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The Decline of England's Bees

Policy Review and Recommendations

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Danny Perez

Honey Bee (Apis mellifera) visiting a garden plant, Californian poppy (Escholtzia sp.)

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Glossary of Abbreviations

AES: Agri-Environment Schemes

AONB: Areas of Outstanding Natural Beauty

BARS: Biodiversity Action Reporting System

CAP: The European Union's Common Agricultural Policy

CFE: Campaign for the Farmed Environment

DEFRA: Department for Environment Food and Rural Affairs

EBS: The New England Biodiversity Strategy

EC: The European Commission

EFA: Ecological Focus Areas

EFSA: European Food Safety Agency

EIA: Environmental Impact Assessment

ELS: Entry Level Stewardship

ETIP: Entry Level Stewardship Training and Information Programme

EU: The European Union

FERA: Food and Environment Research Agency

GI: Green Infrastructure

GM: Genetically Modified

Ha: Hectares, a unit of land area equivalent to 100m x 100m

IBDA: Integrated Biodiversity Delivery Areas

IUCN: International Union for the Conservation of Nature

HGCA: Home Grown Cereals Authority

HLS: Higher Level Stewardship

HSE: Health and Safety Executive

JNCC: Joint Nature Conservancy Council

LNP: Local Nature Partnership

MRL: Maximum Residue Levels

NBU: National Bee Unit

NERC S41: Section 41 of the Natural Environment and Rural Communities Act 2006

NIA: Nature Improvement Areas

NPPF: National Policy Planning Framework

OELS: Organic Entry Level Stewardship

POST: Parliamentary Office of Science and Technology

PPP: Plant Protection Product (inc. Pesticides)

RPA: The Rural Payments Agency

RSPB: Royal Society for the Protection of Birds

RSS: Regional Spatial Strategy

SAC: Special Areas of Conservation

SFS: Small Farmer Scheme

SPA: Special Protection Areas

SSSI: Sites of Special Scientific Interest

UK: The United Kingdom, comprising England, Wales, Scotland and Northern Ireland.

UKBAP: The UK Biodiversity Action Plan

UELS: Upland Entry Level Stewardship

UN: The United Nations

VMD: Veterinary Medicines Directorate

WTO: World Trade Organisation

Executive Summary

Bees are a vital component in ecological networks and provide significant social and economic benefits to humans through crop pollination and maintaining the character of the landscape. Despite their importance, both to people and the natural environment, unsustainable agriculture, diseases and habitat degradation have placed significant pressures on many species of bees, causing widespread declines. In conjunction with the scientific literature this report reviews seven areas of current and proposed government policy in England (Agricultural Production, Agrochemicals, Agri-Environment Schemes, Habitat Conservation, Planning, Species Conservation and Bee Health) to identify areas where these policies can affect bees.

1. Agricultural Production

Agriculture is the largest land use in the UK and can have a significant impact upon bees by affecting the quality and diversity of habitat within the landscape. The report recommends that the UK government takes opportunities to further "green" farming in the UK and provide much needed support to Fruit and Vegetable growers and environmentally friendly farming systems such as agroforestry. This should be accompanied by supporting research into the pollination requirements of crops, with information disseminated to farmers to reduce risks.

2. Agrochemicals

Even when correctly applied pesticides can have adverse impacts upon bees by reducing their breeding success and resistance to disease, and by reducing the availability of valuable forage plants. The report recommends that the government should commit to a targeted reduction in pesticide use by 2020. This should be accompanied by substantially improving pesticide labelling and accreditation regulations to mandate detailed assessments of the impacts upon all bees, not just honeybees.

3. Agri-Environment Schemes

Agri-Environment Schemes have great potential to provide forage and nesting sites to bees but the uptake of the most beneficial options has been limited. The report recommends that greater support is given to Natural England and industry efforts to improve the uptake of these options and develop more targeted objectives for Agri-Environment Schemes.

4. Habitat Conservation

Many habitats of national conservation priority provide important forage and nesting resources for bees, however, despite protected designations, many are still in decline. The report recommends that protection for these sites should be strengthened by designating more sites with priority habitats for bees, reforming Environmental Impact Assessment regulations and improving cross-policy co-ordination to deliver the strongest benefits to bees over the whole landscape.

5. Planning

Despite the importance of bees to the economy and human wellbeing, new planning guidelines do not provide detailed information for local authorities to develop green infrastructure that can significantly benefit bees, such as allotments and flower-rich road verges. The report recommends that new guidelines are made available to local authorities that better integrate these beneficial options and that environmental damage regulations are strengthened to reduce the negative impacts of development on bee habitats.

6. Species Conservation

Although several bee species are recognised as national conservation priorities, as a group, bees have received little formal monitoring and conservation effort. The report recommends that bees should be included as a priority species group in the new England Biodiversity Strategy and that a network of experts should be established to advise local authorities on developing bee-targeted action plans.

7. Bee Health

Policy on bee health has been largely effective but is limited by unnecessary restrictions on veterinary medicine products and does not sufficiently recognise wild bee health. The report recommends that restrictions on veterinary medicines for bees should be lifted and that beekeeper registration should be mandatory. New policy should also be developed to curb the spread of disease between wild and managed bees.

SECTION 1

Why are Bees Important?

The UK is presently home to some 267 species of bees ranging from the widely recognised honeybee (*Apis mellifera*) and bumblebees which live in social colonies with a single reproductive queen to over 220 species of solitary bees that live alone in small nests in bare soil, masonry or wood. Bees have great intrinsic value to people across the UK and were widely regarded as a key symbol of the natural world by respondents in a recent survey of attitudes towards nature conducted by DEFRA (2011a). Due to their diverse life cycles, exclusive diet of pollen and nectar and specialised morphology, bees are considered the primary providers of pollination services[1] for most insect-pollinated crops and wildflowers within the UK. Pollination by insects is thought to be the main reproductive mechanism in 78% of temperate flowering plants and is essential to maintaining plant genetic diversity (Ollerton et al, 2011). Declines in wild bees have been closely associated with similar declines in these plants (Beismeijer et al, 2006; Carvell et al, 2006). These plants, such as bluebells or poppies, can have aesthetic importance to people by improving the overall look of the landscape, gardens and other green spaces from parks to road verges (Willis and Garrod, 1993; Akbar et al, 2003; Lindemann-Matthies et al, 2009). Insect-pollinated plants and their fruits or seeds are also important to wider biodiversity, providing food, shelter and other resources to mammals, birds and other insects. For instance hawthorn (*Crataegus* spp.) is an important forage plant for many of the UKs farmland birds (Jacobs et al, 2009). On a longer time-scale, pollination can also affect the spread of rare habitats such as heathland which has unique biodiversity, cultural and economic value itself (Wessel et al, 2004).

Pollination by bees is an important component of UK food security and several species of bees, including honeybees and the buff-tailed bumblebee (*Bombus terrestris*) are commercially reared specifically to provide pollination to crops such as apples, strawberries, tomatoes and oilseed rape (Delaplane and Mayer, 2000). Although honeybees are effective pollinators of most crops, particularly mass-flowering oilseed rape (Rader et al, 2009), other species can be more effective at pollinating other crops. For instance mason bees (*Osmia* sp) are more effective pollinators of apple (Thomson and Goodall, 2001) and honeybees are ineffective at pollinating tomatoes which require larger bodied bumblebees to "buzz-pollinate" them by vibrating the flowers to release pollen (Delaplane and Mayer, 2000). Long-tongued bees are also essential pollinators of field beans as other bees cannot access their deep nectaries without biting into the side of the flower first, allowing them to feed but not providing pollination to the flower (Free, 1993). However, for some crops, such as strawberry, a combination of wild and managed bees is needed to produce fruits of market quality (Chagnon et al, 1993). Insect-pollinated crops are also major sources of vitamins A and C and minerals such as Calcium and Fluoride (Eilers et al, 2011) and yields of over 20 crops within the UK are increased by pollination services (Klein et al, 2007; Free, 1993). In 2009, these crops covered 19% (0.8m ha) of UK crop area and represented 24% (£1.27bn) of total UK crop sales (calculated from DEFRA 2011a,b using the methods of Breeze et al, 2011). Of this, some £510m of total crop sales value is thought to directly arise from pollination services as of 2009 (Table 1.1), a rise of £80m from 2007 due to the growing farmgate prices of strawberries, apples and oilseed rape (DEFRA, 2011b,c). By contrast, to replace pollination services provided by bees with hand pollination could cost farmers around £1.8bn/year in labour and pollen alone (Breeze, 2012 – Chapter 4). The majority of the benefits to crop production are found within England, particularly the southern and eastern regions where high-value fruit crops and large areas of oilseed rape are grown (Table 1.2). By maintaining yields, these pollination services also allow supply to better meet demand, stabilising prices to consumers in the process (Gallai et al, 2009). In the absence of bees, the farmgate price of British Apples for example would double (Marris et al, 2008). Pollination by bees can also improve the market quality (Chagnon et al, 1993), taste (Hogendoorn et al, 2010) and nutrient profile of crops (Volz et al, 1996; Bommarco et al, 2012) and maintain genetic diversity necessary for fighting disease (Somerville et al, 1999). Beyond crops, bees also pollinate clovers and other nitrogen fixing plants that are important to improving the productivity of pasture systems for livestock grazing which are themselves major agricultural enterprises

1 Pollination Services represent the enhancement of any benefits derived from plants which reproduce by insect pollination. See the Smith et al (2011) for more details.

in Wales, the Highlands and northern and western parts of England. The economic benefits of this are presently unknown but likely to be high.

The demands for pollination by bees to crop markets across England are likely to grow in the near future as more oilseed rape is planted to supply biofuel (Arnoult et al, 2010) and demands for locally-grown produce (Brown et al, 2009) and new crops, such as blueberries and borage, continue to grow (Nix, 2011). Furthermore, trials in North America have demonstrated that managed bees are able to provide additional benefits to crop producers by helping transmit diseases which infect crop pests, thereby reducing the need for pesticides (Kevan et al, 2008). In towns and urban areas, bees can also provide pollination services to fruits and vegetables grown in gardens and allotments (Ahrne, 2008). Allotments are increasingly in demand within urban England, with waiting lists rising dramatically from 4.9 persons/plot in 2009 to 5.7 persons/plot in 2011 (Campbell and Campbell, 2011).

Bumblebee (Bombus sp)

Table 1.1. Crop dependencies on pollinators and annual value of pollination in 2009

Source: DEFRA (2011a,b; Smith et al, 2011)

Crop	Dependence on Pollinators (%)	Value Per Annum (£ millions) 2009
Oilseed Rape	25	117
Strawberries	45	109
Dessert Apples	85	53
Culinary Apples	85	39
Raspberries	45	49
Cucumbers	65	28
Tomatoes	25	22
Runner Beans	85	12
Plums	65	7
Pears	65	7
Other	5-85	68
Total		**Approx. 510**

Table 1.2: Value of Pollination Services to Crop Production in different Regions of the UK in 2009

Source: Calculated from June census data from England, Scotland and Northern Ireland. No data on the area of Insect-pollinated crops is available for Wales as the total grown is too small to be reported anonymously

Region	Value of Insect-pollinated Production	% of total
North West	£9.5m	1.8%
North East	£8.5m	1.6%
Yorkshire & The Humber	£31.8m	6.2%
West Midlands	£70.1m	13.8%
East Midlands	£49.8m	9.8%
Eastern	£88.0m	17.2%
South East	£137.4m	26.9%
South West	£38.0m	7.4%
England	£433m	84.9%
NW Scotland	£2.0m	0.04%
NE Scotland	£9.8m	1.9%
SW Scotland	£3.8m	0.07%
SE Scotland	£43.9m	8.6%
Scotland	£59.4m	11.6%
Wales	NA	NA
N. Ireland	£17.7m	3.4%
UK Total	**£510.2m**	

SECTION 2

Bee Declines

2.1. The Decline of English Bees

In recent years, research has demonstrated substantial declines in many species of bees within the UK. In particular, the number of managed honeybee colonies in the UK fell by 53% between 1985 and 2005 (Potts et al, 2010a) and wild honeybees are thought be nearly extinct throughout the British Isles (Carreck, 2008) although their true status remains unknown. Other studies have demonstrated significant contraction in the ranges of many species of wild bumblebees (Goulson et al, 2008) and solitary bee diversity has declined in 52% of English landscapes assessed by Beismeijer et al, (2006).England's Natural Environment and Rural Communities Section 41 (NERC S41) list of priority species includes 17 wild bees, most of them solitary bees, as targets for potential conservation action (Natural England, 2010a), as most efforts have thus far been focused on gathering detailed ecological and distributional data into these species (e.g. Hymettus, 2011). However, since 1900 only two species of bumblebee have become extinct and some of the most common bumblebee species have become more widespread across England (Edwards and Broad, 2005; Edwards and Roy, 2007), although due to a lack of monitoring schemes, the abundance of these species remains unknown. In general, solitary bees, species with more specialised feeding and nesting habits and those with a low capacity to disperse between habitats, typically smaller-bodied species, are thought to be the most vulnerable (Williams et al, 2010, 2007; Goulson et al, 2008).

