Bumblebee Conservation Trust

Species Knowledge Review:

Shrill carder bee in England and Wales

Dr Cathy Horsley May 2024
Updated version, based on the report by Sam Page, Richard Comont, Sinead Lynch and Vicky Wilkins 2019

Contents

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Introduction

Bombus sylvarum is one of the UK's most rare and threatened bumblebees. It is restricted to only five population areas: the Thames Estuary, Somerset, Pembrokeshire, the Gwent Levels, and Port Talbot to Kenfig.

In this report, 'areas' are defined as apparently separate populations, where there are clear gaps in records between known population areas of >20 miles (32 km). We acknowledge that areas are difficult to define as they vary greatly, and the genetic links between areas are not known (though see Ellis et al 2006).

Bombus sylvarum on Red bartsia, *Odontites vernus*, at Lytes Cary Manor, Somerset. Photo credit: Claire Fidler

Bombus sylvarum is characterised by its straw-coloured hair, sometimes described as grey or greenish, and a thick black band across the thorax between the wings. It has poorly-defined black and yellow stripes over the abdomen and a pale orange tail. Overall, the bee has a fairly shaggy appearance due to its uneven coat.

Much of the current knowledge of *B. sylvarum* builds on extensive work carried out by the Bumblebee Working Group and Hymettus in the 1990s and early 2000s, which was built in part on Paul Williams' PhD thesis (1985). Work was also undertaken on *B. sylvarum* in South Essex and Canvey Wick for English Nature (Harvey, 2000; 2001).

Since then, there have been a few key studies such as genetic research by Ellis et al (2006), Stuart Connop's PhD thesis in South Essex (2007), and a series of CCW/NRW reports and surveys carried out across the Welsh populations between 2000 and 2013. The Back from the Brink project ran from 2017 – 2019 and had Project Officers in the Somerset and Thames Estuary population areas. Following on from this, the original Species Knowledge Review and the Shrill Carder Bee Strategy were produced in 2019 and 2020 respectively, which led to the BBCT post of Shrill Carder Species Recovery Manager (2021 – present).

Taxonomy

In the UK, there is one species, *Bombus sylvarum* (L. 1761).

A melanic form exists, *B. sylvarum* form *nigrescens* (Perez, 1879). These are black with a reddish tail, and may or may not have intermixed grey thoracic hairs; and occur in south-west France, the Atlantic regions and south of Scandinavia (Brasero et al. 2020). The dark form *nigrescens* was recorded several times in Sussex (Mortimer, 1922). More recently, darker specimens have been found in 2011 at Dungeness (BWARS - N Gammans pers. comm) and at Deal (BWARS - RL Evans & ED Moss, pers. comm).

On the continent, there are three subspecies, described in Brasero (2020), although all are considered as *B. sylvarum* with high geographic phenotypic differentiations:

B. sylvarum citrinofasciatus (Vogt 1909), characterised by grey/yellowish bands, and the absence of grey/yellowish bands on the abdomen and occurs in western Turkey.

B. sylvarum daghestanius (Radoszkowski, 1877) which is characterised by white bands and a reddish tail, found in eastern Turkey, Caucasus and Iran.

Bombus sylvarum rogenhoferi (Dalla Torre, 1882) has white/yellowish bands, a red tail and has no thin grey bands on the abdomen. Restricted to south Italy and Sicily.

Conservation status

Bombus sylvarum is listed under the IUCN as Least Concern in Europe (Rasmont et al, 2015), but Endangered on the Irish Red List (Fitzpatrick et al, 2006) and is on the Red List in various other countries including Belgium, Denmark, Germany, the Netherlands and Czech Republic (Kosior, 2007).

Bombus sylvarum is listed as a Priority species of Conservation Concern under Section 41 in England (NERC Act 2006) and Section 7 in Wales (Environment (Wales) Act 2016).

It was a UK Biodiversity Action Plan species and was listed as Notable b (Nationally Scarce Nb) by Falk (1991). Natural England and BWARS are currently in the process of updating its threat status for Great Britain. The UK BAP Species Action Plan for *Bombus sylvarum* was last updated in 2010 (JNCC 2010; Appendix 3). The RSPB has a species action plan for *B. sylvarum* (last reviewed 2016).

The species is identified as a qualifying feature of eight SSSIs which make up the Gwent Levels. It is also listed as a qualifying feature of Castlemartin Range SSSI, Kenfig SSSI and Margam Moors SSSI. It is listed locally as a priority species in some agri-environment schemes (e.g. Countryside Stewardship in parts of Kent, Natural England).

Distribution

World-wide distribution

Bombus sylvarum has a **widespread western-Palaearctic distribution**, and is found in Central Spain, Sicily, southern Italy, Greece and southern Turkey; it reaches Ireland and northern Portugal to the West and Mongolia to the east, and to the north it almost reaches the Arctic circle (Rasmont et al. 2015).

European populations of *B. sylvarum* have become sparse in the last 50 years (e.g. Honchar 2020), although in Hungary, it appears currently stable (Jakab et al, 2023).

UK distribution

Historical distribution

Bombus sylvarum was **once widespread across southern England and Welsh lowland and coastal regions**, with more localised records in central and northern England (Figure 1). Sladen (1912) said *B. sylvarum* was 'widely distributed in England & Ireland and common in a good many places', which was echoed by the New Naturalist Bumblebees (1950), and Hallett indicated good populations in Wales in the 1930s.

Bombus sylvarum Photo credit: Claire Fidler

The second half of the 20th Century saw a major range retraction however (Figure 1). By the time of publication of the 'Bumblebees of the British Isles', *B. sylvarum* was scarce (Alford, 1980). Analysis of these records showed that *B. sylvarum* was one of the Southern Local Species characterised by having been lost from the Central Impoverished Region of Britain (Williams, 1982), for which the most likely explanation was considered to be post-1940 habitat conversion and reduction in food resources (Williams, 1986). The Bumblebee Working Group (BWG) estimated a 75% decline between the periods 1970-1990 and 1990-2001 (Edwards, 2001 *in* Benton, 2006). The species was declared not present in Cornwall in 2005 (last recorded 1971). It was last recorded in Devon in 1978.

In 1997, BWG surveys found few records of individuals (1 in Kent, 1 on Salisbury Plain and 2 at Margam Moors), although weather conditions were not optimal. *Bombus sylvarum* was present on the Somerset Levels but surveying was not possible due to flooding and in 1998, the BWG confirmed six key areas or sub-populations across the UK. In 2003, surveys of the Gwent levels found workers widely across the site (Pavett, 2004).

Current distribution

Bombus sylvarum is **restricted to only five population areas**: the Thames Estuary, Somerset, Pembrokeshire, the Gwent Levels, and Port Talbot to Kenfig. It is possible that a sixth population on Salisbury Plain may remain in very low numbers, but it is likely to have been lost. The most recent record is from 2008, despite surveys being carried out in several areas of the Plain in most years to date. However, substantial parts of the Plain are difficult to access, and it may be in low numbers so as to remain undetected, so there is the possibility that it is still present.

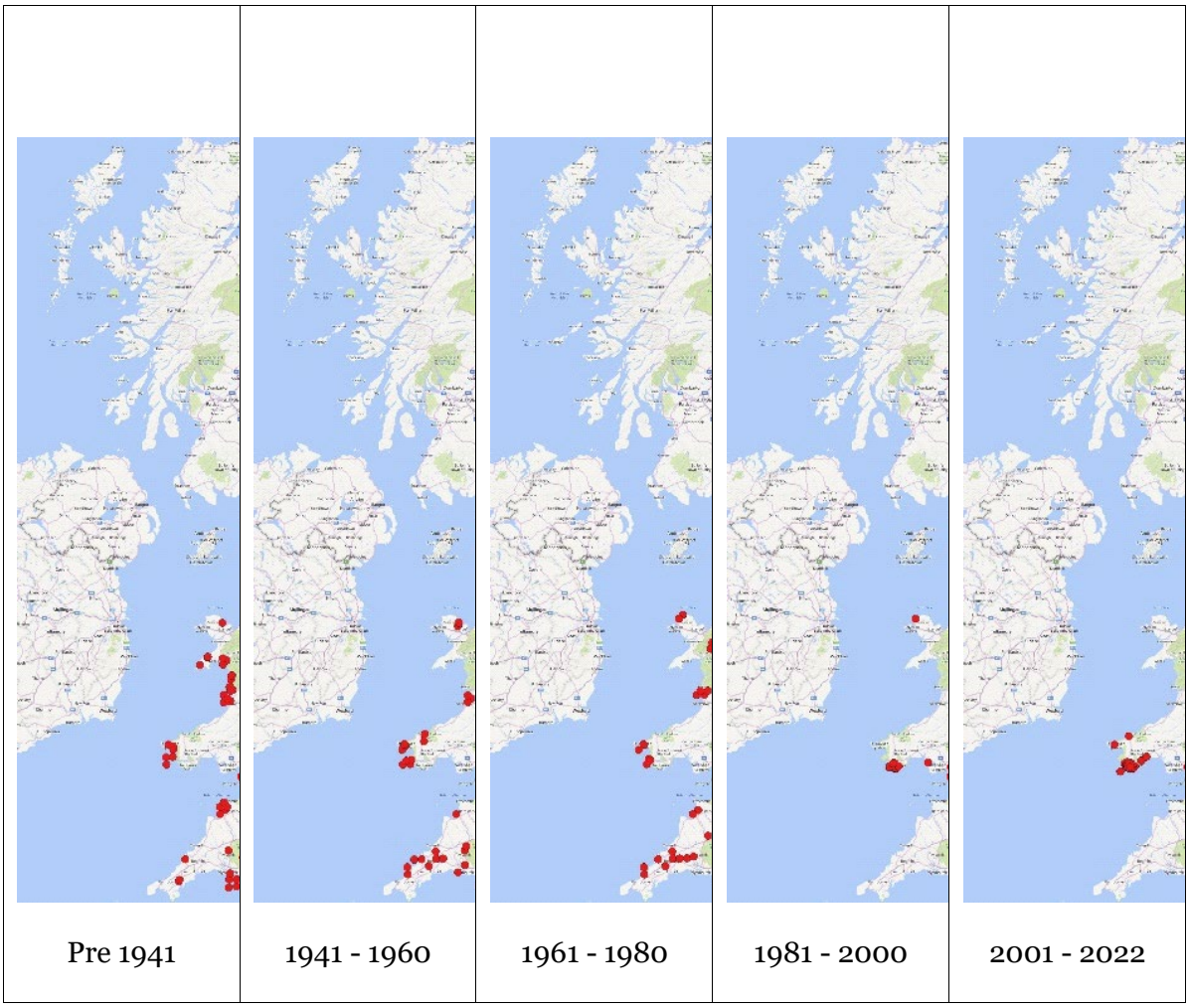

Figure 1: *Bombus sylvarum* distribution (red squares) in the UK between pre 1941 up to 2022, showing recent distribution. Records are displayed as 10km grid squares.

Summary of recent distribution data

The following sections describe the most recent distribution data (i.e. approximately the last 20 years, from 2000 onwards) in the population areas. Note that this data will reflect recorder effort to some degree.

There is reasonably good distribution data for *B. sylvarum*, although the comparatively frequent discovery of new populations and reappearance of old ones suggests that the species may be easily overlooked in a landscape if not searched for specifically. It may also reflect its population dynamics, with small satellite populations disappearing and reappearing.

Pembrokeshire

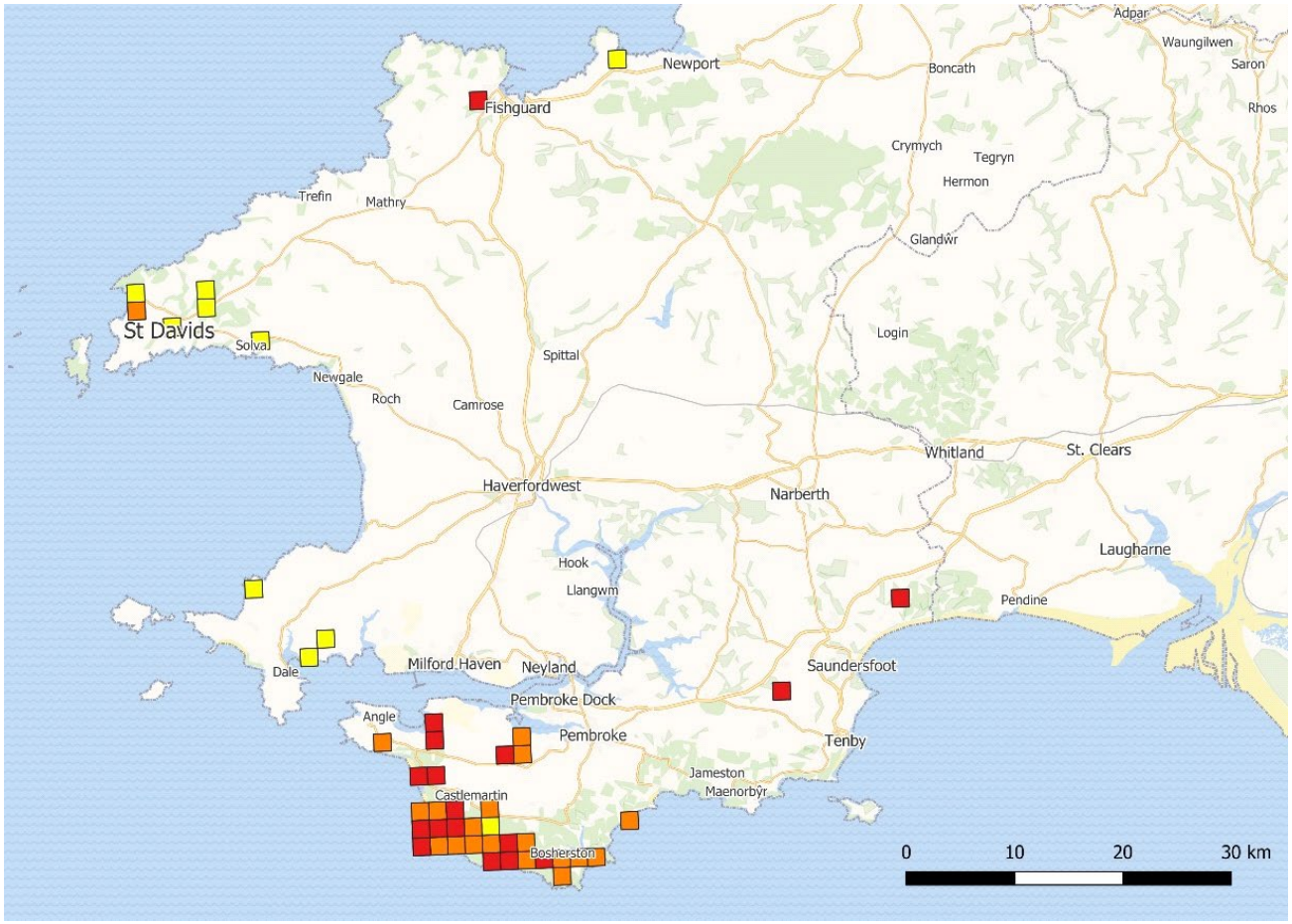

Figure 2: *Bombus sylvarum* in Pembrokeshire, displayed as 1km grid squares, post 2010 (red squares), 2000 – 2010 (orange squares), and pre-2000 (yellow squares).

There is less known about the Pembrokeshire population compared to other UK populations, but it **does not appear to be thriving in a manner equivalent to Thames Estuary or Gwent populations**. Shrill carder bee records in Pembrokeshire indicate its distribution to be primarily restricted to the Castlemartin peninsula (Page et al., 2019). The main known population is found on MOD land at Castlemartin Range East (Stack Rocks, St Govan's Head) and Castlemartin Range West (Linney and Linney head) (Figure 2).

Recording on the MoD ranges has been piecemeal, with occasional coordinated efforts (e.g. in the summer of 2021). It is considered likely that numbers of *B. sylvarum* have declined on Castlemartin Range (and likely the outlier satellite populations too) since initial comprehensive surveys in 2000. This is likely due to a decline in habitat suitability and increased fragmentation (Page et al., 2019). A contemporary assessment of the population condition and habitat suitability on Castlemartin Range and key outlier sites is required as a priority.

Therefore, a survey was commissioned by BBCT, funded by Pembrokeshire Local Nature Partnership, over the summer of 2023. The aim was to understand the distribution of *B. sylvarum* in Pembrokeshire, outside of the Castlemartin Range. No *B. sylvarum* were found

outside of the range however, despite other S41 bumblebee species being present, and conditions suitable for *B. sylvarum* (Harris, 2023, unpublished report).

Previously, outside of the Range, the species has been recorded to the north of the Range using farmland and land owned by the Valero refinery (Figure 2). Outlier records have been noted near Redberth and near Red Roses. There have also been some records on the St David's peninsula but these are not contemporary and are small in number. A record was made in 2014 near Fishguard.

