

FINAL

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Ecological Focus Area choices and their potential impacts on biodiversity

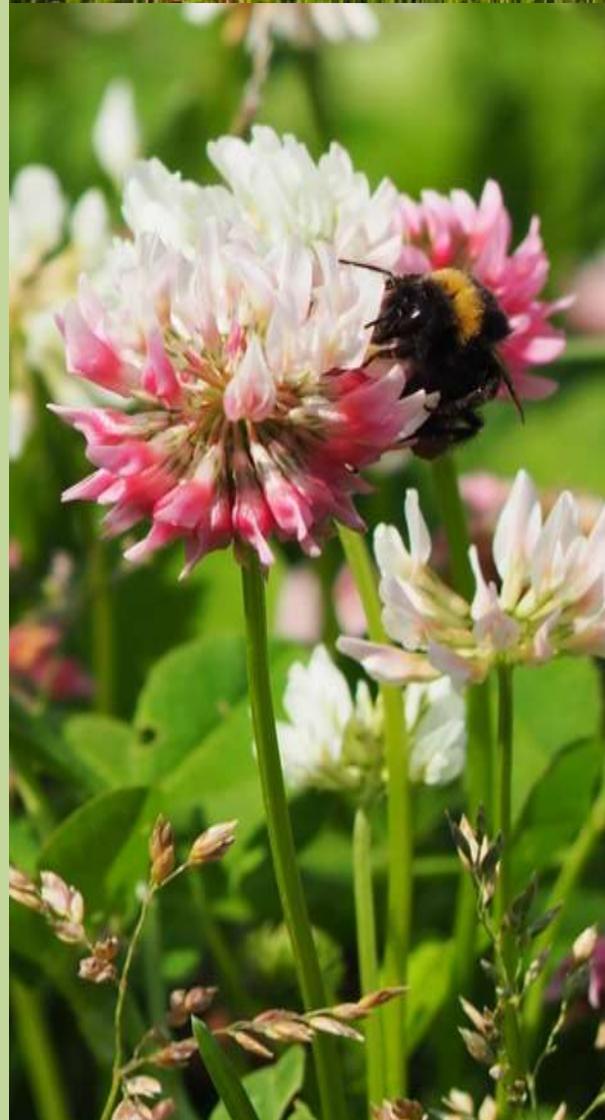
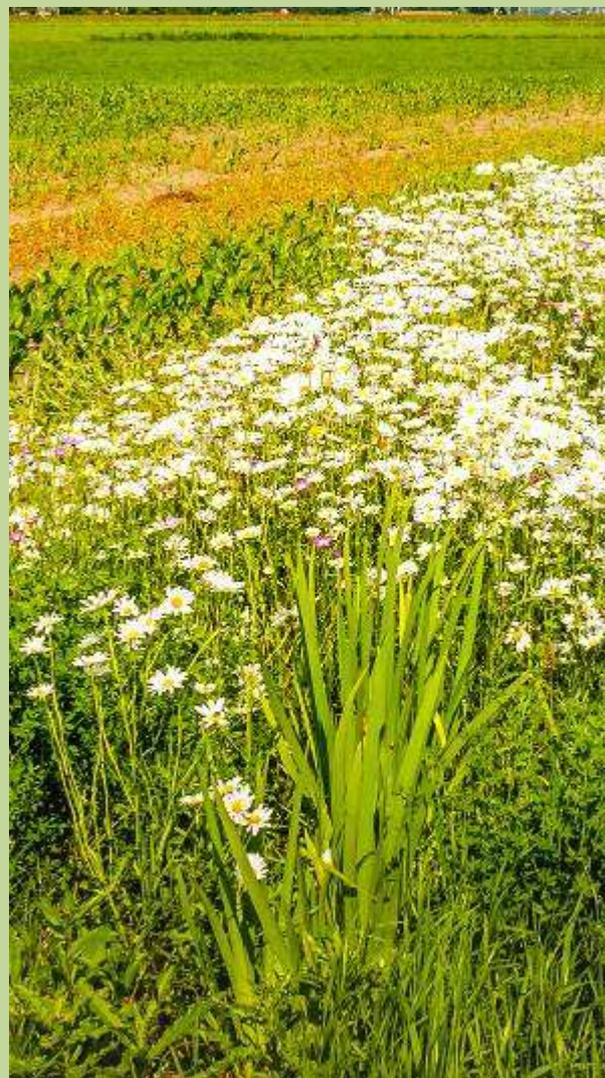
By:

Evelyn Underwood

Graham Tucker

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Corresponding author: Evelyn Underwood, IEEP Eunderwood@ieep.eu

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Institute for European Environmental Policy

London Office
11 Belgrave Road
IEEP Offices, Floor 3
London, SW1V 1RB, UK
Tel: +44 (0) 20 7799 2244
Fax: +44 (0) 20 7799 2600

Brussels Office
4 rue de la Science
1000 Bruxelles, Belgium
Tel: +32 (0) 2738 7482
Fax: +32 (0) 2732 4004

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Executive Summary

Ecological Focus Areas (EFAs), one of the three greening measures for which payments are received under Pillar 1 of the CAP, are intended to safeguard and improve biodiversity on farms, and Member States were required to select crop types and define other elements that benefit biodiversity in their country. Implementation data show that, in 2015, 73% of EFA area has comprised nitrogen-fixing crops, catch crops or cover crops (i.e. the productive EFA options). Of the non-productive options, land lying fallow has been most popular and occupies a fifth of the EFA area. The purpose of this study was to review evidence from the literature of farmland biodiversity impacts of the most widely eligible and most widely used nitrogen-fixing crops, catch crops and cover crops, and compare these with the evidence of biodiversity impacts of the most commonly selected non-crop options, namely fallow, hedges and field margins. The study also reviewed what the EU regulations define regarding EFA requirements and what EFA rules have been put in place in 13 case study countries and regions¹.

The literature shows that under the current EFA rules and conventional farming practices it is unlikely that most nitrogen-fixing crops grown on EFAs will provide significant benefits for biodiversity. The main exception to this being extensively managed nitrogen-fixing forage and green manure crops. For example, there is good evidence that alfalfa, a nitrogen-fixing crop, can provide benefits for some wildlife groups (including some threatened farmland species), if the crop is kept in the ground for a year to several years, cutting is avoided during the summer and pesticides are not applied. In addition, nitrogen-fixing grain legume crops such as peas and beans may develop weed densities that will provide some more modest biodiversity benefits for some invertebrates and birds if these are harvested late and managed extensively with no fertiliser and pesticide use. However, nitrogen-fixing crop EFAs probably rarely produce such biodiversity benefits because: a) the rules governing EFA implementation do not require extensive management; b) grain legume crops tend to be cultivated fairly intensively, including use of fertilisers and pesticides, and forage or green manure crops can be frequently cut or grazed; and c) only one Member State has banned pesticide use on N-fixing crops in EFAs (with the exception of the ban on their use on forage and green manure crops in The Netherlands).

The study also found little evidence from the literature that conventional catch and cover crops are directly beneficial for farmland biodiversity other than soil macrofauna. In fact, they could have a negative impact on some farmland birds if cover crops replace winter stubbles, which are important feeding habitat for seed-eating birds. Catch and cover crops are only likely to provide biodiversity benefits if they comprise plant mixes designed to benefit pollinators or seed-eating birds that are allowed to flower and set seed. However, on the EFAs of most of the case study countries and regions, there is no incentive to grow biodiversity beneficial plant mixes, and even were this to be the case, they are unlikely to flower and set seed as the obligatory cropping period is too short and/or crops may be cut to control weeds.

¹ Flanders (Belgium), Germany, Spain, France, Hungary, Italy, The Netherlands, Poland, Romania, UK-England, UK-Scotland, UK-Wales, UK-Northern Ireland

Compared to the EFA productive crop options under conventional management, the non-crop EFA options examined in this study (i.e. fallow, hedges, and field margins), generally have the potential under typical management to provide much greater, more diverse and more reliable biodiversity benefits. In particular, fallow land that retains stubbles and then allows semi-natural vegetation to regenerate and flower, and that is undisturbed over the breeding period is of particularly high biodiversity value, including for many declining farmland species. However, such potential biodiversity values are often not realised because EFA fallows can be cut and treated with herbicides under the current rules in most Member States, and can be destroyed from mid- to late summer onwards.

In conclusion, the evidence indicates that the farmland biodiversity benefits of nitrogen fixing crops, catch crops and cover crops as grown under the current rules and conventional management regimes are likely to be negligible over most of the EU. However, the biodiversity benefits of EFA productive options and fallow could be considerably increased. Firstly, steps could be taken to increase the uptake of EFA options that provide the greatest biodiversity benefits. Secondly, measures could be taken to encourage farmers to sow species mixes that benefit wildlife on fallow, field margins and buffer strips and grow them long enough to flower and set seed without agro-chemical use. Finally, the biodiversity benefits of EFAs could be enhanced with a few simple changes to the implementation rules. Three key changes would greatly increase the ability of EFAs to meet their biodiversity policy objectives: 1) avoiding the use of fertilisers and pesticides; 2) ensuring the periods over which they are established and removed are suited to biodiversity as well as production cycles; and 3) ensuring that key farming operations (such as cutting of vegetation) are carried out at appropriate times.

1 Introduction

1.1 Background

A feature of the 2014-2020 Common Agricultural Policy (CAP) was the introduction of a new policy instrument under Pillar 1 – green direct payments. Member States are required to dedicate 30% of their Pillar 1 budgets to three ‘greening’ measures, namely Ecological Focus Areas (EFA), crop diversification and the maintenance of permanent grassland. Of these three measures the EFA measure has biodiversity as its core objective², but the final content of the measure, and the way in which it has been implemented by Member States and subsequently by farmers is leading to concerns about the extent to which biodiversity will benefit in practice from this measure (Hart, 2015). Member States had the option of selecting from a wide range of eligible nitrogen-fixing crops and catch or cover crops, which, unlike other elements, were not present in the initial Commission proposal, and to define the management practices associated with them, within the framework defined in the regulations. The biodiversity benefits of some of the EFA options are uncertain, and they may also be reduced by allowable management practices such as the use of fertilisers and pesticides, and by not defining the temporal scale of the option sufficiently that it benefits key species by allowing them to complete their life cycles. The Commission’s analysis of the first year of implementation of the EFA measure (SWD(2016) 218 final) has reviewed Member State implementation data from 2015 which shows that, of all the EFA elements, it is nitrogen fixing crops and catch crops that proved most popular with farmers. However, Member States were only supposed to allow nitrogen fixing crops and catch or cover crops that contribute to the objective of biodiversity, and it is not clear if this is the case.

1.2 Scope and objectives of the study

Given the biodiversity objective of EFAs, the aim of this study was to carry out a review of the available literature to assess the likely impacts of the most popular nitrogen-fixing crops and catch and cover crops on biodiversity and to compare them with the biodiversity potential of other EFA elements that were predominant in 2015, namely: land lying fallow, and landscape features (focusing on hedges and field margins). The EFA options forest margins without production and buffer strips are also partially covered due to their similarity to field margins. The report considers wild biodiversity (i.e. wild flora and fauna associated with farmland), including species of particular conservation importance (e.g. threatened and declining species) and biodiversity that supports sustainable production in agro-ecosystems (e.g. pollinators, soil flora and fauna).

The assessment of the farmer choices in this study focussed on the following 13 countries / regions: France, Germany, Italy, Hungary, the Netherlands, Poland, Romania, Spain, the UK (all four regions) and the Flanders region of Belgium. These were selected in order to build on a previous study of EFA implementation choices in the same Member States (Hart, 2015), with the addition of Flanders. The 10 case study Member States (counting the whole of Belgium and the UK) have 76% of the EU-28 arable land, with France, Germany and Spain together accounting for 40%. However, for the purposes of this study we drew on evidence

² As set out in the recitals of Regulation EU No 1307/2013 (to safeguard and improve biodiversity of farms)

of the ecological impacts of the EFA options from all relevant sources in any country with similar agricultural systems, practices, and soils to the case study Member States.

1.3 The biodiversity which was addressed by this study

Biological diversity is the variability among living organisms from all sources, including the diversity within species, between species and of ecosystems³. This study considered the biodiversity between species within the arable farmland ecosystem at the field or farm scale (without touching on genetic diversity within species or ecosystem /landscape diversity). A simple count of numbers of species (species richness) is, however, a simplified and sometimes misleading view of biodiversity, as species have different levels of conservation importance (e.g. native species that are rare or otherwise threatened, restricted to certain habitats and concentrated or endemic to Europe are a high priority for conservation in the EU). This study therefore focuses on certain species groups that are a high priority for conservation, good indicators of the state of nature, and/or provide particularly important ecosystem services in the farmland environment.

This report focuses on biodiversity in the following categories of wild native species and other taxa, to the extent to which information is available:

- Wild native plants growing within fields (i.e. weeds) and/or in field margins, with a focus on flowering plants that provide nectar and pollen resources for invertebrates (bees, parasitoid wasps, flies, butterflies etc) and plants that provide seeds or fruit for invertebrates, birds, mammals or other wildlife;
- Soil biodiversity, primarily soil macro-organisms, such as earthworms and Collembola;
- Key invertebrate natural enemies of pests, such as weed seed predating and carnivorous Carabid beetles, spiders, predatory bugs, or parasitoid wasps;
- Butterflies and moths associated with farmland, i.e. excluding species whose larval food plants are not likely to be found in or around arable land;
- Pollinators (other than butterflies), including bumblebees, solitary bees, and hoverflies; the review does not consider honeybees;
- Common farmland birds, i.e. those included in the farmland bird index (EBCC et al, 2015);
- Species that are the focus of the Birds and Habitats Directives, i.e. those listed in Annex I of the Birds Directive and Annexes II and IV of the Habitats Directive that are particularly associated with farmland according to the EEA (EEA, 2015).

This study took into account the observation that a high proportion of species in arable farmland landscapes are generalist species, able to adapt to the high disturbance levels and highly modified habitats, as for example, shown for farmland bird communities in the EU (Le Viol et al, 2012). Typically there are few habitat specialists present, and these are most likely to be rare and declining species on farmland. Furthermore, increasing the diversity of structures and habitats on arable farmland will generally increase the diversity of generalists, because of the wider range of niches available, but has more complex and species-specific impacts on specialist species, and can be detrimental to them. It is also

³ Based on the definition in the Convention on Biological Diversity (CBD)

important to consider the scale of changes in farmland landscape heterogeneity and resulting biodiversity impacts, as for the more wide-ranging species groups the effects of agricultural change operate at a landscape level and that examining species diversity at a local level does not reflect total species richness across an agricultural landscape (Hendrickx et al, 2007).

To take these issues into account, we paid particular attention, as far as available data allowed, to the impacts of EFA choices on specialist farmland species, and threatened and declining species, rather than overall species diversity. We also looked for evidence of landscape and population scale impacts rather than local increases in the diversity of species or their abundance.

2 Methods and data sources

2.1 Overview

This study involved the following steps:

1. Identification of the most popular EFA choices by Member States and farmers.
2. Detailed literature review on biodiversity impacts of the nitrogen-fixing crops and the catch or cover crops most frequently allowed by Member States, and the likely effect of these when implemented on EFAs.
3. Meta review of biodiversity impacts of hedges, field margins and land left fallow.
4. Comparative analysis of biodiversity impacts of nitrogen-fixing, catch and cover crops compared to hedges, field margins and land left fallow.

2.2 Identification of the most popular EFA choices

The EFA options made available to farmers in each Member State, and the actual EFA choices made by farmers in each Member State in 2015 were taken from the European Commission communication on greening published in June 2016 (SWD(2016) 218 final). For each of the four most popular EFA options in 2015 we examined the requirements defined by the EU regulations in terms of crop type or size and management, and also the detailed requirements defined by each of the ten case study countries or regions.

We contacted administrations in the UK and other experts in each of the case study countries or regions to try to obtain information on the actual nitrogen-fixing crops, cover or catch crops planted by farmers in 2015⁴. However, we only obtained this information from four countries or regions: Spain, Hungary, Flanders in Belgium and Northern Ireland in the UK. The other countries or regions either replied that the information is not available, or that they do not collect and process the information from the farmers.

From this information, and additional references on management practices of the EFA options, we identified the key EFA options and their most likely crop choices and management regimes, which then became the focus of this literature review.

2.3 Literature review on biodiversity impacts of nitrogen-fixing, catch and cover crops

We carried out a comprehensive identification and review of published literature and other accessible information on the relationship between biodiversity and the crop type in question. Relevant information sources were identified by:

- Searching through references cited by the reports and information sources that the study team knew to be of relevance (Bues et al, 2013; Cussans and Stobart, 2016; den Belder et al, 2014; Doorn, Melman and Griffioen, 2015; Schmidt et al, 2014; Williams et al, 2014), including the Conservation Evidence database (Dicks et al, 2013; Dicks, Showler and Sutherland, 2010; Wright et al, 2013), supplemented by a search of IEEP's Reference Database which currently holds over 10,000 references including at least 1,175 on agriculture and biodiversity.

⁴ We only asked for access to actual data from the agricultural administrations, and did not ask for expert opinions on which crops are most likely to be planted

- Searching for references that cite the references found in the previous step, using Google Scholar.
- Searching for additional references by authors identified above, using Research Gate.
- Systematic literature searches using Science Direct with various combinations of the following key words in the title, keywords or abstract:
 - Legume, Alfalfa, Lucerne, Medicago sativa, Soya, Glycine max, nitrogen fixation
 - Catch crop, cover crop, mustard, buckwheat, Phacelia
 - biodiversity, bird, bee, invertebrate, mammal, pollinator, soil fauna
 - Europe, Romania, Hungary, Czech Republic, Germany, Italy, Poland, UK, Belgium, Spain
- Similar searches using Research Gate.
- Checks of the contents list of the most relevant scientific journals.
- Email consultations with key research institutions and experts (e.g. scientists at the BTO, Centre for Ecology and Hydrology, Institute for Agroecology and Biodiversity, RSPB, Thünen Institut, French National Institute for Agricultural Research (INRA), MTA Centre for Ecological Research, Institute for Sustainable Agriculture (IAS), Spanish National Research Council (CSIC), and various universities identified through Research Gate) to identify unpublished grey literature and papers in press.
- Examination of websites of key research and biodiversity conservation institutions, including those listed above.

To the extent possible the analysis consistently distinguished and quantified biodiversity impacts of each crop type with respect to the biodiversity components listed in section 1.3. All wild species mentioned in the report are listed in Annex Table A1. When reviewing the relevant literature we paid particular attention to evidence of population impacts. However, this was significantly constrained because many research publications report on effects of EFA cropping choice or their management (e.g. of observed foraging individuals or breeding pairs) but do not include data that can be used to infer a population level effect (Dicks, Showler and Sutherland, 2010). It is, for example, possible that some studies could be detecting a redistribution of individuals in the landscape in response to changes in resources, particularly studies of foraging butterflies and bumblebees (Power and Stout, 2011; Westphal, Steffan-Dewenter and Tschardtke, 2009), rather than an overall increase in survival and the reproductive rate that will increase populations.

2.4 Meta review on biodiversity impacts of other important EFA elements

The literature review on fallow, field margins and hedges relied on previous IEEP reports (IEEP, 2008; Underwood et al, 2013) and the existing IEEP literature database supplemented by some targeted search for recent meta-review and meta-analysis papers.

2.5 Comparative analysis of biodiversity impacts

A comparative analysis of the evidence of biodiversity impacts of nitrogen-fixing crops, catch and cover crops versus fallow, field margins and hedges was carried out using the findings from steps 2 and 3, taking into account the relative weight of evidence of each impact. The analysis considers unfavourable and favourable management practices, taking into account the EFA implementation choices in the case study countries and regions.

3 EFA options and their uptake in the case study countries and EU as a whole

This chapter provides an overview of what ecological focus area (EFA) options have been implemented in the EU in 2015 and what specific conditions Member States have set on their management, as these are a critical component of their net biodiversity impact. The chapter also reviews the available information on what farmers have done in practice on EFAs in 2015. The analysis focuses mainly on the case study countries and regions selected for this report. It should be noted that as Member States can amend a number of their implementation decisions every year, this analysis is a snapshot of the situation as it was in 2015 in the ten selected Member States.

3.1 EFA types and area in the EU

The EFA component of greening aims to safeguard and improve biodiversity on farms, as specified by Recital 44 of Regulation No 1307/2013. The EFA measure requires that holdings with more than 15 ha of arable land must maintain at least 5% of this arable land as an ecological focus area, as defined in the legislation. Member States are given considerable flexibility in deciding what elements to allow on EFAs. They choose which of a suite of ten forms of land management or features to allow for farmers to use to fulfil their EFA obligations.

The available EFA elements are:

- Land lying fallow;
- Terraces;
- Landscape features, including those adjacent to the arable land of the holding but not included in the eligible area;
- Buffer strips, including buffer strips covered by permanent grassland provided these are distinct from adjacent eligible agricultural areas;
- Areas of agro-forestry that receive support under the forestry measures within rural development programmes or that have received support under these programmes;
- Strips of eligible hectares along forest edges (with or without production);
- Areas with short rotation coppice with no use of mineral fertiliser and/or plant protection products;
- Previously afforested areas which are still eligible for direct payments;
- Areas with catch crops or green cover established by the planting and germination of seeds;
- Areas with nitrogen-fixing crops.

The EFA elements are considered to be not equally important for biodiversity, so a set of weighting factors have been defined which increase or decrease the extent to which each element contributes to the EFA requirement⁵. The weighting factors that decrease the extent are obligatory, whilst the factors that increase the extent are optional. Obligatory weighting factors decrease the amount of area of the productive elements (nitrogen-fixing crops, catch and cover crops and forest edges under production) on fulfilment of the EFA

⁵ Annex II of Commission Delegated Regulation (EU) No 639/2014 of 11 March 2014

requirement, whilst optional weighting factors amplify the area of buffer strips and landscape features (except stone walls)⁶. Four Member States in the EU have chosen not to use the weighting factors for certain landscape features, and of the 10 case study countries this includes field margins in the Netherlands.

The European Commission reported the proportion of EFA area and EFA elements implemented by farmers in 2015, based on information submitted by Member States, and calculated the proportion of the total arable area of each Member State affected by the EFA requirement using Eurostat crop statistics. In the EU as a whole in 2015⁷, 14% of arable land was under EFA (before weighting), which translated to 9% after application of the weighting factors.

The case study countries examined in this report differ widely in the proportion of their arable area under EFA (before weighting), ranging from 23% in Belgium down to 12% in Italy and 11% in the UK (not including Scotland), which partly reflects the differences in the proportion of the total arable area subject to EFA and partly reflects farmer choices of EFA elements with different relative weightings, mainly the wide use of those of value lower than 1. Italy has a relatively high proportion of arable land that is exempt from the EFA requirement due to farms having less than 15 ha of arable land, and almost all exemptions in the Netherlands and Romania are for the same reason.

3.2 Uptake of EFA elements in 2015

The EFA area at the EU level in 2015 (before weighting) consisted of: 45.4% nitrogen-fixing crops, 27.7% catch and cover crops, 21.2% land lying fallow, 4.3% landscape features, 0.6% buffer strips, 0.6% afforested areas, and smaller amounts of the other EFA elements (SWD(2016) 218 final). In the case study countries, it is notable that the EFA proportions differ greatly from the EU averages (see Annex Table A2) (NB it was not possible to analyse the situation on EFAs in France or Scotland in the UK, as the data were not submitted to the Commission, and we were unable to obtain them). The elements vary in their significance on EFAs (before weighting) in the countries/regions as follows:

- *Nitrogen-fixing crops*
 - Big (30% or more of EFA): Italy, Romania, Poland, Hungary, the UK (without Scotland) and Spain
 - Medium (10-30% of EFA): Germany⁸
 - Little (less than 10% of EFA): the Netherlands and Belgium (both regions)
 - Unknown: France, UK-Scotland
- *Catch and cover crops*
 - Big: the Netherlands, Belgium (both regions), Germany, Poland, Romania

⁶ The greatest decrease in contribution applies to nitrogen-fixing crops, catch crops and forest edges under production (factor 0.3). The greatest increase in contribution applies to hedges, trees in line and ditches (factor 2), followed by isolated trees, tree groups, field margins, ponds, buffer strips, forest edges without production (factor 1.5). The other elements have a weighting factor of 1. As defined in Annex II of Commission Delegated Regulation (EU) No 639/2014 of 11 March 2014.

⁷ NB As no data were submitted by France or Scotland, these were omitted from the Commission reporting.

⁸ NB nitrogen-fixing crops occupy 11.8% and catch crops 68% whilst fallow is 16.2%. Personal communication, Angelika Lischka, NABU – Naturschutzbund Deutschland e.V., 22 August 2016

- Medium: Hungary
- Little: UK-England
- Unknown: France, UK-Scotland
- Not eligible: Spain, Italy, UK-Northern Ireland, UK-Wales.
- *Land lying fallow*
 - Big: Spain
 - Medium: Hungary, Italy, UK (without Scotland), Germany
 - Little: Belgium (both regions) and Poland
 - Unknown: France, UK-Scotland
 - Not eligible: the Netherlands and Romania.
- *Landscape features*
 - Little: the UK without Scotland, Germany, Belgium (both regions), Italy, Hungary, the Netherlands⁹, Poland, Romania
 - Unknown: France, UK-Scotland
 - Not eligible: Spain.
- The other elements make up a very low proportion, except for buffer strips in England and afforested areas in Spain and Poland, or were not selected as eligible.

In the rest of this chapter, we describe the management requirements and uptake of the EFA elements that were predominant in 2015, namely: nitrogen-fixing crops, catch and cover crops, land lying fallow, and landscape features (focusing on hedges and field margins).

In this review we consider buffer strips and forest margins without production to generally have similar impacts on biodiversity as field margins. Buffer strips¹⁰, which can include the obligatory strips defined by cross-compliance along water courses, and also other buffer strips, play a role on EFAs in three Member States¹¹, but are absent or only cover a small area in the other Member States (SWD(2016) 218 final). Forest edge strips play a small role only in five Member States¹². In terms of biodiversity impact they are similar to field margins and buffer strips if they are not under production.

We do not discuss the other EFA elements (afforested land, agroforestry, short rotation coppice, terraces) further, as they make up only a small proportion of the total EFA. Afforested land and agroforestry play a small role only in four Member States¹³ and short rotation coppice has only been taken up by farmers in two Member States¹⁴.

⁹ It should be noted that the Netherlands chose not to use the weighting factors for landscape features

¹⁰ Article 45 of Commission Delegated Regulation (EU) No 639/2014 requires that buffer strips must be located on or adjacent to an arable field, with the long edge parallel to the edge of a water course/ water body; at least 1m wide (MS can set higher minimum widths); without production, although grazing or cutting and permanent grassland is allowed provided the buffer strip remains distinguishable from adjacent agricultural land; and buffer strips along water courses can include riparian vegetation up to a maximum width of 10m

¹¹ Denmark, Ireland and the UK

¹² Poland, Croatia, Belgium, Italy and Germany

¹³ Spain, Portugal, Hungary, and Poland

¹⁴ Sweden and Denmark

3.3 Nitrogen-fixing crops

3.3.1 Definition, types, agronomic & environmental benefits

If Member States make nitrogen fixing crops eligible on EFAs, they are required to select those relevant crops that contribute to improving biodiversity in their territory according to Article 45 point 10 of Delegated Regulation No 639/2014. The EU regulations do not define crop types, and Member States have chosen up to 30 crop groups (SWD(2016) 218 final). The number of eligible species / species groups selected by the case study countries or regions in this report ranges from 3 in UK-Northern Ireland to 20 in France. Ten of the 13 case study countries or regions offer more than ten species / species groups. Annex Table A3 lists the species or species groups that are eligible as nitrogen-fixing crops in one or more of the case study countries / regions.