2.2. Drivers of Bee Declines

Over the past 50 years British agriculture has shifted from labour-intensive, traditionally-managed farms with numerous small fields to an input-intensive system characterised by large crop monocultures and high density livestock farming (Robinson and Sutherland, 2002). This intensification of agriculture has a number of impacts upon the availability of resources for wild and managed bees at a landscape scale (Feon et al, 2010) and is widely regarded as the primary driver of bee declines across Europe (Kundla et al, 2009). This is supported by numerous studies from Europe, the UK and North America that demonstrate that in homogeneous landscapes dominated by few crop species and scattered semi-natural habitats support significantly fewer wild bee species, often with less individuals than more diverse landscapes where abundant resources are available throughout the year (Kuussaari et al, 2011; Brittan et al, 2010a; Feon et al, 2010; Williams et al, 2010). By expanding fields, increasing chemical inputs and ceasing traditional management, many previously common, semi-natural habitats that are important for bees have become increasingly rare within the British countryside. For example, species-rich hay meadows, once a common means to provide hay for livestock fodder over the winter period, have declined by 97% since the 1930's as producers moved towards silage production (Fuller, 1987). Similarly increased use of fertilisers has reduced the area of nutrient poor soil, reducing the area of species-rich bee habitats that require poor soil such as calcareous grassland (Henle et al, 2008). Such semi-natural habitat losses have resulted in substantial declines in the presence of many bumblebee forage plant species throughout England (Carvell et al, 2006). This can be very detrimental to species that have narrow foraging preferences, such as the NERC S41 listed Shrill Carder Bee (*Bombus sylvarum*) (Connop et al, 2010). Many of England's hedges, which act as important corridors for wild bees to move safely between feeding and nesting sites (Hannon and Sisk, 2009), have also continued to decline in total extent (Countryside Survey, 2009). Subsequently, bee populations, particularly solitary bees, can become isolated and unable to access sufficient nesting or forage resources, a particular problem for smaller solitary bees with limited capacity to disperse (Williams et al, 2010). Such isolated populations may also suffer from inbreeding depression or losses in genetic diversity, as has been demonstrated in the NERC S41 listed species *Colletes floralis* (Davis et al, 2010) and *Bombus muscorum* (Whitehorn, 2011).

Modern intensive farming practices within England have used increasingly large quantities of synthetic herbicides and insecticides to control detrimental plants and insects (DEFRA, 2011b). By removing flowering plants which provide feeding resources to bees within fields, herbicide use, along with high nitrogen inputs, can reduce the availability of forage to bees within already homogenised landscapes (Kleijn et al, 2009). Insecticides, particularly neonicotinoids, can also have a more direct effect on populations of all bees by reducing breeding success (Lu et al, 2012; Whitehorn et al, 2012), metabolic efficiency (Hawthorne and Dively, 2011) disease resistance (Pettis et al, 2012) or foraging efficiency (Yang et al, 2008) or by causing direct mortality (Scott-Dupree et al, 2009) or mass homing failure in affected social bees (Henry et al, 2012). The impacts of insecticides on solitary bees have rarely been assessed although evidence suggests they may be more vulnerable than bumblebees or honeybees (Scott-Dupree et al, 2009; Williams et al, 2010). Uncontrolled, plant feeding pest insects may have detrimental impacts both on crop yields and on the availability of nectar for bees to forage upon (Sober et al, 2010), although a range of alternative pest management methods are now in development (section 3.2).

Pests and diseases are thought to be a major cause of mortality among honeybees and other managed bees, although their impact on wild bees remains difficult to assess (Kundla et al, 2009). At present, the main parasites and diseases afflicting honeybees are the mite *Varroa destructor*, the *Nosema* family of fungi, foulbrood bacteria (e.g. *Melissococcus plutonius*) and a number of viruses, each of which can cause substantial losses within honeybee colonies (Formato et al, 2010). *V. destructor*, now widespread throughout the UK, is not a direct cause of mortality itself but acts as a reservoir of diseases that directly afflict parasitized bees. Subsequently it is believed to be the main cause in the virtual extinction of feral honeybees across the UK (Carreck et al, 2008). Foulbrood infections, which infect and kill honeybee brood through infected honey, are another potentially widespread threat as their spores can persist for up to 40 years and they are potentially easily transmitted between hives (Formato et al, 2010). The incidence of foulbrood is thought to be widespread, however the prevalence of *Nosema* fungi and viruses is almost impossible to determine as they require direct genetic analysis and dissection of infected bees to be identified (Formato et al, 2010).

Climate change has had a notable impact upon the distribution of many wild bees, with several species such as the newly arrived Tree Bumblebee (*Bombus hypnorum*) migrating north in the past 20 years as the climate has started to warm (Edwards and Broad, 2005). Climate change can also disrupt the timing of plant flowering or bee emergence, resulting in wild bees emerging before or after ample forage is available (Memmott et al, 2007; Williams et al, 2007). Some authors have also expressed concerns that managed bees may have negative impacts upon wild bees by increasing competition for forage (Goulson and Sparrow, 2009) and spreading diseases to native populations (Meeus et al, 2011; Otterstatter and Thomson, 2011). Other suggested causes of bee declines include the use of mobile phones and power lines, although no study has yet produced evidence in field conditions to support this. A more fundamental issue concerning honeybees may simply be the 78% decline in beekeepers in England and Wales since 1953 as disease control and low honey prices continue to dissuade people from taking up beekeeping in large numbers (Potts et al, 2010a).

2.3. The Impacts of bee declines

Presently, the impacts of bee declines on pollination in wild plants and crops remain largely uncertain due to gaps in understanding of plant-pollinator communities, including the role of hoverflies, approximately 250 species of which are found within the UK and can also be important pollination service providers (Biesmeijer et al, 2006). For instance, while Biesmeijer et al (2006) demonstrate that insect-pollinated wild plants have declined in parallel with solitary bees, it is not clear whether these losses are the cause or effect of bee declines or the result of a common driver. Regardless, several studies have demonstrated that diverse communities of pollinators provide more effective pollination services to crops and wild plants than less diverse communities (Winfree and Kremen, 2009; Hoehn et al, 2008). Furthermore, a recent study by Garibaldi et al (2011) indicates that yields of insect-pollinated crops are more unstable when the pollinator community comprises fewer species. Breeze et al (2011) also note that while the UK's honeybee populations are insufficient to supply more than 34% of British agricultural demands for pollination services in 2007, there was no evidence of general declines in crop yields over the study period, suggesting that wild bees may play a more important role in crop pollination than previously believed. As mass-flowering crops such as oilseed rape, one of England's most widespread arable crops (DEFRA, 2011b), can provide attractive short-term resources for bees (Westphal et al, 2003) it is speculated that honeybee losses have caused a shift in wild bee visitation from wild plants to crops, although no data exists to substantiate this (Breeze et al, 2011). However, increased competition between bumblebee species following the end of mass-flowering crops has been reported by two studies in Germany, putting pressure on already vulnerable long-tongued species (Diekotter et al, 2010; Holzschuh et al, 2011).

Shrill Carder Bee – top, Tree Bumblebee – bottom

Photographs: Jeremy Early

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SECTION 3

English policy and Bees

3.1. Agricultural Production

3.1.1. General farming policies

Agriculture represents approximately 70% of England's land use (DEFRA, 2011b) and as such agricultural production can have a substantial impact upon the resources available to bees throughout the landscape. In particular mass-flowering crops, such as apples or oilseed rape, can provide short-term but highly abundant forage for local bees and pasture grazing can influence the quality of nesting sites and bee forage in grasslands (Dicks et al, 2010). Past agricultural production has been heavily driven by the European Union's Common Agricultural Policy (CAP) which promoted agricultural intensification to maximise production via yield dependent subsidies (Robinson and Sutherland, 2002). Various CAP reforms, notably the 2003 Mid-Term Review, saw the complete removal of these production dependent subsidies in favour of a flat rate per hectare based upon past regional payments and subject to a series of good environmental practices (cross-compliance[2]). Decoupling payments in this manner was projected to reduce the intensity of production, particularly for livestock, although concerns were raised that this would lead to increased land abandonment in disadvantaged areas where subsidies had previously made grazing profitable (Stoate et al, 2009). Abandoned agricultural land can quickly become dominated by scrub, reducing resource availability for bees and other insects (Dicks et al, 2010). Although there have been notable reductions in sheep herds, particularly in upland regions, since the reforms' introduction in 2005, cattle numbers have remained stable and the 5% loss of temporary pasture has been compensated by a 5% increase in permanent pasture (DEFRA, 2011b,d). This is thought to have contributed to a reduction in overgrazing, where livestock density is high enough to damage plant communities by preventing flowers from setting seed, however, under-grazing, where so few livestock are used that land begins to become dominated by scrub, is thought to be more common instead (House of Commons, 2011a)

UK cross-compliance regulations also mandate a minimal management regime for unused land to maintain a minimal environmental quality (GAEC12 – RPA, 2011), potentially minimising adverse impacts. Conversely, agriculture now occupies 2% less total land than in 2005, suggesting that areas may now lie totally abandoned as farmers leave the industry. The lifting of requirements to remove periodically land from production (set-aside) during the 2008 CAP health check reforms has also seen a 23% drop in rotational fallows which are known to benefit wild bees (Kuussaari et al, 2011). In their place, DEFRA has given publicity support to the industry led Campaign for the Farmed Environment (CFE) which has seen some success in persuading farmers to remove land from production and/or manage it for wildlife, including wild bees in particular (CFE, 2011a).

Reductions in price controls have also seen an expansion in market influence on production. In particular, the Renewable Energy Directive[3] has driven a sharp rise in demand for biodiesel from oilseed rape (Arnoult et al, 2010), causing substantial growth in the area planted across the UK and England in particular (DEFRA, 2011d). Large-scale production of oilseed rape has been demonstrated to cause population booms within short-tongue bumblebees, increasing their competition with long-tongue species over the course of the season (Diekotter et al, 2010). As long-tongued bumblebees are thought to be the main pollinators of field beans (Free, 1993), commonly grown in crop rotations for livestock fodder (DEFRA, 2011b), reductions in long-tongue bumblebee populations may have an adverse effect upon the stability of pollination services in such rotations. Growth in demand for oilseed rape is likely to continue as the government aims to meet the fuel obligations of the Renewable Energy Directive (Arnoult et al, 2010) which sets a target of 10% of EU member states road fuel to come from renewable sources by 2020 (EC, 2009a). This growth in the area of other biofuel crops which are not mass-flowering, such as wheat, may reduce the overall availability of arable floral resources with negative impacts on wild bee communities.

3.1.2. Alternative farming systems

Low input farming systems, particularly organic farming, are believed to have lower environmental impacts and support greater biodiversity than conventional, high input systems. At present there is no specific policy encouraging organic production systems in England, although the Organic Entry Level

2 Commission Regulation (EC) No 1122/2009 contains the most recent EU cross compliance guidelines and Agriculture (Cross-Compliance) Regulations 2009 includes additions by the UK government

3 Latest version: Directive 2009/28/EC

Stewardship provides conversion grants for farmers and additional support subsidies to compensate for the added risks involved (Natural England, 2010b). Organic farming prohibits the use of synthetic fertilisers[4] (EC, 2009b) and encourages the use of crop rotations, diverse crop varieties and sympathetic habitat management to reduce pest and disease impacts (Soil Association, 2012; Organic Farmers and Growers, 2006; Organic Food Federation, 2009). Presently there are 392,000 ha of organic land within England, 51% of which is permanent pasture (DEFRA, 2011b); however consumer demand for organic produce has been in decline in recent years (Nix, 2011), although this trend may reverse. Several studies have demonstrated that aspects of organic farming practices can increase the diversity and abundance of bees at a landscape scale in conjunction with well managed semi-natural habitats (e.g. Holzchuh et al, 2008; Power and Stout, 2011) although this is not always the case (e.g. Brittan et al, 2010a; Sarospataki et al, 2009). Mixed cropping systems, whereby farmers plant two crops within the same field, present a means of reducing the impacts of crop monocultures upon bees by providing more mixed resources across a landscape. To date there is no information on the prevalence of this system within English agriculture and no government support is presently available. Another mixed cropping system, Agroforestry, combines crop or livestock agriculture with forestry or orchard production and has been demonstrated to support significantly greater numbers and diversity of bees (Ricketts et al, 2008). Although the EU Rural Development Regulations (1698/2005/EC – EC, 2005) set out a definition of agroforestry with clauses for government support of 70-85% for establishment, to date the UK Government has not adopted these or the definition[5] of agroforestry systems (Smith, 2010). Consequently, there are no specific schemes to support conversion to agroforestry systems and the density of trees planted often qualifies the land as forestry (>500 trees/Ha), disqualifying them from receiving payments under the CAP Single Payment Scheme and thereby limiting Agri-environmental support (Smith, 2010).

3.1.3. Future production policy

The CAP is due for further reforms in 2013. Current proposals (EC, 2011a) aim to further "green" Pillar I, the agricultural subsidies axis of CAP, by mandating the maintenance of permanent grassland and introducing mandatory Ecological Focus Areas (EFA) and a requirement for crop diversification. EFA would require that ≥7% of land entitled to CAP payments should be managed as fallows, buffer strips, hedgerows and other low-input features. Although if implemented this will be likely to have a positive impact on bee populations by encouraging beneficial habitat such as rotational fallows (Kuussaari et al, 2011), the extent of land required is lower than the 10% previously mandated as set-aside and allows boundary features in addition to managed area to be counted towards the target. They also do not include beneficial farm business measures such as planting flowering legumes as cover crops or pasture leys which can provide benefits both to bees, through providing diverse floral resources, and farmers, by increasing soil fertility, reducing disease loads and pest populations (Sarrantonio, 2007). These requirements would be subsidised in addition to standard payments as part of a revised version of the Single Payment Scheme – the Basic Payment Scheme – however an alternative scheme which does not entail these requirements or cross-compliance, the Small Farmer Scheme[6] (SFS), would also be available, for farmers with smaller holdings that have typically received less CAP support in the past. Although SFS would be capped at 10% of the total CAP budget per member state, nonetheless a significant area could still go without even minimal environmental management. Despite promises to encourage the greening of CAP[7] (HM Government, 2011a), the Government has been very critical of these Pillar I reforms, expressing concerns that they may not be cost-effective and do not go far enough to reduce the role of subsidies in farm income (DEFRA, 2011e). Furthermore, CAP reforms would mandate growing at least three different crops, each of which must occupy between 5% and 70% of cropped fields >3Ha on each claimants holding (EC, 2011a). While this will likely encourage the presence of at least some mass-flowering crop for bees to forage upon within farmed landscapes, periods of resource drought may still result if no mass-flowering crops are grown following years of extensive growth and it is possible for farmers to make up these requirements using only token small areas of third crops while growing two main crops in large areas over successive years. Furthermore, as highlighted previously, there may also be negative impacts upon some members of bee communities when planting large areas of a single mass-flowering crop (Diekotter et al, 2010). Stronger measures on diversification could redress this issue by reducing the extent of monocultures and encouraging rotational practices.