Other sightings outside of Castlemartin Range:

- *Bombus sylvarum* queen recorded near Carew Farm on Castlemartin Trail in 2012
- Confirmed sighting at Amroth in 2017
- Confirmed records at Wyndrush Farm, Redberth in recent years
- Numerous records north of Castlemartin Range since 2012 at National Trust's Gupton Farm (low numbers), Valero Refinery (particularly around Kilpaison), and Somerton Farm

Gwent, Glamorgan and Monmouthshire

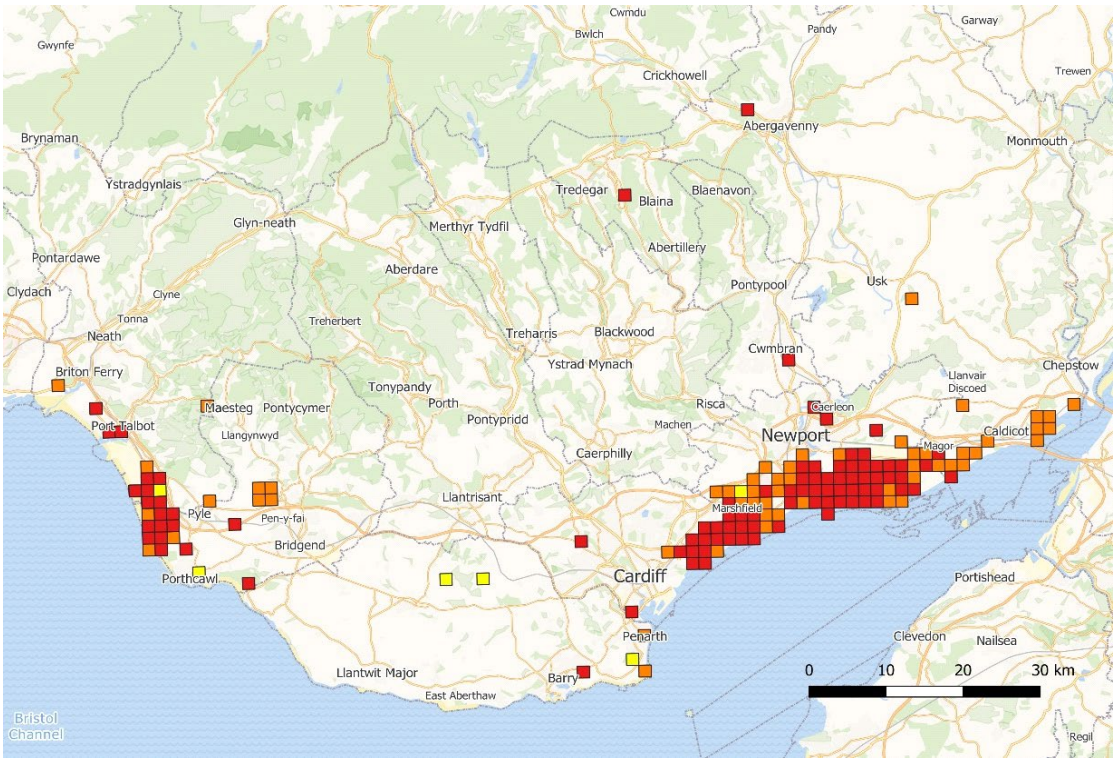

Figure 3: *Bombus sylvarum* in Glamorgan, Gwent, and Monmouthshire, displayed as 1km grid squares, post 2010 (red squares), 2000 – 2010 (orange squares), and pre-2000 (yellow squares).

The Gwent Levels SSSIs are well known hotspots for *B. sylvarum* and the species is consequently well-recorded here on an annual basis. Newport Wetlands and Great Traston meadows are important sites. Male *B. sylvarum* were recorded north of Newport at The Moorings, 2016 (E. Meloy, pers comm).

Kenfig Burrows NNR (Bridgend) is another important site. Kenfig is less well-recorded than the Gwent Levels, but a BeeWalk transect was established at the site in 2019 and immediately recorded the species.

In 2023, two males were seen at Southerndown Bay which is approximately 15 km east of Kenfig National Nature Reserve.

From 2003 to 2014 a comprehensive series of reports were commissioned by CCW/NRW, on the status of *B. sylvarum* on the Gwent Levels and surrounding areas, and at Kenfig and Port Talbot. These and other reports are summarised in Appendix 1.

Ecological reports for the M4 Relief Road highlighted importance of brownfield land at TATA steel.

In 2016 a queen was recorded at Central Valley Nature Reserve in Ebbw Vale by Gwent Wildlife Trust staff, and later in the summer a male was recorded by BBCT staff. The site is approximately 26 km north from nearest records on Gwent Levels, and no records have been confirmed since despite some searches.

A sighting was made in 2022 at Llanwenarth, Abergavenny. This is approximately 20 km away from Ebbw Vale, and 33 km away from the next closest record (Cwmbran, 2017), which suggests it could be a separate population from the Gwent Levels. The area was surveyed in 2023, but no further records were found.

In the Vale of Glamorgan, a record was made in 2023 in Rumney, Cardiff. It was also recorded at Dow Corning, Barry Docks, west of Cardiff by Wildlife Trust and BBCT in 2016 and 2017. There are historic records at Lavernock Point near Penarth.

Somerset

The Somerset population does not appear to be thriving in a manner equivalent to the Thames Estuary population which is more abundant and has a wider distribution. Recent Shrill carder bee records (2012 onwards) in Somerset indicate that **the core population is now found in South Somerset, around Lytes Cary Manor**, a National Trust property approximately 12 miles southeast of the Avalon Marshes complex.

Sightings have been primarily found in an area between Curry Rivel on the western side and Lytes Cary on the eastern side (approx. 12 mile stretch). Interestingly, many of the sightings have followed the path of the Taunton to Reading rail line leading to speculation that dispersal is aided by the railway.

At Lytes Cary, between 2014 and 2016, around 100 individuals were recorded each year. In recent years (2017 onwards) the population at Lytes Cary has been recorded in much lower numbers. Only 25 individuals were recorded at the site in 2018, 29 individuals in 2020 and just 7 records in 2022.

BWARS maps (Edwards and Else 2018) suggest that *B. sylvarum* was widespread across Somerset prior to 1990. Records between 1992 and 2008 show that the population began to concentrate around the Avalon Marshes complex, with the majority of records coming from sites on the Somerset Levels and Moors (SLM) including Shapwick Heath, Ham Wall and Street Heath. This area has been extensively surveyed since 2011 for BBCT's BeeWalk scheme, as well as by the Recorders of the Avalon Marshes (RoAM) volunteer group and site & BBCT staff. The species has only been found once in the area since 2013 (one record at Catcott in 2017) and it is no longer thought to be present. This was confirmed by an extensive survey carried out in 2019 on recent and historic sites on the Somerset Levels and

Moors (SLM) by a consultant as part of the Back from the Brink Project. The Shrill carder was not found on any of the SLM sites and the conclusion was that it had 'retreated from the former core population areas in Kings Sedgemoor, Avalon Marshes, Huntspill and Mark area' (Saunders, 2019). The survey findings suggested that 'the bee is likely to be threatened by scarcity of clover rich pasture and unimproved late flowering meadows. Formerly flower rich disturbed ground associated with peat working sites has been restored to wetland habitat with less foraging resources - this has broken population connectivity' (Saunders, 2019).

Figure 4 shows the pre-2010 distribution in Somerset, compared with the most current records between 2010 - 2022, showing the move to the south of the county.

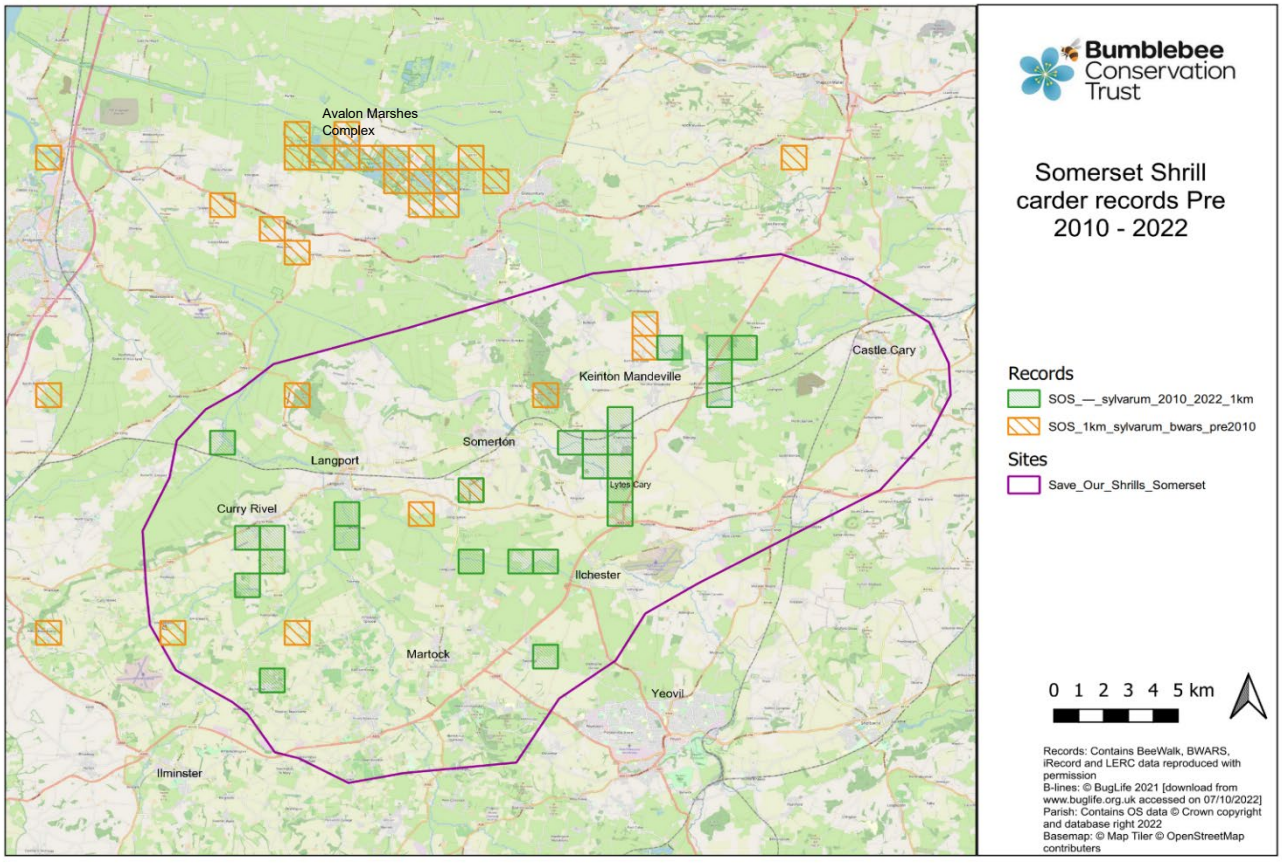

Figure 4: Records of *Bombus sylvarum* pre-2010 (orange hatched squares) and between 2010-2022 (green squares), and the Save Our Shrill Somerset project area (purple line).

Figure 5: *Bombus sylvarum* in Somerset, displayed as 1km grid squares, post 2010 (red squares), 2000 – 2010 (orange squares), and pre-2000 (yellow squares).

Since 2012, there have been scattered sightings in the vicinity of Lytes Cary, including Green Down (a Somerset Wildlife Trust Reserve – original reintroduction site of the Large Blue butterfly), The Old Waterworks (private land just 0.5km from Lytes Cary), Perry's Bridge Farm (near Lydford-on-Fosse) and the village of Charlton Adam to the north. South of Lytes Cary, there have been records from National Trust Tintinhull Gardens and Pill Bridge, Ilchester.

There are also a cluster of records centred around Curry Rivel (Figures 4, 5). In 2015, they were first recorded in the village at Home Farm. The site was monitored more closely during

2018-2019 as part of the Back from the Brink Project, with both ad-hoc surveys and set bee walk transects, generating four further records over this period. Despite regular BeeWalk transects in 2023, *B. sylvarum* has not been found on Home Farm in 2023. Other recent sightings close to Curry Rivel include on North Drove, West Sedgemoor, between Stathe and Oath to the north of Curry Rivel, as well as on the Huish Levels near Westover Farm Bridge, to the east of Curry Rivel. These records are from 2019.

In 2023 there were records from two known existing sites – 21 records at Lytes Cary, and one from Pill Bridge, in Ilchester. A new site was identified in 2023 in the village of Kingsdon, 1.5 km from Lytes Cary. Three individuals were found on verges on White deadnettle and in meadows on Knapweed in the village over the summer.

It appears that the Somerset population is relatively extensive, but occurs at a very low population density. Intensive, repeated surveying in areas with suitable floral resource is often required to confirm presence at each site, and this may be more successful than using standard BeeWalk methodology. Some sites have individuals recorded at a rate of one every few years despite annual surveying. This would explain why records are made in various different locations each year. It does not however, explain the recent and serious reductions in numbers at Lytes Cary Manor, that has received similar surveying effort since 2014, and where the area of suitable habitat has increased.

Kingsdon Shrill carder bee June 2023 by Lucy Dibben

Thames Estuary

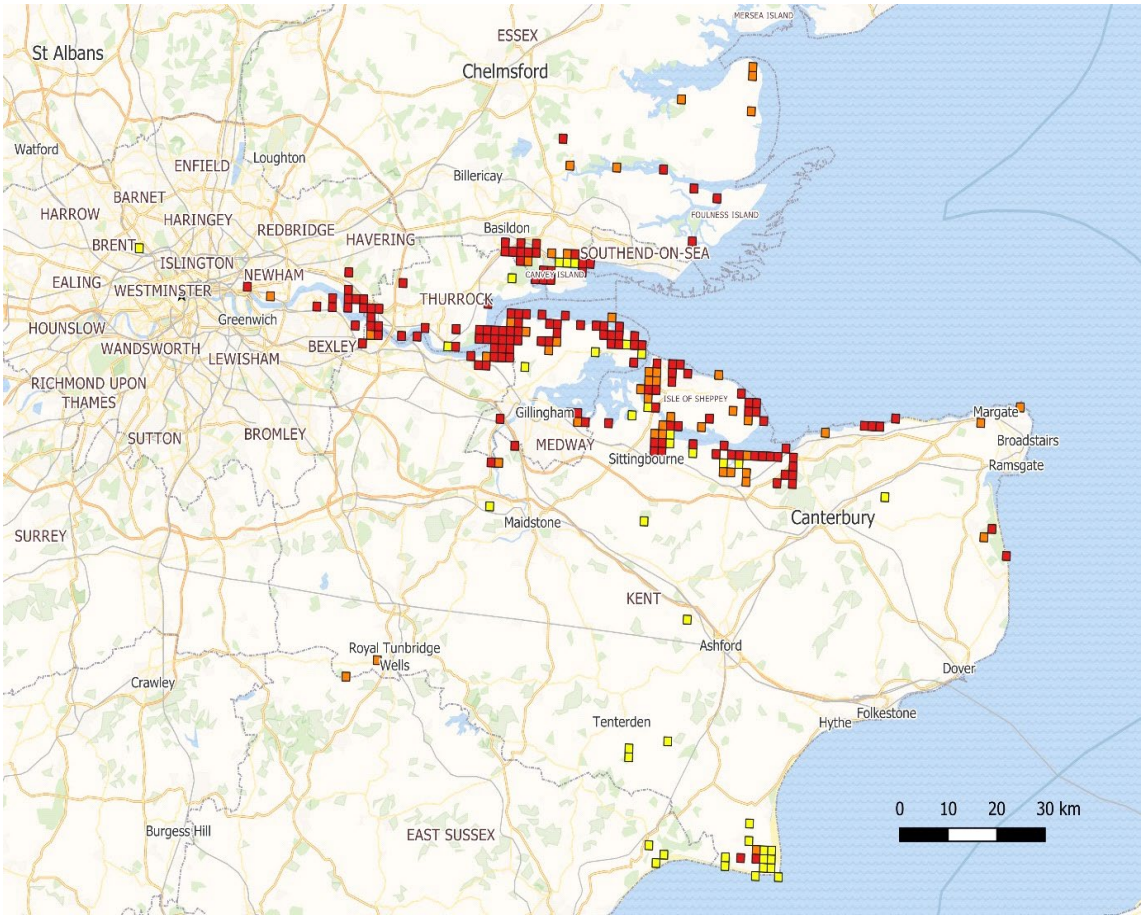

Figure 6: *Bombus sylvarum* in Essex and Kent, displayed as 1km grid squares, post 2010 (red squares), 2000 – 2010 (orange squares), and pre-2000 (yellow squares).

Essex

The area is well-surveyed for bumblebees and has been the subject of considerable recording effort through the Back from the Brink project in recent years. Important sites include Canvey Wick, Rainham Marshes, Coalhouse Fort, Hadleigh Park and East Tilbury Silt Lagoons.

In 2022 and 2023, sites in Essex were successfully surveyed for *B. sylvarum*, focussing on getting up to date records between Basildon and Southend-on-sea (Figure 6).

