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Policy report

Pollinators in the CAP

Integration of pollinator conservation into the Common Agricultural Policy

Institute for European Environmental Policy

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1. AIM OF THIS REPORT

This report addresses the integration of pollinator conservation into the Common Agricultural Policy (CAP), in line with Action 5A of the Pollinator Initiative. Action 5A commits the Commission to "*assess existing experience on the use of pollinator-relevant measures under the common agricultural policy 2014-2020*" with a view to developing guidance for managing authorities and farmers, "*providing technical advice on how to increase the effectiveness of measures*".

This report reviews the types of actions that can be supported by CAP measures, examines what impact CAP Rural Development Programmes during the 2014 to 2020 period may be having on pollinators, and provides recommendations for how pollinator conservation can be integrated into CAP Strategic Plans for the post 2020 period. It is aimed at Member States agriculture managing authorities and other government agencies, and at farm advisors and extension services, as background information and support to the Guide to Pollinator-friendly Farming (Keenleyside and Underwood, 2020).

The report:

- documents the evidence for the effectiveness of different actions for pollinator populations and habitats on farmland and in forests.
- reviews the CAP measures whose implementation may support or hinder such actions, and the ways in which they have been programmed in the EU in the 2014-20 period.
- illustrates the extent to which pollinator needs and priorities have been a driving force for implementation choices of the CAP in the six case study Member States (including whether negative impacts on pollinators have been deliberately avoided).
- shows how advice, training and awareness raising has been undertaken using CAP measures in the six Member States and (if data has been found) whether it has been effective.
- identifies key lessons learnt that are relevant to the decisions Member State managing authorities will make in the process of preparing their CAP Strategic Plans 2022-27.

2. WILD POLLINATORS IN FARMLAND AND FOREST

2.1 What is the situation of wild pollinators on farmland and in forests?

2.1.1 What is the trend of wild pollinator populations and diversity?

Scientific studies provide evidence that European wild bee populations have declined quite drastically on farmland during the 20th century, and that many of the most specialised species are not found on farmland at all anymore (see Box 1 for evidence). There has been an increase in the domination of bee communities by a smaller number of species, as shown in the Netherlands and the UK (Biesmeijer et al, 2006). Intensively managed agricultural landscapes have only a few abundant bumblebee species (mainly *Bombus terrestris*).

Threatened and rare bee species are closely associated with unimproved semi-natural grassland rich in plant species of the Fabaceae family (i.e. legumes, clovers, etc), and with heathland and scrub habitats, dunes, and moorlands. Species with restricted dispersal behaviour and species in need of areas poor in soil nutrients are most threatened, because of habitat loss and degradation (Nieto et al, 2014).

Hoverflies, which are key pollinators, may also be losing species richness, although here is less evidence of whether populations are declining or not (see Box 1). **Butterflies** associated with grasslands are also declining sharply in abundance, and there are studies from Western Europe showing that **moth** populations are declining, though the evidence is mixed (see Box 1).

Whilst it is clear that pollinators are threatened by global change, the magnitude, scale and extent of population declines remain unknown. There is evidence of a severe decline in the insect biomass associated with unimproved semi-natural grassland and scrubland in Western Europe. A recently published study in Germany (Hallmann et al, 2017) estimates that there has been a seasonal decline of more than 75% of total flying insect biomass over 27 years in protected areas surrounded by agricultural land. A comparison of cicada abundances between the 1950s and 1960s and 2008-2010 in Germany found a decline of over half of the biomass on dry grasslands in protected areas, and 78% on agriculturally used wet grassland (Schuch et al, 2019). In contrast, pollinator populations on undisturbed natural scrubland in southern Spain show no long-term declines (Herrera, 2019).

There is far less information available on pollinator trends in **forests**. Although wild bees are not abundant under closed forest canopies, forest edges and open habitats within forests provide important habitats. The other pollinator groups - hoverflies, other flies, wasps, and moths - are abundant and species rich particularly in forests with native tree composition and a diverse forest structure. In Germany, long term monitoring of arthropods in 30 forest sites shows that biomass and species number—but not abundance—decreased by 41% and 36%, respectively, between 2008 and 2017 (Seibold et al, 2019).

Box 1 Evidence of wild pollinator declines in Europe

Wild bees: The European Red List of Bees assessed 9.2% of bee species in Europe as threatened or regionally extinct (Nieto et al, 2014). However, it is important to note that more than half of bee species in Europe were too data deficient to be assessed correctly, so more species extinctions may still be recorded (Nieto et al, 2014). An earlier assessment concluded that 80% of bumblebees and cuckoo bees (*Bombus* spp. and *Psithyrus* spp) are threatened in at least one country of the Western and Central European region (Kosior et al, 2007). In the UK, 23 species of aculeates (bees and wasps) have been lost since the mid-19th century, and though the rate of species loss has slowed since the 1960s, four species went extinct between 1988 and 1990 (Ollerton et al, 2014). The decline in abundance and distribution continues, as between 1980 and 2013 there was an estimated net loss of 11 pollinator species (4 bees and 7 hoverflies) per 1 km grid cell in Great Britain, meaning that species now occur in fewer places (Powney et al, 2019). Upland habitat specialists showed a 55% decline in occurrence, in contrast to dominant crop pollinators, which increased by 12%, perhaps in response to agri-environment measures (Powney et al, 2019). In the Netherlands, a study found that most of the endangered and locally extinct bee species are specialized on a few host plants that have also experienced severe population declines, in particular plants in the Fabaceae family, whilst bee species foraging on crop plant families have stable or increasing populations (Scheper et al, 2015b). Plant species in the Fabaceae family (known as legumes), which are the major pollen source for most bumblebee species, have declined due to the loss of unimproved seminatural grasslands, but also to the drastic decrease in the agricultural use of Fabaceae (clover, alfalfa, lupins etc) as fodder and cover crops during the twentieth century (Goulson et al, 2005). Many bumblebee species have undergone substantial decreases in range and localized extinctions (Goulson et al, 2015), as demonstrated in Denmark (Dupont, Damgaard and Simonsen, 2011) and Sweden (Bommarco et al, 2011). A study in the Netherlands showed that female bees of large-bodied species have decreased in average body size since 1900 (compared to small-bodied bees), which indicates that these bee species are under pressure from declining habitat quantity and quality and are under evolutionary pressure to become smaller (Oliveira et al, 2016). In contrast, monitoring of pollinator populations over two decades in undisturbed vegetation in a protected area in southern Spain showed no signs of pollinator decline (Herrera, 2019).

Hoverflies: Hoverfly species richness at the local level (in 1km2 grid cells) declined steadily in Great Britain from 1987 to 2012 (Powney et al, 2019). In contrast, an earlier study concluded that hoverfly species richness at the local level has increased in The Netherlands over the last decades (Biesmeijer et al, 2006). Hoverfly larvae are not dependent on flower resources and therefore the species may be less sensitive to land use change (Scheper et al, 2015b).

Butterflies and moths: The abundance of grassland butterfly species has declined by about 40% across the EU since 1990, with declines of 75% in some EU Member States (Van Swaay et al, 2019). A third of large moth species in the Netherlands are declining and the abundance of the common species has dropped by a third (Groenendijk and Ellis, 2011). Macromoth populations in Great Britain have also declined substantially in abundance and distribution according to one analysis of the data (Fox, 2013), although this is not reflected in long-term data on overall moth biomass trends since the 1960s, which show post-1980 declines in woodland and grassland species but no declines in arable areas (Macgregor et al, 2019).

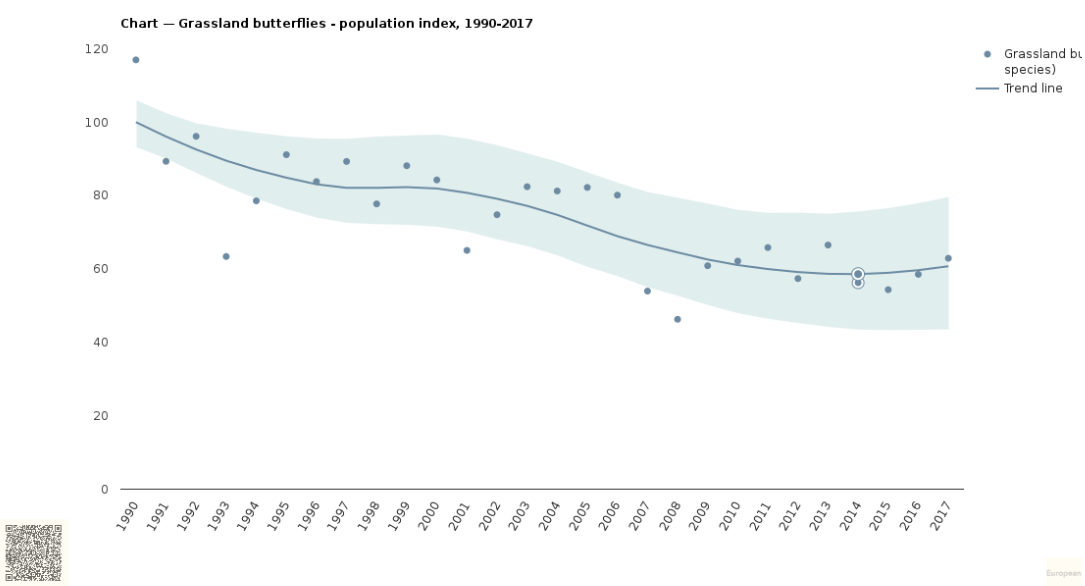

Chart of grassland butterflies population index 1990-2017. Source: EEA (2019) Grassland butterflies - population index, 1990-2017. European Environment Agency. Available at: https://www.eea.europa.eu/data-and-maps/daviz/european-grassland-butterfly-indicator-3#tab-chart_6

2.1.2 What are the main pressures and threats to wild pollinators on farmland?

The main environmental threat to pollinator diversity and abundance in Europe is associated with modern intensive agriculture (with intensive fertiliser and pesticide use) and the loss of extensively managed unimproved grasslands, fallow areas with weedy vegetation, cover crops and forage crops, and field margins with diverse flowering vegetation (IPBES, 2016; Nieto et al, 2014). There has been a large-scale **loss of semi-natural grasslands** in Europe and the loss continues (see Box 2). There has also been a marked **decline in the abundance of flowering weeds** in and around arable crops, due to improvements in cropping efficiency, herbicide use, and fertiliser use, in almost all arable areas of Europe (see Box 2). In some regions and on the remaining patches of unimproved farmland, the main threat to wild pollinators is the abandonment of traditional agricultural land uses including grazing and mowing, resulting in the conversion of semi-natural grasslands into scrub and woodland.

The main factor limiting pollinator populations is the **abundance and diversity of floral resources in the landscape**, particularly in the early spring and late summer periods. Wild pollinators require a diverse range of flowering plants from early spring to late autumn, with the timing varying with the different species, and they also require nesting resources or larval habitats (e.g. shrubs and trees, bare soil with rodent holes and free of pesticides, water in tree holes or other small cracks, or animal dung). Bees feed their larvae on pollen and nectar, whilst other pollinators rely as adults on nectar to provide them with energy and in some cases pollen to provide them with protein. The larvae of non-bee pollinators feed on leaves or insect prey. Neither of these needs can be met entirely in crop fields, although **field margin habitats** such as wide arable weed margins, hedges and woody patches can sustain some species if the vegetation and structure is diverse enough and they are free from pesticides. Therefore, all **pollinators** depend on a diversity of plant species, which are most abundant in **semi-natural and natural habitats**, and only a few pollinator species are found in abundance far away from areas of natural habitat (Ricketts et al, 2008). Wild plant sources are necessary to sustain the food supply for pollinators, as flowering crops provide abundant nectar and pollen for short periods only.

Fabaceae plant species, which are the major pollen source for most bumblebee species, have declined due to the loss of unimproved seminatural grasslands, but also due to the drastic decrease in the agricultural use of Fabaceae (clover, alfalfa, lupins etc) as fodder and cover crops during the twentieth century (Goulson et al, 2005). There is evidence that on arable farmland, bumblebee abundance (mainly the most common species *Bombus terrestris*) is limited by the lack of flower resources after the oilseed rape crop season ends in July, and flower abundance is often insufficient for colonies to successfully reproduce despite an abundance of worker bees early in the season (Persson and Smith, 2013). Experts in the UK estimate (based on research findings), that **for every 100 ha of farmland, an estimated 2% of flower-rich habitat (equal to 2 ha) and up to 1 km of flowering hedgerow** are the minimum needed to supply enough pollen to support populations of the six most common wild bee species (Dicks et al, 2015). A synthesis of landscape-scale studies of agri-environment measures (AEM) in Europe (mainly in western and northern Europe) showed that AEM have had a large positive effect on pollinator species richness (Marja et al, 2019). The review found the greatest effects come from those measures that create the biggest ecological contrast between the measure and surrounding landscape by increasing floral resources.

Habitat heterogeneity has a positive effect on pollinator numbers and diversity (Senapathi et al, 2015). So, farming landscapes with more landscape and field edge features, more diverse crop rotations, smaller fields, and more non-agricultural elements such as woods are generally richer in pollinator populations. A recent analysis of long-term data on insect abundance declines in Germany concludes that the major drivers of arthropod decline act at larger spatial scales and are (at least for grasslands) associated with agriculture (grazing, mowing, fertilization) at the landscape level, as the study found no impact of practices at the local level (Seibold et al, 2019).

Bumblebees and most hoverfly species collect food from a broad range of flower species to meet their nutritional needs (polylectic), whilst most solitary bees are specialists, collecting food from a single plant species or a few species (monolectic or oligolectic). Crops are in general only visited by the polylectic generalist species.