Further changes in crop production are likely to arise from current government commitments to improving fruit and vegetable consumption (HM Government, 2011b) and meeting the demands of a growing population with more sustainable and competitive agriculture (HM Government, 2011a). Past studies have demonstrated using hypothetical initiatives (e.g. "fat taxes"[8]) that altering production

4 Council Regulation (EC) No 834/2007
5 Article 44, paragraph b) defines agroforestry as "land use systems in which trees are grown in combination with agriculture on the same land." This definition is adopted in Northern Ireland (Smith, 2010)

6 Section 92
7 Page 5: Paragraph 19
8 Fat taxes are not presently within current government agendas on food

to reflect increased demands for fruits and vegetables over meats produce substantial declines in pastureland, livestock numbers and the areas of mass-flowering arable crops grown as fodder as demand for meat falls (Arnoult et al, 2010). Similarly, replacing imported soybean meal with locally grown protein crops, such as field beans and dry peas, has also been suggested as a key means of improving sustainability within agriculture by the EU, although such initiatives are not currently on the UK government's agenda (EC, 2010a). If successful this would result in an increase in mass-flowering crop area, however the benefits for bees are likely to be confined to the long-tongued species that can access the nectaries of field beans (Delaplane and Mayer, 2000). Furthermore because of the unfavourable markets for many of these crops Pillar I subsidisation is likely to be required to incentivise their production, contrary to current government agenda (DEFRA, 2011e).

Finally, proposed reforms to Pillar II, the rural-environmental axis of CAP, aim to see greater expansion of funds towards rural development, including income diversification and risk assessment. As pollinators, bee populations can have a substantial impact upon the stability of yields (Garibaldi et al, 2011) and the capacity of farmers to grow diverse, high value crops (Klein et al, 2007). However, despite the growing importance of pollination services to agriculture across the UK (Breeze et al, 2011), there remains little information on pollination service management available to producers. For example, recommended lists from the government-sponsored Home Grown Cereals Association (HGCA) do not contain any information on the pollination requirements of oilseed rape varieties (HGCA, 2012a,b), despite growing evidence that bee pollination affects both yield and quality (Bommarco et al, 2012). Similarly, funding for horticultural crop research has declined substantially in recent years (Fruit and Vegetables Task Force, 2010) with most work concerned with the technical aspects of breeding and production rather than ecosystem service inputs such as pollination. As such the key pollinators and pollination requirements of many modern cultivars remain unidentified. Reducing these uncertainties through further research into on-farm pollination service management is therefore key to meeting the Government's agenda of low risk, highly competitive agriculture, especially in the horticultural sector.

3.2. Agrochemical Policy

3.2.1.Certification and Application Policy

Modern intensive agriculture makes expansive use of pesticides, termed plant protection products, to control plants (herbicides), invertebrate pests (insecticides) and diseases (fungicides) that may adversely affect crop yields. Although not targeted at bees, insecticides have been demonstrated to have severe negative impacts upon bees in experimental and field conditions (Whitehorn et al, 2012; Henry et al, 2012; Lu et al, 2012; Pettis et al, 2012; Scott-Dupree et al, 2009). Trends in the use of pesticides across the UK have varied strongly between crops over the last 5 years (Tables 3.1 and 3.2) but overall, pesticide application rates rose 6.5% between 2005 and 2010 due to increasing treatment intensity per Ha on a number of crops (FERA, 2012). In general, more insecticide treatments are applied per hectare in oilseeds and fruit crops than cereals, increasing the risk of exposure to bees (FERA, 2012). Herbicides, particularly broad spectrum varieties, can also negatively impact upon bees by eliminating forage plants which sustain bees when crops are not in flower (Holzchuh et al, 2008). Neonicotinoids, which are highly effective insect neurotoxins, are widely absorbed by treated plants and coated seeds, resulting in both raw active ingredients and metabolites occurring within pollen and nectar (Dively and Kamel, 2012) and giving rise to concerns about sub-lethal effects that may occur in foraging bees (e.g. Pettis et al, 2012). Although use of Imidacloprid, the active ingredient most widely reported to be detrimental to bees, has declined significantly since 2008 (FERA, 2012) when signs of resistance to the compound appeared (Insecticide Resistance Action Group, 2009) use of other neonicotinoids, such as Thiamethoxam and Clothianidin, have increased substantially (FERA, 2012).

Pesticide policy across the UK is directed by the European Plant Protection Products (PPP) Regulations (1107/2009/EC – EC, 2009c), enshrined in English law via the Plant Protection Products Regulations 2011 (HM Government, 2011c), which set out guidelines for the process of approval, marketing and use of pesticide active substances within the EU and member states. The regulations require an assessment of the toxicity of any active substances on honeybees, requiring that there must be *"no unacceptable acute or chronic effects on colony survival and development, taking into*

account effects on honeybee larvae and honeybee behaviour."[9] No account however, is made for the impacts on other bee species, despite several studies which have indicated that various species can be affected differently by the same chemicals, with solitary bees being more vulnerable than social species (e.g Scott-Dupree et al, 2009). Similar but less detailed requirements are also imposed on non-agricultural pesticides as part of the Biocidal Products Directive (EC, 1998)[10]. Guidelines for assessing exposure and the impacts of exposure, drawn up under the previous PPP regulations (91/414/EEC – EC, 1991), similarly focus exclusively upon honeybees (EC, 2002). At least two other non-target arthropods must be assessed, although these are not specified and evaluating solitary bees and bumblebees may neglect providers of other ecosystem service, such as beetles. While these guidelines cover a range of exposure processes, including exposure via affected pollen and nectar, higher tier risk assessments are only required if the hazard quotients, derived from LD50 assessments[11], are sufficiently high, potentially neglecting non-lethal impacts. Furthermore, "key parameters" of colony survival assessed in these higher level assessments are relatively discretionary and do not include defined methodological guidelines for assessing bee behaviour. Pesticide labels are required, under PPP regulations (EC, 2009c[12]), to include information regarding the use of the pesticide during times when bees are active or when crops are in flower but only if authorisation relates to use during the *"season for bees"*. As, different bee species are active at different points within the year and by lacking a clear definition of *"season for bees"* these regulations may not impose assessments for use during the life-cycle of all bees, particularly short-lived solitary bees which often only fly for a few weeks and may nest in soils near the edge of fields.

Other specific protection for bees is provided by the Control of Pesticides Regulations 1986 (HM Government, 1986) which require 48 hours' notice to be given to local beekeepers before spraying. The Code of Practice for using plant protection products further recommends that spraying should be carried out in the evening or on cloudy days when bees are not active, noting that bumblebees may still be active at this time (DEFRA, 2006). Furthermore, some protection to bee habitat is afforded by the Code of Practice (DEFRA, 2006) which mandates notice to be given to appropriate authorities when spraying near designated sites, notably Sites of Special Scientific Interest, Natura 2000 sites and Nature Reserves (Section 3.4). The distance to the site in question however is not specified and may be of conservation relevance for bees as the use of pesticides in the wider landscape has been linked with changes in wild bee community structure and diversity (Brittan et al, 2010b). Cross Compliance (GAEC14 – RPA, 2011) and the PPP Regulations 2005 provide more widespread protection, requiring that spraying activities be conducted at least 2 metres away from hedges, protecting both bees nesting within them from insecticides and any beneficial weeds from herbicides. However, this protection is not extended to stonewalls and other boundary features such as bare soil at field entrances in which

Table 3.1. Insecticide application rates on flowering crops and habitat in 2010

Crop	Total Treated Area 2010 (Ha) Insecticides	Change in Total Treated Area (Insecticides) 2005-2010	% of total crop area treated with Insecticides 2010
Oilseeds	1.9m Ha	+26%	74%
Peas & Beans	0.6m Ha	+10%	80%
Strawberries	18,133 Ha	+295%	86%
Top Fruit & Hops	55,606 Ha	-20%	77%
Grassland	25,616 Ha	+356%	0.1%
Other Soft Fruit	14,328 Ha	+39%	71%
Cereals	2.4m Ha	-30%	43%

Total treated area = the area of treatment x number of treatments (e.g. 4 ha treated 3 times = 12Ha TTA); seed treatments count as a single application. This does not account for treatment dosage which may be below maximum acceptable levels. Total treated area is a metric of frequency of application. Source: FERA, 2012

Table 3.2. Herbicide application rates on flowering crops and habitat in 2010

Crop	Total Treated Area 2010 (Ha) Herbicides	Change in Total Treated Area (Herbicides) 2005-2010	% of total crop area treated with Herbicides 2010
Oilseeds	3.2m Ha	+78%	96%
Peas & Beans	0.9m Ha	-4%	92%
Strawberries	11,095 Ha	-21%	69%
Top Fruit & Hops	63,708 Ha	-13%	70%
Grassland	1.1m Ha	+3%	2%
Other Soft Fruit	13,956 Ha	-7%	82%
Cereals	13.7m Ha	-5%	87%

Total treated area = the area of treatment x number of treatments (e.g. 4 ha treated 3 times = 12Ha TTA); seed treatments count as a single application. This does not account for treatment dosage which may be below maximum acceptable levels. Total treated area is a metric of frequency of application. Source: FERA, 2012

9 Annex II paragraph 3.8.3
10 Enacted in UK law via the Biocidal Products Regulations 2001 (HM Government, 2001)
11 LD50 assessments assess the concentration of a substance at which 50% of contacts will be fatal and are widely used as an assessment of toxicity
12 See Article 65; Non-incorporated text from 91/414/EEC Article 16 – Paragraph 4

bees may nest. Furthermore, these guidelines only extend to professional users or users of agricultural pesticides and not to non-professional users, such as gardeners, potentially circumventing this protection in developed landscapes (HSE, 2007). Although the Code of Practice contains guidelines to minimise spray drift (DEFRA, 2006), aerial spraying of pesticides may still result in contamination especially as wind speed is only considered prohibitive at 10 knots[13]. However as of June 2012 the Health and Safety Executive (HSE) will further restrict these practices to instances where no alternative can be demonstrated or there is a clear and significant advantage to spraying by air. These guidelines will also enforce the use of detailed action plans, although this does not include Environmental Impact Assessments (HSE, 2012).

The Sustainable Use Directive (2009/128/EC – EC 2009d) sets out guidelines for member states to establish targets for reducing the environmental and health risks of pesticides and further develop integrated pest management and other alternative practices. Although the UK does not yet have a National Action Plan, as mandated by the directive to achieve this, DEFRA's UK Pesticides Strategy has been available since 2008 and has largely identical objectives, setting out a series of action plans to reduce the impacts of pesticides, each using a series of indicators to evaluate their effectiveness (DEFRA, 2008). Among these action plans is the Biodiversity Action Plan (not to be confused with the UK Biodiversity Action Plan) which aims to minimise the impacts of pesticide use on biodiversity, by identifying UKBAP habitats and species which are particularly vulnerable to pesticide use and completing a risk assessment for non-target species, although which species are to be included within this is not defined (HSE, 2011). While these measures are likely to benefit bees by protecting both their habitats (Section 3.4) and the rarer species (Section 3.6), the only headline biodiversity indicators are indices relating to birds and not bees or other invertebrates which are likely to be more directly affected by agrochemicals. Another action plan of note is the Amateur Action Plan which aims to establish best practice for using non-industrial pesticides and encourage uptake of alternatives, reducing the biodiversity impacts of these chemicals within developed landscapes (HSE, 2007). Unfortunately this action plan has not been updated since its creation in 2007 and its indicators are highly industry specific with none concerning biodiversity, despite its stated goals.

3.2.2. Policy on alternative pest control measures

Control of crop pests is a critical component to successful farming across the UK. However, despite a commitment to ecosystem orientated sustainable agricultural production the Government's Natural

Environment White Paper contains no commitments towards expanding lower impact control measures that may reduce pesticide use (HM Government, 2011a). The most basic of these measures is the use of selective herbicides or more precise spraying regimes that only target the most aggressive weeds, as advocated by the industry led-Campaign for the Farmed Environment (CFE, 2011a). Another alternative, commonly recommended to organic farmers, is the use of cover crops such as legumes within rotations, which can outcompete common weeds, as well as reducing disease and parasite burdens and improving soil fertility (Sarrantonio, 2007).