Since 2000, range extensions have been documented along the Essex coast: *B. sylvarum* was recorded at MOD Foulness (2011), Dengie peninsula (2009), Tollesbury Wick (2007) and as far as Mersea Island / East Mersea in 2010 – a shift in range of approx. 30km (Benton et al 2012). It is suggested this range expansion has been heavily dependent on sea wall habitat (Benton pers comm - in Gardiner 2012) which can act both as a forage source and/or as a leading line for dispersing individuals (Stuart Connop, pers. comm.).

It is unclear as to whether the species is still occupying this extended area however. In 2023, *B. sylvarum* was recorded in Hullbridge and Burnham on Crouch, but there are no records further north – this requires field investigation.

Range extensions have also occurred westwards towards London, (see http://www.essexfieldclub.org.uk/portal/p/Species+Account/s/Bombus+sylvarum). However, these seem to be experiencing only limited success: an individual was observed at Barking

Riverside in 2012 but none were found in subsequent years, and the remnant population at Thames Barrier Park appears to be no longer present, nor has *B.sylvarum* been observed on neighbouring brownfield sites around the royal docks (Stuart Connop, pers. comm).

Kent

The area is well-surveyed for bumblebees and has been the subject of considerable recording effort through the Back from the Brink project in recent years. Important sites include RSPB Cliffe Pools and RSPB Northward Hill (Hoo peninsula), plus multiple sites along the north Kent coast from Dartford (Long Reach Sewage Treatment Works) to Seasalter. Records from 2018/19 suggest *B. sylvarum* is widespread in the Sittingbourne area (e.g. South Swale NNR, Milton Creek Country Park) and Isle of Sheppey (e.g. Leysdown Coastal Park, coast between Sheerness and Mister) (Rosie Earwaker pers comm).

Further west, there have been consistent sightings of *B. sylvarum* between 2012- 2019 at Crossness Nature Reserve (Thames Water) / Erith Marshes in the London Borough of Bexley since the species was first recorded there in 2012.

A *B. sylvarum* worker recorded at RSPB Seasalter near Whitstable in 2015. During the BWG surveys, this was the most easterly reliable location for the species (Mike Edwards pers comm). There have been recent records (2014-2019) 12 miles further east at Reculver (Geoff Allen pers comm; Bex Cartwright pers comm), which represents the eastern-most extent of the main North Kent population. This cluster of records is 10km from the nearest records to the west in South Swale and Seasalter levels/Graveney Marshes, and is separated by the heavily built-up areas of Whitstable and Herne Bay.

Important new populations of *B.sylvarum* were discovered in 2018 and 2019. In 2018, the species was recorded at a Woodland Trust arable reversion site (Victory Wood) 2km south of Seasalter levels and just south of A299, and also at adjacent Ellenden Farm and Wraik Hill Nature Reserve (Canterbury City Council, formerly Wildlife Trust managed). Subsequent surveys have revealed a significant population with spring queens foraging in gardens adjacent to the sites and an impressive count of 121 individuals on one day's surveying at Victory Wood in August 2019.

Two records from Sandwich Bay area in East Kent 2009-2013 (Geoff Allen pers comm). The most recent accepted record from this area is from 2017 - a spring queen foraging in the garden at Sandwich Bay Bird Observatory on 29/4/19 (which was seen on two subsequent days, presumably the same individual).

In 2005, two workers recorded at North Foreland/Foreness Point in Margate (11 miles north of Sandwich Bay), however this site has been surveyed by BBCT multiple times in last few years, with no subsequent sightings.

In south Kent, there were sightings at Dungeness in 2010-12 but not since, despite frequent and extensive bumblebee surveying in the area.

Abundance

Estimates of population sizes and trends of bumblebees over the shorter term can be achieved through the BBCT-run BeeWalk bumblebee monitoring scheme (Figure 7). This involves monthly transects, with all bumblebees seen within a 4m x 4m x 2m 'recording box' counted and identified to species (or to *Bombus* sp. where the exact ID is unclear).

Several transects have been set up in or around areas where the Shrill carder has been found. To date, *B. sylvarum* has been **recorded on 52 transects (2008 – 2023), totalling 472 individuals**. Across 2022 and 2023, 27 of these transects were active.

Bombus sylvarum at Canvey, 2022. Photo credit: Daisy Headley

Figure 7: BeeWalk transects recording *Bombus sylvarum*. All transects with *B.sylvarum* records, 2009-2018; no *B. sylvarum* records in 2012. Pembrokeshire transects no longer active. (2019 data not yet processed as field season ongoing.)

BeeWalk records (2010 – 2023) were analysed using a log-linear model applied to monthly sighting rates (bees per kilometre walked) (Figure 8). The overall population trend for the species at BeeWalk-monitored sites is positive, though variation is high.

Ad hoc surveys and observations indicate there are decreases on some sites e.g. RSPB Great Bells, Isle of Sheppey (Gomes, 2015).

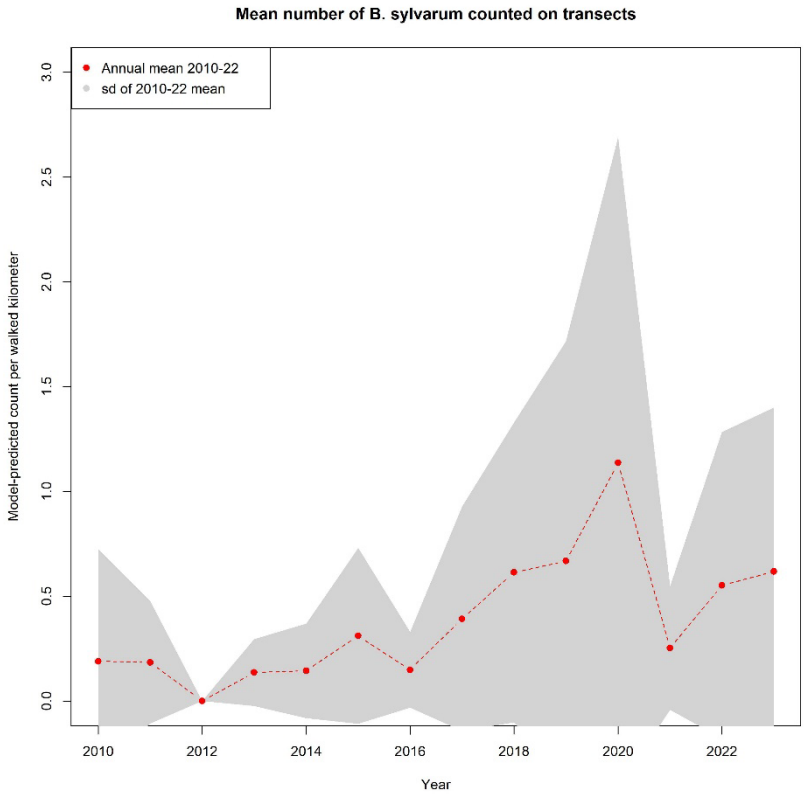

Figure 8: Mean number of *Bombus sylvarum* counted on BeeWalk transects between 2010 and 2023, calculated from model-predicted count per km walked.

BeeWalk transects may not always pick up this species, especially in areas where its populations are at low density (even if sustainable) due to the large area of suitable habitat, for example where this is comprised of ditches within otherwise fairly extensively managed habitat. Such populations may require very long and frequent transects, taking in several km of suitable habitat (e.g. ditch edges), to be adequately surveyed. This species may also be difficult for new bumblebee surveyors as it requires a very targeted search image.

BeeWalk data can also be used to construct a phenology for the species. Analysis demonstrates the species' late-summer peak for workers, a May peak for new queens, and an August/September peak for males (Figure 9). However, caution needs to be taken when deriving trends from the current BeeWalk data due to the small number of transects, low densities being recorded and high variation.

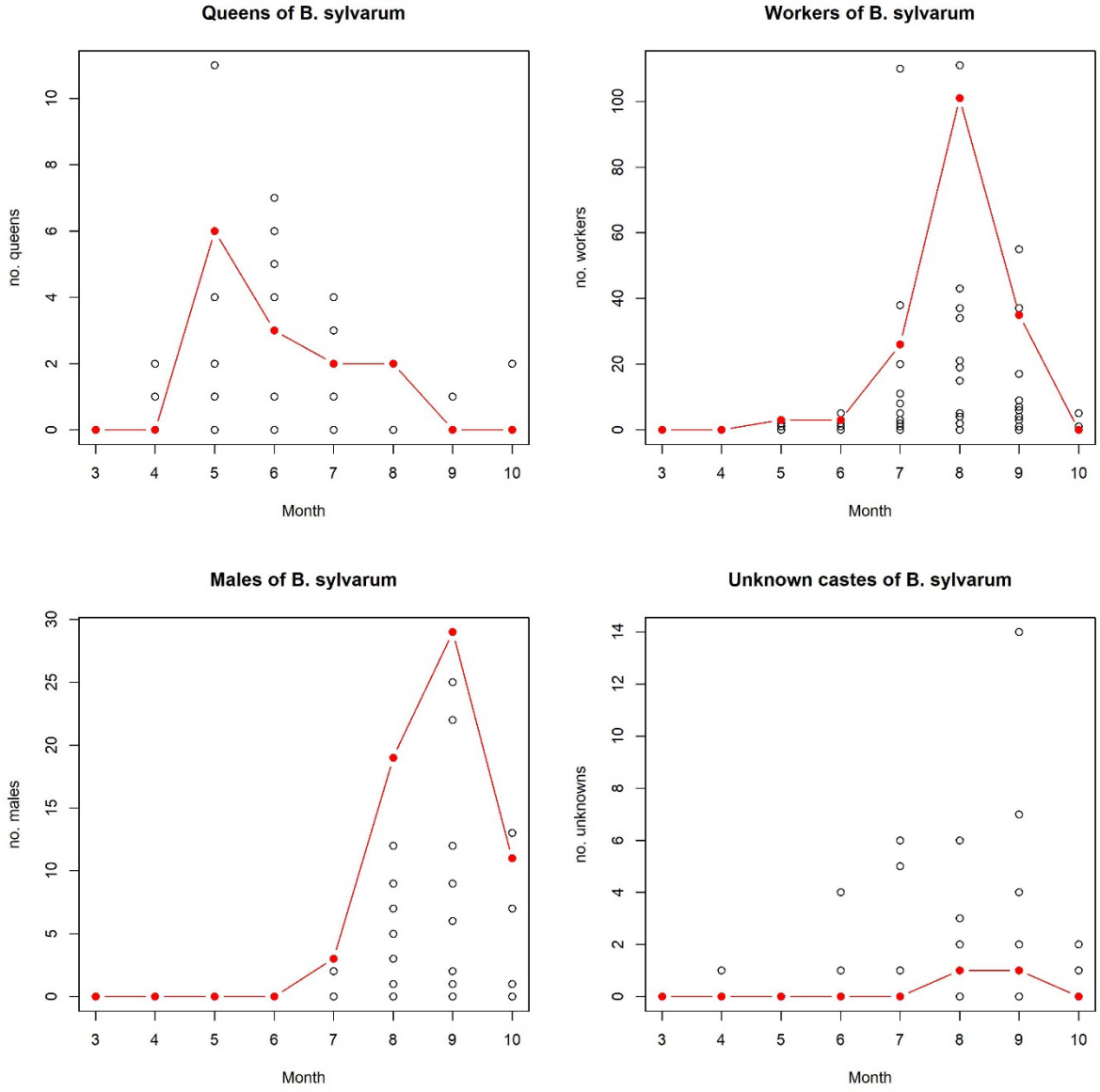

Figure 9: Number of *Bombus sylvarum* queens, workers, males and unknown castes, across months of the year, between 2008 and 2023.

It may be appropriate to combine BeeWalk transects with additional surveying. New methodology for this has been developed and is being tested, which includes targeted surveys of favoured forage plants, nest searches, annual blitzes on selected sites, and timed counts. Timed count data was gathered during 2023 across the five population areas, and plans are to continue to test this method in 2024. This involves surveying a patch of forage plants in a $2m^2$ quadrat for 10 minutes and recording all bumblebee species foraging inside the patch as a way of measuring abundance.

Species ecology

Phenology

Bombus sylvarum is one of the last species of bumblebee to emerge from hibernation in the UK (BWG, 1998), with new colonies being established by a single queen usually in late May (although anecdotally this appears to be becoming earlier, with regular first sightings in April). Workers can be seen from June to September and sometimes October, and males

and daughter queens appear from late August. Overwintering for queens begins in late September/October.

Phenology varies across the range in the UK, with slightly later emergence and nest establishment in western populations, e.g. queens emerging in late May or June in Pembrokeshire. Emergence times also vary annually, for example *B. sylvarum* was recorded in Essex on 30th March in 2024. In Somerset it was recorded on 11th April in 2017. Following this, no workers were recorded after late August (Somerset Shrill Carder Group pers. comm., 2017). Similarly, in years when the species emerges later, colonies seem to be "late" to finish as well, with workers active well into mid-September (Matt Smith pers comm, Gwent Levels) and early-mid October (Sam Page pers. obs. North Kent). Generally, compared to most other bumblebee species, *B. sylvarum* is a 'late-peaking' bumblebee species, similar to *B. humilis.*

Colony size

Colonies are small compared to other bumblebee species with on average 40 – 70 workers (Sladen, 1912). Other references confirm there are usually less than 100 workers per nest (F. Smith, 1868; Hasselrot,1962; Alford, 1975) (In: Philp & Edwards 2001).

Forage

Bombus sylvarum is a longer tongued species. Queen tongue length is 10.6mm and workers are 8.8mm on average. *Bombus sylvarum* appears to have **wide dietary breadth (see below) but with a narrow dietary breadth at a given time of year**, and depending on the forage available on a particular site - which can be limited by issues such as meadow cutting (reducing late forage) and invasive species (e.g. Thames Estuary, Goats-rue invasion). A forage table is in Appendix 2.

There are differing accounts of *B.* sylvarum dietary breadth. Goulson and Hanley (2005) suggest that *B. sylvarum* has a broad dietary breadth, while Connop (2007) indicated that of all of the bumblebee species observed, *B. sylvarum* had the lowest dietary breadth. This statement was reiterated by Connop *et al.* (2010b) stating that *B. sylvarum* has a relatively narrow dietary breadth when compared to *B. humilis* and *B. pascuorum*. In this study in South Essex, over half of the pollen collected (from 30 samples from *B. sylvarum* workers) was from Red bartsia, *Odontites vernus*. Narrow-leaved Bird's-foot trefoil *Lotus tenuis* was the second most commonly collected pollen, making up over a quarter of the pollen collected. In the Gwent Levels, Smith (2013) found workers visiting 25 species of plant, and collecting pollen from seven of these, and males were recorded on 16 plant species (Smith, 2013).
Across the literature and from ad hoc bumblebee records, there are 96 different plant species across 22 plant families upon which *B. sylvarum* has been observed (Appendix 2).

Dietary breadth and preference should vary across the global range as a function of the interaction of foraging profitability of different plants in different climates (Williams, 1985, 2005; Williams et al 2007). Dietary breadth should take account of the number of flower-visit observations and dietary preference may be understood as not just which plants are visited most, but more interestingly, which plants are visited more frequently than would be expected given their different abundances (Williams 1989, 2005).

Bumblebees are known to show food-plant preferences, including as a response to changing relative profitability among forage options. However, these preferences may not necessarily be related to or solely responsible for bumblebee population declines (Williams, 2005).

As with many other species of bumblebee, the Fabaceae is a particularly important family (ACG report, 2004) (Table 1). Globally, in urban areas, *B. sylvarum* is associated with **Asteraceae** and **Fabaceae**, and visited native species 51% of the time (Sikora et al., 2020). Fabaceae and **Lamiaceae** are the most frequently visited plant families in Connop (2007). The **Scrophulariaceae** (which included Red bartsia at the time of this study, since transferred to Orobanchacaea family) and Asteraceae families were also found to be important in the Aculeate Conservation Group pollen load analysis (ACG report, 2004) (Table 1).

Table 1:Pollen analysis by plant family for *Bombus sylvarum* (n=153) using amalgamated data for the analysis of pollen loads carried by bumblebees from 1998-2004. (ACG report, 2004)

Fabaceae %	Scrophulariaceae %	Asteraceae %	Lamiaceae %	Boraginaceae %
62.7 (96)	30.7 (47)	15.0 (23)	10.5 (16)	5.2 (8)

Smith (2010) found *B. sylvarum* workers to display similar preference in Wales with 60% of individuals recorded foraging on Fabaceae (including Narrow-leaved Everlasting pea, Tufted vetch and Common Bird's-foot trefoil), a further 17% were found on Knapweed (Asteraceae).

In south Essex, Connop (2007) presented forage preference in relation to other *Bombus* species foraging rather than in relation to total available flora, and found that the most frequently visited plants were **Red bartsia** and **Black horehound** (for queens Black horehound and **Broad-leaved Everlasting pea**), whereas Black horehound is uncommon in Wales for example.