Box 2 Pollinator habitat loss on farmland

Semi-natural grasslands and other semi-natural habitats that rely on extensive grazing or mowing are key habitats for most wild bee and butterfly species, and many hoverflies and moths. The key features of these grasslands for pollinator species are the season long presence of a highly diverse and abundant flowering vegetation, open hot and sunny ground (including bare rocky and sandy patches suitable for ground-nesting bees and wasps), and the presence of some trees and shrubs that offer breeding opportunities (e.g. in tree holes) and flowers early or late in the season. For example, a study that combined data on distribution and nectar productivity of different flowering species in the UK (Baude et al, 2016), found that calcareous grassland is one of the habitats that produce the greatest amount of nectar per unit area from the most diverse plant sources. Most of these grasslands are classified as habitats on Annex I of the Habitats Directive.

Large areas of these habitats have been lost to arable agriculture or intensification of grass use over the last two centuries. Member States surveillance of the natural and semi-natural habitats in Annex I of the Habitats Directive show losses of habitats particularly important to wild pollinators in the period 2013 to 2018 (EEA, 2020). Almost half of the grassland habitats have unfavourable-bad status assessments and another third have unfavourable-declining assessments of conservation status. Sparsely vegetated land, heathlands and scrub habitats show comparatively higher shares of favourable assessments, but heathlands and scrub still have less than a fifth in favourable status. This poor conservation status is both due to losses in habitat area and to degradation of the remaining area, due to loss of structure and functions.

It is more difficult to quantify the loss of wildflowers from more intensive agricultural landscapes, but an expert consultation across Europe concluded that arable weed diversity has significantly decreased, driven by increased fertilizer and herbicide use (together with changes in field size, management of field margins and landscape complexity) (Storkey et al, 2012). A long-term analysis of the weed flora of cereal fields in a region of Spain indicates a remarkable reduction in weed frequency (58%), species richness (47%) and total weed cover (69%) (Chamorro, Masalles and Sans, 2016). Long-term trends in the arable weed flora in northeast France indicate a drastic decline in twelve common weed species providing important nectar and pollen sources for pollinators (Fried et al, 2009).

The **use of pesticides** – linked to agricultural intensification – are considered a major threat to wild pollinators. The neonicotinoid insecticide active substances imidacloprid, thiamethoxam, clothianidin and thiacloprid are no longer authorized for use on outdoor crops in the EU because of their impacts on wildlife, and particularly because of their impact on bees (Commission Implementing Regulation (EU) 2018/783; Commission Implementing Regulation (EU) 2018/784; Commission Implementing Regulation (EU) 2018/785; EFSA, 2018; EFSA et al, 2018a; Fryday, Tiede and Stein, 2015). The pyrethroid insecticides are also toxic to wild bees (Baron, Raine and Brown, 2014; Ceuppens et al, 2015; EFSA et al, 2018b; Spurgeon et al, 2016) and reduce moth populations because of their impact on moth larvae in field margins (Hahn et al, 2015). The fungicide chlorothalonil negatively affects bumblebee reproduction (Bernauer, Gaines-Day and Steffan, 2015; McArt Scott et al, 2017). Herbicides have an indirect impact on wild pollinators by removing the wildflowers on which they feed. The combined effect of several pesticides together can be worse than their individual effects (van der Sluijs et al, 2015), for example exposure to fungicides in the EBI class (including the azoles) amplifies the adverse effects of neonicotinoid insecticides on pollinators (Sgolastra et al, 2018; Spurgeon et al, 2016; Willow et al, 2019). Wild bees are exposed to a mixture of multiple pesticides when foraging in agricultural landscapes (Botías et al, 2017; David et al, 2016), but knowledge of the synergistic effects of pesticides is still poor. A monotonous diet (from only one plant species) was shown to increase the sensitivity of bumblebees to insecticides (Dance, Botías and Goulson, 2017). It is also possible that the veterinary products used to control parasites in livestock are affecting bees (UNAF and BEELIFE, 2018).

Most pesticide active substances are still not tested on wild pollinator species so their impacts are not known, and pesticide labelling only specifies measures to reduce their impact on honeybees. Wild pollinators are generally considered to be more sensitive to pesticide impacts than honeybees, which can compensate for sublethal effects by producing more workers from the hive (Henry et al, 2015).

2.2 What are the impacts of apiculture on wild pollinators?

Honeybees are important pollinators of agricultural crops. While it is not considered a major threat in general, a high density of beehives can have negative effects on wild pollinators in a local context by competing with them for nectar and pollen resources, or by transmitting diseases and parasites (see Annex 2 for a description of the evidence). The placing of honeybee hives in protected areas with semi-natural vegetation and rare wild pollinator populations could result in conflicts with nature conservation priorities if the honeybees are outcompeting the wild pollinators and depressing their population growth.

Studies of competition between honeybees and wild pollinators have mostly demonstrated negative effects on wild pollinators, mainly on bumblebees but also on solitary bees (Mallinger, Gaines-Day and Gratton, 2017; Wojcik et al, 2018). For example, a study in oilseed rape fields found that the addition of honeybee hives depresses the densities of other insects visiting rape flowers (bumblebees, solitary bees, hoverflies, marchflies, other flies, and other flying and flower-visiting insects) (Lindström et al, 2016). A study in a protected area with heathland found fewer stem-nesting bee species near honeybee hives compared with similar areas without hives (Hudewenz and Klein, 2013). A study in a protected area with Mediterranean scrubland found that at a density of 3.5 hives per ha, the wild bee biomass around hives was lower than in scrubland without bee hives, due to the absence of the large wild bee species (Torné-Noguera et al, 2016). Cane and Tepedino (2017) estimate that a strong honeybee colony gathers as much pollen in a month as a relatively large sized solitary bee species could use to produce 33,000 progeny. In the Mediterranean region, there is evidence of a long term trend of honeybees replacing wild pollinators on both crop flowers and wild flowers, with four times fewer wild pollinators visiting flowers than honeybees, compared to the ratio in the 1960s (Herrera, 2020).

Competition between honeybees and wild bees will vary according to the abundance of flower resources within the foraging range of the honeybees, i.e. in a radius of 1 km from the hive (Elbgami et al, 2014). A study in Sweden found that in arable landscapes with a low cover of semi-natural vegetation (i.e. less than 2% cover, mainly in field edges and road verges), the presence of honeybees reduced bumblebee densities, but no effect was observed in landscapes with at least 4% cover of semi-natural grasslands (Herbertsson et al, 2016).

There is some evidence that honeybees can transmit pathogens to wild bees (Fürst et al, 2014; Manley et al, 2019), and that these pathogens may be contributing to wild bee population declines (Graystock et al, 2016; Mallinger, Gaines-Day and Gratton, 2017). However, the evidence base is still weak as most studies only show correlations between pathogen presence in wild and domesticated bees, or do not show the direction of transmission (Mallinger, Gaines-Day and Gratton, 2017).

Possible negative effects of honeybees on wild bees can be reduced by limiting the number of hives in relation to the abundance of flowering resources, and by managing the spacing of hives. Honeybee hives placed in protected areas should also be strictly controlled for the absence of diseases and parasites before they are brought into the area.

2.3 What is the status of crop pollination in the EU?

Increasing quantities of crops dependent or partly dependent on crop pollination are being grown in Europe. Insect pollination increases yield, by increasing seed set, and can also increase crop quality, by increasing the shelf life of fruit, or their nutritional quality, or other qualities such as oil content (see Box 3).

Wild bees and other flower visiting species are often more effective pollinators than honeybees (Garibaldi et al, 2013). There is good evidence that crops can be pollination limited because of the lack of wild bees even when there are honeybee hives in the landscape. A study of cherry tree pollination in Germany found that the fruit set increased only with more flower visits by wild bees, even though honeybees were abundant (Holzschuh, Dudenhöffer and Tscharntke, 2012). A study of sunflower pollination in Spain found that seed set was significantly higher in fields next to semi-natural vegetation, due to visits by wild bees, even though honeybees were present in all fields (Hevia et al, 2016). Increasing wild pollinator richness and abundance can lead to higher and more stable crop yields than crops that are only visited by honeybees (Garibaldi et al, 2014).

Higher crop yields are often associated with higher species richness of crop visiting pollinators, because different pollinators complement each other (Hoehn et al, 2008), and the diversity ensures more stable yield across space and time (Garibaldi et al, 2011). At the same time, certain abundant insect pollinators are the most efficient pollinators of particular crops; for example, mason bees (*Osmia* spp) are often the most effective pollinators of fruit trees such as apples and pears, whilst bumblebees (*Bombus* spp.) are the most effective pollinators of peas and beans and other legumes, and the common species of hoverfly (Syrphidae) are most likely to pollinate open flowered crops because of their frequent visits (Rader et al, 2016). The diversity or visitation rate of specific pollinator groups may therefore be more strongly linked to crop yield than that of all pollinators combined.

There is good evidence that some crops are pollination limited in Europe - in other words, crop yield or quality is depressed because of the lack of effective pollinators, and therefore, management interventions that increase pollination can have economic benefits. An analysis of the trends in 54 major crops in France showed that the crops dependent on insect pollination have not increased in yield over the last two decades, in contrast to the wind pollinated crops (Deguines et al, 2014). This indicates that intensification failed to increase the yield of these pollinator-dependent crops and decreased the stability of their yield over time. A field study of pollinator exclusion experiments on four flowering crops located in four regions of Europe found that overall yield was consistently enhanced by higher visitation rates, though not by higher pollinator species richness (Bartomeus et al, 2014).

The effect of insect pollination on yield interacts with other factors affecting yield, such as climate, water availability, fertilisation and pest and disease control. A study showed that insect pollination of field bean (*Vicia faba*) reduced yield loss following heat stress, so pollination may become a more important in crop production as the probability of heat waves increases (Bishop et al, 2016). However, management strategies to enhance pollinators can fail to increase pollination benefits if the soil quality for the crop is poor or pest control is ineffective (Tamburini et al, 2019). For example, one study showed that insect pollination of oilseed rape only increased yield at high doses of fertiliser application, not under conditions of low fertiliser use (Garratt et al, 2018). Another study showed that some oilseed rape cultivars benefit more from insect pollination at low fertilisation rates (Hudewenz et al, 2014).

Box 3 Contribution of insect pollination to yield and quality of field crops grown in Europe

Top fruit (apples, pears, plums, apricots) – Apples are the crop with the overall highest economic value associated with insect pollination in Europe (Leonhardt et al, 2013). A field experiment in the UK showed that insect pollination had marked impacts on the quality of apples, influencing size, shape and improving their classification for market (Garratt et al, 2014). The relative abundance of different pollinator guilds visiting apple flowers of different varieties varies significantly, and whilst hoverflies are less effective pollinators than solitary bees and bumblebees they can be the most abundant (Garratt et al, 2016). A field study in apple orchards in Hungary found that pollination success was significantly related to the species richness of wild bees, regardless of the dominance of honeybees (Földesi et al, 2016). Seed set in apple orchards in New York, US, increased with increasing functional group diversity (based on nesting, sociality, and size traits) (Blitzer et al, 2016). Apple fruit set significantly increased with the species richness of native, wild bees during bloom in Wisconsin, US, whilst increasing numbers of honeybees had no effect (Mallinger and Gratton, 2014). Honeybees are not efficient pollinators of apples (Blitzer et al, 2016; Miñarro and García, 2018).

Pear – pollination by bumblebees and solitary bees increases fruit set and fruit size (Fountain et al, 2019).

Strawberry - high dependence on insect pollination. Bee pollination (primarily by the solitary bee *Osmia bicornis*) resulted in strawberry fruits with the highest commercial value compared with wind pollination and self-pollination, as shown in a field experiment in Germany (Klatt et al, 2013). Insect pollination enhanced average strawberry crop yield by 18% and improved the commercial grade (Bartomeus et al, 2014).

Soft fruit on cane and bush (raspberries, gooseberries, black- and red-currants, blueberries etc) – blueberry flower margins increased wild pollinator populations and highbush blueberry crop yield (Blaaw and Isaacs, 2014).

Field Bean (*Vicia faba*) – high dependence on pollination primarily by long-tongued bumblebees. Insect pollination enhanced average crop yield by 40% but did not raise nitrogen content (Bartomeus et al, 2014).

Field peas *(Pisus sativa)* – medium dependence – self-pollinated but pollination increases yield

Field legumes (Red and White Clover, Alfalfa, Lupins, etc) - need pollination by bumblebees and solitary bees to produce seeds and multiply themselves, which is important if they are being used for multi-annual forage or as a natural fertilizer in grassland (Lundin et al, 2013).

Oilseed rape - Insect pollination increases seed set (Garratt et al, 2018), and number of seeds per pod increased with increasing pollinator density (Jauker et al, 2011), but effect varies between varieties (Hudewenz et al, 2014). In one study, insect pollination enhanced average crop yield by 18% and oilseed rape had higher oil and lower chlorophyll contents when adequately pollinated (Bartomeus et al, 2014). A meta-analysis of publications on pollination of oilseed rape crops confirmed that increasing pollinator functional diversity and abundance enhances crop pollination and yield (Woodcock et al, 2019).

Sunflower – wild bee abundance was associated with significantly higher seed set (Hevia et al, 2016).

Buckwheat - Insect pollination enhanced average crop yield by 71% and the buckwheat had a lower proportion of empty seeds (Bartomeus et al, 2014).

3. EFFECTIVE ACTIONS FOR POLLINATOR POPULATIONS AND HABITATS ON FARMLAND

The following section reviews the literature for evidence of the effectiveness of management interventions for pollinators on farmland, and identifies the key management practices for pollinators, based on expert opinion published in Cole et al (2020), information published by the Bumblebee Conservation Trust and Buglife, and the literature reviewed in this section.