More recently, studies in North America have successfully begun to develop means of using managed hoybees and bumblebees to transmit viruses and fungi which attack crop pests (Mand et al, 2010). Although no negative impacts upon the bees used as vectors have been reported, substantial research will be required to assess the effects of this method of control upon wider ecological communities (Kevan et al, 2008). Genetically modified (GM), herbicide resistant crops allowing more potent plant control products to be used in their fields, however this may result in declining diversity of in-field weeds as seed banks become depleted (Strandberg et al, 2005) although this is not always the case (Heard et al, 2003). Other GM crops produce compounds which are toxic to pests which may reduce the need for pesticide use. Although these compounds may be present in the pollen and nectar of these plants, there have not yet been observed negative impacts of these substances upon bees (Duan et al, 2008). There may also be unexpected side-effects of GM that affect foraging bees, for instance a study in the USA demonstrated that female virus resistant pumpkin produced less nectar than conventional varieties while male flowers produced more pollen, altering foraging patterns in squash bees (*Peponapis* spp.) the main pollinators of the crop (Prendeville and Pilson, 2009). At present GM crop marketing in the EU is heavily regulated under regulation 2001/18/EC (EC, 2001) which requires detailed, case-by-case

13 The Control of Pesticides Regulations 1986 Schedule 4

environmental risk assessments, in conjunction with risk assessments from PPP regulations, at a national level before commercial planting of GM seeds is approved. These risk assessments must include a range of assessments of the impacts on non-target organisms, including impacts on food webs, however there is no requirement to assess the impacts on pollinators or pollination services specifically. European Food Safety Authority guidelines for assessing these impacts however do suggest that bees of a range of taxa should be assessed but these are not binding (EFSA, 2010). No GM crops are presently grown in the UK at a commercial scale although the government is open to the possibility of introduction subject to rigorous assessments of their environmental and human health impacts (DEFRA, 2011f).

Within the ecosystem framework, another means of controlling pests within crops is to encourage, or deliberately enhance the numbers of “natural enemies” within crops. Natural enemies are animals, usually invertebrates such as hoverfly larvae, wasps and beetles, which feed upon or parasitize crop pests. The effectiveness of these natural enemies is thought to be closely linked with their diversity within systems (Smith et al, 2011) and can be enhanced by a number of agri-environmental measures beneficial to wild bees such as wildflower margins (Frank et al, 2012). However, this control method is unlikely to be economically viable at present due to a lack of understanding of pest-predator interactions (e.g. Brown, 2012; Cross et al, 2001), artificially increasing the levels of natural enemies may not always have positive effects on this service (Straub et al, 2008) and the effects upon wider invertebrate communities remain largely unknown.

3.3. Agri-Environment Schemes

3.3.1. Entry Level Stewardship

One of the most widely applicable means of providing resources to bees within the farmed environment is the use of Agri-Environment Schemes (AES). AES are mandated in their present form by EU Council Regulation 1698/2005 (EC, 2005) and funded via CAP’s environment and rural development axis (Pillar II) to provide compensation to farmers for environmentally-beneficial work undertaken upon their land. In general AES have been demonstrated to improve bee diversity and abundance on farms and at the landscape scale (Carvell et al, 2011; Dicks et al, 2010; Pywell et al, 2006). Although overall budget for CAP is set to fall, proposals on the forthcoming 2013 reforms to CAP have signalled a strong intention from the EU and the UK Government towards increasing the proportion of CAP funds allocated to Pillar II, changing the emphasis of subsidies to AES and rural development. Presently, however, no proposals have suggested significant overhauls in the structure and implementation of AES (EC, 2011b). The UK Government has been largely supportive of these changes to the point of suggesting reducing direct Pillar I payments to increase incentives for farmers, particularly in severely disadvantaged areas, to join Pillar II funded AES (House of Commons, 2011b).

Within England, a range of AES’s exist to suit the needs of different producers and presently 67.7% of utilised agricultural area[14] is enrolled in the range of AES administered by Natural England, with the Entry Level Stewardship (ELS) scheme being the most widespread, (5.3m Ha – 57.4% of utilised agricultural area as of March 2012 – Natural England, 2012a). These schemes are available to almost all English land owners as long as they own at least 1Ha of land which is managed in a manner suitable to cross compliance. ELS allows participants to select the management they wish to undertake from a range of options, each with an attached points value reflecting their benefit to wildlife and the complexities of management. An Organic Entry Level Stewardship (OELS) which has similar options, with adjusted points values to reflect the differences in income foregone, is also available for organic producers to better reflect their management practices, covering 343,482 Ha as of March 2012 (Natural England, 2012b). To qualify, participants must select a suite of options with an average value of 30 points per hectare (60 for OELS) enrolled in the scheme, paying participants £30 per hectare (£60 in OELS) in reimbursement. More specialised Uplands ELS and Upland OELS schemes have also been launched, adding greater incentives (£62/Ha enrolled and £92/Ha enrolled) and unique options to further encourage uptake within the most disadvantaged areas of English farming (Natural England, 2010c).

Several ELS options have been demonstrated to enhance significantly the abundance and diversity of wild bees within fields by providing additional flowering and nesting resources. The most obvious of these is option EF4 – Nectar flower mixes, which requires the sowing and maintenance of areas of flowering plants containing at least four key families of plants associated with bees. This option was specifically developed to benefit bee populations and has been widely demonstrated to significantly increase the number and diversity of bumblebees found within fields (Potts et al, 2009; Carvell et al, 2007) and at a landscape scale (Pywell et al, 2006). Other managements within ELS that have been demonstrated to be effective at enhancing in-field abundance and/or diversity of wild bees include Wild bird seed mix (EF2 – Potts et al, 2009), buffer strips (EE1-3; Pywell et al, 2005, Marshell et al, 2006), grasslands with low inputs (EK2/3; Batary et al, 2010) and naturally regenerated, uncropped field margins (EF11; Carvell et al, 2007). Studies from Scotland

14 Utilised Agricultural Area is land which is actively used for production of crops, live stock or other farming activities.

have also demonstrated that managed arable field margins can provide attractive nesting sites for queen bumblebees (Lye et al, 2009). However, to date many of these studies have focused heavily or exclusively upon bumblebees and as such their benefits to solitary bees may be more varied. The Upland ELS also introduces options for traditional hay management and uncut hay strips which are also likely to benefit bee populations by providing continuous and diverse floral resources throughout the flowering period (Natural England, 2010c).

While the structure of ELS allows for a great degree of flexibility to participants, this can in turn result in limited delivery of valuable options as participants instead fulfil their points quotes using larger numbers of low cost, limited benefit options (Hodge and Reader, 2010). Some of these options, such as hedge management (EB1/2) involve only very minor changes from the standard requirements of cross-compliance (GAEC14/15 – RPA, 2011). In order to redress this issue, the Campaign for the Farmed Environment (CFE), in conjunction with Natural England, have launched a relatively successful campaign to better encourage participants to adopt these more beneficial options, helping Natural England to raise the uptake of Nectar Flower mix from 1806Ha[15] to 2974Ha (64%) between 2007-2011 (Hodge and Reader, 2010; CFE, 2011a). Similar industry led success has been found in Syngenta and Sainsbury's joint initiative Operation Bumblebee project which encouraged farmers to take up a pollen and nectar mix that was specifically very beneficial to bumblebees (Operation Bumblebee, 2009). However, this still represents less than 0.1% of the total area managed under ELS (5.2m ha)[16] and the high costs and management complexities of this and similar options are likely to remain a deterrent to wider uptake (Hodge and Reader, 2010; Mills et al, 2012). To drive greater uptake of these options Natural England has recently redefined its targets for the scheme, from simply including 70% of farm land, to increasing the contribution of points from the high priority options identified by CFE including Nectar Flower mix, to 61% of the total (Natural England 2011a). As of March 2012, high priority options account for 58% (120m) of ELS points (Natural England, 2012a). Furthermore the ELS Training and Information Programme (ETIP) aims further to bolster knowledge and address concerns regarding Nectar flower mixes and other priority options (Natural England, 2011b). Natural England's Making Environmental Stewardship More Effective (MESME) project is also exploring a range of measures to encourage uptake of the more beneficial options such as reducing the points of low-benefit, high uptake options, and develop new options such as herb and legume rich swards (Natural England, 2012b). Of particular note, these proposals also include allowing Nectar Flower Mixes (EF4) to be fully rotational, allowing farmers to incorporate them into crop rotations as cover crops. Due to World Trade Organisation (WTO) rules on environmental subsidies, however, it is not possible for any AES measures to be financially incentivised as payments may only reflect income foregone and additional costs incurred (WTO, 1995).

Most fundamentally, ELS schemes do not have sufficiently defined, measurable biodiversity objectives or comparative baseline biodiversity data bar the farmland bird index. This makes assessment of their benefits for wild bees and any other taxa near impossible (Kleijn and Sutherland, 2003, but see Boatman et al, 2008). As a result, ELS payments do not account for the potential benefits of employing the scheme, or certain options, within it at different areas, a problem referred to as "adverse selection" (Quillerou and Fraser, 2010). For instance AES in general are thought to be most effective in already intensively managed areas where small changes can produce larger biodiversity benefits (Kleijn et al, 2009). However, many of the most beneficial land use based options remain largely within the least productive land (Hodge and Reader, 2010). The recent introduction of the Upland ELS redresses this in part by providing greater incentives to disadvantaged areas where CAP payment decoupling has substantially increased the likelihood of land abandonment (Mills et al, 2012). Within agreements, although the CFE and ETIP provide advice on where to place options to maximise benefits to wild bees (CFE, 2011b; Natural England 2011b), ELS schemes themselves provide little advice or incentive for participants to collaborate or strategically place options to optimise connectivity and other benefits essential to improving habitat quality for wild bees. Finally, ELS inspection focuses solely upon establishing whether the options claimed have been correctly implemented rather than the quality of implementation or the outcomes that result from their implementation. This can be a particular issue for sown flower mixes as aggressive grasses can often out-compete sown flowers, leaving only a few remnants (Blake et al, 2011). However, monitoring costs, even for indicator species, can prove highly restrictive to the overall effectiveness of AES (Gibbons et al, 2011). In 2013 CAP will undergo further major reforms with the aim of enhancing the environmental benefits of existing policies in Pillar II while introducing stricter environmental standards in Pillar I (EC, 2010a), giving ground to a complete renewal of ELS within the new England Biodiversity Strategy (HM Government, 2011a).

3.3.2. Higher Level Stewardship

Among the AES within England, the Higher Level Stewardship (HLS) is widely regarded as the most effective means of enhancing on-farm biodiversity (HM Government, 2011a). HLS is a discretionary

15 Includes Nectar flower Mix on Set Aside land (EF5), an option which was removed following the removal of mandatory set-aside.

16 Note that this represents the total area covered by ELS agreements, not the total area managed under ELS options

scheme, only accepting applicants subject to approval by Natural England and generally only within one of the 110 target areas defined by Natural England (Natural England, 2010d). HLS agreements include detailed land management plans, drawn in consultation with Natural England, that aim to create a connected, well planned series of measures across the holding that optimise biodiversity benefits subject to specific regional targets (Natural England, 2010d). HLS pays participants in relation to the options they undertake with the highest payments available for the most demanding work such as recreating and maintaining rare habitats. Unlike ELS however there is no strict upper limit on payments. Among these habitats are several which are known to provide high quality forage and/or nesting resources to a wide diversity of wild bees, including meadows (e.g. Feon et al, 2010), species-rich grassland (e.g. Ockinger and Smith, 2007) and heathland (e.g. Forup et al, 2007). HLS also contains a number of supplements that provide additional funding when management is likely to be difficult or particularly costly (e.g. Supplement for Small fields – HR6) or may produce lower profits (e.g. Haymaking Supplement – HK18). Support is also available for collaborative work (HR8, paid at £10/ha) between local participants to encourage integrated management. This option has become increasingly widespread with 123 participants in 2010 collaboratively managing 83,464ha, with many agreements being used to unify the management of closely linked or co-operatively owned SSSIs in lowland areas (Franks et al, 2011). The effectiveness of HLS options can be further augmented by combining them with ELS options; for instance combining floristically enhanced wildflower margins (HE10) with nectar flower mixes (HF4) to create more diverse feeding resources for bees (Carvell et al, 2007). Although there is no limit on the payment a single farmer can receive though HLS, the scheme aims to provide the best possible "value for money" and consequently funding is a strong limitation on the amount that can be spent on a single agreement (£151m as of January 2012 – Natural England 2012a). Although funding is set to increase in the coming years as part of the England Biodiversity Strategy (DEFRA, 2011g), this growth is lower than was previously anticipated (Franks et al, 2011).

As of January 2012 there are 8,588 active HLS agreements encompassing 882,916Ha of land (9% of total English utilised agricultural area) and the scheme is continuing to grow due to the very high demand for participation (Natural England 2012a). As a targeted scheme with specific local objectives, HLS overcomes many of the issues of adverse selection experienced by ELS schemes (Quillerou and Fraser, 2010) and may enhance the benefits of measures targeted towards wild bees (Carvell et al, 2011). HLS agreements are nonetheless still largely located within areas of lower productivity where farming profits are likely to be lower (Quillerou et al, 2011). HLS is likely to benefit wild bees by recreating and maintaining key habitats, with 44% of agreements containing options to manage species-rich semi-natural grassland in 2009 (Natural England, 2009a). Furthermore, a review of parcels of created or restored species-rich grassland in 2011 showed that 85% of sites surveyed now qualified as UK Biodiversity Action Plan priority habitats, demonstrating the effectiveness of the measures at these sites (Natural England, 2012a). Nonetheless, uptake of habitat options is likely to be highly regionally stratified although the creation or maintenance of habitats are often mandatory for participation in some areas (e.g. Soar and Charnwood – Natural England, 2010e) and as of 2009, wildflower margins featured in <15% of agreements (Natural England, 2009a). Despite these potential benefits to wild bee conservation efforts, HLS still lacks defined, quantifiable objectives in terms of biodiversity benefits.