Connop (2007) suggests that Red clover may not be a particularly important forage source for *B. sylvarum,* compared to its importance for other bumblebee species, when other sources of forage such as Red bartsia and **Narrow-leaved bird's-foot trefoil** are available; although in 2008 he noted this plant was of importance to queens (Connop 2008). On Salisbury Plain, **Tufted vetch** *Vicia cracca* is an important forage resource (S. Roberts, pers comm). Conversely, during sea wall surveys in Essex over the last 10 years, 27% of *B. sylvarum* records were recorded on **Red clover** (Tim Gardiner, pers comm). Red clover may be a significant source of pollen. In a Swedish study, mass flowering crops of Red clover grown for seed had higher worker *B. sylvarum* abundance than the surrounding landscape, but there was no such relationship for males (Riggi et al, 2021) suggesting its importance for pollen rather than nectar.

Red bartsia (*Odontites vernus*) is a key forage species for *Bombus sylvarum* (BWG, 1998). Harvey (1998) suggests that Red bartsia is the most important forage plant for *B. sylvarum* in south Essex in August (also Jamie Robins, pers comm), and Connop, et al (2010) found the majority of pollen collected by *B.sylvarum* was from Red bartsia. This preference has also been noted in Somerset, particularly at Lytes Cary Manor (Somerset Shrill Carder Group, 2017) and at Kenfig (Stewart and Roberts, 2014). Stewart and Roberts (2014) note that the **average height of foraging for *B. sylvarum* was 21-30cm which coincides with the height of Red bartsia**. Further to this, Harvey (1998) notes that *B. sylvarum* seems to prefer flying at the height of Red bartsia even when there is neighbouring taller vegetation.

A BWG survey by Peter Harvey in 1999 found a large presence of *B. sylvarum* at two sites (Canvey Wick and East Tilbury Silt Lagoons) where the main worker forage was Narrow-leaved Bird's-foot trefoil *Lotus tenuis*, and Red bartsia was absent from both. In the Thames Estuary, Narrow-leaved Bird's-foot trefoil is a key forage plant for Shrill carder bee, especially on sea walls. Similar to Red bartsia, this species also likes disturbed ground. Benton found large numbers of *B. sylvarum* on Narrow-leaved Bird's-foot trefoil in Sept 2007

at Tollesbury Wick in Essex, and 46% *B.sylvarum* were on Narrow-leaved Bird's-foot trefoil during sea wall surveys in Essex (Gardiner, pers comm). Similar results were found during sea walls surveys in North Kent, with 41-57% *B. sylvarum* on Narrow-leaved Bird's-foot trefoil (Page, 2015). At RSPB Cliffe Pools, 152 workers were recorded on Narrow-leaved Bird's-foot trefoil in August during timed transect and forage patch counts, and 35 workers plus 1 male in September (Gomes, 2012); this matches BWG findings at the same site in the late 1990s (S Roberts, pers comm).

Bombus sylvarum, including queens, have been noted foraging on Broad-leaved Everlasting pea *Lathyrus latifolius* at Canvey (S. Falk pers comm; S. Connop pers comm).

On the Hoo Peninsula in Kent, Asteraceae species such as **Bristly oxtongue** and **Hawkweed oxtongue** were found to be frequently used by workers and males in late summer (e.g. 18% on Bristly oxtongue, n=60, S. Page, sea wall surveys 2013-2015; 33 workers and 2 males on Hawkweed oxtongue at RSPB Cliffe Pools, Gomes 2012). *Bombus sylvarum* also regularly visits **Sea Aster** at Canvey (Matt Smith, pers comm) and Coalhouse Fort (Ray Reeves, pers comm, 2023). At Canvey workers have been recorded on Oxtongues and other Asteraceae species including Hawkbits and Catsear, *Hypochaeris radicata*, Creeping thistle, *Cirsium arvense* at Wallasea, and Bristly oxtongue, *Helminthotheca echioides* at Rainham (S. Falk, pers comm). In the Gwent Levels it was noted that ruderal plants were particularly important, especially stands of **Creeping thistle**, *Cirsium arvense* (Pavett, 2004).

Yellow flag iris is important on wetland Welsh sites for queens (Mike Edwards pers comm), also **White deadnettle** and **Comfrey** have been observed to be important for queens on other sites. Queens have been recorded foraging on White dead nettle *Lamium album* at Leysdown, and numerous workers on **Betony** *Stachys officianalis* at Castlemartin Range (Steven Falk, pers comm.).

Across the literature and from ad hoc records, queens have been recorded on the following species: Meadow vetchling, Kidney vetch, Yellow rattle, Zigzag clover, Lesser hawkbit, Devil's bit scabious, Red clover, Betony, Common vetch, Hairy vetch, Broadleaved everlasting pea, Bladder senna, White deadnettle, Red deadnettle, Apple, Comfrey, Dandelion, Goats rue, Black horehound, Autumn hawkbit, Meadow thistle.

Knowledge gaps:
Forage resource relative to needs over time and space needs mapping and monitoring for key sites and simple vegetation assessment defining

Nesting

Thoracobombus, or carder bumblebees, need leaf litter and moss to build the covering of the nest. Generally nests have been found on the surface or just below ground, and are associated with rough long grass that has a litter layer. However, there is still little data and varying descriptions of *B. sylvarum* nest sites, despite many searches. Currently only broad habitat types with a suite of microhabitat features can be used to ensure that nesting habitat is present.

Bombus sylvarum nests in straw bales in agricultural landscapes, found in a study by Lindstrom et al. (2022). A *B. sylvarum* nest that had been dug out by badgers was found

underneath an active ant hill at Rainham marshes in 2022 (Daisy Headley and Cathy Horsley, pers comm.).

Hibernation

Hibernation sites are suggested to be under mosses, in the open (BWG, 1998). The use of rank grassland and old small mammal burrows has also been suggested (Howe and Haycock, 2007).

It is thought that hibernation sites will not be on south-facing sites, especially as it is one of the last species for queen emergence in spring (M. Edwards, pers comm); however an overwintering queen was found in January 2020 on a south-facing bank (R. Earwaker, pers comm). It was in a sparsely vegetated man-made, south-facing, sandy bee bank at Leysdown Coastal Park, Sheppey (grid ref TR04456966), see photos below. The bank consisted of heavy soil topped with a thin layer of sand. The queen may have been quite shallow under the surface as she was disturbed while weeding the bee bank. When unearthed, she instinctively buried herself back into the sandy soil. (R. Earwaker, pers comm).

In the Karstic lakes of Slovenia, the species has been found to overwinter in the drier, higher areas and then forage in the lower wetlands (M. Edwards, pers comm).

Habitat

Bombus sylvarum has been observed predominantly in **open areas, often tall grasslands** (BWG, 1998; Svensson *et al.*, 2000) both **acid and damp, with a scruffy element to them, plus a litter layer and varied forage**. They are associated with a variety of open, flower-rich habitats including but not exclusively, traditionally managed hay meadows and pastures, chalk downland, sand dunes, brownfield sites, field ditches, coastal and floodplain grazing marsh, sea walls and saltmarsh edges. There is a need for nesting habitats to be close to flower-rich areas for forage.

Given the variety of habitats used by this species, there is still a lack of understanding of their relative importance, and the importance of microhabitats in these sites. Key *B. sylvarum* sites do not necessarily represent the most botanically or otherwise ecologically interesting sites, and may be overlooked; e.g. overgrazed horse pastures supporting Red bartsia (e.g. around Kenfig) and 'weedy' brownfield or grassland/sea wall sites. They particularly utilise grassland and wetland sites that are late flowering (M. Edwards pers comm). They are also found in urban areas in continental Europe (Honchar, 2020), including gardens (Felderhoff et al., 2023), and active quarries in Germany (Kettermann et al., 2022).

BeeWalk data analysis shows them to be positively associated with higher proportions of water/wetlands, and associated with transects at a lower elevation, greater number of growing degree days, and a lower total annual precipitation (Whitehorn et al., 2021), and in Poland they are found in wet meadows (Rozej-Pabijan et al., 2020).

Ditches

Smith (2011) noted that on the **Gwent levels** *B. sylvarum* was primarily found near to the ditches and reens which, for the purpose of safety, are fenced off to livestock. The alleviation of grazing pressure and a lack of cutting results in favoured plant species reaching flowering. This suggests, as Smith (2011) states, that should other areas outside of the levels also be managed in a similar fashion and the availability of forage improved, the area would hold more potential for *B. sylvarum* to expand into.

Ruderal habitat

Bombus sylvarum is often associated with ruderal habitats. On the **Somerset Levels**, their persistence may be associated with the long tradition of peat digging, particularly by hand (BWG, 2000; J. Merritt, pers. comms.). The disturbance caused maintains ruderal habitats. This agrees with Pavett (2004) who found workers on primarily ruderal associated species and the BWG 1998 report that states that "they are often associated with early successional habitat of disturbed grassland to scrub". Many of the preferred food plants for *B. sylvarum* are early-succession ruderals or opportunists which benefit from disturbance. In the **Thames Estuary**, disturbance due to sea-wall works resulted in a big upsurge of clovers (Red and Sea) and Narrow-leaved Bird's-foot trefoil and an associated upsurge in *B. sylvarum* for several years during the time of the BWG surveys (Mike Edwards, pers. comm.). Recent population declines in the Somerset Levels and Salisbury Plain may be due to a lack of disturbance, and succession to longer rank grassland (Richard Comont, pers. comm.).

Grassland

In **Essex** during surveys in August, Harvey (1998) noted that the most important habitat features seemed to be "tall very flower-rich herbage, with abundant Red bartsia and evidence of previous abundance of clovers and other species such as *Lotus* together with the vicinity of scrub".

On the Castlemartin peninsula in **Pembrokeshire**, *B. sylvarum* occurs on the extensive flower-rich grasslands of the MOD's Castlemartin Range. More recently however concerns have been raised that a lack of grazing in some areas is resulting in the reduction in quality of grassland habitat, and the dry rank grassland is at greater risk of fire spreading and damaging habitat. Records have been found at industrial sites to the north of Castlemartin range at Valero refinery, on varied habitats of mosaics of scrub, wet grassland, tall dry grassland, bare ground, ruderal, ditches and banks.

Bombus sylvarum worker on Red clover, *Trifolium pratense*. Photo credit: Bex Cartwright

Brownfield sites

Bombus sylvarum are found on brownfield sites, particularly in the **Thames Estuary.** Here, brownfield sites forage usage alters due to invasive plants Goat's Rue and Alexanders. At RSPB Cliffe Pools where *B. sylvarum* is present in good numbers, there is a mosaic of brownfield (early successional habitat) with flower-rich wet grasslands (managed for breeding waders but with rotational or light grazing to allow flowering), scrub and sea wall habitat.

Flower-rich verges

Newport Wetlands reserve in the **Gwent Levels** contains significant stretches of wide flower rich verges around wetland and reedbed habitat across the reserve. The site benefits from very low nutrient soils since it was created on PFA deposits from Uskmouth power station. Reserve staff (NRW), who are very familiar with *B. sylvarum* habitat needs, are clearing sheltered areas to create wet meadows which are cut every other year in October to encourage ruderal and tall grassland habitat.

Agri-environment

Monitoring of Countryside Stewardship field margins by Mike Edwards, has recorded only two farms where a non-*pascuorum* Thoracobombus species (*B. humilis, B. ruderarius*) used such margins. On both farms there were considerable sections of permanent flower-rich grassland, cut only in late summer/autumn. However, Ted Benton has recorded rare carder species foraging in pollen and nectar margins close to sea wall habitat in Essex (e.g. Dengie peninsula) (S. Page, pers comm) and *B. sylvarum* has been recorded foraging on Countryside Sterwardship field margins as well as pollen and nectar strips in Somerset (Henry Lang's farm) (D. Headley, pers. comm.). *Bombus sylvarum* has also been recorded foraging in flower margins in Germany (Kuppler et al., 2023, von Konigslow et al. 2021, von Konigslow et al. 2022)). *Bombus sylvarum* has been recorded in maize fields intercropped with beans, in Germany (Huber et al., 2022).

Mobility – forage and dispersal distances

Connop *et al.* (2010a) suggest that *B. sylvarum* workers have a minimum average forage distance of 231m from the nest, when compared with *B. humilis*. The maximum foraging distance was 2280m, while the majority of workers foraged from the same forage patches or those less than 1km apart. The study found that sisters from the same nest were more likely to be found foraging from the same patch, which suggests that they are more vulnerable to forage loss. Osborne *et al.* (2008) described them as 'door-step' foragers, due to their tendency to fly only a few hundred metres away from the nest. However, forage distance is likely to be locality-specific and vary considerably between different types of sites and populations (Charman et al, 2010). Proximity to the climatic optima may be a factor in foraging behaviour (Williams, 2005), and therefore may explain differences in foraging behaviour between different populations. Based on Greenleaf 2007, which provided a formula to calculate a maximum foraging distance based on body size, these are 6.78km for queens and 2.1km for workers (Stuart Roberts pers comm).

A recent molecular study of the Tree bumblebee *Bombus hypnorum* suggests that short worker foraging distances (103.6m) coupled with high nest densities (which vary greatly from year to year) are associated with its rapid range expansion in the UK (Crowther et al, 2019). The authors state that low foraging distances are not an autoecological characteristic - but rather indicate that workers in the study population are able to forage more profitably at shorter forage distances (but are capable of foraging at much longer distances).

Connop (2007) hypothesises that one potential reason for the *B. sylvarum* population in south Essex being largely coastal could be due to the coast and other large water bodies acting as leading lines for dispersal. Benton suggests that the sea walls in Essex provide an important dispersal corridor for *B. sylvarum* along the coast (Gardiner 2012). However, it may also simply be a reflection of the restriction of the habitat resource in this area (Mike Edwards pers. comm.) and further study is needed.

Barriers such as roads may not be a big issue for this species - a mark recapture study at Roscommon Way (Connop, 2013) showed that individuals will cross over roads, and *Bombus terrestris* have appeared to cross over estuaries (Stuart Connop pers. comm.). *Bombus sylvarum* was one of the species under-represented in road kills on Dungeness

relative to its local abundance (Williams 1985), suggesting either that it is less likely to cross roads or less likely to get killed doing so.

Lepais et al. (2010) stated that 'rare bumblebee species appear unable to regularly disperse over distances greater than 10km'. In 2004, a *B. sylvarum* male was captured in Groombridge near Tunbridge Wells in Kent, 35-40km away from the main (and nearest) north Kent population (Geoff Allen, pers. comm.). The specimen was found on 13th June which is relatively early to see males, so it may have come from a failed nest, although it is difficult to speculate.

Knowledge gaps:
Forage and dispersal distances (and timing).
Effect of barriers – this will support recolonization and creation/restoration methods for new/suitable forage and nesting habitat.

In terms of understanding what an ideal connected landscape for *B. sylvarum* looks like, in some areas this species shows preference for larger sites, although in the Gwent levels it is using a lot of small linear ditch edges but these are in high number and located close together.

It is unlikely that small isolated patches of habitat are beneficial to this species. There is no exact information on dispersal distances for *B. sylvarum* and more research is needed on this species. To be precautionary, ideal distances of 100ms for foraging should be used.

Barriers will also be important in terms of quality of landscapes for this species in reducing and affecting permeability of landscape, particularly in more industrialised areas such as the Thames Estuary. There are pre-existing connectivity tools such as 'Condatis' that could be used to define and explore connection opportunities in landscapes. Using data on habitat size, density, quality, temporal shifts to define ideal conditions based on current understanding; at the same time collecting data to improve data on requirements. 'Connectivity' for this species will need to take account of resources on a micro-habitat scale in order to understand appropriate conservation actions.

Knowledge gaps:
Better habitat requirement data to underpin connectivity analysis

Disease & pathogens

A study found *B. sylvarum* to host Black queen cell virus and Lake Sinai virus, *Crithidia bombi* and *Apicystis bombi* in Slovenia (Ocepek et al., 2021). The aforementioned viruses primarily affect honeybees. *Crithidia bombi*, an intestinal parasite, can reduce survival of hibernating bumblebee queens, and reduce foraging ability, and *A. bombi* have been recognised as a cause of bumblebee decline (see Ocepek et al. 2021). A second study in Northern Italy also found *B. sylvarum* to host Black queen cell virus (Cilia et al., 2022).

The species is not known to host cuckoo bumblebees.

There are a range of parasites, parasitoids and pathogens which affect bumblebees in general. These parasites and diseases are likely to be able to affect the Shrill Carder as well, although their lower densities may reduce their impact compared with commoner bumblebees.

Several diseases affecting, and first described from, honeybees can be found in bumblebees (Durrer & Schmid-Hempe 1994, Genersch et al 2006, Singh et al 2010, Peng et al 2011, Evison et al 2012, Levitt et al 2013, Fürst et al 2014, Graystock et al 2013, Li et al 2014, Ravoet et al 2014, McMahon et al 2015). Pathogenicity to bumblebees for most of these diseases is not yet precisely known, but bumblebees infected with Deformed Wing Virus (DWV) are known to develop deformed wings (Genersch et al 2006) and suffer higher mortality (Fürst et al 2014). Bumblebees have also been found carrying the fungal pathogen *Nosema ceranae*, an emergent disease of honeybees (Paxton 2010, Graystock et al 2013, Fürst et al 2014) and emergent infectious diseases have been implicated in bumblebee declines (Cameron et al 2011, Meeus et al 2011, Fürst et al 2014, Schmid-Hempel et al 2014).

