

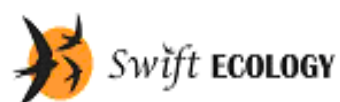
The short-haired bumblebee reintroduction project report 2009-2011



Dr Nikki Gammans



Hymettus



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Executive Summary

To date the project has had enormous success with bumblebee habitat creation. The project has created, advised and assisted in the management of over 550 hectares of flower rich habitat within the release site of Dungeness and Romney Marsh. This involved working with farmers, conservation groups, small holders and other land owners.

The project has also made progress towards the aim of reintroducing *Bombus subterraneus*. Two attempts have been made to collect and rear this species. A reintroduction has not yet been possible but considerable advances have been made in our knowledge of the biology of *B. subterraneus*. It is suggested that for a successful and sustainable population to be reintroduced to the UK, a European stock may be preferable.

To date the project has had great success with public outreach and media engagement. Articles have appeared in national newspapers, regional news and various radio stations in the UK, New Zealand and Australia. Outreach events involving the public have included numerous bumblebee walk and talks, invited lectures and red clover seed picking days. A team of over 25 volunteers have been involved in running these events as well as undertaking bee transect walks and *B. subterraneus* collections in New Zealand.

Project aims and objectives

The short-haired bumblebee project aims to reintroduce the extinct bumblebee *Bombus subterraneus* back to the UK. In order for a successful reintroduction to take place suitable forage habitat must be in place around the release site of Dungeness and Romney Marsh. The project also aims to engage the public in bumblebee conservation, locally through outreach events and nationally through various media.

- Recreate between 20-30 hectares (10km²) of flower rich habitat suitable for *B. subterraneus* around the release site of Dungeness and Romney Marsh
- Give advice to farmers, land owners and conservation groups on bumblebee habitat management and maintenance
- Produce and update a map of areas of habitat creation to aid establishment of habitat corridors
- Reintroduce the short-haired bumblebee back to the UK
- Monitor bumblebee numbers and densities using survey transects across the proposed release site
- Impart knowledge of *B. subterraneus* and habitat creation gained in the form of scientific reports and publications
- Promote the project to various academic forums
- Raise public awareness of the plans to reintroduce the short-haired bumblebee and of the general decline of bumblebee species due to habitat loss
- Generate media interest in the progress of the project

Introduction

The importance of bumblebees- pollination

Bumblebees are important pollinators of both agricultural crops and wildflowers. Bumblebees primarily pollinate strawberries, raspberries, tomatoes, peppers, field beans, runner beans, squashes, cucumber and courgettes. They are worth along with other insect pollinators £440 million annually to the UK economy and \$14.2 billion annually to the European economy (ALARM). To have an actual fixed value on pollination services by insects is hard to estimate, for example in the USA values range from \$1.6- \$40 billion per year. Crops cross-pollinated by bumblebees and other insect pollinators are said to produce a better yield, for example sunflowers (Goulson, 2003). Other crops such as red clover will not set seed unless cross-pollinated (refer to New Zealand introduction). Field beans can self-pollinate but their offspring will produce no or few seeds without insect pollinators (Stoddard and Bond, 1987). Adequate pollination of fruits such as strawberries, melons and kiwifruit ensures maximum fruit size. Fruit size is related to the number of seeds produced (hence the number of ovules fertilised). Despite knowing these facts we are still ignorant of which crops are insect pollinated. There are approximately 250 plant species grown as crops in Europe and 150 of these are known to be pollinated by insects, however little research has been made into which insects. More than a third of all food is thought to have been pollinated by insects (Goulson, 2003).

Bees are equally important in the pollination of wildflowers. Corbet et al. (1991) suggested that flowers of the groups Boraginaceae, Ericaceae, Iridaceae, Lamiaceae, Malvaceae, Orchidaceae, Fabaceae, Scrophulariaceae, Solanaceae and Violaceae are all largely dependent on bees. It has been predicted that the decline in bumblebees must have reduced pollination services for wildflowers (Goulson, 2003). A decline in pollination services does not just reduce seed set, but can lead to reduced outcrossing and inbreeding.

Differences in honeybee and bumblebee pollination

Honeybees, *Apis mellifera*, are often widely cited as the most important pollinator in agricultural systems. However, it is becoming more common to acknowledge the role of bumblebees and solitary bees in pollination. The latter of course being native to the UK and the honeybee being introduced and domesticated over hundreds of years. Honeybees are effective pollinators because of the vast workers which are produced from a hive which can pollinate large fields of crops and provide us with honey. However, in comparison to bumblebees they are less hardy. Bumblebees will emerge from a nest at much cooler temperatures, in light showers and forage for longer in a day. An important difference is also the length of tongue, honeybees have a short tongue length and bumblebees in comparison have a range of tongue lengths from short to long. This means that bumblebees

can visit and pollinate a greater number of crops and wildflowers. Short tongue bumblebees such as *B. terrestris* will pollinate oil seed rape whereas long tongue bumblebees such as *B. hortorum*, field beans and red clover. As bumblebees are hairier than honeybees they also collect more pollen in a visit and therefore deposit more pollen when visiting the next flower.

Bumblebees are also able to 'buzz' pollinate. This is a process where a bumblebee shakes its body by contracting their flight muscles to release the pollen of the plant, crops such as tomatoes and potatoes can only be pollinated in this manner. Also cranberries, kiwifruit and blueberries are pollinated in this way.

The status of the UK Bumblebee fauna

Evidence has shown that some bumblebee species have dramatically declined in the UK, continental Europe and North America (Goulson, 2003). In the UK, work undertaken by Williams (1982), which compared bumblebee ranges pre 1960 to then present day data, suggested strong declines in many bumblebee distributions. Recent work in the UK by the Bees, Wasps and Ants Recording Society has shown this trend has continued (Edwards, 2001; Goulson, 2003).

The UK currently is home to 24 species of bumblebee of which 6 species are cuckoo bees and the remainder are truly social (producing a worker caste). Over the last 60-70 years another two species have become extinct and seven are now classified as BAP (Biodiversity Action Plan) Priority species indicating they have declined. The first species to become extinct was *B. cullumanus*, a southern chalk-grassland species last recorded in 1941. After this period declines in bumblebee numbers escalated. The short-haired bumblebee *Bombus subterraneus* was once widespread across the south of England occurring as far north as Humberside (refer to page 14) but post-1950's its population distribution became isolated and patchy. This bee was last recorded in the UK in 1988 near to Dungeness, Kent. Subsequent searches have been made to try and record *B. subterraneus* but to no avail and it was officially declared extinct in 2000. Other species such as *B. sylvarum* and *B. distinguendus* have also greatly declined in their ranges. *B. sylvarum* is now restricted to only five remaining meta-populations. *B. distinguendus* was once found through the north of England and Scotland but is now restricted to the north of Scotland, the Orkney Islands and the Hebrides. *B. sylvarum*, *B. distinguendus* and *B. subterraneus* are all classed as UK BAP species (unfortunately the latter being included too late), the four others being *B. humilis* (a carder bee formerly widespread in England and Wales), *B. muscorum* (a carder bee mostly restricted to coastal areas), *B. ruderarius* (another carder bee which has experienced a sharp decline) and *B. ruderatus* (once widespread over southern UK and into north-east England but now very scarce although it does respond very well to suitable agri-environment schemes (pers comm. Mike Edwards). It is important to note that these bees all have in common a long tongue length, all emerge late from hibernation (end of May/beginning of June) and all nest as pocket makers (refer to page 17).

However, bumblebee declines may not always be apparent as some species are still abundant in gardens across the UK giving a false impression of high population numbers. Bumblebee experts class six bumblebees as common *B. terrestris*, *B. lucorum*, *B. pascorum*, *B. pratorum*, *B. hortorum* and *B. lapidarius* (Goulson 2003; Edwards and Jenner 2005). Although a new coloniser to the UK *B. hypnorum* (first recorded in the UK in 2001 near Landford [Goulson & Williams, 2001], thought to have colonised from France) is now abundant and is thought by experts likely to become the seventh most common bumblebee species. Although some of these more common bees do have a long tongue length they all emerge early from hibernation (January-March).

It is important to highlight that many of the UK's solitary bee species are also in decline believed to be due to the same reason as bumblebees (Goulson 2003). In comparison honeybee numbers are declining due to diseases such as varroa mite, colony collapse syndrome and American and European foulbrood disease (Goulson 2003).

Causes of bumblebee declines

Loss of habitat

Major loss of habitat is considered to be the main reason for declines in bee diversity in agricultural landscapes. After the Second World War there was a drive for self-sufficiency which led to the developments of low cost fertilisers and pesticides. Grants were also offered to farmers to grub out hedgerows, plough and re-seed pasture and to drain marshy areas and intensify farming methods (Goulson, 2003). As a result large areas of flower rich habitat were lost in the UK (Williams, 1982; Corbet et al. 1991). It has been estimated that more than 3 million hectares of wildflower habitat and over 97% of wildflower hay meadows have been lost over the last 60-70 years.

Many studies have correlated the number of bee species with floral diversity as bees rely entirely on flowers for their food as they exclusively feed on pollen and nectar. Uncropped areas of farmland such as hay meadows, flower-rich borders, hedgerows, shelterbelts and borders of streams and ponds can provide the late season forage essential for the late emerging long tongue bumblebees (refer to page 17) and these areas are known to support a higher diversity of bumblebees than cultivated areas (Goulson, 2003). Lack of flowers or gaps in a flowering season can cause bumblebee colonies to die before producing any sexuals (queens or males) the worker caste being unable to mate, thus causing the population to decline. A decline in bees may then reduce the pollination of important crops and wildflowers which will set less seed ().