Pollinators can benefit from actions to create more flowering resources, extensifying agricultural management of grassland and cropland, and restoration and management of semi-natural habitats such as hedgerows, old fallow fields, meadows, and other non-intensively managed grasslands. Pollinators also benefit from management to create refuge sites where they can nest and hibernate (depending on the species).

Wild pollinator habitats associated with farmland include:

- **Plant species-rich grassland with high flower density** - key habitat and food source for pollinators such as bumblebees and solitary bees, butterflies, moths and flies. Many solitary bee species are completely dependent on semi-natural grassland habitats that feature the flowers on which they specialize. This can include the ground cover in permanent crops such as vineyards, olive groves, orchards, if it is managed extensively with enough flower cover.

- **Pollinator borders (field margins, buffer strips and flowering strips) -** Strips across arable fields or along field edges on which wildflowers are seeded or allowed to naturally regenerate. They may be created deliberately to encourage wildlife, or for other reasons such as buffering watercourses from risk of agricultural pollution.

- **Hedges, trees and wood patches on farmland -** These can provide overwintering habitat (e.g. for bumblebees), larval habitat (e.g. for hoverflies) and flower food resources (nectar and pollen) outside and between cropping seasons for many pollinators.

- **Arable fallow with seeded or spontaneous vegetation -** Fallow arable fields on which wildflowers are seeded or allowed to grow naturally (with no herbicide use). Fallow land with flower-rich vegetation can provide a rich foraging habitat for pollinators. Multi-year fallow can also provide breeding and hibernation habitat.

- **Heath and scrubland -** Heathland and scrub is an important breeding and foraging habitat for many pollinators. Some threatened bumblebees and many solitary bee species are completely dependent on this habitat[1]. Relevant here are open heath and scrub communities that require regular grazing by livestock to maintain their characteristic plant communities and heterogeneous vegetation structure, and not convert to closed woodland.

- **Forests and other wooded land** - Although closed forest is not a key pollinator habitat, open areas in forests, forest pastures or forest meadows are key habitats for many species, and deadwood is a key breeding habitat for hoverflies and other pollinating insects[2]. Forest edges near farmland are important foraging and refuge habitats for pollinators visiting crops and grassland.

3.1 Maintain a mosaic of flower-rich semi-natural habitats for pollinators

Maintaining and improving the characteristic flower richness of **semi-natural grassland** is a key action for pollinator conservation, as such grassland is the key habitat and food source for pollinators such as bumblebees and solitary bees, butterflies, moths and flies (Holland et al, 2017). Many solitary bee species are completely dependent on semi-natural grassland habitats. This can include the ground cover in permanent crops if managed extensively with enough cover of melliferous flowers (i.e. flowers providing pollen and nectar). Areas of open semi-natural vegetation are an important resource for wild bees throughout the year, and they rely on these areas for forage whilst crops are not flowering and for breeding and overwintering habitats. **Heathland and scrub** habitats such as maquis are also important breeding and foraging habitats for many pollinators. Some threatened bumblebees and many solitary bee species are completely dependent on this habitat[3]. Relevant here is the heath and scrub that requires reg-

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[1] E.g. see Bumblebee Conservation Trust briefing Managing moorland for bumblebees available at https://www.bumblebeeconservation.org/wp-content/uploads/2017/08/BBCT_Land_Factsheet_10_Moorland_management.pdf

[2] E.g. see BugLife briefing Managing Woodland for Pollinators available at https://www.buglife.org.uk/managing-woodland-for-pollinators

[3] E.g. see Bumblebee Conservation Trust briefing Managing moorland for bumblebees available at https://www.bumblebeeconservation.org/wp-content/uploads/2017/08/BBCT_Land_Factsheet_10_Moorland_management.pdf

ular grazing by livestock to maintain its characteristic plant communities and heterogeneous vegetation structure (with some low growing plants and open areas), and to prevent succession to closed woodland and scrub.

Agriculturally productive grassland can also be made more attractive to pollinators by adding legumes and forbs to the seed mix, such as *Trifolium* species (clovers) and *Lotus* species (Trefoils), and *Cichorium intybus* (L.) (Wild Chichory). Leaving some corners and field edges uncut or ungrazed during the summer will allow flower provision for pollinators.

3.1.1 Evidence of effectiveness of actions for pollinators on grassland and heath

- Several syntheses of the published literature show that there is substantial evidence for the effectiveness of flower rich semi-natural habitats for wild pollinator populations. A synthesis of 78 European publications showed that most reported a positive effect of semi-natural habitats on pollinators (Holland et al, 2017). A global review showed a strong exponential decline in crop visitation rates with increasing distance from natural or semi-natural habitats (Ricketts et al, 2008). Kennedy et al (2013) suggested that each 10% increase in area of high-quality bee habitat, for instance a conversion of intensively farmed agricultural land to a more natural habitat land-use, could return a 35% increase in wild bee species abundance and richness.

- Sowing temporary grasslands with forb and legume seeds in the mix significantly increased the pollination of strawberry plants placed on the pastures and increased pollinator functional diversity, species richness and abundance (Orford et al, 2016).

- Reduced cattle stocking rates (from >1 cow/ha to 0.5 cow/ha) increased both bees and insect-pollinated plant richness in pastures in Switzerland, whilst it changed the species composition but not the species richness of insect-pollinated plants in semi-natural pastures in Hungary (Batáry et al, 2010).

- A study of the effectiveness of agri-environment support for extensively managed hay meadows found that wild bee abundance and species richness significantly increased in meadows where uncut refuges were left, in comparison to meadows without refuges: there was both an immediate (within year) and cumulative (from one year to the following) positive effect of the uncut refuge treatment (Buri, Humbert and Arlettaz, 2014).

- A study compared species-rich grassland managed under an agri-environment scheme with areas of naturally regenerated, largely unmanaged grasslands on paired farms (Lye et al, 2009). The managed species-rich grassland attracted more nest-searching queen bumblebees in spring because of its structural complexity, whilst the unmanaged grassland attracted the highest abundance of foraging queen bumblebees, because it contained the highest flowering abundance late in the season.

- Two replicated trials in Dorset, England, indicated that long-term restoration of dry lowland heath can restore a bee community similar to that on ancient heaths (Dicks, Showler and Sutherland, 2010).

3.1.2 Key management practices for pollinators on grassland

- Either sow wildflowers, shrubs, and trees rich in nectar and pollen, or encourage their natural regeneration in field edges, in hedge bases, hedges, woodlands and on the edges of tracks and ditches[4].
- Allow wild plants to flower during the pollinator flight season (early spring to late summer) by delaying cutting and removing livestock or using only a very low stocking rate. Cut or graze in early spring and/or autumn to allow for flowering during the summer.
- employ rotational cutting and and/or grazing at varying times to supply a series of flowering resources throughout the season. Ensure some unmanaged vegetation remains to provide nesting and overwintering habitats.
- leave bare patches of ground and bare stone and rock formations as nesting sites, as well as some shrubs or trees and deadwood.

3.2 Flowering margins or strips and fallow on arable farmland

Flowering field margins or strips in crop fields provide flowering resources that attract pollinators to the crop, increasing their local abundance. They contribute to increased populations, thus providing a benefit to future crops and to the conservation of the species, so long as they provide resources throughout the flight season of each species. It is important to provide a continuous supply of food resources throughout the flight period of any bee species. Fallow land with

[4] for example, wild legumes (Fabaceae) such as *Vicia* and *Trifolium* species, composites (Asteraceae) such as *Knautia arvensis*, umbellifers (Apiaceae) such as *Daucus carota* or *Anthriscus sylvestris*)

flower-rich vegetation, either sown or allowed to regenerate naturally, can provide a rich foraging habitat for pollinators. Multi-year fallow can also provide breeding and hibernation habitat. The effects of wildflower strips on bees are largely driven by the extent to which local flower richness is increased, so they are most effective in flower-poor intensive agricultural landscapes (Carvell et al, 2017).

Bumblebee species on farmland are strongly attracted to field margins sown with a mixture of flowers including legumes (Fabaceae) (as compared to grass margins or naturally regenerated unsown margins) (Carvell et al, 2007). Evidence suggests that sowing flower-rich habitats within intensively farmed landscapes will lead to increased residency times of bumblebee populations and therefore suggests a benefit to populations (Carvell et al, 2017). **Solitary bees** are generally more tightly bound to certain native flower species and range only up to around 200m from their nest site, so they are most abundant in semi-natural habitats. As a group, they are found at much lower densities in mass-flowering arable crops compared to honeybees (where hives are present), though certain species (notably *Osmia bicornis*) will readily visit some crop flowers.

3.2.1 Evidence of effectiveness of actions on arable land

Flowering margins with a diverse flower mix including legumes, established for several years, are an effective way to increase the presence of pollinators in fields (Nowakowski and Pywell, 2016). However, small areas of flowering margins may not provide enough resources to increase populations of pollinators on farmland, so it is important to ensure that flowering resources are increased at a landscape scale; for example, a 2.4 ha area of wildflowers would significantly enhance solitary bee numbers in an area of 10-26 ha (Kleijn et al, 2018). Bumblebee populations tend to respond more rapidly to interventions than solitary bees, as they can increase colony size and reproductive output during the season, whereas solitary bee populations expand through the dispersion of newly emerging females in the seasons following the intervention. Patches of at least 1 ha size sown with legumes and grass, providing forage resources all year round, can improve bumblebee reproduction in intensively farmed areas (Carvell et al, 2015).

There is evidence that fallow with natural regeneration of vegetation can rapidly provide flower resources for wild bees and hoverflies, and also provides attractive nesting habitat for solitary bees (Gathmann, Greiler and Tscharntke, 1994). However, cultivation of fallow after half a year will destroy bee nests, so only multi-year fallow offers nesting habitat for ground-nesting solitary bees. Fallows sown with diverse seed mixes containing flowering plant species also quickly benefit foraging bumblebee numbers (Alanen et al, 2011), with some evidence that field-size (1 ha) patches may have a population-level effect (Carvell et al, 2015). Well-chosen seed mixtures (Box 4) can improve the availability of nectar and pollen sources in short-term fallow as most arable fields have small seedbanks lacking in perennial broad-leaved weeds which provide the most important resources (Alanen et al, 2011).

Box 4 Creating pollinator habitat by sowing or natural regeneration?

There is considerable debate as to whether we should let nature take its course and colonise naturally or introduce species as seed (Nowakowski and Pywell, 2016). There are no hard and fast rules, but here are some guiding principles to help with this decision: Natural regeneration of wild-flowers is most appropriate and likely to be successful immediately next to existing species-rich grasslands. Only seed mixes collected from local meadows should be sown within 400m of grassland designated as a protected area. On infertile and light soils, naturally regenerated habitats are likely to contain a greater range of wildflowers and fewer undesirable weeds. However, on most fertile arable land natural regeneration tends to be unreliable and rapidly becomes dominated by weeds. On most farms experience suggests that the introduction of wildflower seeds is the best way to guarantee the establishment of good quality pollinator habitats.

Butterflies and diurnal moths are more abundant on fallow than on crop fields (Kovács-Hostyánszki et al, 2011), but abundance on fallow increases relatively slowly compared to abundance in existing field margin habitats (Alanen et al, 2011; Kuussaari, Hyvönen and Härmä, 2011; Toivonen, Herzon and Kuussaari, 2015), so only the most mobile generalist species are likely to benefit from short-term fallow. One study recommended a fallow duration of at least 5 years when aiming to enhance lepidopteran populations (Alanen et al, 2011).

Flowering strips or fallows are frequently funded through agri-environment schemes, and their impacts on pollinators have been tested in numerous studies:

- A systematic study of wildflower strips in four European countries showed that they enhance local bee abundance and richness, including Red-listed (threatened) species (Scheper et al, 2015a).
- A study of the UK agri-environment flowering strip option (Pywell et al, 2011) recommends that nectar flower mixtures are refined by the inclusion of the best performing plant species to provide mid- and late-season forage resources (*Trifolium* spp., *Lotus corniculatus* and *Centaurea nigra*), and

the removal of competitive grass species. Summer cutting in May or early June, with removal of herbage where possible, should be applied to half the patch to extend the flowering season, and minimise damage to butterfly breeding habitat. This should be accompanied by the typical autumn cut to the whole patch. Even with best management practice, such nectar flower mixtures are only effective for 3–4 years and this should be recognised in policies aimed at enhancing pollinator populations in agricultural landscapes.

- A replicated five-year study (Buhk et al, 2018) examined a network of perennial flowering strips covering 10% of a conventionally managed agricultural landscape in southwestern Germany. It showed that there was a three to fivefold increase in species richness of bees and butterflies. The numbers of specialist (oligolectic) bee species also clearly increased after the third year. The authors believe the key to success was that the strips covered 10% of the arable landscape, used a variety of perennial seed mixes and were sown at different times.

- A study in England found marked differences between the responses of different bumblebee species and sexes to field margin management over time (Carvell et al, 2007). The seed mix with agricultural legumes established quickly and attracted most bumblebees in the first year of sowing, including the rare long-tongued species *Bombus ruderatus* and *Bombus muscorum*, but provided low numbers of flowers in May and June, when bumblebee queens of late-emerging species are foraging, compared to the wildflower mixture. The agricultural legume mix also declined in flower numbers in year three, when it did not support significantly more bumblebees than the wild flower seed mixtures (Dicks, Showler and Sutherland, 2010).