3.3.3. Forestry Practice and Standards

At present there are no specific AES for forested or agro-forested land; although some ELS and HLS options can be applied to on-farm woodland, the applicability of this to forestry operations is limited because of the requirements that land be managed under cross-compliance to partake in AES. The Forestry Commission does however offer funding for the maintenance and improvement of forested woodlands via Woodland Maintenance Grant (Forestry Commission, 2011a). These pay land owners up to 80% of the costs of certain maintenance operations that maintain and enhance the quality of public benefits derived from forested land and allow them to meet UK Forestry Standards (Forestry Commission, 2011b). Many of these standards may have substantial benefits to wild bees, such as reducing very heavy shade to allow ground vegetation to develop around edges, and deliberately creating low shade corridors. However, although very flexible and mandating that participants use defined objectives, the scheme does not incentivise the enhancement of biodiversity for specific taxa in a way that ELS options can.

3.4. Habitat Conservation

3.4.1. Priority Habitats, Designations and Impacts

Within England and across Europe the loss, degradation and isolation of bee habitats, driven by intensified agriculture, is widely regarded as a major factor behind population declines in wild bees (Potts et al, 2010b). Although AES can provide resources for bees via in-field habitats such as margins, it is unlikely that these resources alone will be sufficient to support the full diversity of wild bee species, resulting in "partial habitats" providing nesting but not feeding resources or vice versa particularly for specialist species (Westrich, 1996). Improving

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the quality, extent and connectivity of low-input semi-natural habitats is therefore an essential step to improving wild bee populations and the flows of pollination services within the landscape (Dicks et al, 2010). Although no current study exists which evaluates the relative importance of different UK habitats for bees, wild bees can be found in a wide range of habitats but are often associated with species-rich grasslands (e.g. Ockinger and Smith, 2007), heathland (e.g. Forup et al, 2007) and wildflower meadows (e.g. Feon et al, 2010), all of which have declined across England, particularly within the more productive lowland areas (JNCC, 2011a). Consequently, several such habitats are listed alongside hedgerows and arable field margins as priority habitats for conservation in Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006 (HM Government, 2006a). NERC S41 listing does not in itself confer legal protection, only that the habitats listed should be considered in planning and development initiatives, however a number of designations can be applied to sites which contain them. Lawton et al (2010) classify these designations into three tiers according to the degree of policy protection afforded to them; Tier 1 having the greatest protection, Tier 2 encompassing less protected sites and Tier 3 covering sites which are not managed specifically for biodiversity but which can have benefits.

Table 3.3: Summary of the UK wide distribution of key priority habitats for bees within each of the tiers of the Lawton Report, their habitat trends and UKBAP Targets within England

	Area within each Habitat Designation				Median Patch Size	Habitat Trends		UKBAP Targets	
Habitat	Tier 1	Tier 2	Tier 3	No Tier		Area	Quality	Set	Achieved
Lowland Calcareous Grass	71%	25%	47%	5%	1.9 Ha	Increasing	Declining	7	2
Lowland Meadows	51%	42%	27%	9%	1.8 Ha	Declining	Stable	7	4
Lowland Dry Acid Grass	83%	17%	65%	4%	2.0 Ha	Declining	Increasing	7	5
Lowland Heathland	75%	23%	90%	5%	3.0 Ha	Increasing	Increasing	5	5
Upland Calcareous Grass	75%	2%	86%	7%	3.1 Ha	Stable	Stable	3	2
Upland Hay Meadow	54%	26%	79%	8%	2.5 Ha	Unknown	Increasing	7	3
Upland Heathland	72%	6%	47%	6%	4.1 Ha	Stable	Stable	3	2
Lowland Fens	94%	3%	51%	3%	???	Unknown	Increasing	4	2
Purple Moor Grass and Rush Pastures	72%	27%	79%	6%	1.5Ha	Unknown	Declining	7	1

Source: Lawton et al (2010); BARS (2011). Habitat trends represent a generalisation based upon information from the first BARS website. Targets Achieved includes all targets that were, as of 2008 either achieved or on schedule to be achieved by 2010 in England only. Habitats were selected on the basis of inclusion within a broad habitat type ranked 1-3 for quality of habitat for bees by Osborne et al (1991) and analysis by Lawton et al (2010) Hedgerows and wasteland are discussed elsewhere.

Tier 1 sites[17] include Sites of Special Scientific Interest (SSSIs[18]) and Natura 2000 sites (Special Protection Areas (SPA) and Special Areas of Conservation (SAC)[19]), which are designated by virtue of EU priority habitats or species listed in the Habitats Directive (92/43/EEC – EC, 1992a) and Birds Directive (2009/147/EC – EC, 2009e). SSSIs are heavily protected in different legislations and it is impossible to develop on them without permission from Natural England who may enforce compensatory habitat reconstruction among other conditions. Nonetheless these designations may, according to the Habitats directive, be over-ridden if there are *"imperative reasons of overriding public interest"*[20] involved, although these are not specifically defined. Furthermore, Natural England is empowered to prescribe management efforts to maintain and improve the quality of SSSIs and Natura 2000 sites, usually in the form of HLS agreements (Natural England, 2010d).

17 Ramsar sites are also included in Tier 1 as are sites owned by conservation NGOs, however Ramsar sites are only of interest to wetland birds and NGO sites are difficult to specifically identify

18 Established by the Wildlife and Countryside Act 1981 (HM Government, 1981)

19 Established by The Conservation of Habitats and Species Regulations 2010 (HM Government, 2010)

20 Habitats Directive Article 6 Paragraph 4.

Subsequently, as of 2012 only 0.03% of designated SSSI sites had been destroyed and 96.6% were in recovering or favourable condition (Natural England, 2012c). Tier 2 sites have much more limited protection include nature reserves and other local wildlife sites that are designated at a local level. Nature Reserves are designated in agreement with land owner who must also consent to a prescribed management plan; however there are no clauses in place to fine or penalise infractions of these agreements, or to enforce the reconstruction of loss or damage. Although these sites can allow for well managed, locally important habitats for bees, protection for them is very limited – between 1984-2008, 130 were lost and a further 62 reduced in size in Derbyshire alone (Lawton et al, 2010). Tier 3 sites comprise of National Parks and Areas of Outstanding Natural Beauty (AONB) which are not designated for their wildlife value specifically but can often contain important habitats and SSSIs. Instead these sites are designated if they are considered *"expedient in the national interest"*[21] to be managed as such, although what these interests are is not specifically defined. These designations cover larger areas of land, placing restrictions and permissions upon development within them, however only the

21 National Parks and Access to the Countryside Act 1949 (HM Government, 1949); Article 16, Paragraph 1

features relating to the designation receive specific protection and the National Parks Authorities are also not empowered to level fines or mandate restorative work for damages done.

Protection within these tiers is bolstered by several Environmental Impact Assessment (EIA) regulations, mandated under the EU's Environment Impact Assessment Directives[22], which require the environmental impacts of certain developmental activities, possible alternatives and mitigation measures to be reviewed by local planning authorities with special note to sensitive sites. Although generally managed in a similar manner, there are some notable differences in the levels of protection afforded; Section 105 of the Highways Act 1980[23] (HM Government, 1980a) for instance mandates an EIA for any road or rail development. In a bid to streamline development, more recent EIA regulations[24] only require an assessment when development is to take place on sites over a certain threshold size, with smaller thresholds for sensitive sites. The addition of these thresholds, particularly in the Environmental Impact Assessment (Agriculture) Regulations 2006 (HM Government, 2006b), allows for un-assessed agricultural landscape restructuring of 2-50Ha, depending on activity, even on sensitive sites and can pose a serious threat to priority habitats important for wild bees. This is a particular concern for lowland hay meadows and calcareous grassland habitats as much of their area across the UK lies beyond designated sites and both have median patch sizes below 2Ha (Table 3.3). However, National Parks and AONB are considered to be sensitive areas throughout these legislations, conferring this additional sensitivity across their expansive areas and potentially extending to landscape wide considerations which are otherwise lacking within these regulations. Government aims to streamline the planning and development process, including when concerning threatened habitats, may therefore lead to similar negative legislative exemptions unless carefully managed (HM Government, 2012)

Protection and restoration of priority habitats has previously been conducted as part of the UK Biodiversity Action Plan (UKBAP) which defined specific goals for maintenance, restoration and expansion of priority habitats, including NERC S41 habitats, throughout England. Table 3.3 summarises the distribution of several key priority habitats for bees, as identified using Osborne et al (1991)[25], throughout these tiers and the success of their UKBAP targets as of 2008 the final reporting period for the scheme. Notably, the number of BAP targets set varied strongly between these habitats with less set for important upland habitats, including a lack of expansion targets for Upland Calcareous Grass. As of 2008, important habitats for wild bees were mostly stable or increasing in extent and/or quality, however it should be noted that there were also substantial losses in lowland meadows, attributed in part to the weakening of EIA regulations and continuing agricultural encroachment (BARS, 2011). This is likely to be exacerbated by the high proportion of both upland and lowland meadows which are not contained within any form of designated sites, leaving them vulnerable to neglect or inappropriate management. There are also concerns that the definition of upland meadow may be too narrow, leading to many declining community types being overlooked for management (Natural England, 2011c). By contrast, as an EU priority habitat under the Habitats Directive, Lowland heath has received strong investment in management and protection, achieving or set to achieve, all five UKBAP targets set, including expanding the total coverage (T4) and increasing the number of patches >30ha (T5). However, a review of 104 non-SSSI lowland heath sites across England identified no sites in favourable condition, even those enrolled in AES, compared with 17% within SSSIs, and 41% of these sites failed to meet even the most basic conditions (Hewins et al, 2007). A common shortcoming among most UKBAP habitat action plans, in particular Purple Moor Grass and Rush Pastures, was a lack of clear accountability and incomplete monitoring resulting in many targets remaining of unknown status (BARS, 2011).

More recently the UKBAP has been superseded by the new England Biodiversity Strategy (EBS) which presently eschews habitat specific targets for broader conservation goals; in particular by halting completely nationwide net loss of priority habitats, as well as providing 200,000 Ha of new priority habitat and maintaining 90% in favourable or recovering condition by 2020 (DEFRA, 2011g). Unfortunately, like the UKBAP, the new EBS does not lay out specific responsibilities or guidelines for the delivery of these goals and, lacking habitat specific plans, could produce trade-offs between the protection and expansion of habitat types. For instance targets for creating habitats could be achieved with a few, more common priority habitat types, such as arable field margins, rather than a diverse range of habitats. Local BAPs and designated site management may therefore play an increasingly significant role in the protection

22 Directive 85/337/EEC and amendments (EC, 1985)

23 As amended by The Highways (Environmental Impact Assessment) Regulations 2007 (HM Government, 2007)

24 Environment Impact Assessment (Agriculture) Regulations 2006; The Town and Country Planning (Environmental Impact Assessment) Regulations 2011; The Electricity Works (Environmental Impact Assessment) (England and Wales) Regulations 2000 and Environment Impact Assessment (Forestry) Regulations 1999 – For brevity, not all are referenced.

25 It should be noted that Osborne et al (1991) is a European scale review, however no more recent or UK centric data on the relative importance of habitats for bees is available.

of habitats, however, lacking a structured guide to the development of Local BAP management, local authorities lacking in-house ecological expertise are unlikely to be able to develop these initiatives successfully without outside consultation. The Higher Level Stewardship (HLS) may also play an increasingly significant role in maintaining and restoring priority habitats, although, establishment of some habitats using HLS has in the past been low (e.g. Purple Moor Grass – BARS, 2011)[26].

3.4.2. Other habitats

Although wild bees are threatened by the loss of species-rich landscapes, habitat quality and connectivity of more common habitats can prove beneficial to bees, even in intensive landscapes. At a broader scale, cross compliance regulations enforce appropriate management of some broader habitats like Heathland (GAEC10), grassland (GAEC9), particularly those sensitive to nitrate inputs (SMR4), and hedgerows (GAEC15 – RPA, 2011) on all CAP pillar I claimants. Hedgerows, which can act as important corridors for bees (Hannon and Sisk, 2009; Osborne et al, 1991) and other insects, are further protected under the Hedgerows Regulations 1997 (HM Government, 1997). These regulations impose requirements for permission to be granted for the removal of hedges ≥30 years old or those of historic or biodiversity significance and have been credited with slowing the decline of hedgerows across the UK (BARS, 2011). Nonetheless, these regulations do not consider the wider ecological significance of hedges, such as their capacity act as a corridor between habitats or provide shelter to wild plants within field borders, nor do they include clauses to mandate the replacement of lost hedges.

While not as significant a land use as agriculture, forested land accounts for 13% of total land area across UK land (Forestry Commission, 2011a) and, while the total area managed for wood harvest is unknown due to the variety of ownerships the rising demands for renewable energy supported by the Energy Crops Scheme (Natural England, 2009b) and the Woodland Grant Scheme (Forestry Commission, 2011b) may cause potentially substantial rises in the area of Short Rotation Coppice for biofuels. Although US studies have demonstrated that forested land can act as valuable habitat and corridors for wild bees (Grundel et al, 2010) little research has been conducted on the value of these habitats to bees in the UK or Europe as a whole. Forests are protected by the Forestry Act 1967 (HM Government, 1967) which requires all felling of trees to be done under license and the Environment Impact Assessment (Forestry) Regulations 1999 (HM Government, 1999) which places strict thresholds upon the scale of forestry activity that can be conducted without requiring EIA, only allowing <0.5Ha of aforestation and deforestation activities to be conducted without assessment. The Forestry Commission recently released a new series of guidelines that, although not strictly required for grants, contain several measures that may potentially benefit wild bees, such as preventing vegetation overgrowth and excessive cover at forest edges (Forestry Commission, 2011a).