In addition intensive farming methods may result in less nesting resources for bumblebees. The carder bees for example tend to nest in dense grass tussocks, while other species nest underground (Sladen, 1912; Alford, 1975; Edwards and Jenner 2005). Little is known about the nesting ecology of bumblebees but it is thought that a large number of nests are formed

in old rodent nests (Goulson 2003). The loss of hedgerows and unimproved pastures may mean less nesting habitat is available for rodents and in turn bumblebees (Goulson, 2003). Less weeds and wild flowers on farm land may also mean less seeds available for mice and voles and therefore their populations may decline which again would lead to less nests (Goulson, 2003).

Pesticides

Little is known of the impact of pesticides on bumblebees, although pesticides are routinely tested on honeybees (Goulson, 2003). As bumblebees collect pollen and nectar from plants their contact with pesticides is viewed to be considerable. It is important for research to be undertaken on the impacts of pesticides on all bee populations. Timing of spraying may also be of great importance to reduce the impact on foraging bees.

Impacts of habitat fragmentation

Due to farming intensification across the UK many wildlife habitats which were once connected have now become isolated. Some areas where farming did not become so intensive such as in the crofting regions in Scotland or military training areas such as Salisbury Plain have become a haven for some rare bumblebee species (Edwards, 1998; Carvell, 2002; Benson 2006). Similarly, habitats in coastal locations such as Dungeness and the Thames Corridor have largely remained intact due to being unsuitable for intensive agriculture (Goulson, 2003). However, many insects are now thought to exist as metapopulations in semi-natural ecosystems surviving on fragments of suitable habitat (Goulson, 2003). Populations which have become isolated are more vulnerable to extinction due to inbreeding, habitat degradation or stochastic events. Isolated bumblebee populations may also be at a higher risk from inbreeding, male bumblebees can become diploid making them infertile. This will result in decreased colony fitness (Goulson, 2003). A diploid male of BAP species *B. sylvarum* was recorded in Lydden, East Kent in 2010 (pers. obsv. Nicola Gammans). Work by Edwards (1999) has suggested that *B. ruderatus* requires 10 km² of flower-rich habitat to maintain a healthy bumblebee population.

Land management for bumblebees

Agri-environment schemes

Environmental Stewardship is an agri-environment scheme funded by the UK government and the European Union that provides funding to farmers and other land managers in England to environmentally manage part of their land. Environmental stewardship scheme is managed by Natural England on behalf of Defra (Entry level stewardship handbook, 3rd edition, 2010). There are three schemes which can be applied for; entry level, organic entry level and higher level scheme. In the entry level scheme there are over 80 management options, some of which are suitable for bumblebees such as pollen and nectar buffer strips, unimproved/semi improved grasslands, enhanced hedgerow management, beetle banks (nesting habitat), management of field corners and management of woodland edges. This scheme is open to all farmers and is an agreement which lasts for five years. There is a standard payment of £30 per hectare per year (Entry level stewardship handbook, 3rd edition, 2010).

The organic entry level scheme is the organic version to entry level scheme. This scheme is open to all organic farmers and again runs for five years. There is a standard payment of £60 per hectare per year (Organic entry level stewardship handbook, 3rd edition, 2010). The same options are available as in the entry level scheme.

The higher level entry scheme is a more advanced and demanding level for farmers to achieve. This scheme is aimed at farmers within a Natural England target area or for specific target themes. It is a ten year agreement but can run for longer. This scheme requires greater management input from farmers and land owners and thus attracts a higher payment. Payment varies according to which options are chosen. A FEP (farm environmental plan must be submitted and approved before being accepted into the scheme) (Higher Level Scheme handbook, 3rd edition, 2010). Again the options for bumblebees are similar to entry level scheme but require greater management and maintenance and may have more restrictions.

Management options for bumblebees

Included is a description of the management, sowing and maintenance of pollen and nectar buffer strips and hay meadows.

Pollen and nectar mixes

The cheapest seed to use is a mix of agricultural legumes, including clovers, vetches and trefoils. Agricultural red clover is short lived, and will need to be resown after 3-4 years, but produce abundant pollen and nectar at a low cost. It is best to avoid any grasses in the mix as they generally outcompete the legumes; however non aggressive grasses such as timothy, meadow fescue and cocksfoot are fine. There are long term wild seed mixes

available, which can last over 10 years/permanently if managed correctly and this would be favoured for permanent buffer strips. There are several pollen and nectar mixes available, below is an example.

Short term mix:

36% red clover
20% sainfoin
20% alsike clover
20% birdsfoot trefoil
2% musk mallow
2 % common knapweed

Sowing times

It is best broadcast on the surface of a firm, fine seed bed from mid April to mid May, or mid July to mid August (pers comm. Marek Nawcowski). First plough or disturb the soil. For a very dense grass sward use Round Up or Glyphosate. If the grass sward is not dense, using a topper or mow will create open spaces for the wild flowers to germinate. Pollen and nectar seed mixes tend to do best on infertile impoverished soil. If thistles are present first use round up and follow this with mowing the area. Alternatively, single spray thistles with thistle X or a target chemical. Thistles and docks may continue to be a problem so will need continuing control but using only spot spraying otherwise this can damage the clovers.

Managing buffer strips

Cutting depends on the weed pressure and fertility but 3 cuts in the first year are generally needed. From year two onwards a cut in September usually suffices. Fertile soils may benefit from an extra April cut. Remove the cuttings as this may increase the nutrient content of the soil. For best results a 50% cut of the margin in June will prolong the flowering season.

Managing grazing pasture for hay meadows

Graze hay fields from September through to April/May and leave the field during the summer months for the flowers to grow through and flower. For long season bumblebee forage allow some fields to grow an early summer hay crop, and others a late summer hay crop this will maintain suitable flowery fields for the bees throughout the important summer months.

Creating or enhancing a clover-rich field

On grassland there are various options: If the sward already contains red clover allow the field to stand ungrazed until the clover sets seed and falls from the seed-heads. Then cut and remove the hay crop and graze the field until the following spring. Over time the

amount of clover in the sward can be expected to increase. Other useful legumes include bird's-foot trefoil, tufted vetch and meadow vetchling.

If red clover is not present the most cost-effective way of acquiring local legume seed is to cut a hay crop containing legume seeds, and then spread the hay on the field and graze animals on it. Seeds will fall onto the field and germinate the following winter. Keep the field well grazed until the following spring before allowing the field to grow a hay crop.

The fields should be grazed during the winter from September through to April/May, with the grazing animals removed from the field a few weeks before you want the field to start to flower. During the harvesting of the field a one metre margin should be left uncut as this will provide continuous forage for the bees until regrowth.

Gardening for bumblebees

Gardens cover over 3 million hectares in the UK more than all the nature reserves added together. Gardens are and can be a mosaic for bumblebees to disperse and move across habitats within the country. Gardens also have the opportunity to offer continuous forage from March through to September when it is most needed by bumblebees (Benton, 2006).

Many cultivated plant species offer little nectar and often no pollen but wild flowers or cultivated flowers from wild flowers can be an excellent forage source for bumblebees (Goulson, 2003; Benson, 2006). Examples of cultivated flowers from wild flowers are lavender, snap dragon and sweet pea. Wild flowers such as foxglove, *Digitalis purpurea*, viper's bugloss, *Echium vulgare*, and cornflowers, *Centaurea cyanus*, and both red and white clover *Trifolium pratense* and *T. repens*, are late flowering species ideal for bumblebees (refer to appendix one for a full list of flowers suitable for bumblebees).

Gardens can also provide important nesting sites for bumblebees, for example under sheds, paving stones, rockeries, compost heaps and bird boxes (Benton, 2006; pers obs Nicola Gamman).

Wider ecological benefits

The creation of pollen and nectar strips and the management of flower rich hay meadows can also benefit many other species of invertebrates such as moths, butterflies and flies, the invertebrates will then in turn be a food source for bats and birds. The flower rich habitats will also provide nesting habitat for yellow hammers, skylarks and lapwings. The management of these areas may also benefit species sensitive to grazing such as the marsh mallow plant and the rare marsh mallow moth, the water vole and greater water parsnip. Rodents will also nest in these areas and in turn may become food for barn owls. By creating habitat for bumblebees across the countryside it will restore an ecosystem of flower rich diversity which has largely been lost in the UK, this will also provide possible benefits for many other species. This applies to creating foraging habitat for bumblebees in gardens.

Short-haired bumblebee (*Bombus subterraneus*)

Description

B. subterraneus has a large queen and worker size, the former's length being 20-22mm and expanse 38-41mm and the worker length 12-18mm (Sladen, 1912). Queens and workers have two yellow thoracic bands, the second band being narrower than the first. Often the front thoracic band may have a smudge of black in the centre (sometimes referred to as a notch), (Sladen, 1912; pers. obs. Nicola Gammans). This species is short haired and the centre of thorax is absent of hair, appearing bald (pers. obs. Nicola Gammans). The abdomen is black with the 4th and 5th segments being white and a white tail (see photograph 1). Males are also large in length 15-16mm and an expanse of 28-31mm. The males' abdomens are elongate and the body is yellow with the exception of a black face (with yellow on top and middle of face) and black band across the thorax between the wings (see photograph 2) (Sladen, 1912).



Photograph 1; Queen *B. subterraneus*



Photograph 2; Male *B.subterraneus*

Nest construction

Queens emerge from hibernation at the end of May or beginning of June (Sladen, 1912). They are poor at nest construction with honey pots clumsily constructed and larvae often not completely covered (Sladen, 1912; pers. Obs. Nicola Gammans). This species forms nests as a pocket-maker (Benton, 2006). Nests are constructed underground (Edwards and Jenner, 2005) but little is known of preferred locations. However a nest of *B. subterraneus* and nests of the closely related species *B. ruderatus* were observed in rabbit holes in New Zealand where these bees were artificially introduced (refer to page 18) (pers. obs. Nicola Gammans).

