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Executive summary

Scope and methodology of the study

This study is a first attempt to use the EFA (Ecological Focus Area) calculator as a tool to support an assessment of policy impacts on biodiversity and ecosystem services of the EFA implementation at European level. Based on a literature review, the EFA calculator has been developed by the University of Hertfordshire, with the coordination of the Joint Research Centre (JRC), as a farm-level tool with the scope of raising farmers' awareness about the implementation of EFA and providing guidance and direction to farmers with regard to EFA selection and management. In this study, the tool was used to calculate potential impacts at NUTS3 level using the data on EFA implementation in 2015 notified by the Member States. The tool is run with aggregated data at NUTS3 level: this use implies that the region is populated by an average farm, and context data used to run the calculator are average regional data on soils, climate, etc. Some specific attributes and practices linked to the EFA elements (e.g. floral diversity, landscape connectivity, hedges cutting season, etc.) and used to fine-tune the EFA calculator scores, could not be taken into account. These assumptions and constraints should be considered in the analysis of the results obtained. The scores calculated for each NUTS3 region represent potential impacts generated by average regional data, and are not based on specific characteristics, management practices and landscape conditions of a real farm. Therefore these scores should not be considered as absolute values of the actual impact of EFA implementation on the environment, but they can be used as a proxy to represent the potential impact on the environment of the EFA type composition that was declared in the NUTS3 region.

Analysis of the EFA implementation data

Data on the implementation of EFA at NUTS3 level in 2015 shows that catch crops, nitrogen-fixing crops and land laying fallow were the EFA types most often declared by farmers to fulfil the EFA requirement. Nevertheless, there are also some NUTS3 regions with a high share of other EFA types, such as landscape features or buffer strips. Based on this, it was possible to classify NUTS3 regions in nine categories, according to the different percentages of EFA types declared. These categories also apply to Member States, and for some of them one category is sufficient to describe the composition of EFA types declared in the country (e.g. in the Netherlands more than 70% of EFA declared is represented by catch crops, in Poland EFA is composed mainly of catch crops and nitrogen-fixing crops, in Lithuania EFA declared is mainly represented by nitrogen-fixing crops, land laying fallow and (to a lesser extent) catch crops, in Ireland more than 50% of EFA is declared as landscape features). In almost all Member States, two categories are sufficient to describe the composition of the EFA types declared, except in Germany, where there is a variability moving from north-west to south-east, and in the United Kingdom where the three categories identified are almost systematically those with an abundant presence of landscape features and buffer strips.

Declared implementation data also show that, in many NUTS3 regions, the actual declared EFA area is much greater than the minimum 5% requested by legislation. As an average, in all EU NUTS3 regions where data were available and reliable, the EFA declared (after applying the weighting factor) accounts for 9.4% of the arable land.

Results: potential impacts at NUTS3 level according to EFA types declared

The assumption of the study is that the composition of the EFA types declared represents the main factor influencing the impact of the EFA implementation on biodiversity and ecosystem services. The EFA calculator was run on a sample of 121 NUTS3 regions. Results were analysed for categories of NUTS3 regions.

Resulting impact scores for biodiversity are highest in NUTS3 regions where landscape features represent more than 50% of EFA declared. High scores are also obtained in NUTS3 regions where more than 70% of EFA is declared as land laying fallow. Lowest scores are

obtained in NUTS3 regions where more than 70% of EFA declared is catch crop. When analysing scores disaggregated per species group, results show that the presence of landscape features could have potential positive impacts for invertebrates, birds and terrestrial plants, while for reptiles and amphibians the presence of buffer strips and fallow land is more relevant.

Impact scores calculated for ecosystems services show that NUTS3 categories with no or limited impacts on biodiversity can obtain positive scores in terms of ecosystem services, at least for some specific services. If one considers the total score obtained by summing up the scores of the different ecosystems services analysed, NUTS3 regions where landscape features account for more than 50% of EFA declared perform much better than the others, not only in terms of biodiversity, but also considering the sum of ecosystem services scores. Conversely, when analysing specific ecosystem services, positive impacts are also found in other NUTS3 region categories. This is the case for the NUTS3 regions where catch crops constitute more than 70% of the EFA declared (in this case good scores are reached for the ecosystem service chemical condition of freshwaters) or NUTS3 regions with more than 70% of fallow land declared as EFA, where good scores are obtained for the ecosystem service of pollination.

Impact scores for ecosystem services related to mass stabilisation and control of erosion rates are generally very low, with almost no degree of variability among different categories of NUTS3 regions, as these impacts are probably more dependent on local conditions (such as ground cover types) that are not taken into account in the analysis at NUTS3 level. Only for categories containing a high percentage of buffer strips do positive impact scores seem to be slightly higher than those calculated for all other categories.

Results: potential impacts of EFA types

From the analysis of scores of different categories of NUTS3 regions, it has become evident that the percentage of each EFA type greatly affects the impact scores of the NUTS3 categories. A simulation has been carried out to generate impact scores for each EFA type and to allow for comparisons among them. The results obtained show the impacts of different EFA types on biodiversity and ecosystem services, with hedges being the EFA types having the greatest positive effects on biodiversity, and hedges and buffer strips having the greatest positive effects on ecosystem services. Hedges, buffer strips and fallow land are the EFA types with best results for pollination. For the ecosystem control of erosion, the only positive evidence available is for buffer strips, while catch crops give good scores for the chemical condition of freshwaters, although not quite as good as hedges and buffer strips. Fallow land can have negative impacts on chemical conditions of freshwaters and erosion control, but this depends on ground cover types (e.g. bare soil).

The same analysis performed in different geographical contexts highlights the fact that potential impacts on ecosystem services vary much more among regions, compared to the potential impacts on biodiversity. This is probably due to the fact that biodiversity scores are more dependent (in the model) on very specific factors and features (which are not described in the region files, for which an average value is used), whereas ecosystem services can vary more with broader spatial variables such as soil and climate (which are defined in the region files). In fact, the variability of impacts can depend on specific attributes of the features and surrounding landscape characteristics that are taken into consideration when modelling at farm level, but cannot be taken into account in the NUTS3 level analysis. These features include floral diversity, hedge height, density of hedgerow trees, cutting techniques, buffer width, and the presence of adjacent vegetation structures or wildlife corridors.

The results of all these analyses are considered sufficient to draw conclusions on the existence of a clear correspondence between the EFA types declared and the potential impacts on biodiversity and ecosystem services.

Results: potential spatial impacts on biodiversity

Results obtained from the analysis of the potential impacts of the different EFA type compositions could be further examined through a spatial analysis where potential impacts are overlaid with specific environmental issues. This helps understand whether the declared EFA composition could possibly address specific territorial issues. A spatial analysis was performed on the basis of the impact scores obtained in 121 NUTS3 regions.

With regard to biodiversity decline, as we do not have sufficiently detailed data to calculate the "real" baseline, we used as proxy a descriptor of the green network supporting biodiversity: the map of the distribution of semi-natural vegetation in agricultural land (Garcia-Feced et al., 2015).

By overlaying the two sources of information (NUTS3 regions with scarce semi-natural vegetation and NUTS3 regions with good scores for biodiversity), it is possible to highlight areas where the EFA type composition declared may generate benefits in terms of biodiversity: this is the case for NUTS3 regions in East England, the North of Spain and the South-East of Hungary, where semi-natural vegetation is scarce, but biodiversity scores are good. Some benefits, even if smaller, can also be seen in regions which obtained good biodiversity scores and where semi-natural vegetation is not abundant but is less scarce than in the regions mentioned above (North and West of England), or where the percentage of arable land affected by EFA is not high (South of Spain, Greece, Estonia, Latvia). The great number of landscape features and fallow land declared as EFA determines these results. It must be highlighted that landscape features declared for EFA may not be newly planted hedges, but only hedges that are already established (in fact, this information is not known). In any case, the fact that they are declared as EFAs should prevent them for being removed. On the other hand, micro features (e.g. field margins) are not detected in the map of semi-natural vegetation, which is derived from satellite data.

By overlaying NUTS3 regions with scarce semi-natural vegetation and NUTS3 regions with lower scores for biodiversity, it is possible to highlight areas where EFA type composition declared seems unable to create benefits in terms of biodiversity. In such cases, EFA features declared are represented by EFA types that have low impacts on biodiversity (mainly catch crops) in areas where the presence of semi-natural vegetation is also scarce (e.g. Denmark, some regions in the Netherland and Belgium, south-west of Hungary, Romania).

Results: potential spatial impacts on erosion

An analysis was carried out on the possible contribution of EFA implementation on reducing erosion rates. Impact scores for this ecosystem service in NUTS3 regions were overlaid with a map of soil erosion by water in the European Union produced by the JRC Soil Bureau, aggregated at NUTS3 level. This overlay highlights NUTS3 regions characterised by high to moderate risk for water erosion where the EFA calculator estimates high positive scores for erosion control, and vice versa where negative scores are obtained. The first case occurs when the EFA type composition declared could generate benefits, and this is found in some NUTS3 regions in Germany, Slovenia and South of Poland. The second case occurs when the EFA type composition seems unable to generate benefits, and is found in some NUTS3 regions in Spain and Greece.

Results: potential impacts of fallow land types, catch crops and nitrogen-fixing crop species

Impact scores calculated using the EFA calculator are derived from the characteristics of the EFA element itself. In the analysis made at NUTS3 level, only general characteristics referring to the whole NUTS3 region were taken into account (predominant soil texture, mean annual rainfall, etc.). However, some specific attributes related to each specific EFA element can be used by the EFA tool to calculate the impact scores. Some additional simulations were carried out to assess how scores are linked to EFA type characteristics.

A first simulation concerned land laying fallow: impact scores were calculated specifying different typologies of vegetation cover (sown bird seed mix, sown grass only, natural

regeneration, bare soil, sown wildflowers). If impact scores for fallow land are considered, results show that <u>for pollinators (and therefore also for the ecosystem service pollination), sown wildflowers induce the highest scores, and bare soil the worst</u>. Bare soil also performs badly in terms of supply of other ecosystem services. Natural regeneration is also a good option to foster biodiversity and pollination.

Another simulation was carried out for catch crops, specifying the main crops planted by the farmers for this EFA type in Belgium and Poland (the analysis at NUTS3 level was carried out using the same crops, *Sinapis alba* and *Lotus spp.*, for all Member States). The <u>scores obtained by specifying the species used do not vary compared to those used in the analysis for all NUTS3 regions</u>. This indicates that the results obtained in the analysis for NUTS3 regions would not change much even if catch crop species were known. This depends of the level of detail of the calculator, where impacts are based on plant families and not on individual species, which is often the case for data in the literature on plant families. In any case, under the greening rules, a mixture of species must be used rather than just one single species.

A similar approach was used for a simulation of nitrogen-fixing crop species. In this case, impact scores calculated using *Vicia faba* as nitrogen-fixing crops species (species used for the analysis in all NUTS3 regions) were compared with those obtained for the main crop species used by farmers in Poland and Belgium. This exercise shows that, <u>impact scores vary for nitrogen-fixing crops, especially with respect to biodiversity</u> (in fact *Vicia faba* gave better scores for pollinators than the species cultivated in reality); this demonstrates that the analysis could be improved if EFA nitrogen-fixing crops species are known.

Further development

There is scope to fine-tune the analysis when new data become available (e.g. nitrogen-fixing crop species cultivated as EFA in reality). Improvement of the knowledge base which represents the foundation of the EFA calculator could be needed. It would also be interesting in the longer term if the structure of the EFA calculator could be reviewed and upgraded in order to automate the input process and the extraction of results. With such an update, it would no longer be necessary to manually insert the data from the NUTS3 regions, as they could be automatically inserted into the EFA calculator to generate scores for the entire EU. Analyses could then be performed in a reasonable amount of time on the whole EU instead of on a limited sample of NUTS3 regions. This could also help estimate the trends of potential impacts in different years of EFA implementation in the whole EU.

1 Introduction

The scope of the study was to assess the possible impact of the Ecological Focus Area[1] on ecosystem services and biodiversity, as implemented in the Member States after the first year of application (2015). The implementation is based on farmers' choices from a list of options available at Member States level (Regulation (EU) No 1307/2013).

In particular, the aim of the study was to cover the following issues:

- Taking into account EFA types as declared by farmers, is it possible to identify areas where EFA type implementation can be considered more or less effective for biodiversity and ecosystem services?
- Are these areas situated in regions where one should expect more benefits from the EFA policy (better targeting)?
- What suggestions can be made to make the implementation of the EFA policy more effective in improving biodiversity and ecosystem services?

Given the data available for this analysis, it should be noted that:

- it is not possible to assess the modifications induced by the EFA policy with respect to a baseline situation (i.e. to compare before and after EFA implementation), as this baseline does not exist;
- no information is available regarding what elements were newly introduced due to the EFA policy. In fact, the EFA elements taken into account are only those declared by the farmers to be compliant with the EFA obligation. Furthermore, other potential EFA elements can be present in the territory but not declared. Anyway, it should be mentioned that, although the EFA policy may not result in the creation of new features, it contributes to the protection of existing features;
- when analysing results carried out at NUTS3 level, it is assumed that the region is populated by an average farm. For a better view on the spatial distribution of impact scores, an analysis of sample farms should be performed;
- the results obtained do not represent the actual impact of EFA implementation on the environment, but only the potential impact on the environment of the EFA type composition that was declared in the NUTS3 region.

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[1] The reform of the Common Agricultural Policy in 2013, whose implementation started in 2015, introduced a "greening payment" with the scope of enhancing the environmental performance of the holdings through a support to agricultural practices beneficial for the climate and the environment (Reg. 1307/2013). These practices include diversifying crops, maintaining permanent grassland and dedicating 5% of arable land to "ecological focus areas (EFAs)". The European legislation establishes a list of elements and areas that can be used to describe EFAs, such as landscape features, terraces, buffer strips, catch crops, and nitrogen-fixing crops. On the basis of the common EFA list, Member States draw up a list of EFA types in line with national priorities and farming systems, from which their farmers can choose in order to fulfil the EFA obligation. To calculate the EFA, the basic regulation established a system according to which each EFA type is assigned specific conversion and weighting factors, the first to simplify the measurement of some EFA types such as trees and ponds, the latter to reflect the fact that EFA types have different characteristics and consequently different impacts on biodiversity.

2 Methodology and data

The analysis carried out in the study is based on the use of the EFA calculator, a software tool developed by the University of Hertfordshire and coordinated by the JRC. For a detailed description of the tool and of its scientific basis, see the final report of the Study on the EFA calculator (Tzilivakis, J., et al. 2015):

https://ec.europa.eu/jrc/sites/jrcsh/files/ReqNo_JRC99673_final_report.pdf

- the paper by J. Tzilivakis, et al., An indicator framework to help maximise potential benefits for ecosystem services and biodiversity from ecological focus areas, *Ecological Indicators* 69 (2016) 859–872

http://www.sciencedirect.com/science/article/pii/S1470160X16302278.

The latest version of the EFA calculator software is freely available to download from:

https://sitem.herts.ac.uk/aeru/efa/

The explanation of the tool (given in paragraph 2.1 below) is mainly taken from the final report of the Study on the EFA calculator (Tzilivakis, J., et al. 2015).

2.1 The EFA calculator

A literature review forms the foundation for the software tool. Over 350 papers, reports and guides were collated, reviewed, and structured according to the individual EFA types specified in the EFA legislation. The knowledge gleaned from the literature review was then converted into a form that could be utilised within the software.