Since B. sylvarum is a late-season bumblebee it may not be very suitable for *Aphomia*, since it seeks out big nests and may therefore prefer species such as *B. terrestris*, *B. hypnorum* or *B. lapidarius* which have big nests late in the season, while *B. sylvarum* nests are still small at that time (A. Gekiere, pers. comm., 2024).

Disease transfer takes place through shedding of disease particles and direct bee-bee contact on shared flowers (Durrer & Schmid-Hempel 1994, McArt et al. 2014, Graystock et al 2015, Manley et al 2015). In DWV, the best-studied of these pathogens, the anthropogenic movement of managed honeybee stocks has been found to be the source of DWV outbreaks in bumblebees (Wilfert et al 2016, Manley et al 2019). Managed honeybees are likely to be linked to the dispersal of many diseases observed in wild bees, therefore it is reasonable to assume that the proximity of managed bees of any species may be detrimental to vulnerable populations of native bees (Fürst et al 2014, Manley et al 2015, McMahon et al 2015, Graystock et al 2016, Mallinger et al 2017).

The use of commercially reared bumblebees also represents a potential risk. These colonies have been found to contain pathogens on arrival (Graystock et al., 2013.; Murray et al., 2013; Trillo et al., 2019), including honeybee-associated parasites which can also infect bumblebees (Graystock et al., 2013), most likely as a result of honeybee pollen being fed to bumblebees during the rearing process (Goulson and Hughes, 2015). As these bees forage in the environment they risk transmitting parasites and diseases via shared flowers (Colla et al., 2006; Meeus et al., 2011; Schmid-Hempel et al., 2014). They can also compete for food resources and, if new queens become established in the wild, for nesting sites (Matsumara et al., 2004; Morales et al., 2013).

Knowledge gaps:
More research is needed on the impact of diseases

Climatic range and climate change

Bombus sylvarum has a west-Palaearctic distribution (Williams, 1998) with a narrower climatic niche in Western Europe then their more common cousin *B. pascuorum* (Williams *et al.,* 2007).

Williams *et al.* (2007) found *B. sylvarum* to be associated with warmer and drier areas of Western Europe, with much of the losses towards the cooler areas (northern Britain). The paper suggests the retreat is due to the species becoming restricted to a climatic optimum, stating: “the areas where they persist in Britain from 2000 onwards are closer climatically to the centres of their pre-decline west-European climatic niches than the areas from which they have been lost” and “it is in areas nearer the edges of their climatic niches where these

species are most vulnerable to decline, although this can be ameliorated locally by high food-resource levels." (Williams et al, 2007).

B. sylvarum used to be found around Carlisle (Figure 1) and has not always been restricted to the Southern England and Wales, and so can be present in parts of the England that are not so warm and dry; this suggests that given sufficient resources (food and nesting habitat), it could occur further north and west.

In Ireland the species is still present in the Karstic areas of the Burren in County Clare, as well as small areas of County Galway, which is wetter and more evenly warm (not hot) than south east England. *Bombus sylvarum* occurs in areas of France, Italy, Turkey, Bulgaria and Iran with warmer climates than Britain (Williams pers. comm.). It is also common in Slovenia, close to the Mediterranean - an area which is decidedly hot, with an early season (Mike Edwards pers comms). The species reaches its northern range extent in Britain and is part of Williams' southern-continental grouping – a warming climate may well help the species (alongside others such as *B. humilis*).

Other impacts of climate warming, particularly increased frequency of extreme weather conditions as a result of climate change (such as intense rainfall and drought periods) may have a negative impact, especially on small isolated populations more vulnerable to stochastic events. Sea level rise and flooding events may be damaging to *B. sylvarum* populations, particularly in the Gwent Levels and Somerset levels. Unseasonably warm spring temperatures may result in emergence of queens from hibernation before sufficient suitable forage is available. UK queen emergence time may become more akin to current continental timings (April [Slovenia], Gradisek et al., 2023), as temperatures increase.

Unlike five other bumblebee species studied, *B. sylvarum* maintained brood temperature at night through short heat cycles, whereby the temperature drops considerably then rises to 28-30C (Gradisek et al., 2023). This heats the brood at intervals rather than constantly, although it should be noted that this is based on the study of only one colony. Too great a temperature rise from climate change could cause heat stress on the colony.

Population genetics and area

There is debate regarding minimum viable population size but, in general, populations of less than 50 nests are expected to quickly become inviable through inbreeding; and even populations of up to 500 will be vulnerable to loss of genetic diversity through drift (Ellis et al, 2006). Ellis et al. (2006) found significant population structuring, indicating isolated populations and thus ideal conditions for inbreeding depression, and one population (Castlemartin) showed signs of having passed through a recent genetic bottleneck. This was backed up by the finding of a diploid male at Castlemartin (Ellis et al, 2006). Diploid male production in bumblebees can be an indicator of severe inbreeding and results in sterile or inviable offspring, significantly reducing colony fitness (Whitehorn et al, 2009). This can lead to increased extinction risk resulting from a 'diploid male extinction vortex' (Zayed and Packer, 2005).

The Bumblebee Working Group estimated bumblebee nesting densities at 1-2 successful reproductive nests per km^2, with some variation between species (BWG 1998) and that individual populations require a minimum of 10-20 km^2 of good matrix habitat to be viable (BWG 1998, 2000). A viable metapopulation structure would presumably require multiple habitat matrices across a much wider landscape.

Space available varies greatly between populations. The population on the Gwent levels found by the Bumblebee Working Group live in an area of ~9 km^2 (although the colonised area is over 27 km long so this seems like an underestimation - Richard Comont, pers.

comm.) whilst those that were found on Salisbury Plain have access to over 600 km^2 of habitat (BWG, 1998). The range of *B. sylvarum* in the areas surrounding Bridgend was estimated to cover 66 km^2 of which just under half (30 km^2) contained suitable foraging habitat (Stewart and Roberts, 2014). Peter Harvey notes that *B. sylvarum* seems to require much larger areas of habitat than *B. humilis* in south Essex (Harvey, 2015). This account is confirmed anecdotally by Stuart Connop based on the ability of *B. humilis* to persist on smaller more fragmented sites towards London whereas *B. sylvarum* does not.

Population viability and understanding conservation success

To enable the long-term conservation of *B. sylvarum* it is important to be able to define when conservation success has been achieved. Currently, there is no clear method for attempting to define or record when a viable population has been achieved. Existing BeeWalks would not provide sufficient information to do this and therefore a combination of other monitoring techniques need to be employed. A combination of spring queen monitoring, evidence of occupancy expansion (via regular monitoring), as well improved understanding of habitat as a proxy and genetic viability of populations could be used to define viability. Monitoring of nest sites would be valuable too but these are difficult to find.

By far the most effective method of establishing population viability is direct monitoring through genetic methods, although this is expensive and can be difficult to implement. Monitoring of abundance, especially if individuals can be identified to caste, can provide a useful adjunct to this, though it should be noted that there is no guarantee that a spring queen equates to a successful colony at the end of summer. It can be generally assumed that a population becomes more viable as it increases in size, so increased population viability can be inferred from evidence of expansion in a population from a baseline of population monitoring, using thorough repeated monitoring coverage to pick up expansions and retractions. A strategic implementation of BeeWalk could help to achieve this.

Analysing genetic viability is also important so that the general health of Shrill carder bee populations can be understood. This would not be as regular as other monitoring but could be used intermittently to complement it. Finally, the integration of habitat monitoring could eventually be used as a proxy, therefore data should be collected at the same time as other monitoring methods, so that an evidence base is built (e.g. creation/presence of certain habitats types and features will increase *B. sylvarum* success).

Conservation and management

Management recommendations for *B. sylvarum* tend to focus on ensuring plentiful flower-rich habitat with suitable forage is available from April to late September/October (e.g. rotational cutting/grazing, leaving uncut strips, ceasing summer grazing, rotational hedge/bank/ditch cutting, restoration or establishment of new wildflower grasslands and/or pollen & nectar margins), in addition to providing nesting habitat (e.g. rough/tussocky grass and scrubby areas left undisturbed March-October, south-facing aspect). The management of brownfield habitats to maintain mosaic habitats (with open flowery areas alongside undisturbed nesting habitat) is also recommended (e.g. rotational vegetation clearance and disturbance).

Mosaic management

This late emerging and ‘late-peaking’ species is susceptible to mid-summer cutting or grazing which restricts forage availability in late summer and early autumn when colonies are at peak numbers and producing reproductives (queens and males). It is possible that the

species is also victim of ‘pollinator conservation’ headlines and the perception that flowers shouldn’t be cut when pollinators are foraging (S. Connop, pers comm), leading to ‘no cut’ policies or a single late cut in autumn. However, a **mosaic of cutting times** from May through to September/October may be more beneficial for *B. sylvarum* to ensure continuity of forage rather than late cutting alone. For example, cutting grassland areas in May will help to encourage flowering later in the summer. Experiments at Hadleigh Park in south Essex showed that a mosaic May cut on some parts of the meadows can be very beneficial in extending the flowering season and providing late forage (Connop 2017). This type of management may also be useful for mitigating against early flowering and seed set (in relation to warming climate) by cutting to stimulate re-flowering.

Disturbance

In south Essex, Harvey (2002) notes that Narrow-leaved Bird’s-foot trefoil *Lotus tenuis* - a key forage plant for *B.sylvarum* - appears to favour seasonally-wet conditions, but can cope with reasonably dry summers with water available below the ground surface. In grasslands without disturbance the plant seems to survive for a number of years until it is out-competed by grasses and other vegetation. Harvey (2003) also notes that the very long flowering season of Narrow-leaved Bird’s-foot trefoil together with topographical and hydrological gradients across a site enables the vegetation to respond to different annual weather conditions to provide extended availability of forage.

Seeding and plug trials on trial plots at Canvey Wick demonstrated that Narrow-leaved Bird’s-foot trefoil can be re-established by seeding but by far the most extensive *L. tenuis* areas present in 2003 were adjacent to these trial plots, where vehicular disturbance had opened up previously closed species poor grassland (Harvey, 2012). There could therefore be real gains to be made on the site by deliberately disturbing certain areas of species poor grassland to expose the underlying sandy substrate, allowing the development of a flower rich vegetation with areas of Narrow-leaved Bird’s-foot trefoil. The use of disturbance to deliberately produce variation in topography and hydrology could also help ensure that Narrow-leaved Bird’s-foot trefoil areas are in flower over different parts of the season. It should be noted that site suitability for management through ground disturbance needs to be carefully considered.

Plots cut in summer with winter disturbance (cut and rut) in unmanaged grassland on sea walls significantly increased bumblebee forage plant species richness; *B. sylvarum* was seen exclusively on Red clover *Trifolium pratense* (Gardiner and Fargeaud, 2020). Queen *B. sylvarum* were seen foraging on these plots four years after management was initiated (Gardiner and Fargeaud, 2020). Diversity in sward structure created by rotational management may provide nesting habitat (Gardiner and Fargeaud, 2020).

Hadleigh Park invertebrate conservation analyses

Results from a three year study of the south Essex populations of *B. humilis* and *B. sylvarum* (Connop, 2007), and a study on foraging behaviour and dietary breadth (Connop et al., 2010) were fed into an experimental programme of forage creation at Hadleigh Park. The site, which runs between South Benfleet and Hadleigh in south Essex, was selected due to its suitability for a bumblebee habitat improvement program. The site has received Higher Level Stewardship funding for management of habitat. Monitoring has demonstrated that habitat interventions have increased the area of suitable forage and nesting habitat. The study concludes that soil inversion plus green haying and the subsequent late hay cut proved to be an effective and rapid method of habitat creation created suitable forage areas for *B. sylvarum* and *B. humilis*. The study also found that a combination of an early (May) hay cut on some established forage areas, along with the later hay cuts on other areas, was an effective method of creating a mosaic of forage during the peak foraging season and for

creating more abundant forage in late summer. Continued monitoring to determine the long-term success of this project is recommended.

Sea wall management

Small scale studies have been carried out to compare Environment Agency cutting regimes and timings on sea wall flood defences in the Thames Estuary. Gardiner and Vetori (2015) found that species richness and abundance of bumblebees on one-cut sea wall in mid-late September (20 *B. sylvarum* recorded) were higher than two-cut plots which were cut in June and August (0 *B. sylvarum* recorded); these two-cut sections also had correspondingly lower forage plant species richness. Sea wall monitoring surveys on the Hoo Peninsula in north Kent found that abundance of *B.sylvarum* was higher in sections receiving two cuts where an early (spring) and late (autumn) cut was being carried out, compared to sections with summer sea wall cutting (Page, 2015).

A Managing Sea Walls for Rare and Scarce Bumblebees factsheet has been produced by the Trust.

Knowledge gaps:
Robust research is needed on the impact of targeted management, including for queens (e.g. White deadnettle planting) and population level monitoring

Projects

There are a range of conservation projects benefitting *B. sylvarum,* and there is management for the species through the agri-environment schemes in England and Wales, as well as individual landowner management activities, including on several nature reserves.

Save our Shrills: Somerset (Bumblebee Conservation Trust, the Trust) – Five year landscape scale project (2023-2028) connecting known sites through habitat creation and restoration, and monitoring and recording

Natur am Byth (the Trust) – focusing on three population areas in Wales, working to protect threatened species of which *B. sylvarum* is one. (Years)

Buzzing in the East End (the Trust) – one year development phase (2024) working with communities, especially diverse and under-represented groups to determine where rare and threatened bumblebees are, and assess habitat quality; leading to a five year project.

Connecting the Carmarthenshire Coast (the Trust) – a possible priority area for *B. sylvarum*, the project aims to improve habitat across protected sites, and increasing knowledge of target species (2023 – 2025)

Hymettus has worked closely with farmers, local authorities, policy makers and land managers on *B. sylvarum*.

Back from the Brink 'Shrill carder bee recovery project' (the Trust & Buglife) – Part of the wider Natural England and Rethink Nature-led 'Back from the Brink' partnership in England. Focus on Somerset and the Thames Estuary. Activities include: surveys and monitoring (via BeeWalk), landowner advisory work, development of a species action plan to inform future targeted conservation. The Shrill carder bee Back from the Brink project ended in March 2020.

Making a Buzz for the Coast (the Trust) – landscape-scale project focussing on the Kent coast from Dartford to Deal. Multiple elements including: habitat restoration & creation for priority bumblebee species including *Bombus sylvarum* (with partners including RSPB, Kent Wildlife Trust, Thames Water, Thanet district council), landowner advice, bumblebee identification training and promotion of recording (BeeWalk, iRecord), and public engagement/awareness raising. The project ended in 2021.

Bee Wild West Wales (BBCT) – Focus on recording and monitoring across west Wales, including areas supporting *B. sylvarum.* Surveys have taken place at target sites in south Pembrokeshire. Targeted conservation work parties and land management advice at Castlemartin Range, and Valero refinery/Greenhill farm to north of Castlemartin range. Project ended in December 2018.

Short-haired bumblebee reintroduction project (BBCT, Natural England, RSPB (and formerly Hymettus)) – although focused on another species, the activity to increase flower rich diversity within the Romney Marsh and Dungeness area which spans from Hythe, Kent to the High Weald in East Sussex and north to Ashford, has resulted in benefits for lots of other rare bumblebees and provides important learning for other conservation initiatives.

Living Levels: Pollinating the Levels (BBCT, Buglife, RSPB) – NLHF funded landscape project across Gwent Levels led by RSPB (Living Levels), BBCT and Buglife are jointly delivering Pollinating the Levels. Includes targeted habitat management, restoration and creation for *B. sylvarum,* as well as monitoring and bumblebee identification training. Three year delivery phase to Dec 2020.

Important Invertebrate Areas (IIA) (Buglife) - identified the broad-scale IIA network ahead of fine-scale mapping in 2018/19. However, IIAs do not account for aculeates (and any other invertebrates) not treated by recent status reviews, as a result there are significant invertebrate areas missing in Wales (and elsewhere), including the Gwent Levels and the north Castlemartin peninsula.

B-lines (Buglife) – mapped outline of an IIA / a B-lines network for the Thames Estuary and parts of south Wales.

Planning work (Buglife) – site protection through engaging with planning applications to protect the best sites and/or improve mitigation outcomes.