- A two-year monitoring of the availability of flower resources (pollen and nectar) on pollinator field margins in Belgium concluded that they provide flower resources to pollinators and support pollination services, but spring and autumn flower resources remain poor and could reduce the strips' effectiveness for supporting long-term insect diversity (Ouvrard, Transon and Jacquemart, 2018). The ten sown plant species were all present after 8 years of strip settings. Three of them, *Centaurea jacea*, *Lotus corniculatus*, and *Daucus carota* were mainly visited for nectar collection, and a spontaneous non-sown species, *Trifolium repens*, had a key role in providing high-quality pollen to insects.

3.2.2 Key management practices for pollinators on arable land

- Sow seed mixes with native wildflower species that are rich in pollen and nectar. Sow species with a range of flower structure and colours to benefit the widest range of pollinator species.
- Sow annual and perennial seed mixtures on different sites as they require different management. Annual mixes need to be re-established each year (often best on a new site) and cannot be managed by cutting as this eliminates the annuals. Perennial seed mixture can be managed by cutting and can remain on the same site for many years.
- Maintain flowering margins for several years to allow establishment and flowering of perennial species.
- Actively manage undesirable and competitive species by cutting or grazing to ensure establishment of sown species. It may also be possible to control undesirable species with targeted (e.g. spot) application of selected herbicides subject to the relevant legislation and the pesticide label approval. Consider rotational establishment of perennial wildflower seed mixtures on a range of soil types and locations to ensure a variety of successional states.
- Maintain fallow overwinter without deep ploughing (as this destroys nesting habitat) but maintain patches of bare ground.
- Maintain some long-term fallow areas (at least five years).
- Avoid drift of fertilizer and pesticide onto flowering margins and fallow from crop treatments but prepare the ground before sowing as if it were for a crop.

3.3 Maintain and diversify hedges, trees, and wood patches for pollinators

Hedges, trees and wood patches on farmland can provide overwintering habitat (e.g. for bumblebees), larval habitat (e.g. for hoverflies) and flower resources outside and between cropping seasons for many pollinators. Hedges and woody strips are key foraging and dispersal habitats for butterflies and moths in arable farmland, as well as providing larval food plants in the hedge base vegetation (Feber et al, 2007). Hedges can provide hibernation and nesting sites for wild bees provided the base of the hedge is wide enough to include sunny patches for ground nesters, and old trees provide cavities for tree nesters, although sunny herbaceous field margins and fallow are preferred by ground nesting bumblebees (Lye et al, 2009).

3.3.1 Evidence of effectiveness of actions: hedges and trees

Hedges provide flower resources for bees from flowering plants in the hedge base and from the woody trees and shrubs and creeping plants such as brambles, roses and ivy (Jacobs et al, 2009), which are particularly important in early spring or autumn for solitary bees (Wood, Holland and Goulson, 2016) and bumblebee queens. A study in Mediterranean arable landscapes in northern Italy (Dainese et al, 2016) found that increasing hedgerow cover in the landscape from 1 to 6% enhanced pollinator flower-visitation rate (bumblebees, solitary bees, hoverflies, other flies, butterflies, and other species) along the field margins. A study in the UK found that bumblebee movement along hedges is strongly influenced by their connectivity, and more connected hedges had higher pollination rates of flowers preferred by bumblebees (Cranmer, McCollin and Ollerton, 2012).

Farmland that is rich in hedges and tree patches hosts some Lepidopteran species that are typical of forest as well as the common farmland species, greatly increasing species richness in impoverished arable Lepidoptera communities (Belfrage, Björklund and Salomonsson, 2015; Dainese et al, 2015). In the UK it is estimated that around 40% of resident or regular migrant butterfly species potentially breed in hedgerows (Dover and Sparks, 2000). Hedges with trees and extended width margins have increased Lepidopteran species richness compared to hedges without these features (Merckx et al, 2012). However, hedges generally have a lower moth species richness compared to patches of woodland (see below) as they lack woodland specialists (Fuentes-Montemayor et al, 2012).

Hedge management has a significant impact on butterfly and moth abundance, as well as the abundance of flower resources for other pollinators, especially a low frequency of cutting (once every three years) and cutting in winter rather than autumn (Staley et al, 2016; Staley et al, 2012). Hedge management by cutting only once every three years in winter increased Lepidoptera abundance and the diversity of components of the Lepidoptera community linked with specific lifecycle traits, compared to annual trimming in autumn (Staley et al, 2016). Reducing cutting frequency from every year to every 3 years resulted in 2.1 times more flowers and a 3.4 times greater berry mass over 5 years and cutting in winter increased berry biomass compared to autumn cutting (Staley et al, 2012). However, the most common agri-environment funded management in the UK, cutting once every two years in autumn, had no influence on butterfly abundance, an intermediate effect on flower abundance, and no effect on berry biomass compared to annual cutting (Staley et al, 2016). Many arable farmers choose to cut immediately after harvest when no crops are present to restrict access, immediately before sowing winter crops, whilst cutting in winter is often limited by poor access across wet soils.

Hedges and trees also have significant benefits for crop production by increasing crop pollination and biological control of crop pests. Hedges have been shown to enhance the abundance of hoverflies in adjacent arable crops, where they act as biological control agents (Haenke et al, 2014). Strawberry plants grown next to hedgerows that are connected to forest patches produced more high quality (marketable) strawberries than plants grown next to isolated hedges (surrounded by arable) and grassy field margins distant from hedges and forest patches. The forest-connected hedges had higher pollinator abundances, which increased strawberry weight (Castle, Grass and Westphal, 2019).

3.3.2 Key management practices for pollinators: hedges and trees

- Plant early flowering trees and shrubs and diversify tree and shrub species composition to include a range of nectar and pollen-rich (non-toxic) woody species and do not clear out flowering creepers (ivy, bramble, etc);
- Frequency of hedgerow cutting has a significant impact on provision of flowers for pollinators. Hedges cut every three years provide more flowers than hedges cut every year.
- Timing of hedge or tree cutting has an important impact on flower provision and breeding habitat for certain butterfly and moth species. Cutting in late winter rather than autumn increases the number of flowers and berries produced by hedges cut every two years. There are more butterflies and moths if hedges are cut in late winter every 2 years, but not in autumn.
- Intensity of hedgerow cutting has an important impact on flower provision for pollinators. Reducing the intensity of hedge cutting (by around 10cm higher than the previous cut) significantly increases the abundance of flowers, and butterfly and moth species.
- Employ rotational hedge cutting across the farm to ensure some hedgerows flower every year.
- Maintain veteran trees, deadwood resources, tree holes, stone banks, stone walls or stone piles and other micro-habitats.
- Fence off hedge to prevent livestock from trampling hedge bases and maintain a wide hedge base (minimum 2 m), protect hedge from damage by compaction or field machinery use.

- Along tree lines, ensure that the aspects that provide favourable conditions for pollinators are buffered from potentially harmful crop management practices (i.e. south facing for sun and warmth in northern countries and north facing for shade in southern countries). Avoid pesticide and herbicide drift into tree lines, hedgerows, and hedge margins, particularly insecticides.
- Under tree lines, if practical, introduce extensive grazing or cutting outside the plant flowering season to encourage floristic diversity.
- If invasive plants/injurious weeds must be controlled, use only targeted cutting or spot treatments with selective herbicides subject to label approval and local regulations on pesticide use.

3.4 Pollinator conservation in agroforestry, soft and top (tree) fruit crops

Pollinators in agroforestry and soft and top (tree) fruit systems respond to flower resources present in the non-cropped components of the landscape, including field margins, tree lines, hedgerows, shrubs and grasslands. Wild pollinators, particularly some species of solitary bees, are the most effective pollinators of fruit trees (apple, pear, plum and cherry), so measures to promote wild pollinator abundance also have commercial benefits by increasing fruit yield and quality (Garibaldi et al, 2014). Top fruit (apples, pears, plums, cherries etc) and soft fruit (currants, gooseberries, raspberries etc) are high value crops across Europe and there is extensive scientific evidence that enhanced insect pollination can increase yield and profitability of these crops. Many commercial producers use reared commercially available pollinators but measures to increase wild pollinators can be equally effective. Other permanent fruit crops, notably olives and vines, do not require insect pollination to produce the crop, but can provide important pollinator habitat and pollinators will visit their flowers, particularly in spring when other pollen is scarce (Canale and Loni, 2010).

3.4.1 Evidence of effectiveness of actions in permanent crops

A study in cherry orchards in Germany (Holzschuh, Dudenhöffer and Tscharntke, 2012) concluded that the wild pollinator populations pollinating the cherry trees rely on the presence of significant proportions of semi-natural habitats in the landscape (half of the land area) surrounding the orchards, and that cherry production was limited by insufficient pollination by wild bees. The study found that the orchards that are surrounded by landscapes with a 50% proportion of habitats with a high value for bees (hedgerows, old fallows, orchard meadows and other non-intensively managed grasslands) had fruit set that was 150% higher than orchards surrounded by a landscape with 20% of high-diversity bee habitats. The wild bees pollinating the cherry flowers came primarily from nearby patches of semi-natural vegetation that provide enough flower resources for bees during the year. Another study found that cherry trees close to woody habitats (hedges, woodland and individual trees in field margins) were visited more often by pollinators than cherry trees isolated from such habitats (Schüepp, Herzog and Entling Martin, 2014). Both studies found that increasing the flower cover in the ground vegetation beneath the orchards did not increase pollination of the cherry trees.

In apple orchards, research show that insects are essential in the production of two varieties of apple in the UK, both yield and quality, contributing an estimated £36.7 million per annum (Garratt et al, 2014). Another study showed the addition of flowering strips to apple orchards increased visit rate of wild insects to apple flowers by 40%, without however increasing pollination (Campbell et al, 2017). The authors recommend that planting of flower species and addition of nesting resources could be more tailored to the andrenoid solitary bees that provide the most effective pollination of apples.

In olive groves, maintaining an extensively managed, flower-rich herbaceous cover significantly increased the colonisation rate of cavity-nesting solitary bees (Martínez-Núñez et al, 2019). Sown ground cover strips with a mixture of flowering species[5] in olive groves are highly attractive to bumblebees (*Bombus* spp.) and mining bees and megachilid bees, as well as honeybees, and the patches also attract large numbers of natural enemies of crop pests (parasitoids and insect predators) (Karamaouna et al, 2019).

In vineyards, a higher proportion of surrounding natural habitats significantly increased wild bee abundance in the vineyards (Shackelford et al, 2013).

3.4.2 Key management practices for pollinators in permanent crops

- Maintain patches of bare ground for ground-nesting wild bee species.
- Maintain dead wood snags and tree holes as nesting sites, and if trees are still young install bee nesting aids.

[5] *Sinapis alba* L. (Brassicaceae), *Glebionis segetum* (L.) Fourr. and *Glebionis coronaria* (L.) Cass. ex Spach (Asteraceae), *Vicia sativa* L. and *Pisum sativum* L. (Fabaceae), *Borago officinalis* L. (Boraginaceae), *Coriandrum sativum* L. and *Pimpinella anisum* L. (Apiaceae).

- Maintain the flower-rich ground vegetation with (extensive cutting or grazing management), suitable to the site conditions.
- Minimise pesticide use through integrated pest management or use organic cultivation techniques.
- Maintain semi-natural vegetation features in and around the crop (hedgerows, old fallows, orchard meadows and other non-intensively managed grasslands).

3.5 Reduce pesticide use and implement integrated pest management methods or organic farming

There is clear evidence that pesticides, especially insecticides, are a major pressure on wild pollinators, as well as the lack of wildflowers linked to herbicide use. Therefore, measures to reduce pesticide use and implement integrated pest management on farms are likely to benefit wild pollinator populations. IPM systems are particularly key on crops that are highly attractive to pollinators, including fruit trees (apple, pear, plum, cherry) and soft fruit, sunflower, and legumes (beans, peas, clover, alfalfa, lupins, etc.).

IPM systems and organic farming systems include a number of farming practices that are likely to increase wild pollinator abundance, including: reduced or zero pesticide use, cover crops and green manure crops, tolerance of weeds, high densities of field margins and landscape features, diverse crop rotations, and a diverse mix of crops, grassland and woody vegetation.

3.5.1 Evidence for effectiveness of IPM or organic farming

Reducing pesticide use and Integrated Pest Management (IPM)

A study of five growing seasons of oilseed rape crops showed that a high pollinator abundance (and therefore a high rate of pollination) leads to a greater yield gain and greater gross margins than increases in pesticide use (Catarino et al, 2019). Fungicide use showed a significant positive effect on yield, but the data did not reveal any yield gains from insecticide or herbicide use. There was a negative relationship between bee abundance and pesticide use. Another study demonstrated that oilseed rape yield benefits from insect pollination when fertiliser is not limiting, but not when fertiliser input is suboptimal (Garratt et al, 2018).

Organic farming

A comparison between organic farms and similar nearby conventional farms in the UK showed that the organic farms supported higher floral and wild bee abundances during the months of May and July (Austin, Lawson-Handley and Gilbert, 2019). The study did not clarify which farming practices resulted in the higher floral abundance during these critical periods. In southern Sweden, a comparison of pollinator species community composition on organic and conventionally managed farms showed that hoverfly species benefited from organic farming (Andersson et al, 2013). The organic farms had a higher pollination rate of Field Bean (*Vicia faba*) compared to conventional farms, because of the higher bumblebee abundance (Andersson et al, 2014). Pollination on organic farms increased the more semi-natural habitat there was in the landscape, whilst on farms with conventional levels of fertiliser and pesticide use, the pollination rate was unaffected by either semi-natural habitat or leys, indicating that bumblebee abundance on these farms was constrained by other factors than foraging resources. However, isolated organic vineyards did not offer more floral resources or semi-natural habitat than the surrounding conventional vineyards and pollinator species richness and abundance did not differ, indicating that the impact of the surrounding landscape was stronger than the local management (Brittain et al, 2010).