Ecosystem services and biodiversity were selected as a means of assessing the possible ecological benefit of EFAs. In this analysis, ecosystem services are the positive tangible provisioning, regulating and cultural services that EFAs can provide to humans. Ecosystem disservices, which are harmful to human well-being, are not directly covered in this analysis, but negative impacts resulting from ecosystem services are covered (e.g. creation of woodland may reduce water provision downstream in a catchment). The Common International Classification of Ecosystem Services (CICES) system was taken as a reference (Haines-Young and Potschin, 2013). For biodiversity, this analysis focuses on the diversity and populations of species, with a specific focus on the latter with respect to the potential impact EFA may have on enhancing populations. The European Environment Agency (EEA) European nature information system (EUNIS) species groups were used as reference (EEA, 2015b).

Throughout an impact assessment process, the knowledge synthesised in the literature review was analysed and converted into a set of guidelines, criteria and rules that could be embedded in the core database that underpins the software. There were no established techniques available that could be used to undertake this task, so a bespoke approach was developed, albeit utilising established frameworks where possible. For example, the CICES was used as the basis for the ecosystem service impact categories. A bespoke scoring system was developed. <u>The potential impact of each of the EFA features on ecosystem services and biodiversity was determined</u> (the feature impact). Each EFA feature may have one or more impacts, which are characterised by one or more parameters, which may have two or more parameter classes (chapter 3.3. in Tzilivakis, J., et al. 2015, gives an overview of feature impacts and associated parameters for each EFA type; a list of parameters and classes used are provided in Annex E of the same report). For example, the parameter 'soil texture' with classes of coarse, medium, medium-fine, fine, and very fine, will affect the impact on soil erosion, thus these classes were used to derive different impact scores (in combination with other parameters), as in Figure 1.
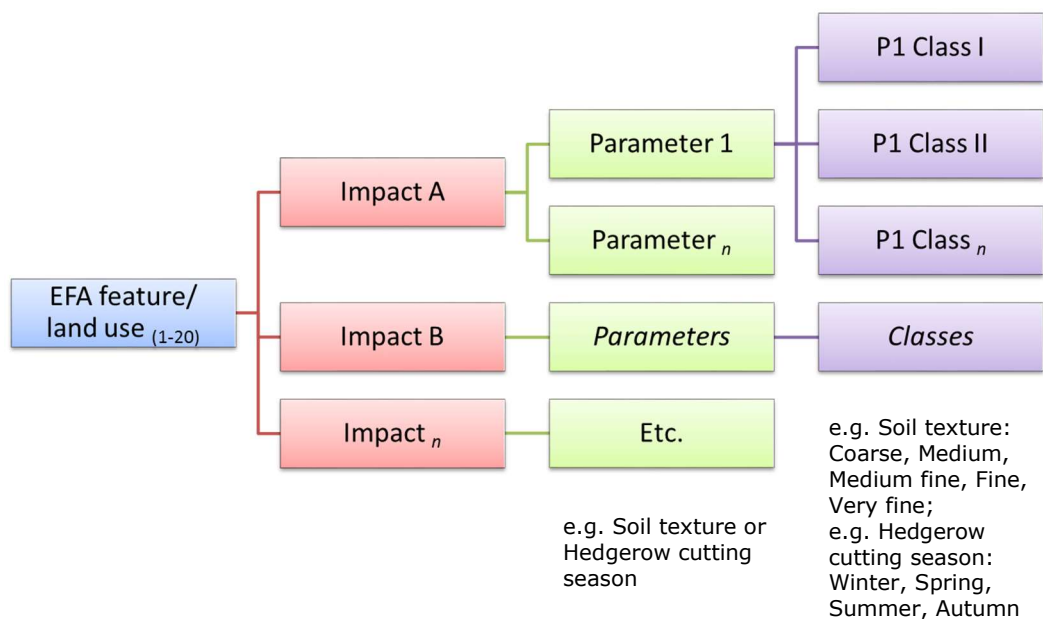
Figure 1- The conceptual structure of the indicator framework (from J. Tzilivakis et al., 2016)

In Figure 2, the first table summarises the impacts on different ecosystem services of each EFA feature (the impact categories). The ticks in the matrix indicate where the EFA feature has an influence on the corresponding impact category (e.g. impacts of fallow land are highlighted in the red rectangle). The impact categories in the table are based on an aggregation of the CICES structure at the class level, listing only classes where an impact was identified in the literature review. It should be noted that the feature impacts listed are based on the scientific evidence collected. Other potential impacts may be associated with the EFA land management and landscape features, and a lack of evidence and/or a lack of scientific consensus in the collected evidence led to their exclusion.

Figure 3 summarises the impacts of each EFA feature on biodiversity EUNIS groups. The ticks in the matrix indicate where the EFA feature has an influence on the corresponding impact category for biodiversity (e.g. impacts for fallow land are highlighted in the red rectangle).

Impact category	Agroforestry	Ancient monuments	Ancient stones	Archaeological sites	Catch crops or green cover	Ditches	Fallow land	Garrigue	Hedges or wooded strips	Isolated trees	Land strips (adjacent/parallel to water)	Land strips (other)	Natural monuments	Nitrogen fixing crops	Ponds	Short rotation coppice	Terraces	Traditional stone walls	Trees in line	Woodland
Ecosystem services																				
Provisioning:																				
Provision of water as a material																	✓			✓
Provision of water for nutrition																				✓
Regulation & maintenance:																				
Global climate regulation																				✓
Pollination & seed dispersal	✓				✓		✓	✓	✓		✓	✓		✓	✓	✓				✓
Pest control	✓			✓			✓		✓						✓			✓		✓
Chemical condition of freshwaters	✓			✓	✓		✓		✓			✓		✓	✓	✓			✓	✓
Flood protection					✓															✓
Mass stabilisation & control of soil erosion	✓			✓			✓					✓			✓		✓	✓		✓
Filtration/sequestration by flora and fauna									✓			✓							✓	
Mediation of smell/noise/visual impacts									✓										✓	
Cultural:																				
Aesthetic services		✓	✓	✓		✓			✓	✓			✓		✓		✓	✓	✓	✓
Heritage & cultural services		✓	✓	✓						✓										

Figure 2 - Broad impact matrix that provides an overview of the feature-impact combinations (EFA features along the top, and impact categories on the left).Ticks in the matrix correspond to where evidence was found that the EFA feature has an impact (positive or negative) on the corresponding category of ecosystem services, based on <u>CICES</u> classification. The feature impact of fallow land is highlighted in the red box as an example.

Figure 3 - Broad impact matrix that provides an overview of the feature-impact combinations. (EFA features along the top, and impact categories on the left). Ticks in the matrix correspond to where evidence was found that the EFA feature has an impact (positive or negative) on <u>EUNIS</u> biodiversity groups. The feature impact of fallow land is highlighted in the red box as an example.

2.1.1 Impact scores

Relative impact scores for each feature-impact combination were derived. A feature-impact represents the impact of an EFA feature on an ecosystem service or a biodiversity species group. Each feature-impact was scored on a scale of −100 (highly negative impact) to +100 (highly positive impact).

Two techniques were developed to score impacts (details on the impact assessment framework are given in chapter 3.2 in Tzilivakis, J., et al., 2015):

- <u>A semi-quantitative approach</u>, which utilises quantified data and calculations. A score is awarded for each of the possible combinations of parameters, based on the quantified data; calculations were derived for each of the possible combinations of relevant parameters, then converted into the scale of -100 to +100, using a calibration table.
- <u>A qualitative approach</u>, where scores are awarded for each class, then the scores for the classes selected are summed and weighted for each parameter.

The semi-quantitative approach has the advantage that all impacts are comparable across features, and it tends to be less subjective than the qualitative approach. Unfortunately, as there is a limited number of robust models or methods available from which to derive quantitative data, this approach can only be applied to a few impacts (e.g. nitrate leaching, phosphate run-off, soil erosion).

The qualitative approach is more subjective (compared to the quantitative approach) and relies more on expert knowledge. To circumvent this, a protocol has been used to systematically derive the scores and weights based on the following criteria:

- Identification of any existing scoring techniques, indicators or indices in the literature, especially those with documented practical field-based application, and adaptation of these to the scoring system;
- Identification of any established relationship (e.g. linear or sigmoidal) in the literature for the specified parameters, classes and impacts, and allocation of scores accordingly;

- Identification of any critical parameters or thresholds, and allocation of scores accordingly;
- In the absence of any of the above, an equal distribution of scores across the parameters and classes was applied.

The example of fallow land is used to clarify the concept (Figure 4). If we select an impact category, for example amphibians, we can then see the parameters that affect amphibians, and then the classes within those parameters that influence the end impact, along with the score that has been awarded for each of the classes to reflect their relative importance. Based on this, we can see that optimal conditions of fallow land for amphibians is where fallow land has: good adjacent water bodies quality (clear water, abundant organisms); is surrounded by a large area (>1 ha) of rough grassland, scrub, hedges or woodland; has diverse and complete linear features; with >1.3 ponds per km²; and with either natural regeneration or sown grass on the ground. This situation gets a score of 93.4 (the average of the five scores). The worst conditions of fallow land for amphibians is where fallow land has: no adjacent water bodies or some with very poor water quality; is surrounded by large areas of bare ground; has no linear features; no ponds; and the fallow land has bare soil (score 0). Obviously, there are many combinations in between.
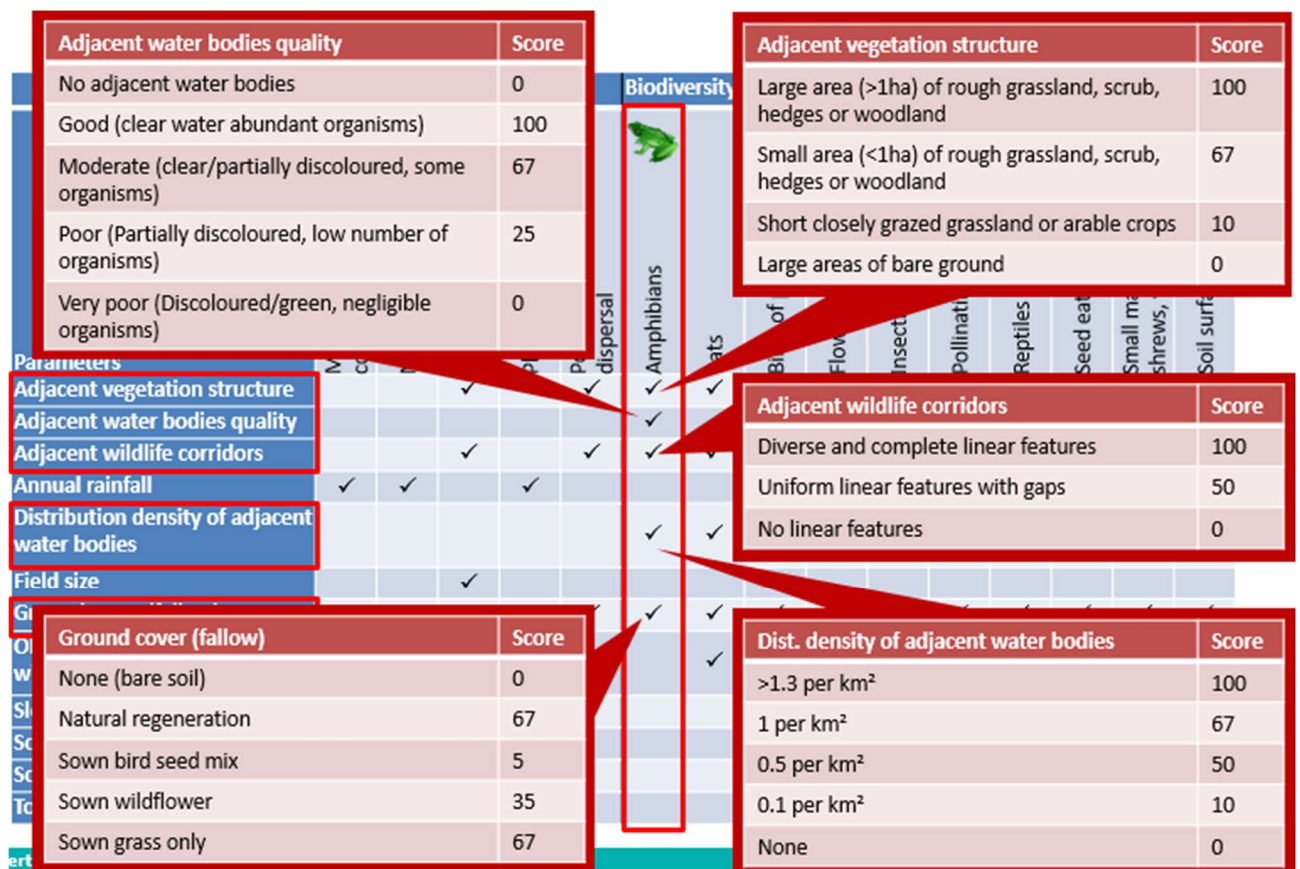
Adjacent water bodies quality	Score
No adjacent water bodies	0
Good (clear water abundant organisms)	100
Moderate (clear/partially discoloured, some organisms)	67
Poor (Partially discoloured, low number of organisms)	25
Very poor (Discoloured/green, negligible organisms)	0

Adjacent vegetation structure	Score
Large area (>1ha) of rough grassland, scrub, hedges or woodland	100
Small area (<1ha) of rough grassland, scrub, hedges or woodland	67
Short closely grazed grassland or arable crops	10
Large areas of bare ground	0

Adjacent wildlife corridors	Score
Diverse and complete linear features	100
Uniform linear features with gaps	50
No linear features	0

Ground cover (fallow)	Score
None (bare soil)	0
Natural regeneration	67
Sown bird seed mix	5
Sown wildflower	35
Sown grass only	67

Dist. density of adjacent water bodies	Score
>1.3 per km²	100
1 per km²	67
0.5 per km²	50
0.1 per km²	10
None	0

Figure 4 - Impact matrix for fallow land on amphibians

2.1.2 The aggregation process

Given the range of potential impacts on ecosystem services and biodiversity and the number of impact indices and data, some aggregation was required to facilitate simple assessment and interpretation. Positive and negative impact scores are averaged and aggregated separately. This is to avoid potential negative impacts becoming hidden by being 'cancelled out' by positive scores (and vice versa). As impacts have been scored at

different levels, the averaging process accounts for the scores awarded directly to an impact category and any sub-categories. Thus the aggregation process starts at the bottom (class level) and then works up the hierarchy, transferring the aggregated data at each level to the next level. In the end, the aggregation process potentially results in four values: positive and negative values for ecosystem services, and positive and negative values for biodiversity.

Each feature can be described in terms of its dimensions (e.g. area, length, width, height, etc.) and parameters that describe spatial and management factors (e.g. soil texture, climate, ecological zone, adjacent vegetation structure, etc.). The parameters are used as 'look up' variables to retrieve the potential impact on ecosystem services and biodiversity (as were determined in the impact assessment). These impact values are then multiplied by the area of the land/feature: <u>impact scores are expressed as a proportion of the maximum score obtainable by the feature multiplied by the area of the feature</u>. Feedback on the relative impact or ecological performance of the feature can then be provided for an individual feature, a group of features or all features on the farm.

In order to make results comparable, <u>impact scores per hectare</u> are also calculated. The impact scores per hectare are those used in the analysis carried out in this study at NUTS3 level (in this way, comparison is possible as results are not influenced by the farm size of an "average farm" in the NUTS3 region).