Essex sea wall management (EA, Tim Gardiner) **–** e.g. Canvey Wick, Dengie, Goldhanger, Paglesham – rotational cutting / sea wall annual cut mid-Sept & rotational on berm.
Sites with active management for Shrill carder bee, including Lytes Cary National Trust, RSPB Thames Estuary reserves, Wildlife Trusts reserves, Natural Resources Wales reserves, MOD Pembrokeshire, Valero (Pembs), Landfill restoration Thurrock Cory.
Management through agri-environment payments – in England, there are some NGO managed sites that are receiving agri-environment payments of *B. sylvarum* habitat in North Kent and the Thames Estuary, and a private farm BBCT is working with in Somerset is actively managing for *B.sylvarum* under a Countryside Stewardship agreement*;* in Wales, *Bombus sylvarum* is a target species under Glastir but take up through the scheme is unknown.

Resources

Hymettus produced a factsheet on bumblebees (including *B. sylvarum*) as part of the '*Aculeate Information Sheets: How the habitat requirements of BAP aculeates relate to their HAP'* series. http://hymettus.org.uk/downloads/Grassland_Bumblebee_info_sheet.pdf

BBCT has produced a Shrill carder bee factsheet, as well as an 'ID card' (pocket sized laminated card for use as identification reference and directing people to submit photographic records on iRecord). These are also available in Welsh.
https://www.bumblebeeconservation.org/wp-content/uploads/2017/08/BBCT037-Shrill-Carder-bee-Leaflet-02.17.pdf

Buglife has produced a Species Management factsheet for Shrill carder bee and Brown-banded bee, and a factsheet on 'Managing brownfields for scarce bumblebees'.
https://www.buglife.org.uk/sites/default/files/Shrill%20and%20Brown-banded%20carder%20bee%20species%20management%20sheet.pdf
https://www.buglife.org.uk/sites/default/files/Species-Management-Shrill-carder-bee-and-Brown-banded-carder-bee-OCT-2018.pdf
https://www.buglife.org.uk/sites/default/files/Managing%20brownfields%20for%20scarce%20bumblebees_0.pdf

There are factsheets on Managing sea walls for rare and scarce bumblebees and a range of factsheets on Sourcing wildflower seeds for Shrill carder bees in different habitats.

Community engagement

As part of the Species Champions project, which pairs at-risk species with elected politicians, there are currently two Shrill carder bee species champions: In Wales, Delyth Jewell AM for South Wales East (Plaid) and in England, Thangham Debbonaire MP for Bristol West.

Threat analysis

As with many other bumblebee species in the UK, habitat loss and fragmentation is a key threat for *B. sylvarum,* in particular loss of flower-rich habitat mosaics which provide the life cycle requirements (for foraging, nesting and hibernation). Threats will vary with spatial scale and temporally, meaning each key site and population will have different key threat attributes. Small, isolated populations and the loss of genetic diversity are other key threat factors.

Drivers for loss include:

- Inappropriate management (e.g. badly timed cutting, over-grazing, use of fertiliser)
- Lack of management, resulting in degradation or loss of habitats, grass dominance, scrub encroachment, invasive species.
- Development (housing, industry, roads) – major threat in heavily populated and industrial areas such as the Thames Estuary (e.g. Tilbury expansion), and parts of south Wales (e.g. M4 relief road, Gwent Levels solar farm).
- General land use change – e.g. agricultural intensification, pesticide use, managed realignments

A complexity of threats are likely to be acting on the species in the UK, from habitat change; climatic changes (e.g. possible phenological shifts impacting foraging, drought, flooding); pesticides, pathogens, and possible competition with imported bumble bees/ honey bees. The majority of threats may coalesce around their impacts on colony size, number and viability.

Two threat factors are particularly worth noting for this species: isolation through the increasing fragmentation of habitats is leading to the isolation of populations leaving them vulnerable to the effects of inbreeding as well as single catastrophic events such as flooding and extreme weather events. Also, the loss of genetic diversity (one consequence being the

development of sterile, diploid males) could well be exacerbating the threats to the species; a better understanding of genetics is a key knowledge gap in informing appropriate conservation interventions.

The drivers behind the decline and possible disappearance of the Salisbury Plain *B.sylvarum* population are unclear. The Salisbury Plain Training Area (SPTA) consists of huge expanses of flower-rich grasslands which support high insect diversity and many nationally scarce species, including *Bombus humilis* (which appears to have similar habitat requirements to *B.sylvarum*) and several other rare bumblebee species. It is suggested that something must be preventing the specific habitat niches required for *Bombus sylvarum* - do sufficient plants of the right kind flower within the habitat mosaic at the right time? Is there sufficient litter development to provide the right nesting habitat? (S. Roberts, pers comm) - but isolation, small population size and (lack of) genetic diversity could also be factors.

To define a national threat analysis, an initial exercise was undertaken in June 2019 involving members of staff from BBCT, Buglife and Natural England, and facilitated by the IUCN. This workshop analysed and defined threats for the species, exploring drivers and linkages; this resulted in a causal flow diagram of the species threats. See Figure 5 below.

After the national threat mapping exercise, the workshop looked in more detail at threats within key Shrill carder bee population areas, ranking the degree of threat level and assigning directional change (see Table 2 below). To develop further understanding around wider system changes that could impact threats at each of the metapopulations, the workshop participants also undertook a PESTLE analysis. This analysis considers the Political, Economic, Social, Technological, Legal and Environmental factors they were aware of that could impact each metapopulation, positively or negatively (see Tables 3-9 below).

It should be noted that the following diagrams and tables provide an initial threat analysis to generate further thought and discussion, and are not comprehensive.

Knowledge gaps:
Deepening our understanding of threats to *Bombus sylvarum*
Acquiring new knowledge on the extent of loss of genetic diversity across the population
Preferred nesting/ hibernating habitat
Understanding the extent to which habitat fragmentation is impacting the population (a gap which could be partly filled through genetic studies)
Impacts of inappropriate land management, pathogens, imported honeybees and/or bumblebees
Loss of foraging habitat at colony level
Competition for forage/nest sites.

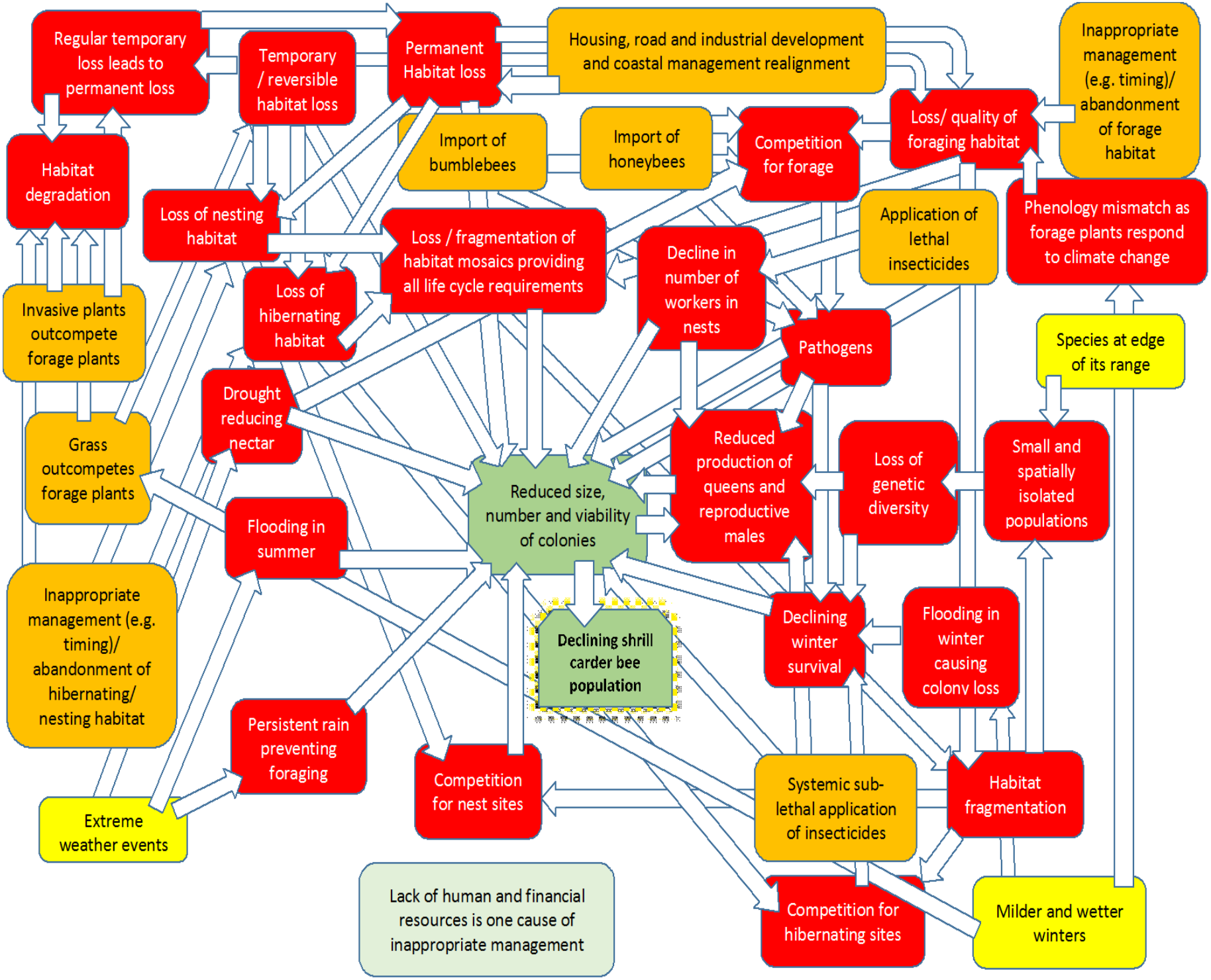
Regular temporary loss leads to permanent loss
Temporary / reversible habitat loss
Permanent Habitat loss
Housing, road and industrial development and coastal management realignment
Inappropriate management (e.g. timing)/ abandonment of forage habitat
Habitat degradation
Import of bumblebees
Import of honeybees
Competition for forage
Loss/ quality of foraging habitat
Loss of nesting habitat
Loss / fragmentation of habitat mosaics providing all life cycle requirements
Application of lethal insecticides
Phenology mismatch as forage plants respond to climate change
Invasive plants outcompete forage plants
Loss of hibernating habitat
Decline in number of workers in nests
Pathogens
Species at edge of its range
Drought reducing nectar
Grass outcompetes forage plants
Reduced production of queens and reproductive males
Loss of genetic diversity
Small and spatially isolated populations
Flooding in summer
Reduced size, number and viability of colonies
Inappropriate management (e.g. timing)/ abandonment of hibernating/ nesting habitat
Declining shrill carder bee population
Declining winter survival
Flooding in winter causing colony loss
Persistent rain preventing foraging
Competition for nest sites
Systemic sub-lethal application of insecticides
Habitat fragmentation
Extreme weather events
Lack of human and financial resources is one cause of inappropriate management
Competition for hibernating sites
Milder and wetter winters

Table 2: Threat ranking for the six key population areas, highlighting the perceived degree of threat on a scale of 0-5 (0=no threat; 5=extreme threat), and presumed directional change over the next 5-10 years. Boxes are colour-coded, green signifying low threat scores (0-1), orange medium threat scores (2-3), and red high threat scores (4-5). Question marks highlight areas of high uncertainty.

Population areas / Direct threats	Salisbury Plain	Thames Estuary	Somerset	Gwent Levels	Kenfig	Pembroke-shire	'National' threat categories (average score)
Inappropriate forage management	2 →	5→	5↑	2-4	4-5 ↑	4-5 ↑?	4
Inappropriate nesting and hibernating sites management	4-5 →	3-5 →?	3-5 →?	3 ↑	3 ↑	3-4 ↑?	3.6
Industrial development (incl. wind farms)	0 →	5↑↑	1→	3 →	3-4 →	1 →	2.2
Housing development	1 →	5↑	1↑?	1-2 →	4 →	0 →	2.1
Road development	0 →	5↑	1↑↑	2-4 ↓	2 →	0 →	1.8
Coastal realignment	0 →	2↑	0→	0 →	0 →?	0 →	0.3
Herbicide usage	0? →	3 ?	3-4?	3 →	1 →	2 →	2.1
Insecticide usage	0? →	4-5?	4-5?	4 →/ ↑	0 →	2 →	2.5
Disease/ pathogens/ competition from imported bumblebees	1 ↑?	3↑	2↑?	1 →	0-1 →	0-1 →	1.3
Disease/ pathogens/ competition from imported honeybees	2 →?	3-4↑?	3↑?	1-3 →	1-3 →	1-3 →	2.4
Extreme weather events	3-4 ↑	4↑	3-4↑	4-5 ↑	4 ↑	3 ↑	3.8
Mild, wet winters	2-3 ↑	3-4↑	3-4↑	2-3 ↑	2 ↑	3 ↑	2.8
Invasive plants	1 →	4-5↑	1-2↑	3 ↑	3 ↑	1 →	2.4

PESTLE analysis

In addition to developing a prioritized threats table at the local and national level, a PESTLE analysis was undertaken to begin to identify some of the Political, Economic, Social,

Technological, Legal and Environmental risks and opportunities faced (**Tables 3-9 below**). Whilst this should be considered an initial rather than comprehensive analysis, it did begin to provide additional information as to how the threats might change in the foreseeable future given these wider considerations.

Table 3. National populations- combined threat analysis and PESTLE analysis Key: Text in red refers to potential negative factors. Text in blue refers to potential positive factors.

Key Sites/ Direct threats	Extract from threats table	Political factors	Economic factors	Social factors	Technological factors	Legal factors	Environmental factors
Inappropriate forage management	4	AES post-Brexit emphasis on public good, sustainable agriculture Access to funding and staff resource for local councils - habitat management e.g. verges	Current push for pollinators means potential for more funded work due to public interest.	Pressure for 'tidy' green space	Better understanding of species genetics. Better disease screening with DNA barcoding. Precision agriculture Possible development of drones to track bees & nests (address knowledge gaps). BeeSteward modelling (e.g. impact of habitat interventions - currently being tested) but *B.sylvarum* autecology knowledge gaps = limitations of model	?	Risk of weakening legislation, including environmental standards, planning/EIA, pesticide regulations, etc. Wales Environment Act, Well-being & Future Generations Act promotes more positive use and engagement with nature.
Inappropriate nesting and hibernating sites management	3.6						
Industrial development (incl. wind farms)	2.2						
Housing development	2.1						
Road development	1.8						
Coastal realignment	0.3						
Herbicide usage	2.1						
Insecticide usage	2.5						
Disease/ pathogens/ competition from imported bumblebees	1.3						
Disease/ pathogens/ competition from imported honeybees	2.4						
Extreme weather events	3.8						
Mild, wet winters	2.8						
Invasive plants	2.3						

Table 4: Thames Estuary- combined threat analysis and PESTLE analysis. Text in red refers to potential negative factors. Text in blue refers to potential positive factors.

Key Sites/ Direct threats	Extract from threats table	Political factors	Economic factors	Social factors	Technological factors	Legal factors	Environmental factors
Inappropriate forage management	5→	Potential for bigger Brexit impact as closer to the continent. Environmental concerns may be less important there. Procedures linked to sea wall development have increased suitable habitat for *B.sylvarum*. National Park City status and Greater London Authority is big driver for Green Infrastructure and Nature-based Solutions. Biodiversity Net-Gain in housing developments.	More money for nature reserves due to location and # of visitors. High pressure on land for housing and industrial development. High redevelopment value of land means great potential for funding biodiversity net-gain and offsetting schemes Are there more financial opportunities, projects, etc. in Thames Estuary?	Risk of arson, anti-social behaviour etc. diverting resource and funds from conservation objectives. Removal of anti-social activities which can be providing the random disturbance needed to retain a site's value. Pressure for 'tidy' green space.	Precision farming, including targeted use of pesticides, etc.	?	Warmer and drier so risk of drought and associated risks (less nectar, fire). Will wetter winters lead to less drought stress and less flowery landscape? Is there a risk of mismatch between phenology of bee and flowering species? Is the area more susceptible due to microclimate? Invasive plants (e.g. Goat's rue, Alexanders, Sea buckthorn, Buddleia) threatening key sites and wider landscape
Inappropriate nesting and hibernating sites management	3-5 →?						
Industrial development (incl. wind farms)	5↑↑						
Housing development	5↑						
Road development	5↑						
Coastal realignment	2↑						
Herbicide usage	3?						
Insecticide usage	4-5?						
Disease/ pathogens / competition from imported bumblebees	3↑						
Disease/ pathogens / competition from imported honeybees	3-4↑?						
Extreme weather events	4↑						

Mild, wet winters	3-4↑						
Invasive plants	4-5↑						

Table 5: Salisbury Plain - combined threat analysis and PESTLE analysis. Text in red refers to potential negative factors. Text in blue refers to potential positive factors.