3.5.2 Key management practices on cropland

- Grow cover crops and intercrops that include legumes (e.g. alfalfa, clover and lupins) and leave them in the field long enough to flower (though this should be avoided directly following a crop treated with a systemic insecticide such as sulfoxaflor)
- Implement integrated pest management methods to reduce the use of pesticides, and in particular to reduce or eliminate the use of systemic pesticides and seed treatments and foliar sprays applied during the flowering period of the crop
- Reduce herbicide use and maintain weed populations along field edges and between crop rows, including long-flowering and bee-friendly species such as Red Deadnettle (*Lamium purpureum*) and thistles (*Cirsium* spp.)

3.6 Manage forest for pollinators

Although closed forest is not an important habitat for most pollinator species, open areas in forests, forest pastures or forest meadows are key habitats for many species, and deadwood is a key breeding habitat for hoverflies and other pollinating insects[6]. Forest edges near farmland are important foraging and refuge habitats for pollinators visiting crops and grassland. Coppice woodland is a highly important habitat for pollinators. Most woods will have small-scale features such as wood banks, exposed root plates of windblown trees, ditches and small pits and quarries. When located in warm, sunny and dry conditions these can be very valuable for ground-nesting bees. Woodland butterflies require plentiful larval foodplants, often growing in specific conditions, though adult butterflies may be encountered in parts of the woodland away from the vital breeding habitat, especially when searching for nectar (Clarke et al, 2011).

3.6.1 Evidence for effectiveness

A survey of the pollinator community in 16 forest fragments showed that the pollinator community in the edges of small forest fragments is strongly influenced by forest and forest edge characteristics (Proesmans et al, 2019). Old forest fragments with a well-developed herb layer had more diverse bee communities than recent forests or old forests without a herb layer, but overall lower activity-abundances, while sun exposure of the forest edges had a strong positive effect on pollinator activity-abundance in general. The hoverfly community had higher activity-abundances in forest edges with a higher flower-index, while saproxylic hoverflies were caught in higher numbers in sites with a higher forest cover in the surrounding landscape.

The Woodland Brown butterfly (*Lopinga achine*) has experienced a dramatic decline in Central Europe. A study in Germany found that it requires forests with a light canopy on south-facing slopes with a medium-high and dense herbaceous layer rich in low-competitive sedges (Streitberger et al, 2012).

3.6.2 Key management practices for pollinators in forest and woodland

- Avoid use of neonicotinoids and other insecticides, and avoid herbicide use unless there are no alternatives (e.g. for spot treatment of invasive alien species).
- Encourage flower rich trees and shrubs as well as climbing plants (*Rubus*, *Hedera*) and perennial herbs attractive to pollinators along forest edges and clearings.

[6] E.g. see BugLife briefing Managing Woodland for Pollinators available at https://www.buglife.org.uk/managing-woodland-for-pollinators

- Create forest edge habitat by fencing and cutting tall overhanging trees: a few metres of uncultivated or unmown habitat where perennial flower plants beneficial to pollinators can grow.
- Forest tracks, road edges and clearings should be sufficiently large and sheltered to provide warm, sunny conditions. Clear or coppice trees and shrubs to create uneven edges with embayments and sheltered glades, especially on south-facing edges.
- Manage clearings and tracks (both cutting of woody material and mowing of grassland areas) in rotation (every 3-5 years) and in relatively short sections at a time to produce more diverse conditions.
- In clear cut areas, allow natural regeneration of vegetation wherever possible and do not clear away scrubby vegetation. Do not use pesticides, particularly insecticides, in clear cut areas.
- Maintain and restore coppice woodland, wooded pastures, and wooded meadows wherever possible, to promote flower rich ground vegetation.
- Leave tree snags, tree hollows and hollow tree trunks to ensure breeding sites for hoverflies.
- Maintain sun-exposed topographical features in forests, such as stone piles, banks, rocks, and rock faces. If they are absent, plan to develop these features by creating low banks along open areas or using any soil or rock arising from, for example, ditch management.

3.7 Conclusions

Maintaining and improving the characteristic flower richness of **semi-natural grassland** is a key measure for the conservation of rare and threatened pollinator species, as many pollinator species only occur in this type of habitat. Similarly, heath and scrub are also key pollinator habitats that largely depend on extensive agricultural management, i.e. grazing and periodic cutting.

There is also substantial evidence that flowering strips and enhanced field edges provide resources for more taxonomically and functionally abundant, diverse, and compositionally different bee communities than fields and field edges without flowers. Multi-year interventions also have positive effects on other dimensions of biodiversity, such as soil invertebrates and invertebrate predators.

Pollinator populations need enough habitat and resources at the landscape scale (see Box 5), so coordinated measures that target clusters of farms within target regions are more effective, but individual actions to maintain and create habitat at the field scale can still contribute to maintaining populations.

It is worth bearing in mind that increasing crop pollination is not the same as protecting wild pollinator diversity. Flowering strips and margins do not always increase the abundance or diversity of bees visiting crops, indicating that they do not necessarily increase the supply of pollination services to crop production. There is a need for more research to identify the conditions that promote effective co-management of the biodiversity of wild pollinators and the ecosystem service of crop pollination.

Only a small proportion of the species of bees in Europe visit crop flowers, however infrequently, and a significant proportion of all bees are brood parasites on other bees, so the vast majority of bee species currently have no direct economic importance (Senapathi et al, 2015), although some bee species are indirectly important because they pollinate and therefore maintain the alternative flowering resources that the crop pollinators rely on after the crop has finished.

Box 5 Need for coordinated action at the landscape scale

A review of actions to benefit pollinators on farmland supported by agri-environment schemes (Scheper et al, 2013) showed that small-scale habitat creation practices enhance pollinator richness, but their effectiveness varied with (1) the magnitude of increase in flowering plant cover resulting from the practices, (2) farmland type, and (3) landscape context. Local effects were more positive in structurally simple landscapes (1-20% semi-natural habitat) than in cleared (<1% semi-natural habitat) or complex (>20% semi-natural habitat) landscapes, presumably because cleared landscapes lack sources of pollinator colonists and complex landscapes have less need of restoration. The authors conclude that in order to increase crop pollinators, diverse and high-quality habitats need to be provided within 13 ha around the crop (i.e. the area within a 200-m-radius), because small bee species have a foraging range up to around 200 m from the nest. Rollin et al (2019) showed that bee species richness at the arable field scale is influenced by both local floral richness and the proportion and type of semi-natural habitats in the landscape within a 1 km radius.

4. POTENTIAL OF CAP MEASURES TO SUPPORT POLLINATOR CONSERVATION

A wide range of CAP measures, in both Pillars, can be used to support actions beneficial to pollinators. These are summarised in Table 1 below. Some operate directly, paying for the creation or maintenance of features of the farmed environment which are food sources, such as flowering strips, or provide habitat, such as woodland or hedges, whilst others may benefit pollinators indirectly, by providing economic support to agricultural activity such as grazing which is necessary to maintain certain types of habitat.

4.1 Measures that support maintenance and management actions

For the maintenance of **species-rich grassland** and **grazed heath or scrubland** the key measures are the eligibility rules (set by Member States within a framework set at EU level) and definition of permanent grassland (set at EU level but with options for Member States to include additional types of grassland). Together these determine which types of permanent grassland may receive area-based income support through direct payments. The availability of such support, in turn, influences the economic viability of undertaking agriculture on such grassland and hence the probability that grazing activity will take place which prevents it from reverting to scrub. The extent to which Member States have designated permanent grassland as "environmentally sensitive" is relevant because such designation requires Member States to prevent the land from being ploughed.

Farmers may be paid directly for specific actions such as maintaining grazing, mowing in certain ways or at certain times, and avoiding inputs of pesticide and fertiliser to maintain species-rich grassland under the agri-environment climate measure in Pillar 2.

Table 1 Actions that can be taken for pollinators on farmland and corresponding support measures in the CAP (2014-2020)

Action for pollinators	CAP measures that can be used for action (2014-2020)
Protect and maintain species-rich grassland – meadows, pastures, orchards, vineyards, and other permanent crops	M10.1: species-rich grassland maintenance (extensive grazing/mowing/no fertiliser and pesticide use); pollinator-friendly ground cover management in permanent crops. Direct payments: eligibility rules and definition of permanent grassland; permanent grassland protection (ESPG etc) that support and maintain species-rich grasslands.

Create pollinator borders (field margins, buffer strips and flowering strips)	M10.1, or EFA and/or Voluntary Coupled Support: flowering margins or perennial forage legumes (such as alfalfa or clover); GAEC and/or EFA requirements for pollinator friendly management of buffer strips.
Arable fallow – self-seeded or sown to melliferous seed mixes	M10.1 or EFA: flowering fallow or fallow with self-seeded vegetation or melliferous seed mix.
Maintain and diversify hedges, trees and wood patches on farmland	M10.1 and/or M4.4: creation, restoration and maintenance of woody landscape features (taking into account the needs of pollinators) GAEC and EFA: landscape feature options with advice on their pollinator value and pollinator-friendly management GAEC requirements for pollinator friendly management of landscape features.
Maintain grazed heath and scrubland	M10.1 and M4.4: Targeted support with nature conservation advice and appropriate planning/objectives Direct payment: eligibility rules and permanent grassland protection (ESPG etc) that support and maintain grazed heath and mixed grass and scrubland
Maintain diverse edge structures and open habitats in forests and other wooded land	M8, agroforestry or afforestation M15.1 forest-environment contracts
Organic farming IPM and reduced intensity pesticide practices on arable and in permanent crops	M10.1 IPM and pesticide use reduction M.11 organic farming M.16 for area-wide IPM and reduced pesticide approaches

Pollinator borders and flowering strips may also be funded directly through M10.1, protected through cross-compliance (a mechanism through which area-based support such as direct payments may be reduced for an individual farmer who does not meet its requirements).

The growing of **leguminous crops** is incentivised where Member States designate such crops as a means of meeting the requirement on arable farmers for a minimum percentage of "Ecological Focus Area", which is part of the greening requirements. All Member States except Denmark allow farmers to designate such crops, whilst 15 Member States also make Voluntary Coupled Support (VCS) available for protein crops, which include certain leguminous crops. However, most such VCS is given to soya, a crop which is often of limited benefit to pollinators because of associated pesticide use.

Arable fallow may be funded directly through M10.1 or incentivised as eligible for EFA. For 2018 a separate category of melliferous fallow was created within the EFA rules. Member States are permitted to apply a higher weighting factor to melliferous than to ordinary fallow, potentially increasing the attractiveness to farmers of growing pollinator-friendly plant cover on their fallow

Hedges, trees and woodland patches may be maintained if Member States list them among the landscape features that farmers must protect as part of their cross-compliance obligations. The Pillar 2 investment measure M4.4 may pay for their creation, whilst M10.1 may be used to support their maintenance. Such features may also be designated as EFA which strengthens farmers' incentives to retain them, particularly if they are not already protected through cross-compliance.

Forest measures M8 and M15.1 in Pillar 2 may be used to pay directly for the maintenance of **diverse edge structures and other open habitat in forests and other woodland**.

Reductions in pesticide use may arise because of specific support for organic farming under the dedicated measure M11 in Pillar 2, or through support via M10.1 for integrated pest management and other pesticide reduction measures.

In the case of the Pillar 2 measures, Member States were required, for the 2014-20 period, to prepare a Rural Development Programme setting out their strategic needs. For the upcoming CAP period the requirement for a strategic plan will apply to both Pillars.

Table 2 CAP measures with effect on wild pollinators and their habitats, relevant programming decisions & factors

CAP measure	Programming decisions	Relevant factors
Farm Advisory Service Support for advice, training and farm-to-farm exchanges (M1 / M2)	Whether to offer advice or training through FAS, M1 or M2 on: • how to manage species rich grassland to encourage pollinators • the creation and management of pollinator borders, in field strips or buffer strips to encourage pollinators • creation and management of pollinator-friendly arable fallow • pollinator-friendly creation and management of hedges, trees and wood patches • the management of heath and scrubland to promote pollinators • ways to manage forest land to promote pollinators	

Agri-Environment Climate Measure (AECM) and linked non-productive investments (M4.4) (e.g. for habitat creation and restoration)	Whether to offer AECM support for biodiversity-friendly grassland management practices & whether management requirements consider pollinator relevance	Late mowing to allow flowering, and/or low intensity grazing. No or very little fertiliser and pesticide use.
	Whether to offer AECM funding for the creation of pollinator borders or strips on arable land	Does the support include restrictions on pesticide and fertiliser use? Does it define the required species or seed mixes and are they appropriate for pollinators?
	Whether to offer AECM support for Integrated Pest Management and reduced pesticide use	
	Whether to support the creation, restoration and biodiversity-friendly management of hedges, trees and wood patches through the AECM.	Hedgerow management - 'little and late' principle for management for pollinators. Dead wood and water (e.g. in tree holes) key habitats for hoverflies.
	Whether to offer AECM for the creation and maintenance of wildlife fallow, e.g. through natural regeneration over a year or more or with wild seed mixes for pollinators.	
	Whether to program AECM for restoration and maintenance of grazed heath and scrub habitats.	