An important distinction in any impact assessment is whether impacts are assessed on the basis of a change from a baseline situation (baseline impact assessment - BIA) or whether they are assessed on a functional basis (functional impact assessment - FIA). For example, 100 m of hedgerow could be declared as an EFA. This could be a hedgerow that is newly created/planted or an existing hedgerow. The new hedgerow is a change from the baseline, but in the case of the existing hedge there is no change from the baseline. Thus in the context of a BIA, the existing hedge has no impact whereas the new hedge does have an impact. However, in the context of an FIA, the assessment would target the impact the hedge has in terms of the functions and services it provides (for both biodiversity and ecosystem services). Both the new and existing hedges would have an impact in the context of an FIA, with the impact (performance) being determined by the attributes of the respective hedges in the circumstances in which they are located. Therefore, the performance of each of the EFA elements will be based on the function it performs in relation to ecosystem services and biodiversity. This applies to both existing and new features (including features that may have been specifically created for EFA). Performance will not be based on changes to a baseline.

For further details on the foundation of the EFA tool and on the scoring system, please refer to the Annex.

2.1.3 Use of the EFA calculator assuming NUTS3 regions as one average farm type

To date, it is still very difficult to find and to set up robust greening impact studies due to sparse and incomplete data availability. As described in previous chapters, the EFA calculator tool estimates, for a considered farm, the current level of performance concerning biodiversity and ecosystem services, depending on its EFA share and composition. It is then possible for a user to test changes of composition and quantity of the EFA in the farm and to simulate the resulting impact in terms of biodiversity and ecosystem services.

Data reported by Member States to the European Commission on the greening implementation are mainly available at regional scale and not at farm level. Therefore, the JRC has established a methodology that uses the EFA calculator at a different scale of application than the one originally planned. The tool was run at NUTS3 level by simulating EFA farm characteristics that are representative of each analysed NUTS3 region (the 'average farm') using data reported by Member States.

In this way, it is possible to make a rough estimate of the current potential impact of EFA on biodiversity and ecosystem services in a considered NUTS3 region (through the 'average representative farm'). Further analyses were then made to estimate the potential impact of EFA in a considered NUTS3 region, depending on its general natural and semi-natural characteristics.

The EFA calculator is based on a large and robust scientific review. Underlying assumptions for its use at regional level should be kept in mind when analysing the actual quantitative results. Further analyses are needed to test its robustness. Nevertheless, it is currently a useful method to make an early estimate of the potential impact of EFAs.

The EFA calculator was used to make a first assessment of the impact of EFA implementation on biodiversity and ecosystem services. The approach consists in running the EFA calculator considering a NUTS3 region as a single average farm as declared within the corresponding NUTS3 region. The area of each of the EFA types for this NUTS3 farm was derived maintaining the same proportion of the EFA types declared in the NUTS3 region. For this, EFA implementation data for 2015 notified by Member States to the European Commission at NUTS3 level were used (data provided by DG AGRI).

The EFA calculator was run on a sample of 121 NUTS3 regions in 17 Member States (Figure 5).

The **sample** was selected using the following process:

- exclusion of MSs and NUTS3 regions whose data were not notified to the European Commission or presented inconsistencies when the study was carried out (Italy, France, UK-Scotland);

Among the remaining NUTS3 regions (1 053), it was decided that the sample should contain:

- NUTS3 regions covering different percentages of EFA types declared;
- NUTS3 regions in each ecological zone of the EU (Temperate oceanic forest, Temperate continental forest, Temperate mountain, Boreal coniferous forest, Boreal mountain, Sub-tropical dry forest, Sub-tropical mountain, Temperate steppe)
- NUTS3 regions that present potential risk for biodiversity and ecosystem services due to specialist cereals systems or a low level of semi-natural vegetation;
- neighbouring NUTS3 regions (clustering) in order to check that the EFA calculator provides similar outputs for similar NUTS3 regions (i.e. same type of farming systems, landscapes, climate conditions, etc.).
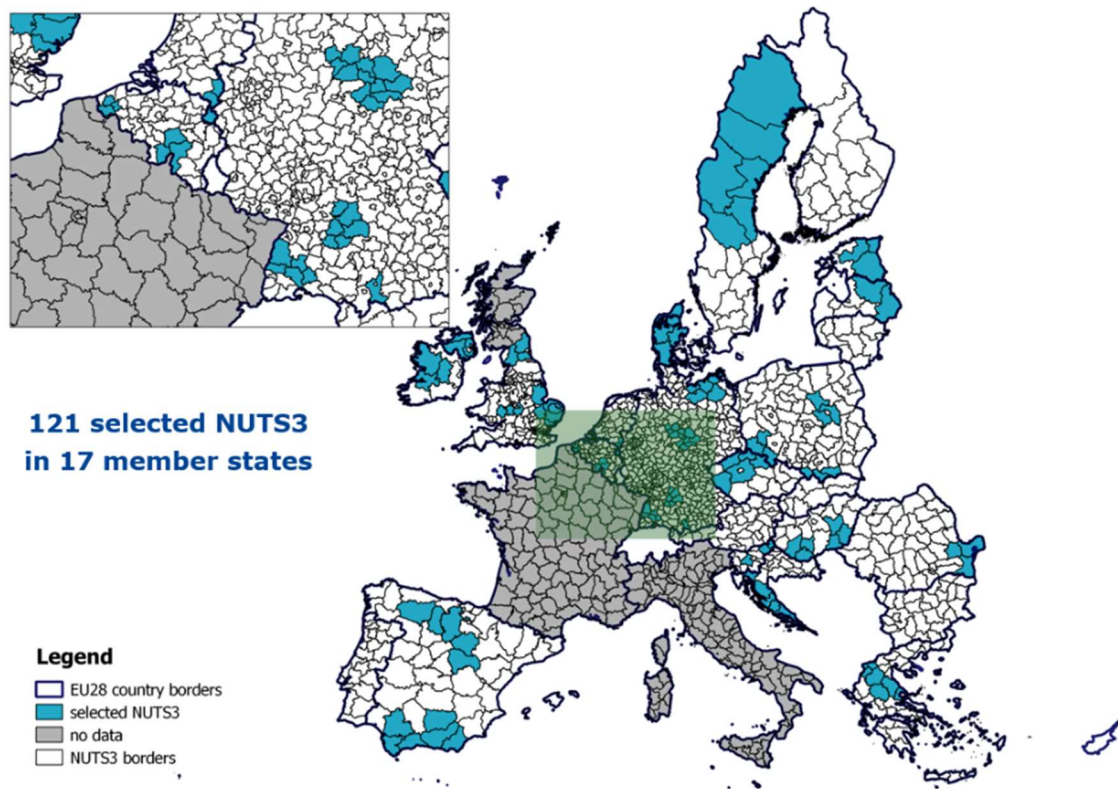
Figure 5 - NUTS3 Regions selected for the study

Among NUTS3 regions selected, some have a high percentage of holdings exempted from EFA (e.g. in Member States with EFA forest exemptions, such as Sweden, Estonia, Latvia or with small holdings such as in the South of Poland). Even if the percentage of the arable land affected by EFA in these regions is low, it was important to include them in the sample as the scores calculated by the tool are influenced by the regional characteristics (soil, climatic data, etc.), and excluding them would have made the sample less representative (some ecological zones would not have been represented). When analysing the results at the territorial level, these regions will be excluded due to the low potential effects that the EFA policy can have in areas where an insignificant amount of holdings implement EFA.

Figure 6 describes the steps of the methodology applied to use the EFA calculator with NUTS3 regions.
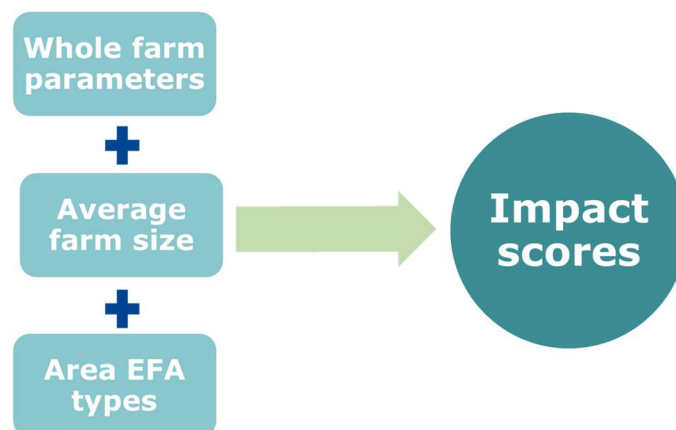
Figure 6 - Schema of the EFA calculator use

1. Characterisation of the NUTS3 farm (whole farm parameters)

In order to characterise the target farm, the EFA calculator requires parameters that describe location, landscape factors, attributes of the features, management practices (e.g. soil texture, climate, ecological zone, adjacent vegetation structure, etc.). These parameters (whole farm parameters) are used to retrieve the potential impact on ecosystem services and biodiversity (as they were determined in the impact assessment).

For the analysis at NUTS3 level, the parameters that could be used are those that describe the NUTS3 regions as a whole: dominant soil texture, prevalent slope class, mean annual rainfall, mean annual precipitation, risk of acid deposition, risk of N deposition, ecological zones, mean annual temperature, mean hydraulic conductivity of the soil, and erosion risk in catchment.

2. Average farm size

The arable area of the NUTS3 farm was calculated as the average arable area of all farms that implement EFA in the specific NUTS3 region.

3. Area of EFA types

The area of each EFA type for this NUTS3 farm was derived maintaining the same proportion of the EFA types declared in the NUTS3 region.

4. Impact scores

The EFA calculator was run for the 121 selected NUTS3 regions. Although results for each NUTS3 region were produced for each ecosystem service and biodiversity group modelled in the software tool, the analysis was carried out for the following impact categories, which are those for which the literature review presents relative strengths.

For <u>biodiversity</u>:

- Biodiversity total impact,
- Biodiversity: amphibians,
- Biodiversity: birds (birds of prey, farmland birds, insectivorous birds, scrubland birds, seed eating birds),
- Biodiversity: invertebrates (bees, butterflies and moths, pollinating invertebrates, soil surface invertebrates),
- Biodiversity: mammals (bats, small mammals),
- Biodiversity: reptiles,
- Biodiversity: terrestrial plants (flowering plants, mosses and liverworts).

For <u>ecosystem services</u> (in brackets, examples of services as they are described by the CICES structure):

- Ecosystem services total impact positive (aggregation of the positive scores for all ecosystem services analysed),
- Ecosystem services total impact negative (aggregation of the negative scores for all ecosystem services analysed),
- Ecosystem service: pollination and seed dispersal (pollination by bees and other insects; seed dispersal by insects, birds and other animals),
- Ecosystem service: pest control (pest and disease control including invasive alien species),
- Ecosystem service: chemical condition of fresh water (maintenance / buffering of chemical composition of freshwater column and sediment to ensure favourable living conditions for biota, e.g. by denitrification, remobilisation/remineralisation of phosphorous, etc.),
- Ecosystem service: mass stabilisation and control of erosion rates (erosion / landslide / gravity flow protection; vegetation cover protecting/stabilising

terrestrial, coastal and marine ecosystems, coastal wetlands, dunes; vegetation on slopes also preventing avalanches (snow, rock), erosion protection of coasts and sediments by mangroves, sea grass, macroalgae, etc.).

It should be noted that:

- comparison of impact scores makes sense only within the same impact category;
- negative impact scores can be obtained for some impact categories (e.g. the implementation of bare fallow on land at risk of erosion).

2.2 Statistical methods

For each of the selected impact factors, two statistical tools were used: the boxplots and the ANOVA test.

A boxplot is a graphic that allows for the visual comparison of different samples or populations at once. For each group, several statistics (first and third quartiles, the median, the range of values within 1.5 times the interquartile range and the potential outliers) are computed and graphically represented.

In Section 3, the positive impacts are always represented with green boxplots. In addition, if both the positive and negative impacts are produced by the EFA calculator, they are represented together in the same graphic, the negative impacts being represented in red.

The ANOVA test (from *analysis of variance*) is a statistical test for assessing whether the observed variability of a variable could be explained by the presence of categories in the population (also called a factor). In practice, the test compares the variability within the categories to the total variability of the population. A large reduction of variability is then considered to be due to the presence of markedly different categories in the population, and is expressed as a low p-value for the test (the threshold of 5% is commonly used).

2.3 Warnings and limits to the use of the calculator

The EFA calculator is a farm-level-based tool which uses literature findings and evidence to build the impact matrix. The impact scoring system draws upon a broad variety of different measures and metrics, which it harmonises using a common scoring scale (-100 to +100). This means that the results are not absolute in numerical terms, but they are relative to the circumstances of the farm described. This also means that the results do not facilitate, especially for biodiversity, assessment of whether one EFA element is generically better than another – this will depend on the circumstances in which it is applied.

To characterise the circumstances of the farm and its landscape context, each feature can be described in terms of its dimensions (e.g. area, length, width, height, etc.), and parameters that describe spatial and management factors are used (e.g. soil texture, climate, ecological zone, adjacent vegetation structure, etc.). When applying the EFA calculator at NUTS3 level, it must be remembered that the parameters that describe the geographical context are considered (even if as an average in the NUTS3 region), while those related to management factors and local landscape conditions (e.g. floral diversity, landscape connectivity etc.) cannot be included.

Additionally, the software tool is structured in a way that not all data has to be entered, but the more that is entered the more accurate the impact assessment will be. In the event that not all data are entered, a range of potential impact values will exist for the feature that can range from best case to worst case scenario. For the NUTS3-level analysis, the software was set to an average case (following the precautionary principle). This allows us to calculate results even if some data are missing. Obviously, the results obtained have

less variability than those that can be calculated in a real farm, as the parameters that refer to specific management factors and local landscape characteristics (e.g. connectivity) can fine-tune the impacts.

Another point to underline, which probably applies to all studies of this nature, is that the evidence for the impacts is variable in terms of quantity and robustness. For some EFA elements, such as hedgerows, there are many studies, for others, such as nitrogen-fixing crops, there is less evidence for some impact categories. It should therefore always be borne in mind that scientific understanding of these issues could be improved.

Tables 1 and 2 provide an overview of the relative level of detail (basic (1), moderate (2) and advanced (3) – shaded cells are not applicable) that was available for each feature-impact combination for ecosystem services and biodiversity respectively. It should be noted that the figures shown in Tables 1 and 2 are generic compilations made to provide an indication of potential strengths and weaknesses of each feature impact.