The EU regulations do not define restrictions on the production of nitrogen-fixing crops other than that the crop should be present during the growing season¹⁵, so crops can be harvested, mown and/or grazed. The crop can be a single species or a mix of nitrogen-fixing species, but cannot be grown in a mix with a non-nitrogen-fixing crop such as grass. Legumes are also often used as a component of cover crop mixes that might be undersown under a cereal crop, but these are discussed below as catch /cover crops. Nitrogen-fixing crops are all legumes and can be divided into crops grown for their grain (e.g. field peas, faba beans, lentils and soyabeans) and crops grown as green forage and/or green manure (e.g. Lucerne/alfalfa, sainfoin, vetches, clovers). Certain cultivation practices are different for these two groups.

Legume crops can provide various agronomic and environmental benefits on the area of farmland on which they are grown. Legumes can increase yields in the following cereal crop, partly because of the nitrogen they add to the soil (Preissel et al, 2015), partly because of suppression of fungal disease (Kirkegaard et al, 2008), and partly because they generally have lower water demand and so leave more soil moisture for the next crop (Köpke and Nemecek, 2010; Peoples et al, 2009). Legumes are often grown as break crops in arable rotations, partly because they break the cycle of cereal-specific soil-borne fungal diseases and partly because they provide an opportunity to use different weed control strategies to achieve better weed control over the complete crop rotation. Legume fodders and green manures can reduce herbicide use in subsequent crops because of their weed suppression effect. However, the possibility of disease transmission between different legume crops can limit their use as both break crop and green manure or cover crop in the same crop rotation (Bues et al, 2013).

The nitrogen benefit is mainly obtained from green manure legume crops, as most of the nitrogen in grain legumes is harvested and removed in the grain (Peoples et al, 2009). However, if legumes are harvested during the high rainfall season, there is a risk that most of the nitrate is swiftly leached from the soil (Jensen et al, 2012), although legume cover crops reduce leaching compared to bare fallow (Tonitto, David and Drinkwater, 2006). The Delegated Act requires that Member State rules shall take into account the need to meet

¹⁵ According to Art 45(10) of Commission Delegated Regulation No 639/2014

the objectives of the Nitrates Directive and the Water Framework Directive given the potential of nitrogen-fixing crops to increase the risk of nitrogen leaching in the autumn.

Nitrogen-fixing crops can reduce greenhouse gas emissions through reduced nitrogen fertiliser use on the crop and on subsequent crops, provided farmers actually choose to reduce fertiliser applications (Nemecek et al, 2008). Lower nitrogen fertiliser use has other knock-on environmental benefits such as reduced eutrophication of field margin habitats and water bodies. As nitrogen fixation is inhibited in soils with high nitrate levels, the benefits are only gained if surplus nitrogen does not remain after the previous crop.

Green fodder and green manure legumes are very suitable for increasing soil organic matter, due to their long growing season, high root biomass, and the practice of leaving the residues in or on the soil, and the crops can be associated with use of minimum or no-till techniques, which reduce soil organic matter loss (Köpke and Nemecek, 2010; Nemecek et al, 2008). However, grain legumes such as lentil produce low amounts of dry matter and have little impact on soil organic matter. Soybeans, sainfoin, alfalfa and lupins are deep rooted and therefore help to reduce soil compaction (Jensen et al, 2012; Kahnt, Hijazi and Rao, 1986). However, lupins are also sensitive to soil compaction which will affect growth¹⁶. Legumes also mobilise phosphorus (Li et al, 2007), though the effect is relatively small (Köpke and Nemecek, 2010).

3.3.2 Management and Member State rules

Member States must establish rules on where nitrogen-fixing crops qualifying as EFA may be grown¹⁷. Most countries /regions allowing nitrogen-fixing crops on EFAs considered that their whole territory could be used to grow the crops without increasing the risk of nitrogen leaching, whilst some informed the Commission that they consider that their water legislation and/or nitrate action programmes already deal with this issue, so they take the position that there is no need for additional rules restricting the location of nitrogen-fixing crops on EFAs in their Member State (SWD(2016) 218 final).

Member States may also impose specific conditions on how nitrogen-fixing crops on EFAs can be grown¹⁸. The impact of nitrogen-fixing crops on biodiversity is influenced by the way in which they are grown, including:

- the timing and length of the crop growth season,
- whether they are grown as an annual or multi-annual crop,
- whether the crops are treated with fertiliser or pesticides,
- whether full tillage or minimum tillage is used before sowing, or whether farmers have adopted zero-tillage system, and
- whether the crops are harvested by combining or mowing or burned down with herbicide.

¹⁶ Sustainable Agri-Food Innovation Platform (2014) Lupin Agronomy Guide. <http://www.pgro.org/images/site/news/nov-14/Lupin-Agronomy-Guide-2014.pdf>

¹⁷ according to Art 45(10) of Commission Delegated Regulation No 639/2014

¹⁸ according to Art 45(10) of Commission Delegated Regulation No 639/2014

From a review of the conditions set by the case study countries and regions, it can be concluded that most have not imposed specific conditions on nitrogen-fixing crops that would improve their biodiversity value (see Box 3-1).

Box 3-1 Conditions applied to nitrogen-fixing crops on EFA in the case study countries

Of the case study countries or regions in this report, four have chosen not to specify conditions (France¹⁹, Italy, Poland, Romania), whilst the following have:

- *BE- Flanders*²⁰: 6 eligible species / species groups. Crop must be sown before 1 June and remain until 15 February (in polders and dunes until 15 October). Dry harvested fodder peas and beans should remain until 1 July and be followed by a green cover. If the crop is maintained for more than one year, the legume must remain predominant, and the crop should be resown after 31 May (with prior notice). Peas and beans are only allowed dry harvested for human consumption.
- *Germany*²¹: 13 eligible species / species groups. Soyabeans, lupins and beans must be in the ground between 15 May and 15 August, whilst all other species must be in the ground between 15 May and 31 August. These must be followed by a winter crop or cover crop which must stay in the ground until 15 February the following year to avoid nitrate leaching.
- *Spain*²²: 13 eligible species / species groups. Crops for food must be left until grain is mature, whilst crops for fodder must be left to grow until flowering starts. Nitrogen-fixing crops must be followed by a crop needing nitrogen (i.e. not fallow) to avoid risk of nitrogen leaching, and cannot be preceded by a nitrogen-fixing crop, with the exception of multiannual forage crops (e.g. alfalfa) which can be present as EFA during their entire life cycle.
- *Hungary*²³: 17 eligible species / species groups. Crops must be in situ during the following periods: herbaceous crops 01/04-31/05, for perennial crops 01/05-30/09, for soybean 15/5-15/7, for peas and faba beans 01/05-31/05. Minimum area 0.25 ha.
- *The Netherlands*²⁴: 7 eligible species / species groups. Mixtures are not allowed. Nitrogen-fixing crop must be followed by catch / cover crop on sensitive soils when the main crop is harvested before 1 October. On other soils the nitrogen-fixing crop must stay in the field from 1 November to 1 March. Plant protection products are banned on alfalfa, clover, esparcette, birdsfoot trefoil and vetches, but not on lupin and beans.
- *UK-England*²⁵: 14 eligible species / species groups. Minimum area is 0.01 ha.
- *UK-Northern Ireland*²⁶: 3 eligible species / species groups and can include winter beans and lupins as well as spring crops. Crop must be in situ from 1 June to 31 July.
- *UK-Scotland*²⁷: 11 eligible species / species groups. Crop cannot be harvested before 1 August in order to protect ground-nesting birds, and (as an additional requirement from 2016) there must be at least two different EFA nitrogen-fixing crops on the EFA area to extend the flowering period for pollinators (main crop should not exceed 75% of area). The nitrogen-fixing crop area must have an adjacent field

¹⁹ <http://agriculture.gouv.fr/les-derniers-ajustements-relatifs-la-definition-des-sie-pour-les-aides-de-la-pac-2015-definitivement>

²⁰

http://lv.vlaanderen.be/sites/default/files/attachments/fiche_13_huisstijl_vergroening_ecologisch_aandachtsgebied_0.pdf

²¹ <http://www.lwl-web.de/app/greening/erlaeuterungen.pdf>

²² http://www.fega.es/sites/default/files/imported/PwfgGcp/imagenes/es/AAFF_ficha_3_WEB_tcm5-49268.pdf

²³ <http://www.nak.hu/kiadvanyok/kiadvanyok/411-zoldites-gazdalkodoi-kezikonyv>

²⁴ <http://www.rvo.nl/sites/default/files/2015/04/Vergroening-2016-gevolgen-voor-beheerovereenkomsten-PSAN-SNL-ANLb.pdf>

²⁵ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/528144/BPS_Handbook_-_final_v1.0.pdf

²⁶ <https://www.daera-ni.gov.uk/sites/default/files/publications/dard/guide-to-the-greening-payment-2015.pdf>

²⁷ <https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/basic-payment-scheme/greening-guidance/efa-ecological-focus-areas/>

margin, which can also be EFA.

- *UK-Wales*²⁸: 15 eligible species / species groups. Crops must be sown by 15th May and present for 14 weeks after sowing or until 1st August, whichever is the later.

Length of growing season and flowering and seeding periods

On EFAs, the legume crop must be in the field during the specified period in spring and summer (as defined by Member States). Grain legumes may be planted as spring or winter crops, and are left in the field until the grain is dry. In northern and western Europe, peas and beans are mainly grown as spring crops, but also as winter crops. In southern Europe, peas, beans and lupins are three-month winter or spring crops unless they are irrigated. Southern soybean cultivars are the exception as they require four months of warm and rainy conditions to reach maturity, and are often irrigated in France, Italy and Spain (Rüdelshiem and Smets, 2012). Most legumes planted for fodder need to be harvested in full bloom or earlier, partly because of the decrease in nutritional value after flowering and partly because they have toxic or inedible seeds²⁹. Many legume fodder crops such as alfalfa, sainfoin, clovers, birdsfoot trefoil and esparcette are suited to perennial cropping, but there is currently no regulatory incentive for farmers to make the nitrogen-fixing crop proportion of their EFA perennial and therefore we assume that it is unlikely that this occurs. Flanders has specified that fodder/green manure legumes must remain until 15 February (except in the polders and dunes region), allowing for a long flowering period if the crop is not mown. Fodder crops can be mown regularly throughout the growing season in the case study countries/regions except Scotland, which imposed a ban on mowing until 1 August in order to protect ground-nesting birds. However, many intensive arable farms have no use for animal fodder, as there are no livestock nearby, due to the increasing geographical specialisation between arable and livestock in the EU. Therefore it is possible that some arable farmers are not cutting these crops, but are using them as green manure leys and incorporating them into the soil after the EFA period.

Fertiliser use

Nitrogen-fixing crops do not require the application of any nitrogen fertilisers. None of the case study countries or regions has banned the use of fertilisers in the greening requirements³⁰. However, within nitrate vulnerable zones, Member States have often applied lower fertiliser thresholds for nitrogen-fixing crops to avoid the problem of nitrate leaching through their nitrate action programmes. A survey of agronomic experts in five regions reported that fertiliser savings from including nitrogen-fixing crops in the rotation are significantly less than they could be as many farmers continue with normal fertiliser practices after legumes and treat the legume-derived nitrogen as a bonus (Bues et al, 2013).

Pesticide use

Grain legumes are rather susceptible to pest and disease damage compared to other arable break crops. Insecticide use is therefore generally quite high compared to cereal crops, and fungicides are also commonly used as seed treatments, although to a lesser extent than on

²⁸ <http://gov.wales/docs/drah/publications/150812-basic-payment-scheme-greening-guidance-2016-en.pdf>

²⁹ On the other hand, if the legume is to be used as a self-regenerating crop for a second season, it must be managed to facilitate seed set. This means avoiding or reducing grazing from flowering onwards, particularly in the first year, in order to build up a seed reserve in the soil.

³⁰ The Netherlands have done so in the equivalent packages only

winter cereals (Rüdelsheim and Smets, 2012). The Netherlands is the only Member State to have implemented a pesticide ban on nitrogen-fixing crop EFA (Hart, 2015). The use of neonicotinoid insecticide seed treatments on legume crops is currently banned³¹, but they are frequently used on winter cereals, which may precede legumes in the crop rotation and leave residues in the soil. It has been demonstrated that crops and weeds take up neonicotinoid residues and they are present in pollen and nectar (David et al, 2016). Grain legumes such as soybean are generally weaker competitors to weeds than cereal or oilseed rape crops, and therefore herbicides are also commonly used, usually prophylactically (Rüdelsheim and Smets, 2012). For example, in the UK, 83% of pea and bean crops received one or more insecticide applications (57% more than one), 95% received one or more herbicide applications, and 79% received one or more fungicide applications during the 2014 season, compared to 52% of cereal crops that received one or more insecticide applications (13% more than one) in the same period³². A study that looked at pea crops in France and Germany in 2005 (Nemecek et al, 2008) cited use of broad-spectrum insecticides³³ and fungicide on the crop (but also in one of the four crop rotations a reduction in fungicide use on the following wheat crop). In contrast, legume forages such as alfalfa and sainfoin require relatively little pesticide use, but may include a pre-sowing herbicide treatment for example if minimum tillage is being used (Williams et al, 2014).

The Commission³⁴ has set out proposals to modify some of the rules pertaining to greening to simplify their operation as well as to improve their environmental performance by banning the use of pesticides on EFA nitrogen-fixing crops from 2017 or 2018³⁵. The Commission also propose to allow mixtures of nitrogen-fixing crops with other crops, such as grass and clover mixes.

3.3.3 Uptake of options

In the EU, nitrogen-fixing crops take up almost half (45.5%) of the total EFA area before weighting and 40% of the area after weighting, and are applied in all Member States except Denmark. In the case study countries/regions, nitrogen-fixing crops are the dominant component of EFAs in Italy and Romania, and take up a half to two thirds of the unweighted area in Poland, Hungary, the UK (excluding Scotland), and Spain, but occupy only minor shares in the Netherlands and Belgium (Annex Table A2). There is no EU-wide information on the types of nitrogen-fixing crops actually grown by farmers on EFAs in 2015. However, responses were received to this study's data request (see section 2.2) from Spain, Hungary and Northern Ireland in the UK. In summary these indicate that:

³¹ Commission Implementing Regulation (EU) No 485/2013 of 24 May 2013 amending Implementing Regulation (EU) No 540/2011, as regards the conditions of approval of the active substances clothianidin, thiamethoxam and imidacloprid, and prohibiting the use and sale of seeds treated with plant protection products containing those active substances Text with EEA relevance. Official Journal of the European Union L 139, pp12-26. 25/5/2013.

³² UK Pesticide Usage Survey at <https://secure.fera.defra.gov.uk/pusstats/>

³³ pirimicarb, cypermethrin and lambda-cyhalothrin insecticides; chlorothalonil fungicide

³⁴ 8/7/2016 AgraFacts No 51-16 COMMISSION (DG AGRI) PREPARES FIFTEEN GREENING SIMPLIFICATION MEASURES

³⁵ 11 October 2016 ENDS EUROPE DAILY Jose Rojo EC mulls postponing fresh CAP greening rules for a year

- In **Spain**, 30% of the nitrogen-fixing crop EFA area was planted to alfalfa, 30.5% to vetches (including 8.5% to bitter vetch³⁶), 20% to field peas, 6% to faba beans, 4.5% to chick peas, 3.5% to lentils, 2.6% to sainfoin, 1.7% to vetchlings, and 0.4% to sweet lupins.
- In the **UK-Northern Ireland**, where only three nitrogen-fixing crop types are eligible, 74% of the nitrogen-fixing crop EFA area was planted to faba bean (7% winter crop, 67% spring crop); 18% was planted to spring field peas, and 8% to lupins (all as spring crop).
- In **Hungary**, 50% of the nitrogen-fixing crop EFA area was planted to alfalfa, 31.5% to soybean, 15% to field peas (mostly spring cropped), 1.6% to clovers, and areas of less than 1% to the other available legumes³⁷.

In the absence of information on actual farmer choices of nitrogen-fixing crops in most of the EU, an analysis of the Eurostat crop statistics was carried out. It is assumed that farmers are most likely to select nitrogen-fixing crops on their EFA that they or other farmers in their region are already familiar with, and therefore that the proportion of nitrogen-fixing crops on EFAs will be similar to the overall proportions of the legume crops grown in that country, provided that the crops are eligible on EFAs. It is important to note, however, that in some countries certain widely planted nitrogen-fixing crop types are not eligible for EFAs, for example soya in Spain.

Overall, the total nitrogen-fixing crop area was 2.54 million ha in the EU-28 in 2015, as shown in Annex Table A4. According to Eurostat, the area of pulses and protein crops for production of grain increased from 1.46% of the arable area in 2014 to 1.99% in 2015. Unfortunately, there are no comparable statistics for the increase in the area of legumes harvested green in 2015. In Poland, the crop area of legumes harvested green increased from 1.01% of the arable area in 2014 to 2.29% in 2015, but in Italy, which grows by far the largest area, it decreased significantly.

It is also relevant to note that in six of the case study countries (Spain, France, Hungary, Italy, Poland, Romania) some nitrogen-fixing crops are funded under voluntary coupled support for protein crops. For example, in Spain, 17 nitrogen-fixing crops are funded under both mechanisms³⁸, in France 11³⁹, and in Romania four⁴⁰. This provides an additional incentive to plant certain nitrogen-fixing crops as farmers can obtain voluntary coupled payments and fulfil the EFA and crop diversification requirements for the greening payment on the same crop area.

³⁶ Yero in Spanish

³⁷ Personal communication, Nóra Dobozy, Agricultural and Rural Development Agency, 23 August 2016

³⁸ Alfalfa, sulla, vetchlings, lupins, sainfoin, field pea, faba bean, vetches (grown for animal feed) and chickpeas, lentils, common beans, faba beans grown for human consumption (but not soya), according to <http://www.siteafex.es/actualidad/pac-2015-ayudas-acopladas-o-asociadas-la-produccion>

³⁹ Soya, vetchlings, lupins, alfalfa, melilots, sainfoin, serradella, field pea, clover, faba bean, vetches, according to https://www3.telepac.agriculture.gouv.fr/telepac/pdf/tas/2015/Dossier-PAC-2015_notice_aides-couplees.pdf

⁴⁰ Alfalfa, soya, field peas and faba beans, according to <https://www.stiriagricole.ro/ce-subventie-pe-hectar-plateste-apia-ca-spriijn-cuplat-pentru-fiecare-cultura-in-parte-39055.html>

The Eurostat analysis indicates that probably in all case study countries except the UK, the most important nitrogen-fixing crops are the various legumes that are harvested green (i.e. grown as forage, green manure and/or cover crops), primarily alfalfa/lucerne⁴¹. In second and third place are generally faba and field beans, field peas, and soya as row crops. Other crops are significant in certain countries: sweet lupins are significant in Poland (and to a lesser extent in Germany); and the other dry pulses category is most likely to consist of bitter vetch⁴² and lentils in Spain, and brown (common) beans in the Netherlands.

From the analysis of the case study country responses and the Eurostat data, the nitrogen-fixing crop types that are most frequently chosen by farmers in the Member States appear to be:

- Alfalfa / Lucerne – *Medicago sativa*
- Field pea (Yellow pea, Feed pea, Mangetout, Marrowfat pea, Snap pea, Snow pea, Vining pea) – *Pisum sativum* (can be spring or autumn/winter crop)
- Faba bean (broad bean, field bean, tic bean) – *Vicia faba* (can be spring or autumn/winter crop)
- Clovers – *Trifolium* spp
- Forage vetches – *Vicia* spp
- Soyabeans – *Glycine max*
- Common/French/Haricot beans, Runner beans, Lima beans – *Phaseolus vulgaris*, *P. coccineus*, *P. lunatus*
- Vetchlings - *Lathyrus* spp.
- Blue /Narrow-leaved Lupin, Yellow Lupin and White Lupin – *Lupinus angustifolius*, *Lupinus luteus* and *Lupinus alba* (all available in sweet and bitter varieties)

The review of evidence of biodiversity impacts in the next chapter therefore focuses on the following crop types:

- Alfalfa/lucerne (*Medicago sativa*)
- Faba/field bean (*Vicia faba*) and field pea (*Pisum sativum*)
- Soyabean (*Glycine max*)
- Clovers (*Trifolium* spp) and vetches (*Vicia* spp other than *faba*)

3.4 Catch and cover crops

3.4.1 Definition, types, agronomic & environmental benefits

Areas of catch and cover crops eligible to count towards an EFA include obligatory cover crops established under cross compliance rule SMR1 (i.e. compliance with the Nitrates Action Programme) and also other catch crops. They must be established by sowing a mixture of crop species or by undersowing grass in the main crop, but must not include areas under crops sown in autumn for harvesting or grazing (Article 45 in Commission Delegated Regulation (EU) No 639/2014). Member States must determine the list of mixtures of crop species that can be used and the period for sowing of catch crops and/or green cover, which must not be later than 1 October, and can also specify additional

⁴¹ NB it was not possible to do this estimate for Flanders and Scotland

⁴² Yero in Spanish

conditions relating to production methods. Catch and cover crops may replace bare soil or crop stubbles or they may replace a main crop in the crop rotation. Some Member States require the sowing of a catch or cover crop in their nitrate vulnerable zones (according to their Nitrate Action Programme), and some Member States require farmers to sow a catch or cover crop or leave crop stubbles in order to comply with the GAEC for minimum soil cover⁴³. This means that in some Member States, for example the Netherlands and Hungary, farmers may use cover crops to comply with both cross-compliance and EFA, but in others, for example UK-Northern Ireland, cover crops are part of cross-compliance but not EFAs.

Catch crops are designed to reduce nitrogen losses by taking up excess nitrogen from the soil before it can be leached following a heavily fertilised crop. Cover crops are designed to reduce nutrient losses by reducing soil erosion. In both types of crop these effects primarily rely on vigorous growth and vegetation cover; for catch crops this should be straight after the main crop harvest and for cover crops during the part of the year when soil erosion is greatest, which is generally the autumn and winter in most of Europe.

The range of catch and cover crops available to farmers varies greatly amongst Member States. Annex Table A5 lists the catch or cover crops eligible in one or more of the nine case study countries or regions applying this EFA option. The crops commonly included in these lists of eligible species include:

- Brassicas: mustards, cress, oilseed rape, forage kale, rocket, Camelina, radish
- Legumes: alfalfa, faba bean, clovers, vetches, vetchlings, lupins
- Grasses: rye grasses, grass mixes, grass-clover mixes
- Cereals: rye, buckwheat, barley, oats, sorghum, pearl millet
- Others: Phacelia (Purple Tansy), flax, Niger seed, sunflower, Mexican marigolds

3.4.2 Management and Member State rules

According to the EU regulation⁴⁴, catch crops and winter green cover indirectly affect biodiversity through a reduced use of inputs on the farm, which implies that management of the following crop(s) is a crucial component of their impact. In the case study countries and regions, the number of eligible species ranges from 7 to 84, in some cases grouped into seed mixes or categories, and management requirements also vary significantly (see Box 3-2).

Box 3-2 Conditions applied to catch and cover crops on EFA in the case study countries

In the case study countries or regions that offer the catch and cover crops option, the rules differ as follows:

- *Belgium - Flanders*⁴⁵: Certified or commercial seed mixes of at least two of the specified crops and undersown grass allowed (so long as grass cover is dense enough). Crops must be in the ground between 1 September and 15 October in the polders and dunes region, between 1 October and 1 December in the clay soil region, and between 1 October and 1 February in all other regions. No

⁴³ For example, Northern Ireland in the UK, according to <https://www.daera-ni.gov.uk/publications/cross-compliance-verifiable-standards>; and Hungary, according to http://njt.hu/cgi_bin/njt_doc.cgi?docid=117887.290869

⁴⁴ Preamble (44) of Regulation (EU) No 1307/2013 of the European Parliament and of the Council

⁴⁵

http://lv.vlaanderen.be/sites/default/files/attachments/fiche_13_huisstijl_vergroening_ecologisch_aandachtsgebied_0.pdf

fertiliser use or pesticide use during this period except for herbicide use to destroy grass-dominated covers before incorporation. Cover crops can be mown or grazed provided the vegetation cover is dense enough.

- *Germany*⁴⁶: 84 eligible species, minimum two species (or undersown with grass), no one species or grass proportion to be more than 60%. Cereals are not allowed. Cover crop must be sown between 16 July and 1 October and remain until 15 February. No mineral fertiliser or pesticides or slurry allowed, farm manure is permitted. Area can be grazed by sheep and/or goats but not mown.
- *France*⁴⁷: 42 eligible species. Crop must be undersown in a main crop or sown between 1 July and 1 October. The crop must produce a cover in order to be eligible.
- *Hungary*⁴⁸: Minimum two of 16 eligible species⁴⁹. Crops must be sown between 1 July and 1 October. Minimum area 0.25 ha. Crop must be ploughed in or otherwise destroyed before setting seed.
- *The Netherlands*⁵⁰: Mixture of at least 2 of the 23 eligible species in 2 categories (second one specifically for nematode control) plus an all grasses category, with sowing density at least 75% of the 'normal' sowing density for the species. Crops must be sown between 15 July and 30 September and be in the ground for at least 10 weeks. No herbicides until 31 December on category 1 crops. Fertiliser use is allowed. Catch crops grown after maize on sand or loess cannot count as EFA. Some exceptions for flax and Indian hemp. Plant protection products are banned.
- *Poland*⁵¹: Either undersown grass or a mix of at least two species from the following groups: cereals, oilseeds, fodder, grain legumes, fodder legumes, pollen providers. These species should not be used as a main crop on that land in the following year. Overwinter crops must be sown between 1 July and 1 October and be in place until at least 15 February. Stubble intercrops must be sown between 1 July and 20 August and be in place until at least 1 October.
- *Romania*⁵²: Choice of 10 species / species groups. Must be sown between 1 August and 15 October and be in place until 1 March.
- *UK-England*⁵³: Sown mix of at least two cover types (one cereal, one non-cereal from a list of 7 species⁵⁴). Grass can be used as long as it was undersown in the previous crop and is sufficiently established. Crops must be sown between 1 July and 1 October. Catch crops must be visible by 31 August and retained until 1 October. Cover crops must be visible by 1 October and retained until 15 January. Minimum area of 0.01 ha.
- *UK-Scotland*⁵⁵: Undersown grass after a cereal (catch crop) or green cover (minimum of two species from list of 7⁵⁶). Catch crop grass must be sown between 1 March and 1 August and retained until 31 December. Grazing is permitted after harvest of main crop. Green cover must be established between 1 March and 1 October and maintained in the field until 31 December. Green cover cannot be grazed or harvested.

Length of growing season, flowering and seeding

⁴⁶ <http://www.lcl-web.de/app/greening/erlaeuterungen.pdf>

⁴⁷ http://agriculture.gouv.fr/sites/minagri/files/150209_fiche-sie_cle49c446.pdf

⁴⁸ <http://www.nak.hu/kiadvanyok/kiadvanyok/411-zoldites-gazdalkodoi-kezikonyv>

⁴⁹ Eligible species/species groups in Hungary are oilseed rape, white mustard, radish, garden cress, buckwheat, rye, sorghum, rye grass, vetchlings, lupins, sweet clovers, clovers and vetches. Information submitted by personal communication, Nóra Dobozy, Agricultural and Rural Development Agency, 23 August 2016

⁵⁰ <http://www.rvo.nl/sites/default/files/2015/04/Vergroening-2016-gevolgen-voor-beheerovereenkomsten-PSAN-SNL-ANLb.pdf>

⁵¹ <http://www.minrol.gov.pl/Wsparcie-rolnictwa/Platnosci-bezposrednie/Archiwum/Platnosci-bezposrednie-w-2015-r/Zazielenienie-WPR/Obszary-proekologiczne-EFA>

⁵² http://www.apia.org.ro/files/pages_files/ghid_EFA.PDF

⁵³ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/528144/BPS_Handbook_-_final_v1.0.pdf

⁵⁴ Eligible species/species groups in UK-England are a combination of a cereal (rye, barley, oats) and a non-cereal (vetch, Phacelia, white mustard, lucerne/alfalfa)

⁵⁵ <http://www.gov.scot/Resource/0047/00472454.pdf>

⁵⁶ A mix of two of the following crops: rye, vetch, Phacelia, barley, mustard, oats, alfalfa, triticale

Catch crops are generally present over a short period from late-summer to the autumn, although in Scotland undersown grass or cover crops may be retained for up to 10 months. Most of the studied countries require cover crops to be planted in the late summer or autumn. Whilst in Scotland planting may be from 1st March, in practice cover crops will normally be planted following crops that are harvested in late summer. Therefore, catch and cover crops usually do not set seed because the period of cultivation is too short (and too cold or dry)⁵⁷. Furthermore, in several countries farmers are allowed to mow or graze the crop before seed set to avoid possible weed problems in subsequent crops.