3.4.3. Landscape Scale Policy

A common shortcoming among all of the policies above is the lack of landscape-scale considerations inherent within the protection and assessments mandated which may affect the effectiveness of conservation measures for wild bees (Carvell et al, 2011). Smaller sites in particular, such as Coombe Bisset Down, a small calcareous grassland SSSI in Wiltshire, may be vulnerable to spill over effects resulting from activities and development in the immediate landscape. Furthermore several authorities can be involved in the running of a single small site and many of these authorities may have little capacity to communicate with one another or encourage/mandate collaborative management between stakeholders. While some closely linked SSSIs such as the Dorset Heathlands, a collection of 43 SSSI heathlands of varying size and isolation managed in collaboration, producing favourable results for overall habitat quality and landscape scale considerations for development impacts (Natural England, 2012c)[27], there is little evidence to indicate how widespread this collaborative practice is. Most recently, these concerns have been partially addressed within the new National Policy Planning Framework for England (NPPF) which highlights both the need for National Parks and AONB to consider landscape management and the effects that development near SSSI may have upon the site itself (Department of Communities and Local Government, 2012). At a broader scale, following the designs of Lawton et al (2010), 12 Nature Improvement Areas (NIAs) have been instigated on a trial basis supported by a £7.5m fund as part of the recent Natural Environment White Paper (HM Government, 2011a). A key component of EBS, NIAs aim to optimise connectivity between habitats and instigate sympathetic, landscape scale management of wide areas to optimise biodiversity protection and ecosystem service provision. By their very design NIAs are likely to be extremely beneficial to bees by reconnecting habitats, improving unfavourable patches and reducing the pressures faced by them through encouraging sustainable agricultural practices. However, NIAs are not a wholly new innovation; similar initiatives have been fostered by Natural England in their Integrated Biodiversity Delivery Areas (IBDA), eight of which have been operating on a trial basis since 2009 (Natural England, 2011d), the RSPBs 40 Futurescape initiative areas (RSPB, 2010) and the Wildlife Trusts

26 As of 2008 only 10Ha of Purple Moor Grass had been established through HLS option HK8

27 http://www.naturalengland.org.uk/regions/south_west/ourwork/heathlands/default.aspx

110 Living Landscape initiatives (Wildlife Trusts, 2012). Each of these initiatives contains several areas with a high proportion of important habitat for bees such as the South Downs IBDA and the Bredon Hill Living Landscape and could, with policy support, be integrated into a more expansive network of conservation areas.

3.5. Planning Policy

3.5.1. Development Policy

By 2031 the population of the UK is expected to reach 69 million people (Foresight Land Use Futures Project, 2010). In addition to growing pressures for sustainable agricultural production, likely driving further intensification and pressure on land presently used for Agri-Environment schemes, this population growth is likely to drive substantial increases in demand for development, necessitating substantial expansions in developed land (Royal Commission on Environmental Pollution, 2011). This expansion in development presents new challenges for safeguarding designated sites; for example in south east England where population growth is projected to be greatest, ~35% of land is protected by designation increasing the risk of conflict between designation and development (Royal Commission on Environmental Pollution, 2011). These pressures may be exacerbated by the removal of Regional Spatial Strategies (RSS) which aimed to foster co-operation in planning and development between local authorities (House of Commons, 2011c). As such, formally targeted development, particularly housing may be inappropriately distributed across local authorities. While designated sites are protected by their parent legislation and Environmental Impact Assessments (Section 3.4), the Government's recent Red Tape Challenge and Habitats Directive Review have accepted arguments from industry that these regulations can be overly complex and burdensome (HM Government, 2012; DEFRA, 2012). This has resulted in commitments to consolidate the statutory instruments and amendments of the Wildlife and Countryside Act 1981 and instigate a revision of the Conservation of Habitats and Species Regulations 2000 (DEFRA, 2012). Such amendments are expected to include rights to grant additional rights of appeal against refusal of planning permissions but do not include proposals to strengthen protection of habitats at the landscape scale, for instance by including considerations of the connectivity value of non-designated habitat features (HM Government, 2012).

Although current policy primarily aims to prevent development on designated sites, issues of *"over-arching public interest[28]"* may enable development despite its detrimental impacts and many priority habitats lie beyond these designated areas (Section 3.4). Policies designating sites and the Environmental Damage (Protection and Remediation) Regulations 2009 (HM Government, 2009) allow Natural England or relevant authorities to mandate that new habitat be created to replace that which is lost, however the objectives of this recreation are not specified. More recently DEFRA has developed the biodiversity offsetting programme which aims to enhance the effectiveness of existing measures for habitat replacement contained within site designations. The programme emphasises that lost habitat should be replaced with habitat of equal or greater quality, ideally before development is conducted and contribute to wider ecological networks (DEFRA, 2011h). Although stronger than other reconstruction policy, as these plans are guidelines there is no obligation for local planning authorities to follow them and issues of cost and management responsibility may remain (Briggs et al, 2009). Furthermore the guidelines do not explicitly account for the age of the habitat which can affect its quality and community composition or recommendations for new habitats to be created with genetic material (seeds etc) from the previous site to maintain local genetic diversity.

3.5.2. Sustainable Development

To instigate development sustainably, the government's recently published National Planning Policy Framework (NPPF) now forms the basis of development across England (Department for Communities and Local Government, 2012). The NPPF recognises the importance of environmental considerations and states its aim to minimise impacts on biodiversity, supporting net gains where possible in the planning system. To this end it recommends that green belts and other undeveloped land should be integrated into wider biodiversity networks (including NIAs) and that, where possible, land of low environmental value should be prioritised for development. Although development on green belts and most designated sites is defined as "unsustainable", these protections are not extended to local nature reserves, despite their potential multi-functionality within the community as both biodiversity hotspots and recreational space, and there is no mention of incorporating habitat replacement measures of any kind into any planning. Furthermore, despite the economic and aesthetic benefits pollination and other ecosystem services can provide, particularly in rural areas, the NPPF contains no mention of maintaining or enhancing these services within the developing landscape, only that they should be recognised[29]. While the NPPF highlights the need for multi-functional development it does not emphasise exploration of the potential for all development projects to deliver this goal. For instance flower rich road verges have been demonstrated to provide substantial benefits to wild bees as habitat corridors (Noordijk et al, 2009; Hopwood, 2008),

28 Habitats Directive Article 6 Paragraph 4.

29 NPPF Section 11 Para 109

as recognised by the Natural Environment White Paper (HM Government, 2011a), and can provide aesthetic benefits to road users (Akbar et al, 2003). A *"duty to co-operate"* with neighbouring authorities is included within the framework to mitigate the loss of RSS, however the extent and structure of this co-operation is unclear. Finally the NPPF does not address the current shortage in the availability of allotments and other common land in urban areas. Although the Allotments Act 1925 (HM Government, 1925) mandates that local authorities should provide this land wherever demand exists, demand has risen significantly even during the last few years to >500% of supply (Campbell and Campbell, 2011). Increasing the supply of allotments would not only benefit bees by providing highly diverse flowering habitat (Ahrne, 2008) but would also provide greater opportunities for urban residents to establish connectivity with nature, a key goal of the Natural Environment White Paper (HM Government, 2011a). However, the Governments Red Tape Review has identified a need to revise the legislations concerning development on common land which could have detrimental impacts upon long-term availability (DEFRA, 2012).

Beyond these challenges there should also be substantial opportunities for conservation and for bees within urban landscapes in the Government's recent commitments towards sustainable development, particularly aims to deliver Green Infrastructure (GI) as a key component of planning and development policy (HM Government, 2011a) including in the NPPF (Department for Communities and Local Government, 2012). GI represents green spaces within the developed landscape that link urban and rural areas while delivering multiple benefits to the environment and people and, as of 2010, was a strategic objective of 67% of local planning authorities in England (Parkhurst, 2010). Such green spaces, when well managed, have been demonstrated to support abundant and diverse bee populations and, if well positioned, can enhance pollination services within surrounding agricultural landscapes (Henning and Ghazoul, 2011). Providing green infrastructure for bees within the urban landscape can be as simple as creating diverse, flower rich patches in existing green spaces, such as public parks, however connectivity between patches is essential to optimise benefits (Ahrne, 2008). Unfortunately the NPPF does not contain any specific guidelines for local authorities to effectively develop localised high quality GI planning as part of development strategies and large areas of gardens and other potential GI are increasingly lost to inner city development (CCC, 2011). Despite the commitments of the Natural Environment White Paper towards ingraining GI in planning agendas, the Government's "top 40" national Infrastructure projects include no direct mentions of GI, focusing instead upon developing transport networks and renewable energy (HM Treasury, 2011). Furthermore, NPPF guidelines place a strong emphasis upon securing land for transport, energy and housing infrastructure but not for the expansion of green infrastructure, such as securing land for biodiversity provision or restoring habitat lost in the course of development (Department for Communities and Local Government, 2012).

Although only recently recognised as a government priority several, Local Authorities have developed GI targets within Local BAPs or similar biodiversity efforts which may benefit bees, such as increasing the number and quality of flower-rich road and rail verges (e.g. Islington, – Islington Council, 2011), increasing floral diversity within church yards (Warwickshire – O'dell, 2004), promoting green roofs (Sheffield – Sheffield Local biodiversity Action Partnership, 2010), using previously developed land as habitat (Shropshire – Shropshire Biodiversity Partnership, 2009) or encouraging all city schools to contain wildlife habitat (Newcastle-upon-Tyne – Newcastle City Council, 2001). Beyond these specifically managed public spaces, home gardens can also increase the abundance and diversity of bees in a habitat by providing suitable nesting (Osborne et al, 2008) and foraging resources (Samnegård et al, 2011). Subsequently, several initiatives have aimed to capitalise upon these potential benefits by encouraging home owners to maximise the biodiversity benefits of their gardens, such as the Sheffield Local BAP (Sheffield City Council, 2002 – GA 4.2[30]), the London Gardens Living Landscape Project (Wildlife Trusts, 2012) and the Big Wildlife Garden project (The Big Wildlife Garden, 2012), which is to receive additional Government funding in the near future (HM Government, 2011a). Buglife and the Co-operatives joint B-Lines project, currently being trialled in Yorkshire, may also provide valuable lessons and support to local authorities wishing to enhance connectivity between habitats using floral strips (Buglife, 2011).

3.5.3. Local Planning

As demonstrated above, many of the planning and GI policies that affect bees are products of local, rather than national policy. The present government has pursued a strong agenda of locally driven, "bottom-up" decision making with several policy changes to further devolve power to local authorities. Most notably, the Localism Act 2011 allows greater autonomy to be sought by any local authority in planning and development policy, requiring less central approval from development inspectors or the secretary of state[31]. While this can allow a greater autonomy in local development there is a danger that local authorities may be ill-equipped to develop effective biodiversity and environmental policy, particularly as only 35% of local authorities have access to in-house ecological expertise (HM Government, 2012).

30 The present status of this Local BAP initiative is unknown.
31 Sections 112-114

This is of particular importance with regards to planning policy as the NPPF and Environmental Damage Regulations allow substantial room for local interpretation of GI development and damage prevention, without providing structured guidelines to maximise their benefits. Subsequently, the quality of GI initiatives, particularly those concerning specialised taxa such as wild bees, and assessments of the damage inflicted by development are likely to be weaker or more costly as external consultants are contracted to fill knowledge gaps. Furthermore, the NPPF encourages local authorities to develop upon previously developed land (aka. Brownfields) unless they are of *"high environmental value"*. While they are less valuable than some other semi-natural habitats, brownfields and other "wasteland" habitats can still provide valuable refugia to bees within otherwise inhospitable urban landscapes (Osborne et al, 1991). As such, local authorities lacking sufficient expertise are unlikely to be able to effectively identify sites of high importance or mitigate the loss of what can be very unique habitats. Although LNPs may be able to alleviate this burden, there is no requirement of LNPs to demonstrate expertise in any particular areas of ecology or conservation, despite the broad range of conservation and planning initiatives they are expected to influence (HM Government, 2011a). As such it is doubtful that most locally designed planning and development policy will be able to meet national biodiversity interests or even those of bees and other key taxa unless better guidance is provided and expertise made available.

3.6. Species Conservation

Species conservation policy in England, largely driven by the stipulations of the Convention on Biological Diversity (United Nations, 1992) and the EU-wide Habitats and Birds Directives (EU, 2009, 1992), primarily offers specific legal protection to those species listed in annexes of the Wildlife and Countryside Act of 1981 (HM Government, 1981). This legislation protects these species from unauthorised killing and taking and provides some added protections to their habitats. To date, no species of bee, wild or managed, has been listed within these annexes, however as the pressures facing bees are, unlike those of birds, not a result of human persecution, it is doubtful that such listing would provide any additional protection. Furthermore, such protections may restrict the ability of volunteers to collect specimens and provide vital basic information on distribution and ecology of bees. Instead policy to protect bees focuses upon encouraging focused conservation efforts and research. However, 17 species of bees in England are given some minor legal protection by Natural England under Section 41 of the Natural Environment and Rural Communities Act 2006 (HM Government, 2006a). This list, (NERC S41 – Natural England, 2010a), should be used by local authorities as part of their biodiversity conservation goal development and integrate the conservation of these species into their local planning policy development goals, effectively forcing them to consider the impacts of planning upon the species. Although offering some protection to the habitats of rarer bees, these considerations do not explicitly restrict development on these habitats nor do they enforce decision-making to account for landscape scale effects.