Table 1 - Relative strength and weakness of EFA features with respect to ecosystem services (strengths are where the average score exceeds 2, and weaknesses are where the average score is 1)

Impact categories	Agroforestry	Ancient monuments	Ancient stones	Archaeological sites	Catch crops or green cover	Ditches	Fallow land	Garrigue	Hedges or wooded strips	Isolated trees	Land strips (adjacent/parallel)	Land strips (other)	Natural monuments	Nitrogen-fixing crops	Ponds	Short rotation coppice	Terraces	Traditional stone walls	Trees in line	Woodland
Aesthetic services		1	1	1		2			2	1			1		2		2	2		2
Heritage and cultural services		1	1	1						1										
Provision of water as a material																	2			3
Provision of water for nutrition																				3
Global climate regulation by reduction of greenhouse gas concentrations																				2
Pollination and seed dispersal	2					1	2	1	2		2	2		2	1	2				1
Pest control	2				3		2		1					2		2			1	
Chemical condition of freshwaters					3										3					3
Microbial/pathogen run-off											3									
Nitrate leaching	3			3		3								3		3				
Nitrogen run-off											3									
Pesticide drift									2		2								2	
Phosphate run-off	3			3		3			3							3				3
Sediment-bound pesticides											3									
Soluble pesticide run-off											3									
Flood protection						2														2
Mass stabilisation and control of soil erosion	3			3		3			3							3	3	3		3
Filtration/sequestration by flora and fauna									1		1								1	
Mediation of smell/noise/visual impacts									1										1	

Table 2- Relative strength and weakness of EFA features with respect to biodiversity (strengths are where the average score exceeds 2 and weaknesses are where the average score is 1)

Impact categories	Agroforestry	Ancient monuments	Ancient stones	Archaeological sites	Catch crops or green cover	Ditches	Fallow land	Garrigue	Hedges or wooded strips	Isolated trees	Land strips (adjacent/parallel)	Land strips (other)	Natural monuments	Nitrogen-fixing crops	Ponds	Short rotation coppice	Terraces	Traditional stone walls	Trees in line	Woodland
Amphibians	3				3	1	3			2	3	3		3	3	3				
Aquatic plants: All						2									3					
Aquatic plants: Emergent aquatic plants						2									2					
Aquatic plants: Submerged and floating aquatic plants						1									1					
Biodiversity (general)						1									3					1
Birds: All						1			3	1					3			2	1	3
Birds: Birds of prey	3				3		3				3	3		3		3				
Birds: Farmland birds									1											
Birds: Insectivorous birds	3				3		3				3	3		3		3				
Birds: Scrubland birds									1											
Birds: Seed-eating birds	3				3		3				3	3		3		3				
Birds: Waders															1					
Birds: Woodland birds									1											
Fish						1									2					
Fungi			1															1		1
Invertebrates: All								1	1	2										2
Aquatic invertebrates: All						1									3					
Aquatic invertebrates: Crustaceans						1														
Aquatic invertebrates: Molluscs															1					
Arachnids																				1
Invertebrates: Bees									2									1		1
Invertebrates: Beetles (canopy coleoptera)																				1
Invertebrates: Beetles (carabids)																		1		1
Invertebrates: Butterflies and moths									1									1		2
Invertebrates: Dragonflies and damselflies (Odonata)															2			1		

Impact categories	Agroforestry	Ancient monuments	Ancient stones	Archaeological sites	Catch crops or green cover	Ditches	Fallow land	Garrigue	Hedges or wooded strips	Isolated trees	Land strips (adjacent/parallel)	Land strips (other)	Natural monuments	Nitrogen-fixing crops	Ponds	Short rotation coppice	Terraces	Traditional stone walls	Trees in line	Woodland
																				Features
Invertebrates: Hoverflies and hoppers															2					1
Invertebrates: Pollinating invertebrates	3					3					3	3		3		3		1		
Invertebrates: Snails			1															1		
Invertebrates: Soil surface invertebrates	3			3		3					3	3		3		3				
Lichens																		1		1
Mammals: All						1		1	1						2					2
Mammals: Bats	3					3			2	2	3	3		3		3				
Mammals: Small mammals (mice, shrews, voles)	3			3		3					3	3		3		3		1		
Reptiles	3		1	3		3	1			2	3	3		3		3	2	1		
Terrestrial plants: All					1															
Terrestrial plants: Conifers																				1
Terrestrial plants: Ferns																		2		1
Terrestrial plants: Flowering plants	3			3		3	1	1	1		3	3		3		3				3
Terrestrial plants: Mosses and liverworts			1					1	1									2		1

With regard to the features, the greatest strengths are, not surprisingly, associated with features that could be considered land management activities or are known to be important features in the landscape (agroforestry, catch crops, fallow land, land strips, nitrogen-fixing crops).

With regard to impacts, the priority ecosystem services used in the analysis (pollination, pest control, water quality control and soil erosion) are covered from a moderate to advanced level. For ecosystem services, the strengths provided in Table 1 reflect the good amount of literature and knowledge that are available relating to land use and ecosystem services (i.e. knowledge on water flows, pollutants and soil erosion).

With regard to impacts on biodiversity, the strengths seem to reflect the available literature (i.e. cover some of the key species groups: amphibians, birds, invertebrates, mammals, plants and reptiles). The weaknesses for biodiversity appear to relate to more species-specific impacts, as the level of detail tended to be lower. However, it must also be remembered that the data in Table 2 needs to be interpreted in the context of the impact hierarchy. For example, farmland, scrubland and woodland birds are impacts associated with hedgerows and have been flagged up as a weakness here. However, there is also detailed information on hedgerows for the impact category 'Birds: All', of which farmland, scrubland and woodland birds are sub-impacts in the impact hierarchy. Thus, they simply strengthen the detail, and perhaps should not be viewed as a weakness in the knowledge base. The case is similar for invertebrates and aquatic plants.

2.4 Spatial distribution of EFA percentage declared

EFA implementation data for 2015 notified by Member States to the European Commission shows that, in many NUTS3 regions, the actual declared EFA area is much higher than the minimum 5% requested by the legislation. As an average, in all EU NUTS3 where data were available and reliable, the EFA declared (after applying the weighting factor) represents on average 9.4% of the arable land (Figure 7).
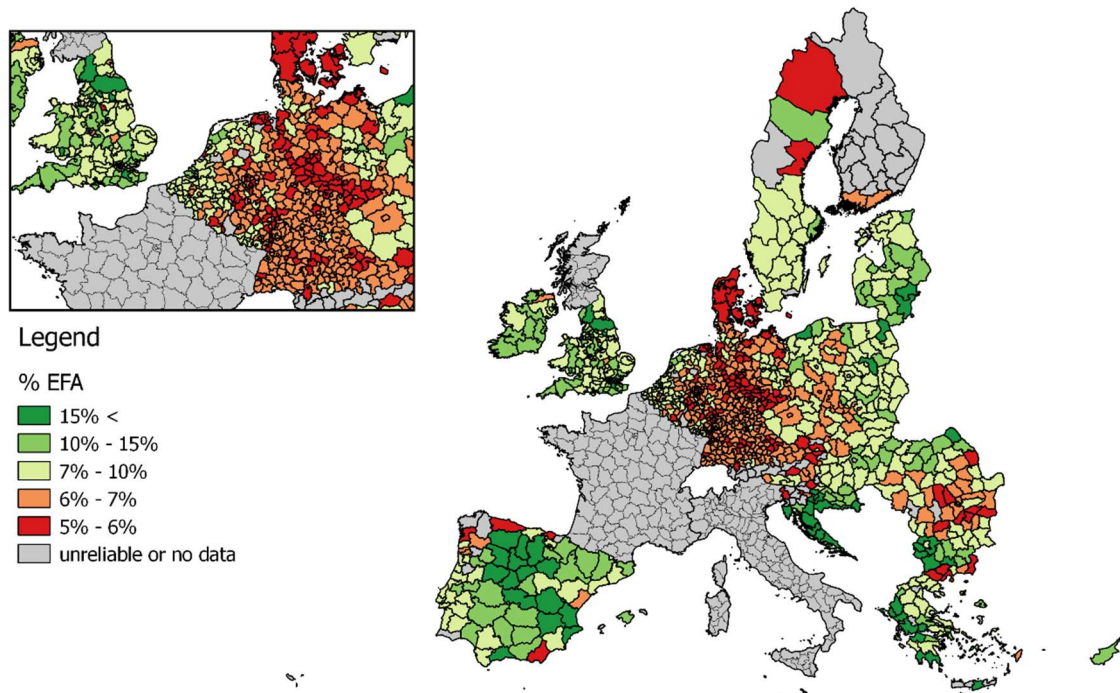
Figure 7- Implemented EFA share of arable land in the NUTS3 regions

The composition of the EFA types in relation to the percentage of the EFA declared was analysed for all NUTS3 regions, excluding those with unreliable data or with an EFA percentage greater than 15%. It is interesting to observe that farmers seem to use and declare EFA types differently depending on the percentage of EFA reached (Figure 8).

For the NUTS3 regions where the EFA declared was between 5 and 6% (lower share of EFA implemented), catch crops is the most used EFA type. The percentage of catch crops starts to decline in the NUTS3 regions with a percentage of EFA greater than 8%. In the NUTS3 regions with a higher percentage of EFA (from 10 to 15%), the percentage of landscape features and nitrogen-fixing crops declared increases, while the percentage of catch crops decreases. The contribution of land laying fallow on EFA appears to remain stable (around 30%) for the NUTS3 regions with a lower EFA percentage, but starts to increase when the EFA percentage reaches 9%; it becomes very high (around 60%) in NUTS3 regions where the EFA percentage is more than 15%.

Figure 9 shows the areas of the most common EFA types in relation to the EFA percentage declared, calculated before the application of the weighting factor. It displays the real presence on the ground of the different EFA types. Figure 10 shows the areas of the most common EFA types after the application of the weighting factor.

These data suggest that catch crops are mainly used to reach the requested 5% threshold. One can also assume that landscape features are not systematically declared, even if they are present. This behaviour should be better analysed with case studies. Furthermore, it should be considered that this distribution could also depend on the combinations that may exist between the EFA percentage and the list of EFA types available to farmers (Member State options on the EFA list can limit farmers' uptake).
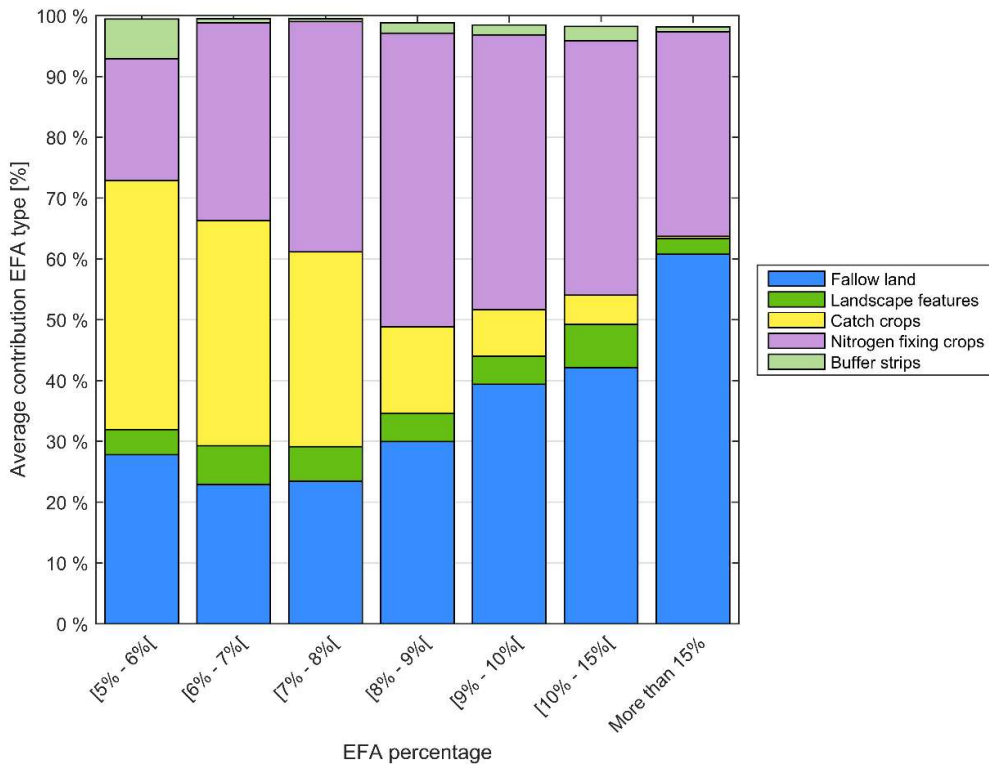
Figure 8 – Percentage distribution of the most common EFA types in all NUTS3 regions with reliable data in relation to the EFA percentage declared (not limited to the 121 NUTS sample)
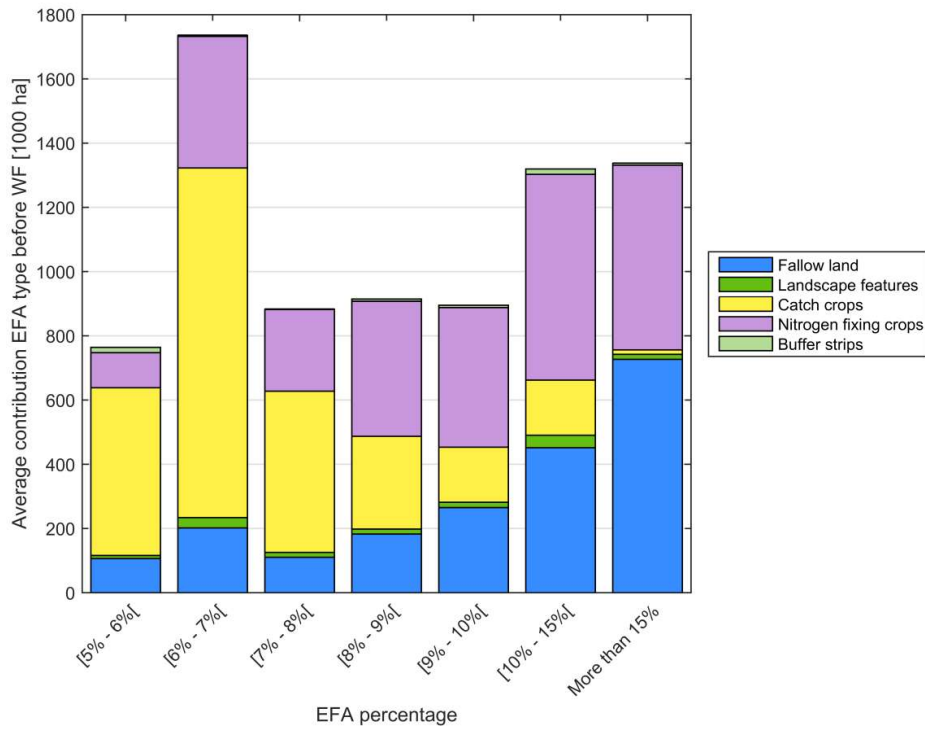
Figure 9 - Area (before weighting factor) of the most common EFA types in all NUTS3 regions with reliable data in relation to the EFA percentage declared (not limited to the 121 NUTS sample)
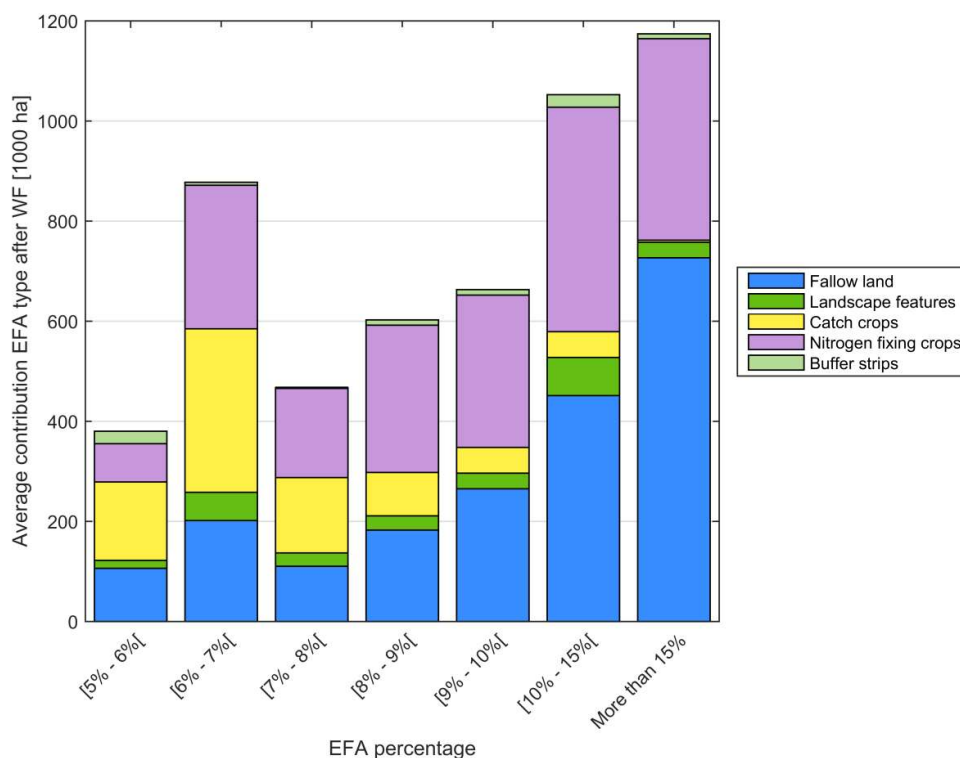
Figure 10 - Area (after weighting factor) of the most common EFA types in all NUTS3 regions with reliable data in relation to the EFA percentage declared (not limited to the 121 NUTS sample)

2.5 Classification of NUTS3 regions according to the composition of the EFA types

Data on the implementation of EFA shows that catch crops (CC), nitrogen-fixing crops (NFC) and land laying fallow (LLF) were the EFA types most often declared by farmers to fulfil their EFA requirements in 2015. Nevertheless, some NUTS3 regions were also covered with a high share of other EFA types, such as landscape features (LF) or buffer strips (BS).