Catch and cover crops may be cut and removed or incorporated into the soil. Soil incorporation can be carried out through tillage before the spring crop, but is now most often done through 'burning down' with herbicides (primarily glyphosate), especially where minimum or no tillage techniques are used.

Some of the eligible catch and cover crops listed by Member States are being grown by farmers under agri-environment schemes as winter wild bird seed crops or summer pollinator seed mixes. However, there are no incentives in the EFA rules to encourage farmers to select these crops rather than other eligible crops such as grass as EFA catch or cover crops or to allow them to flower or set seed.

Fertiliser and pesticide use

From a review of requirements in the case study countries, it appears that only a few Member States have actually banned fertiliser (Germany) or both mineral fertiliser and manure application (Belgium-Flanders) on catch and cover crops. However, the use of fertilisers and manure application is possible before or after the obligatory EFA catch or cover crop period, for example in order to increase the yield of ryegrass when harvested in spring. Belgium-Flanders, Germany, and the Netherlands have restricted pesticide use, but the use of herbicides to kill off cover crops before incorporation into the soil is allowed in most situations except in the Netherlands. For example, this is a common practice on ryegrass cover crops, as they are less easy to incorporate into the soil⁵⁸. This study assumes that very few farmers apply insecticides or fungicides to catch and cover crops, as possible pest or disease outbreaks that might affect subsequent crops are more easily prevented by suitable choice of crop than pesticide applications, which are relatively expensive in comparison.

The Commission⁵⁹ has set out proposals to modify some of the rules pertaining to greening to simplify their operation, as well as to improve environmental performance, by banning

⁵⁷ However, in Flanders farmers are being encouraged in a few local projects to plant Japanese / Black Oat *Avena sativa* cover crop to provide winter bird food, which is possible if it is sown early enough after harvest in summer (before 15th August), so it comes to grain, as it must then remain for at least four months until 1 February (in all regions except dunes and polders and the clay soil region). Personal communication, EEB member from Flanders

⁵⁸ Personal communication, EEB member from Flanders

⁵⁹ 8/7/2016 AgraFacts No 51-16 COMMISSION (DG AGRI) PREPARES FIFTEEN GREENING SIMPLIFICATION MEASURES

the use of pesticides on EFA catch and cover crops⁶⁰. The Commission also propose to get rid of the deadline for sowing and introduce a common minimum duration of 10 weeks for catch and cover crops.

3.4.3 Uptake of options

In the EU in 2015 catch and cover crops occupied 27.7% of the EFA area (before weighting) and 15% after weighting. In the case study countries and regions, they were particularly dominant on EFAs (before weighting) in Belgium (both regions), the Netherlands, Germany, Poland and Romania, whilst they play a minor role in England⁶¹, and are not an option in Spain, Italy, Northern Ireland and Wales (Annex Table A2). In those Member States where catch or cover crops are already required under Nitrate Action Programmes, the EFA requirement is partly replicating already existing farmer practices. Several Member States are not collecting information on which eligible catch and cover crops are actually planted on EFAs, which makes it impossible to analyse their actual overall impact⁶². In contrast, for example, farmers in Hungary must report the planned time of sowing, the position of catch or cover crops and plants to be sown in their application, and then after sowing they must report definite data on location, growth, crops sown, time of sowing, time of harvesting⁶³.

Data on what crops farmers planted in 2015 were obtained from Hungary and from Flanders in response to this study's data request (see section 2.2).

- In Hungary, the most frequent catch/cover crops in 2015 were white mustard on 30% of the area, radish on 25% of the area, oilseed rape on 20% of the area, clovers on 5%, and the other eligible cover crops on much smaller areas⁶⁴. The crops must be destroyed before setting seed.
- In Flanders, grasses were planted on 47% of the catch/cover crop area (mainly mixtures of perennial/english rye-grass and Italian rye-grass), white mustard on 21%, fodder radish on 13%, oilseed rape on 5%, Japanese oat on 5%, and Phacelia on 4%, with small amounts of various other mixes⁶⁵. The area of undersown grass was not quantified. The grass mixes and the Mustard-grass mix were the most popular seed mixes.

Due to the lack of information on what crops farmers actually planted in 2015, the crops most commonly listed as eligible crops in the case study countries and regions were prioritised (according to Annex Table A5). The literature review therefore focuses on the following catch/cover crop groups:

⁶⁰ 18/7/2016 AgraFacts No 54-16 CAP GREENING: GERMANY SLAMS COMMISSION MOVE TO BAN PESTICIDES ON EFAs, 7/10/2016 AgraFacts No 74-16 Council push to end EFA pesticide ban under fire and 23/9/2016 AgraFacts No 70-16 Farmers want simpler farm rules

⁶¹ The finding refers only to England as Scotland was excluded from the analysis, and Northern Ireland and Wales do not allow catch/cover crops

⁶² For example, in Denmark the rural payment agency is not asking farmers to report catch crop types. Personal communication, Tobias Feld, Center for Landbrug, The Danish AgriFish Agency, 19 August 2016

⁶³ Personal communication, Nóra Dobozy, Agricultural and Rural Development Agency, 25 August 2016

⁶⁴ Personal communication, Nóra Dobozy, Agricultural and Rural Development Agency, 23 August 2016

⁶⁵ Personal communication, Nele Vanslebrouck, Diensthoofd Dienst Communicatie, Departement Landbouw en Visserij, 9 September 2016. NB the area is calculated separately for each component of the seed mix, so there is double counting of the area. The area data are derived from the parcels that were visited for an on the spot check (i.e. approx. 5% of the farmers using green cover for their EFA).

- Rye grass (grasses)
- Mustards and radish (Brassicas)
- Phacelia (to represent flowering plants other than Brassicas)

3.5 Land lying fallow

3.5.1 Definition, types, agronomic & environmental benefits

The EU regulation defines fallow land that can count towards an EFA as land on which there is no production⁶⁶, and permanent grassland is not eligible. The EU rules do not define where the fallow areas should be in consecutive years, so farmers are free to choose whether to leave land fallow for several years to meet the EFA requirement in consecutive years or rotate fallows in a different field and place each year. The EU rules do not specify a time period for EFA fallow, and Member States have defined different cut-off dates after which farmers are allowed to plough and sow an autumn crop.

It is not currently possible to draw any more specific conclusions about how farmers are managing EFA fallow land. As fallow land is subject to cross-compliance including the GAEC requirements to avoid soil erosion and maintain soil cover, Member States have set some rules requiring that soil must be protected on fallow land at risk from soil erosion (i.e. sloping land of 12 degrees or more) through cover, for example as crop stubbles. However, only a few Member States or regions require minimum soil cover (stubbles or cover crops) on all arable soils throughout the year⁶⁷.

3.5.2 Management and Member State regulations

The rules that Member States have set for this land vary considerably, including different rules for the timescale over which fallow must be in situ, the activities that are permitted on the land and considered compatible with the 'no production' rule, and the minimum dimensions (see Box 3-3).

Box 3-3 Conditions applied to land lying fallow in the case study countries and regions

⁶⁶ The duration of this rule is not defined in the regulation, and as a result of a request by the UK, the Commission allowed the planting of crops after mid-summer

⁶⁷ For example, England (UK) requires that farmers must take all reasonable steps to protect soil by having a minimum soil cover all year around unless there is an agronomic justification for not doing so (such as land that has been cultivated or ploughed to prevent weeds going to seed), or where establishing a cover would conflict with requirements under GAEC 5. https://assets.publishing.service.gov.uk/media/5684e7dbe5274a0367000002/Guide_to_cross_compliance_2016_-_v_1.0.pdf Denmark requires that fallow land must be sown with a green cover within 14 days of harvest, unless harvest is too late in the year to allow establishment, in which case the cover must be established as soon as possible, and at the latest by 31 May of the following year. <https://www.retsinformation.dk/Forms/R0710.aspx?id=166965>

France did not set any specific rules. In the other case study countries and regions the rules vary as follows:

- *Belgium-Flanders*⁶⁸: land must be fallow between 1 March and 31 August, after which a crop can be sown or planted so long as it is not harvested before 31 December. Temporary grass can only be treated as fallow if the grass was sown before the start of the eligible period. Sowing of flower mix for biodiversity is allowed. No use of fertiliser or pesticides.
- *Germany*⁶⁹: There must be no agricultural use until 31 July, after which a crop can be sown or planted so long as it is not harvested before 31 December.
- *Spain*⁷⁰: arable land that is not under production during at least nine consecutive months after harvest in the period between October of the previous year and September of the current year. Fallows must not have been planted with a nitrogen-fixing crop in the previous year.
- *Hungary*⁷¹: Land must be fallow from 1 January to 30 September and areas can be grazed and cut to ensure they are kept in good agricultural condition. Minimum area 0.25 ha.
- *Italy*⁷²: Fallow must be in place between 1 March and 31 July. No agricultural production, mowing or soil management.
- *Poland*⁷³: Land must be fallow from 1 January to 31 July, with no crop production, grazing or mowing. After this time the farmer can restart crop production. Herbicide use is allowed to prevent encroachment of unwanted vegetation according to GAEC. Wild plant seed mixtures can be sown to benefit wildlife, provided they are not used for productive purposes or for animal fodder.
- *UK-England*⁷⁴: No crops, harvesting or grazing permitted from 1 January to 30 June. Temporary grass counts, and grass seed can be sown for biodiversity or environmental reasons, whilst sown wild bird seed mixes and pollen & nectar seed mixes count and at least two crops must be grown. Minimum width 2 m. Herbicides to control weeds are allowed and green cover or crop residues can be topped. Fertiliser or manure is allowed on sown wild bird seed or pollen/nectar mixes.
- *UK-Scotland*⁷⁵: No crop production or grazing from 15 January to 15 July inclusive, without pesticide use with the exception of spot control of invasive/injurious weeds, and no fertiliser use (with the exception of wild flower/bird food crop establishment). Wild flower mixes, wild bird seed mixes and grass are permitted but no topping is permitted. Basal fertiliser is permitted to support the growth of ground cover. Minimum area 0.01 ha, minimum width 2 m.
- *UK-Wales*⁷⁶: No crops permitted from 1 February to 31 July. Fallow can be either temporary grass in an arable rotation (but can only be sown during the fallow period under an agri-environment or Natura 2000 agreement); or bare with natural regeneration; or sown with an unharvestable seed mix for wildlife and/or pollinators which must include at least two crops. Vegetation can be topped during the fallow period only to control injurious weeds and cuttings must be left. Minimum area 0.01 ha, minimum width 2 m.
- *UK-Northern Ireland*⁷⁷: No crops permitted from 1 February to 31 July. Seeding is allowed but must be primarily for purposes other than agricultural production e.g. biodiversity and the environment. No grazing or harvesting is allowed during the fallow period; but grass can be cut (topped) provided the cuttings are not removed. No fertilisers or animal manure allowed. Herbicides for the purposes of weed control can be applied during the fallow period but not whole surface application of broad-

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http://lv.vlaanderen.be/sites/default/files/attachments/fiche_13_huisstijl_vergroening_ecologisch_aandachtsgebied_0.pdf

⁶⁹ <http://www.lwl-web.de/app/greening/erlaeuterungen.pdf>

⁷⁰ http://www.fega.es/sites/default/files/imported/Pwfgcp/imagenes/es/AAFF_ficha_3_WEB_tcm5-49268.pdf

⁷¹ <http://www.nak.hu/kiadvanyok/kiadvanyok/411-zoldites-gazdalkodoi-kezikonyv>

⁷² http://www.avepa.it/avepa-document-list-portlet/service/stream/e26e3d57-f99f-4e7c-9c8c-3eb82ffe1335/manuale_presentazione_aiuti_diretti.pdf

⁷³ <http://www.minrol.gov.pl/Wsparcie-rolnictwa/Platnosci-bezposrednie/Archiwum/Platnosci-bezposrednie-w-2015-r/Zazielenienie-WPR/Obszary-proekologiczne-EFA>

⁷⁴ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/528144/BPS_Handbook_-_final_v1.0.pdf

⁷⁵ <https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/basic-payment-scheme/greening-guidance/efa-ecological-focus-areas/>

⁷⁶ <http://gov.wales/docs/drah/publications/150812-basic-payment-scheme-greening-guidance-2016-en.pdf>

⁷⁷ <https://www.daera-ni.gov.uk/sites/default/files/publications/dard/guide-to-the-greening-payment-2015.pdf>

Length of fallow season

The obligatory fallow season varies between Member States, as farmers can plant a new crop on the fallow from the middle of the EFA year. In six of the case study countries/regions, the fallow lasts for six to eight months within the first half of the year (starting in January), after which a crop can be sown on the land. The earliest end, in UK-England on 30 June, falls within the bird breeding season of some species. In Spain, the obligatory 9 month fallow can start at any time during October to January and therefore also end at any time after the end of June to end September. In Italy and Belgium-Flanders, it does not include the winter period and must only last 5 months.

Size and type of vegetation

As Member States have not defined a minimum area or set a small minimum threshold, it is possible for farmers to implement fallow on part of an arable field accompanying a crop, for example in a strip along a field margin or in field corners that are less productive. All types of fallow are allowed (within different restrictions), including temporary grassland, with no particular incentives to farmers to adopt one type over another. Unseeded and ploughed fallow is no longer a component of intensive and non-organic arable crop rotations in most of western and central Europe, but in the Mediterranean region annual or biennial unseeded fallows that conserve soil moisture are still a common component of unirrigated arable systems, and in northern Europe winter fallows with crop stubbles are relatively frequent because the climate is too cold for winter crops (IEEP, 2008). In the rest of Europe, intensive arable rotations are likely to include temporary grassland leys, but some farmers may choose fallow with crop stubbles and natural regeneration of vegetation for ease of management. During the obligatory fallow period, the soil should not be tilled or otherwise disturbed. Of the case study countries/regions, Hungary and France allow grazing and/or cutting during the fallow period, and England, Wales and Northern Ireland allow topping of green cover or crop residues, whilst all others forbid such actions.

In some Member States, farmers can declare as EFA fallow areas planted with seed mixes for wildlife under agri-environment contracts if they accept a reduction in the agri-environment payment to avoid double funding⁷⁸, but in others agri-environment cannot be used to fund extra actions to benefit biodiversity on EFA areas⁷⁹. It is possible that some farmers may sow plant mixes designed for environmental and biodiversity benefits on EFA fallow because they have received information on the added benefits of these seed mixes⁸⁰ and/or already have experience of these through agri-environment schemes. However, as it is likely that the agri-environment funding is higher than the greening payment, we assume in this study that most farmers are not applying plant mixes to fallow, but continue to fund these under agri-environment where available.

⁷⁸ For example, in France, farmers can receive agri-environment payment for biodiversity seed mixes on EFA fallow land under the *Création et entretien d'un couvert d'intérêt floristique ou faunistique* scheme, so long as they accept a reduced funding level and maintain the seed mix for the specified period (at least until end August) (French national framework RDP 2014-2020)

⁷⁹ For example, in Finland, farmers cannot receive agri-environment payment for sowing biodiversity seed mixes on EFA fallow land under the biodiversity in arable land environments scheme (Finnish RDP 2014-2020)

⁸⁰ For example, as done by the Campaign for the Farmed Environment in England, <https://www.cfeonline.org.uk/cap-greening/>

Fertiliser and pesticide use

Fallow land is not normally treated with insecticides or fungicides, but may be treated with herbicide to control problematic weeds. For example, in England, herbicide use to control black grass (*Alopecurus myosuroides*) is allowed on EFAs. Half of the case study countries explicitly allow herbicide use on EFA fallow to control weeds in the form of spot treatment, but not on the whole surface. In Flanders, the use of fertilisers and pesticides on EFA fallow is prohibited. In a few Member States the EFA herbicide rules may correspond to their implementation of rules about managing unwanted vegetation such as noxious weeds under GAEC 7⁸¹. For example, in Poland under GAEC 7, farmers are required to mow fallow or carry out other operations preventing the appearance and spread of weeds at least once a year by 31 July, and on EFAs they are allowed to use herbicides to prevent the encroachment of unwanted vegetation in accordance with the GAEC 7 rule⁸².

The Commission⁸³ has set out proposals to modify some of the rules pertaining to greening to simplify their operation, as well as to improve environmental performance, by banning the use of pesticides on EFA land laying fallow⁸⁴ and setting the obligatory period of fallow at 9 months⁸⁵. Although the Commission has stated that currently the EFA fallow lasts six months across the EU⁸⁶, in Italy and Belgium-Flanders, for example, it must last for only five months.

3.5.3 Uptake of option

All Member States except the Netherlands and Romania have chosen to offer fallow as an option (SWD(2016) 218 final). Fallow occupied around 1.18 million ha of EFA in 2015 (21% of the total EFA), including almost 1 million ha in Spain and significant areas in Germany, Italy and Hungary (before weighting). This is less than a quarter of the 4.35 million ha of set-aside fallow that was implemented between 1993 and 2003 in the EU-15 (Alliance Environnement, 2007); however, some set-aside fallow was planted with crops and therefore differed from EFA fallow.

No information was available on what types of fallow farmers were implementing on EFAs. It is also not possible to state whether farmers are planning to keep EFA fallow areas for more than one season. In this review we therefore assume that EFA fallow may be managed in four different ways:

⁸¹ For example, UK-Northern Ireland requires the control of certain invasive alien species and noxious weeds under GAEC 7, according to <https://www.daera-ni.gov.uk/publications/cross-compliance-verifiable-standards>

⁸² Derived from a comparison of the GAEC 7 rule as compiled by the Joint Research Council and the Polish EFA specifications available at <http://www.minrol.gov.pl/Wsparcie-rolnictwa/Platnosci-bezposrednie/Archiwum/Platnosci-bezposrednie-w-2015-r/Zazielenienie-WPR/Obszary-proekologiczne-EFA>

⁸³ 8/7/2016 AgraFacts No 51-16 COMMISSION (DG AGRI) PREPARES FIFTEEN GREENING SIMPLIFICATION MEASURES

⁸⁴ 18/7/2016 AgraFacts No 54-16 CAP GREENING: GERMANY SLAMS COMMISSION MOVE TO BAN PESTICIDES ON EFAs, 7/10/2016 AgraFacts No 74-16 Council push to end EFA pesticide ban under fire and 23/9/2016 AgraFacts No 70-16 Farmers want simpler farm rules

⁸⁵ 23/9/2016 AgraFacts No 70-16 Farmers want simpler farm rules

⁸⁶ 10/10/2016 AgraFacts No 75-16 HOGAN TABLES "MINOR CHANGES" TO DRAFT GREENING SIMPLIFICATION MEASURE

- Bare (with crop stubbles ploughed in) and natural regeneration of vegetation (on flat land where it does not contravene the GAEC rules)
- Crop stubbles with natural regeneration of vegetation
- Sown with plant mixes designed for environmental and biodiversity benefits
- Temporary grassland (sown before fallow period commences)

3.6 Landscape features (focusing on hedges and field margins)

3.6.1 Definition and types

Member States are able to select landscape features protected under cross-compliance rules (GAEC 7, SMR 2 or SMR3, as referred to in Annex II to Regulation (EU) No 1306/2013) and/or one of the landscape features as defined in Article 45 of the Delegated Regulation⁸⁷.

The following landscape features are eligible in one or more countries and regions in the EU:

- Hedges or wooded strips (16 MS /regions)
- Isolated trees (13 MS /regions)
- Trees in line (16 MS /regions)
- Trees in groups and field copses (18 MS /regions)
- Field margins without agricultural production (17 MS /regions)
- Ponds (13 MS /regions)
- Ditches (16 MS /regions)
- Traditional stone walls (8 MS /regions)

Field margins differ from all the other landscape features in that if they are not protected by cross-compliance rules, they can be established and relocated from year to year (and can be sown with a crop after 1 August if it is not harvested before the end of the year). All the other elements must be retained in the same location over the whole CAP period.

According to the EU regulation⁸⁸, landscape features are considered to directly affect biodiversity. Member States are able to choose whether to define landscape features according to their own GAEC standard or Article 45, or a combination of both. In the EU, ten Member States or regions have applied the EFA option only to landscape features that are already protected under GAEC, without requiring any particular management for biodiversity (SWD(2016) 218 final). The EFA therefore partly replicates previous cross-compliance requirements in these countries, but may be helping to maintain the presence of landscape features on intensive arable farmland because of the incentive provided by the payment and the EFA controls and audits.

3.6.2 Management and Member State rules

In the case study countries, the number of features available to farmers ranges from the maximum of nine in Italy to one in UK-Scotland and the Netherlands, whilst Spain has

⁸⁷ Article 46 of Commission Delegated Regulation (EU) No 639/2014 of 11 March 2014

⁸⁸ Preamble (44) of Regulation (EU) No 1307/2013 of the European Parliament and of the Council

chosen not to allow landscape features at all. Annex Table A6 shows which landscape features are eligible in the case study countries and regions examined in this report and how they have chosen to define them. In four of the case studies, the landscape features element applies only to GAEC defined features (see Box 3-4).

Box 3-4 Conditions applied to hedges, wooded strips, trees and field margins in Article 45 and case study countries and regions

The EU rules (in Article 45) and some diverging examples of rules for hedges and field margins in the case study countries examined in this report (Hart, 2015):

- *Hedges or wooded strips* – maximum width of 10m (gaps can be a maximum of 2m) (Article 45). In Belgium-Flanders⁸⁹ gaps can be up to 4m. UK-England and UK-Wales define a minimum length of 20m, UK-Northern Ireland minimum 5m and gaps up to 5m, but the hedge can only be maximum 2m wide from the centre at the base. In the Netherlands⁹⁰ and UK-Wales⁹¹, hedges must be maximum 10m wide.
- *Isolated trees* – crown diameter of a minimum of 4m (however, MS can include trees with a smaller crown diameter if they are recognised as valuable landscape features in that country) (Article 45).
- *Trees in line* – crown diameter of minimum 4m, with the space between the crowns not exceeding 5m (trees with a smaller crown diameter are permitted for the same reasons as for isolated trees) (Article 45). Italy⁹² and France have defined tree species whose crown can be smaller than 4m.
- *Trees in groups (ie overlapping crown cover) and field copses* – maximum area covered cannot exceed 0.3 ha (Article 45).
- *Field margins without agricultural production* – no agricultural production is permitted and width can be 1-20m⁹³ (Article 45). In Germany, field margins protected by GAEC 7 must be permanent vegetated strips over 2m wide, whilst other margins have no specific rules. In Hungary, EFA field margins must consist of at least 50% herbaceous vegetation. In the Netherlands⁹⁴, EFA field margins must remain intact all year unless they border a winter crop, when they must stay intact until 31 August. In Romania, fertiliser and pesticide use should not occur but control of invasive weeds with pesticide is allowed⁹⁵. In the UK-Scotland⁹⁶, wild flower mixes, wild bird seed mixes and grass sward are permitted; no pesticide use permitted with the exception of spot control of invasive/injurious weeds, and no fertiliser use with the exception of wild flower/bird food crop establishment.

Location of landscape features

According to the EU regulation, an EFA landscape feature must be ‘at the disposal’ of the farmer and can be outside the eligible arable area if it is adjacent to it on at least one long edge⁹⁷. Member States have interpreted adjacent to the cultivated arable area in different ways. For example, in France hedges are not eligible if there is a ditch in between the hedge and the arable field. In Poland, both ditch and hedge may be eligible if they do not go

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http://lv.vlaanderen.be/sites/default/files/attachments/fiche_13_huisstijl_vergroening_ecologisch_aandachtsgebied_0.pdf

⁹⁰ <http://www.rvo.nl/sites/default/files/2015/04/Vergroening-2016-gevolgen-voor-beheerovereenkomsten-PSAN-SNL-ANLb.pdf>

⁹¹ <http://gov.wales/docs/drah/publications/150812-basic-payment-scheme-greening-guidance-2016-en.pdf>

⁹² http://www.avepa.it/avepa-document-list-portlet/service/stream/e26e3d57-f99f-4e7c-9c8c-3eb82ffe1335/manuale_presentazione_aiuti_diretti.pdf

⁹³ MS can establish a lower maximum width but none chose to do so in 2015 (SWD(2016) 218 final)

⁹⁴ <http://www.rvo.nl/sites/default/files/2015/04/Vergroening-2016-gevolgen-voor-beheerovereenkomsten-PSAN-SNL-ANLb.pdf>

⁹⁵ http://www.apia.org.ro/files/pages_files/ghid_EFA.PDF

⁹⁶ <https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/basic-payment-scheme/greening-guidance/efa-ecological-focus-areas/>

⁹⁷ Article 46(2)c of Regulation (EU) No 1307/2013 of the European Parliament and of the Council

beyond the maximum width⁹⁸. In UK-Northern Ireland, lengths of hedge, ditch, earth bank or dry stone wall are only eligible if they are physically touching the arable area on at least one long edge with no ineligible feature in the way except a fence. In the Netherlands⁹⁹ and UK-Wales¹⁰⁰, the landscape feature can be separated by up to 5m from the arable land.

Structure and management of field margins

The EFA field margin requirements set out by Member States in part maintain the status quo with regard to the minimum field margin requirements defined by Member States GAEC standards, but in some regions can provide an incentive to arable farmers with farms above 15 ha to increase the width of their field margins in order to meet the EFA area requirement. Obligatory GAEC field margins must have permanent herbaceous vegetation in order to serve as buffers to soil erosion, nutrient leaching and pesticide drift, so are generally covered mainly by grass species. In contrast, EFA margins that go beyond GAEC requirements can be cleared and sown with seed mixtures that benefit wildlife in some way. This review therefore considers these margin types separately, and also considers bare (unvegetated) field margins, which are allowed for example in Germany and Romania, but not in UK-Scotland.

Little information is available from Member States to characterise a ‘typical’ arable field margin. A review of field margins in 8 Member States concluded that grassy margins along water courses and hedges had increased as a result of cross-compliance rules except in Germany and Italy (Farmer et al, 2008). A survey of arable field boundary habitats in 39 regions in 10 European countries in summer 2014 recorded that field margins covered 0.1% - 1.1% of the arable land area with median widths of 1.1 - 5.5 m in different regions (IFAB, 2015). Evidence from two intensive agricultural regions in Germany in 2008-9 indicated that in one region around 80% of field margin length was narrow grassy strips (1-3m wide), and that these form a large proportion of the semi-natural habitat in arable areas, whilst in the other region around half of the margin length was wider than 3m and included hedges and/or trees (Hahn, Lenhardt and Brühl, 2014).

The Commission¹⁰¹ is proposing to simplify the rules by streamlining the characteristics of some landscape features such as ‘trees in line’ & ‘hedges & wooded strips’ and allowing greater flexibility in the rules determining how EFA landscape features must be adjacent to arable land.

3.6.3 Uptake of options

The EU level information shows that landscape features make up 4.26% of the unweighted EFA at the EU level and are only significant in the UK and Germany (see Annex Table A4.