Key Sites/ Direct threats	Extract from threats table	Political factors	Economic factors	Social factors	Technological factors	Legal factors	Environmental factors
Inappropriate forage management	2 →	Current changes in MOD use of the land may be reducing disturbance, which could be an issue Increased activity on SPTA since reduction in availability of large training areas in Germany. Limited control over tenant farmers / graziers? Potential impact of MOD land if sold (low risk)	Changes in farming practice of the graziers on SPTA (West and East) are a threat (e.g. changes from silage cropping to grazing, stocking densities/ ha, areas grazed, length of grazing periods). These are economic factors as the importance of cattle in the rural economy fluctuates. (Stuart Roberts, pers. Comm.)	Complexity of gaining access to the area as MOD land makes monitoring / action problematic. Possibility of housing development on the periphery of the plains?	?	?	Drought reducing forage, chance of fires from lightning strikes. Lower risk of warmer mild winters impacting as chalk so porous? Not enough known in terms of potential impact of milder winters on fungal diseases, etc. Flooding wouldn't be an issue here
Inappropriate nesting and hibernating sites management	4-5 →						
Industrial development (incl. wind farms)	0 →						
Housing development	1 →						
Road development	0 →						
Coastal realignment	0 →						
Herbicide usage	0? →						
Insecticide usage	0? →						
Disease/ pathogens / competition from imported bumblebees	1 ↑?						
Disease/ pathogens / competition from imported honeybees	2 →						

Extreme weather events	3-4 ↑						
Mild, wet winters	2-3 ↑						
Invasive plants	1 →						

Table 6: Somerset- combined threat analysis and PESTLE analysis. Text in red refers to potential negative factors. Text in blue refers to potential positive factors.

Key Sites/ Direct threats	**Extract from threats table**	**Political factors**	**Economic factors**	**Social factors**	**Technological factors**	**Legal factors**	**Environmental factors**
Inappropriate forage management	5↑	Pollinator strategy acting as an opportunity Would new agri-environment schemes be positive or negative without being bound to EU regulations?	Possible conversion of current A303 into a carriageway	Range and number of landowners makes coordination of land management and access to the land problematic.	Precision farming, including targeted use of pesticides, etc.	?	Strong overlap with warmer, milder winters for flooding, as both catastrophic and long-term trends are an issue. Flooding potential to be very significant and could worsen in future. Is *B.sylvarum* already in sub-optimal areas due to flooding?
Inappropriate nesting and hibernating sites management	3-5 → ?						
Industrial development (incl. wind farms)	1→						
Housing development	1↑?						
Road development	1↑↑						
Coastal realignment	0→						
Herbicide usage	3-4?						
Insecticide usage	4-5?						
Disease/ pathogens / competition from imported bumblebees	2↑?						
Disease/ pathogens / competition from	3↑?						

imported honeybees							
Extreme weather events	3-4↑						
Mild, wet winters	3-4↑						
Invasive plants	1-2↑						

Table 7: Gwent Levels- combined threat analysis and PESTLE analysis. Text in red refers to potential negative factors. Text in blue refers to potential positive factors.

Key Sites/ Direct threats	**Extract from threats table**	**Political factors**	**Economic factors**	**Social factors**	**Technological factors**	**Legal factors**	**Environmental factors**
Inappropriate forage management	2-4	M4 cancellation (but road development threat remains) *B.sylvarum* now on all 8 Gwent Levels SSSIs as qualifying feature Pollinator action plan in development (also Monmouthshire) Newport council/Cardiff council owned land / WG opportunity for habitat Ongoing pressure for infrastructure development Likely intensification of	Allocated land for development, ABP, Tata steel unclear what's going to happen Big potential threat from industrial development as small population, relies on larger proportion of brownfield habitat. Use of pesticides as oil seed rape area. Also use of pesticides for 'spot on' treating cattle	Some housing allocations but mostly outside main areas More people moving to Newport since bridge toll, influx of people	?	?	? No known coastal realignment plans ? AES / farming changes (Brexit influence) - unknown impact
Inappropriate nesting and hibernating sites management	3 ↑						
Industrial development (incl. wind farms)	3 →						
Housing development	1-2 →						
Road development	2-4 ↓						
Coastal realignment	0 →						
Herbicide usage	3 →						
Insecticide usage	4 →/↑						
Disease/ pathogens / competition from imported bumblebees	1 →						
Disease/ pathogens	1-3 →						

/ competition from imported honeybees		agriculture post-Brexit					
Extreme weather events	4-5 ↑						
Mild, wet winters	2-3 ↑						
Invasive plants	3 ↑						

Table 8: Kenfig-Port Talbot - combined threat analysis and PESTLE analysis. Text in red refers to potential negative factors. Text in blue refers to potential positive factors.

Key Sites/ Direct threats	**Extract from threats table**	**Political factors**	**Economic factors**	**Social factors**	**Technological factors**	**Legal factors**	**Environmental factors**
Inappropriate forage management	4-5 ↑	Bridgend council handing over Kenfig NNR management but not yet agreed to whom. Influence/ pressure from Friends of group (against grazing).	Lack of funding to manage Kenfig NNR & SSSI and not targeted for SCB Tata steel closure - key brownfield site? Potential improvement area / development	Pressure for housing development at Port Talbot. Friends of group Kenfig Pressure to manage Kenfig for orchids (may conflict with *B.sylvarum*) Dog walking (impacts on management)	?	?	No known coastal realignment plans
Inappropriate nesting and hibernating sites management	3 ↑						
Industrial development (incl. wind farms)	3-4 →						
Housing development	4 →						
Road development	2 →						
Coastal realignment	0 →?						
Herbicide usage	1 →						
Insecticide usage	0 →						
Disease/ pathogens / competition from	0-1 →						

imported bumblebees							
Disease/ pathogens / competition from imported honeybees	1-3 →						
Extreme weather events	4 ↑						
Mild, wet winters	2 ↑						
Invasive plants	3 ↑						

Table 9: Pembrokeshire - combined threat analysis and PESTLE analysis. Text in red refers to potential negative factors. Text in blue refers to potential positive factors.

Key Sites/ Direct threats	**Extract from threats table**	**Political factors**	**Economic factors**	**Social factors**	**Technological factors**	**Legal factors**	**Environmental factors**
Inappropriate forage management	4-5 ↑	MOD land - key landowner. This could make the site vulnerable to complete change, e.g. should government decide to cut budgets to MOD. Land use - changed/less grazing = less forage (Landmarc graziers)	Some intensive land management north of ranges for dairy farming Bee-keeping area- possible risk of disease? Valero & RWE brownfield - large landowners / development or could revert to arable = volatile industry	?	?	?	MOD - impact of blasts - could be positive = disturbance MOD grass fires - related to lack of management = increased risk of fires, increases grass coverage
Inappropriate nesting and hibernating sites management	3-4 ↑						
Industrial development (incl. wind farms)	1 →						
Housing development	0 →						
Road development	0 →						
Coastal realignment	0 →						
Herbicide usage	2 →						
Insecticide usage	2 →						
Disease/ pathogens/	0-1 →						

competition from imported bumblebees			Tourism – opportunity ? Tourism - disturbance, development pressure				
Disease/ pathogens/ competition from imported honeybees	1-3 →						
Extreme weather events	3 ↑						
Mild, wet winters	3 ↑						
Invasive plants	1 →						

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Appendix 1: Survey reports for *Bombus sylvarum* with summary of findings

Authors / report	Year (publ.)	Summary of findings
Bumblebee Working Group Report	**1997**	**The establishment of a Bumblebee Working Group to execute the Biodiversity Action Plan initiative for scarce and declining species of bumblebee is reported. Searches of potential localities for the Short List species *Bombus sylvarum* are reported. Confirmation of the acute conservation status of this bumblebee is reported. The future direction of research under this programme is suggested. It was decided to concentrate on re-surveying for the species at as many post-1970 sites and selected pre-1960 ones as possible in order to establish the 1997 distribution and identify suitable areas for more intensive autecological research. Survey of these sites was to be carried out during August 1997 by teams under the leadership of designated lead surveyors who were familiar with the bee. Details of each site survey were recorded in a standardised way. Survey areas included: Salisbury Plain and adjacent areas, Dorset downland, Chiltern Hills and Somerset levels; North Kent Marshes and Dungeness; East Sussex Downs, South Essex, Portsdown Hill. North Cornwall was a possible area but there was insufficient time in the 1997 programme. A worker was found in Kent near Sittingbourne, a worker was found on Salisbury Plain near Tilshead and two queens were found during June in the course of other survey work at Margam Moors near Swansea.**
Bumblebee Working Group Report	**1998**	**Searches for the southern target bumblebees, *Bombus humilis, B. ruderatus, B.subterraneus* and *B. sylvarum* were carried out between June and August 1998. It was decided to concentrate on further searches of areas where the species had been sighted during 1997 in order to try and locate a suitable study population for more detailed work in 1999. Several promising areas had been identified during the 1997 programme and it was decided to carry out further searches at these, as well as some which had come to our notice since then. The general areas searched were: Essex; Kent; Salisbury Plain and Dorset; Somerset; South Wales coast. The 1998 searches found many more individuals of this species than the 1997 searches and confirmed the existence of three more populations at Kenfig/Margam Moors, Newport Levels, Somerset Levels, Salisbury Plain Training Area and the higher ground at the fringes of the North Kent and South Essex Marshes, a total of six populations. The Kenfig population was the study of some preliminary autecological investigation during 1998.**
Bumblebee Working Group Report	**1999**	**In the south of the UK the research programme concentrated on *Bombus sylvarum*, although data for *B. humilis* was also collated. Individual projects were based in: South Essex; North Kent coast; Dungeness/Romney Marsh; Salisbury Plain Training Area; Somerset Levels; North Cornwall; South Wales coastal areas. Further foraging data was collected for all species and a large series of pollen samples was collected from worker bumblebees at study sites throughout the UK. Experimental management of farmland margins was commenced in Kent and adjacent to Salisbury Plain Training Area. A series of meetings with agri-environment advisers and site managers was held throughout the winter months. These were followed by a series of field identification meetings. Many**

		papers concerned with bumblebees were gathered together and a literature search was commenced.
Harvey, P.R.	**1999**	**1998 fieldwork: The author visited fourteen sites in Essex to search for *Bombus sylvarum* including potential sites in North Essex where there are old records for the species (ITE 1980). *Bombus sylvarum* was only found at two sites, both in south Essex, Wat Tyler C.P. where it was recorded in 1993 and a new site at Benfleet Downs. At Wat Tyler two workers and one male were seen on the 9th August 1998 and then over 20 workers were seen on the 12th August.**
Bumblebee Working Group Report	**2000**	**BWG 2000 Work programme included: A detailed study of *B. humilis* and *B. sylvarum* at Castlemartin and Kenfig was carried out. Further distributional studies of B. sylvarum were made in Somerset. Further distributional studies of all bumblebees were made on Salisbury Plain TA and a further survey visit made to a set of good unimproved meadows to the west of Kidderminster which had first been visited in 1999. 200 artificial nest boxes were made, deployed and monitored in various sites throughout the UK. Research into restoring bumblebee habitat and monitoring the effects of this were continued at Cholderton, Hants and on Romney Marsh. Liaison with relevant conservation bodies and land-owners was continued. Further pollen samples were collected and sent to for analysis. Preliminary analysis of the 1997/8 samples was carried out. Research project not under the BWG were carried out on the foraging and distribution of B. sylvarum in south Essex.**
Carvell, C.	**2000**	**Studies of the distribution and habitat requirements of *Bombus sylvarum* (the Shrill Carder Bee) and other bumblebees at Castlemartin Range, Pembrokeshire and Kenfig National Nature Reserve, Glamorgan and surrounding areas. Report for Countryside Council for Wales, Bangor.**
Poole, A.	**2000**	**Nest site study (Annex in Carvell 2000) Not yet sourced**
Bumblebee Working Group Report	**2001**	**No field research could be undertaken at the start of the 2001 season as a consequence of the restrictions imposed for the Foot and Mouth epidemic. This gave an opportunity to travel to southern Germany to look at early-season bumblebee (in particular *B. sylvarum* and *B. humilis*) ecology. Further distributional studies of *B. sylvarum* in Kent and Somerset were carried out. The research on *B. sylvarum* and *B. humilis* in southern Essex was continued (not a BWG project, but in full consultation with BWG).**
Bumblebee Working Group Report	**2002**	**Further distributional studies in North Kent, surveys on The Isle of Sheppey, at Murston and on the Hoo Peninsula (Cliffe Poools) were completed in 2003. These surveys confirmed the continuing presence of B. sylvarum on the Hoo Peninsula and gave an idea of the size of the population at Cliffe Pools RSPB Reserve. They confirmed the species' continued presence at Murston, Lower Swale NR (Kent Wildlife Trust) and the Elmley area of Sheppey, giving a much better idea of the size of the population in the Elmley area (which is narrowly separated from Murston by The Swale). The research on *B. sylvarum* and *B. humilis* in southern Essex continued (not a BWG project, but in full consultation with BWG). Monitoring of *B. sylvarum* (Wales) and *B. distinguendus* (Scotland) (not BWG projects, but liasion with BWG is to be maintained). Survey work on Salisbury Plain found Bombus sylvarum on isolated occasions and never more than one or two individuals. Altogether, it was found in three out of nine sample sites and only found on two occasions in one sample site. The low**

		numbers/density of this species was rather surprising as the forage plants in many of the areas we were sampling were in very good overall condition for bumblebees.
Pavett, M	**2003**	**Recording of B. sylvarum in the Gwent Levels; study which first highlighted *B. sylvarum* population in Gwent Levels.**
Aculeate Conservation Group	**2005**	**B. sylvarum recorded at RSPB Minsmere, an area it had been considered absent from and where it is unlikely that they have been missed in the intervening years as they have been visited quite well.**
Howe, M, Haycock, B	**2007**	**Castlemartin Range: Field tests conducted Aug 2007, 16 individuals seen on 4 transects.**
CCW Contract Science Report No. 919 (Smith, 2010)	**2010**	**Significant numbers were found during surveys in the Gwent Levels east of the River Usk (Magor & Undy SSSI, Whitson SSSI, and Newport Wetlands NNR) in 2009**
Connop, S., Hill. T., Steer, J. & Shaw, P.	**2010a**	**Minimum mean foraging distances calculated using microsatellite analysis of 150 *B. sylvarum* workers, in south Essex.**
Connop, S., Hill, T., Steer, J. & Shaw, P.	**2010b**	**The role of dietary breadth in national bumblebee (Bombus) declines: Simple correlation? Biological Conservation, 143, 2739-2746. 3yr study on foraging behaviour of *B. humilis* and *B. sylvarum* at sites in south Essex, 2003 to 2005. Transects recording flower visits, and pollen samples taken.**
Connop, S.	**2007-2011**	**Hadleigh Park bumblebee habitat improvement: experimental forage plot surveys. Floral surveys and timed bee counts were carried out to assess the value of green haying as a management technique for quickly generating substantial areas of suitable wildflowers for foraging *Bombus sylvarum* and *Bombus humilis* at Hadleigh Country Park, south Essex.**
CCW Contract Science Report No. 972 (Smith 2011)	**2011**	**Low numbers of *B. sylvarum* were found between Magor and Chepstow, and were not recorded at key grassland sites such as Caerwent. However, these surveys did identify several new sites on the eastern end of the Gwent Levels, and at inland locations outside of the Gwent Levels. The report also documents records at urban localities at Newport Docks and Maesglas landfill site.**
Gardiner, T	**2012**	**Sea wall surveys in Essex (June): *B. sylvarum* recorded on red clover, narrow-leaved bird's foot trefoil, tufted vetch and oil seed rape (field adjacent to bank). Transect counts: 7 *B.sylvarum* recorded on uncut folding (Paglesham); Mean 5.3 *B.sylvarum* per kilometre on unmown bank; 0 on mown bank (Tilbury Marshes).**
Gomes, B (RSPB)	**2012**	**RSPB Cliffe Pools bumblebee survey, Aug & Sept 2012. Timed transects & timed counts.** **Large numbers of *B.sylvarum* recorded. Narrow-leaved Bird's foot-trefoil *Lotus tenuis* was the dominant flowering plant and the main forage species utilised by B.sylvarum. 152 workers were recorded foraging on *L.tenuis* in August, and 35 workers (plus 1 male) in September.** **Other key species utilised by these bees e.g. Red Clover and Red Bartsia had passed their flowering peak and much more patchy in distribution. Similarly, Black Horehound had mostly finished flowering at the times of visits. (Red bartsia = 8 workers. Black horehound = 9 workers. Red clover = no records.) Asteraceae were visited by mainly males of all species but also by workers. Hawkweed oxtongue – 34 sylvarum workers plus 2 males (August/Sept, 12 nectaring).**