On the basis of the notified data, NUTS3 regions with no or unreliable data were excluded from the analysis. All remaining 926 NUTS3 regions were first automatically classified using the k-means clustering algorithm on the distribution of the EFA types declared. A test was made by varying of the number of clusters in the algorithm. It appeared that using nine clusters was the optimal configuration (i.e. optimal compromise between homogeneity within the clusters and heterogeneity between the clusters, while keeping the number of clusters low). These nine clusters were distributed as:

-   six clusters with high cumulated percentages of CC, NFC and LLF
-   three clusters with high cumulated percentages of LF and BS

It must be noted that in the NUTS3 regions with a high proportion of LF, LF are essentially represented by hedges.

Based on this first exploratory analysis, the final categories were defined in rounded percentages of EFA types declared as reported in Table 3 and Figure 11. All NUTS3 regions with data (1 053) were classified according to the nine categories (the presence of some inconsistencies in the NUTS3 regions data was not considered to be significant for the designation in the category groups).

Table 3 - Classification of NUTS3 regions in relation to the proportion of EFA types declared (LLF - land laying fallow, CC - catch crops, NFC – nitrogen-fixing crops, LF - landscape features, BS - buffer strips)

Category	First sub-division	Second sub-division	Occurrence	EFA Area after WF [1 000 ha]	Occurrence in sample	EFA Area after WF in sample [1 000 ha]
1	LLF+CC+NFC < 80%	LF ≥ 50%	52	166.02	7 (13.5%)	17.80 (10.7%)
2	LLF+CC+NFC < 80%	LF < 50% BS < LF	72	186.06	9 (12.5%)	68.06 (36.6%)
3	LLF+CC+NFC < 80%	LF < 50% LF < BS	19	162.98	6 (31.6%)	111.33 (68.3%)
4	LLF+CC+NFC ≥ 80%	LLF ≥ 70%	98	759.87	9 (9.2%)	200.47 (26.4%)
5	LLF+CC+NFC ≥ 80%	CC ≥ 70%	144	233.74	13 (9.0%)	33.84 (14.5%)
6	LLF+CC+NFC ≥ 80%	NFC ≥ 70%	73	403.37	7 (9.6%)	83.42 (20.7%)
7	LLF+CC+NFC ≥ 80%	LLF < 30% mix of CC and NFC	231	1 055.07	17 (7.4%)	144.02 (13.7%)
8	LLF+CC+NFC ≥ 80%	30% < LLF < 70% NFC > CC	222	2 075.83	25 (11.3%)	427.83 (20.6%)
9	LLF+CC+NFC ≥ 80%	30% < LLF < 70% NFC < CC	142	278.54	15 (10.6%)	76.58 (27.5%)
TOTAL NUTS3 REGIONS			**1 053**	**5 321.48**	**121 (11.5%)**	**1 163.35 (21.9%)**
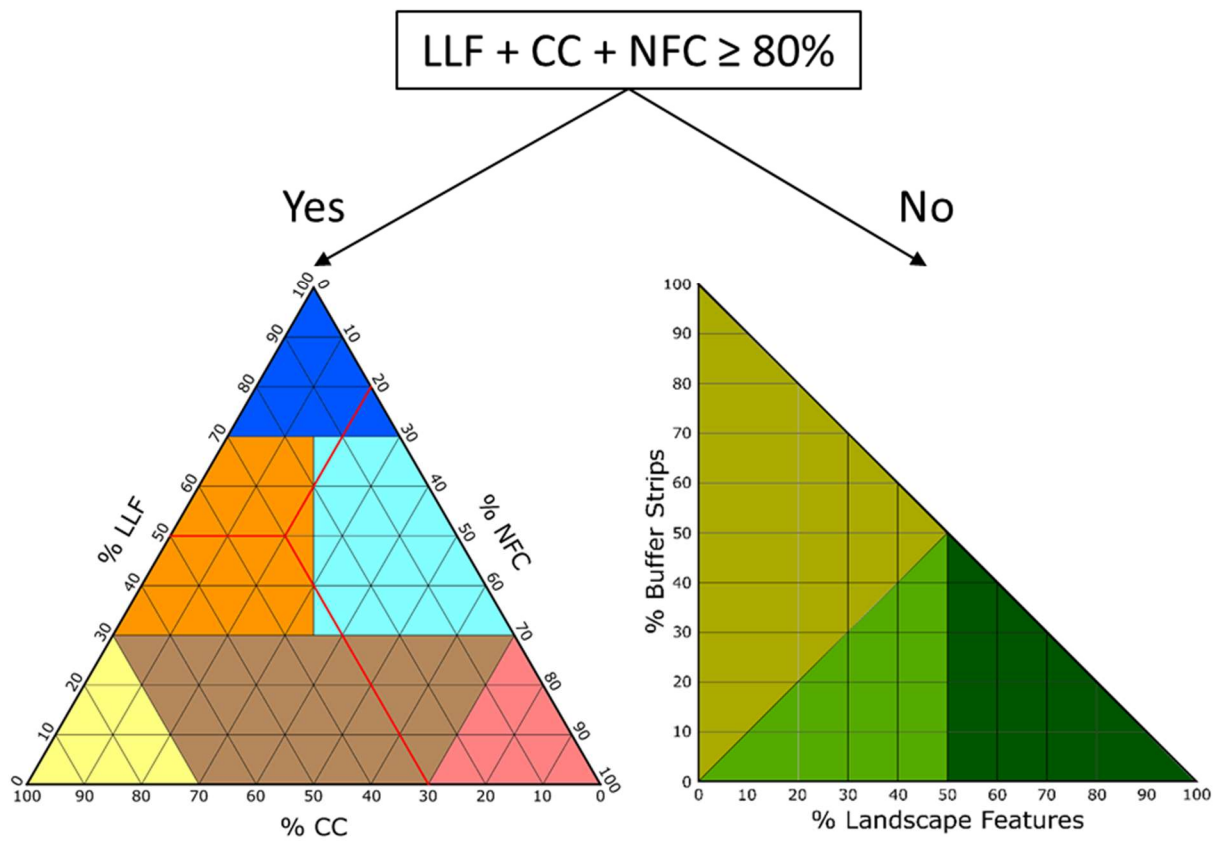
Figure 11 - Visual representation of the nine categories defined among the LLF (land laying fallow), CC (catch crops), NFC (nitrogen-fixing crops).
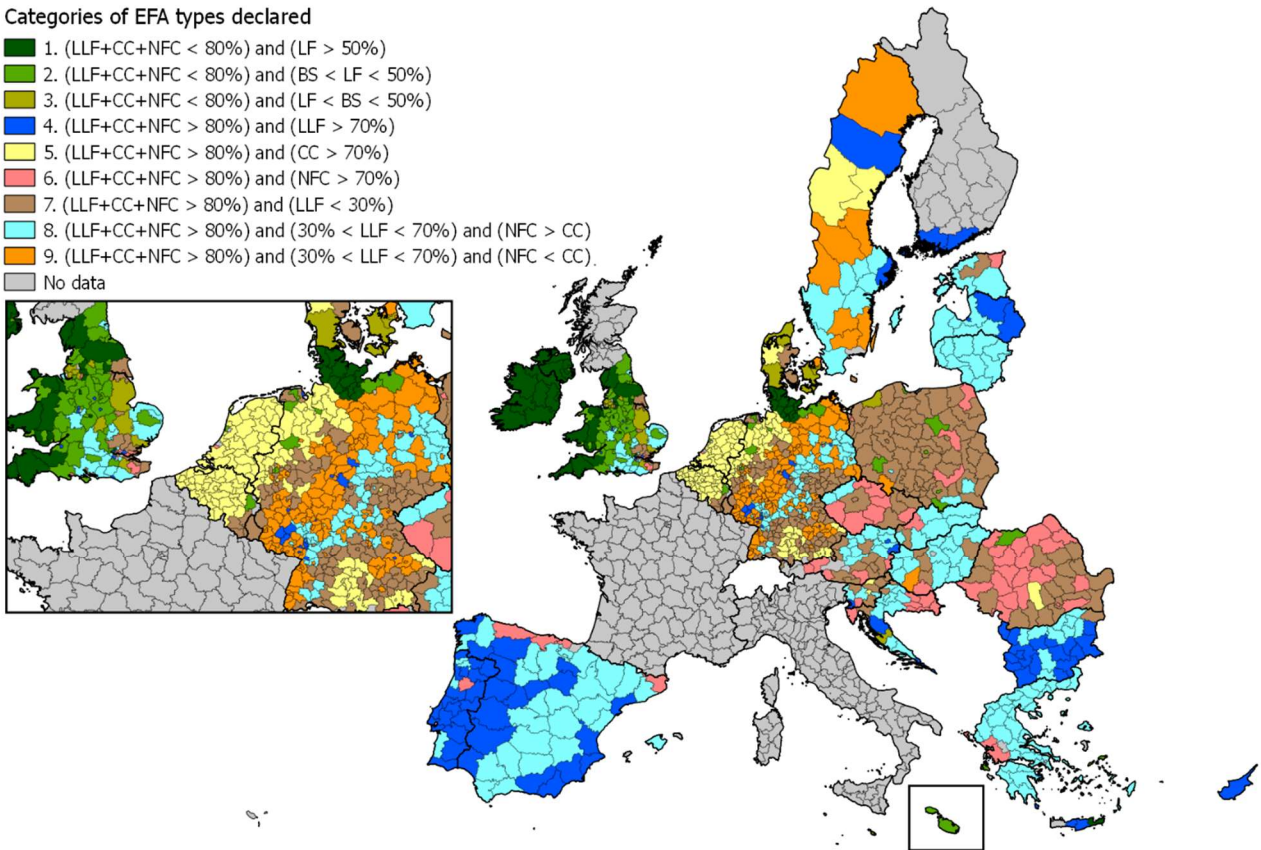
Figure 12 - Spatial distribution of the categories attributed for each NUTS3 region (no data for France, Italy and Scotland).

Figure 12 shows the spatial distribution of the categories attributed for each NUTS3 region. It gives a clear indication of how the different categories are distributed in the Member States. In some Member States, one category is sufficient to describe the composition of EFA declared in the country (e.g. Poland, Netherlands, Lithuania and Ireland). Table 4 shows the different categories per Member State and the total EFA declared.

Table 4 - Percentage of declared EFA (area after weighting factor) with respect to the nine categories of EFA distribution in the Member States

Member State	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Cat 6	Cat 7	Cat 8	Cat 9	Total EFA area after WF [1 000 ha]
Austria	0	0	0	0	0	6	53	41	0	20.68
Belgium	0	0	0	0	98	0	2	0	0	52.72
Bulgaria	0	0	0	54	0	0	7	38	0	233.31
Croatia	0	0	0	1	0	71	2	26	0	99.53
Cyprus	0	0	0	100	0	0	0	0	0	8.57
Czech Republic	0	0	0	0	0	48	47	5	0	174.54
Denmark	0	0	58	0	16	0	23	0	2	109.91
Estonia	0	0	0	0	0	0	43	57	0	30.55
Finland	0	0	0	100	0	0	0	0	0	26.77
Germany	6	4	0	1	16	0	23	15	35	688.72
Greece	0	0	0	0	0	1	0	98	0	80.55
Hungary	0	0	0	0	0	6	19	70	5	332.34
Ireland	100	0	0	0	0	0	0	0	0	40.36
Latvia	0	0	0	40	0	0	0	60	0	81.00
Lithuania	0	0	0	0	0	0	0	100	0	208.58
Luxembourg	0	0	0	0	0	0	100	0	0	2.93
Malta	0	100	0	0	0	0	0	0	0	0.02
Netherlands	0	0	0	0	100	0	0	0	0	51.24
Poland	0	4	3	0	0	6	84	0	2	508.39
Portugal	0	0	0	94	0	0	0	6	0	53.52
Romania	0	0	0	0	1	45	53	0	0	350.4
Slovakia	0	0	0	0	0	7	17	76	0	90.3
Slovenia	0	0	0	0	0	0	86	14	0	2.92
Spain	0	0	0	33	0	0	0	66	0	1 510.85
Sweden	0	0	0	4	0	0	0	89	7	113.92
United Kingdom	19	32	19	0	0	1	11	18	0	431.00

3 Results

The EFA calculator was run only for the NUTS3 regions which are part of the sample, and results were analysed for each of the categories defined in Table 3.

3.1 Potential impacts on biodiversity and ecosystem services for different categories of NUTS3 regions

3.1.1 Biodiversity

The score for biodiversity of the 121 NUTS3 regions were analysed using the boxplot aggregating the population of NUTS3 according to the nine categories defined above.

It should be highlighted that this type of analysis is the result of two components that influence impact scores: the composition of the EFA types (scores depend on the impact of each EFA type) and the geographical variability (general characteristics of the NUTS3 region influence impacts).

The total scores for biodiversity are the results of the aggregation and normalisation process of the impacts for the different EUNIS species groups (EEA, 2015b). These species groups are: amphibians, aquatic plants, birds, fishes, fungi, invertebrates, lichens, mammals, reptiles, and terrestrial plants.

Figure 13 shows total scores of biodiversity for the nine categories of NUTS3 regions. As described in the methodological paragraphs, these scores, as well as all scores discussed in this chapter, should not be considered as absolute values of the actual impact of EFA implementation on biodiversity, but they represent the potential impact on biodiversity of the EFA type composition that was declared in the NUTS3 region. They can be used in order to compare how different compositions of EFA types declared can potentially affect biodiversity.

It is evident from the boxplot that category 1 (where landscape features account for more than 50% of EFA declared) performs much better than the others. Category 4 (more than 70% of EFA is land laying fallow) also presents good scores. Lowest scores are obtained for category 5 (more than 70% of EFA declared as catch crop).

