural margins north of Thetford represent the species' Breckland stronghold (Telfer, 2009b).



Thetford SUE masterplan. Taken from <http://www.thetfordse.co.uk/masterplan/> [Accessed 20th March 2015]



Thetford SUE development area aerial image edited from Google Earth ©2015 Google Earth, Infoterra Ltd & Bluesky.



Map of beetle records relative to the Thetford SUE development boundaries, showing records within the site boundary for *O. laticollis* (orange), *H. froelichii* (green), in addition to records from the surrounding area of the two species alongside *H. smaragdinus* (pink). Only records with a minimum of four figure grid references have been used, but the points should still only be considered representative at this scale. Please note that there are also overlapping records. Contains OS data © Crown copyright [and database right] 2015 (Licence information: <http://www.ordnancesurvey.co.uk/oswebsite/docs/licences/os-opendata-licence.pdf>)

The Thetford SUE application is clearly likely to impact on the scarce ground beetles which use the site. However, with suitable mitigation and habitat creation options, these impacts could be mitigated and attempts made to bolster the local population through a combination of on and off site management proposals.

It is essential that prior to any land being affected by development, a full study is undertaken of the use of the site by both *O. laticollis* and *H. froelichii*, in addition to any other brecks specialists which may be recorded. This must be by an experienced entomologist with experience of Breckland habitats and species. The results should be used to influence local elements of the plan where possible, aiming to maintain key areas of high quality habitat where possible.

Thetford SUE mitigation recommendations

In situ preservation of high quality features

Where populations of *O. laticollis* are discovered, every effort should be made to maintain habitats *in situ* perhaps within green infrastructure or open spaces, with the aim of continuing annual disturbance management in the long-term. Based on the studies of Mark Telfer, it seems likely that *O. laticollis* would favour field margins where uncropped cultivated margins meet permanent

grassland cover. This could include relatively dense vegetation and hedge lines which might provide shelter, so long as a south-facing aspect is provided and a friable soil substrate.

Should any arable margins be in suitable positions to be protected, it is essential that a significant area is protected to provide a buffer. This should include both the cultivated margins themselves and the associated permanent grassland habitat, while the existing management plan should be continued to provide the suitable disturbed situations for the species. These areas could both be on the boundary of the Thetford SUE development or maintained within planned open space. Such resources within planned open spaces could be fenced off as small nature reserves and used as educational resources complete with interpretation. This would effectively highlight the value of the Brecks for wildlife while also providing habitat stepping stones for the beetle within the Thetford urban landscape. Considering the aim of retaining 22ha of open space within the development, there would clearly be ample opportunities to retain habitat

Creation of new habitat

As well as retaining key areas of habitat for *O. laticollis* it is also essential to create new opportunities for the species both within Thetford SUE and in the surrounding landscape.

As the details of the Thetford SUE are fine-tuned as the development progresses, it should aim to create new opportunities for *O. laticollis*, which would also benefit a range of other brecks specialists. This should ideally target the boundaries of the development where there are existing permanent grassland margins, many complete with hedges and tussocky grasslands that could provide shelter for overwintering and refuge from ploughing. Adjacent to these areas, 6m strips should be disturbed annually by ploughing to create opportunities for annual plants to germinate and provide the range of seeds needed for the species. These areas should never be sown or sprayed, with a buffer of 2m around the ploughed area also kept free of spraying. Where margins are already managed in this way, they should be retained where they hold high potential to be colonised by *O. laticollis*, even where no records have been reported and enter long-term disturbance management.

In addition to retaining existing arable field margins, the 22ha of proposed open space presents opportunities to also create new disturbed features. As with the retention of existing populations within open spaces, areas should be fenced off and managed as an annually ploughed 6m strip adjacent to a strip of permanent grassland or scrub cover. Such areas should target areas of friable soil, preferably more calcareous in nature and with a south-facing aspect.

Efforts should also be made to provide opportunities in the landscape surrounding the Thetford SUE development as even with the retention of key areas and introduction/maintenance of management on suitable areas within the application site, there will likely still be a significant net loss of potential habitat. This should take the form of encouraging nearby landowners to also manage 6m uncropped margins adjacent to permanent grassland as has already been detailed. Such an approach could contribute to enhancing the landscape resources for the species and encourage it to colonise new sites.

It is essential that all newly created habitat, is in place and under management as far as possible before the loss of any *O. laticollis* and *H. froelichii* habitat to allow these sites to be colonised and best help maintain populations throughout the development of the Thetford SUE project.

Further work

It is recommended that a suitably qualified entomologist is contracted to assess the value of all margins within the development site, and the results of this work used to identify key areas for retention as well as areas which could be enhanced with management to provide suitable habitat for *O. laticollis* and other invertebrates.

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