⁹⁸ <http://www.minrol.gov.pl/Wsparcie-rolnictwa/Platnosci-bezposrednie/Archiwum/Platnosci-bezposrednie-w-2015-r/Zazielenienie-WPR/Obszary-proekologiczne-EFA>

⁹⁹ if the land in between is natural vegetation, ditch or track under the farmer’s control. <http://www.rvo.nl/sites/default/files/2015/04/Vergroening-2016-gevolgen-voor-beheerovereenkomsten-PSAN-SNL-ANLb.pdf>

¹⁰⁰ <http://gov.wales/docs/drah/publications/150812-basic-payment-scheme-greening-guidance-2016-en.pdf>

¹⁰¹ AgraFacts No 51-16 8/7/2016 COMMISSION (DG AGRI) PREPARES FIFTEEN GREENING SIMPLIFICATION MEASURES

According to the European Commission, the type of landscape feature most often selected by farmers in 2015 were hedges and wooded strips followed by field margins¹⁰². The data reported by the European Commission indicates that 80-90% of EFA landscape features declared by German, Italian and Hungarian farmers (for which all features were available) in 2015 consisted of hedges, field margins and ditches. In the case study countries and regions, these are also the predominant elements selected by farmers (Box 3-5).

Box 3-5 EFA landscape features in the case study countries and regions in 2015

The case study countries and regions that implemented the landscape features element differ significantly in the farmer uptake of options and the weighted proportions of different features in 2015 (SWD(2016) 218 final).

- In the *UK*, hedges predominate as most of the arable land lies in England where only hedges are eligible.
- In *Germany*, hedges take up over half the landscape features area, followed by field margins, with smaller areas of ditches, tree groups, and tree lines.
- In *Belgium*, ditches are dominant, followed by field margins and hedges.
- In *Italy*, field margins and hedges predominate, followed by ditches.
- In *Hungary*, field margins are dominant, followed by hedges and ditches.
- In the *Netherlands*, only field margins are eligible (but see equivalent practices below). The Netherlands chose not to use the weighting factor for field margins.
- In *Poland*, tree lines, tree groups and ditches take up roughly equal proportions, followed by isolated trees.
- In *Romania*, field margins are slightly dominant over ditches, tree groups and tree lines.

Of the case study countries examined in this report, only the Netherlands applied to the Commission with equivalent practices applicable mainly to field margins. Two separate certification schemes are offered:

- The arable strip package¹⁰³ consists of obligatory managed borders or in-field strips at least 3m wide, sown before 15 April with a mix of particular herbaceous species designed for wildlife or specific fauna. No pesticides, manure or mineral fertilisers. The strips can be supplemented with hedges, trees, ponds, ditches, riparian strips, catch crops, and nitrogen-fixing crops.
- The Skylark Foundation package consists of either: uncultivated buffer strips and field margins between 1 and 20 m wide, seeded before 15 April with a certified biodiversity improving mix (flower mix and/or grass and forb mix), no pesticides except spot spraying and mown at least once before 1 October; or nitrogen-fixing crops; or catch crops; or management of landscape features.

However, the uptake of both packages is a small proportion of the total EFA area under landscape features in the Netherlands (SWD(2016) 218 final).

In summary, based on the information analysed in this chapter, the following EFA crops and elements appear to be the most popular and widely eligible, and are therefore the focus of the literature review of EFA biodiversity impacts:

- Nitrogen-fixing crops (alfalfa, faba bean, field pea, soya, clovers & vetches)
- Catch and cover crops (mustard/radish, grasses, certain other flowers e.g. Phacelia)
- Land lying fallow (bare with natural regeneration, seed mixes, temporary grassland)
- Landscape features (hedges or wooded strips, field margins)

¹⁰² These represent almost all of the landscape feature area in the Netherlands, the Czech Republic, Slovakia, Latvia and Sweden

¹⁰³ akkerbouw-strokenpakket

4 Biodiversity impacts of nitrogen-fixing crops, catch crops and cover crops

4.1 Introduction

This section looks at nitrogen-fixing crops (i.e. plants in the Fabaceae family, referred to in this report as legumes) grown as a single crop or mixed legume crop during the spring and summer cropping period, according to the EFA specifications set out in the previous chapter. The section also looks at catch crops grown over the summer period after a main spring crop, and cover crops grown from the summer or autumn harvest into winter, as specified by the EFA requirements in each Member State set out in Chapter 3. The cover/catch crop types include both nitrogen-fixing (i.e. legume) and non-legume plant species. This review does not address the use of nitrogen-fixing shrubs or trees as these are only currently eligible on EFAs as part of agroforestry systems.

Nitrogen-fixing crops, catch or cover crops and land lying fallow (described in Chapter 5) differ from the other EFA options because they are implemented on the cropping surface as part of productive crop rotations. Their impact on biodiversity is influenced by the way they are grown and managed, as described in the previous chapter. In this review, we assume that both nitrogen-fixing crops and catch or cover crop EFAs are primarily being inserted into large-scale conventionally managed arable systems characterised by intensive weed control using herbicides and conventional or minimum tillage, as well as use of fertilizers, insecticides and fungicides on most or all of the crops in the rotation. We assume that a few extensively managed arable farms are also subject to the EFA requirements, but that most extensive arable farms are exempt because of their small size (i.e. <15 ha of arable land), or because they already contain more than 75% of their arable land under temporary grassland, legumes, fallow or fodder crops¹⁰⁴. Organic farms are also exempt from the greening requirements. We assume that some arable farms in the Mediterranean region are growing multi-annual fodder crops such as alfalfa on their EFA, perhaps because it is part of their standard crop rotation. However, most intensive arable farms in northern and central regions are likely to be growing fodder crops as green manure for only one cropping season.

A positive biodiversity impact from catch and cover crops and from reduced fertiliser use from crop rotations with nitrogen-fixing crops may arise in some sensitive areas from reduced soil erosion and nitrate leaching from the cropping surface into field margins and nearby water courses. Nitrate and phosphate leaching are a major driver of negative impacts on aquatic biodiversity (Grizzetti et al, 2011; Smith, 2003). However, the significance of these potential indirect effects on biodiversity in habitats beyond the arable field are highly uncertain and it was not possible within the scope of this review to attempt to quantify them.

¹⁰⁴ According to Paragraph 4, Article 46, Commission Delegated Regulation (EU) No 639/2014 of 11 March 2014. Farms with more than 75% of their eligible agricultural area as permanent grassland are also exempt.

4.2 Nitrogen-fixing crops

4.2.1 Evidence of biodiversity impacts of EFA type and management

Wild native plants

Legumes, being broad-leaved (dicotyledonous) plants, compete with non-crop plants for space, water and nutrients in ways that contrast with grass-type cereal crops, so their weed populations can be expected to differ from cereals. However, weed densities and species composition within crops are generally more heavily influenced by tillage, herbicide use and soil type than by crop type or diversity of crops in the rotation (Ulber et al, 2009).

The review found little evidence that weed diversity in conventionally managed legume crops differs from other conventionally managed crops (Box 4-1). One study showed a shift towards broad-leaved perennial weeds in multi-annual forage alfalfa crops (Meiss et al, 2010a), and these weed species tend to provide more food resources for flower-visiting insects. Another study found more diverse weeds in alfalfa managed without herbicides or summer cutting (Badenhausser et al, 2008). Only one study differentiated weed groups with benefits for wildlife, and it found a higher coverage of flowering plants that provide bumblebee foraging in the margins and crop edges with organic or low input legume-containing rotations (clover and other legumes) (Marja et al, 2014). However, these cases are not typical for most EFAs as they involve reduced or no herbicide use to control weeds before sowing and no summer cutting.

Grain legume crops are liable to high weed densities due to their long germination period and slow initial growth compared to cereal crops, but as their cultivation involves soil tillage and/or pre-sowing herbicide use, this is expected to keep the weed density low. Studies in Finland and Germany found that under conventional management, the weed flora of spring cropped field pea did not differ significantly from other spring crops on similar soils (Andreasen and Skovgaard, 2009; Gathmann, Greiler and Tschardt, 1994). It can be expected that this will also apply to grain legume crops grown in conventionally managed intensive arable rotations across Europe, in which weed densities are generally kept very low, as shown by a survey of wild plant coverage in arable fields in 39 regions in 10 European countries which found wild plant coverage below 1% except in two regions (IFAB, 2015). If faba bean is harvested late in the season, this can allow perennial weeds to flower (Köpke and Nemecek, 2010), providing resources for flower-visiting insects. No evidence was found regarding the weed flora in soybean crops.

Under organic management, the weed flora of field pea is more species rich and has a higher biomass than in field pea or spring cereals pre-treated with herbicide (Deveikyte, Kadziulienė and Sarunaite, 2009; Graziani et al; Salonen, Hyvönen and Jalli, 2005). Minimum tillage had little influence on weed density in a legume-containing crop rotation managed intensively with herbicides and fertiliser over two decades (Hernández Plaza et al, 2011), whilst over a shorter period it reduced diversity in a low-input legume-containing rotation (Santín-Montanyá et al, 2014).

Box 4-1 Evidence of weed flora abundance and diversity in nitrogen-fixing crops

Field pea (*Pisum sativum*)

A survey of the weed flora of 11 crop types across Denmark (Andreasen and Skovgaard, 2009) under

conventional intensive management found that the weed flora of spring cropped field peas was very similar to spring barley and spring rape but differed significantly from winter cereal crops, and from spring grown beet and maize. In a German study, field pea crops contained a slightly higher mean plant species richness than rye fields and slightly lower than barley fields after one growing season (Gathmann, Greiler and Tschardt, 1994). The study did not record how the pea crops were managed.

A study that compared weeds in field pea fields in southwestern Finland under conventional management with herbicide and organic fields that mostly used no pre-crop weed management following spring cereal (Salonen, Hyvönen and Jalli, 2005) found 59 weed species under the conventional management, with an average of 10 species per field, and 68 under the organic management, with an average of 18 species per field. An experiment in Lithuania found that weed biomass in field pea managed without the use of herbicides or inorganic fertiliser was significantly higher than in the spring grown cereal crops and total weed number was 1.3 to 1.6 fold higher (Deveikyte, Kadziuliene and Sarunaite, 2009). In a crop rotation with field pea in Mediterranean Italy (Graziani et al, 2012), the adoption of organic management resulted in a significant increase in weed seedbank density, particularly four competitive summer weed species (*Portulaca oleracea* L., *Amaranthus retroflexus* L. and *Chenopodium album* L.), compared to a low-input but non-organic management.

An experiment of a low input dry pea crop-winter wheat-barley-fallow rotation in semi-arid Spain found that over four growing seasons weed density was higher in minimum tillage than in conventional and zero-till systems, in which weed density decreased (Santín-Montanyá et al, 2014). It is likely that minimum tillage facilitates the germination of weed seeds in the upper soil layer. Pea plots under zero-tillage had less diverse and less balanced weed communities compared to the other forms of tillage, mainly due to the dominance of Ryegrass (*Lolium rigidum*) which was favoured by the higher soil humidity. This annual grass matures at the same time as the pea and its seeds are removed and redistributed on the field through the harvesting process.

Another experiment on the same site measured weed diversity in an intensively managed winter wheat-vetch (*Vicia sativa* L.) or pea rotation over 25 years and found that the rotations with minimum tillage appeared to support, on average, more species than conventional tillage or zero tillage, but no large differences in weed diversity arose between the tillage systems (Hernández Plaza et al, 2011). The crop rotation and management used are typical of non-irrigated arable land in the semi-arid Mediterranean climate of central Spain. Richness, Shannon diversity index and evenness of weeds varied greatly through the years in all tillage systems but this variation was not related to type of crop sown (cereal or leguminous). The study did find that the weed community has shifted towards species with smaller seed size (Hernández Plaza, Navarrete and González-Andújar, 2015). This is consistent with the findings of a long-term study of non-legume arable rotations in France (Fried et al, 2009), and is attributed to the selective pressure of herbicide use and cropping, rather than the presence of legumes.

Alfalfa (*Medicago sativa*)

A French study showed that the weed species composition in perennial alfalfa crops differs significantly from annual crops, suppressing some annual weeds that are common (and problematic) in annual crops while favouring other rarer species (Meiss et al, 2010b). Another study measured weed diversity trend in cereal crop rotations with multi-year (2 to 6 year) alfalfa forage crops (Meiss et al, 2010a). In the perennial alfalfa crops there was an increase in perennial and annual broad-leaved rosette plants, including long-flowering species frequently visited by insects (*Taraxacum* spp, *Malva* spp, *Picris* spp, *Crepis* spp etc), although these decreased again in the following wheat crop. Alfalfa volunteers frequently appeared in the following wheat. Both these impacts will tend to make the crops more attractive to flower-visiting insects. Alfalfa shifted weed communities away from some annual broad-leaved species with an upright or climbing morphology, due to the frequent cutting, and also reduced Creeping Thistle (*Cirsium arvense*). The effect was also visible in the following wheat. This shift is desirable from an agronomic point of view, but it is not possible to judge its impact on flower-visiting insects from the study. The impacts of the forage alfalfa on weed communities is most likely due to the absence of soil tillage and herbicide applications, the frequent mowing, and the continuous vegetation cover (Meiss et al, 2010a).

Another French study compared weed species richness in conventionally managed alfalfa fields (at least one herbicide and one insecticide treatment and cutting in spring and July) with extensively managed alfalfa fields (without any input and with no cutting from June to August) (Badenhausser et al, 2008). The number of weed

species in alfalfa plots under the extensive management was significantly higher (mean \pm SE = 31.8 \pm 4.2) than in the conventionally managed plots (mean \pm SE = 17.0 \pm 2.0).

A study measured coverage of wild flowering plants suitable for bumblebees in the field margins and legume crops on farms with legumes in the crop rotations and restrictions on herbicide use, compared to conventional farms without legume crops in northern and southern Estonia (Marja et al, 2014). It found that in two years the flower coverage was significantly higher on the farms under organic management and tended to be higher on farms under environmentally friendly management agreements than on the conventional ones (although the difference between these was not statistically significant). It is not possible to say from the study whether the higher flower coverage in the margins was entirely due to the lack of broad-spectrum (i.e. glyphosate) herbicide use compared to the conventional farms or partly due also to the legume-containing crop rotations.

Soil macro-organisms

Legumes can be attractive to soil macro-invertebrates because of the input of nitrogen rich residues into the soil and because legume roots stimulate soil microbial activity. There is evidence that soil macro-invertebrates are more abundant under forage/green manure legume crops than non-legume crops (Box 4-2). For example, alfalfa leys had higher mean population densities and biomass of above ground arthropods, particularly detritivores/microvores, than barley and grass ley (Curry, 1986). There were more surface-feeding (anecic) earthworms under four-year galega than under a grass crop and bare fallow (Epie, Cass and Stoddard, 2015), and more earthworms under four-year clover than under grass (Crotty et al, 2015). However, the evidence refers mainly to multi-year forage legume plots, which are expected to be rarely implemented on EFAs unless they are already part of standard cropping practices that correspond to the EFA rules (see Chapter 3). Multi-year forage legume crops are characterized by reduced belowground disturbance due to the absence of frequent tillage (which is strongly detrimental to earthworms) (Krogh et al, 2007; Nieminen et al, 2011), and the accumulation of plant litter on the soil surface, which favours detritivores.

Insecticides and fungicides applied to grain legume crops can negatively affect soil macro-invertebrates. Earthworms are highly susceptible to neonicotinoid insecticides that are currently widely used in arable crop rotations in the EU (Chagnon et al, 2015), and residues are likely to be present in the soil even though their use is currently banned on legume crops. Earthworms are also affected by other insecticides and fungicides through both sublethal and lethal effects (Jänsch et al, 2006; Tu et al, 2011).

Box 4-2 Evidence of impacts of nitrogen-fixing crops on soil invertebrates

Alfalfa (*Medicago sativa*)

Alfalfa leys in an experiment in Sweden had higher mean population densities and biomass of above ground arthropods than barley and grass ley plots, with a higher share of the biomass made up by detritivores/microvores compared to the herbivore and predator biomass (Curry, 1986).

Gallega (*Galega orientalis*)

An experiment in Finland (Epie, Cass and Stoddard, 2015) found more earthworm numbers and biomass (*Aporrectodea caliginosa*, *A. rosea*, *Lumbricus rubellus*, and *L. terrestris*) under plots of pure four year stands of the legume crop galega (*Galega orientalis*), compared to a mixture of galega and reed canary grass, pure stands of Reed Canary Grass (*Phalaris arundinacea*) and bare fallow, although the increase was statistically significant only in summer.

Clovers (*Trifolium spp*)

A UK experiment (Crotty et al, 2015) found higher earthworm abundance and biomass under four year plots of

White Clover (*Trifolium repens*) than under plots of Ryegrass (*Lolium perenne*) or Chicory (*Chicorium intybus*), especially the anecic species. Nematode fungal feeders and detritivorous Collembola (Poduromorpha) dominated under the Red Clover (*Trifolium pratense*) and White Clover and Chicory, whilst nematode herbivores and herbivorous Collembola (Symphypleona) dominated under the Ryegrass.

Invertebrate natural enemies of crop pests

Some legumes have a high structural complexity, with climbing and creeping growth forms, compared to cereal crops, which may make them more attractive to canopy-dwelling invertebrate predators such as spiders. Faba bean and vetches (*Vicia* species) offer extra-floral nectaries on the underside of the stipules, which are accessed by invertebrate natural enemies of pests, such as parasitoid wasps, ants, and bugs. There appears to be little evidence of actual impacts, but two studies showed that uncut alfalfa provides good habitat for weed seed predating Carabid beetles (Meiss et al, 2010a) and for spiders (Samu, 2003), but did not show whether this increased their abundance in the main crops (Box 4-3). Farmers planting alfalfa on EFAs are allowed to cut it more regularly than this in most Member States, although in Spain it cannot be cut until it has started to flower. Furthermore in some cases, eg where farmers lack livestock, they might not cut the alfalfa for fodder but instead treating it as a green manure crop and therefore not cut it until the end of the EFA period.

If nitrogen-fixing crops are not treated with insecticide, they have the potential to build-up invertebrate predator densities and carry over natural enemy populations into the subsequent arable crop, providing enhanced natural biological control. However, the potential benefits of grain legumes for natural enemies of crop pests is likely to be limited by conventional farming practices including pesticide and fertiliser use (Kovács-Hostyánszki, Batáry and Báldi, 2011). A comparative study in England (UK) (Holland et al, 2012b) found a lower total biomass of invertebrates in commercial faba bean and pea crops than in cereal crops, indicating that despite the variety of insects that feed on legumes, a high level of insecticide use is suppressing invertebrate abundance.

Box 4-3 Evidence of impacts of nitrogen-fixing crops on invertebrate predators of pests

Alfalfa (*Medicago sativa*)

Uncut alfalfa provides good foraging habitat for seed-eating Carabid beetles compared to cut alfalfa and grass and bare soil (Meiss et al, 2010a), as shown by a French experiment using seeds of three common annual weed species (*Alopecurus myosuroides*, *Sinapis arvensis* and *Viola arvensis*). An experiment (Samu, 2003) in Hungary found that unmown strips of alfalfa had an average of over one and a half as many spiders than continuously-cut alfalfa plots over three years. It is likely that spiders are attracted to the unmown strips from the mown strips and also from other habitats. However, the presence of unmown strips did not increase spider abundance in the cut strips in between. Five spider species made up over three quarters of all spider numbers in both cut and uncut Alfalfa, but spider species diversity was greater in the unmown strips.

Butterflies & moths (Lepidoptera)

Little direct evidence was found of the use of nitrogen-fixing crops by butterflies and moths. As indicated in Box 4-4, some species use legumes as their larval host plants, and can reproduce if alfalfa or clover is managed extensively with delayed mowing and low inputs (Loos et al, 2014; Manil and Chague, 2014). This is, however, unlikely to be the case on most EFAs.

Adult butterflies will collect nectar on flowering legume crops when they are available, and for some species, adult foraging can have an impact on population size by increasing female egg productivity and male fecundity (Settele et al, 2009). However, butterflies are negatively affected by neonicotinoid insecticide use (Gillburn et al, 2015) and may be affected by insecticide residues in the legume flowers and weeds originating from previous treated crops. Although neonicotinoids are currently banned on legume crops, they are still widely used as seed treatments on winter cereals which may precede the EFA crop. Experimental evidence has shown that traces of neonicotinoid insecticides and various fungicides are present in the pollen of oilseed rape and of weeds growing in the field margins of treated crop fields (Botías et al, 2015; David et al, 2016). Such levels of these insecticides have been shown to have detrimental impacts on some bees (see below), and may also affect butterflies (Gillburn et al, 2015).

Box 4-4 Evidence of impacts of nitrogen-fixing crops on Lepidoptera

Alfalfa (*Medicago sativa*)

An experiment on alfalfa in France (Manil and Chague, 2014) found that delayed mowing of alternate bands of Alfalfa forage fields was significantly favourable to butterfly species richness (31 species, compared with 15 in and on the edge of cereal fields) and abundance (53 ± 6 butterflies per 10 minutes of counting in the non-mown strip, against 15 ± 2 on the edge of mowed alfalfa crops and 6 ± 1 on the edge of cereal fields). The study did not measure larvae of Common Blue (*Polyommatus icarus*) and Clouded Yellow butterfly (*Colias croceus*) on alfalfa but assumed that the delayed mowing would provide better conditions for reproduction of these species that use alfalfa as a host plant. In traditionally managed diverse low-input farming landscapes in Transylvania, Romania (Loos et al, 2014), many butterflies were found to use the abundant alfalfa forage crops for nectar, and several butterfly species were using it as a larval host plant (e.g. Green-undersided Blue *Glaucopsyche alexis*).

Pollinators – bumblebees, solitary bees, hoverflies

Nitrogen-fixing crops on EFAs increase the presence of mass-flowering crops on arable farmland at the landscape scale, which can influence the highly mobile flower visiting insects including bumblebees (Box 4-5). The commoner bumblebee species are influenced by landscape wide effects because they will range up to 5 km around the nest if there is insufficient food available nearby (Greenleaf et al, 2007; Osborne et al, 2008). Honeybees are also highly attracted to mass-flowering crops (Montero-Castaño, Ortiz-Sánchez and Vilà, 2016; Rollin et al, 2013), but are not further considered in this literature review as they are not wild species.

Solitary bees as a group are less likely to respond to mass-flowering crops than bumblebees, as they have shorter foraging ranges and tend to have more specialist flower preferences for various plant groups (Rollin et al, 2013), whilst legume species are the major pollen source for bumblebee species (Goulson et al, 2005). The majority of solitary bees forage within a few hundred metres of their nest site, although some individuals of the larger species are capable of foraging up to 1.5km from the nest (Zurbuchen et al, 2010). This make them more dependent on local conditions and less sensitive to landscape-scale crop composition (Gathmann and Tschardt, 2002; Holzschuh et al, 2011). Solitary bees are dependent on the presence of undisturbed patches of semi-natural vegetation in which to nest and on the constant presence of flowers offering nectar and pollen within their foraging range, and are therefore unlikely to benefit significantly from nitrogen-fixing crops

on EFAs (except multi-year alfalfa). For example, one study in Germany found no effect of oilseed rape crops on solitary bee richness and abundance in the field margins (Kovács-Hostyánszki et al, 2013).

Faba bean and field pea have flowers that are only effectively pollinated by bumblebees. These crops therefore act as a strong filter on flower-visiting insects by providing bumblebees with a food resource that is relatively free from flower visiting competitors. However, bumblebees and the larger solitary bees often cut holes in the flower base, providing access for short-tongued bees and other nectar seeking insects, so faba bean is visited by a more diverse range of flower-visiting insects if these large bees are already present (Tasei, 1976, cited by (Garratt et al, 2014). Some soyabean cultivars have been bred to self-pollinate, with flowers offering little nectar and a large proportion of flowers that do not open for flower visiting insects at all, but cultivated soybean cultivars have significant differences in flower attraction and reward traits and some are heavily visited by bees (Milfont et al, 2013; Suso et al, 2016).

A number of studies indicate the attractiveness of faba beans to foraging bumblebees during the 3-4 weeks in which they are flowering on EFAs, but there is little evidence that the crops are contributing to population growth. After the crop harvest, the survival of bumblebee colonies depends on the availability of weeds in and around crops, flowering plants in field margins and hedges, and the presence of semi-natural grassland or scrub and woodland patches. Consequently, bumblebees have been observed to decline sharply in simplified landscapes after late July if the availability of herbaceous flowers is low (Persson and Smith, 2013). Mass-flowering crops provide a significant boost to bumblebee nests that have survived up until they flower in May and June, but in an intensive arable landscape with few non-cropped areas many colonies will not survive until then. Mass-flowering crops may therefore be temporarily attracting large numbers of workers from a small number of nests (Herrmann et al, 2007), which does not result in population growth in the next year. Even when colonies produce more bumblebee workers as a result of the crops, this does not necessarily result in an increase in the number of queens at the end of the season, which is a determining factor for colony number in the following year (Westphal, Steffan-Dewenter and Tschardt, 2009).

Forage legume species show a greater variability in flowering time than grain legume crops. They may therefore have a more lasting beneficial effect on wild bee populations than grain legumes, particularly if grown for a whole year or longer and allowed to flower regularly (Kovács-Hostyánszki et al, 2016), although this is unlikely to be the case on most EFAs. There is some evidence that late season red clover fields have a population level effect on bumblebees (Rundlöf et al, 2014), by increasing queen production. Forage legumes may also promote small mammal populations, which provide nesting sites in their burrows for ground-nesting bumblebees (e.g. *Bombus terrestris*).

Nitrogen-fixing crops in conventionally managed arable crop rotations can contain traces of systemic pesticides, such as neonicotinoid insecticides, that were applied to the preceding winter crop and that the plants have taken up from residues in the soil. Neonicotinoids have been shown to have sublethal effects on bumblebees at concentrations similar to those found in the study (Whitehorn et al, 2012), and also have sublethal effects on solitary bees

(Sandrock et al, 2014). It is not yet possible to say whether EFA requirements will have any influence on this pressure on bee populations, other than that forage legumes do probably represent a summer break in the application of most systemic insecticides and fungicides on most arable farms.

Box 4-5 Evidence of impacts of nitrogen-fixing crops on pollinators

Faba bean (*Vicia faba*)

A study of faba bean in the UK (Garratt et al, 2014) found the vast majority of flower visits (including raids) were by six species/species groups of bumblebee, representing the most common species. The flowers were also visited by a large number of non-syrphid flies, as well as hoverflies (syrphids), butterflies, beetles and sawflies. Another UK study of bumblebees foraging along field margins of faba bean crops (Hanley et al, 2011) found that although no single bumblebee species showed any consistent change in relative frequency in response to the presence of the crop, when taken across all years and bumblebee species combined, twice as many bumblebees were visiting flowers adjacent to the faba bean compared to other arable margins. However, two weeks after bean flowering, the bumblebee activity along hedgerows was no different between crops. There therefore seemed to be no long lived effect on bumblebee populations.

A study in Sweden (Andersson et al, 2014) found a higher pollination rate of faba bean on organic farms compared to conventional farms, and that pollination on organic farms increased the more semi-natural habitat there was in the landscape, indicating that bumblebee abundance was higher where there was more of these habitats. In contrast, on conventionally managed farms with fertiliser and pesticide use, the pollination was unaffected by either semi-natural habitat in the landscape or leys on the farm, indicating that bumblebee abundance on faba bean on these farms was constrained by other factors. A UK study of insects visiting faba bean (Carré et al, 2009) found that the abundance and diversity of wild bees in the crop (which were almost all bumblebees) increased in landscapes with a greater abundance of transitional woodland-shrub habitats. The area of these patches was correlated with wild bee abundance and their perimeter:area ratio was correlated with sub-generic diversity. Another UK study of bumblebees visiting faba bean (Nayak et al, 2015) found that foraging bumblebees were more abundant on the crop the more semi-natural habitat cover and flower abundance there was within the surrounding 2 km.