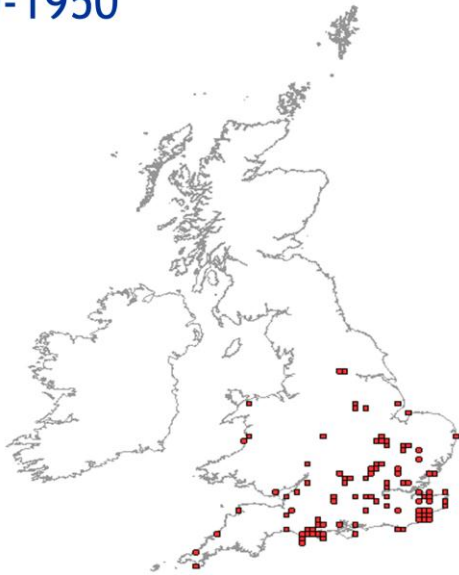
Habitats

B. subterraneus in the UK were found on a variety of flower-rich habitats such as shingle, saltmarsh, dunes and grasslands (Benton, 2006). Short-haired bumblebees forage on a variety of legumes such as red clover, birds-foot trefoil, knapweeds and vetches (Edwards and Jenner 2005; Benton, 2006). In New Zealand *B. subterraneus* is restricted to introduced flowers red clover, viper's bugloss and lupins.

Distribution

B. subterraneus was once commonly found across the South of England (Sladen, 1912; Free and Butler, 1959) and north to Humberside but is now thought to be extinct in the UK as no recordings have been made since 1988 (Benton 2006; Edwards and Jenner 2005), (see Map 1). This species is thought to have become extinct in the UK due to agricultural intensification over the last 70 years (Williams, 1986; Osborne and Corbet, 1994; Goulson 2003; Benton 2006). See page 8 for further discussion of causes of bumblebee declines.

1900-1950



1950-2000



2000-2007



Map 1; *B. subterraneus*'s decline in the UK over time. Note Dungeness, Kent remaining a strong hold for the population until the 1980's.

B. subterraneus is declining across its European range, with populations still remaining in low densities in Germany, France and the Czech Republic (pers comm.; Dave Goulson, Stuart Roberts, Jaromir Cizek). Populations of *B. subterraneus* are still thought to remain at good densities in Sweden and Estonia (pers comm. Paul Williams, Stuart Roberts, Bjorn Cederberg). This species also remains on the South Island of New Zealand where it was deliberately introduced in the 1880's. The population is thought to be stable but has declined over the last forty years (pers comm. Barry Donovan).

Bumblebee lifecycle

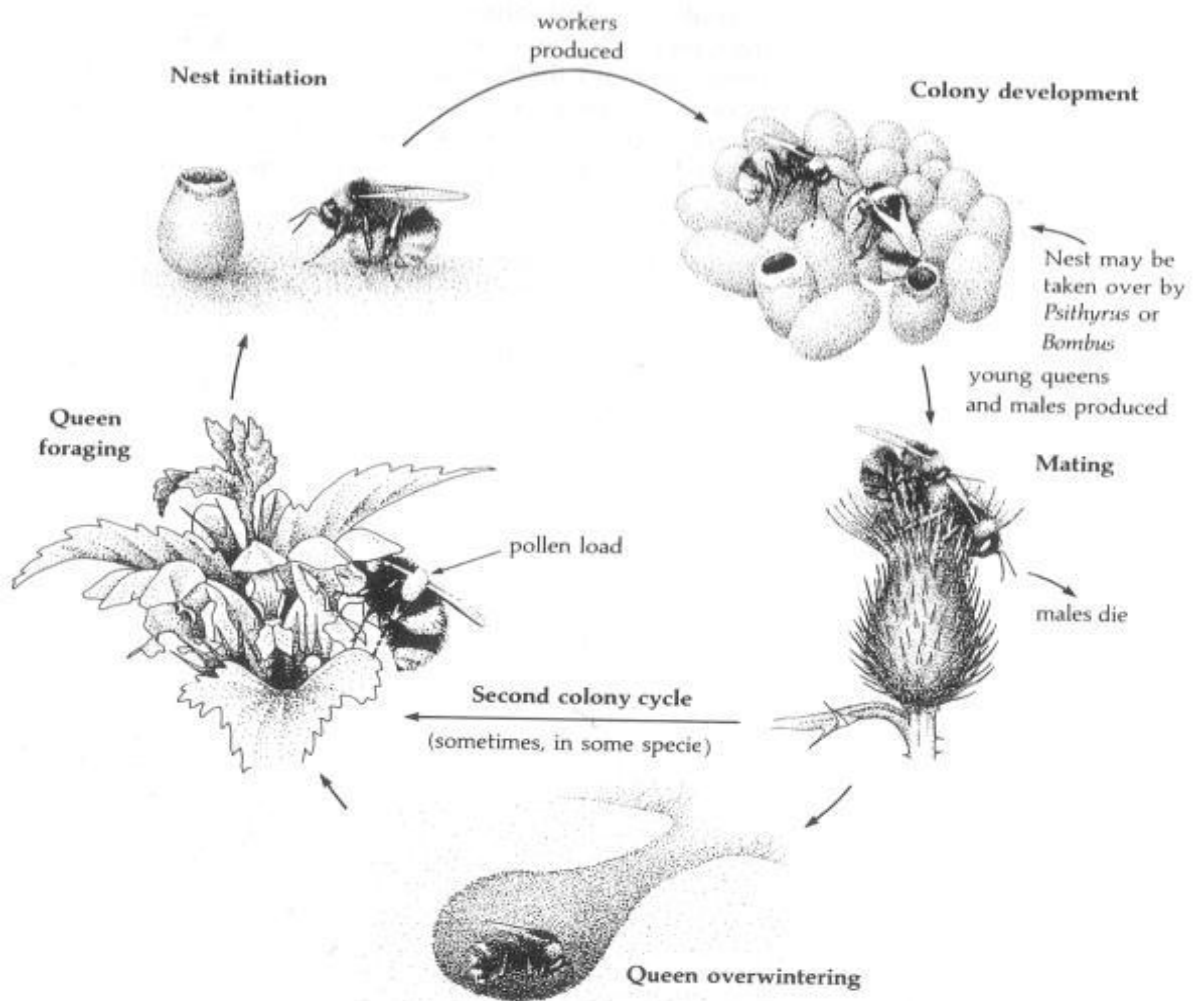


Figure 1; Diagram of bumblebee lifecycle. Edwards and Jenner (2005)

B. subterraneus queens may spend between 6-9 months in hibernation. Once *B. subterraneus* emerges between late May and early June (in northern Europe) the queens forage for a period of two weeks, firstly collecting nectar and then pollen. They build a waxy pot for the nectar and mass the pollen together. The queen begins to construct waxy cells in which she lays eggs. Pollen is fed directly to the larvae through a 'pocket' (hole) within the cell. The queen will continue to forage until the first brood of workers are able to take over these duties. After approximately three months (mid August onwards), nearing the end of the colony cycle, the new generation of queens and males are produced. The males leave the colony first, followed a week later by the queens. Males and queens will mate and the queen will forage for a day and then hibernate. The males and old colony die. The colony cycle is then repeated.

The colony cycle is important to consider when creating habitat for *B. subterraneus*. This species is late emerging and will need forage until the end of August. Habitat must be created and managed to be available for this duration.

New Zealand bumblebee introduction

The first recorded attempt to establish bumblebees in New Zealand was in 1875. Expatriate farmers emigrated to New Zealand and took with them red clover seed as it was (and still is) used as cattle, horse and sheep fodder. However, when they began to grow red clover they noticed it was not being pollinated and not setting seed. Farmers had to continue importing seed annually from the UK, which was very expensive. Charles Darwin (1859) had discovered that only the long-tongued bumblebees such as *B. subterraneus* were capable of pollinating red clover. New Zealand does not have any native bumblebee species and has only 25 solitary bee species (compared to 250 in the UK), therefore, nothing was pollinating the red clover crop (Donovan, 1978).

The North Canterbury Acclimatisation Society then sent messages back to the UK via a member Thomas Nottidge to send over long tongue bumblebee queens (Lamb, 1964). Queens were dug up whilst still in hibernation and sent across to New Zealand. Unfortunately a few attempts had to be made before any were successful, as early attempts did not keep the bees cool enough (below the 5 °C needed to maintain hibernation), so when the boats reached the tropics the bees awoke but had no foraging resources. On the first four attempts all the bees had died on arrival. Finally the problem was solved when the bees were sent on steamships which contained a refrigeration unit. In total 282 queens of the four species *B. subterraneus*, *B. hortorum*, *B. ruderatus* and *B. terrestris* were sent to New Zealand. On arrival in Canterbury on the 8th January 1885 48 queens were still alive, including queens of each of the four species. These were then released. Another consignment of bumblebees arrived on the 5th February carrying 260 queens and 49 survived (Lamb, 1964). In 1886 bumblebees were found 100 miles south, 86 miles west and 55 miles north of the release area (Lamb, 1964). The introduction was such a success that by 1892, the red clover farmers were now exporting seed back to the UK at great profit. Although all species were successful and established in New Zealand, results of recent genetic research by Lye et al. (*in press*) suggest that only two queens of *B. subterraneus* survived the original journey.