Foremost, the UK Red List of threatened species, drawn up in 1987, which summarises the status of individual species across the UK, includes 71 species of wild bees among its auspices classifying 47 as Vulnerable or Endangered (JNCC, 2011b). However, classification under the 1987 Red List is based upon the species' perceived rarity rather than threat of extinction, as is the case for the International Union for the Conservation of Nature's (IUCN) global Red List (IUCN, 2001). For instance *Melitta dimidiata*, a solitary bee listed as Endangered on the UK Red List, is only found in Salisbury Plain where it is often abundant and scattered across the entire Plain. Whilst being rare at a national level, the threats of extinction are perceived to be fairly low, and its status is now considered to be "Vulnerable" or "Near Threatened" rather than "Endangered". Despite the species national rarity, Salisbury Plain itself is strongly protected as a combination of SSSI and Ministry of Defence owned land (Natural England, 2012c). This shortcoming is set to be rectified during the course of the next year and will culminate in the publication of the updated UK Red-list in 2013, which applies current IUCN classifications at the regional level. It is hoped that these classifications will enable more focused research and monitoring of the bees considered to be declining or most vulnerable to decline for example the presently unlisted solitary bee *Colletes halophilus*, which is found within coastal salt marshes and for which England alone holds a significant proportion of the global population (Hymettus, 2011). Although found at several sites across the eastern and southern coasts of England, the species' habitat is likely to be adversely affected by sea level rises and resultant changes in coastal defence strategy in the near future.

Previously, the other major policy instrument of wild bee species conservation within England has been the UK Biodiversity Action Plan (UKBAP) which listed 23 species of wild bee among its national priority species. UKBAP priority species were set specific targets for their conservation at a national level, usually by maintaining their existing populations and increasing habitat connectivity (e.g. *Bombus sylvarum* – JNCC, 2010b). To date, there has been no net loss of populations[32] of the 12 originally listed priority species for which targets have been established and monitored since 2006,

32 Of these species one, *Bombus subterraneus*, is nationally extinct with the BAP containing plans to reintroduce the species from stock from Sweden.

although few targets for expansions of species have progressed (BARS, 2011). The effectiveness of many UKBAP Species Action Plans for bees have been curtailed by a shortage of funding (e.g. *Andrena ferox* – JNCC, 2010a) and a lack of dedicated monitoring schemes but has generally been successful in better identifying and qualifying the pressures facing these species (e.g. *Bombus humilis* – JNCC, 2010c). Recently, the UKBAP has been superseded by the establishment of the England Biodiversity Strategy (EBS[33] – DEFRA, 2011g), which establishes new targets for species and habitat conservation within England, using NERC S41 as a priority list, which includes all English Bees listed in the UKBAP. Despite their importance to society and ecosystems as pollination service providers, bees are not among the selected species for which the EBS will assess trends in abundance and distribution (DEFRA, 2011g). Furthermore, while £1.2m for biodiversity monitoring has been announced under the EBS it remains unclear whether this funding will extend to bees, although the new Biodiversity Action Reporting System will facilitate co-ordination among more local level bee conservation efforts (BARS, 2012). In its present form, the EBS also does not draw explicit links between priority species and the quality and connectivity of their habitats required to provide effective conservation and no indicator species are proposed to assess habitat quality for bees.

Under Section 40 of the Natural Environment and Rural Communities Act 2006, local authorities are given a "duty to conserve" biodiversity including the maintenance and restoration of habitats and locally threatened species. However, this does not oblige the local authority to produce targeted goals or action plans for biodiversity conservation. Although the Localism Act 2011 (HM Government, 2011d) would allow them to do so, few local authorities are likely to have access to the relevant expertise to develop effective action plans (HM Government, 2012). Nonetheless, some local authorities, have developed their own Local BAPs which contain more localised plans to enhance biodiversity and will continue to receive support under the new EBS. None of these Local BAPs however include locally targeted objectives for protecting locally threatened bees, although some contain broader conservation efforts to protect bees as a group. For instance Islington's Local BAP has recently been expanded to include a range of conservation efforts for wild bees, including managing flower rich habitats, raising awareness and monitoring populations in conjunction with relevant organisations (Islington Council, 2011). However, this plan does not include clauses to link with similar schemes that may arise to create diverse, continuous and connected habitat throughout the landscape that bees need to thrive. The Government's recently introduced Local Nature Partnerships (LNP) may therefore have great potential to redress these balances by better linking different stakeholders and experts within and beyond Local Authorities' area and providing suitable expertise on wild bees and other taxa (HM Government, 2011a).

3.7. Bee Health

3.7.1. Policy to control pests and diseases in managed bees

Pests and diseases are a major cause of loss among bees within England, particularly within managed bee populations. Among honeybees, the ecoparasitic mite *Varroa destructor* is widely considered the most significant of these pests and the primary driver of winter colony losses in England and Wales, acting as a vector for many diseases that weaken or kill afflicted bees (Potts et al, 2010a; NBU, 2011a). The main legislation concerning Bee health in England is the Bee Diseases and Pests Control (England) Order 2006 (HM Government, 2006c)[34], a statutory instrument created from the powers granted to DEFRA in the Bees Act 1980 (HM Government, 1980). Although these policies do not define bees as any particular taxa, they are almost exclusively aimed at honeybees. This legislation primarily serves to establish European and American Foulbrood, small hive beetle (*Aethina tumida*) and Asiatic honeybee mites (*Tropilaelaps* sp.) as notifiable diseases and pests, legally mandating beekeepers to inform DEFRA if they know, or suspect, their colonies are carrying any of these. Despite concerns about their potential impacts


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33 Similar strategies are in development in Scotland, Wales and Northern Ireland

on honeybee populations (Smith et al, 2011), no viruses are presently listed as notifiable diseases, although as identifying viral incidence can often be very difficult (Formato et al, 2010) controlling *Varroa destructor*, as the main vector of viruses, is likely to be more effective than treatment under notification. *Varroa destructor* itself is widely established across England and consequently no longer listed as a notifiable pest[35] (NBU, 2011b).

The control of notifiable pests and diseases is carried out by the National Bee Unit (NBU) who provide free inspections, training and diagnostic analyses to registered beekeepers under DEFRAs Bee Health Programme. These efforts are further supported by the DEFRA and the Welsh Assembly government £2.7m Healthy Bees Plan, aimed at improving bee health and beekeeping standards in England and Wales over the proceeding decade (DEFRA, 2009) and the. Current policies on notifiable disease appear to have been effective as the number of recorded incidents of foulbrood has remained within the relatively low range of 3-7 cases per 1,000 hives with occasional peaks and troughs since 1955 (NBU, 2012a; Figure 1). It must be noted that while incidence appears to spike after 2008, this is an artefact of improved data on the lower total number of colonies compared to previous years. Rates of detection also grew substantially between 1988-2005 when total inspections had fallen, suggesting that existing detection protocols have been effective at containing these diseases (Figure 2). However, monitoring is only conducted on hives registered with the NBU's Beebase database which is entirely voluntary, resulting in potential risks of transmission from unregistered hives. There is concern that unregistered beekeepers may not have adequate information on best practices for *Varroa* or disease management, potentially curbing measures to control them (NBU, 2011a). This concern is further emphasised by the very low number (<5%) of foulbrood incidents reported by unregistered beekeepers and the difficulty many beekeepers have expressed in identifying the diseases (National Audit Office, 2009). The Healthy Bee Plan aims to redress this issue by encouraging greater numbers of beekeepers to register with Beebase and collaborating with local beekeeping associations to further spread information on pest and disease management (DEFRA, 2009). These efforts appear to have been successful, with 2291 beekeepers registering in 2011 alone (NBU, 2011a) and recent declines in the proportion of hives found dead (NBU, 2012a).

To control introduced pests and diseases, the Bee Diseases and Pests Control Order (England) 2006 set post-import controls on live honeybees and bumblebees from outside the EU. Imports of bees may only come from EU countries or approved "third countries" as listed in EU regulation 206/2010

Figure 1. Total foulbrood (FB) detection per 1,000 hives in England and Wales 1952-2011

Source: National Bee Unit; Potts et al (2010b)

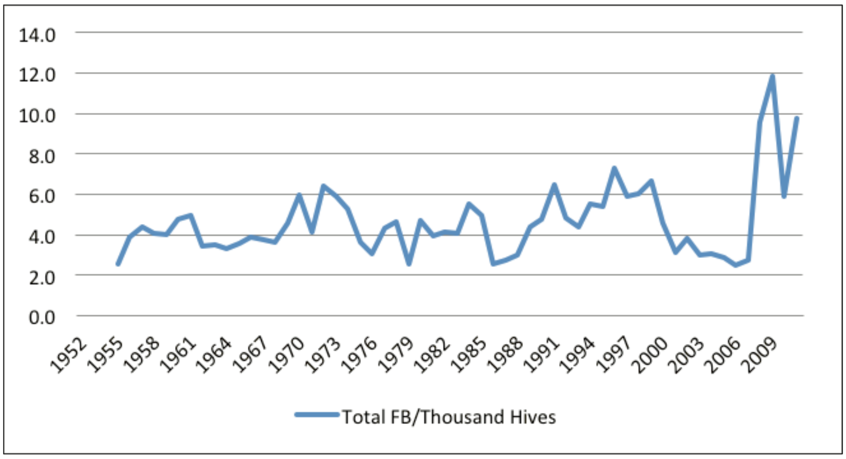
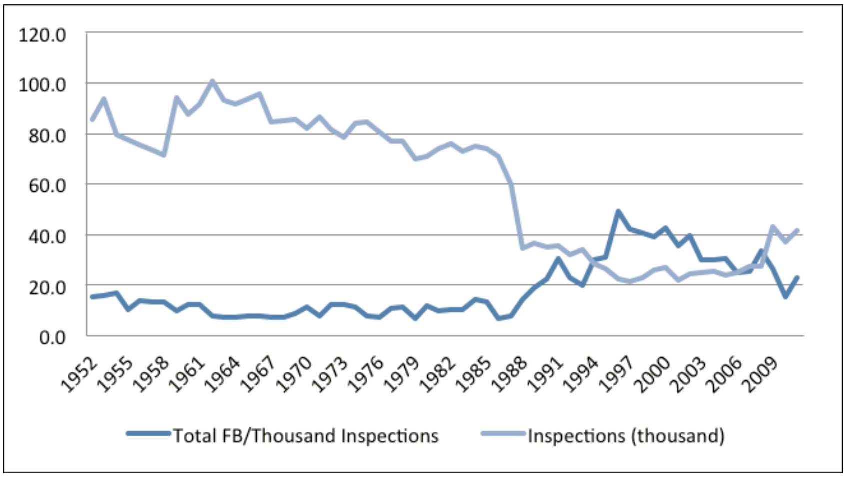


Figure 2. Total number of inspections (thousands) and total foulbrood (FB) detection per 1000 inspections in England and Wales 1952-2011

Source: National Bee Unit



(EC, 2010b). All imports must be accompanied by a veterinary health certificate confirming their freedom from notifiable diseases following the EU guidelines[36]. EU Directive 142/2011 (EC, 2011c) further strengthens these controls by imposing strict conditions for the import of honeybee hive products such as honeycomb, royal jelly or honey, which may carry pests or diseases, into and within the EU. These controls appear to have been successful as no incidents of notifiable pests have been reported within England, and the NBU presently conducts regular screening of registered hives in areas at risk of exotic pest introduction (Anderson et al, 2009). EU regulations have also been effective at protecting member states from these pests with a case of small hive beetle (*Aethina tumida*) in 2 colonies in Portugal being immediately contained (Marilhas, 2005). These measures are

35 Varroa destructor was previously listed under the Bee Diseases Control Order 1982

36 Specifically those of regulations, 206/2010, 92/65/EEC (EC, 1992b) and 90/425/EC (EC, 1990)

further bolstered under the Bee Health Programme by identifying possible entry routes for particular invasive pests and measures to effectively control them (DEFRA, 2009). Despite these successes however, the threat of many invasive species remains, for instance, a recent NBU risk assessment identified illegal imports from third countries and limited physical inspections of bees imported from within the EU as significant points of entry for the species (Anderson et al, 2009). Furthermore, significant concerns have been raised regarding the possible invasion of the Asiatic Hornet (*Vespa velutina*), a predatory insect against which European honeybees have no defensive behaviour and which has recently migrated across Europe, particularly in France (Smith et al, 2011). FERA and the Non-Native Species Secretariat has identified the possible routes the species may enter the UK and suggested an eradication campaign to control the species (NBU, 2012b; Marris et al, 2011). Unfortunately Marris et al (2011) conclude that any attempts to eradicate the species are unlikely to succeed and, lacking any EU-wide measures to curb the spread of the species, specific national action is likely to prevent its arrival.

3.7.2 Policy on veterinary medicines for bees

A major concern with the control of bee pests and diseases is the limited availability of medication for bee pests. Presently there are only 7 commercially available products for treating pests in bees (Formato et al, 2010), although veterinarians are able to order medication approved for use in other EU countries through Special Import Permits (VMD, 2011). Of particular concern is the growing resistance of *Varroa* to standard treatments such as pyrethroids (NBU, 2012a). Honeybees, as a food producing animal, fall under EU Directive 470/2009 (EC, 2009f) which aims to minimise the levels of medicinal residues within the human food chain by imposing requirements for Maximum Residue Levels (MRL) to be known before any treatment is to be used. Presently no exceptions are made for honeybee hives owned by amateurs or which are not managed for honey production (National Audit Council, 2009). Furthermore many effective treatments for *Varroa* control remain unlicensed for sale or use as a treatment across the UK and much of Europe, notably Oxalic Acid[37] (Formato et al, 2010) which has been shown to be extremely effective as a Varroacide (Rademacher and Harz, 2006). A review by the European Agency for the Evaluation of Medicinal Products (The European Agency for the Evaluation of Medical Products, 2003) further found no evidence of risks to human health, resulting in the chemical being listed as exempt from EU MRL requirements[38]. Exceptions are also in place for similarly effective Lactic Acid and Formic Acid (Formato et al, 2010). However these chemicals remain unlicensed for treatment use in England as no companies have yet sought licenses (VMD, 2011), despite their exemption under EU law qualifying them for approval under the Veterinary Medicines Regulations 2011 (HM Government, 2011e).