Organic farming support	Whether pollinator conservation is mentioned as a reason for supporting organic farming.	
Other RDP measures	Whether to programme the RDP measures for agroforestry forest conservation, and environmental afforestation Whether to offer forest restoration support for the conversion of closed coniferous stands to open mixed deciduous forest.	Could create pollinator-friendly habitats if appropriate tree species are planted e.g., willow (*Salix* spp). Restoration of coppicing management and/or pollarding.
GAEC rules	Whether to protect buffer strips through cross-compliance by listing them under GAEC 7 (beyond what is legally required by Water Framework Directive rules and/or nitrate action plan rules). Whether to protect hedges, trees, and tree patches from destruction by listing them as landscape features under cross-compliance GAEC 7, and whether any additional conditions are defined that might benefit pollinators.	Are there any rules or linked support or advice that encourages pollinator-friendly buffer strips, landscape features or other GAEC-protected feature? Is there a requirement for buffer strips for hedges and field margins to reduce possible impacts of pesticide drift from fields?
Permanent grassland rules (greening)	Whether to protect permanent grassland from ploughing completely by designating it as ESPG	Are all the important Annex I grassland habitats designated as ESPG?

		MS may have intended the ploughing ban as a means of preventing the intensification of grassland management with potential loss of pollinators.
Ecological Focus Areas (greening)	Was the pesticide ban on nitrogen-fixing crops communicated as being good for pollinators and were pollinator-friendly N-fixing crops included? Whether to allow hedge, tree and tree patch landscape features to count towards the greening EFA requirements. Whether to allow fallow with naturally developed vegetation to count towards the greening EFA requirements Whether to allow forest edges, short rotation coppice, agroforestry and environmental afforestation to count towards the greening EFA requirements.	See table in Annex 1 for necessary conditions for EFAs to be pollinator-friendly.
Direct payment eligibility rules	Whether the Member State has chosen to extend its definition of "permanent grassland" to include other land on which traditional grazing practices take place. Whether the MS has chosen to protect grassland from ploughing without re-seeding, and from conversion to	MS may have wanted to preserve traditional grazing as a means of encouraging pollinators and seen giving access to direct payments via a wide PG definition as a means of doing this.

	arable, by defining "permanent grassland" to include traditionally grazed areas. Whether to define the eligibility rules for wooded agricultural land to help support the viability of wood pasture farming systems	

4.2 Direct payments and definition of permanent grassland

As discussed above, one of the most important decisions a Member State makes about such land is whether to count it as "permanent grassland" under the direct payments regulation, because designation of non-arable land on which permanent crops are not grown as "permanent grassland" is necessary in order to confer eligibility to area-based income support. The basic definition of permanent grassland in the CAP is land which has not formed part of the arable rotation for 5 years or more and is covered more than 50% by grasses or other herbaceous forage. Member States must define such grassland as "permanent". However, if they restrict the definition to this – the minimum required coverage – they potentially exclude large areas of semi-natural habitat which requires grazing or other agricultural activity for its maintenance but on which there is less than 50% coverage of grasses or other herbaceous forage.

To enable them to address this issue if they wish to, Member States have the option to include land in which grasses or other herbaceous species do not amount to 50% in two circumstances:

- If traditional grazing practices are present on other land; and/or
- In order to protect habitats or biotopes important for the Habitats or Birds Directives.

If heath and scrubland is not defined as "permanent grassland" then those managing it will not receive CAP direct payments and the protections for permanent grassland afforded by the greening instrument do not apply. Land which is not "permanent grassland" can, however, still receive payments under Rural Development measures.

4.3 Advice provision, cooperation, and innovation

Member States can choose whether to provide information on topics beyond the obligatory requirement to provide information to farmers about cross-compliance obligations, the operation of the Pillar 1 greening measures, the application of rural development measures relating to farm competitiveness, farm modernization, innovation and market orientation and entrepreneurship. The way national FAS operate varies significantly in terms of the information provided, the organizations providing the advice, the content of the advice provided and the way it is communicated to farmers.

Member States can also provide more targeted biodiversity advice to farmers through EAFRD (M2). An evaluation of the impact of the CAP on biodiversity

(Alliance Environnement, 2019) concludes that biodiversity outcomes often require specialist, targeted advice and knowledge exchange at a level beyond that which the Farm Advisory Service normally provides, both to ensure that farmers understand the biodiversity benefits of their activities and to help them apply 'the right management in the right place' to achieve these. It is important that the advisers providing this support can demonstrate their credibility through a detailed understanding of both the farming system and biodiversity management.

Farmer engagement with pollinator measures can be significantly influenced by advice provision, the action of network bridging organizations that foster cooperation and social learning amongst farmers and other actors such as scientific experts, and information from trusted sources (Box 6).

Box 6 Factors driving farmer engagement in pollinator measures

Network bridging organizations that foster cooperation and social learning in agri-environmental communities lead to a higher propensity for change (Dedeurwaerdere, Polard and Melindi-Ghidi, 2015; Polman, Peerlings and Slangen, 2008). More broadly, social networks and organizations are an important catalyst for farmer behaviour (Beckmann, Eggers and Mettepenningen, 2009; Pascucci et al, 2011; Peerlings and Polman, 2009; Polman and Slangen, 2008). In general, the use of technical advice or extension services is found to play a positive role in farmers' willingness to adopt an AES (Espinosa-Goded, Barreiro-Hurlé and Ruto, 2010; Niens and Marggraf, 2010). Similarly, farmers who read the farming press have been found to be more likely to adopt an AES (Defrancesco et al, 2008). Longevity and expertise in service provision are more important than the public, private or charitable status of specific advisory service in engendering trust Sutherland et al (2013). Furthermore, study participants put their trust in services that were perceived as 'impartial' or actively 'pro-agriculture'. More generally, agriculture-related organizations are considered to have the potential to play an important role in policy design, because they provide useful information to support this process, reducing public transaction costs, and also potentially making the proposed AES more acceptable for farmers by stimulating a greater level of trust in the final scheme design (Mettepenningen et al, 2013).

4.4 Results-based payments for flowering strips

The results-based payments for biodiversity pilot in East Anglia, England, paid farmers for providing areas of flowering plants that boost essential food sources for beneficial pollinators between early and late summer (such as bumblebees, solitary bees, butterflies, and hoverflies). The payments were made according to the score achieved based on the number of specified flowering plant species present, and in the second year after establishment the percentage cover of specified species (Chaplin et al, 2019). The environmental performance of the sown areas was higher on farms in the results-based pilot than on farms under the current agri-environment option, which supports the same margins but based on the management undertaken. The farmer self-assessments of their scores agreed with the governmental adviser scores in over two-thirds of the on-farm surveys. A results-based approach provides motivation and encourages behavioural change, and the associated training and advice were well received. The farmers expressed a strong sense that the results-based approach is fair and rewards knowledge, skills, and effort. For example, the farmers chose to sow a wider range of plant species to ensure the success of their pollen and nectar plots, and over half of them discussed and shared their learning and experience with other participating farmers on how to improve their habitat scores.

5. IMPLEMENTATION OF CAP MEASURES FOR POLLINATORS IN THE 2014-2020 FUNDING PERIOD

The ways in which the CAP measures described above have been implemented were investigated through case studies in six Member States or regions. These were chosen on the basis that they were known to offer, collectively, examples of a wide range of ways in which the CAP is currently used for the benefit of pollinators. These included examples of the use of on-site advice from ecological experts which, according to the literature review, is of interest given that the concurrent provision of appropriate habitat and forage is shown to be so important. The case studies included Member States which had adopted both broad and narrow definitions of "permanent grassland" – thereby including or excluding areas of heathland from income support – as well as those with highly complex (e.g. France) or simpler (e.g. Romania) suites of agri-environment-climate support using measure M10.1. Spain (Andalucía) was included because it offers support through M10.1 to beekeepers who establish hives in semi-natural landscapes, with the declared intention of encouraging wild pollinators through a beneficial ecological interaction. The Andalucía Rural Development Programme (RDP) does not provide any evidence to justify this assumption, so the case study explored the potential for negative or beneficial impacts on wild pollinators (see conclusions).

Each case study author was asked to collect evidence of:

- the extent to which pollinator considerations had played a part in the Member State and/or region's CAP implementation decisions
- the extent to which the CAP was being used to provide advice on wild pollinator management to land managers
- the impact of including or excluding traditionally grazed heathland as "permanent grassland" and so its access or lack of access to income support payments; and
- the effectiveness of actions or schemes deliberately intended to assist wild pollinators. This was not a systematic review of all such schemes, but a search for particularly good or less good practice which could be highlighted for the benefit of others.

Case studies were carried out in Germany (Baden-Württemberg), Spain (Andalucía, France, Croatia, Austria, Romania. The relevant findings by topic are reported below. The full case study reports are in Annex 2

5.1 The extent to which pollinator considerations played a part in Member State and regional CAP implementation decisions

Despite the prominence of wild pollinator decline as an issue, few of the case studies found evidence that the needs of pollinators had been explicitly considered when strategic decisions were taken about how to implement CAP Pillar 1 or how to programme rural development funding. Explicit reference to pollinators was in general made only in connection with the provision and design of specific types of operation such as agri-environment support for flowering strips or extensive grassland management.

In Germany, the 122-page brochure in which the ministry (BMEL) described the "agrarian reform" of 2015 – the implementation of the CAP – contained just one mention of pollinators, in the context of flowering strips which are described as providing cover, food and habitat to wild pollinators. However, in agreeing to enact a broad definition of "permanent grassland", the federal government invoked the need to ensure agricultural activity for environmental and conservation reasons[7]. The needs of pollinators were also considered in the design of the agri-environment-climate schemes for flowering strips, extensive grassland management and to some extent, pesticide reduction, as well as in the design of the rules Germany applied to the new EFA option for melliferous fallow in 2018, for which care was taken over the mix of flowering plants required and the flowering period they would offer[8].

In France, where a national pollinator action plan was in place at the time of CAP implementation, the position is similar with explicit tailoring of a number of agri-environment climate options towards pollinators' needs not reflecting any strategic overview. Some of the (few) experts interviewed during the case study felt that stronger links between the Agriculture and Environment Ministries would have led to a better result. The long national list of "types of operation" (agri-environment-climate options – a national list from which France's regions choose their own selection) contains a number which are expressly for the benefit of wild

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[7] Deutscher Bundestag (2014) Entwurf eines Gesetzes zur Durchführung der Direktzahlungen an Inhaber landwirtschaftlicher Betriebe im Rahmen von Stützungsregelungen der Gemeinsamen Agrarpolitik (Direktzahlungen-Durchführungsgesetz – DirektZahlDurchfG). 25.03.2014. Drucksache 18/908. Available at: http://dip21.bundestag.de/dip21/btd/18/009/1800908.pdf

[8] Deutscher Bundestag (2018) Verordnung des Bundesministeriums für Ernährung und Landwirtschaft. Dritte Verordnung zur Änderung der DirektzahlungenDurchführungsverordnung und der InVeKoS-Verordnung. 26.02.18. Drucksache 61/18. Available at https://www.bundesrat.de/SharedDocs/drucksachen/2018/0001-0100/61-18.pdf?__blob=publicationFile&v=1

pollinators including options for flower cover on fallow, field margins and arable land, ecological corridors in which phytosanitary products are not permitted, a scheme to adapt the provision of cover crops to pollinators' needs and an option to protect ageing and decaying hedges specifically for the value as insect habitat.

In Spain, the case study found no overt mention of wild pollinators, even in the descriptions of those specific agri-environment-climate options which might be of benefit to them such as (in Andalucía's RDP) those targeted at preserving the biodiversity-rich agroforestry systems in the *dehesa*.

In Croatia RDP implementation was strongly geared towards biodiversity, in part due to support from a World Bank project to assist Croatian officials with the design of appropriate measures. As with other case studies, however, explicit references to pollinators appeared only in the explanations for particular scheme options, such as the M10.1 option for maintaining traditional orchards.

The Austrian case study found evidence of high-level discussion between the national authorities, experts and stakeholders as they designed Austria's small but highly strategic range of agri-environment-climate options. Separate options for grassland, arable and organic farming are taken up by over 90% of Austrian farmers so their design is very influential.

Pollinators are not mentioned specifically in Romania's RDP, but the importance of M10 (AECM), M08 (afforestation) and M15 (Forest-Environment-Climate) for the "maintenance and development of insect populations" is consistently highlighted, with a specific emphasis upon the two HNV grassland packages (submeasures) under M10. There is also a dedicated package under M10 targeting around 23,000 ha of permanent grasslands important for butterflies (*Maculinea* sp.) with payments for the maintenance of traditional management practices.

The lack of high-level strategic consideration of wild pollinators during CAP implementation means that the full range of appropriate CAP interventions may not be in place. For example, given the need for both habitat and forage, one would expect there to be systematic consideration of the scope to:

- Protect existing semi-natural features by designating all of them under GAEC7 cross-compliance.
- Provide funding for new ones where needed, for example in "simple" landscapes as described above.
- Focus support for flowering strips in places where habitat is already present or due to be provided.

- and support extensive grassland management in the most appropriate areas.

- The extent to which the CAP was being used to provide advice on wild pollinator management to land managers.

Advice available to farmers in the German Land of Baden-Württemberg includes a brochure on bee pasture published by the Ministry for Rural Areas and Consumer Protection, which is responsible for apiculture as well as agriculture. The brochure describes steps farmers can take such as sowing flower mixtures, flowering crops, mixed cultivation, growing catch crops with undersowing, avoiding or reducing herbicide use, conserving field margins, leaving strips of sparse vegetation in arable fields, and creating bee banks. In addition, the University of Hohenheim hosts an Institute of Bee Science which offers free seminars, and an NGO promoting "blooming landscapes" across Germany is based in the State.

Advice on pollinators is not one of the functions of the FAS, but Baden-Württemberg offers a range of 69 advice modules funded 100% under M2. Two of these have biodiversity as their theme. Pollinators are not specifically mentioned. Farmers receive a site visit of two to three hours during which a list of actions which can be undertaken to increase on-farm biodiversity is drawn up. The ten organisations accredited to offer this service include eight from the agricultural sector and two from the environmental and conservation sector. None employs advisers specialised in pollinators. 50 farm visits under the biodiversity modules took place between 2015 and 2018, affecting 0.1% of Baden-Württemberg's farms.