A UK study observed an increase in colony density of the long-tongued bumblebee *Bombus pascuorum* in the locality of faba bean crops within a 1km radius, as well as a significant effect of oilseed rape fields and non-cropped semi-natural habitat areas, in late July (Knight et al, 2009). Another UK study (Goulson et al, 2010) found very little correlation between mass flowering crops (oilseed rape and faba beans) and the nest density and nest survivorship of two bumblebee species (*Bombus lapidarius* and *Bombus pascuorum*), but did find a significant positive correlation with the area of urban gardens and grassland. Interestingly, one site (which was excluded from the statistical analysis) appeared to have approximately four times as many *B. lapidarius* nests in both early and late season samples, and approximately five times as many *B. pascuorum* in late samples, compared to the other sites, almost certainly because of a ~5-ha clover ley adjacent to this site.

Sulla (*Hedysarum coronarium*)

A study on the Mediterranean legume crop sulla (*Hedysarum coronarium*) on Menorca, Spain, found 9 wild bee species visiting sulla compared to 19 species on wild flowers in adjacent semi-natural scrubland patches (Montero-Castaño, Ortiz-Sánchez and Vilà, 2016). The single bumblebee species, *Bombus terrestris*, and one of the solitary bee species *Eucera numida*, were found only on the sulla and not in the scrubland, whilst seven species were present on both. Wild bee abundance was not significantly different in the crop versus the scrubland.

Alfalfa (*Medicago sativa*)

A study in traditionally managed diverse farming landscapes in Transylvania, Romania (Kovács-Hostyánszki et al, 2016), found that on arable land alfalfa provided a high density of flowers, which were well utilised by bumblebees (especially *Bombus terrestris*) and some oligolectic wild bee species such as *Andrena labialis*, *Eucera nigrescens*, *Melitta leporine*. Hoverflies showed high abundance in alfalfa and fallows. The alfalfa is managed for forage with very low inputs. Very little of the arable farmland in this region is subject to the EFA requirements due to the small farm size.

Red Clover (*Trifolium pratense*)

A Swedish study (Rundlöf et al, 2014) found higher bumblebee queen densities of six *Bombus* species in established late-season red clover fields than in linear field borders in the surrounding landscapes.

Common farmland birds

Nitrogen-fixing crops contribute to increasing crop diversity at the landscape scale. It might therefore be expected that this benefits common farmland birds, as increases in crop diversity can increase breeding and feeding opportunities for some species (Benton, Vickery and Wilson, 2003), such as observed for nesting Skylarks (Chamberlain, Vickery and Gough, 2000; Miguet, Gaucherel and Bretagnolle, 2013; Wilson et al, 1997). However, the structure of each crop and timing of their establishment is also important, so increasing crop diversity is not necessarily beneficial, as found by Chamberlain et al (1999) for Skylarks.

Currently there appears to be no direct evidence of possible crop diversity related benefits and little evidence of other possible impacts of nitrogen-fixing crops on common farmland birds (Box 4-6). One study found that Skylarks achieve high reproductive success in a multi-year alfalfa crop if it is not mown more than twice a year, thereby retaining a suitable height for breeding throughout the year (Kuiper et al, 2015). However, alfalfa on EFAs may be cut more frequently than this, so breeding success rates would be expected to be low in such circumstances. Reproductive success of ground nesting birds is also expected to be low for conventionally managed grain legumes, as observed for Yellow Wagtail (Gilroy et al, 2011). Furthermore, one study found that invertebrate food resources required by chicks are less abundant on conventionally managed grain legume crops than on cereal crops (Holland et al, 2012b).

Box 4-6 Evidence of impacts of nitrogen-fixing crops on common farmland birds**Faba bean (*Vicia faba*)**

A study in southern Poland found no particular effect on the farmland bird community of the loss of clover and faba bean crops from farming systems (Kopij, 2008). A UK study found that Yellow Wagtail (*Motacilla flava*) nested in faba bean crops but had a high nest failure rate from predation, compared to nests in cereal fields (Gilroy et al, 2011; Kirby et al, 2012). A UK study compared the availability of bird chick food invertebrates in different conventionally managed crops and found that numbers were lower on peas and beans than in the winter and spring cereals, and estimated biomass was also lower (Holland et al, 2012b).

Alfalfa (*Medicago sativa*)

A study of Skylark breeding success in crops in the Netherlands (Kuiper et al, 2015) found that the highest reproductive success was achieved in alfalfa compared to grassland and cereal crops. Nestling weight was significantly higher in alfalfa and grassland compared to cereals, but survival was low in grassland due to frequent silage cutting, whereas the alfalfa was mown twice a year and retained a suitable height for breeding throughout the year.

Species that are the focus of the Birds and Habitats Directives

The evidence regarding nitrogen-fixing crops and species that are the focus of the Birds or Habitats Directives refers only to alfalfa crops grown as green manure and fodder (Box 4-7). Multi-year alfalfa crops are good quality habitats for small mammals, such as Common Voles (*Microtus arvalis*), owing to their long-term stability and suitability for vole colony formation (as they remain unploughed for 5–6 years) and hold high densities even if regularly cut (Jareño et al, 2015; Rodríguez-Pastor et al, 2016). These are key prey items for birds of prey

on the Birds Directive Annex II such as Montagu's Harrier, Hen Harrier and Black-winged Kite.

Alfalfa also provides important habitats for the Little Bustard (Badenhausser et al, 2008; Bretagnolle et al, 2011a; Bretagnolle et al, 2011b; Lapiedra et al, 2011; Silva, Faria and Catry, 2007) and Great Bustard (Martín et al, 2012). However, whilst the introduction of irrigated crops has increased land cover diversity it has reduced overall landscape suitability for Little Bustard in southern Portugal (Moreira et al, 2012). Alfalfa crops are also an important feeding habitat for European Hamster (*Cricetus cricetus*) in intensively managed arable farmland (Albert, Reiners and Encarnação, 2011; O'Brien, 2015). However, the low intensity management necessary to realise these benefits (with infrequent cutting, long cropping periods and little other disturbance) is not likely to occur on most EFAs. As mentioned above for other farmland birds, if these crops are cut during the breeding season then they can become ecological traps, leading to nest destruction and very high levels of egg and chick mortality.

Box 4-7 Evidence of impacts of alfalfa on species in the Birds and Habitats Directives

Alfalfa

Ortolan Bunting (*Emberiza hortulana*)

The occurrence of the Ortolan Bunting in Italy is linked to the presence of alfalfa crops and bare soil (Morelli, 2012).

Little Bustard (*Tetrax tetrax*)

A study of Little Bustard in southern France found that the provision of five year alfalfa crops in cereal rotations with no mowing between mid-May and end July has led to a sharp increase in female productivity (Bretagnolle et al, 2011b). Differences in grasshopper availability appear to be critical to productivity, as estimated by the number of fledglings counted in post-nuptial groups, but alfalfa crops had rather low grasshopper densities (about 0.8 individuals per m²) compared to other temporary grasslands (about 3.1 individuals per m²) (Bretagnolle et al, 2011a). Alfalfa crops that were not cut or treated with herbicide or insecticide between May and August had higher densities of immatures (0.07 to 17.4 m⁻²) and adults (0 to 5.66 m⁻²) than alfalfa treated with pesticides and cut in July (Badenhausser et al, 2008). A study of female Little Bustards on the cereal pseudo-steppe of the Spanish Lleida plains (Lapiedra et al, 2011) found that unharvested alfalfa crops were preferred foraging habitats for sedentary females after the main cereal harvest, but wandering females predominantly shifted to field margins and bare fallows. However, females were mainly breeding in cereal fields, and the Lleida plain population's breeding success is similar to the lowest estimations for the endangered population in France and is not enough to guarantee the long term viability of the population.

Great Bustard (*Otis tarda*)

Alfalfa crops are very important foraging and nesting crops for Great Bustard (Magaña et al, 2010; Nagy, 2010), such that it has been estimated that in Spain it should represent at least 8% of the breeding area in order to provide ideal habitat for the species (Alonso and Alonso, 1990). Consequently, declines in the species were considered to be due in part to reductions in the area of alfalfa and other pulses, resulting in LIFE programme project to reverse this trend (Rosell and Viladomiu, 2005). Increases in Great Bustard numbers in Castilla y León province in central Spain were also found to be positively correlated with increases in the extent of unirrigated alfalfa and vetch crops grown with no cutting, fertilizer or pesticide use between May and August (Martín et al, 2012).

Birds of prey such as Montagu's Harrier (*Circus pygargus*), Hen Harrier (*Circus cyaneus*) and Black-winged Kite (*Elanus caeruleus*)

In Spain (Rodríguez-Pastor et al, 2016), irrigated (and some unirrigated) multiannual (at least 5 year) Alfalfa crops contained higher densities of small mammals than cereal crops. Though alfalfa crops are cut at least four times during the summer, they provide a stable habitat for burrowing colonies and enough protective cover

against avian predators, and were the habitat with the highest percentage of green vegetation cover (80-90%) from spring to autumn, providing mammals with year-round protein-rich green food. However, field margins were the most stable habitat, with small mammal densities about 2.3 times higher on average than within fields (and 8-9 times higher than in cereal fields in spring and autumn when soils are tilled and bare), and provide a key refuge in winter and spring. These small mammals are key prey items for birds of prey that use arable farmland for hunting in Spain, such as Montagu's Harrier, Hen Harrier and Black-winged Kite.

Montagu's Harriers also forage over alfalfa sown on fallow fields in the Netherlands intensively (Schlaich et al, 2015), preferring mown to unmown strips, as voles were more easily caught on the mown strips. Vole abundance was at least five times higher on the fallow fields, which were sown half with alfalfa and half with a cereal-grass-flower seed mix designed to benefit small mammals, than in other arable crops.

Hamster (*Cricetus cricetus*)

The European Hamster is closely associated with arable farmland on deep well-drained soils such as loess soils. Hamsters are therefore typical inhabitants of highly arable farmland areas. Their distribution in France (O'Brien, 2015) and Germany (Albert, Reiners and Encarnaç o, 2011) has been found to be related to the cultivation of alfalfa in cereal rotations. However, a German study found that hamsters were much more abundant on wild-flower sown fallow than any other habitat type within arable farmland (Fischer and Wagner, 2016). The fallow was sown with a diverse flower-rich seed mix and then left undisturbed for five years.

Table 4-1 Summary of evidence of biodiversity impacts of nitrogen-fixing crops compared to typical arable farmland

Biodiversity component	Crop type: alfalfa (<i>Medicago sativa</i>) and clovers (<i>Trifolium spp</i>)
Wild native plants	Weed diversity is significantly lower in conventionally managed alfalfa (with frequent cutting, herbicide and insecticide application) than in extensively managed alfalfa (without inputs or cutting between May and August). Multi-annual forage alfalfa shifts weed composition to broad-leaved perennials, which could benefit flower-visiting insects.
Soil macro-organisms	There is evidence that soil macro-invertebrates are more abundant under forage/green manure legume crops than non-legume crops. Multi-annual forage alfalfa and clover crops without tillage or herbicide applications have higher densities of earthworms and detritivore invertebrates (eg detritivore Collembola), than non-legume forage crops.
Invertebrate natural enemies of crop pests	Delayed mowing of parts of alfalfa crop benefits spiders and seed-eating carabid beetles.
Butterflies & moths	Delayed mowing of parts of alfalfa crop benefits foraging butterflies. It may also benefit some butterfly species that use alfalfa as larval host plant (although no specific evidence was found).
Pollinators – wild bees	There is evidence that late season red clover increased the population of a bumblebee species in the following year. Forage alfalfa grown in small-scale low-input farming systems has abundant bumblebees and also some less specialised solitary bees. It would provide a key resource if allowed to flower for several months in spring or in late summer (but no specific evidence was found). However, forage alfalfa is generally cut before it comes into full flower, limiting its foraging value for bumblebees, although it will still be more valuable than non-flowering cereal crops (no specific evidence found). Nitrogen-fixing crops are unlikely to provide significant benefits for solitary bees as few species forage heavily on legumes and crops do not provide nesting opportunities.
Common farmland birds	Uncertain impacts. Although Skylark have been found to achieve high reproductive success in alfalfa if it is not mown more than twice a year, this infrequent mowing is unlikely to be common practice. Evidence of impacts of other forage legumes and grain legumes is lacking but nesting success is likely to be low.
Species focus of the Birds	Alfalfa is an important nesting and feeding habitat for Little Bustard and Great

and Habitats Directives	Bustard, if harvesting is delayed until chicks fledge, and no pesticides are used as is often the case in extensive cereal systems. Alfalfa also provides stable habitat for small seed-eating mammals, which are a key prey item for many birds of prey, several of which are target species of the Birds Directive. Alfalfa provides suitable habitat for European Hamster if it remains unharvested during the summer. However, the management necessary to realise these benefits is not likely to occur on most EFAs.
External impacts outside farmland ecosystems	Legumes used as a green manure can increase soil organic matter and fertility and prevent soil erosion and nitrate losses and associated negative effects on aquatic biodiversity. Increased soil nitrogen content can also reduce need for nitrogen fertiliser in subsequent crops. However, soil nitrogen fixed by legumes can be rapidly leached away after harvest by tillage and rainfall, increasing rather than decreasing nitrate losses.
Crop type: faba bean (<i>Vicia faba</i>) and field pea (<i>Pisum sativum</i>)	
Wild native plants	Weed diversity within conventionally managed grain legume crops with herbicide use and/or tillage is similar to other spring crops. Organically managed grain legumes generally have higher weed density and diversity than other spring crops or conventionally managed grain legumes. Zero tillage in a pea-containing crop rotation led to a weed community shift but biodiversity value is unclear.
Soil macro-organisms	Legumes may stimulate microbial activity and attract more soil macro-invertebrates because of the greater input of nitrogen rich residues into the soil, but no evidence was found of the impact of single season grain legume crops on soil macro-organisms.
Invertebrate natural enemies of crop pests	No evidence found. Extra-floral nectaries may attract some invertebrate predators into crop but insecticide use likely to have detrimental effects.
Butterflies & moths	No evidence found. Insecticide use likely to have detrimental effects.
Pollinators – wild bees & hoverflies	Foraging bumblebees are abundant on flowering beans and peas, but there is little evidence that this translates into a population level effect. Faba bean flowers are visited by hoverflies, non-syrphid flies, butterflies, beetles and sawflies but there is no evidence of population level effects. Small bees and non-bee species benefit from bumblebee flower raids, which create access holes to flower calyx. However, nitrogen-fixing crops are unlikely to provide significant benefits for solitary bees as few species forage heavily on legumes and crops do not provide nesting opportunities. Insecticide use likely to have detrimental effects.
Common farmland birds	No specific evidence was found. Loss of faba bean and clover crops from the farming landscape did not particularly affect farmland birds. Yellow wagtail suffers high nest predation in faba bean crops.
Species focus of the Birds and Habitats Directives	No specific evidence was found.
External impacts outside farmland ecosystems	Faba bean and field pea do not require nitrogen fertiliser and so can lower fertiliser use and associated energy use in the crop rotation if farmer follows recommendations (though it is likely that some farmers are applying fertiliser to bean and pea crops in order to guarantee a good yield). These crops do not contribute much soil nitrogen to the subsequent crop as much of the plant's fixed nitrogen is harvested in the grain, so are unlikely to result in significantly reduced fertiliser use in the crop rotation.

4.3 Catch and cover crops

4.3.1 Evidence of biodiversity impacts of EFA type and management

Wild native plants

Catch and cover crops are generally selected because of their capacity for vigorous and rapid growth of a vegetation canopy, thereby competing with and suppressing weed biomass and reducing weed flower and seed production. On EFAs, catch and cover crops only qualify for the payment if they establish a sufficiently dense crop cover. They are therefore generally not expected to increase wild plant diversity or abundance in cropping systems. There is some evidence from a study that weeds in forage legume cover crops were less abundant than fallow in an organic system (see Box 4-8). However, this is not directly applicable to EFAs.

Box 4-8 Evidence of the impacts of catch/cover crops on wild plant diversity

Legume cover crops

An experiment in Greece compared Vetch (*Vicia sativa*) and Red Clover (*Trifolium pratense*) winter cover crops with winter fallow following wheat under organic management (Bilalis, Karkanis and Efthimiadou, 2009). The legumes contained lower weed density and biomass than the fallow, with the vetch significantly lower than Red Clover. The cover crops were not fertilised. The vetch developed a rapid vegetation cover, inhibiting the growth of most autumn-germinating weeds, whilst the Red Clover was slow to establish and was therefore a poorer weed competitor.

Soil macro-organisms

Catch and cover crops that are incorporated into the soil are expected to contribute to increased soil organic matter, which is a driver of soil macrofauna abundance. Legume cover crops provide high quality plant residues and root biomass for decomposers such as surface-feeding earthworms (Eisenhauer et al, 2009). Even if catch crops are harvested and removed from the field, they may have a beneficial effect on soil macrofauna by reducing soil erosion and retaining soil moisture over the summer period.

Invertebrate natural enemies of pests

No specific evidence was found, but these crops are unlikely to provide abundant prey or hosts as they are only present in the field for a short period or only overwinter, and do not flower. They do not provide any year-round refuge or overwintering habitat. They do however provide a more hospitable environment than bare soil. If summer catch crops are allowed to flower they can provide prey or host and/or nectar or pollen resources that may carry over larger predator populations into the next crop or help to maintain populations throughout the season, compared to bare fallow¹⁰⁵.

Butterflies & moths (Lepidoptera)

Some common cover crops in the Brassica family (mustards, charlock, radish etc) are larval food crops for pierid butterflies (Pieridae), but these are the most common and ubiquitous species and generally regarded as crop pests, and so are not considered to be of conservation importance. Adult butterflies of generalist mobile species will visit some summer flowering catch crops for nectar, if they are allowed to flower profusely and if they contain a mix of plant species, which might increase the egg laying rate of some species (Settele et al, 2009). Because catch and cover crops generally reduce weed abundance and

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<http://ipm.uconn.edu/documents/raw2/Use%20of%20Cover%20Crops%20and%20Green%20Manures%20to%20Attract%20Beneficial%20Insects/Use%20of%20Cover%20Crops%20and%20Green%20Manures%20to%20Attract%20Beneficial%20Insects.php?display=print>

diversity, they are likely to have an overall negative effect on Lepidoptera. However, no direct evidence was found to substantiate this.

Pollinators – bumblebees, solitary bees, hoverflies and other taxa

Winter cover crops are not expected to have any direct impact on pollinators as they rely on semi-natural habitats for the winter period¹⁰⁶. There is some evidence that overwinter stubbles provide early-season resources from flowering weeds (Evans, Armstrong-Brown and Grice, 2002), and replacing them with winter cover crops could worsen the situation for pollinators, if flowering weeds are less available.

The benefits of summer catch crops to pollinators will depend greatly on the length of time the crop flowers and the type of flower (see nitrogen-fixing crops for the evidence on green manure legumes). One study found that summer clover-grass leys had fewer nesting solitary bees than fallow with naturally regenerated vegetation (Gathmann, Greiler and Tschardtke, 1994). Brassica species such as mustard or radish are attractive to a wide range of flower visiting bees, hoverflies and non-syrphid flies (Wood, Holland and Goulson, 2016a), and certain flowers such as Phacelia are very nectar-rich and attract high abundances of flower visiting insects. There is no evidence that this has an impact on the population level as it may simply temporarily draw foraging individuals away from other habitats (see nitrogen-fixing crops section for more discussion).

Box 4-9 Evidence of the impacts of catch/cover crops on pollinators

A review of UK agri-environment options found that overwinter stubbles benefited bumblebees and sawflies (Symphyta), especially when followed by spring fallow, but the study did not compare stubbles with winter cover crops (Evans, Armstrong-Brown and Grice, 2002). In a German study, clover-grass leys had only half as many nesting solitary bee species as fallow fields with naturally regenerated vegetation (Gathmann, Greiler and Tschardtke, 1994).

Common farmland birds

Catch and cover crops are unlikely to provide good foraging habitats for seed-eating farmland birds given their typically low weed densities, and they are normally cut before setting seed. They are probably therefore generally detrimental if they replace stubbles which are richer in seeds, as for example found in a study in Poland (Golawski et al, 2013). But this impact is difficult to quantify as stubbles of conventionally managed arable crops now provide limited seed reservoirs due to the reduction of weeds through tillage and herbicide use, and stubbles are frequently ploughed soon after harvest. Significant benefits for seed-eating birds could therefore arise if winter cover crops comprise seed-bearing species that are favoured by farmland birds and are allowed to set seed, but this is unlikely to be common practice on EFAs (see Chapter 3).

As catch and cover crops are likely to increase soil invertebrates, this may provide increased food resources for some birds especially immediately after the crop is ploughed in. Some catch crops may provide suitable breeding habitat for some birds and those that hold high densities of invertebrates (e.g. mustard, radish, Phacelia) may provide good foraging habitats. However, no evidence was found on any of these potential biodiversity benefits.

¹⁰⁶ Crops must remain until March in Romania, but due to the continental climate it is unlikely that bees will emerge from hibernation or legumes such as clover flower before the end of March.

Box 4-10 Evidence of impacts of cover/catch crops on farmland birds compared to winter stubbles and fallow

A Europe-wide study at the landscape scale (Geiger et al, 2010) observed more farmland birds foraging in winter in landscapes with higher proportions of green manure cover crops, overwinter stubble, and pasture, but did not differentiate between these crop types. A study in low-intensity arable farmland in Poland (Golawski et al, 2013) compared winter foraging birds on winter catch crops of mustard, on cereal stubbles and on bare soil. The study recorded 28 species, of which the most numerous were Yellowhammer (*Emberiza citronella*), Corn Bunting (*Emberiza calandra*), Tree Sparrow (*Passer montanus*) and Shorelark (*Eremophila alpestris*). The stubbles supported a relatively greater density of birds than the mustard winter catch crop and ploughed fields. The study concluded that increasing the area of winter catch crops instead of leaving fields bare and ploughed may favour birds, but when winter crops are sown in fields that would otherwise be left as stubble, wintering conditions for birds deteriorate, especially for buntings (see review of fallow in the next section). A study of winter foraging birds in England (Stoate, Szczur and Aebischer, 2003) found that birds were most abundant on wild bird cover crops compared to other crops on the farm (but did not compare overwinter cereal stubbles or fallow). The bird cover sown with kale (*Brassica napus*) and quinoa (*Chenopodium quinoa*) was used by Redpoll, Tree Sparrow, Reed Bunting, Song Thrush, and Linnet, whilst Yellowhammer and Goldfinch mainly used the cereals and linseed mix. Farmers in the Netherlands are being encouraged to plant Black Oat (*Avena strigosa*) as a cover crop because of its value as winter feeding habitat for granivorous birds¹⁰⁷. However, flax (*Linum usitatissimum*), which is being promoted as a catch crop in some regions, was not preferred by Skylarks and Yellowhammers for establishing territories relative to autumn-sown crops on lowland farmland in Northern France (Tolhurst et al, 2014).

Species that are the focus of the Birds and Habitats Directives

Little evidence of the possible impacts on species that are the focus of the Birds and Habitats Directives was found (see Box 4-11). However, it is likely that, as for common farmland birds, losses of cereal stubbles to autumn sown cover crops would reduce food resources for some species, such as the Little Bustard (Faria and Silva, 2010). Such losses of stubbles could also have negative impacts on some plant weeds. On the other hand cover crops could provide additional plant foliage food resources in the autumn compared to bare soil.

Box 4-11 Evidence of impacts of catch/cover crops on species that are the focus of the Birds and Habitats Directives

Little Bustard

A study in southern Portugal found that Little Bustard preferred cereal stubbles and vegetated fallow lands over crops and ploughed lands during the autumn, which were characterized by the growth of fresh green weeds (Faria and Silva, 2010). However, the study also found that fallow has decreased in area and most cereal stubbles were being ploughed in rather than left.

European Hamster

A project in France is testing the use of spring legume mixes undersown in winter wheat on the European Hamster population (LIFE Alister project, 2016), but no results are available yet.

Rare arable weeds

Ploughing of cereal stubbles directly after harvest is a threat to the rare EU protected arable weed *Notothylas orbicularis* (IUCN, 2015).

¹⁰⁷ Coelembier, D., Clarysse, K., Depoortere, M. (2015) Leaflet: Japanse haver goed voor bodem en vogel. Ijzer & Polder Regionaal Landschap, West-Vlaamse Heuvels Regionaal Landschap, VLM.

Table 4-2 Summary of evidence of biodiversity impacts of catch and cover crops compared to typical arable farmland

Biodiversity component	Crop type: mustard / radish
Wild native plants	Catch and cover crops are not expected to increase wild plant diversity or abundance in cropping systems as they are grown for their vigorous plant cover that suppresses weeds.
Soil macro-organisms	Catch and cover crops that are incorporated into the soil increase soil organic matter, which is a driver of soil macrofauna abundance. However, these benefits may be counteracted by tillage and herbicide applications for crop establishment and/or destruction, which have significant negative effects on soil macrofauna.
Invertebrate natural enemies of crop pests	Not expected to provide much prey or host abundance due to short or winter cropping period and no flowers, but if summer catch crops are allowed to flower they can provide some prey/host and/or nectar/pollen resources to carry over predators into next crop or into hibernation compared to bare soil. Do not provide refuge or overwintering habitat.
Butterflies & moths	Lower weed diversity & abundance in summer catch crops compared to fallow is expected to have overall negative effect, whilst winter cover crops are not expected to have an impact as they are available at a time when very few species are active.
Pollinators – wild bees & hoverflies	Winter cover crops are not expected to have any direct impact on pollinators as they rely on semi-natural habitats for the winter period, but crops that remain until March could provide flowering resources to early emerging queen bees. There is some evidence that overwinter stubbles provide early-season resources, and replacing them with winter cover crops could improve or worsen the situation for pollinators, depending on the relative value of the flowering resource provided by crop and/or weeds.
Common farmland birds	If winter cover crops replace winter cereal stubbles, seed-eating farmland birds are negatively affected. If the stubble would be quickly ploughed in for an autumn crop anyway the effect is neutral as the cover crop is partly replacing an autumn-sown cereal crop. Benefits would arise if bird seed mixes were used as winter cover crops as they provide a high quality food resource for foraging birds, but this is unlikely on EFAs as cover crops are normally cut before going to seed. Catch crop impacts on breeding birds are uncertain, but unlikely to be beneficial.
Species focus of the Birds and Habitats Directives	Only anecdotal evidence. Some catch/cover crops could provide autumn food resources but also could lead to reductions in food resources due to loss of summer cereal stubbles.
External impacts outside farmland ecosystems	Reduced soil erosion and nitrate leaching from the cropping surface into field margins and nearby water courses will benefit aquatic biodiversity. However, autumn harvest followed by tillage and bare soil could result in soil erosion which would lose the accumulated nitrate and mean these benefits are not realised. It is therefore good practice for the environment to immediately follow a nitrogen-fixing crop with a catch crop or a winter arable crop.
Crop type: green manure legumes	
Wild native plants	Some evidence, eg from Vetch and Red Clover winter cover crops under organic management (unfertilised), that weed density is significantly lower than bare fallow.
Soil macro-organisms	Legume residues provide good quality resources for decomposers eg for earthworms.
Invertebrate natural enemies of crop pests	Not expected to provide much prey or host abundance due to short or winter cropping period and no flowers, but if summer catch crops are allowed to flower they can provide some prey/host and/or nectar/pollen resources to carry over predators into next crop or into hibernation compared to bare soil. Do not provide refuge or overwintering habitat.
Butterflies & moths	Lower weed diversity & abundance in summer catch crops compared to fallow is expected to have overall negative effect, whilst winter cover crops are not expected to have an impact as they are available at a time when very few species are active.