The influence of the EFA type distribution on the impact scores is high, as confirmed by the p-value of the ANOVA test (observed p-value is less than 0.01%). In fact, a great reduction in variability (the presence of markedly different categories in the population) is confirmed for all analyses presented hereafter on biodiversity species groups.
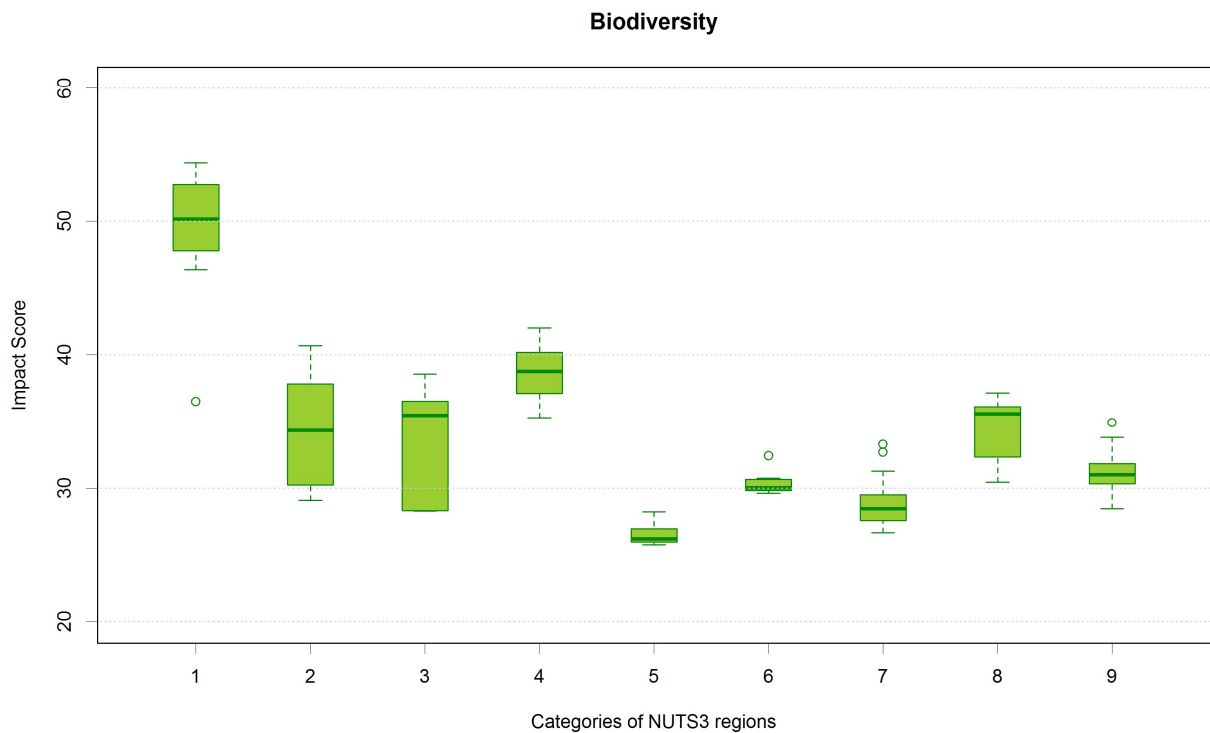
Biodiversity

Figure 13 - Potential impact on biodiversity of categories of NUTS3 regions.

When results are analysed disaggregated per EUNIS species group, similar trends are confirmed for different species groups such as invertebrates (Figure 14) (this group presents the species most interesting for pollination and it includes bees, butterflies and moths, pollinating invertebrates, soil invertebrates), birds (Figure 15) and terrestrial plants (Figure 16).

For reptiles (Figure 17) and amphibians (Figure 18), NUTS3 categories with a greater presence of buffer strips and fallow land perform better. Please note that the scores represent potential impacts generated by average regional data and are not based on specific characteristics, management practices and landscape conditions of a real farm. This means that the scores represent different degrees of conditions that can support the presence of the species group, but they do not obviously indicate their real presence.
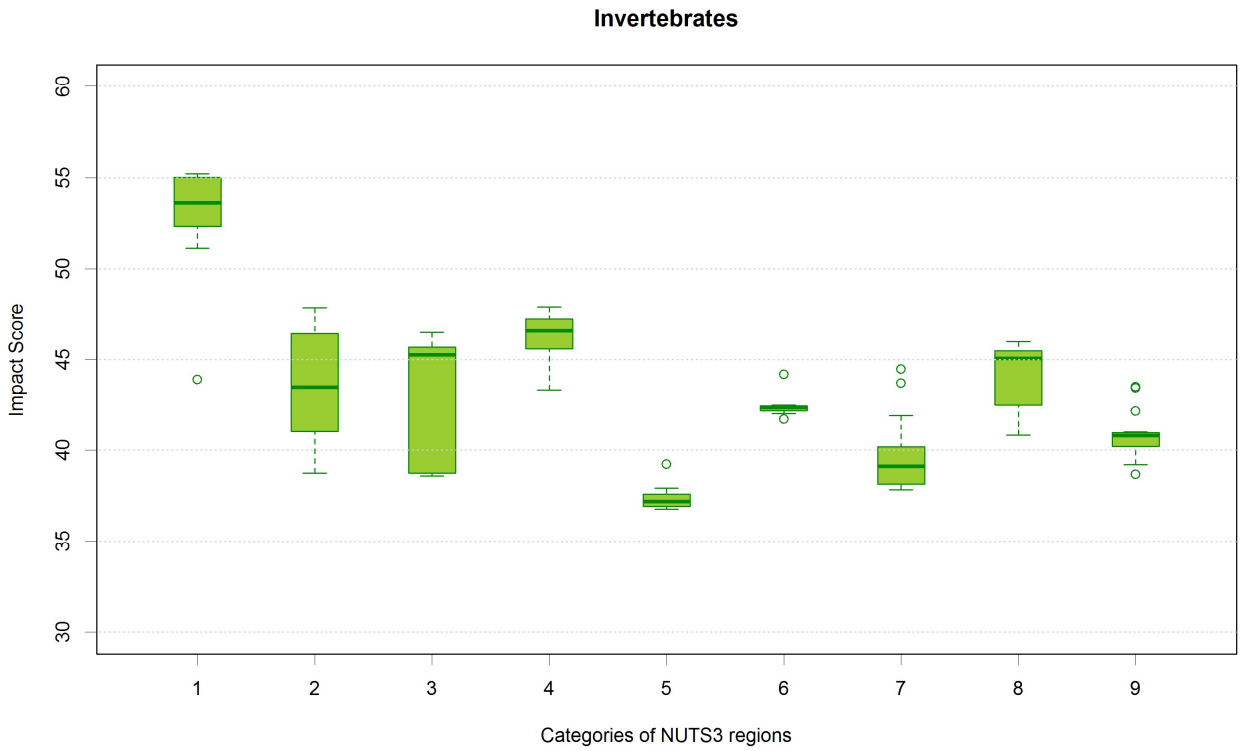
Invertebrates

Figure 14 - Potential impact on invertebrates of categories of NUTS3 regions.
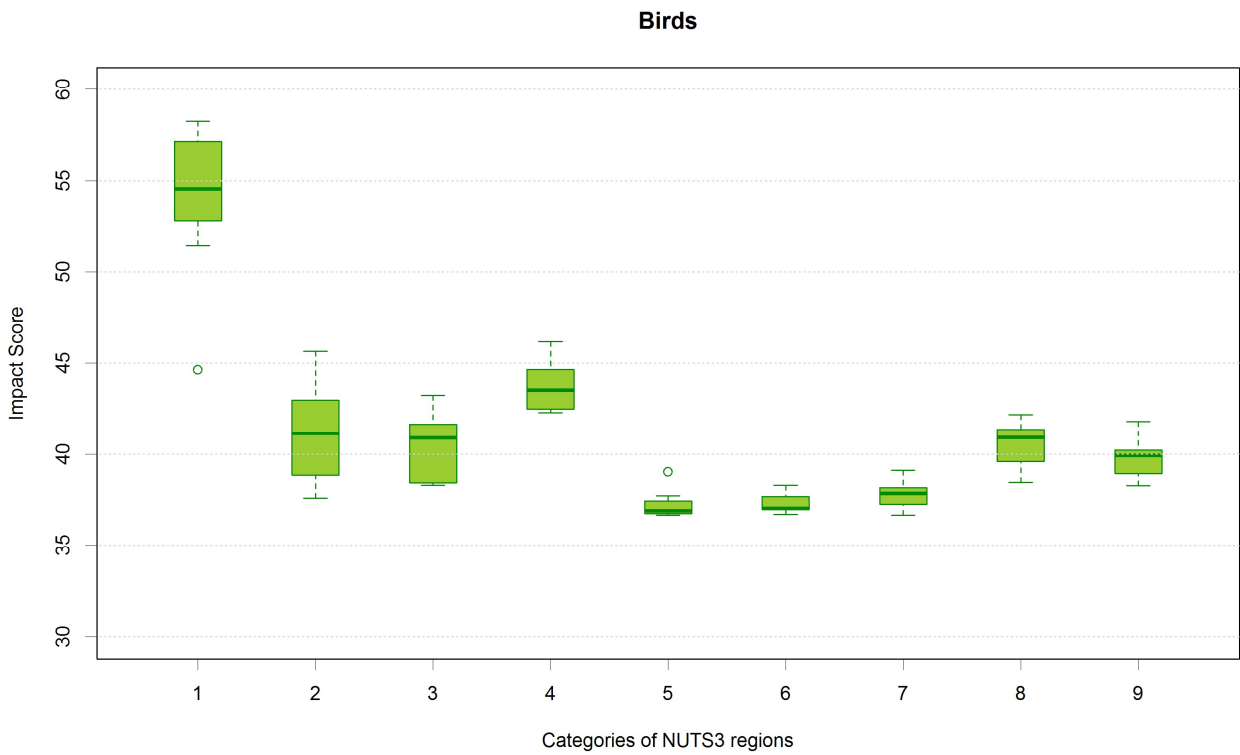
Birds

Figure 15 - Potential impact on birds of categories of NUTS3 regions

Terrestrial plants
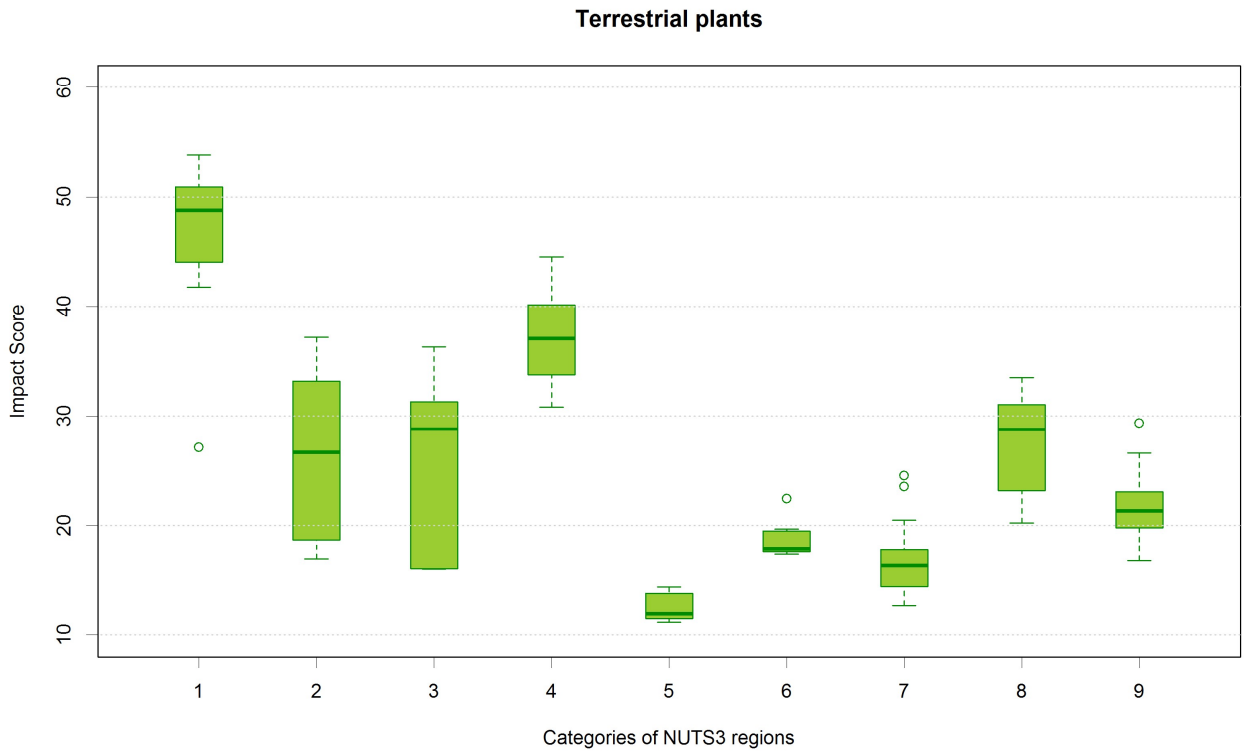
Figure 16 - Potential impact on terrestrial plants of categories of NUTS3 regions
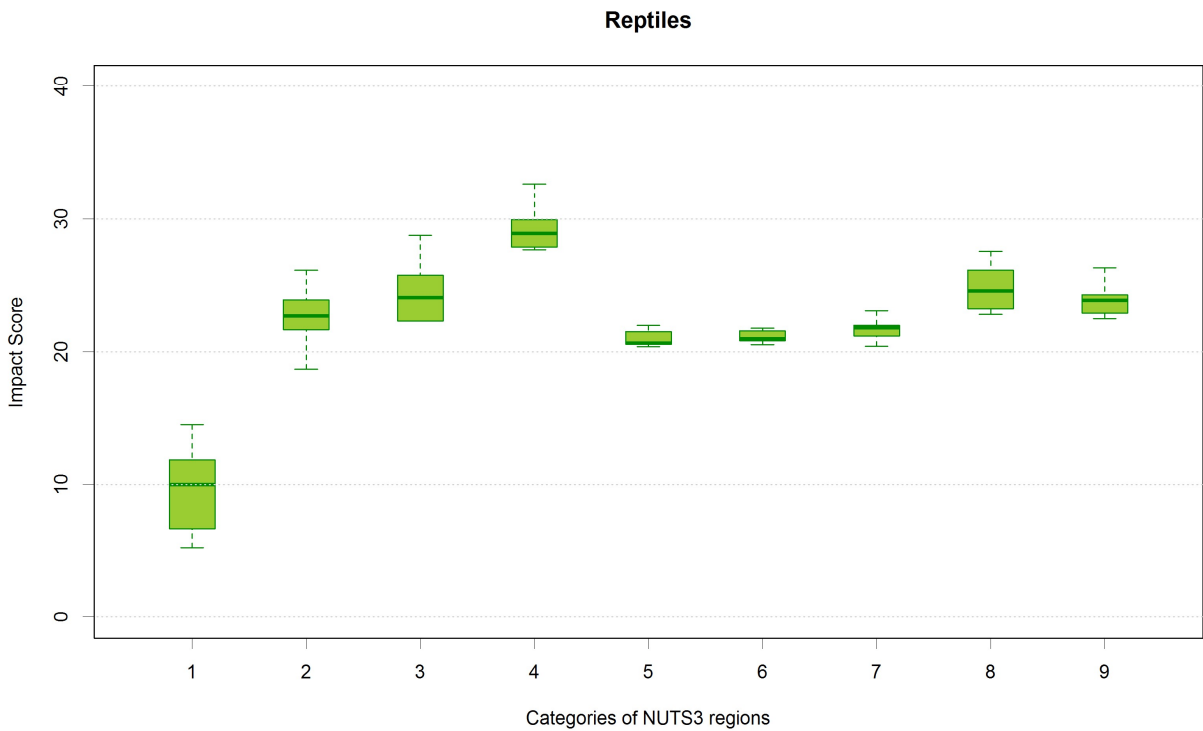
Reptiles