The French case study identified little use of the CAP to support advice on wild pollinator management. Administrative difficulties are reported to have deterred regions from making use of measures M1 and M2. There is, however, a rich and diverse system of advice provision centred around the well-established *chambres d'agriculture***.** In southwest France an Interbranch organisation – Sojadoc – established to manage the production of GM-free soya has developed measures by which interested farmers can increase the attractiveness of their farms to wild pollinators. Resources include a tool for assessing the pollinator-friendliness of each farm and generating farm-specific recommendations. The organisation has also offered collective training about pollinators and produced a guide to their needs along with signposting to the relevant regulations and sources of financial support. Several groups of farmers have collectively undertaken to plant flowering fallow and to monitor the outcome. The introduction of demonstrator honeybee hives onto soya farms is being planned for 2020 on the theory that increasing farmers' understanding of the life cycle of honeybees will also increase their understanding of wild pollinators.

The availability of advice on wild pollinators in the Spanish region of Andalucía is limited. There are courses on apiculture including one for beekeepers wanting to work in Natura 2000 areas, but just a single private course for 15 farmers has been RDP-funded on the topic of wild pollinators. Whilst this course covered different types of pollination, flower types and how farmers can help to ensure habitat for wild pollinators, it also dealt with the siting of honeybee hives and thus was not solely dedicated to wild pollinators.

Croatia's Farm Advisory Service (FAS) has provided dedicated advice on wild pollinators since 1999. Training modules are compulsory for all farmers receiving support under the organic measure and M10 support for traditional orchards, flowering strips, and extensive olive groves. Training is delivered in person by the FAS' team of agronomists, each of whom has been trained by a specialist in wild pollinators. Solitary bees are the central theme of the 1-hour training session for beneficiaries, but information is also provided on bumblebees, lacewing, hoverflies, and others. As well as the ecology of pollinators and the science of pollination, farmers are trained in how to construct habitats such as bee houses. Between 2016 and 2019 some 265 sessions were run for organic farmers with over 4,000 participants.

As well as compulsory training sessions, Croatia's FAS uses a wide range of dissemination methods to spread knowledge and advice about pollinators. These include national TV and radio broadcasts, its own and farming magazines, a website (general rather than focussed on pollinators), on-farm demonstrations of the effectiveness of bee houses (harnessing the enthusiasm of farmers who frequently report large increases in yield following their installation) and lectures and presentations at agricultural fairs and shows. The FAS' efforts to promote wild pollinators are not limited to professional farmers. There is an initiative to encourage domestic beekeepers to support solitary bees, and lectures and other information for students, schools, and the public.

In Austria advice on biodiversity is a component of the compulsory training for the 50,000 farmers taking up the "environmentally friendly farming" (UBB) agri-environment climate option. Courses are delivered differently in the different Provinces – sometimes as small seminars for those with specialist interests, sometimes for much larger groups. The training materials were developed by the Rural Training Institute which is reported to have been popular with farmers. The 20,000 farmers participating in the "nature conservation" agri-environment climate option receive a field visit from an ecologist. Options from a funding package (e.g. late mowing) are chosen and there is scope for farmers who are interested to receive additional advice on the needs of individual species.

Romania's FAS and private advice provision are not well developed, and implementation of the RDP measures to support advice and training has also been delayed. However, the Romanian Lepidoptera Society has involved itself heavily in the design of Romania's agri-environment climate option for species-rich grassland. Members of the NGO have supported farmers in the field and are judged to have contributed to the level of uptake of this measure, targeted at the *Maculinea* species.

5.2 The impact of including or excluding heath and scrubland in the definition of "permanent grassland"

No case study found evidence that the needs of pollinators were explicitly considered by a Member State when choosing whether to use the narrow or a broader definition of "permanent grassland".

In Germany, the broader definition was adopted for agricultural and conservation reasons, with the intention of ensuring the viability of extensive grazing[9]. Prior to 2015 heath and scrubland with less than 50% herbaceous cover were ineligible for direct payments, which created a perverse incentive for their poor management. In Baden-Württemberg and elsewhere heath and scrubland has reverted to forest. The effect of the wider post-2015 definition of permanent grassland is to make all the heathland Germany protects under the Natura 2000 directives eligible, as well as some but not all other valuable heathland. Combined payments under direct payments and agri-environment climate support of around €500/hectare are thus available to farmers grazing the land.

The German case study found some ongoing difficulties in operating the wider definition. The first was that the German authorities had not succeeded in defining which types of scrubby vegetation should be regarded as suitable for grazing, which resulted in continuing uncertainty about whether some types of land should be regarded as eligible. By contrast, firm classifications of eligible heathland types had been achieved.

The second difficulty was that rules requiring eligible land to be mapped digitally each year were not easy to operate where land was in a transitional state, such as

[9] Deutscher Bundestag (2014) Entwurf eines Gesetzes zur Durchführung der Direktzahlungen an Inhaber landwirtschaftlicher Betriebe im Rahmen von Stützungsregelungen der Gemeinsamen Agrarpolitik (Direktzahlungen-Durchführungsgesetz – DirektZahlDurchfG). 25.03.2014. Drucksache 18/908. Available at: http://dip21.bundestag.de/dip21/btd/18/009/1800908.pdf

at the margins of pasture and forest. Such habitats are important for certain pollinators. Greater flexibility in how Member States may design their own eligibility rules proposed for the post-2021 CAP may help to resolve this problem.

Like Germany, France has adopted a broad definition of “permanent grassland” with the intention of maintaining extensive grazing in areas where it is marginally viable. In the case study region (Aquitaine, PACA) such land is, as in Baden-Württemberg, expected to revert to forest if not grazed, rather than to arable production. France has adopted a pro-rata system in its eligibility rules whereby farmers receive a higher direct payment the fewer ineligible features are present on their land. Whilst heath and scrubland are eligible by virtue of the broad definition, some other elements of valuable pollinator habitat such as stands of trees are not. The case study notes that the pro-rata system presents farmers with an incentive to remove such elements to receive higher payments but did not find evidence that this was happening in practice.

In Spain there are complex and ongoing discussions between the national authorities and the European Commission about how best to apply the broad definition of “permanent grassland” Spain has chosen to Spanish circumstances. Spain has a high proportion of grazing land with woody or scrub rather than herbaceous vegetation. The case study reports that changes to the eligibility for direct payments of this land during the current CAP period have not resulted in the abandonment of grazing by the affected farmers, even though some have lost access to direct payments as a result.

Croatia has not adopted a broad definition of “permanent grassland” but the national legislation which implements the CAP explicitly refers to karst pasture as an eligible type of grassland. Such land has low agricultural productivity but is extremely rich in biodiversity with up to 50 different plants per square meter, and caverns and sinkholes formed by the action of water on the limestone substrate, all of which provide resources for numerous pollinator species. As in France and Spain a pro-rata system for scaling down payments in respect of land parcels containing ineligible features operates. In Croatia large continuous areas (over 500 m2 are first excluded, before a coefficient is applied to the remaining land based on the proportion of smaller ineligible features it contains. Croatia also supports grazing on karst land directly through its RDP (measure M10.2), providing payments to farmers who graze traditional breeds of goat, cattle, horses etc.

Austria has not adopted a broad definition of “permanent grassland”. Its pro rata scheme allows direct payments to be made in respect of land containing very low (c3%) proportions of forage area, based on the actual area. The case study notes the difficulty of operating such a system in areas of forest pasture where ascertaining the amount of genuine forage present – if any – is challenging for the farmer and paying agency. Although Austria's approach to administering direct payments for scrubby grassland in this way can lead to low direct payments per hectare, this type of land benefits from relatively generous payment rates under the RDP.

Romania has not adopted an extended definition of "permanent grassland" and the case study found no evidence that such an option had been considered, either in connection with pollinators or for other reasons.

5.3 The effectiveness of actions deliberately intended to assist wild pollinators

Most German Lander offer flowering strips as an agri-environment climate option for arable farmers. An evaluation of uptake of the relevant option in Baden-Württemberg attributed an increase in uptake to the fact that the payment per hectare had been raised from its previous level, that it could be combined with declaration of the relevant hectares as EFA, with a resulting reduction in the payment rate and that farmers were socially rewarded for providing patches of flowers in the countryside. The case study noted, however, that research demonstrating a positive impact on wild pollinators from the provision of flowering strips in Germany was based on examples involving a higher proportion of land (10% as opposed to 1.5%) and multi-annual rather than annual flowering strips. By contrast uptake in France of the "COUVER" option for flowering fallow was low (0.8% of all fallow), despite also having one of the highest per hectare payment rates.

In Andalucía, Spain, just one RDP action has so far been taken with the (partial) aim of improving conditions for wild pollinators. Funding from the Environmental Innovation Partnership measure (M16) is being used by an agrarian organization to advise and monitor flowering strips which have been put in place by four farmers. Soil samples (to test the impact on carbon sequestration) and pitfall traps are being used. The low participation rate may reflect the fact that the call for participants was recent (2018) and the payment rate (€91/ha) lower than in France or Germany.

Austria has also evaluated the contribution its arable flowering strips and extensive grassland management options make to wild pollinators. Controlled transect-based surveys (using the same observer on the same day to count species within a 20m radius on similar parcels which are or are not enrolled in the option) have demonstrated a clear impact on butterfly numbers on arable land but no impact on them from the grassland management option. This is thought to be because the requirements of "environmentally friendly management" for grassland are not sufficiently dissimilar to the way intensive grassland is usually managed.

Romania's agri-environment climate option in support of *Maculinea* butterflies has been designed with the involvement of the Romanian Lepidopteran Society and a University-based expert. It prohibits the use of pesticides and fertilisers, other than traditional uses of manure equivalent to no more than 40kg/hectare. Grazing must be kept lighter than 0.7 LSU/ha, mowing must not take place before 25 August (the end of the *Maculinea* breeding season) and land under commitment must remain undrained. There is a higher rate of payment for farmers willing to undertake hand- rather than light mechanical mowing or scything. These requirements are broadly in line with the species management plan for *Maculinea* produced by Butterfly Conservation Europe. Unfortunately plans by the Romanian authorities for controlled monitoring of this grassland option were deferred as a result of resources being diverted to assessing the Farmland Bird Index.

6. HOW TO INCREASE POLLINATOR ACTION IN THE CAP STRATEGIC PLANS FROM 2021

The preparation of a new CAP Strategic Plan (CSP) in each Member State provides an important opportunity to integrate support for wild pollinators and their habitats throughout both pillars of the CAP. This requires an explicit wild pollinator objective within the broader biodiversity objectives and green architecture of each Member State's CSP, setting out the intervention logic for a coherent suite of wild pollinator friendly measures across both CAP funds.

This first step will be to **identify and prioritise wild pollinator needs within the Member State.** This should take a regionalised approach, working closely with the environmental authorities at both national and regional level to integrate and build on priorities set out in existing policy frameworks. These include the Prioritized Action Framework (PAF) for Natura 2000 (the Natura 2000 network protects many key pollinator habitats and directly protects more than 15 pollinator species); national and regional biodiversity strategies and action plans with objectives and measures targeted at wild pollinators; EU Habitat Action Plans for key pollinator habitats (e.g. those for European dry heaths and for calcareous grasslands which contain key measures for wild pollinators); species action plans for pollinator species and/or other national protection measures; and the national action plan for the sustainable use of pesticides and requirements for implementation of IPM.

At the same time as identifying specific needs, **the baseline status of wild pollinators should be established** (by collating existing data and setting up initiatives to gather new data if there are gaps). This will inform **setting a specific target and relevant indicators specifically for wild pollinators** in the national CSP monitoring framework; and putting in place monitoring mechanisms for bees, butterflies, moths, hoverflies, and other pollinators, (in cooperation with environmental authorities), to ensure that the impacts of the CSP can be measured[10]. This could be funded through the technical assistance budget of the CSP Plan. A key step is to make the geospatial IACS[11] crop data available so that evaluators can assess the impacts of specific CAP interventions against the pollination deficit of crops.

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[10] Potential approaches to monitoring pollinators and examples across the EU can be found in the report on an EU Pollinator Monitoring Scheme https://wikis.ec.europa.eu/display/EUPKH/EU+Pollinator+Monitoring+Scheme

[11] Integrated Administration and Control System for the Common Agricultural Policy measures

With wild pollinator needs established, the second step is to define how the CSP will protect existing wild pollinator populations and habitats from damage – including but not limited to those associated with Natura 2000 sites –in the detailed **definition of detailed CAP land eligibility rules for semi-natural habitats and features** and **conditionality standards**. This provides a firm foundation for designing **a coherent package of intervention measures in both pillars of the CAP**, targeted at maintaining, improving and restoring habitat management for pollinators in different farming systems and at creating new habitats and landscape features. These interventions should be designed to provide multiannual forage sources with a diversity of flowering plants from early spring through to late autumn, as well as nesting and over-wintering habitats. CAP interventions should also support the provision of specialised information, advice and training for farmers and advisers from trusted sources, and co-operation and innovation among land managers and others involved in pollinator support (e.g. by setting up Wild Pollinator Operational Groups as part of the EIP for agricultural productivity and sustainability).

The decisions that would benefit pollinators for each of the main CSP elements are described in Table 3 and more detailed guidance for managing authorities can be found in the Guide to Pollinator-friendly Farming (Keenleyside and Underwood, 2020).