	Extensively managed summer cover crops may provide larval habitat for a few species (see N-fixing crops).
Pollinators – wild bees	Summer clover-grass leys are expected to be less rich in nesting solitary bee species than bare fallow. Flowering legumes will attract large numbers of bumblebees but will only increase the population if available for a long or critical period (e.g. autumn).
Common farmland birds	If winter cover crops replace cereal stubbles, they will reduce food resources for seed-eating birds. Soil invertebrate feeding birds may benefit after cover crop is ploughed in, but there is no supporting evidence. Impacts of summer catch crops are uncertain.
Species focus of the Birds and Habitats Directives	Impacts on birds likely to be generally detrimental for the same reasons as for common farmland birds.
External impacts outside farmland ecosystems	Legume cover crop/green manure can increase soil organic matter and fertility and prevent soil erosion (see nitrogen-fixing crops literature). However, soil nitrogen fixed by legume cover crop/green manures can be rapidly leached away after harvest by tillage and rainfall, increasing rather than decreasing nitrate losses and associated negative effects on aquatic biodiversity (see nitrogen-fixing crops literature).
Crop type: grasses	
Wild native plants	Grass catch and cover crops are not expected to increase wild plant diversity or abundance in cropping systems as they are grown for their vigorous plant cover that suppresses weeds.
Soil macro-organisms	Catch and cover crops that are incorporated into the soil increase soil organic matter, which is a driver of soil macrofauna abundance. However, these benefits may be counteracted by tillage and herbicide applications for crop establishment and/or destruction, which have significant negative effects on soil macrofauna.
Invertebrate natural enemies of crop pests	Not expected to provide much prey or host abundance due to short or winter cropping period and no flowers, but can provide some prey/hosts (eg aphids) to carry over predators into next crop or into hibernation compared to bare soil. Do not provide refuge or overwintering habitat.
Butterflies & moths	Lower weed diversity & abundance will have overall negative effect.
Pollinators – wild bees	There is some evidence that overwinter stubbles provide early-season resources, and replacing them with winter cover grass could worsen the situation for pollinators.
Common farmland birds	Some cereals planted as part of seed mixes for birds in winter cover crops provide abundant food for granivorous farmland birds, eg <i>Avena strigosa</i> . Ryegrass summer catch crops or winter cover are unlikely to provide very valuable foraging habitat for farmland birds. If winter cover crops replace winter cereal stubbles, some seed-eating farmland birds are negatively affected.
Species focus of the Birds and Habitats Directives	No specific evidence found. Impacts on birds likely to be similar to common farmland birds.
External impacts outside farmland ecosystems	Reduced soil erosion and nitrate leaching from the cropping surface into field margins and nearby water courses will benefit aquatic biodiversity. However, poor timing of harvest and tillage could mean these benefits are not realised.

5 Biodiversity impacts of fallow, field margins and hedges

5.1 Introduction

The following section considers the biodiversity impacts of land lying fallow and the most commonly implemented EFA options for landscape features, namely field margins and hedges or wooded strips. EFA fallow must be maintained for around half a year, from January or March to a cut-off date at the end of June, July or August (depending on the country or region). As no data are available to allow an assessment of how much fallow was under each type of management in 2015 (see Chapter 3), and as temporary grassland is allowed on EFA fallow, the literature review considered four ways in which fallow can be managed:

- Bare (tilled) and natural regeneration of vegetation
- Crop stubbles with natural regeneration of vegetation
- Sown with plant mixes designed for environmental and biodiversity benefits
- Temporary grassland (sown before the EFA fallow period commences)

Field margins subject to cross-compliance must be retained through the year, but EFA field margins that are not protected by cross-compliance only have to be retained until the beginning of August.

5.2 Land lying fallow

5.2.1 Evidence of biodiversity impacts of EFA type and management

There is a large body of evidence of the biodiversity benefits of fallow land. However, most of it refers to land that is left fallow for a year or several years, whilst on EFAs Member State rules have defined that the fallow lasts only 5-8 months from the start of the year or from March. A meta-analysis of the impacts of fallow (as set-aside) concluded that land withdrawn from conventional production unequivocally enhances biodiversity of birds, insects, spiders and harvestmen, and plants in Europe (Van Buskirk and Willi, 2004). The study found that benefits are greatest on large parcels of land, and on older fallow for all taxa except bird species richness, which declined significantly with increasing age of fallow. A review in the UK found that farmland birds benefited from (unsprayed) one-year fallow (rotational set-aside) more than multi-year fallow, whilst mammals benefited mostly from multi-year fallow (Silcock and Lovegrove, 2007). A review of the impacts of long-term fallow (as set-aside) on biodiversity (Tscharrntke, Batáry and Dormann, 2011) concluded that the impact is highest in simple landscapes, where improvements have the highest relative effect and are influenced by sowing patterns and age of succession, whereas in complex landscapes fallows cannot add much to an already high biodiversity. However, fallows in more complex or extensively managed landscapes can provide key resources for some species of conservation concern. As fallow land on EFAs cannot be tilled or otherwise disturbed during the fallow period, and pesticide treatments are generally limited to spot treatment of problematic weeds and a final herbicide burn-off of vegetation before ploughing, it generally offers broadly greater biodiversity benefits than the nitrogen-fixing crops or catch and cover crop options. It should be noted, however, that cereal stubbles

that are ploughed and left fallow as bare soil are highly prone to soil erosion (Boellstorff and Benito, 2005), which may cause biodiversity losses off-site, for example in aquatic habitats.

Wild native plants

Fallow with natural regeneration of vegetation generally provides a relatively rich plant diversity after one or two seasons, that includes plant species that are Lepidopteran larval plants, that provide nectar and pollen resources for flower visiting insects, and that are food plants for farmland birds (Boatman et al, 2011; Van Buskirk and Willi, 2004). Fallow sown with species-rich seed mixes also tends to reach maximum plant species richness in the second year (Tscharntke, Batáry and Dormann, 2011). Fallow sown with temporary grassland will generally only provide plant diversity that supports other wildlife if the grass species mix is made up of less competitive species and/or in areas with arable crop rotations that have received low levels of nitrogen fertiliser (Kovács-Hostyánszki et al, 2011; Kuussaari, Hyvönen and Härmä, 2011). This is likely to be rarely the case on EFAs.

Box 5-1 Evidence of wild plant abundance and species diversity on fallow

Bare (tilled) and natural regeneration of vegetation

Bare tilled fallow is a conservation measure for rare arable weeds, but it is only effective on the soil types and cropping systems that still contain substantial seed banks of the threatened species (Höft, 2012).

Crop stubbles with natural regeneration of vegetation

In a German study, weed species richness was much higher on one-year old fallow plots with natural regeneration of vegetation than in field pea crops, but fallow plots sown with *Phacelia tanacetifolia*¹⁰⁸ had fewer species than field pea crops (Gathmann, Greiler and Tscharntke, 1994). A survey of long-term set-aside fallow in the UK (Boatman et al, 2011) found that although few sites had developed plant communities of significant conservation interest after several years, over 40% of plant species present after the first few years were larval food plants for butterflies and over 60% were food plants for farmland birds. An earlier review in the UK found that plant species richness was greater on natural regeneration than on sown grass covers, though the species richness, particularly broad-leaved weeds, was significantly poorer in intensive arable landscapes than in areas with mixed farming (Firbank et al, 2003). A study in Finland (Kuussaari, Hyvönen and Härmä, 2011) found that plant species richness was highest in fallows with unsown stubbles and in fallow sown with less competitive grasses in the second year, compared with fallow sown with a competitive grass-clover mix.

Sown with plant mixes designed for environmental and biodiversity benefits

Studies found that fallows sown with species-rich seed mixes tend to reach maximum plant species richness in the second year when both annuals and perennials are present (Tscharntke, Batáry and Dormann, 2011), whereas 3 to 4 year old fallows can become dominated by perennial grasses and therefore have lower plant species richness (Toivonen, Herzon and Helenius, 2013).

Sown with temporary grassland

Fallow fields (one to three years old) sown with a legume (usually alfalfa) and two grass species in arable farming areas in Hungary had higher plant species richness and insect-pollinated plant species richness compared to neighbouring winter cereal fields after one year, in some cases even exceeding the plant species richness in semi-natural grasslands in the same landscapes (Kovács-Hostyánszki et al, 2011). The fallow was not treated with herbicide or fertiliser and mown once in the second half of June. The fields had previously received only moderate levels of fertiliser, with an average of 70kg N/ha/yr applied to winter wheat crops in the area.

¹⁰⁸ However, this may be influenced by the fact that the fallow fields had been fallow for at least 6 months before the start of plant sampling, whilst the *Phacelia* was sown at the start of the sampling period.

Soil macro-organisms

Fallow can be expected to increase soil macro-fauna abundance primarily because of the lack of disturbance from tillage and pesticides, compared to arable soils (Krogh et al, 2007; Nieminen et al, 2011). The effects increase over time in long-term fallow (Kautz et al, 2010), as the diversity and the biomass of soil organisms, including bacteria, fungi or earthworms, is generally significantly lower in arable soils compared to areas with permanent vegetation (de Vries et al, 2013). For some groups, the differences may only be apparent after more than one season of fallow (Tóth et al, 2016).

Box 5-2 Evidence of impacts of fallow on soil macro-organisms

Sown with temporary grassland

A four-year grass and clover or alfalfa fallow on crop headlands in Germany led to higher biomass and abundance of anecic earthworms compared with a crop rotation with annual ploughing to 30 cm soil depth (Kautz et al, 2010). A study of set-aside fallow in Hungary (Tóth et al, 2016) sown with a grass-legume mix found that species richness and abundance of woodlice (isopods) was significantly higher in 2-year old fallow than in wheat fields, though in the first year no differences were detected. Millipedes were also more abundant on 2-year old fallow than in wheat although the effect was not statistically significant, and in three-year-old set-aside fields the species richness of millipedes was higher than in grasslands. Plant diversity had a significant positive effect on almost all species.

Invertebrate natural enemies of crop pests

Fallows can provide undisturbed overwintering refuges for common Carabid and Staphylinid beetle predator larvae and parasitoid wasps that overwinter in the soil (Holland et al, 2016).

Butterflies & moths

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), but this is unlikely to be happening on EFAs.

Box 5-3 Evidence of impacts of fallow on butterflies & moths

Sown with plant mixes designed for environmental and biodiversity benefits

Diurnal Lepidoptera (butterflies and diurnal moths) were monitored on long-term fallow (6 years) sown with three different seed mixtures and mown or not mown compared to surrounding field margins in Finland (Alanen et al, 2011). Abundance of butterflies and diurnal moths reached the level of the field margins after 3 years, whereas the corresponding species richness level was not reached. The most successful colonizers were butterflies with grass feeding larvae and diurnal moth species feeding on leguminous plants at the larval stage. In Finland, adult butterflies were more abundant on long-term grassland fallow than on short-term fallow sown with wild flower seed mixes, and more abundant in forested landscapes than in open landscapes (Toivonen, Herzon and Kuussaari, 2015).

Sown with temporary grassland

Fallow fields (one to three years old) sown with a legume (usually alfalfa) and two grass species in arable farming areas in Hungary had significantly higher butterfly abundance and species richness compared to neighbouring winter cereal fields (Kovács-Hostyánszki et al, 2011). Species composition was dominated by the large and highly mobile pierid species whose larvae feed on Brassicaceae species which were abundant on the fallow. The fallow was not treated with herbicide or fertiliser and had previously received only moderate levels

of fertiliser, with an average of 70kg N/ha/yr applied to winter wheat crops in the area. A study in Finland (Kuussaari, Hyvönen and Härmä, 2011) found that butterfly and day-active moth species richness was significantly higher in fallow sown with less competitive grasses (*Agrostis capillaris-Festuca ovina*) and in fallow with stubbles than the competitive grasses fallow (*Festuca pratensis-Phleum pratense-Trifolium pratense*). Lepidopteran species richness was higher after two years than in the one-year fallow. However, no lepidopteran species significantly preferred the fallow plots over the field margin habitats.

Pollinators – bumblebees, solitary bees, hoverflies

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 Tschardtke, 1994). However, destruction of EFA fallow after half a year will destroy bee nests, and it does not therefore offer nesting habitat for 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 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). See field margins section below for a discussion of the evidence that small-scale sown seed mixes (field margin strips and patches) benefit pollinators.

Box 5-4 Evidence of impacts of fallow on pollinators – wild bees and hoverflies

Crop stubbles with natural regeneration of vegetation

Fallow with naturally developed vegetation (two years old) had twice as many cavity-nesting solitary bee species as sown crops, whereas the predatory species (wasps and parasitoids) showed a rather uniform distribution between the fields (Gathmann, Greiler and Tschardtke, 1994). Management by cutting greatly increased plant species richness in early-successional set-aside fields and thus doubled species richness of solitary bees.

Sown with plant mixes designed for environmental and biodiversity benefits

Bumblebees were monitored on long-term fallow (6 years) sown with three different seed mixtures and mown or not mown compared to surrounding field margins in Finland (Alanen et al, 2011). Bumblebees showed a very strong positive response to the diverse seed mixture with abundant floral resources, and their abundance peaked in the first year. Short-tongued bumblebees were very abundant in the year of establishment on *Phacelia tanacetifolia*, whilst long-tongued species increased during succession. Bumblebees were systematically more abundant on the fallow than on field margins. A UK study (Heard et al, 2007) showed that legume-grass flowering patches of 0.25, 0.5 and 1 ha sown with a mixture of 20% legumes (*Trifolium pratense*, *Trifolium hybridum* and *Lotus corniculatus*) and 80% fine-leaved grasses (*Festuca rubra*, *Poa pratensis* and *Cynosurus cristatus*) attracted significantly higher densities of bumblebees than patches of non-crop vegetation typical of the site (average 26 bumblebees/200 m² on forage patches compared to 2 bumblebees/200 m² on control patches). A large-scale study of the same legume-grass flowering patches found that the larger patches (1 ha) may be increasing the population level of bumblebee species in the landscape over more than one season. The biomass of bumblebee males and queens was higher in landscapes surrounding larger (1 ha) than smaller (0.25 ha) sown patches, although the effect of the presence of flower patches on biomass of bumblebee males and queens overall was not significant (Carvell et al, 2015).

Sown with temporary grassland

A study in Finland (Kuussaari, Hyvönen and Härmä, 2011) found that sowing one to two year fallows with a grass seed mixture with less competitive grasses (*Agrostis capillaris-Festuca ovina*) increased bumblebee species richness in the fallow, compared to fallow sown with a grass-clover seed mix of competitive species (*Festuca pratensis-Phleum pratense-Trifolium pratense*). Bumblebee abundance was highest in the stubbles and the less competitive grasses mix where the species richness of flowering plants was highest, though it should be noted that the surveying was carried out before the clover started to flower.

Common farmland birds

There is strong evidence from the UK that winter fallows, and set-aside as it was, with cereal stubble provide valuable foraging habitat for farmland birds (Dicks et al, 2013; Gillings et al, 2010). Stubble fields left after harvesting of cereal crops in the autumn provide an important food source for granivorous farmland birds, which feed on both spilt grain and weed seeds in the soil (Moorcroft et al, 2002), and there is some evidence of subsequent positive effects on breeding abundance (Gillings et al, 2005).

There is also strong evidence that fields or field margins sown with wild bird cover seed mixes provide key food resources for farmland birds, most importantly during the winter (Dicks et al, 2013; Vickery, Feber and Fuller, 2009).

Sowing fallow with temporary grassland seed mixtures based on competitive grasses produces a dense sward which is of low value for most foraging birds (Henderson et al, 2000). But it can provide breeding habitat for some grassland birds if the sward structure is suitable (Chamberlain, Vickery and Gough, 2000; Henderson et al, 2000; Herzon et al, 2011). Small unsown fallow patches within winter-sown cereals and summer fallow can provide good breeding habitats for farmland and grassland birds such as Skylark and Lapwing (Natural England, 2009). Although the surface area of these patches is too small to make a significant contribution to the overall EFA, the studies show the value of small fallow patches as targeted interventions to benefit particular species. However, the destruction of EFA fallow in mid-summer for planting cuts short the breeding period of some ground-nesting species, potentially leading to losses of eggs and young. The EFA may therefore become an ecological trap for such species, especially if they are attempting to rear a second or third brood.

Box 5-5 Evidence of impacts of fallows on farmland birds

Crop stubbles with natural regeneration of vegetation

A systematic review (Dicks et al, 2013) found evidence in seven studies and reviews from the UK that leaving overwinter stubbles leads to higher densities of farmland birds in winter, increased Grey Partridge (*Perdix perdix*) productivity, and increased Cirl Bunting (*Emberiza cirlus*) population size (in combination with several other conservation measures) and territory density (Aebischer, Green and Evans, 1999). Seed-eating birds, in particular Linnet (*Carduelis cannabina*), Grey Partridge (*Perdix perdix*), Chaffinch (*Fringilla coelebs*), Yellowhammer (*Emberiza citrinella*), Reed Bunting (*Emberiza schoeniclus*) and Corn Bunting (*Emberiza calandra*) all benefit from overwinter stubbles that have a substantial weed flora and bare ground (Moorcroft et al, 2002). An analysis of data from 30 UK studies on set-aside stubble fields (Gillings et al, 2010) demonstrated that winter farmland bird densities tended to be higher on stubbles than on either cereal or oilseed rape crops. Small unsown fallow patches (4mx4m) in winter-sown cereals provided spring and summer nesting habitats for Lapwing (*Vanellus vanellus*) (Natural England, 2009) and Skylark (Morris et al, 2004).

Sown with plant mixes designed for environmental and biodiversity benefits

A systematic review (Dicks et al, 2013) identified that 21 comparative studies out of 31 from the UK and France found positive effects on birds of sowing wild bird seed or cover mixture on fields or field margins. Ten studies and four reviews from the UK found that fields sown with wild bird cover mix had higher abundance, density, species diversity and species richness of birds than other farmland habitats, recommending a seed-mix combination of kale, quinoa and seeding cereals. Nine replicated studies from France and the UK reported mixed or negative effects of wild bird cover on birds compared to other farmland habitats.

Sown with temporary grassland

A study in Finland (Herzon et al, 2011) found that long-term grass-sown set-aside fallow supported 25 to 40% more bird species and held 60 to 105% more pairs of birds typical of open farmland in comparison with cereal fields within a similar landscape setting. However, a UK study found that bird abundances were significantly higher on unsown set-aside than on temporary grassland fallow and winter cereals, and all bird functional groups were most abundant on short-term (one year) unsown fallow except crows (which preferred grassland) (Henderson et al, 2000).

Species that are the focus of the Birds and Habitats Directives

Fallow land can provide feeding, breeding and refuge habitat for species of conservation concern if it is in the right location at the right time of year (see Box 5-6). For example, there is evidence that Lesser Kestrel (Catry et al, 2012), Little Bustard (Santangeli and Dolman, 2011), Great Bustard (Rocha, Morales and Moreira, 2012) and the European Hamster (Fischer and Wagner, 2016) benefit from fallows in cereal rotations, either stubbles with natural regeneration of vegetation or planted with targeted wildflower seed mixes. However, the value of fallow as foraging habitat for birds may be reduced if it becomes too tall and dense. Hence, for example, Montagu's Harriers have been found to preferentially hunt in alfalfa rather than fallow (Schlaich et al, 2015).

Box 5-6 Evidence of impacts of fallows on species that are the focus of the Birds and Habitats Directives

Stone Curlew

Small fallow plots (4mx4m) in winter-sown cereals provide spring and summer nesting habitat for Stone Curlew in England (Natural England, 2009).

Lesser Kestrel (*Falco naumanni*)

A model of the foraging decisions of Lesser Kestrels in a cereal steppe landscape in Spain showed that the location of cereal and fallow patches within a 2-km radius of a kestrel colony influences the total food supply delivered to the nestlings, explaining the differences in breeding success between years and colonies (Catry et al, 2012). A decrease in the proportion of fallow fields within the cereal rotations is predicted to negatively influence breeding success, but the field harvesting sequence can play an important role in alleviating the effects.

Montagu's Harrier

Montagu's Harriers caught the largest numbers of vole prey on cut strips in alfalfa, where prey were more available than in the fallow with tall vegetation, but fallow had highest vole abundance (Schlaich et al, 2015).

Great Bustard

Great Bustard in southern Portugal showed a clear preference for nesting in cereal fields, followed by young fallows, old fallows, ploughed fields and then other habitats (Rocha, Morales and Moreira, 2012).

Little Bustard

A study of displaying male Little Bustards in a pastoral landscape on Sardinia (Santangeli and Dolman, 2011) found that they were influenced by the cover of legumes and green herbs on fallow and grassland, by short vegetation structure on grasslands and by distance from roads. Little Bustard males in southern Portugal were associated with vegetation with high floristic richness and high abundance of legume species (Faria, Rabaça and Morales, 2012).

Hamster

Long-term (5 year) sown wildflower fields in Germany (Fischer and Wagner, 2016) (with seed mixtures containing annual and perennial wild and cultivated plants, intermixed with e.g. sunflowers, fennel, mallow and chicory), and with no applications of pesticides, synthetic fertilizers, tillage and mowing, contained higher densities of hamster burrows than any other habitat type within the arable farmland.

Table 5-1 Summary of evidence of biodiversity impacts of land lying fallow compared to typical arable farmland

Biodiversity component	Bare fallow with winter stubbles and naturally regenerated vegetation
Wild native plants	Generally provide a relatively rich plant species diversity after one or two seasons, though plant species richness is lower in intensive arable regions due to the denuded seed bank and limited seed rain from more species rich habitats, and the high soil fertility levels.
Soil macro-organisms	Fallow can be expected to increase soil macrofauna abundance primarily because of the lack of disturbance from tillage and pesticides, compared to arable soils, with the effect increasing from year to year. For some groups, the differences may only be apparent after more than one season of fallow.
Invertebrate natural enemies of crop pests	Fallow can provide overwintering habitat for predatory beetle larvae and parasitoid wasps in soil, and early season prey/hosts and nectar/pollen resources on flowering weeds. This can enable populations to build up and move into crops by mid-summer.
Butterflies & moths	Butterflies and diurnal moths are more abundant on fallow than on crop fields, but populations increase slowly so are only likely to benefit from long-term fallow
Pollinators – wild bees & hoverflies	Can rapidly provide flower resources for wild bees and hoverflies. Long-term fallow provides attractive nesting habitat for solitary bees, but destruction of EFA fallow after half a year will destroy bee nests, and it does not therefore offer nesting habitat for solitary bees.
Common farmland birds	Young fallows with cereal stubble provide valuable foraging habitat for farmland birds and can be suitable breeding habitat for some species. However ploughing before August will detrimentally affect the breeding of some species.
Species focus of the Birds and Habitats Directives	As for common farmland birds, there is evidence that Lesser Kestrel, Little Bustard, and Great Bustard benefit from fallows of cereal stubbles with natural regeneration of vegetation as foraging and breeding habitat.
External impacts outside farmland ecosystems	Overwinter stubble fields reduce erosion compared to bare tilled soil but may have some nutrient and pesticide residue run-off. Bare tilled fallow with no stubbles can result in substantial soil erosion and nutrient run-off that negatively affects aquatic biodiversity.
	Sown wild seed mixes
Wild native plants	Tend to reach maximum plant species richness in the second year when both annuals and perennials are present.
Soil macro-organisms	Similar to bare fallow but a denser plant biomass can be expected to boost the abundance of macro-decomposers.
Invertebrate natural enemies of crop pests	Seed mixes can provide early season prey/hosts and nectar/pollen resources associated with mix of flowering plants. This can allow build-up of populations that spill over into crops.
Butterflies & moths	Sown wild flower mixes increase abundance of foraging butterflies & moths. Long-term fallow particularly benefits butterflies with grass larval plants and moths with legume larval plants.
Pollinators – wild bees & hoverflies	Diverse flowering seed mixes quickly benefit foraging bumblebee numbers with some evidence of population effect into the next year, more than unseeded fallow where arable seed banks are small. Over time, wild seed mixes on nutrient-rich soils may become dominated by grasses and vegetatively vigorous perennials, reducing flower abundance and decreasing its value for flower visiting invertebrates.
Common farmland birds	Sowing wild bird and/or game seed mixes provides important and abundant food resources for a range of declining species when other food sources are depleted, and therefore can increase populations and species richness.
Species focus of the Birds and Habitats Directives	Impacts have been little studied, but European Hamster has been found to have high burrow density in long-term wildflower sown fallow.
External impacts outside	Sown wild seed mixes are expected to reduce soil erosion and run-off to

farmland ecosystems	insignificant levels compared to bare soil.
Fallow sown with grass or grass-clover ley	
Wild native plants	Only provides plant diversity if the grass species mix is made up of less competitive species and/or in areas with arable crop rotations that receive low levels of nitrogen fertiliser which will be rare on EFAs.
Soil macro-organisms	Similar to sown seed mixes as a dense plant biomass can be expected to boost the abundance of macro-decomposers.
Invertebrate natural enemies of crop pests	Fallow sown with grass can provide overwintering habitat for predatory beetle larvae and parasitoid wasps in soil.
Butterflies & moths	No evidence found.
Pollinators – wild bees & hoverflies	Grass has little effect but abundant flowering clover attracts large numbers of foraging wild bees, and may result in a population level effect on the common bumblebee species if suitable nesting sites are available nearby. Destruction of EFA fallow after half a year will destroy bee nests, and it does not therefore offer nesting habitat for solitary bees.
Common farmland birds	Due to the low abundance and diversity of weeds and invertebrates and tall dense vegetation that develops, grass-sown fallows are likely to be poor foraging and breeding habitats.
Species focus of the Birds and Habitats Directives	No specific evidence found but impacts on birds expected to be similar to common farmland birds.
External impacts outside farmland ecosystems	Sown grass-clover ley prevents soil erosion and run-off and builds up soil organic matter.

5.3 Field margins

5.3.1 Evidence of biodiversity impacts of EFA type and management

Field margins and buffer strips can be a valuable habitat on farmland because they provide permanent relatively undisturbed habitat, and generally contain a wider range and diversity of species than the cropped area (Marshall and Moonen, 2002). Their value as habitats is greatly increased if they border onto another structurally rich habitat such as a hedge or ditch with riparian vegetation. Field margins up to a few metres from the crop edge are affected by herbicide and fertiliser drift (Boutin et al, 2014; de Jong, de Snoo and van de Zande, 2008; Dise, 2011; Prosser et al, 2016; Storkey et al, 2012), but they also buffer other bordering habitats such as hedges, ditches and wetlands from the negative impacts of crop management practices, especially fertiliser and pesticide applications.

Wild native plants

Field edges with their reduced management intensity and increased immigration have higher plant species richness than arable crops independently of the crop type and management (Batáry et al, 2012). The plant flora of field margins is dominated by species unique to the boundary habitats beyond the margin (Cordeau, Reboud and Chauvel, 2010; Marshall and Moonen, 2002). At the same time, field margins still provide a habitat for many arable weed species of conservation value which have disappeared or seriously decreased in the field core (Fried et al, 2009). However, many narrow field margins are heavily affected by fertiliser and pesticide drift from the crop, which results in the dominance of competitive-ruderal plant species and reduces overall plant diversity

(Marshall and Moonen, 2002). Bare (cultivated) field margins provide habitat for rare arable plants in those fields where they are still present in the seed bank.

Box 5-7 Evidence of the importance of field margins for wild plant diversity

Unvegetated (cultivated) field margins

Uncropped annually cultivated field margins provide habitat for rare arable plants (Pywell et al, 2012).

Sown field margins versus grassy margins

The vegetation of buffer strips in England (Critchley et al, 2013) established by species-rich seed mixtures or natural regeneration had greater value for wildlife than those established with a simple grass seed mixture, with greater bumblebee food plant richness, diversity of food plants for farmland birds and butterfly larvae, and perennial forbs important for invertebrates. Another UK study (Marshall, West and Kleijn, 2006) found that the herbaceous flora of the pre-existing field margin adjacent to sown 6 m margin strips was significantly more species-rich than controls, probably reflecting the way the additional sown strip buffered the impact of herbicide drift from the crop.

Soil macro-organisms

Soil macro-invertebrates are much more abundant in undisturbed (i.e. untilled) field margins and other off-field habitats compared to legume crops (Smith, Potts and Eggleton, 2008) and other crops (Nieminen et al, 2011). In contrast, field margins that are sown with seed mixes are likely to have similar soil macro-fauna abundances and species composition as neighbouring crops, as the soil disturbance from tillage and herbicide treatments will have significant negative impacts on most soil macrofauna groups (Smith et al, 2008).