Results

Habitat creation- progress to date

The queens of *B. subterraneus* were planned to be released on the RSPB Dungeness nature reserve in Kent, close to the last known recorded site for this bee. This area of Dungeness and Romney Marsh is very important for bumblebees as six of the UK's seven BAP species (see page 7) once occurred here. Now only two remain, *B. muscorum* and *B. humilis*, but with the exception of *B. subterraneus* the others are still present in Kent. This area is also designated a SSSI and lies within a target area for higher level stewardship agreements (refer to page 10). Advisors to the project Mike Edwards (consultant entomologist) and Brian Banks (formerly of Natural England, now consultant for Swift Ecology) have also worked with local farmers and land owners on recreating flower rich habitats during the last 15 years. The project's aim was to recreate 20-30 hectares (10km²) of bumblebee habitat within the release zone of Dungeness and Romney Marsh.

Acquiring farming contacts

A variety of techniques were used to contact farmers and land owners. Many farmers were introduced by Brian Banks (Swift Ecology and project advisor) and Natalie Smith (Natural England advisor Romney Marsh and Dungeness SSSI). Briefed farmers were then asked to recommend any other farmers who may be interested in talking to the project.

Unfortunately, due to data protection law, no farmers' names were allowed to be passed to the project officer unless communicated by telephone or in writing from Natural England. Farms and farmers were also identified through Yellow Pages and various internet search engines.

The project also sought to work with local government and conservation bodies. Over the two years the project worked closely with FWAG, Kent Wildlife Trust (in particular Living Landscapes), Rye Harbour Nature Reserve, The Environment Agency, Natural England Ashford office, the Internal Drainage Board, Little Cheyne Court wind farm, Hastings Country Park and The National Trust. The project has begun discussions with the National Farmers Union, Lydd Council and the Ministry of Defence.

Farmers, land owners and conservation groups have been given advice on management, maintenance and sowing of bumblebee flower-rich habitat. Advice was also given on existing contracts and joining the agri-environment schemes (refer to page 10). Information was available in the form of a booklet 'Information pack for farmers' discussing management and advice.

Farm day events

Two annual farm day events have taken place to date in June 2009 and 2010, at Larry Cooke's Money Penny Farm and Chris Strangeway's Bosney Farm (photographs 3-8

appendix two). The first farm day event at Money Penny farm attracted 20 farmers and 20 members of the previously cited conservation groups and local government bodies. A marquee was erected and information was given out to all guests on arrival. Farmers and land owners were also asked to mark on an OS map the area of land they owned.

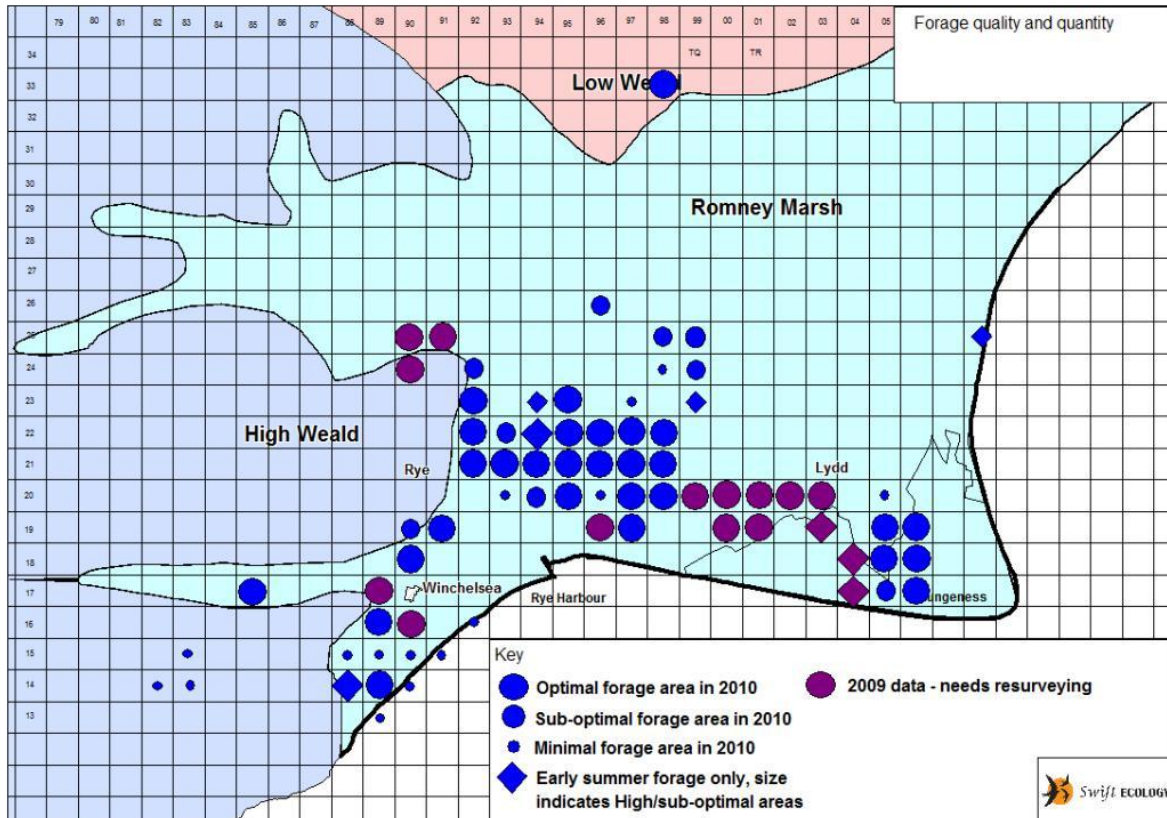
The attendants at Money Penny Farm were then taken around the farm to look at red clover hay meadows, during which the farmer discussed management techniques. The party then moved on to view flower rich field margins created for bumblebees where further discussions were held. The attendees were taken to and shown a pea field where a group discussion took place about the potential for creating suitable habitat for bumblebees which would facilitate the pollination of crops. Finally the guests were invited to take part in a bumblebee identification walk with Kent aculeate recorder Geoff Allen.

A similar protocol was undertaken at Bosney farm in 2010. Twenty local farmers attended. Two detailed talks were given. The first talk was on the importance of bumblebees for pollination. The second gave an account of agri-environment schemes and was given by Paul Cobb of FWAG. After the talks a tour around the farm took place to look at hay meadows. Advice was given to leave a parcel of land uncut within a field after hay cut to provide late forage for bees. In addition discussions were made on habitat suitable for bumblebee nesting and arable reversion field margins.

At both events farmers were asked for their contact details. A date was agreed with them for a follow up visit to their farm. The project officer duly re-visited the farm and noted down all habitats currently managed for bumblebees. Help and advice was given where needed. If the farmer was interested in joining or currently completing their FEP for an agri-environment scheme further advice and encouragement was given on creating bumblebee habitat. A map of the farm with bumblebee habitat areas marked on it was then passed to Brian Banks who inputted the map data into the Map Info software being used by the project.

The habitat was graded on a 1-5 flower-rich scale, current management, and the length of the flowering season (see Map 2). This gave the project the quantified total of habitat created, measured in hectares. The data analysis suggested areas to next focus on. A current map of habitat on Romney Marsh and Dungeness is shown in map 2. Map 2 demonstrates that the project has now created and given advice on the management and maintenance of over 550 hectares of bumblebee friendly habitat. The amount of habitat may vary year to year depending on farmers' hay field rotation, improvements to land and land taken out of stewardship. In 2010 some areas of re-created habitat had to be removed from the database e.g. at Rye Harbour where truck access to the site for ongoing works meant land was damaged in 2010 and will need to be reseeded in autumn 2011; at Lydd ranges where there were ongoing discussions with Natural England surrounding management issues; some areas of farm land that were going into HLS schemes where some land was already

suitable but further improvements were being made and an HLS agreement was still being negotiated. Therefore the estimate of habitat available for bumblebees was conservative.



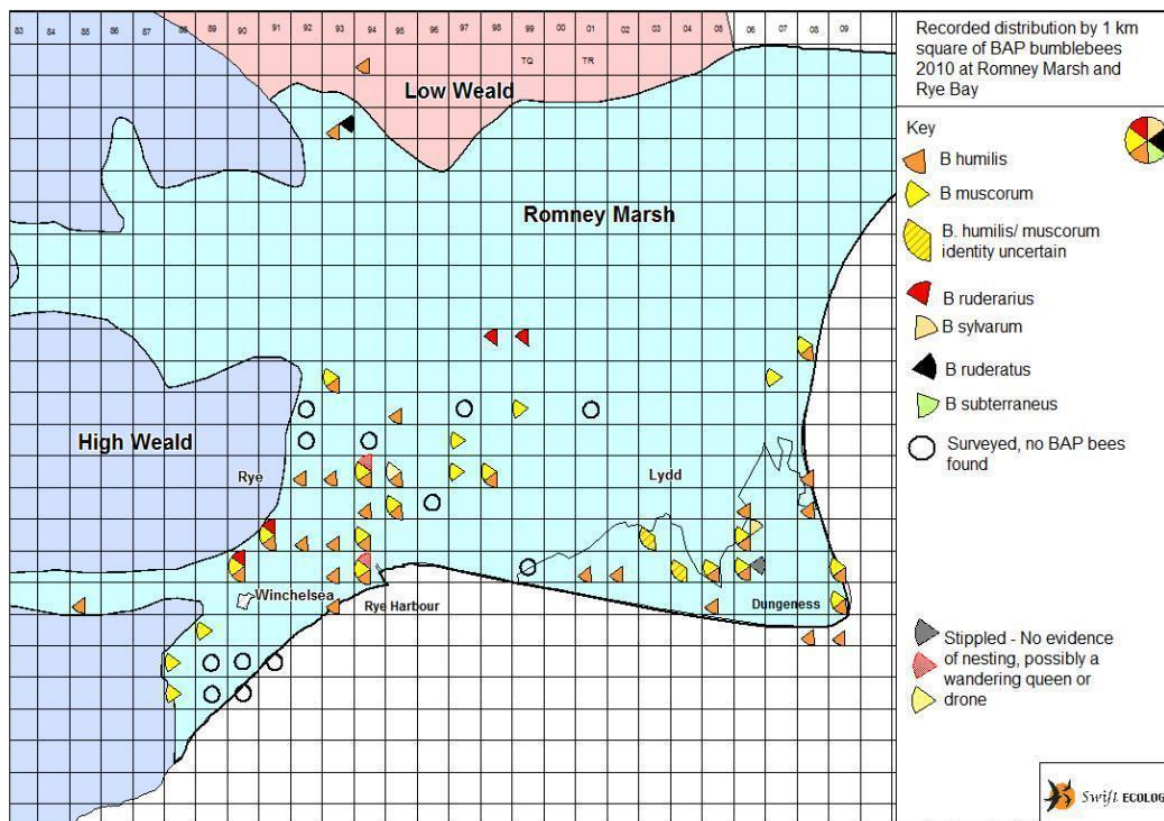
Map 2; Habitat created for the *B. subterraneus* reintroduction to Dungeness and Romney Marsh. By April 2011 over 550 hectares of flower rich habitat was in place.