Figure 17 - Potential impact on reptiles of categories of NUTS3 regions
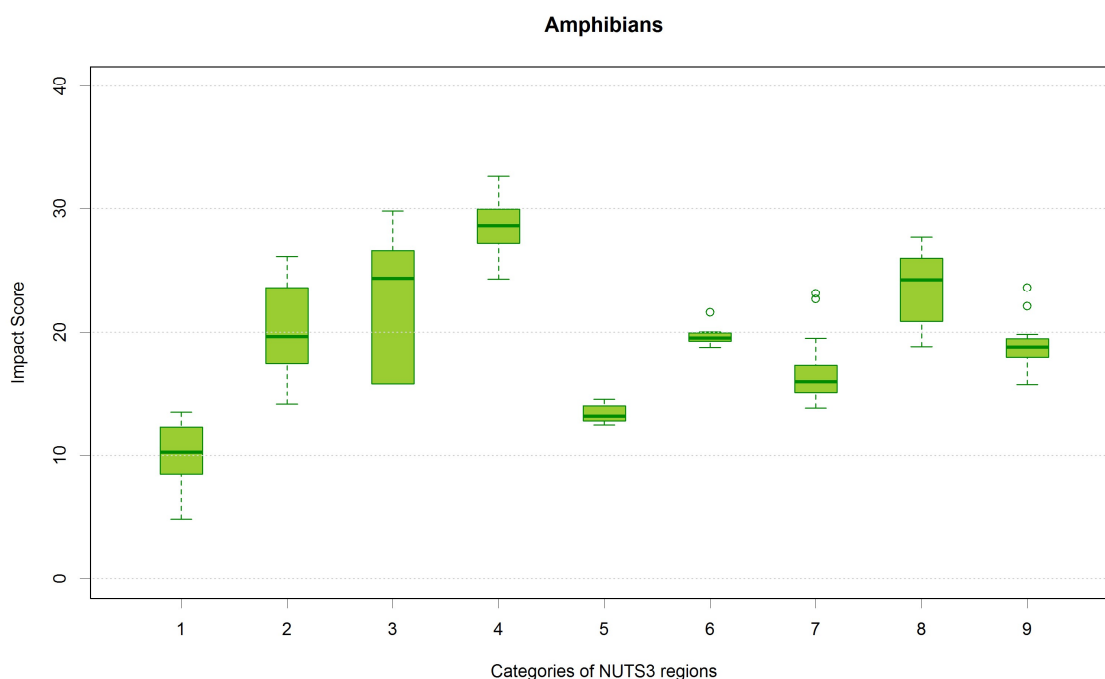
Amphibians

Figure 18 - Potential impact on amphibians of categories of NUTS3 regions

3.1.2 Ecosystem services

The analysis was also carried out for ecosystem services, and scores have been analysed for the population of NUTS3 regions in the sample for the nine categories defined.

For some ecosystem services, such as regulating the chemical condition of freshwaters and control of erosion rates, negative scores can result from negative impacts (e.g. bare fallow land in sloped areas prone to erosion). It must be noted that negative scores are generally much lower than positive ones.

Figure 19 shows the positive and negatives scores obtained by the nine categories of NUTS3 regions for the total of ecosystem services analysed. The total positive impact scores for ecosystem services show that, as obtained for biodiversity, category 1 (where landscape features account for more than 50% of EFA declared) performs much better than the others. Similar positive scores are calculated for all remaining categories, with slightly lower scores for category 6 (where nitrogen-fixing crops account for more than 70% of the EFA declared). Negative scores are generally low, except for categories 4 (land laying fallow accounting for more than 70% of the EFA declared) and 8 (high presence of nitrogen-fixing crops and land laying fallow).

As for biodiversity, the influence of the EFA-type distribution on the impact scores is high, as confirmed by the p-value of the ANOVA test (observed p-value is less than 0.01%). The only case with a slightly less significant influence was observed for the ecosystem service "Control of erosion rates negative impact", with a p-value equal to 1.6%, which remains under the 5% threshold.

To better illustrate these results, scores are calculated for four ecosystem services. The results are shown in Figures 20 to 23.

The ecosystem services considered are the following:

• chemical condition of freshwaters (considering nitrate leaching to surface and groundwater),

- mass stabilisation and control of erosion rates,
- pest and disease control,
- pollination and seed dispersal.

Impact scores for the <u>chemical condition of freshwaters</u> are shown in Figure 20. Higher impact scores were obtained again in NUTS3 regions were landscape features represent more than 50% of the EFA declared (category 1). Fairly positive scores are also obtained for NUTS3 regions where catch crops constitute more than 70% of the EFA declared (category 5). Lower impact scores are obtained in NUTS3 regions with a predominance of land laying fallow and nitrogen-fixing crops. In mixed categories, scores increase as the percentage of land laying fallow decreases. From these results one can see that some EFA types (e.g. catch crops) with a general low positive impact for biodiversity can pay back in terms of some ecosystem services.

Ecosystem Services
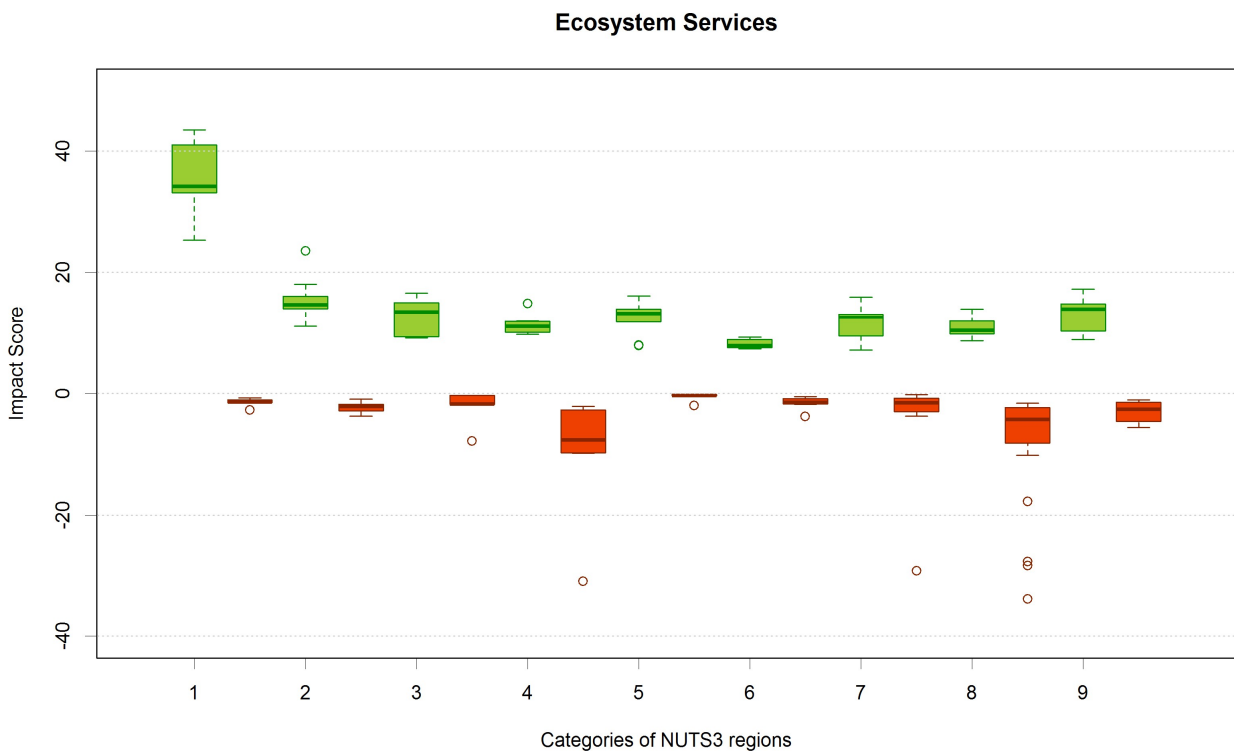
Figure 19 - Potential impact on ecosystem services of categories of NUTS3 regions. Scores for positive impacts are in green, scores for negative impacts in red.

Chemical condition of freshwaters
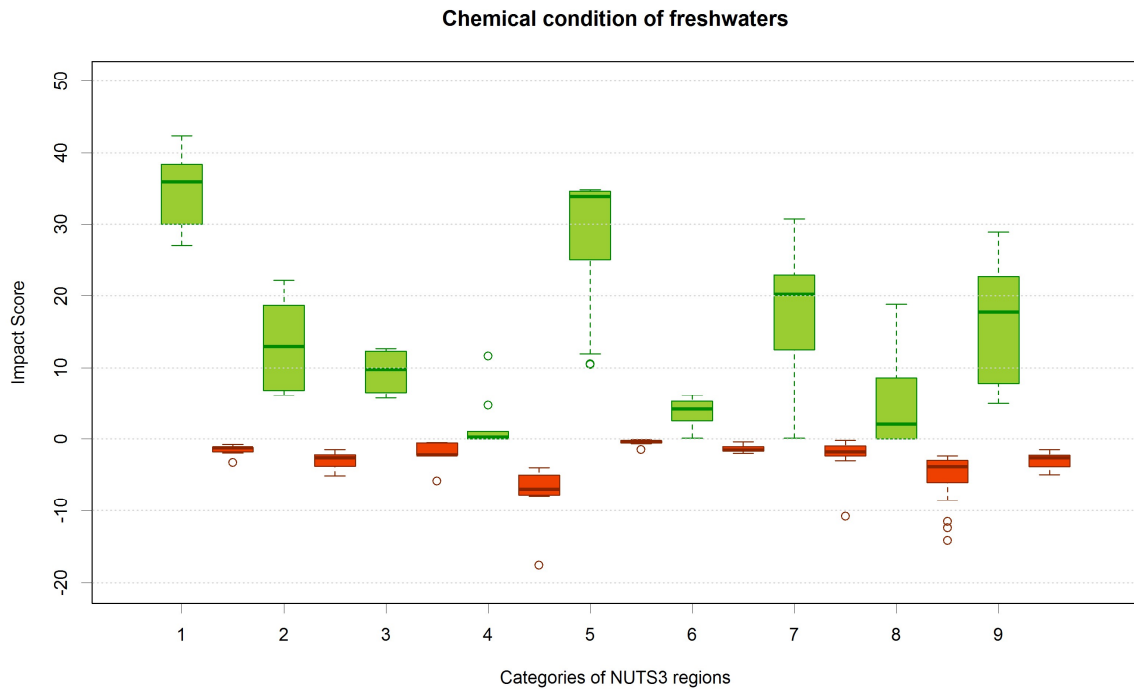
Figure 20 - Potential impact on the ecosystem service of regulating the chemical condition of freshwaters of categories of NUTS3 regions. Scores for positive impacts are in green, scores for negative impacts in red.

Mass stabilisation and control of erosion rates
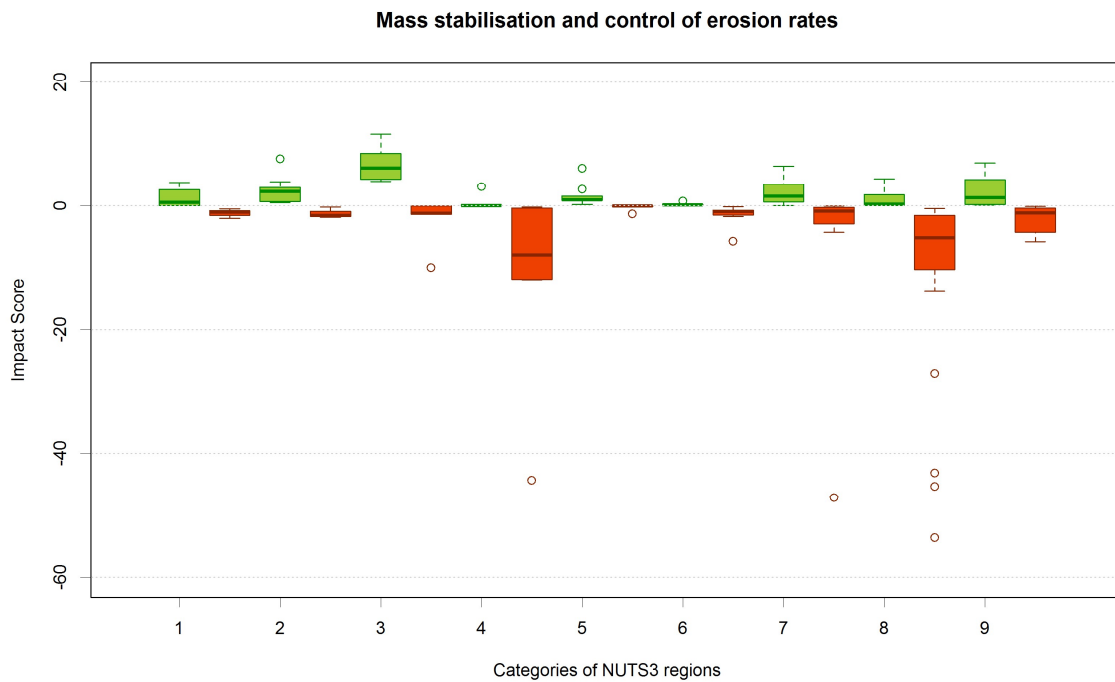
Figure 21 - Potential impact on the ecosystem service of mass stabilisation and control of erosion rates. Scores for positive impacts are in green, scores for negative impacts in red.

Impact scores for the ecosystem service <u>mass stabilisation and control of erosion rates</u> are generally very low, with almost no degree of variability among different categories of NUTS3 regions (Figure 21). These scores are too small and uniform to draw conclusions of the impacts of different categories of NUTS3 regions, probably because these impacts are greater depending on local conditions (such as ground-cover type) which are not taken into account in the analysis at NUTS3 level. Only for categories that contain a high percentage of buffer strips, can positive impact scores be considered slightly greater than those obtained for all other categories. Some negative impact scores calculated for classes with a prevalence of land laying fallow can be observed, but no general conclusion can be drawn as they largely depend on the ground-cover type, as expained above.
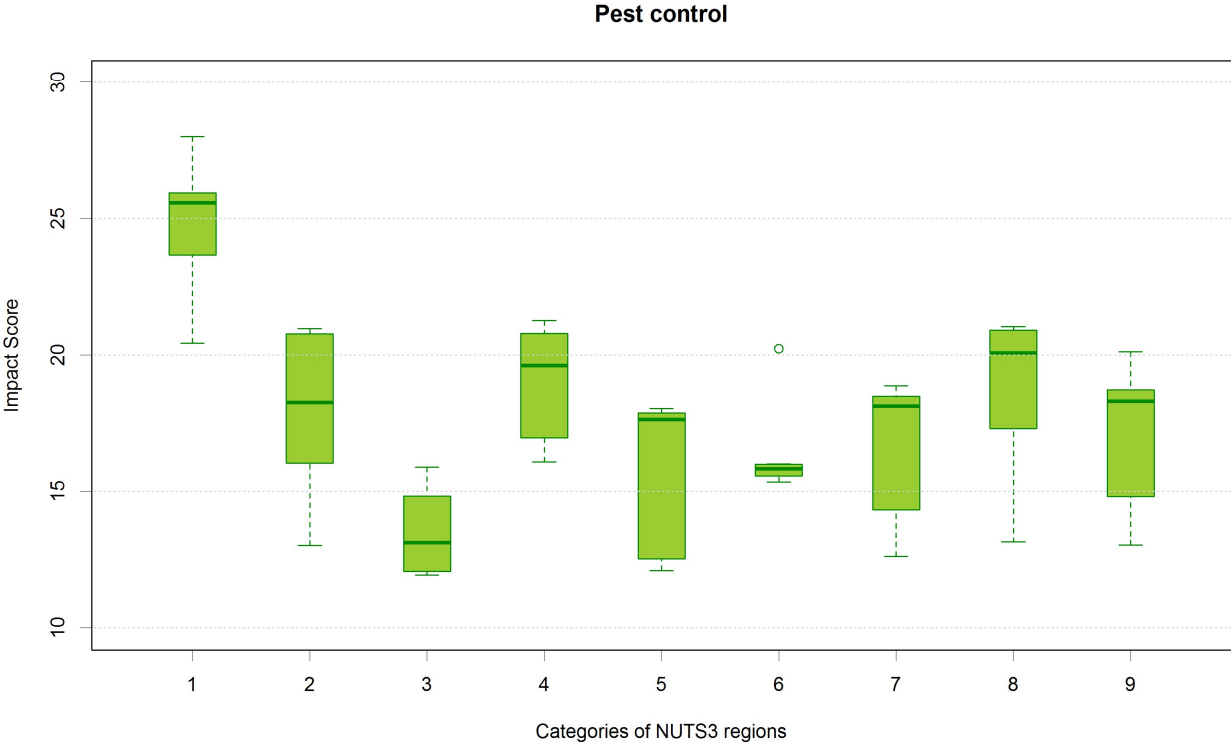
Pest control

Figure 22 - Potential impact on the pest control ecosystem service of categories of NUTS3 regions.