Box 5-8 Evidence of the importance of field margins for soil macro-organisms

Grass field margins

A UK study (Smith, Potts and Eggleton, 2008) found that earthworms (Lumbricidae), woodlice (Isopoda), and rove beetles (Staphylinidae), as well as the three main soil macro-invertebrate feeding groups (litter consumers, soil ingesters and predators) had higher abundance and species density in sown grass strips compared with the faba bean crop. The species composition of soil macrofaunal communities in grass strips was different compared with the crop, the hedge next to the field margin, and with other habitats on the farm. Another UK study (Smith et al, 2008) of soil macrofauna under sown four year old field margins found that diversity in the field margins was higher than in the crop, with earthworms, woodlice and beetles having significantly more species and/or higher abundances in the margins. However, scarification of the margins resulted in lower abundances and fewer woodlice species (Isopods) and also reduced soil- and litter-feeder abundances and predator species densities, although populations appeared to recover by the autumn, probably as a result of dispersal from neighbouring plots and boundary features. The species composition of the scarified margins was similar to that of the crop. Arable field margins in Finland harboured over twice the density and almost double the number of earthworm species in comparison to the adjacent cultivated fields, and eight of the nine species had wider regional distribution in the margins than in the fields (Nieminen et al, 2011).

Invertebrate natural enemies of crop pests

Permanent vegetated field margins are refuges for invertebrate natural enemies of crop pests, from which they spill over into crops once pest populations develop (Bianchi, Booij and Tscharrntke, 2006; Inclán et al, 2016). There is also evidence that beetle banks - raised earth banks across fields planted with grasses - increase predatory beetle activity in crop fields by providing overwintering habitat and a refuge from disturbance from which beetles can spill over into the field when pests become available (Collins et al, 2002; Wright et al, 2013). Sown wildflower field margins also attract ground beetles and spiders (Aviron et al,

2009), but wild bird or game cover margins tend to host a lower diversity of predatory invertebrates than permanent (uncropped) margins (Vickery, Feber and Fuller, 2009).

Box 5-9 Evidence of the importance of field margins for invertebrate natural enemies of crop pests

Sown wildflower or wild bird /game cover margins

A comparison in Switzerland (Aviron et al, 2009) found wildflower strips sown with 20–40 species contained significantly more (8–60% more) ground beetle (Carabidae) and spider (Araneae) species than crop fields in the same region, but did not compare with other margin types. A review concluded that temporary margins with natural regeneration can provide similar benefits to species rich permanent margins, but only once sufficient diverse vegetation with structural complexity and flowering resources have developed, whilst sown wild bird or game cover margins rarely support as high predatory invertebrate diversity as permanent (uncropped) margins (Vickery, Feber and Fuller, 2009).

Grassy margins

A review and a UK study (Collins et al, 2002; Wright et al, 2013) showed that beetle banks - raised earth banks across fields planted with grasses – increase predatory beetle activity in crop fields by providing overwintering habitat and a refuge from disturbance from which beetles can spill over into the field when pests become available. However, effects on ground beetle species diversity may take a number of years to appear (Irmiler, Sommer and Neumann, 2015). Another review concluded that simple grassy margins provide overwintering habitat for predatory Carabid and Staphylinid Beetles, whilst more species rich sown permanent margins also provide habitat for spiders and nectar and pollen resources for predatory and parasitoid wasps, beetles, flies and bugs (Vickery, Feber and Fuller, 2009). Levels of cereal aphid control by epigeal and aerial natural enemies in winter wheat were positively related to the proportion of linear grass margins in a UK study (Holland et al, 2012a). A study in Italy (Inclán et al, 2016) showed that the spillover of tachinids (Diptera: Tachinidae) into maize crops was higher from grass margins than from hedgerows, suggesting that the spillover of this group may be related to the low contrast between the vegetation structure of the margin and the crop, whilst aphidophagous hoverfly predators (Diptera: Syrphidae) were abundant in crop centres next to all field margins. A study found that increasing the quantity and connectivity of grassy field margins increased wasp predation and parasitism of caterpillars (Holzschuh, Steffan-Dewenter and Tschardt, 2009).

Butterflies and moths

Permanent field margins can be key habitats for Lepidoptera on arable farmland if they are wide and have a high diversity of wild grasses and flowering plants that serve as larval plants (Fuentes-Montemayor, Goulson and Park, 2011; Merckx et al, 2012)¹⁰⁹. Sown wildflower field margins attract foraging adult butterflies (Aviron et al, 2009; Holland et al, 2013). Field margins are also corridors for butterfly and moth movement in the arable landscape (Delattre, Vernon and Burel, 2013).

Box 5-10 Evidence of the importance of field margins for butterflies and moths

Sown wildflower margins

A comparison in Switzerland (Aviron et al, 2009) found wildflower strips sown with 20–40 species contained significantly more butterfly (Lepidoptera) species than crop fields in the same region. A UK study found a positive relationship between butterfly species diversity and the area covered by uncropped sown field margin strips at the farm scale (Holland et al, 2013). Another UK comparison found that the abundance and species richness of micromoths was significantly higher within field margins under wildlife friendly management in comparison to conventionally managed margins (Fuentes-Montemayor, Goulson and Park, 2011). In contrast, hedgerows under wildlife-friendly management enhanced neither micromoth nor macromoth populations.

Grassy field margins

A UK study (Merckx et al, 2012) found that extended-width tussocky grass field margins increased macro-moth

¹⁰⁹ <https://butterfly-conservation.org/files/habitat-butterflies-and-farmland.pdf>

species richness but not abundance, compared to GAEC standard 1m wide mown grass field margins. A study in an arable landscape in France (Delattre, Vernon and Burel, 2013) found that Meadow Brown (*Maniola jurtina* L.) butterfly movement was facilitated by arable landscapes with dense networks of grassy field margins compared to those without margins.

Pollinators – bumblebees, solitary bees, hoverflies

There is ample evidence that field margins sown with pollen- and nectar-rich plants enhance pollinator richness, although their effectiveness varies with the magnitude of increase in flowering plant cover resulting from the practices, farmland type, and landscape context (Scheper et al, 2013). A systematic review found that 50 comparative studies out of 65 in northern Europe¹¹⁰ (Dicks et al, 2013) showed some benefits of wildflower strips to one or more wildlife groups. Common species are the main beneficiaries of the establishment of wildflower strips, but there is some evidence that margins sown with pollen- and nectar-rich plants also attract rare species (Pywell et al, 2012). There is less evidence that sown flowering strips benefit solitary bees, many of which require resources in the spring (Wood, Holland and Goulson, 2016b).

Grass margins and naturally regenerated margins support lower insect abundances and diversity than in sown pollen- and nectar-rich flower mixtures and other wildflower strips (Carvell et al, 2007; Marshall, West and Kleijn, 2006). However, grassy margins can provide undisturbed bee nesting and hibernation sites if they are not too frequently mown but contain some bare or sparsely vegetated patches and some flowering plant resources. Hoverflies with aphidophagous larvae may favour grass margins because of their importance for larvae (Holland et al, 2015).

It is important to note that all these studies measured the attraction of sown flower mixes to foraging invertebrates, and the abundance of foraging invertebrates on the strips may not necessarily represent an increase in the populations as they may have moved from wild flowers in other farmland habitats. Even if the overall population is temporarily increased, this may not result in an enduring effect on the species population if it does not translate into an increased number of emerging bumblebee queens or solitary bee nests. However, a recent UK study (Wood et al, 2015) found that farms with pollen- and nectar-rich margins and/or floristically enriched buffer strips had a significantly positive effect on *Bombus hortorum* and *Bombus lapidarius* bumblebee nest density and foraging bumblebee abundance, but had no significant effect on *B. terrestris* and *B. pascuorum*, compared to farms with simple grass margins.

Box 5-11 Evidence of the importance of field margins for pollinators

Wildflower strips

A literature review (Haaland, Naisbit and Bersier, 2011) found that in a significant majority of European studies, sown pollen- and nectar-rich flower mixtures and other wildflower strips support higher insect abundances and diversity than in other margin types such as sown grass margins and natural regeneration. A meta-analysis of 71 European studies of species richness and/or abundance of insect pollinators that compared sites with small-scale habitat creation measures (including field margin strips) with conventionally managed control sites (Scheper et al, 2013) showed that small-scale habitat creation practices enhanced pollinator richness, but their effectiveness varied with the magnitude of increase in flowering plant cover

¹¹⁰ most of the studies from the UK, a third from Switzerland, a fifth from Germany, the other studies from Sweden, Norway, Austria, Ireland, the Netherlands

resulting from the practices, farmland type, and 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 already have available habitat. In a UK study, the sown margins had 10-fold to greater than 100-fold more rare bumblebee species per sample area than generalized conventional conservation measures (Pywell et al, 2012).

Grassy field margins

A UK experiment (Carvell et al, 2007) found that 6 m-wide margins of cereal fields sown with pollen and nectar flower mixture supported significantly more foraging bumblebee species and individuals than cropped, grassy or naturally regenerated field margins. An earlier UK study (Marshall, West and Kleijn, 2006) showed that bumblebee abundance in July and August was significantly higher on pollen and nectar margins compared with wildflower margins, mature grass margins and recently sown grass margins. Bumblebee abundance along grassy ditch margins in Sweden (Persson and Smith, 2013) in late season (but not early season) was positively related to total amount of herbaceous flowers, and to the presence of potential nesting habitats in grass-clover leys and semi-natural pastures in the surrounding landscape. Ditch borders in simple landscapes had on average only 16% of the flower density found in other border habitats, while those in complex landscapes had 78%.

Common farmland birds

The benefits for field margins for birds vary considerably depending on how the margins are established and managed (Box 5-12). Whilst some species benefit from naturally regenerated or grass sown margins, these often develop dense and species poor vegetation on the highly fertile arable soils, with limited food resources and accessibility for birds. Cutting can increase their value for foraging birds, but they are likely to be of greatest value if sown with a bird seed mix.

Box 5-12 Evidence of the importance of field margins to farmland birds

Sown versus grassy margins

According to Vickery et al, (2002) sympathetically managed field margins can provide a range of plant and invertebrate food resources for birds both in summer and winter at higher densities than in adjacent cereal fields. In general, the best winter food supplies (mainly seeds) are provided by game cover / seed crops and naturally regenerated rotational strips. The most abundant summer food supplies (invertebrates and seeds) will be provided by a diverse sward; grass/wildflower strips, uncropped wildlife strips and naturally regenerated rotational set-aside strips followed by conservation headlands (i.e. cereal headlands with reduced pesticide applications). Species that tend to forage on field margins such as Yellowhammer and Tree Sparrow (*Passer montanus*) are most able to benefit from these habitat features whilst whole-field approaches are required for boundary-avoiding species such as Skylark and Lapwing. A later review found that Yellowhammer and Tree Sparrow used wildflower strips more than margins sown with grass seed only (Vickery, Feber and Fuller, 2009). Grassy field margins generally have swards that are too dense for farmland birds to forage successfully, but cutting significantly increased foraging Yellowhammers in late summer (Douglas, Vickery and Benton, 2009). Sown legume field margins provided sufficient invertebrate biomass to support developing game bird chicks but may be too dense for foraging (Wood et al, 2013).

Species that are the focus of the Birds and Habitats Directives

Some evidence was found that grassy field margins are foraging habitats for farmland species that are the focus of the Birds and Habitats Directives, such as Little Bustard (Lapedra et al, 2011) and birds of prey that prey on small mammals that are abundant in grassy field margins (Rodríguez-Pastor et al, 2016).

Box 5-13 Evidence of the importance of field margins for species that are focus of Birds and Habitats Directives

Little Bustard

Grassy field margins in Mediterranean Spain were heavily used by foraging female Little Bustard after the breeding season in preference to grassland or crops (Lapiedra et al, 2011).

Birds of prey in Spain

In Spain (Rodríguez-Pastor et al, 2016), a survey of small mammals in arable fields found that grassy field margins were the most stable habitat, with densities about 2.3 times higher on average than within fields (and 8-9 times higher than in cereal fields in spring and autumn when soils are tilled and bare), and provide a key refuge in winter and spring before crops develop. These small mammals are the main prey items of a number of birds of prey on Spanish arable farmland that are the focus of the Birds Directive Annex II, such as Black-winged Kite and Hen Harrier.

Table 5-2 Summary of evidence of biodiversity impacts of field margins compared to typical arable farmland

Biodiversity component	Margins sown with seed mixes to produce abundant flowers / seeds
Wild native plants	Sown field margins are generally richer in broad-leaved flowering species than grassy field margins but their biodiversity value is constrained by the typically high fertility of arable soils. Bare (cultivated) field margins provide habitat for rare arable weeds where they are still present in the seed bank.
Soil macro-organisms	Likely to have similar soil macro-fauna abundances and species composition as neighbouring crops, as tillage and herbicide treatments will have significant negative impacts.
Invertebrate natural enemies of crop pests	Provide nectar and pollen resources for predatory and parasitoid wasps, beetles, bugs, and flies, which can provide enhanced pest control during the flowering period, but unless they are perennial they will not provide overwintering refuges. Wild bird /game cover margins are less likely to provide good habitat for predatory invertebrates and may host some pest species such as aphids or slugs. Bare (cultivated) field margins provide little habitat.
Butterflies & moths	Can be important habitats for larvae and adults especially if planted with diverse grasses and flowers and wide. Bare (cultivated) field margins provide no habitat.
Pollinators – wild bees, hoverflies	There is ample evidence that margins sown with pollen- and nectar-rich plants consistently attract large numbers of foraging bumblebees, solitary bees and hoverflies. There is some indicative evidence that this might have a population-level effect.
Common farmland birds	Major benefits if sown with seed-mix crops that provide winter food.
Species focus of the Birds and Habitats Directives	No evidence found, but unlikely to benefit many species. Bare (cultivated) field margins provide habitat for a few rare arable weeds protected by the Habitats Directive in those regions where they still occur.
External impacts outside farmland ecosystems	Sown margins can buffer field margin habitats (hedges, woody strips, and permanent vegetated margins) from the effects of pesticides and fertiliser use. Bare (cultivated) field margins also provide a buffer but may lead to increased soil erosion.
Grass margins	
Wild native plants	Grass field margins are relatively poor in wild plant diversity, containing few broad-leaved flowering perennials. Wider margins contain more species. However, they are nearly always more species rich than the crop.
Soil macro-organisms	Provide a stable habitat and refuge from tillage for soil macrofauna which are likely to be much more abundant than under crops including legume crops.
Invertebrate natural enemies of crop pests	Permanent vegetated field margins are refuges for invertebrate natural enemies of crop pests, from which they spill over into crops once pest populations develop. Grassy margins provide refuges and overwintering sites for soil surface-active predatory beetles so long as they are not too frequently disturbed or cut.
Butterflies & moths	Key larval habitats for species with grass-feeding larvae. Key foraging and movement corridors for adults.
Pollinators – wild bees &	No evidence found.

hoverflies	
Common farmland birds	Some modest benefits from natural regeneration and grass sown field margins, especially (although swards can become too dense to allow foraging).
Species focus of the Birds and Habitats Directives	Little evidence found, but likely to provide nesting habitat for some species, eg Little Bustard if undisturbed. They also support high mammal densities so may provide good foraging habitat for birds of prey.
External impacts outside farmland ecosystems	Permanent grass margins can reduce soil and water run-off into off-field habitats and watercourses. They can also buffer the impacts of pesticide and fertiliser drift on any other semi-natural habitat bordering the field.

5.4 Hedges and wooded strips

5.4.1 Evidence of biodiversity impacts of EFA type and management

There is a very large and wide-ranging evidence base that shows that hedgerows and other woody field boundary habitats benefit wildlife by providing habitats, feeding sites, refuges, and movement corridors for invertebrates, birds, mammals, reptiles and amphibians, and they support some species that would not otherwise exist in arable landscapes (Farmer et al, 2008). The research indicates that hedges vary greatly in their character, with old hedges containing rich mixes of woody and herbaceous plant species and diverse habitats in trees, shrubs, internal gaps, bank, basal vegetation and bordering margins offering the greatest biodiversity value. Other woody field boundary habitats include tree lines, lines of Mediterranean scrub and maquis, and copses and small woody patches within fields or in field corners.

It is not within the scope of this study to review the extensive literature on hedges and other woody field boundary habitats, so the following sections summarise key findings only. However, it is important to recognise that hedge and woody habitat communities are very different to those of farmland fields, and are often closer to those of scrubland and woodland. Therefore, hedge and wooded strip conservation tends to benefit different species than other elements used for implementation of EFA complementing in-field conservation rather than being an alternative.

Wild native plants

Hedges contain greater herbaceous plant species richness than crop areas, as well as the woody species they contain (Marshall and Moonen, 2002). They also usually contain a higher herbaceous plant species richness than grassy field margins of comparable age (Pywell et al, 2005).

Soil macro-organisms

Soil macro-invertebrates are likely to be much more abundant in undisturbed (i.e. untilled) hedges and other woody margins than in crops (Nieminen et al, 2011). Species composition and richness is also likely to be significantly greater under hedges and woody borders than in crops because of the diverse vegetation structure with tree and shrub roots both above and below ground.

Invertebrate natural enemies of crop pests

There is evidence that hedges are refuges for invertebrate natural enemies of crop pests, including predatory carabid beetles and spiders (Pywell et al, 2005), hoverflies with aphidophagous larvae, and parasitoid wasps (Macfadyen et al, 2011), which spill over into crops once pest populations develop (Haenke et al, 2014; Inclán et al, 2016). One study found that hedges increased cereal aphid parasitism in winter wheat crops (Dainese et al, 2016) compared to fields with no hedges.

Butterflies & moths

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 so long as it is wide enough (Feber et al, 2007). In the UK it is estimated that around 40% of resident or regular migrant butterfly species potentially breed in hedgerows (Dover and Sparks, 2000). 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). Hedges with trees and extended width margins have increased Lepidopteran species richness (Merckx et al, 2012).

Pollinators – wild bees & hoverflies

Hedges can provide stable 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). 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. Hedges can also provide foraging resources 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, 2016b) and bumblebee queens. The value of hedges for pollinators is strongly influenced by hedge and hedge base width, the timing and frequency of hedge trimming and the management of hedge base vegetation¹¹¹.

Common farmland birds

There is a considerable amount of evidence that in structurally simplified arable landscapes, hedges provide one of the most important on-farm habitats for birds (Hinsley and Bellamy, 2000), and increasing hedge length significantly increases bird species richness (Batáry, Matthiesen and Tschardtke, 2010). However, it is important to bear in mind that such increases in species mainly relate to the addition of generalist species that are more typical of woodland and scrub habitats, than farmland specialists. In fact some open land specialist bird species (such as some larks) are deterred by the presence of hedges and woody field boundaries (as they can hold and hide predators) and are less abundant when they are present. On the other hand, some farmland species (such as some game birds, buntings and finches), do rely on hedges as nesting sites in farming landscapes that lack semi-natural

¹¹¹ Bumblebee Conservation Trust Factsheet Hedges and Edges. https://bumblebeeconservation.org/images/uploads/Resources/BBCT_Land_Factsheet_6_Managing_hedges_edges.pdf

vegetation. Therefore, in most situations farmland bird communities require a mix of habitats, including shrubby and woody vegetation in hedges and trees, and suitable open field habitats.

Species that are the focus of the Birds and Habitats Directives

Hedges and woody strips are key breeding and feeding habitats for a few Annex I bird species such as Red-backed Shrike (*Lanius collurio*) and Lesser Grey Shrike (*Lanius minor*). Numerous bat species also forage along hedgerows and tree lines (European Commission and Eurobats, 2014), including the Habitats Directive Annex II species *Rhinolophus hipposideros* and *Barbastella barbastellus*, and are highly sensitive to losses of such habitat features in farmland (Frey-Ehrenbold et al, 2013; Pocock and Jennings, 2008). Other Habitats Directive Annex II species associated with hedges are the European Ratsnake *Zamenis situla*, and Mouse-tailed Dormouse *Myomimus roachi*.

Table 5-3 Summary of evidence of biodiversity impacts of hedges and woody strips compared to typical arable farmland

Biodiversity component	Hedges
Wild native plants	Hedges contain greater herbaceous plant species richness than crop areas, as well as the presence of woody species. They also usually contain higher herbaceous plant species richness than grassy field margins of comparable age; however they do not provide habitat for specialist arable weeds which require disturbed open habitats. However, diversity in many hedges is reduced due to fertiliser and pesticide drift if the hedge or woody strip is not buffered by a grassy field margin.
Soil macro-organisms	Likely to be much more abundant in undisturbed (i.e. untilled) soils below hedges and woody strips. Species composition and richness is likely to be significantly greater than in crops because of the diverse vegetation structure with tree and shrub roots.
Invertebrate natural enemies of crop pests	Presence of hedges increases rate of parasitism of cereal aphids by aphidophagous hoverfly larvae. However, very narrow (i.e. heavily trimmed) and species poor hedges with no accompanying field margin do not provide much benefit for invertebrates due to the lack of flowering weeds and other hedgerow plants that offer invertebrate food resources.
Butterflies & moths	Hedges are key foraging and dispersal habitats and wide hedge bases can provide larval food plants. High density of hedges and tree patches may allow the presence of forest-specific lepidopteran species on arable farmland. Species-poor hedges as for invertebrate predators.
Pollinators – wild bees & hoverflies	Hedges can provide key foraging resources particularly for solitary bees and bumblebee queens in spring and autumn, and hibernation sites, though their value is strongly influenced by hedge and hedge base width, the timing and frequency of hedge trimming and the management of hedge base vegetation. They also provide nesting sites for wild bees, though sunny habitats are preferred by many species.
Common farmland birds	Provide important breeding habitats and food resources for many species, greatly increasing overall bird diversity in farmland landscapes, although these are mainly generalists / woodland species rather than farmland specialists.
Species focus of the Birds and Habitats Directives	Not of high value for most threatened and declining specialist farmland birds, but are nesting and feeding habitats for a few, and important foraging habitats for some bats, reptiles and mammals.
External impacts outside farmland ecosystems	Hedges reduce soil erosion and buffer arable field run-off, filtering out nutrients and pesticides. They also provide shelter and habitat corridors for species that would otherwise not be present on arable farmland. Even badly managed and species poor hedges will have some role in reducing soil erosion and buffering arable field run-off

	by filtering out nutrients and pesticides. However, very narrow (i.e. heavily trimmed) hedges with no accompanying field margin will offer fewer benefits than wide and tall hedges.
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6 Expected biodiversity impacts of crop EFAs compared to conventional arable farmland and non-crop EFAs

6.1 Introduction

This chapter brings together the findings of Chapters 3, 4 and 5 to provide a synthesis of the expected biodiversity impacts of nitrogen-fixing crop, catch crop and cover crop EFAs in relation to conventionally managed arable land and other selected EFA options (hedges, field margins and fallow land). The analysis takes into account the representativeness, balance and weight of reviewed evidence on each potential impact and its relative magnitude. It also considers the effects of the range of management practices that are allowed on these EFAs under the overarching CAP rules and their varied application by the Member States examined in this study (as described in Chapter 3). Of particular relevance are the effects of pesticides and fertiliser use (as these are allowed under EFA rules and in most Member States for nitrogen-fixing crops, cover crops and catch crops), the length and timing of the cropping period, and whether the crop is cut or grazed or otherwise not allowed to flower and set seed.

6.2 Nitrogen-fixing crops: biodiversity potential under EFA management

There is little evidence of any significant farmland biodiversity benefits from legume forage crop and green manure crops when under conventional management within an EFA, apart from possibly for soil invertebrates. A key reason for this is that these crops are probably normally grown over a relatively short cropping period and frequently cut, and therefore not able to produce flowers that can provide benefits for butterflies, bees and other pollinators. Furthermore, frequent cutting can be reliably expected to result in very low rates of breeding success of ground-nesting birds. In fact, such forage crops can form ecological traps as the vegetation appears to be suitable for nesting but the eggs or young are later destroyed by cutting or other farming operations. However, it is possible that some of these crops are being grown as green manure and are therefore not subject to frequent cutting. Whilst forage legumes normally have low levels of pesticide use, it is possible that pre-emergent herbicides may be used, and weed diversity is expected to be low as these crops generally form a dense cover.

In contrast, there is evidence that some forage legumes, principally alfalfa, can provide benefits for some wildlife groups if managed in a certain way, principally by keeping the crop over several years, avoiding cutting in the summer and avoiding the use of pesticides. Under such favourable management multi-year alfalfa has been found to support high densities of invertebrates (including bees, butterflies, invertebrate predators of pests, and soil invertebrates), and small mammals, and as a result provides an important breeding and foraging habitat for some birds. It can then be of particularly high value for some threatened farmland species that are protected under the Birds and Habitats Directives, such as observed for the European Hamster in arable farmland in Germany and France, and for Great Bustard, Little Bustard and Montagu's Harrier in the steppelands of Spain and Hungary.

On most EFAs it is unlikely that legume forage or green manure crops will be managed in the favourable way that will provide the biodiversity benefits identified in the literature. Frequent cutting is allowed in all of the case study countries and regions except UK-Scotland (where they cannot be harvested before 1 August in order to protect ground-nesting birds) and to a lesser extent Spain (where forage legumes cannot be cut before they flower). Furthermore, there is no financial incentive under an EFA for farmers to maintain multi-season crops, although some farmers may already maintain such legume forage crops as part of their established cropping practice. The evidence for biodiversity benefits from multi-season legume forage crops reviewed in this study mainly came from farms where they have been grown as part of agri-environment-climate schemes, which provide specific prescriptions and compensation for appropriate management, unlike EFAs. This form of particularly favourable management is therefore likely to be rare and mainly within extensive arable farming systems, such as in areas of Spain, Italy and parts of eastern Europe. Many farms within these systems may not be subject to EFA requirements, and where they are, the data are unavailable to determine whether or not farmers are using these areas to count towards their EFA obligations.

Under current rules it is likely that grain legumes grown as nitrogen-fixing crops on EFAs will be managed relatively intensively, with pre-sowing herbicide application and some fertiliser application, according to typical practice when a component of conventionally managed non-organic arable crop rotations. As a result, evidence indicates that grain legume crops under conventional management have very low weed densities, which show little difference with other conventionally managed spring arable crops. This limits their benefits to wider biodiversity as weeds provide key food resources in the form of nectar and pollen, herbivorous insects, and seeds, which in turn support higher trophic level species in the arable food chain (Marshall et al, 2003). Furthermore, grain legumes under non-organic management are often treated with fungicides and/or insecticides because of their susceptibility to pest and disease damage. There is extensive evidence that most insecticides have negative effects on a range of species, including many bees, butterflies, spiders, and other invertebrates, and some fungicides have negative effects on earthworms. These impacts will further reduce food resources for other species such as invertebrate-feeding birds and small mammals.

Grain legume crops have the potential, if they are managed extensively with no fertiliser and pesticide use and harvested late, to provide some in-crop habitat for invertebrates and birds, for example through the presence of flowering weeds. Some grain legume crops such as faba bean and field pea are strongly attractive to bumblebee species and increase their local abundance whilst they are in flower, although there is very little evidence that this results in a population-level increase. However, given that pesticides are normally used on grain legume crops and are allowed under EFA rules, it is highly unlikely that any significant areas of these EFAs are under biodiversity friendly extensive management. Although the Netherlands have implemented a pesticide ban on nitrogen-fixing forage/green manure crops on EFAs, this does not apply to lupin and beans (Hart, 2015).

Overall, we conclude from the evidence that nitrogen-fixing crop EFAs, as they are likely to be typically managed over most of the EU, provide few if any significant farmland

biodiversity benefits, especially when subject to pesticide applications and when forage-legumes are frequently cut.