Survey Transects

Transects were used to determine whether newly created habitat, existing habitat, and habitats undergoing improvements were attracting bumblebees. Fortnightly transects were walked by the project officer and four volunteers from the end of May to the beginning of September (photographs 9-11 Appendix two). The transects were walked over 6 areas; Little Cheyne Court wind farm, Black Horse Farm hay field, Dungeness Coast Road, Littlestone Golf Course, RSPB Dungeness hay field and a small holding. Brian Banks also completed transect walks across Romney Marsh and Dungeness. Bumblebee species and density were recorded by walking along fixed transects. Some rarer species had to be captured and examined to determine species. All data was recorded to species level and caste. All bumblebee records are passed to Kent Biological Records Centre, Bee Wasps And Ants Recording Society, the Romney Marsh ranger service and Bumblebee Conservation Trust.

In 2010 two of the once present bumblebee species *B. ruderatus* and *B. sylvarum* were recorded at RSPB Dungeness. These species had not been recorded at this site for over ten

years and 25 years respectively (see Map 2). Records of *B. ruderarius* were also found across Romney Marsh where it had not been recorded for over 10 years (see Map 2). The populations of *B. humilis* and *B. muscorum* also appeared in new monads where they had not previously been recorded.



Map 3; the distribution of BAP bumblebee species found in Romney Marsh and Dungeness in 2010.

Habitat corridors, Lydden reserve

If the reintroduction of *B. subterraneus* is successful at RSPB Dungeness then a second reintroduction will take place at RSPB Lydden reserve in the East of Kent. Currently management plans are being written for this new site in which the project officer is giving advice on bumblebee habitat creation. The project then aims to create corridors between Dungeness, Romney Marsh and the Lydden reserve. The latter was chosen for the second reintroduction because it holds good populations of BAP bumblebee species *B. sylvarum*, *B. ruderarius* and *B. muscorum* (refer to page 7). By creating a corridor between the two nature reserves it is hoped that the bumblebee populations will be able to spread and increase their distribution.

Red clover seed pick day

The first annual red clover seed pick day took place last year in August. The project officer with ten volunteers collected ripe red clover seed heads and tufted vetch seeds from a red clover field at RSPB Dungeness. The seed heads were packed into bags and then laid out on

a tarpaulin sheet to dry for three days in a shed. Bags of the seed were then passed onto interested parties such as The Environment Agency, The National Trust, Internal Drainage Board and small holders.

Summary

To date the project has had significant success in recreating, managing and giving advice on bumblebee habitat. This has been made possible through outreach events to farms on bumblebee farm day events and by individual farm visits. Agencies such as Internal Drainage Board, The Environment Agency and Kent Wildlife Trust have supported the project and resown areas with locally produced red clover seed.

The survey work undertaken by the project officer and Brian Banks has given the project an understanding of how newly created and improved habitat creation is helping bumblebees species spread. The project categorises habitat by specific criteria to improve our knowledge of Dungeness and Romney Marshes flowering season and distribution of habitat highlighting areas needed to create linking corridors. The project is then able to focus on specific areas within the release zone.

Transect surveys completed by the project officer; project volunteers and Brian Banks monthly across the release zone suggests that populations of rarer bumblebees are increasing in number and dispersing due to habitat creation (see Maps 1 and 2). For example in one day's survey at Little Cheney Court wind farm (habitat created 2010) 46 *B. muscorum* were recorded.

Reintroduction of *Bombus subterraneus*- progress to date

February 2009 initial visit to assess field sites and *B. subterraneus* abundance in New Zealand

An initial expedition was undertaken to the south island of New Zealand in February 2009 to establish the distribution and abundance of *B. subterraneus*. The project met with Gillian Lye and her assistant who were gathering data on introduced bumblebee populations (refer to page 18). Advice was given to the project on site locations where queens, males and workers had been observed. The project officer spent three weeks searching these locations and looking for new sites. The field sites visited were Twizel, Wanaka and Lake Tekapo (map 4). The presence of *B. subterraneus* was confirmed at these sites. The main food resource for *B. subterraneus* in these sites is *Echium vulgare*, *Lupinus* spp, and some small areas of *Trifolium pratense*. During this expedition very few *B. subterraneus* were recorded and no second generation queens were found.

Queens of *B. terrestris*, *B. hortorum* and *B. ruderatus* were collected in order to examine suitable methods of rearing, feeding and transporting bumblebee queens. The outcomes of these endurance trials were to inform decisions on how *B. subterraneus* queens would be exported from New Zealand and imported to the UK. It was established that queens could be kept in hair rollers in refrigeration at 5°C for one to two weeks before deaths occurred. Queens were fed nightly with artificial nectar solution soaked into cotton wool. Queens were removed from the fridge and fed and left for between 30-60 minutes until they became very active and then returned to the fridge so they did not lose energy.

It was established that under current import and export laws wild caught bumblebee queens are not allowed into the UK from third countries, which includes New Zealand. Therefore a captive rearing and breeding process would have to be implemented in New Zealand to bring back second generation queens (refer to page 17). Also, specimens of maternal queens, workers (from the same nest) and males (mated with second generation queens) would need to be collected and sent to the UK for disease screening before an import licence could be obtained.

Contacts were sought in New Zealand to assist with captive rearing of *B. subterraneus*. Rosemary Read's name was given as someone who had previous experience of rearing *B. hortorum* and *B. terrestris*, and had once successfully reared *B. subterraneus* whilst working at the Plant and Food Institute laboratories. Detailed discussions were held with Rosemary Read and Plant and Food bee specialist Dr Barry Donovan about collecting and rearing *B. subterraneus*. Contract agreements were made with Plant and Food for Rosemary Read and Barry Donovan to work with the project officer and the team of volunteers on a return visit in November 2009 to collect and rear *B. subterraneus*.

B. subterraneus captive rearing 2009/10

Field sites and collection

The project officer with a team of three volunteers travelled to New Zealand at the end of November 2009 (photograph 12 Appendix two). On arrival the project officer met with Barry Donovan and was informed of a site which in the 1970's held a good population of *B. subterraneus*. The site was in Clyde, Central Otago (see Map 4) and was later investigated by the team. The team found red clover hay fields were present and emerging *B. subterraneus* queens were observed. In summary four geographic locations were surveyed for queens in 2009/10; Lake Tekapo near Twizel, Lake Ohio (40 miles south of Twizel, a site suggested by Barry Donovan), Lake Wanaka and Clyde (see Map 4).



Map 4; Field sites on the South Island of New Zealand. Christchurch is where the queens were sent to be reared.

When the project officer and volunteers first visited Clyde the red clover hay fields were beginning to flower. On searching these fields *B. subterraneus* queens were found. The other two volunteers stayed at Twizel to monitor the queens' emergence. In Twizel the *Echium vulgare* and *Trifolium pratense* were still to flower and no *B. subterraneus* were recorded. Following these findings all volunteers were assembled in Clyde to begin collecting *B. subterraneus*. Once caught the queens were stored individually in specimen tubes or hair rollers and kept in refrigeration at 5°C overnight. The following morning the bees were sent by overnight post to Rosemary Read in Christchurch. The tubes containing

queens were packed into a polystyrene box (normally used for wines) with freezer packs to keep the bees chilled and newspaper was used for insulation. No bumblebees died during this transportation procedure.

Two volunteers regularly visited Twizel and Lake Tekapo to monitor emergence of *B. subterraneus*, whilst two remained collecting in Clyde. Alexander (6 miles from Clyde) is the hottest location in New Zealand during the spring and summer seasons and thus flowering times are earlier than elsewhere in New Zealand. Twizel and Lake Tekapo are in higher altitudes and mountainous and their spring and summer temperatures can be high, but these localities reach these high temperatures more slowly than Clyde. Temperature variations effect the emergence times of *B. subterraneus*. Clyde queens are the first to emerge then Twizel, and finally Lake Tekapo as confirmed during this field trip. Visits were also made to Lake Wanaka (see Map 4) as field worker Gillian Lye had previously recorded the presence of *B. subterraneus*. Lake Wanaka does have small patches of *T. pratense* and *E. vulgare* but alas these areas are frequently mowed. The project officer decided to focus the team's effort on the remaining sites which have continuous and larger areas of foraging available.