		The high proportion of visits to Lotus may have demonstrated a preference for foraging on this species but may also have been a result of the limited availability of other forage resources in the late summer/autumn. It appears, however, to be of major importance to both B.sylvarum and B.humilis in the autumn, at a time when other key species such as Red Clover are at the end of their flowering season.
Connop, S.	**2013**	**Roscommon bumblebee research project. University of East London. Roscommon, Canvey Island, Essex. Included nest searches and mark recapture studies. *B. sylvarum* noted foraging along sea wall in significant numbers.**
CCW Contract Science Report No. 1030 (Smith 2013)	**2013**	**Surveys on the west of the Gwent Levels at Rumney & Peterstone SSSI, and in the east at Nash & Goldcliff SSSI, found *B. sylvarum* to be widely distributed on those SSSIs. This status is summarised as follows: 'Newport Wetlands (542 individuals at 18 sites in 2009), Nash & Goldcliff (381 at 32 sites in 2009), Rumney and Peterstone (305 at six sites in 2003), Whitson (300 at one site in 2003; 87 at 29 sites in 2009), St.Brides (220 at two sites in 2003) and Redwick & Llandevenny (61 at 20 sites in 2009). Numbers on Magor & Undy and Magor Marsh (5 individuals) are too small to merit this status unless considered part of a wider Gwent Levels population'.**
NRW Evidence Report No. 23 (Stewart & Roberts 2014)	**2014**	**Survey work undertaken in the Kenfig-Port Talbot area in 2013, with 101 individuals recorded across 49 transect sites. The range of *B. sylvarum* was estimated to be 66km2 with half of that area providing suitable forage habitat. The largest concentrations of records were found at the northern margins of Kenfig NNR and fields on the periphery of the NNR.**
Gardiner, T & Vetori	**2015**	**Sea wall mowing in Essex: Transect monitoring results for 2013 and 2014 indicated that the species richness and abundance of bumblebees on the one-cut sea wall in mid/late September (20 sylvarum recorded) were higher than the two-cut plots which were mown in June and August (0 sylvarum recorded) and had correspondingly lower forage plant species richness.**
Gomes, B (RSPB)	**2015**	**RSPB Great Bells Farm bumblebee survey, August 2015. *B. sylvarum* not recorded on timed transects but individuals were seen on an isolated *Buddleja davidii* bush and on Black Horehound *Ballota nigra*. This species was recorded much less frequently than in 2010. *NB. Not accessed 2010 survey report.***
Page, S (BBCT)	**2015**	**Sea wall surveys on Hoo Peninsula, Kent in 2013, 2014 and 2015 (early July, early Aug, early Sept repeat surveys). 12 transects across 6 sections (based on cutting management regimes).** **2013: 17 *B. sylvarum* (6% total records); plus 11 workers/1 male outside survey** **2014: 21 *B. sylvarum*, all workers (9% total records)** **2015: 22 *B. sylvarum*, all workers (6% total records); plus 1 queen outside survey** **Only 1 sylvarum recorded in early July surveys (across all years). Peak numbers in in 2013 and 2014 were in early Sept surveys, whereas in 2015 similar numbers of sylvarum were recorded across August & Sept.** **Abundance of *B.sylvarum* was higher in sections where an early and late cut was being carried out (rather than summer sea wall cutting).**

		Narrow-leaved bird's-foot trefoil = 47% records in 2013; 57% records in 2014; 41% in 2015. Bristly oxtongue and autumn hawkbit = September forage.
Connop, S, and Nash, C	**2017**	**Hadleigh Park invertebrate conservation analyses 2017. London: University of East London.** **Long term study (surveys from 2007-2011, 2015-2017), includes May cut trials, annual timed count comparisons, green-haying experiment analyses.**

Appendix 2: Known forage plant species used by *B. sylvarum*

(NB. This list is a working document not complete.)

Plant family	Forage species	Caste	Pollen/ nectar (known)	References	Notes/regions
Aizoaceae	Iceplant *Mesembryanthemum crystallinum*			Smith (2013)	Gwent Levels
Araliaceae	Common Ivy	workers/ males		pers comm Ray Reeves 2021	Essex
Asteraceae	Common fleabane *Pulicaria dysenterica*	Males		S. Lynch, Bex Cartwright	Wales, Kent
Asteraceae	Common ragwort *Senecio jacobaea*	Males		Smith (2013) Gardiner, pers comm Gomes (2012), Connop (2007) ad hoc record	Gwent Levels Thames Gateway Newport wetlands
Asteraceae	Sea aster *Tripolium pannonicum*	Males		Gomes (2012)	RSPB Cliffe Pools
Asteraceae	Lesser hawkbit, Leontodon taraxacoides	queen		ad hoc record	Kenfig pools and surrounds
Asteraceae	Dandelion *Taraxacum spp*	Queens, workers		Rosie Earwaker, pers comm (2018 surveys), Bex Cartwright (2021) ad hoc record	Thames Gateway, Gwent Levels (workers)
Asteraceae	Cotton thistle, Onopordum acanthium	worker		ad hoc record	Newport Wetlands
Asteraceae	Prickly sow thistle, Sonchus asper	worker		ad hoc record	Newport Wetlands
asteraceae	Autumn hawkbit, Scorzoneroides autumnalis	Worker, Queen		ad hoc record	Sker Point
Asteraceae	Sunflower *Helianthus annuus*	Workers and males		Gwent Levels, Smith, 2010 and 2011.	Gwent Levels
Asteraceae	Common knapweed *Centaurea nigra*	workers, males		Smith (2010) Gardiner T, pers comm Ad hoc record	17% workers on *Centaurea nigra* in 2009 surveys - Gwent Levels (Smith, 2010). Connop, et al (2010) Thames Gateway
Asteraceae	Meadow thistle, Cirsium dissectum	workers, queen		ad hoc record	Kenfig NNR
Asteraceae	Creeping Thistle *Cirsium arvense*			Pavett, (2004); Smith, (2010), Page (2015), Connop, et al (2010)	Gwent Levels, Thames Gateway
Asteraceae	Marsh thistle *Cirsium palustre*			Smith (2013)	Gwent Levels
Asteraceae	Sow-thistle *Sonchus sp.*			Smith (2013) Gomes (2012)	Gwent Levels; RSPB Cliffe Pools
Asteraceae	Spear thistle *Cirsium vulgare*			Smith (2013), Connop (2007), Cartwright (2021: pers comm) ad hoc record	Gwent Levels, Castlemartin ranges Newport Wetlands, Goldcliff lagoons
Asteraceae	Teasel *Dipsacus fullonum*			Gomes (2012) Cartwright pers comm (2021)	RSPB Cliffe Pools, Kent coast, Gwent Levels

Plant family	Forage species	Caste	Pollen/ nectar (known)	References	Notes/regions
Asteraceae	Hawkweeds / hawkbits / hawksbeard			Page (2015) Gomes (2012) Gardiner, pers comm adhoc record	Thames Gateway
Asteraceae	Bristly oxtongue *Helminthotheca echoides*			Page (2015) Gardiner, pers comm	Thames Gateway Page - BBCT sea wall surveys 2013-2015 - 18% records on bristly oxongue (n=60 sylvarum)
Asteraceae	Hawkweed oxtongue *Picris hieracioides*			Gomes (2012), Page 2015	RSPB Cliffe Pools
Asteraceae	*Picris echioides*			Connop (2007)	
Asteraceae	Chalk knapweed, centaurea debauxii			ad hoc record	Newport Wetlands, sea wall track
Asteraceae	Aster tripolium var. discoideus			ad hoc record	Newport Wetlands
asteraceae	Senecio erucifolius			ad hoc record	Newport Wetlands, sea wall track
Asteraceae	Dahlia			ad hoc record	St Brides, Wentlooge
Asteraceae	Musk thistle, Carduus nutans			ad hoc record	Kenfig dunes, north east
Asteraceae	Smooth sow thistle, Sonchus oleraceaus			ad hoc record	Rhymney
Asteraceae	Lesser Burdock	males		Cartwright, B. (2021, pers comm)	Gwent Levels
Balsaminaceae	Himalayan balsam *Impatiens glandulifera*			Smith (2013) Ad hoc record	Invasive species; Gwent Levels Kenfig marshalling yard
Balsaminaceae	Impatiens glandulifera			Najberek et al (2023)	Izerian foothills
Boraginaceae	Vipers bugloss *Echium vulgare*	male, workers		BWG 1998 Ad hoc record	Kenfig NNR Margam Moors, West
Boraginaceae	Comfrey *Symphytum spp*	Queens (and workers)		S. Lynch, pers.comm ad hoc record	Magor Marsh and Newport Wetlands
Boraginaeceae	Phacelia tanacetifolia			Konisglow et al (2022)	Ukraine
Brassica	Oil seed rape *Brassica napus*			Gardiner (2012)	Thames Gateway
Brassica	Perennial wall rocket *Diplotaxis tenuifolia*			Gomes (2012), S Page	Thames Gateway
Brassicaceae	Hedge mustard, Sisymbrium officinale			ad hoc record	Dyffryn

Plant family	Forage species	Caste	Pollen/ nectar (known)	References	Notes/regions
Convolvulaceae	Large Bindweed *Calystegia silvatica*	worker		Smith, 2013 ad hoc record	Gwent Levels - reported as main forage source for workers in 2012 surveys Ty Mawr Lane Wentlooge
Dipsacaceae	Devil's-bit Scabious *Succisa pratensis*	queen, workers		Howe and Haycock, 2007 Ad hoc record	Castlemartin Range Kenfig NNR
Dipsacaceae	Field scabious *Knautia arvensis*			Connop, et al (2010)	
Fabaceae	Meadow vetchling *Lathyrus pratensis*	queen		Smith (2013) Cartwright, B. (2020: pers comm) Ad hoc record	Thames Gateway Newport Wetlands
Fabaceae	Kidney vetch, Anthyllis vulneraria	queen		ad hoc record	Kenfig NNR
Fabaceae	Zig zag clover, Trifolium dmedium	queen		ad hoc record	Tranch Pyle, former lime works
Fabaceae	Red clover *Trifolium pratense*	queen, workers		Gardiner (2012; pers comm) Page S (2015) Benton et al (2012), Connop, et al (2010), Connop (2007)	Thames Gateway Gardiner, pers comm- 27% sylvarum sea wall records from last 10yrs on red clover Page - BBCT sea wall surveys 2013-2015 - only 2 records on red clover (n=60 sylvarum). Connop (2008) observed T. pratense to be of importance for queen *B.sylvarum.*
Fabaceae	Common Vetch *Vicia sativa*	Queens		Connop (2007), Rosie Earwaker, pers comm (2018 surveys)	Thames Gateway
Fabaceae	Hairy vetch *Vicia villosa*	Queens		Connop (2007)	Essex
Fabaceae	Broad-leaved everlasting pea *Lathyrus latifolius*	Queens		Connop (2008)	Thames Gateway
Fabaceae	Bladder senna *Colutea arborescens*	Queens		Connop (2008)	South Essex
Fabaceae	Goat's-rue *Galega officinalis*	Queens, Workers		Connop (2007)	
Fabaceae	White melilot, Melilotus albus	worker		ad hoc record	Wentlooge level
Fabaceae	Narrow-leaved everlasting pea *Lathyrus sylvestris*	Workers		Smith (2010)	Gwent Levels & Newport Wetlands
Fabaceae	Common Bird's-foot trefoil *Lotus corniculatus*	Workers		Smith (2010) Page S (2015), Connop (2007)	
Fabaceae	Black medick	workers		Cartwright (2020)	Regularly see small workers using whit clover and black medick in Milton Creek CP (Kent)
Fabaceae	Tufted vetch *Vicia cracca*	Workers			Gwent Levels Thames Gateway

Plant family	Forage species	Caste	Pollen/ nectar (known)	References	Notes/regions
Fabaceae	*Vicia tenuifolia*	Workers		Connop (2007)	Essex
Fabaceae	Grass Vetchling	Workers		Cartwright, B. (2021: pers comm)	Thames Gateway
Fabaceae	Ribbed melilot *Melilotus officinalis*	Workers		Connop (2007) ad hoc record	Newport Wetlands NNR, melilot
Fabaceae	Greater bird's-foot trefoil *Lotus pedunculatus*				
Fabaceae	Narrow-leaved bird's-foot trefoil *Lotus tenius*			Connop, et al (2010) Benton et al (2012) Gardiner (2012) Page S (2015), Connop (2007)	Thames Gateway - key forage plant (especially on sea walls); Benton - large numbers on *L.tenuis* in Sept 2007, Tollesbury Wick; Gomes 2012 - 152 workers were recorded foraging on L.tenuis in August, and 35 workers (plus 1 male) in September; Gardiner, pers comm- 46% sylvarum sea wall records from last 10yrs on *L.tenius. Connop, et al (2010) ~40% of pollen samples taken from B. sylvarum.*
Fabaceae	Strawberry clover *Trifolium fragiferum*			Page S (2015) Cartwright, B. (2020: pers comm)	Castlemartin Range, Thames Gateway
Fabaceae	White clover *Trifolium repens*			Smith (2013) Benton et al (2012) Connop, et al (2010), Cartwright (2021: pers comm)	Thames Gateway
Fabaceae	Lucerne *Medicago sativa*			Gardiner, pers comm	Thames Gateway
Geranicaeae	Meadow cranesbill, Geranium pratense			ad hoc record	Kenfig NNR
Iridaceae	Yellow Flag Iris *Iris pseudacorus*	Queens		Edwards, M (Pers comm)	Welsh sites
Lamiaceae	Betony	queen, workers		Falk (Pers comm.) Ad hoc record	Castlemartin Ranges Compt 40 Saddle Point - calcareous grassland & heath
Lamiaceae	White Dead-nettle *Lamium album*	Queens		Rosie Earwaker, pers comm (2018 surveys) Benton et al 2012 S. Page pers comm, Connop (2007)	Thames Gateway
Lamiaceae	Red Dead-nettle *Lamium purpureum*	Queens		Rosie Earwaker, pers comm (2018 surveys)	Thames Gateway
Lamiaceae	Ground-Ivy *Glechoma hederacea*	Queens		Rosie Earwaker, pers comm (2018 surveys)	Thames Gateway
Lamiaceae	Black horehound *Ballota nigra*	Queens, workers		Gomes (2012), Page (2015), Benton et al 2012, Connop, et al (2010), Connop (2007)	Thames Gateway; This species is uncommon in Wales

Plant family	Forage species	Caste	Pollen/ nectar (known)	References	Notes/regions
Lamiaceae	Salvia turkestanica	workers		Somerset SCB Group 08/07/2023	Somerset
Lamiaceae	*Lavandula* spp.	Workers		Connop (2007)	
Lamiaceae	Lambs-ear *Stachys byzantina*	workers		Somerset SCB Group 08/07/2023	Somerset
Lamiaceae	Marsh woundwort *Stchys palustris*	workers, males		Smith (2013) Ad hoc record	Wentlooge level
Lamiaceae	Selfheal *Prunella vulgaris*			Smith (2013) Ad hoc record	Somerton Farm
Lamiaceae	Common sage *Salvia officinalis*			Connop (2007) ad hoc record	Jordanston mountain
Lamiaceae	Water mint *Mentha aquatic*a			Smith (2013)	
Lamiaceae	Salvia pratensis			Sillo et al (2024)	Germany
Lamiaceae	Origanum majorana			ad hoc record	Redhourse barns, Newport wetlands NNR
Lamiaceae	Hedge woundwort, Stachys sylvatica			ad hoc record	near SWT Green Down
Lythraceae	Purple loosestrife *Lythrum salicaria*			ad hoc record	Gupton farm
Onagraceae	Great willowherb *Epilobium hirsutum*			Smith (2013), Somerset SCB group Ad hoc record	Kenfig pools and surrounds
Onagraceae	Rosebay willowherb, Chamerion angustifolium			ad hoc record	Newport Wetlands, sea wall track
Orchidaeceae	Autumn lady's tresses, Spiranthes spiralis	workers		ad hoc record	Sker Point
Orchidaeceae	Southern marsh orchid *Dactylorhiza praetermissa*			photo by Jeremy White (2021) at Newport Wetlands- Twitter	Newport Wetlands. Likely nectaring
Orobanchaceae	Yellow rattle, Rhinanthus minor	queen		ad hoc record	Kenfig NNR
Orobanchaceae	Red bartsia *Odontites vernus*	Workers		BWG, 1998 Somerset SCB Group, 2017 Stewart and Roberts, 2014 J Robins, pers comm Essex Gomes, 2012	All regions Connop, et al (2010) found majority of pollen collected by B.sylvarum was from Odontites verna.
Plantaginaceae	Foxglove, Digitalis purpureum			ad hoc record	Nefyn
Plantaginaceae	Purple toadflax, Linaria purpurea			ad hoc record	Kenfig Reserve Centre
Polygonaceae	Pale persicaria, Persicaria lapathifolia	worker		ad hoc record	Wheel Lane, Wentlooge
Rosaceae	Apple *Malus spp*	Queens		Connop, et al (2010)	Thames Gateway
Rosaceae	Bramble *Rubus fruticosus agg.*	workers, males		Smith (2013), Gomes (2012), Connop (2007) ad hoc record	All regions Ty mawr lane, Wentlooge
Rosaceae	Dewberry, Rubus caesius			ad hoc record	Margam Moors SSSI
Scrophulariaceae	Butterfly bush *Buddleia davidii*			Smith (2013)	
Solanaceae	Woody nightshade *Solanum dulcamara*			Smith (2013) Ad hoc record	Hendre lake
Verbenaceae	Verbena bonariensis	Worker			Video received via e-mail from Dr Janine Watts, Cardiff of a worker necatring on Verbena in a garden.