Treatments for foulbrood and other diseases afflicting honeybees are very limited. European Foulbrood can be treated antibiotically using oxytetracycline or, in some cases by shaking the bees onto new hive frames and destroying the old combs (known as shook swarm). By contrast, no treatment is available for American Foulbrood, which has demonstrated antibiotic resistance in North America (Murray and Aronstein, 2006) leaving mandatory destruction of colonies as the only present means of control (FERA, 2009). No compensation is paid for these destructions, although some beekeepers are insured against these destructions (National Audit Office, 2009). There are also concerns that oxytetracycline and other antibiotics may cause metabolic disorders in honeybees, resulting in toxicity from Varroacides (Hawthorne and Dively, 2012). Recent research has, however, demonstrated the effectiveness of certain essential oils found in plants such as Grapefruit (*Citrus* x *paradisi* – Fuselli et al, 2008) and Palmorsa (*Cymbopogon martinii* – Fuselli et al, 2010) in eliminating American Foulbrood infections and may prove a viable alternative to colony destruction.

In a bid to address the limited access to veterinary medicines for bees, the Veterinary Medicines Directorate (VMD) in 2009 published the Action Plan on the Availability of Medicine for Bees in collaboration with the NBU and other related organisations to improve access to these treatments (VMD, 2011). This plan has eight active objectives, most significantly aimed at reviewing and seeking amendments to European regulations for bee medications, encouraging manufacturers to apply for product approval in the UK, improving access to beekeeping medicines and encouraging further research in this area. Although these objectives are still in progress the action plan has resulted in the varroacides ApiLifeVar and Thymovar 15g Bee-Hive Strips being authorised for use in the UK and is chairing a review of how MRLs for honey are established as part of the Codex Committee on Residues of Veterinary Drugs in Foods. Through this plan the VMD has also developed a range of disease information sheets for members of the British Beekeepers Association and compiled a nationwide database of veterinarians willing to assist in acquiring Special Import Certificates for bee medication on behalf of beekeepers (VMD, 2011).

3.7.3. Policy affecting wild bee health

Presently, all policy concerning bee health has focused upon managed bees and honeybees in particular, for which pests and diseases are thought to be a major factor in population declines

37 Oxalic Acid compounds are legally available as means of cleaning empty hive frames http://www.vmd.defra.gov.uk/fsf/bee_authorised.aspx

38 See Council Regulation 37/2010

White-tailed Bumblebee (Bombus lucorum agg.)

(Potts et al, 2010a). As the Bees Act 1980 does not concern any particular groups of bees, policy could be broadened to provide protection to other managed bee species and wild bees as well, however, diseases in wild bees are very difficult to study and likely near impossible to treat, at the current level of scientific understanding. Nonetheless the spill over of diseases and pests between wild and managed bees has become increasingly observed in a range of agricultural systems (Meeus et al, 2011; Morkeski and Averill, 2010) and is now considered a major threat to wild bees (Kuldna et al, 2009). This is a particular concern as 16-71% of honeybee consignments from registered third countries are found to carry non-notifiable diseases such as *Nosema* sp. fungi which parasitize bee guts, sometimes in quite high levels, potentially acting as disease reservoirs to wild populations (National Audit Office, 2009). *Nosema* sp. infections in managed honeybees can also reduce the effectiveness of certain *Varroa* treatments in honeybees, increasing their exposure to diseases (Botías et al, 2012). Managed bumblebees escaping from glasshouses in Canada have also been observed to cause significant increases in *Nosema* sp. infection in surrounding wild bumblebee populations (Colla et al, 2006). By reducing the prevalence of pests and diseases in managed bees, policy to improve bee health is likely to be reducing this spill-over to wild and other managed bees, however there are presently no explicit control measures to curb transmission between managed and wild bees which may arise when infected colonies are used in or near habitat for these species.

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SECTION 4
General Conclusions

Bees are an essential functional group both in the natural world and to human societies, providing a broad range of benefits which would be costly to achieve in their absence. In recent years, a number of government policies have provided strong positive steps towards halting declines in wild and managed bees in England. In particular the recent shift in focus towards integrated, well-connected and high quality ecosystem-scale conservation via Nature Improvement Areas (HM Government, 2011a) and other landscape-scale initiatives will likely help redress many of the major issues affecting bees in those areas. Government aspirations to encourage Green Infrastructure, environmentally based development, within towns and cities also offers great potential to provide habitat for bees in gardens, allotments, nature reserves and road verges. Agri-Environment Schemes have also begun to move towards delivering greater benefits for bees and other key wildlife, encouraging farmers to adopt higher benefit options such as nectar flower mixes and offering significant payments for habitat preservation and creation (Natural England, 2010b,c,d). Measures to limit pest and disease outbreaks among managed bees have also proven largely successful, although the large number of unregistered beekeepers has limited this success (NBU, 2011). Although these policies represent great steps to reduce the pressures on bee populations, their effectiveness cannot yet be accurately inferred because of a lack of dedicated monitoring schemes and detailed research.

In addition to these successes this review has identified a number of shortcomings in current policy which could exacerbate pressures on bees. Although pesticide regulations and guidelines provide some protection to honeybees and restrict the time of spray, few requirements for assessing the toxicity of these chemicals upon other bees at field level exposure are made. The new National Planning Policy Framework establishes local authority commitments towards providing Green Infrastructure but does not provide detailed guidelines for this to be achieved. Green Infrastructure is also notably absent from the government's 'Top 40' development projects (HM Treasury, 2011). In farming, potentially beneficial "greening" reforms under the EU's Common Agricultural Policy are strongly opposed by the government out of concerns towards the competitiveness of English farming. Despite this reasoning and the potential growth in demand for pollination services to agriculture, government policy does not account for the great potential of bees to improve the rural economy by enhancing and stabilising crop yields. Of final note is the lack of recognition of bees and the specific habitats which support them in the new England Biodiversity Strategy (DEFRA, 2011g).

Perhaps the greatest shortcoming identified by this study is the failure of government to fully recognise the importance and conservation needs of bees across the country. In general, current government environmental policy places a very strong emphasis upon economic expansion and development within the natural landscape, focusing strongly on the prospect of tapping into the "multi-million pound opportunities available from greener goods and services" (HM Government, 2011a,d, 2012) and although bees can make substantial contributions towards this aim (Section 2), policy remains largely negligent of them. Redressing this shortcoming will assist not only in promoting bees as pollination service providers to agriculture but can also contribute towards other government objectives, such as encouraging healthier diets (HM Government, 2011b), protecting broad ecological networks (DEFRA, 2011f) and meeting commitments towards agricultural sustainability (HM Government, 2011a). However, in light of present government policy on expanded localism, the success of all such efforts will depend heavily upon the strength of support given to local authorities, especially the 65% without in-house ecological expertise. Based upon the policies reviewed in this study and the gaps in legislation, evidence and action highlighted, the following recommendations are submitted as very positive steps towards conserving wild and managed bees within England.

Recommendations

1. Agricultural production

1.1. Take opportunities under the Common Agricultural Policy (CAP) Pillar I to improve sustainable agriculture and the environmental quality of farmed land for bees and other biodiversity by:(i) strengthening existing cross-compliance protections for boundary features, not just hedgerows, (ii) expanding the area required for Ecological Focus Areas (EFA) to 10%, and (iii) incorporating novel land uses such as planting legumes and other cover crops within land eligible for EFA and mandatory crop diversification proposals.

1.2. Encourage and support development and diversification of the British fruit and vegetable industry to provide more diverse and abundant mass-flowering crops for bees within the farmed landscape and improve sustainable food security.

1.3. Develop support for alternative sustainable farming systems such as agroforestry and infield mixed cropping which can have substantial benefits to bees but which currently do not receive CAP single payment scheme support.

1.4. Develop a system of knowledge exchange for the pollination requirements of current crop cultivars and foster stronger links between farmers, researchers, agronomists and beekeepers to reduce risks to crop growers and bee populations within farmed environments.

1.5. Support research into identifying key pollinators of current crop cultivars, quantifying the benefits of pollination on crops and evaluating the long-term impacts of crop rotations upon bee communities, paying close attention to the impacts of oilseed rape monocultures.

2. Pesticides

2.1. As part of the forthcoming National Action Plan on pesticides, commit to encouraging a sustainable long-term reduction in the use of pesticides, with quantitative targets for the reductions in the total application of all pesticide active ingredients, and encourage the uptake of alternative pest management methods including the use of natural enemies.

2.2. Amend pesticide accreditation to include independent, quantifiable and cross-taxa risk assessments of their impacts, including sub-lethal effects, on a range of bees in both laboratory and field conditions, including the presence of residues within the pollen and nectar of mass-flowering crops.

2.3. Improve pesticide label regulations to include more specific recommendations which account for the seasonal activity patterns and nesting habitats of a range of on-farm bee taxa, based on up-to-date ecological information, and extend these standards to non-agricultural pesticides.

2.4. Any risk assessments carried out on the introduction of Genetically Modified crops for commercial release should include case-specific evaluations of their impacts upon both a range of bee species and wider plant communities.

2.5. Support research into using managed bees as biocontrol vectors and improving the economic viability of natural enemies as pest control.

3. Agri-Environment Schemes

3.1. Enhance the effectiveness of all Agri-Environment Schemes (AES) by setting specific long-term objectives at a range of spatial scales and develop more precise option quality and delivery monitoring schemes.

3.2. Further increase funds to the Higher Level Stewardship to increase the number, extent and quality of agreements and encourage participants to collaborate and innovate within the scheme to further diversify the resilience of farming systems.

3.3. Support industry led efforts to encourage the uptake and effective management of AES options that benefit bees, especially within the Entry Level Stewardship. Follow Natural England recommendations on changing the points for these options if appropriate including recognition of the full economic costs of options.

3.4. Develop and encourage new AES options which provide forage and, in particular, nesting resources for bees for a range of conventional and alternative farming systems.

3.5. Support research into the benefits of current and potential AES options for bees, how they can be bundled together and spatially targeted in the wider landscape to maximise their benefits as part of a range of farming systems and the effectiveness of farmer self-monitoring of the performance of their AES agreements.

4. Habitat Conservation

4.1. Enhance protection via designation for priority habitats, particularly those that act as source habitats for bees, in particular lowland meadows, and develop updated and new targets as appropriate to further enhance their contribution to overall landscape habitat quality for bees.

4.2. Reform Environmental Impact Assessment regulations to remove, or reduce, the thresholds for assessment free development on habitats recognised as national priorities.

4.3. Improve cross-policy co-ordination to strengthen protection and restoration work for existing ecological networks, in particular designated sites, hedgerows and other boundary features, taking lessons learned from Nature Improvement Areas as appropriate.

4.4. Support research into the benefits of woodland and forest habitats for bees, including those used commercially, and the management of these sites to optimise their benefits for bees.

5. Planning Policy

5.1. Provide clear guidance to local planning authorities on how to implement Green Infrastructure within the National Planning Policy Framework in order to enhance the quality of the built landscape for bees by, for example enhancing the area of wildflowers on green spaces around new developments, and increasing protection of local wildlife sites. This should be accompanied by recognition within the framework to preserve pollination and other ecosystem services for sustainable development.

5.2. Revise Environmental Damage Regulations to establish objectives and maintenance plans for replacement habitat within wider ecological networks or local green infrastructure, including lessons from Biodiversity offset trials and other similar schemes.

5.3. Support a dedicated network of bee and pollination service experts to advise LNPs and local authorities on effective conservation policy at local scales, especially where specific ecological expertise is lacking.

6. Species Conservation

6.1. Take opportunities under the new England Biodiversity Strategy to develop targeted, species and habitat specific conservation measures for bees, including guidelines for local authorities to develop high quality, locally tailored conservation measures that have clear systems of monitoring and accountability.

6.2. Develop a systematic nationwide scheme of tools and resources to monitor the diversity, abundance and populations of bees and the pollination services they provide.

6.3. Encourage local authorities to establish measures to improve habitat for bees within Local Nature Partnerships (LNPs), or other local biodiversity schemes, with appropriate indicator species. These measures should incorporate the goals of the England Biodiversity Strategy and the upcoming new Red List of bees where sufficient expertise is available or, where expertise is unavailable, introduce broad targets that benefit a range of bees.

6.4. Support further research into the drivers of bee declines at a range of local and national scales and the identification of bees that act as indicators of localised ecosystem health.

7. Bee Health

7.1. Revise the Bees Act 1980 and its associated orders specifically to include provisions for maintaining health of all bees in addition to honeybees.

7.2. Revise regulations on veterinary medicines explicitly to legalise treatments allowed in other EU countries and encourage the pharmaceutical industry to register these products and invest further in developing effective control measures, recognising the differences between hives used for commercial honey production and those used for pollination only.

7.3. Develop measures and legislation to reduce the potential for pest and disease transmission between managed and wild bees, particularly in areas where priority species are present.

7.4. Continue to fund dedicated research into remaining evidence gaps for: (i) honeybee and other bee diseases, (ii) preventing the arrival and spread of new pests and diseases, including emergency funds to eradicate these species as soon as they enter, (iii) improving the screening of hives and beekeeping imports, and (iv) supporting VMD efforts to further enhance beekeeper training in disease identification.

7.5. Instigate compulsory registration of honey beekeepers, and importers/users of managed bumblebee colonies, alongside a renewed commitment to monitor and manage diseases in beehives with a dedicated target for reducing the incidence of foulbrood in honeybees.

SECTION 5

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Buff-tailed Bumblebee (B. terrestris)

This research was undertaken by the University of Reading for Friends of the Earth.

More information about the University's work on bees can be found at www.reading.ac.uk/caer/staff_simon_potts.html

Information about Friends of the Earth's The Bee Cause campaign can be found at www.foe.co.uk/bees

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