B. subterraneus queens were collected over the period 28th November to the 18th January. The peak of queen emergence was between the 1st December and the 7th December. Queens were collected in the mornings and late afternoons because few *B. subterraneus* queens forage during the hottest part of the day. Searches for queens could be hampered by adverse weather conditions, queens will not forage in constant rain or cold weather.

In total 67 queens were collected, 36 in Clyde, 24 in Twizel, three at Lake Ohio, and four at Lake Tekapo. All 67 queens were sent to Christchurch to be captive reared by Rosemary Read.

Captive rearing techniques

Once the bumblebees arrived in Christchurch each queen was placed in a separate wooden box (15.5 by 12.5cm) with a perspex lid and a perforated steel plate bottom (see photograph 26-27, Appendix two). The boxes contained a small piece of cardboard and a cotton wool ball for the bees to use as nest material. The bee rearing room was kept within a temperature range of 26-28 °C and 50-70% relative humidity. An artificial fructose nectar solution was offered in a plastic tube feeder. Honeybee pollen was provided in small plastic lids. *B. subterraneus* are very particular about which pollen they collect (pers comm. Jaromir Cizek). In New Zealand they have a limited choice (compared to Europe) due to lack of native bee pollinated wild flowers. Red clover is thought to be the optimum forage plant providing both nectar and pollen, but they also collect *Lupin* spp. pollen and will feed on *E. vulgare* pollen. Due to the number of queens collected and the difficulty in obtaining red clover pollen (honeybees cannot collect red clover pollen, which is how pollen is sourced), the queens were not fed an optimum pollen quality from the beginning of their captive

rearing. They were offered a mixture of flower pollens with a small amount of nectar. Once available *E. vulgare* and *T. repens* (white clover) were offered. However, is it unknown whether white clover is as acceptable as red clover to *B. subterraneus*.

Within a month of arrival a small piece of *B. hortorum* brood was given to the queens (photograph 26, Appendix two). This was intended to encourage the queen to incubate and raise the brood and to lay her own eggs (photograph 26-27, Appendix two). In New Zealand there are only four species of bumblebee, all of which were introduced from the UK and Ireland. Three of these are long tongue pocket makers *B. subterraneus*, *B. ruderatus* and *B. hortorum* (refer to page 18). The latter emerges approximately 2-3 months before the others. This species was chosen to use as brood as *B. ruderatus* emerges at the same time as *B. subterraneus* and therefore it would be a number of weeks before brood could be removed from a *B. ruderatus* nest to give to a *B. subterraneus* queen. However, due to the difference in age of the species, much of the *B. hortorum* brood pupae were male, as worker brood had already developed. Worker brood is optimal as they will help look after the nest once emerged and will feed and incubate the developing brood. Males will incubate brood but not tend young or forage for the colony. *B. hortorum* worker bees were also placed into each nest to aid incubation and to tend the queens. It was hoped they would stimulate the queen to lay eggs. Unfortunately, due to the older age of *B. hortorum* workers, many died within days of being placed in with a *B. subterraneus* queen. With a large number of queens in captivity the need for a large number of *B. hortorum* workers was great. A ready supply of a large number of *B. hortorum* workers was not available. Therefore workers were rationed, with between 1 and 10 workers given to each queen (photographs 26-27, Appendix two).

Initially, *B. subterraneus* queens showed a keen interest in the *B. hortorum* brood. Most proceeded to incubate until the pupae emerged but if the queens then failed to lay eggs the nest would decline and fail. Of the 67 queens collected 38 were seen to lay eggs and tend them but many of their eggs did not develop into larvae. Thirty two queens produced eggs before dying soon afterwards (unfortunately their eggs did not develop into larvae). Eight queens did progress their nests and they produced workers and males (photograph 27, Appendix two). Two other queens produced male offspring only, although in small numbers. Three queens did produce five queens before they also died. A high mortality was recorded amongst the *B. subterraneus* queens.

Hibernation and mating of *B. subterraneus* queens

The five captive breed second generation queens were mated with unrelated males in a glass aquarium and fed with pollen and an artificial nectar solution. Queens were seen to mate with more than one male. The queens post mating were then transferred into an incubator for hibernation. The queens were placed in match boxes in a plastic container. The temperature was set at 4°C and a relative humidity of 70%. The queens were removed

after three months to proceed with shipment to the UK. On removal it was noted by Rosemary Read that the queens were severely dehydrated and had died during hibernation. Bumblebee deaths during hibernation in all species can reach 50%. With such a high mortality rate the chances of five hibernating queens dying in hibernation was high.

Discussion on egg development

Many queens laid a large number of eggs, which failed to develop into larvae. Over 60% of queens died after laying eggs and only three of the 67 queens laid new queens. High mortality is experienced and expected in bumblebee nests, even the common carder bee, *B. pascuorum*, has 80-90% nest mortality (Goulson 2003). A number of possibilities could have been the cause of lack of egg development, for example insufficient high quality pollen, environmental stress such as disturbance, infertile queens. However, no predation of the eggs by queens was observed. Two queens produced just males, implying they could have been unmated or under environmental stress. Perhaps even the small number of founding queens initially sent to New Zealand may have had an impact on *B. subterraneus* fertility following genetic inbreeding.

Although a high death rate of *B. subterraneus* queens occurred, over half the captive queens did lay eggs, which is a considerable achievement. The production of sexuals must also be viewed in the same way. The results of this captive breeding experiment have led to new knowledge of *B. subterraneus* which can be utilised in future work

Nest box rearing 2010/11

Possible causes of why the queens did not develop their brood in 2009/10 may have been environmental stress or the lack of sufficient quality pollen i.e. red clover pollen. In the following season it was decided to try a more natural method. The steering group had previously discussed a revised captive rearing, breeding and hibernation methodology with Rosemary Read but this methodology could not be agreed upon at an acceptable price. The project therefore agreed with Rosemary Read and Barry Donovan that a new method would be tried. This new method required the use of one hundred and five bee nest boxes placed in the wild. Fifty wooden nest boxes, twenty five 'old' polystyrene boxes, and thirty new polystyrene boxes were placed in areas around the field sites where bumblebees would be nest searching (photographs 28-29, Appendix one). All nest boxes had entrance holes open at all times, unless a queen was caught and placed inside. Once a queen was caught she was marked (with pink nail polish) and sealed in the nest box for a period of 1-4 days. The nest box contained loft insulation, a clover honey solution, artificial nectar solution and worker brood removed from a *B. hortorum* nest. Five *B. hortorum* nests were brought by Barry Donovan for the purpose of using their brood and workers for queen *B. subterraneus*. This

method was aimed at encouraging and stimulating the queen into taking an interest in the brood, rearing the workers contained and laying her eggs on top of the existing brood.

Field site locations

The main field site for nest boxes was chosen to be Clyde (see Map 4, photographs 13,14, 20, 22,23 Appendix one) as potential nesting sites for the bumblebees were thought to be limited at this location and during the prior year the Clyde field sites contained the highest density of *B. subterraneus* queens. Some nest boxes were also deployed at Twizel and Lake Tekapo (see Map 4, Photographs 15, 16, 17, 18, 19, 21, 24, 25 Appendix one). Lake Wanaka was not used this year due to small numbers of *B. subterraneus* being observed in January 2009, and again in November/December 2009. Lake Ohio was surveyed as last year queens were present in small numbers but no nest boxes were to be placed there (map 4).

Collections and placing of queens in nest boxes

During the first week in New Zealand the project officer, Barry Donovan and Rosemary Read travelled to the field sites to place out the nest boxes. On arrival at Twizel initial searches were undertaken for *B. subterraneus*. A total of six queens were collected on garden plants *Robinia pseudo-acacia* and *Wiegelia* (no *E. vulgare* or *T. pratense* were flowering at this time). This year's emergence of *B. subterraneus* during the week of November 15th was approximately 2-4 weeks earlier than the previous year. A significant cause may have been the high spring temperatures.

Once collected, queens were put into a refrigerator at 5°C for 30 minutes to chill. The nest boxes were prepared and fresh *B. hortorum* brood added. The queens were then placed on top of the brood and covered with loft insulation and the nest box sealed. The nest boxes were then placed in an area which provided sufficient shelter and close proximity to food forage plants. These queens were released from their boxes the next day (other queens were sealed in for between 1-4 days) and observations were made of their exit (discussed later). As queens were beginning to emerge in Twizel, it was thought that queens would already be emerging in Clyde. So the decision was taken to continue on to Clyde to begin setting up nest boxes.

On arrival at Clyde the team immediately began to capture queens. However, it soon became apparent that many of the queens had already begun collecting pollen. Bumblebee queens that have begun collecting pollen may already have a nest and have laid eggs. Any queens with pollen were not collected as it can prove hard for them to lay more eggs when a nest site is changed and moreover it is not ethical to remove a queen from a fledgling colony. Queens with pollen were marked with blue nail polish, so they would not be caught at a later date and queens without pollen were marked with pink nail polish and placed into a nest box for a period of 1-4 days. Once unsealed the nest boxes were watched for 30 minutes to observe the queen's exit. The boxes were then left untouched for two weeks so

as not to disturb any nesting queens. After four days of field work in Clyde *B. subterraneus* queens collecting pollen had reached over 50%, and it became more difficult to find freshly emerged queens. In total 10 queens were found without pollen and 23 queens with. Given this ratio the decision was made to return to Twizel and focus efforts there. Any nest boxes not used for queens were moved to Twizel.

Due to the early spring *B. subterraneus* queens had emerged much earlier than the previous year. This meant by the time the project officer had arrived in New Zealand the bees had already been foraging for approximately 2 to 3 weeks in Clyde. However, due to differing micro climates between the field sites, Clyde queens emerge first, followed by Twizel and then Lake Tekapo.