It is not recommended that CAP funds are used to support beekeeping in protected areas or other areas that may have wild bee species of conservation concern, such as species-rich grasslands. As shown by the evidence in Annex I, there is a possibility that honeybees will outcompete native bees for nectar resources, and transmit diseases and parasites to the wild species.

Table 3 Making wild pollinator-friendly decisions in CAP Strategic Plan design

Strategic Plan decision point **(references to COM(2018) 392 final)**	**Key choices for the benefit of wild pollinators**
Needs and SWOT assessment and intervention strategy (Articles 96 and 97)	identify land management and agricultural practices needs of wild pollinators, including the needs and actions identified for pollinator species and habitats in the PAF

	detail how these are to be addressed through the coherent choice of interventions for wild pollinators, as part of the green architecture identify cropping systems that need the pollination service from wild pollinators and may already be suffering a pollination deficit
Definition of 'permanent grassland' and 'permanent pasture' (Article 4(b)iii)	ensure that this definition includes permanent grassland habitats with shrubs and/or trees, where these provide food, breeding or hibernating resources for pollinators
Sectoral support for the fruit and vegetable sector (Article 43)	prioritise support measures that favour wild pollinators, including agroecological practices, organic production, IPM and integrated production, and other actions to create and maintain habitats favourable for biodiversity or the landscape.
Sectoral support for the apiculture sector (Articles 48 and 49)	ensure that support for this sector (for example on rationalising transhumance or combating pathogens) does not conflict with the conservation of wild pollinator populations in the target area, for example with regard to the spread of diseases, competition for resources or the impacts of veterinary medicines.
Farm Advisory Service and Agricultural Knowledge and Innovation System (Articles 13 and 72)	ensure that farm advisory services and the wider AKIS system provide up-to-date technical advice on needs/benefits of wild pollinators and the management and creation of habitats and features to support them provide technical training on pollinator management for advisory services (public and private)
Conditionality (Articles 11 and 12)	ensure protection of EU Habitats Directive Annex 1 habitat types important for pollinators[12] (SMR 4)

[12] See ETC BD report available at https://www.eionet.europa.eu/etcs/etc-bd/products/etc-bd-reports/etc-bd-technical-paper-1-2020-report-for-a-list-of-annex-i-habitat-types-important-for-pollinators

	prohibit use of pesticides in Natura 2000 areas (SMR 13)[13] protect all permanent grassland habitats in Natura 2000 sites (GAEC 10) prohibit use of pesticides on non-productive areas and retained landscape features (GAEC 9) define minimal share of landscape features and non-productive areas such that additional pollinator habitats need to be created (GAEC 9) specify minimum proportion of legumes in crop rotation (GAEC 8) actively promote integrated pest management among farmers and pesticide contractors (SMR 12)[14]
Eco-schemes (Article 28)	support to High Nature Value Farmland non-rotational set-aside for nature regeneration melliferous fallow landscape features going beyond requirements set out in GAEC 9, accompanied by pollinator-friendly management results-based payment schemes for pollinator friendly management at whole farm level or landscape scale

[13] Article 12 of Directive 2009/128/EC

[14] Under SMR 12, Member States must ensure that farmers using plant protection products comply with the principles of good plant protection practice and in particular those of integrated pest management. Member State should '*take all necessary measures to promote low pesticide-input pest management, giving wherever possible priority to non-chemical methods, so that professional users of pesticides switch to practices and products with the lowest risk to human health and the environment among those available for the same pest problem. Low pesticide-input pest management includes integrated pest management as well as organic farming*' (Article 14 and Annex III of Directive 2009/128/EC, referred to in Article 55 of Regulation (EC) No 1107/2009.)

Environmental management commitments (Article 65)	support for the pollinator habitat measures indicated in PAF and Species Action Plans Result-based payment schemes for pollinators support for management of existing pollinator habitats and creation of new pollinator resources in the most effective locations
Natura 2000 disadvantages (Article 67)	provide compensation payments for habitats that depend on agricultural management (for example species-rich grasslands)
Investments in biodiversity, ecosystem services, habitats and landscapes (Articles 68(2) and 6(1)f	restoration/creation of new landscape features and/or agroforestry to meet needs of pollinators
Cooperation (Article 71)	Set up European Innovation Partnership Operational Groups for the conservation of wild pollinators

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8. ANNEX 1: ADDITIONAL INFORMATION

8.1 How can the effectiveness of Ecological Focus Areas be improved for pollinators?

Table 4: How can the effectiveness of Ecological Focus Areas be improved for pollinators?

EFA option and uptake (selected options only)	Standard management requirements	Potential to improve pollinator friendly management
Catch crops/ Green cover (51% of EFA area in 2018 – before weighting)	Catch crop sown after the main crop. Under-sowing grass in the main crop. Catch crop should be established for a minimum period and sowing dates are specified by country. Catch crops are typically in situ during winter and ploughed into the soil in spring. Mixtures with specified plant species and seed density are defined by some countries.	The following management options are more pertinent to South Europe where flowering can occur prior to spring ploughing: • Allow plants to flower (e.g. delay ploughing so catch crop can provide early season resources). • Use nectar and pollen-rich species (e.g. clover, *Phacelia*) and include more than one species to increase continuity/diversity of floral resources. • Avoid using insecticide seed coating and plant protection products during the catch crop presence in the field. • Avoid putting flowering catch crops in after a neonicotinoid treated crop.
Nitrogen-fixing crops	Minimum area in some countries.	• Use nectar and pollen-rich species (e.g. lupins, clover)

(24% of EFA area in 2017 – before weighting)	Crop has to be present for a certain amount of time in some countries. Specific choices of species (differs greatly across countries).	• Include more than one species to increase continuity/ diversity of floral resources. • Restrict agro-chemical inputs. Use Integrated Pest Management. • Avoid planting flowering crops following crops receiving systemic pesticides. • Allow plants to flower.
Land lying fallow (21% of EFA area in 2018 – before weighting. NB melliferous fallow is only a small proportion of this area, mostly in Germany and France.)	No cultivation of crops during a minimum period (e.g. during the first half of the year), but generally no specifications about no. of years/cultivation cycles Land must be "kept in good condition": mowing, grazing, mechanical or chemical weed control, fertilizer application may therefore be, under restrictions, allowed in some countries, while not allowed in others; also variable prescriptions regarding timing of management (e.g. cutting) and removal of biomass.	Retain fallow for more than one year to encourage both annual and perennial forbs. Consider allowing longer term succession in which woody species are allowed to grow. • Introduce low level disturbance (e.g. via restricted grazing or mowing) to encourage floristic diversity. Frequency dependent on Member State and site conditions. • Maintain patches of bare ground and a balance of annual and perennial plant species. • Stagger mowing to create a diversity of successional stages and/or to avoid seasonal gaps in floral resources. • Avoid pesticide/fertilizer use.

		• If invasive plants/injurious weeds must be controlled, use only targeted mechanical or spot treatments. • Spatially target botanically diverse locations (e.g. areas of previous low intensity management). • If naturally regenerated vegetation provides poor floral resources for pollinators encourage botanical diversity via sowing of wildflower mixtures. Select resource-rich species with diverse characteristics (e.g. flower shape, flowering period)
Landscape features (5% of EFA area in 2018 – before weighting – mostly hedges and trees in a line, followed by ditches and trees in a group)		
Hedges (MS with highest proportion of EFA area as hedges and trees in line - UK, France, Germany)	Maximum width in some countries (up to 10m in Estonia and Hungary). Vegetation should be bushes and trees (Estonia) or woody material (UK-NI and HU) Cross compliance rules also apply which include not cutting between 1 March and 31 August, although there are exemptions.	Select nectar and pollen-rich (non-toxic) woody species with diverse characteristics (e.g. flower shape, flowering period). • Maintain a vegetated buffer (minimum width 2 m) adjacent to feature where ploughing and use of agro-chemicals is not permitted. • Hedge cutting interval should allow shrubs/plants to flower

		(i.e. at least two years between cuts) and cutting should be staggered within a farm to ensure some hedgerows flower every year. • Protect from field management practices to avoid damage (e.g. compaction, spray drift, ploughing). • If invasive plants/injurious weeds must be controlled, use only targeted mechanical or spot treatments.
Trees in line (MS with highest proportion of EFA area as hedges and trees in line - UK, France, Germany)	Perished trees must be replaced. Minimum crown diameter of 4m, minimum separation of tree crowns 5m, minimum length of the line of trees 20-25m and minimum area 0.1 ha (based on crown diameter). Management of cutting regime, such as pruning, during dormancy applied to no more than a third of the total area. No pesticide or fertiliser applied within 3 m radius of the trees.	Select nectar and pollen-rich (non-toxic) woody species with diverse characteristics (e.g. flower shape, flowering period). • Introduce low level disturbance (e.g. via restricted grazing or mowing) to encourage floristic diversity. Frequency dependent on Member State and site conditions. • Do not remove dead wood, stones. • Maintain patches of bare ground and a balance of annual and perennial plant species. • If invasive plants/injurious weeds must be controlled, use only targeted mechanical or spot treatments.

		• Maintain a vegetated buffer (minimum width 3 m) adjacent to feature where ploughing and use of agro-chemicals is not permitted. • Ensure aspects that provide favourable conditions for pollinators are protected from field management practices (i.e. south facing for sun and warmth in northern countries and north facing for shade in southern countries)

Table 4 source: summarised extracts from (Cole et al, 2020).

8.2 What evidence is there that honeybees have negative effects on wild pollinators?

Honeybees could have negative effects on wild pollinators by competing with them for nectar and pollen resources, or by transmitting diseases and parasites to wild pollinators.

Honeybees and wild bees share a number of parasites and pathogens. The literature suggests that honeybees can transmit pathogens to wild bees (Fürst et al, 2014), and that these pathogens may be contributing to wild bee population declines (Graystock et al, 2016; Mallinger, Gaines-Day and Gratton, 2017). However, there are very few studies that test pathogen transmission from honeybees to wild bees, as most studies only show correlations between pathogen presence in wild and domesticated bees, or do not examine the direction of transmission (Mallinger, Gaines-Day and Gratton, 2017).

Several systematic reviews of studies of competition between honeybees and wild pollinators have concluded that the few studies that measured impacts on reproduction and population growth mostly demonstrated negative effects on wild pollinators, mainly on bumblebees but also on solitary bees (Mallinger, Gaines-Day and Gratton, 2017; Wojcik et al, 2018). However, most of the published competition studies only measured abundance and foraging behaviour and found mixed effects or no effects. This is because most bees are generalists and are capable of adapting their foraging behaviour in response to competition, for example by foraging on less rewarding plant species or by foraging in different resource patches to honeybees, which concentrate their efforts on the most highly nectar rich flower patches.

A study in oilseed rape fields found that the addition of honeybee hives depresses the densities of other insects visiting rape flowers (bumblebees, solitary bees, hoverflies, marchflies, other flies, and other flying and flower-visiting insects) (Lindström et al, 2016).

Competition between honeybees and wild bees will vary according to the abundance of flower resources within the foraging range of the honeybees, i.e. in a radius of 1 km from the hive (Elbgami et al, 2014). A study in Sweden found that in arable landscapes with a low cover of semi-natural vegetation (i.e. less than 2% cover, mainly in field edges and road verges), the presence of honeybees reduced bumblebee densities, but no effect was observed in landscapes with at least 4% cover of semi-natural grasslands (Herbertsson et al, 2016).

The placing of honeybee hives in protected areas with semi-natural vegetation and rare wild pollinator populations could result in conflicts with nature conservation priorities if the honeybees are outcompeting the wild pollinators and depressing their population growth. (Cane and Tepedino, 2017) estimate that a strong honeybee colony gathers as much pollen in a month as a relatively large sized solitary bee species could use to produce 33,000 progeny. A way to measure the possibility of competition is to measure relative bee abundances (honeybees versus wild bees) at increasing distances from the hives. A study in a heathland protected area found fewer stem-nesting bee species near honeybee hives compared with similar areas without hives (Hudewenz and Klein, 2013). A study in a Mediterranean scrubland protected area found that at a density of 3.5 hives per ha, the wild bee biomass around hives was lower than in scrubland without bee hives, due to the absence of the large wild bee species (Torné-Noguera et al, 2016). A broad scale data review concluded that in the Mediterranean region, there is evidence of a long term trend of honeybees replacing wild pollinators on both crop flowers and wild flowers, with four times fewer wild pollinators visiting flowers than honeybees, compared to the ratio in the 1960s (Herrera, 2020).

Honeybees could also change the composition of vegetation by pollinating certain plants more heavily (which then produce more seed). There is little evidence that honeybees change wild plant communities in ways that endanger sensitive species. Some studies have shown that the presence of honeybees has positive effects on native plant communities, indicating that in some contexts, honeybees may aid in restoration or conservation efforts (Mallinger, Gaines-Day and Gratton, 2017).

The possibility of competition can be reduced by limiting the number of hives in relation to the abundance of flowering resources, and also by managing the spacing of hives.

9. ANNEX 2: CASE STUDIES

See separate annex report.

9.1 Austria

Authors: Johanna Huber & Wolfgang Suske

9.2 Croatia

Authors: Sonja Karoglan Todorović and Darko Znaor, Organisation: Environmental Institute Ecologica (HR)

9.3 France

Author: Oréade-Brèche

9.4 Germany: Baden-Württemberg

Authors: Dr. Rainer Oppermann and Johannes Mangerich (IFAB)

9.5 Romania

Authors: Mark Redman, Ioana Stanciu and Raluca Barbu

9.6 Spain: Andalucía

Author: Pablo Acebes Vives, Ecology Department, Centro de Investigación en Biodiversidad y Cambio Global (CIBC-UAM), Universidad Autónoma de Madrid

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