6.3 Cover and catch crops: biodiversity potential under EFA management

Grass and legume catch and cover crop EFAs are likely to have similar biodiversity impacts as when grown conventionally as part of arable rotations. In such situations these crops generally have low weed plant diversity, as they grow vigorously and crops are selected and planted for their capacity to suppress weeds, and this will constrain benefits to wider biodiversity. Where weeds do become significant then farmers are likely to use herbicides according to typical conventional arable crop practices, and under current EFA rules they are allowed to do so, except in the Netherlands and Germany.

As it is agronomically beneficial to establish cover and catch crops quickly after harvesting the previous crop, these crops are likely to reduce the area of crop stubbles and fallow in the landscape. Invertebrate and plant diversity is higher in stubbles and fallow than cover crops, and winter stubbles are particularly important for seed eating farmland birds, many of which are declining in Europe as a result of food shortages in winter. Thus the replacement of stubbles with cover crops is likely to be detrimental for seed eating farmland birds.

The only situation where catch and cover crop EFAs are likely to provide significant biodiversity benefits is where they comprise plants that provide flowering resources for invertebrates (e.g. pollinator seed mixes) and/or seed food resources for birds (e.g. Brassica species or Black Oat), and the crops are allowed to flower and set seed. There is strong evidence that bird seed mixes provide an important food resource for some farmland birds in winter, a period in which other resources are depleted. Some eligible crops such as Phacelia and sunflower provide abundant flowers that are strongly attractive to flower-visiting insects, and may have a population-increasing effect if present for long enough in the late summer.

For the potential benefits of planted pollinator catch crops to be realised, they need to remain for more than a month during the summer so that they start flowering. The EFA rules in the studied countries allow varied lengths of cultivation period mostly over the late summer into the autumn. The main exception is in Scotland, where catch and cover crops can be established from 1st March, but these must comprise under-sown grass, which will not provide benefits for pollinators as described above. Furthermore, farmers are allowed to cut vegetation to prevent flowering and seeding in order to prevent the spread of weeds.

To provide seed for birds, winter cover crops need to be planted sufficiently early to enable them to flower and set seed, which would need to be in the spring or early summer. Most of the studied countries require cover crops to be planted in the late summer or autumn. Scotland allows planting of green cover such as cereal-legume or cereal-mustard mixes from 1st March, and in some other countries farmers may choose to sow the crop earlier than the obligatory period. This could provide sufficient time for flowering and seed set, provided the crop is not mown or grazed. But in practice cover crops will normally be planted following crops that are harvested in the summer or early autumn. Therefore, catch and cover crops

probably do not normally set seed because the period of cultivation is too short (and too cold or dry), except perhaps in some areas of southern Europe.

However, of most relevance to the potential biodiversity benefits of catch and cover crops, is that there is no incentive to grow pollinator seed mixes or seed food resources for birds. Furthermore, grass undersowing is allowed in all the case study countries and regions. Therefore, although we have no data on the numbers of farmers that choose to do so, it is likely that some are planting undersown grass or grass seed mixes with little benefit for wildlife rather than more diverse mixes and broad-leaved flowering species such as Brassicas or Phacelia.

In conclusion, the reviewed evidence indicates that, under current rules and typical conventional management, grass and legume catch and cover crop EFAs are unlikely to provide any significant farmland biodiversity benefits over the majority of areas where they are applied.

6.4 Comparison of productive and non-productive EFA options

In general, field margins and hedges provide substantially more benefits for biodiversity than the productive (crop) EFAs. There is also ample evidence that fallow land with naturally regenerated vegetation or sown with seed mixes for pollinators or birds generally supports a higher biodiversity than any other in-field habitats in arable farmland, provided that undisturbed fallow is available for a sufficiently long period. However, fallow that is sown with temporary grass is likely to be of very low biodiversity value. The weight of the evidence from the literature thus shows that, under typical management, the non-productive EFA options examined in this study, i.e. hedges, field margins and fallow, generally have the potential to provide much greater, more diverse and more reliable biodiversity benefits than the EFA productive options under conventional management.

However, it is important to bear in mind that field margin and in-field habitats tend to provide different and complementary ecological requirements for species. Thus, some farmland species rely on both, such as hedges or field margins as breeding, refuge, and over-wintering sites and open field habitats for foraging. Whilst hedges generally have higher bird species richness than crop areas, these are mainly generalists and more typical of woodland or scrub habitats, whilst more farmland specialists are only present in open habitats. It is therefore important to ensure that both field margin habitats and in-field habitats and features are conserved and appropriately managed in the farmland landscape when they have significant biodiversity values. In fact, some studies have found that for declining farmland bird populations, the highest conservation priority is to increase the area and quality of in-field resources and habitats, rather than those in field margins (Butler et al, 2010; Poláková et al, 2011). Therefore it is particularly important to improve the biodiversity value of fallow land, by ensuring that they are not sprayed with herbicide and are left for long enough and undisturbed over the breeding season. It is also worthwhile improving the most promising productive EFA options, such as multi-annual alfalfa, through improved rules that prohibit the use of pesticides, and ensure appropriate crop establishment, cutting and ploughing periods.

7 Conclusions

Implementation data from the Member States (excluding France and Scotland) show that Ecological Focus Areas (EFAs) in 2015 have mainly comprised nitrogen-fixing crops, catch crops and cover crops, although land lying fallow occupies a fifth of the EFA area. In the first year of greening, the EFA requirement resulted in an EFA area covering 14% of the EU-28 total arable area¹¹², with 45% of EFA area under nitrogen-fixing crops, 28% under catch or cover crops, 21% land lying fallow, and 4% landscape features (mainly hedges and field margins). Therefore, in 2015, 73% of the EFA area was under the productive EFA options and 27% under the non-productive options (before weighting)¹¹³. In this study, we searched for and reviewed evidence of farmland biodiversity impacts of the most widely eligible nitrogen-fixing crops, catch crops and cover crops on EFAs in the 13 case study countries and regions selected for this study, and compared these with the evidence of biodiversity impacts of the most commonly selected non-crop EFA options, namely, fallow, hedges and field margins.

The overall balance of evidence indicates that, under typical conventional management (e.g. with fertiliser and pesticide use, and relatively short cropping periods and/or cutting), nitrogen-fixing crops, cover crops and catch crops provide few benefits for farmland biodiversity, and that these benefits are variable, context-specific and generally apply to a limited groups of species. For these elements the current management requirements in EFAs set by most of the case study countries and regions examined in this report are not sufficient to fulfil the ecological niche of the target organisms, and therefore they are unlikely to support their populations. In contrast, under typical management the non-crop EFA options examined in this study, i.e. hedges, field margins and fallow, generally have the potential to provide much greater, more diverse and more reliable biodiversity benefits than the EFA crop options under conventional management.

The biodiversity benefits of EFA productive (i.e. crop) options and fallow could be considerably increased by ensuring their management is more favourable for biodiversity, in particular through avoiding the use of fertilisers and pesticides and ensuring the periods over which they are established and removed, and key farming operations (such as cutting of vegetation) are carried out at appropriate times. For example, evidence indicates that under such favourable management, multi-year alfalfa can provide considerable biodiversity benefits, including for a range of threatened species that are the focus of the EU Birds and Habitats Directives. With similar favourable management some other EFA crop options might be able to provide significant biodiversity benefits (e.g. forage legumes such as alfalfa or clover).

Just before this report was completed, an independent analysis of EFA implementation and its likely biodiversity benefits, based on a survey of experts, was published (Pe'er et al, 2016). The authors came to similar conclusions as this study, including that field margins,

¹¹² These figures represent the total area before weighting factors are applied

¹¹³ The productive options are nitrogen-fixing crops and catch or cover crops whilst the non-productive options are all the other options that Member States can choose to make eligible

buffer strips, fallow land, and landscape features as most beneficial for biodiversity. They also propose that EFA implementation can be improved by prioritizing EFA options that promote biodiversity (through changes in weighting and options) and offering incentives for expanding options like landscape features and buffer strips, setting stricter management requirements (e.g. limiting agro-chemical use), and reducing administrative constraints.

In conclusion, the evidence indicates that the farmland biodiversity benefits of nitrogen fixing crops, catch crops and cover crops as grown under the current rules and conventional management regimes are likely to be negligible over most of the EU. However, there is substantial scope for improving the effectiveness of the EFA greening option in achieving its biodiversity objectives through increasing the uptake of the most beneficial EFA options (including fallows, field margins and landscape elements such as hedges) and requiring more favourable management of EFAs, in particular restrictions on pesticide and fertilizer use and cutting / ploughing times.

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Annex Tables

8.1 Table A1: List of wild native farmland species mentioned in the report

Group	English name	Latin name	Family / Order / Taxon
Wild plants	Black-Grass	<i>Alopecurus myosuroides</i>	Poaceae
Wild plants	Red-root Amaranth	<i>Amaranthus retroflexus</i>	Amaranthaceae
Wild plants	White Goosefoot	<i>Chenopodium album</i>	Chenopodiaceae
Wild plants	Chicory	<i>Chicorium intybus</i>	Asteraceae
Wild plants	Creeping Thistle	<i>Cirsium arvense</i>	Asteraceae
Wild plants	Hawksbeards	<i>Crepis spp</i>	Asteraceae
Wild plants	Ryegrass	<i>Lolium rigidum</i>	Poaceae
Wild plants	Mallows	<i>Malva spp</i>	Malvaceae
Wild plants	Reed Canary-Grass	<i>Phalaris arundinacea</i>	Poaceae
Wild plants	Oxtongues	<i>Picris spp</i>	Asteraceae
Wild plants	Common Purslane	<i>Portulaca oleracea</i>	Portulacaceae
Wild plants	Charlock Mustard	<i>Sinapis arvensis</i>	Brassicaceae
Wild plants	Dandelions	<i>Taraxacum spp</i>	Asteraceae
Wild plants	Field Pansy	<i>Viola arvensis</i>	Violaceae
Earthworms	Grey Worm	<i>Aporrectodea caliginosa</i>	Annelida
Earthworms	Rosy-tipped Worm	<i>Aporrectodea rosea</i>	Annelida
Earthworms	Red Earthworm	<i>Lumbricus rubellus</i>	Annelida
Earthworms	Common Earthworm	<i>Lumbricus terrestris</i>	Annelida
Woodlice	Woodlice		Isoptera
Beetles	Ground Beetles	Carabidae	Coleoptera
Beetles	Rove Beetles	Staphylinidae	Coleoptera
Flies	Hoverflies	Syrphidae	Diptera
Flies	Tachinid Flies	Tachinidae	Diptera
Butterflies	Clouded Yellow	<i>Colias croceus</i>	Lepidoptera
Butterflies	Green-undersided Blue	<i>Glaucopsyche alexis</i>	Lepidoptera
Butterflies	White butterflies	Pieridae	Lepidoptera
Butterflies	Common Blue	<i>Polyommatus icarus</i>	Lepidoptera
Bees & wasps	Large Meadow Mining-Bee	<i>Andrena labialis</i>	Hymenoptera

Bees & wasps	Garden Bumblebee	<i>Bombus hortorum</i>	Hymenoptera
Bees & wasps	Red-tailed Bumblebee	<i>Bombus lapidarius</i>	Hymenoptera
Bees & wasps	Common Carder Bee	<i>Bombus pascuorum</i>	Hymenoptera
Bees & wasps	Early Bumblebee	<i>Bombus pratorum</i>	Hymenoptera
Bees & wasps	Buff-tailed Bumblebee	<i>Bombus terrestris</i>	Hymenoptera
Bees & wasps	Scarce Long-horned Bee	<i>Eucera nigrescens</i>	Hymenoptera
Bees & wasps	Clover Melitta	<i>Melitta leporina</i>	Hymenoptera
Bees & wasps	Parasitoid wasps	various	Hymenoptera
Birds	Skylark	<i>Alauda arvensis</i>	Alaudidae
Birds	Stone Curlew	<i>Burhinus oediconemus</i>	Burhinidae
Birds	Linnet	<i>Carduelis cannabina</i>	Fringillidae
Birds	Hen Harrier	<i>Circus cyaneus</i>	Accipitridae
Birds	Montagu's Harrier	<i>Circus pygargus</i>	Accipitridae
Birds	Crows	<i>Corvus spp.</i>	Corvidae
Birds	Black-winged Kite	<i>Elanus caeruleus</i>	Accipitridae
Birds	Corn Bunting	<i>Emberiza calandra</i>	Emberizidae
Birds	Cirl Bunting	<i>Emberiza cirlus</i>	Emberizidae
Birds	Yellowhammer	<i>Emberiza citrinella</i>	Emberizidae
Birds	Ortolan Bunting	<i>Emberiza hortulana</i>	Emberizidae
Birds	Reed Bunting	<i>Emberiza schoeniclus</i>	Emberizidae
Birds	Shorelark	<i>Eremophila alpestris</i>	Alaudidae
Birds	Lesser Kestrel	<i>Falco naumanni</i>	Falconidae
Birds	Chaffinch	<i>Fringilla coelebs</i>	Fringillidae
Birds	Yellow Wagtail	<i>Motacilla flava</i>	Motacillidae
Birds	Great Bustard	<i>Otis tarda</i>	Otididae
Birds	Tree Sparrow	<i>Passer montanus</i>	Passeridae
Birds	Grey Partridge	<i>Perdix perdix</i>	Phasianidae
Birds	Little Bustard	<i>Tetrax tetrax</i>	Otididae
Birds	Lapwing	<i>Vanellus vanellus</i>	Charadriidae
Reptile	European Ratsnake	<i>Zamenis situla</i>	Reptilia
Mammals	Barbastelle Bat	<i>Barbastella barbastellus</i>	Chiroptera
Mammals	European Hamster	<i>Cricetus cricetus</i>	Rodentia
Mammals	Mouse-tailed Dormouse	<i>Myomimus roachi</i>	Rodentia
Mammals	Lesser Horseshoe Bat	<i>Rhinolophus hipposideros</i>	Chiroptera
Mammals	Common Vole	<i>Microtus arvalis</i>	Rodentia

8.2 Table A2: Percentage of arable land subject to EFA, under EFA, and proportion of EFA under the different elements, before weighting, in each case study country / region

Source: (SWD(2016) 218 final) with own calculation of area before weighting in the case study countries based on the weighted areas reported in the SWD and the country choices re use of weighting factors for landscape features

EFA element	BE	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Wal	UK Sc	EU
Percentage of total arable land that belongs to farms subject to EFA	88.0%	92.0%	82.0%	n/a	45.0%	91.0%	60.0%	56.0%	58.0%	67.0%			n/a	68.0%
Percentage of arable land under EFA before weighting	23.0%	12.5%	18.0%	n/a	12.0%	14.0%	26.0%	17.0%	15.0%	11.0%			n/a	14.0%
Percentage of arable land under EFA after weighting	7.5%	6.0%	16.0%	n/a	9.0%	9.0%	8.0%	8.0%	7.5%	10.0%			n/a	9.0%
Proportion of EFA before weighting:	BE	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Wal	UK Sc	EU
Proportion of EFA as: land lying fallow	1.1%	14.2%	37.2%	n/a	10.2%	15.4%		3.1%		16.3%			n/a	21.2%
Proportion of EFA as: landscape features	0.7%	2.8%		n/a	0.2%	1.0%	0.6%	0.8%	0.2%	7.7%			n/a	4.3%
Proportion of EFA as: terraces		0.0%		n/a	0.0%	0.0%			0.0%					0%
Proportion of EFA as: buffer strips	0.3%	0.2%		n/a	0.0%	0.0%		0.9%	0.0%	4.8%			n/a	0.6%
Proportion of EFA as: agroforestry	0.0%	0.0%	0.3%	n/a	0.0%	0.0%					0.0%			0%
Proportion of EFA as: strips along forest	0.2%	0.5%		n/a	0.4%	0.0%		0.4%						0.1%
Proportion of EFA as: SRC	0.0%	0.0%		n/a	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%			0.1%
Proportion of EFA as: afforested areas	0.0%	0.0%	1.4%	n/a	0.0%	0.9%		0.5%	0.0%		0.0%			0.5%
Proportion of EFA as: catch & cover crops	93.3%	57.8%		n/a		20.0%	93.3%	38.0%	31.3%	3.7%			n/a	27.7%
Proportion of EFA as: nitrogen-fixing crops	4.3%	24.5%	61.1%	n/a	89.2%	62.8%	6.1%	56.4%	68.6%	67.3%			n/a	45.5%

8.3 Table A3: List of species eligible as nitrogen-fixing crops in the case study countries / regions

Sources: see references cited in Chapter 3 Box 3-1

English name	Botanical name	BE FI	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Sc	UK Wal
Kidney Vetch	<i>Anthyllis vulneraria</i>													
Peanut	<i>Arachis hypogaea</i>				x	x								
Crown Vetch	<i>Coronilla varia</i>						x							
Chickpea	<i>Cicer spp</i>			x	x	x	x		x	x	x		x	x
Dolichos	<i>Dolichos lablab / Lablab purpureus</i>				x	x								
Galega (Goat's rue)	<i>Galega orientalis</i>						x							
Soybean	<i>Glycine max</i>		x		x	x	x		x	x	x			x
Liquorice	<i>Glycyrrhiza glabra</i>					x								
Sulla / French Honeysuckle	<i>Hedysarum coronarium</i>			x		x								
Vetchlings / Sweet Peas	<i>Lathyrus spp</i>			x	x	x	x		x					
Lentil	<i>Lens spp</i>		x	x	x	x	x		x	x	x		x	x
Birds-foot Trefoil	<i>Lotus spp.</i>		x		x	x	x	x	x		x		x	x
Lupin (Yellow, Narrowleaved)	<i>Lupinus spp</i>	x	x	x	x	x	x	x	x	x	x	x	x	x
Alfalfa / Lucerne	<i>Medicago sativa</i>	x	x	x	x	x	x	x	x	x	x		x	x
Hop Clover / Black Medick	<i>Medicago lupulina</i>				x	x								x
Melilot / Sweet Clover	<i>Melilotus spp</i>		x		x		x		x		x			x
Sainfoin	<i>Onobrychis spp</i>		x	x	x	x	x	x	x	x	x			x
Serradella	<i>Ornithopus spp</i>		x		x				x					
Bean (Common, French)	<i>Phaseolus spp.</i>		x	x	x	x	x		x	x	x		x	x
Field Pea	<i>Pisum spp</i>	x	x	x	x	x	x		x	x	x	x	x	x
Clover	<i>Trifolium spp.</i>	x	x	x	x	x	x	x	x	x	x		x	x
Fenugreek	<i>Trigonella</i>			x	x	x	x				x			
Vetch (excl. Faba bean)	<i>Vicia spp. (except Vicia faba)</i>	x	x	x	x	x	x	x					x	x
Faba Bean	<i>Vicia faba</i>	x	x	x	x	x	x	x	x	x	x	x	x	x

Mung Bean	<i>Vigna spp.</i>				x	x				x	x		x	x
Total species / groups		6	13	13	20	20	17	7	14	11	14	3	11	15

8.4 Table A4: Nitrogen-fixing crop types planted in the EU and in the case study countries in 2015 on whole cropping area

Source: Eurostat crop statistics. Crop area is in thousands of ha. The three largest areas in each country are marked in bold.

Nitrogen-fixing crop type	2015	BE	DE	ES	FR	IT	HU	NL	PL	RO	UK	EU
field peas	Crop area	1.00	79.10	164.11	159.02	11.18	23.50	0.00	12.00	31.56	44.00	723.57
	Proportion	0.12%	0.67%	1.31%	0.86%	0.17%	0.54%	0.00%	0.11%	0.36%	0.71%	0.67%
faba & field beans	Crop area	0.74	37.60	50.31	85.76	48.03	0.16	0.00	35.30	22.21	170.00	620.77
	Proportion	0.09%	0.32%	0.40%	0.47%	0.71%	0.00%	0.00%	0.32%	0.25%	2.72%	0.58%
sweet lupins	Crop area	n/a	n/a	n/a	n/a	n/a	0.2	0.00	207.80	0.00	0.00	n/a
	Proportion	n/a	n/a	n/a	n/a	n/a	0.00%	0.00%	1.91%	0.00%	0.00%	n/a
other pulses / proteins dry	Crop area	0.98	n/a	297.00	26.16	14.27	n/a	0.00	105.40	0.62	0.00	538.39
	Proportion	0.12%	n/a	2.38%	0.14%	0.21%	n/a	0.00%	0.97%	0.01%	0.00%	0.50%
soya	Crop area	0.00	n/a (2016: 15.2)	1.43	101.07	308.98	72.58	0.00	6.20	127.19	0.00	871.25
	Proportion	0.00%	n/a (2016: 0.13%)	0.01%	0.55%	4.59%	1.68%	0.00%	0.06%	1.45%	0.00%	0.81%
legumes harvested green	Crop area	4.50	258.40	See below	228.83	See below	See below	5.00 (2014)	See below	See below	12.00	3841.31 (2014)
	Proportion	0.55%	2.18%		1.24%		0.48%				0.19%	3.58%
Lucerne / Alfalfa	Crop area	See above	See above	257.06	See above	670.41	133.71	See above	44.00	361.68	See above	See above
	Proportion			2.06%		9.96%	3.09%		0.40%	4.12%		
Other green legumes	Crop area	See above	See above	148.41	See above	331.82	11.81	See above	205.20	267.61	See above	See above
	Proportion			1.19%		4.93%	0.27%		1.88%	3.05%		

8.5 Table A5: List of species eligible as catch or cover crops in the case study countries / regions

Source: references cited in Chapter 3 Box 3-2 and (Hart, 2015)

English name	Latin name	BE FI	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Sc	UK Wal
CATCH/COVER: GRASSES	undersowing allowed?	YES	YES	-	YES	-	YES	YES	YES	YES	YES	-	YES	-
Oats	<i>Avena sativa</i>	x			x				x	x	x		x	
Black Oat	<i>Avena strigosa</i>	x	x					x						
Buckwheat	<i>Fagopyrum esculentum</i>	x	x		x		x							
India Buckwheat	<i>Fagopyrum tataricum</i>							x						
Triticale	<i>Triticum x Secale</i>								x		x		x	
Barley	<i>Hordeum vulgare</i>				x		x		x	x	x		x	
Ryegrass	<i>Lolium perenne</i>	x			x		x							
Pearl Millet	<i>Pennisetum glaucum</i>				x									
Grasses (undersown)	Poaceae	x	x		x			x			x			
Rye	<i>Secale cereale</i>	x			x		x		x	x	x		x	
Foxtail Millet	<i>Setaria italica</i>				x									
Sorghum	<i>Sorghum bicolor</i>		x		x		x	x						
Sudangrass	<i>Sorghum sudanense</i>	x	x											
CATCH/COVER: LEGUMES		BE FI	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Sc	UK Wal
Kidney Vetch	<i>Anthyllis vulneraria</i>								x					
Chickpea	<i>Cicer arietinum</i>				x									
Soya	<i>Glycine max</i>		x		x				x					
Vetchlings	<i>Lathyrus spp</i>		x		x		x							
Birdsfoot Trefoil	<i>Lotus corniculatus</i>		x		x				x	x				
Lupins	<i>Lupinus spp</i>	x	x		x		x	x	x					
Hop Clover / Black Medick	<i>Medicago lupulina</i>		x		x				x					
Alfalfa / lucerne	<i>Medicago sativa</i>	x	x		x				x		x		x	

CATCH/COVER: LEGUMES		BE FI	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Sc	UK Wal
Sweet Clovers	<i>Melilotus spp</i>		x		x		x		x					
Sainfoin	<i>Onobrychis viciifolia</i>		x		x				x					
Serradella	<i>Ornithopus sativus</i>		x		x			x	x					
Peas	<i>Phaseolus spp</i>				x									
Field Peas	<i>Pisum sativum</i>		x		x			x	x	x				
Clovers	<i>Trifolium spp</i>	x	x		x		x	x	x	x				
Lentil	<i>Lens culinaris</i>		x											
Fenugreek	<i>Trigonella spp</i>		x		x									
Faba Beans	<i>Vicia faba</i>	x	x		x									
Vetches	<i>Vicia spp</i>	x	x		x		x	x	x	x	x		x	
CATCH/COVER: OTHERS		BE FI	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Sc	UK Wal
Borage	<i>Borago officinalis</i>	x	x											
Ethiopian Mustard	<i>Brassica carinata</i>		x					x		x				
White Mustard	<i>Brassica hirta / Sinapis alba</i>	x	x		x		x	x	x	x	x		x	
Brown Mustard	<i>Brassica juncea</i>	x	x		x			x	x	x				
Oilseed rape	<i>Brassica napus</i>	x	x		x		x	x	x					
Black Mustard	<i>Brassica nigra</i>		x						x	x				
Charlock / Field Mustard	<i>Sinapis arvensis</i>									x				
Forage Kale	<i>Brassica oleracea var. medullosa</i>	x	x		x				x					
Field Mustard / Bird Rape	<i>Brassica rapa subsp. oleifera</i>	x	x		x				x					
Camelina / False Flax	<i>Camelina sativa</i>		x		x			x						
Cornflower	<i>Centaurea cyanus</i>		x											
Rocket	<i>Eruca sativa</i>	x	x		x			x						
Niger Seed	<i>Guizotia abyssinica</i>		x		x			x						
Topinambur	<i>Helianthus tuberosus</i>								x					
Sunflower	<i>Helianthus annuus</i>	x	x		x									

CATCH/COVER: OTHERS		BE FI	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Sc	UK Wal
Garden Cress	<i>Lepidium sativum</i>		x		x		x							
Flax	<i>Linum usitatissimum</i>		x		x			x						
Nigella	<i>Nigella spp</i>		x											
Phacelia	<i>Phacelia tanacetifolia</i>	x	x		x		x	x	x	x	x		x	
Radish	<i>Raphanus sativus</i>	x	x		x		x	x	x					
Spinaches	<i>Spinacia spp.</i>		x											
African Marigolds	<i>Tagetes spp.</i>	x	x					x						
Corn Spurrey	<i>Spergula arvensis</i>		x					x						
Sticky Nightshade	<i>Solanum sisymbriifolium</i>							x						
Various			more spp											
Total no of species / groups eligible as catch and/or cover crops		21 spp	84 spp	not eligible	42 spp	not eligible	15 spp	23 spp (grouped in 2 categories)	5 families	13 groups (only green cover)	7 spp	not eligible	7 spp	not eligible

8.6 Table A6: Landscape features qualifying as EFA in each case study country / region and how they are defined

Source: (SWD(2016) 281 final)

EFA element	BE - FI	DE	ES	FR	IT	HU	NL	PL	RO	UK En	UK NI	UK Wal	UK Sc
Hedges or wooded strips	Art 45	GAEC 7		Art 45	GAEC 7, SMR 2, SMR 3	Art 45	(in arable strip package)	Art 45	Art 45	GAEC 7	GAEC 7	Art 45	
Isolated trees		GAEC 7		Art 45	GAEC 7, SMR 2, SMR 3	Art 45, GAEC 7	(in arable strip package)	Art 45, GAEC 7	Art 45				
Trees in line		GAEC 7		Art 45	GAEC 7, SMR 2, SMR 3	Art 45	(in arable strip package)	Art 45	Art 45				
Trees in group and field copses	Art 45	GAEC 7		Art 45	Art 45	GAEC 7	(in arable strip package)	Art 45	Art 45				
Field margins	Art 45	Art 45, GAEC 7		Art 45	Art 45	Art 45	Art 45	Art 45	Art 45				Art 45
Ponds	Art 45			Art 45	GAEC 7, SMR 2, SMR 3	GAEC 7	(in arable strip package)	Art 45, GAEC 7	Art 45				
Ditches	Art 45	GAEC 7		Art 45	GAEC 7, SMR 2, SMR 3	Art 45	(in arable strip package)	Art 45, GAEC 7	Art 45		GAEC 7		

)						
Traditional stone walls		GAEC 7		Art 45	GAEC 7, SMR 2, SMR 3						GAEC 7	Art 45	
Other landscape features under GAEC or SMR		GAEC 7			No descript ion	GAEC 7					GAEC 7		
NO OF LF PER MS	5	8	0	8	9	8	1	7	7	1	4	2	1