Further queen collection began on return to Twizel, as *E. vulgare* and *T. pratense* were just coming into flower. Therefore many of the queens caught had not begun to collect pollen. The method of placing and sealing queens into nest boxes was repeated at Twizel.

Mornings and evenings are the most productive times for finding *B. subterraneus* queens (pers comm. Rosemary Read, per obsv Nikki Gammans). During the heat and strong sunlight of midday through until late afternoon (12-16:30pm), very few queens are found. The most productive collecting time is 30 minutes before dusk when queens come out for their last feed of the day.

Two weeks after leaving Clyde the project officer and a volunteer returned to Clyde to check nest boxes. The checks were carried out after dark using a red light to ascertain the presence of the queens and to reduce disturbance. The checks revealed no *B. subterraneus* queens had remained within the nest boxes. The same checks were later repeated in Twizel and again no *B. subterraneus* were found in the nest boxes. It was noted that three *B. ruderatus* had taken nests in Twizel and one *B. terrestris* in Clyde.

In total 46 queens were placed into nesting boxes using the previously described method. Records of observations of queens emerging from the boxes were positive. Queens would leave the nest box clean themselves, many would begin to scent mark on the box or on a nearby grass stem. Before the bees flew away they would circle around the box (up to six times) to orientate their position, two queens were observed re entering the box during this time. However, six of the 46 did fly straight away without any orientation. Following the lack of uptake of the boxes by the queens a decision was made to place queen excluder plates over the nest box entrance holes.

Nest boxes with metal queen excluders

The same wooden boxes were used and a small metal excluder plate with several holes 8mm in diameter was attached over the entrance hole of each box. Placed inside the nest box was the same food as before but pollen was now added. The food was changed daily to avoid mould or contamination. Pollen was offered mixed with a small amount of nectar and

slightly crushed together. Fresh brood was also placed inside the nest, along with five *B. hortorum* workers. The metal excluder allowed the workers to leave the box and forage but trapped the queen inside. The nest boxes were sealed until workers were sub dominant to the queen (between 3-7 days). Prior to placing the queens and workers together inside the nest box, they were all chilled in a refrigerator separately for 30 minutes and then placed together for a further 30 minutes (photograph 30, Appendix one). During the latter 30 minutes the queen and workers were shaken and mixed together to share their pheromones and to deter any attack. During the initial time period the queen was fed with artificial nectar solution on a small cotton wool ball. When the bees were mixed together this cotton wool feeder would remain and both queen and worker would rest on or around it and feed from it. This close feeding proximity would further integrate them.

The excluder method was used on eleven *B. subterraneus* queens, four collected from Twizel and seven from Lake Tekapo. Four of the eleven queens showed no interest in the brood or workers, but seven of the queens became dominant over the workers and cared for the brood. Six of these queens then laid eggs. However, the same problem occurred as last year with eggs not developing into larvae. Eventually three of these nests developed larvae (but unfortunately within the other remaining nests the queens had died (see photograph 31, Appendix one). Again high queen mortality was observed in *B. subterraneus*. Initially many queens would be active on the nest, tending the brood, and become dominant over the workers, but the queen would then become 'lethargic' and 'disinterested' in the nest. She would be found sitting on top of the nest covering or in a corner and she would not be protective of her nest. Within two or three days of the queen exhibiting this behaviour the queen would be found dead. Unfortunately before any *B. subterraneus* workers hatched all queens had died, therefore leaving no remaining chance of any sexuals being produced.

Summary

Again high *B. subterraneus* queen mortality was observed. This species has proved to be difficult to rear in captivity, as with other species of long tongue pocket makers. Although some success was observed in larval production the queens would often die before they pupated and emerged. Captive rearing of long tongue pocket makers has proved to be difficult in a laboratory and with nest boxes. If New Zealand continues to be used as a source population for *B. subterraneus* queens a new rearing method must be developed, which may prove to be difficult. Investigations into European populations of *B. subterraneus* should be researched as queens can be caught wild and directly transported back to the UK.

Public engagement and media coverage

The project aims to create public awareness of the reintroduction and to raise awareness of declining bumblebee numbers. This has been achieved by various methods such as

bumblebee identification walks and talks, information stalls at events, talks at conferences and meetings and assisting in lessons in primary and secondary schools.

Bumblebee walks and talks

A one hour talk was given on the conservation and importance of bumblebees and discussing why some bumblebee species are declining. The talk content contained several themes; the conservation and importance of bumblebees, working with farmers and land owners to recreate flower rich habitat, gardening for bumblebees and a short introduction to identification. The talk was then followed by a one hour walk to search, find and identify bumblebees (photograph 32, Appendix two). Merchandise was also sold at the talks with profits going to the project. On average, attendance at the bumblebee walks and talks was between 15-20 people. For a full list of bumblebee walk and talks refer to Appendix 1.

Invited talks

The project also offered talks to interested societies and was invited to give talks at Tunbridge Wells Museum, various beekeeping societies, Lydd District Council, various small holder groups, Kent Field Club, Kent Wildlife Trust, the Co-op group, and the Women's Institute. Merchandise was sold at these events and donations from the organisations were given to the project. At invited talks the average attendance was 25-30 people. For a full list of invited talk see Appendix three.

Events

The project has also been represented at various events such as the South of England show, BBC's Spring Wild Day Out, Natural England fairs, local carnival events, various Kent Wildlife Trust events, RSPB Dungeness bird fairs and a CAFE (Campaign for the Farmed Environment) event. For a full list of events see Appendix three.

To raise awareness amongst local people about gardening for bumblebees in July 2010 a bumblebee garden party was held at the home of a local supporter of the project, Louise Barton of Littlestone. This major event included talks, bumblebee identification walks, the showing of various garden plants suitable for bumblebees and the sale of wild flowers. Merchandise was available for purchase, tea and cakes were supplied, and a raffle was drawn to raise money for the project. Everyone who came to the event was given an information pack containing factsheets on gardening and conserving bumblebees. The packs also contained a free packet of wild flower seeds (donated by The English Cottage Garden Nursery Ltd). Over 100 people attended.

Conferences

The project has given talks at various conferences and academic fora such as National honeybee inspector convention (FERA), Bees, Wasps and Ants Recording Society (BWARS) AGM, British Ecology Society science festival, Natural England agri-environment scheme

conference and Bombus Working Group (academic bumblebee forum) meeting. Refer to Appendix three.

School groups

The project has also visited school groups to enthuse students about bee conservation (photograph 33, Appendix two). Currently five primary and secondary schools have been visited. Talks were given on bumblebee conservation, their importance and decline. The children then carried out age related activities.

Bumblebee Identification one day course

A one day bumblebee identification course was run for local people at the RSPB Dungeness visitor centre in June 2009 with 26 people attending. The event was jointly run by the project officer, Geoff Allen, the Kent aculate recorder, and Dr Ian Beavis, an entomologist from Tunbridge Wells Museum. Talks were given on the project, conservation and identification of bumblebees. These were followed by identification of specimens and finally a bumblebee walk to identify bumblebees in the field.

Donations

To date the project has raised over £2,500 in donations from attending various events, the selling of merchandise and donations given for talks. In addition Swift Ecology (Brian Banks an advisor to the project) had also donated £1,000 and local lady Louise Barton £2,000. Any profits from BBCT merchandise sold at events are given to the project. The project has also agreed deals with bumblebee book authors. Field Guide to British Bumblebees (Edwards & Jenner) is sold for £10 with £5 going to the project, Bumblebee Identification (Pinchen) is sold for £5 with £1.50 going to the project) and Bumblebees (Feltwell) is sold for £10.99 with £2.20 going to the project.

Articles

Various articles have been written by the project officer for high profile publications such as British Wildlife, BBC Wildlife magazine, Country Life, The Ecologist, New Zealand Geographic and Science. The project is also hoping to publish two papers on the rearing of *B. subterraneus* and the current work on habitat creation. Refer to Appendix four for a full list of articles.

Media coverage

The project has received excellent media coverage over its two years. Articles have appeared in many national newspapers for example Guardian, Independent, Daily Telegraph, Sun, Daily Mirror, Daily Mail, Metro and The Times. Articles have also appeared in regional, New Zealand and Australian newspapers. Many radio interviews have taken place such as with the Today programme, BBC five drive time, BBC farming today, and

regional and national radio stations in the UK, New Zealand and Australia. Television appearances have been shown on Meridian news and BBC Southeast. Articles have also appeared on the BBC website, British Ecological Society website, Farm Business and Planet Earth. A blog also appears on the BBCT website which is updated fortnightly on the projects progress, to date the blog has received over 1,500 hits. Please refer to appendix four for a full list of TV, radio and newspaper appearances.

The project is also currently involved in the filming of a BBC programme 'Rivers of Flowers', a three part programme concentrating on flower rich habitat creation in urban, gardens and the farming environment. The project will feature in the farming programme and two days of filming were undertaken with the project officer in 2010, including the bumblebee farm day event at Bosney farm. More filming is expected in 2011.

Conclusion and further recommendations

In summary the project to date has created and given advice on the management and maintenance of over 550 hectares of bumblebee flower rich habitat within the release site of Dungeness and Romney Marsh. Working with farmers and land owners has been highly successful and the project has been received positively by the local farming community. The project has also worked closely with local conservation and government bodies and given advice on cutting and sowing methods involved in creating flower rich habitats. The advice given to these bodies has been put into practise, and the net result of this work has seen an increase in the length of foraging season for bumblebees on Romney Marsh and Dungeness.

Walking transects recording bumblebee numbers and density provides the project with evidence of bumblebee species and their dispersal. Regular monitoring of habitat creation allows the project to also check on the responses of bumblebee species to newly created habitat. Work on improving corridors between habitats is thought to have resulted in the return of three BAP bumblebee species, *B. ruderatus*, *B. sylvarum* and *B. ruderarius* to areas such as Dungeness, where they have not been recorded for over ten years. A significant achievement for all those groups involved in the project. It is hoped the positive formula for working with land owners used by the project in this area can be used as a case study for the future. The project success demonstrates what can be achieved and replicated across the UK.

Although no reintroduction has taken place of *B. subterraneus* a considerable advancement of knowledge of this bee's ecology has been made. It is suggested that the project researches *B. subterraneus* population densities in European countries as wild queens may be caught directly and returned to the UK. This may greatly enhance the chances of a successful reintroduction and establishment of *B. subterraneus* back in the UK.

The project will continue with its well received outreach program of conducting bumblebee walks and talks, having stalls at events, attending invited talks and working with teachers in local schools. The project will also continue to promote itself at scientific and academic forums. It is intended within the next year to publish further papers on bumblebee habitat creation and *B. subterraneus* ecology.

Constraints to further progress

Although the project has made significant achievements with captive rearing *B. subterraneus* and gained new knowledge it is thought a more sustainable option for the reintroduction would be to collect queens from a European source. Current genetic research by Lye et al. (*In press*) suggests that the New Zealand population of *B. subterraneus* arose from only two queens, which implies the population has very low genetic diversity. If a small subset of this population is introduced to the UK they may not be genetically diverse enough to survive environmental changes. Although using New Zealand as a stock would

reintroduce the same genetic genotype (albeit small) the long term sustainability of this population would be reduced. An alternative would be to use a European stock. Initial research has shown that Sweden and Estonia have good populations of *B. subterraneus*, although in Estonia the bees are still classed as near-threatened. Contact with bumblebee expert Bjorn Cederberg in Sweden has said that *B. subterraneus* are a good population both in the south province of Skane and the northern province of Stockhlo and Uppsala and they would approve the collection of *B. subterraneus* for a future reintroduction.

Using a European stock would also reduce the difficulties of life cycles being out of synchronisation and the need for hibernation. As Sweden is within the EU the queens can be directly caught, checked for mites in Sweden and brought back to the UK for release without the need for captive rearing. This would greatly increase the chances of a successful reintroduction as more queens could potentially be returned compared to New Zealand (due to problems with captive rearing and hibernation). Initial talks with FERA with regards to import licenses have suggested Sweden would be a better alternative as specimens do not have to be returned prior to queens being exported.

The cost of importing queens from Sweden would also be greatly reduced compared to New Zealand as payment is not needed for captive rearing and hibernation. The project officer would also not be required to spend as much time in Sweden and local contacts could inform us of when the queens emerge as oppose to New Zealand where last minute flights and campervans would be fully booked or very expensive.

Appendix one garden flowers for bumblebees

| Flowering time | Plant |
|-----------------|--|
| March and April | Bluebell Bugle Flowering Currant Lungwort Pussy Willow Rosemary Dead-nettle <i>Erica carnea</i> |
| May and June | <i>Aquilegia</i> <i>Campanula</i> Chives Comfrey <i>Cotoneaster</i> Everlasting Pea <i>Geranium</i> Foxglove Honeysuckle Laburnum Lupin Thyme |

| | |
|------------------------|------------|
| July and August | Buddleia |
| | Cornflower |
| | Hollyhock |
| | Lavender |
| | Marjoram, |
| | Rock-rose |
| | Scabious |
| | Sunflower |
| | Heathers |

Appendix two photographs of events, volunteers, field sites and captive rearing



Photograph 3; Bosney farm day event



Photograph 4; Bosney farm day event, tour begins of farm



Photograph 5; Bosney farm day event advice on cutting hay fields



Photograph 6; Money Penny farm day event greeting marquee



Photograph 7; Money Penny farm tour of fields



Photograph 8; Money Penny farm bumblebee walk

Transect volunteers



Photograph 9; Geoff Allen and Nick Withers transect walkers (Little Cheyne Court wind farm)



Photograph 10; Duncan Lawrie transect walker (Littlestone golf course)



Photograph 11; Sue Trangamer transect walker (Dungeness road)

New Zealand volunteers 2009/10



Photograph 12; Andy and Maggie Tibbs and Rob Jones

Field sites New Zealand



Photograph 13; Clyde; George's farm red clover fields



Photograph 14; Clyde; George's farm new polystyrene boxes placed under tree shade



Photograph 15; Lake Tekapo; Godley peaks road, *E. vulgare* and Lupin's along road side



Photograph 16; Lake Tekapo; Godley Peaks Road



Photograph 17; Lake Tekapo New build site



Photograph 18; Lake Tekapo; new build site, volunteer Ian Gammans



Photograph 19; Twizel; Black stilt pond site



Photograph 20; Clyde; Neil Ford's red clover field



Photograph 21; Twizel rubbish dump



Photograph 22; Clyde; Springvale grove



Photograph 23; Clyde; McIntosh road hay field



Photograph 24; Twizel; Kelland pond



Photograph 25; Twizel New Build



Photograph 26; *B. subterraneus* queens in wooden captive rearing boxes



Photograph 27; *B. subterraneus* queen with five *B. hortorum* works and brood. Note *B. subterraneus* larvae developing



Photograph 28; Wooden nest box located in Clyde



Photograph 29; Polystyrene box located at Clyde



Photograph 30; Queen *B. subterraneus* with five *B. hortorum* workers chilled together for 30 minutes



Photograph 31; Queen *B. subterraneus* with *B. hortorum* workers tending queen larvae



Photograph 32; Bumblebee ID walk Kent Wildlife Trust Romshed farm



Photograph 33; Primary school Playden

Appendix three- Events attended

2009

Hymettus annual meeting- talk

Natural England Ashford office- talk

Bumblebee working group- talk

CSL honeybee inspector conference- talk

Farmer tea and cake bumblebee event

Dungeness bumblebee walk and talk

MOD conservation forum – talk

High wealds bumblebee walk and talk

Farm day event Money Penny Farm

East Sussex garden centre weekend event- stall

FWAG conservation farmer of the year East Sussex- attendance

Wye National Nature Reserve festival- stall

Bumblebee walk and talk Kent wildlife trust

Bumblebee walk and talk Rye harbour Nature Reserve

Dungeness countryside fair weekend- stall

Bumblebee identification course one day host Dungeness

British Ecological Society conference, University of Surrey- talk

Saint Michaels Primary School Playden- lessons taught

Tunbridge Wells Museum- invited talk

BWARS symposium- talk

Ashford beekeepers association- invited talk

Lydd council- talk

2010

Dungeness RSPB-talk

Kent field club AGM- talk
Thomas Hardy secondary school 'meet the scientist'
Brookes Ward School- teach lessons
Saint Andrews Primary School- lessons
RSPB Sandy Lodge- talk
Environment Agency- talk
Kent Wildlife Trust- talk
Natural England agri-environment conference- talk
Maidstone honeybee society- talk
Lullingstone Castle event- stall and talk
Womens Institute talk for invited talks
Campaign for the farmed environment- talk
Rye Harbour bumblebee walk and talk
BBC Spring Wild day out- stall
South of England South three day event- stall
Lydd carnival- stall
RSPB Dungeness bumblebee walk and talk
Romney Marsh Stakeholders group- talk
Saint Andrews school- lessons taught
Romshed farm bumblebee walk and stall
Tunbridge Wells bumblebee walk and talk
Hastings country park bumblebee walk and talk
East Kent small holders bumblebee walk and talk
RSPB Dungeness bumblebee walk and talk
Co-op plan B bumblebee walk and talk
RSPB Dungeness bird fair weekend- walk and talk, stall

Kent Wildlife Trust Sevenoaks wildlife reserve festival bumblebee walks and talks, stall

Woodland festival –stall

Ashford honeybee keepers association- invited talk

Worthing honeybee keepers association- invited talk

National Honey show three day event- stall

2011

Netherfield Honeybee keepers- invited talk

Womens Institute- invited talk

Orpington honeybee keepers- invited talk

Whitstable field club- invited talk

Bumblebee working group- attendee

Womens institute- invited talk

British Heart Foundation- invited talk

Women's institute- invited talk

Faversham Royal Entomological Society conference- attendee

Littlebourne Tuesday Club- invited talk

Appendix four Media coverage

Web pages

- Guardian on line
- BBC
- Country Life
- Farm business
- 3 news NZ
- RSPB news page
- Natural England
- E! Science news
- BES
- Treehugger
- apn.co.uk
- Redorbit.co.uk
- Yahoo.com
- www.surfbirds.com
- www.birdguides.com
- RX wildlife (numerous times)
- Natural History Museum
- Planet earth
- This New Zealand life
- www.habitat.org.uk
- Smallholder.co.uk

Television

- BBC Southeast 2009/10
- ITN but with honeybees 2009
- Meridian news 2010

Newspapers

- The Times
- The Daily Mail
- The Daily Mirror
- The metro
- NZ Herald
- Sydney morning herald
- New Zealand press association
- The Daily Telegraph
- The Sun

- Guardian
- Meridian news
- Hawkinge gazette
- BBC home page
- Yorkshire post
- Manchester wired
- Teletext

Radio

- Radio Live New Zealand
- BBC Radio New Zealand
- Today programme BBC 4
- Radio 2
- BBC farming today
- BBC five live drive time
- Today programme (two slots)

Journals

- New Zealand geographic
- Country life
- BBC Wildlife Magazine
- British wildlife magazine
- Science
- The ecologist