Pest control and pollination are ecosystem services that are highly relevant for ensuring food production. Natural enemies that control agricultural pests provide a service by regulating pest populations; they provide value to farmers and consumers by protecting crop yields and reducing the need for chemical pest control. The scores calculated for the ecosystem service of <u>pest control</u> try to assess these aspects.

Scores obtained by the different categories of NUTS3 regions show that NUTS3 regions where landscape features are greater than 50% of the total EFA declared perform better (Figure 22). Among the remaining categories, scores are generally low and their distribution quite uniform, with some positive impacts linked to the presence of fallow land.

Pollination and seed dispersal
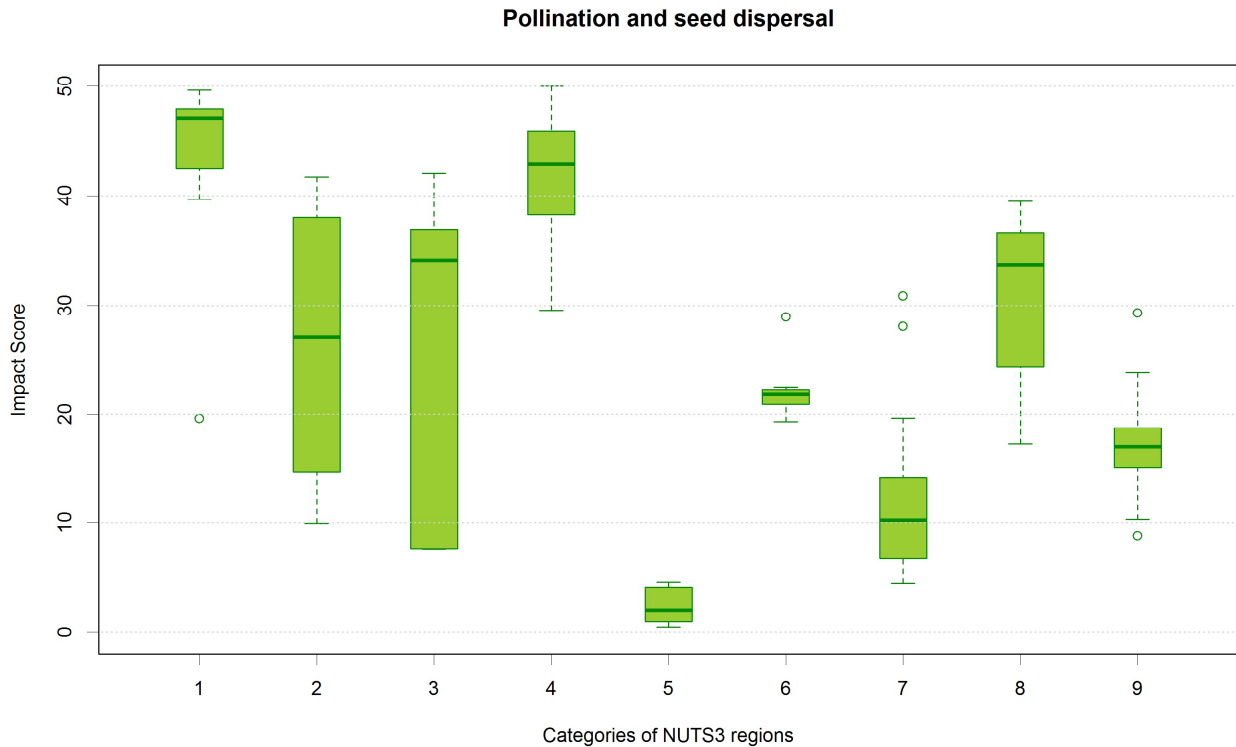
Figure 23 - Potential impact on the pollination ecosystem service of categories of NUTS3 regions

Scores calculated for the ecosystem service <u>pollination and seed dispersal</u> clearly shows that categories with a high presence of landscape features and land laying fallow are by far the best performers, with catch crop generating the lowest scores (Figure 23).

These latter ecosystem services (pest control and pollination) are more related to biodiversity. If one compares the scores of these two ecosystem services with those obtained for biodiversity, trends of the different categories of NUTS3 regions look similar.

3.2 **Estimates of the potential impacts of EFA types**

It is evident from the analysis of scores of different categories of NUTS3 regions that the percentage of each EFA type greatly affects the impact scores of the NUTS3 categories. In order to explore the impact of each EFA type, a simulation was carried out to generate impact scores for each EFA type individually. Results allow for the comparison of the net effects of their impacts. The most representative EFA types were chosen for this analysis: catch crops, nitrogen-fixing crops, land laying fallow, hedges and buffer strips. These types also represent the features with good associated strengths of the knowledge base, as described in section 2.3: Warnings and limits to the use of the calculator.

The EFA calculation was run for two fictitious farms composed of one hectare each of the abovementioned EFA types. The arable land of the farms was set at 110 hectares so that the EFA (after applying the weighting factors) accounts for exactly 5% of the area. In order to obtain results in different geographical contexts, the farms were located in the following regions: UKH12 and ES618 (i.e. the farm parameters of these regions were used).
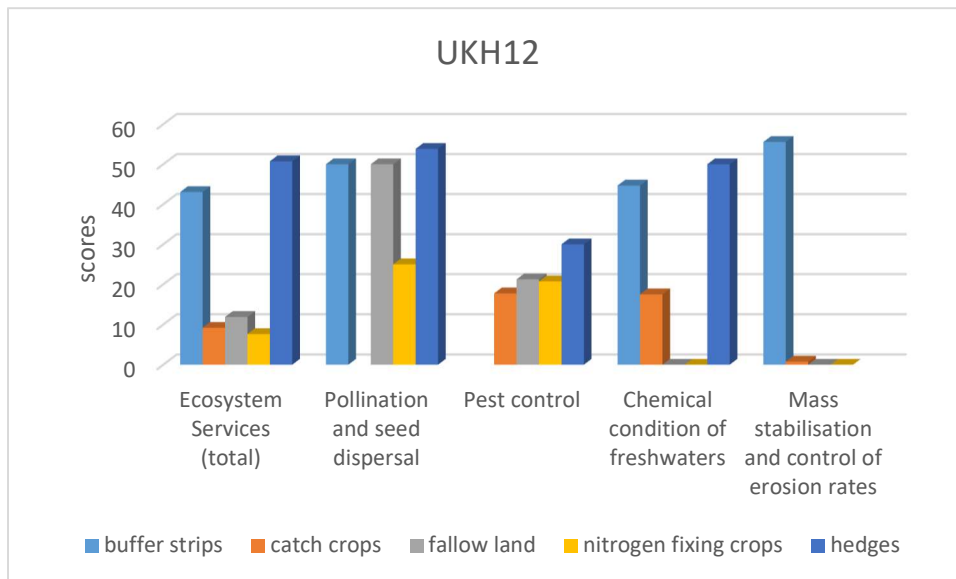
Figure 24 - Impact scores of different EFA types calculated for all ecosystem services included in the EFA calculator (Ecosystem Services total) and four specific ecosystem services in the NUTS3 UKH12 region
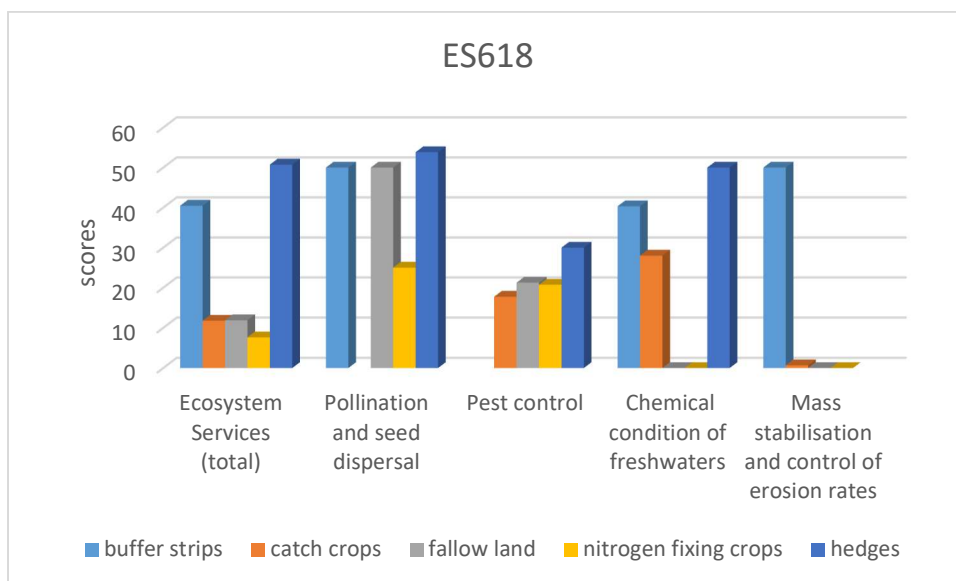
Figure 25 - Impact scores of different EFA types calculated for all ecosystem services included in the EFA calculator (Ecosystem Services total) and four specific ecosystem services in the NUTS3 ES618 region

Figure 24 and Figure **25** show the scores obtained by the same amount of land (one hectare) of each EFA type for the ecosystem services as a total and for four ecosystem services. When no score is present for the EFA type, it means that the calculator does not provide any impact due to lack of evidence, or non-consensus, on the issue in the scientific literature analysed.

These results also explain the foundation of the calculator and how impacts are generated with the different combinations of EFA types and geographical context.

It is interesting to highlight that hedges and buffer strips are the EFA types with highest positive effects on ecosystem services. Hedges, buffer strips and fallow land are the EFA types with best results for pollination. For the ecosystem control of erosion rates, positive results were found only for buffer strips. Catch crops present beneficial effects for the chemical condition of freshwaters.

The EFA calculator also provides scores for negative effects (Figure 26 and Figure **27**). Negative effects are generated only for fallow land (but they depend on the ground cover type) and nitrogen-fixing crops. It should be stressed that these are extremely low compared to the positive scores (i.e. the scale of the axis should not be misleading).
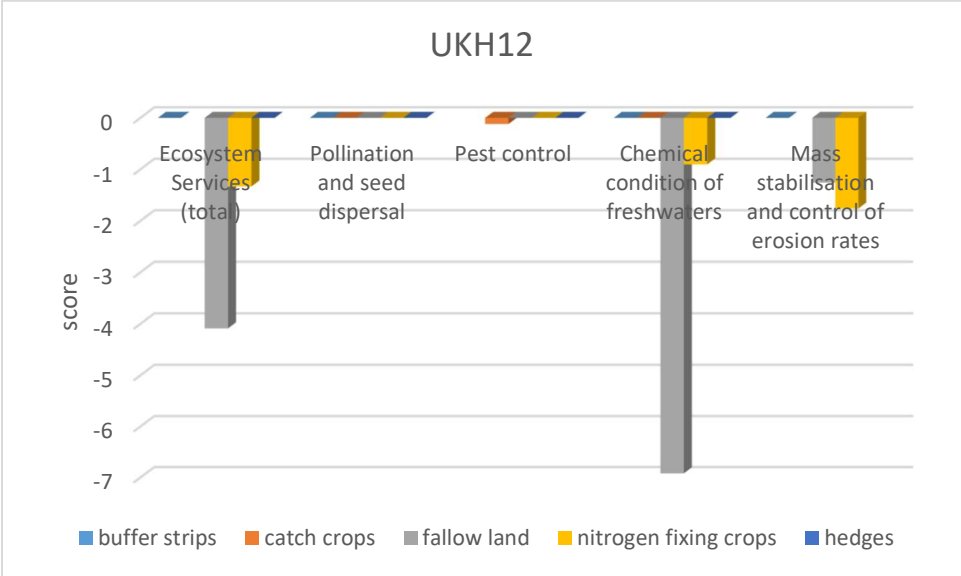
Figure 26 - Negative impact scores of different EFA types calculated for all ecosystem services included in the EFA calculator (Ecosystem Services total) and four specific ecosystem services in the NUTS3 UKH12 region
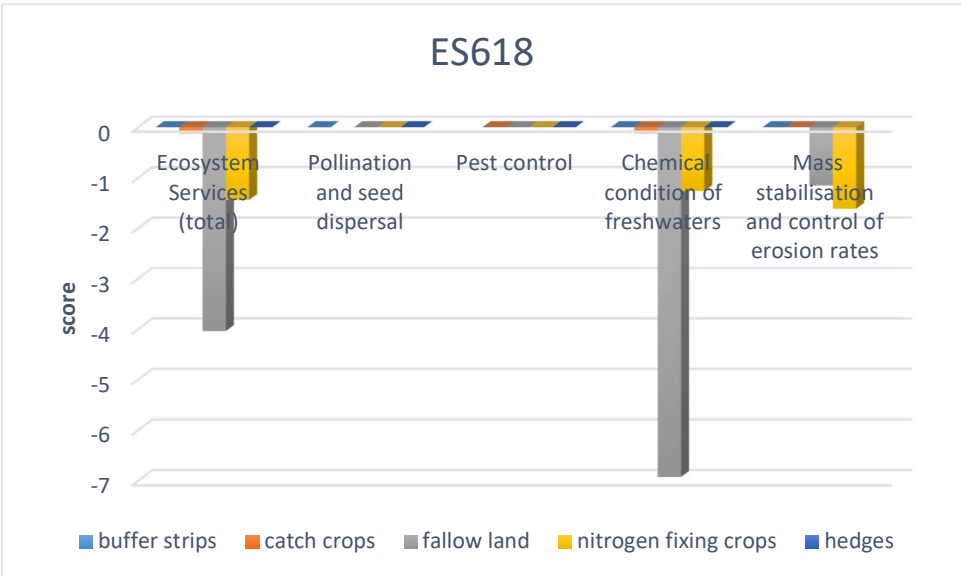
Figure 27 - Negative impact scores of different EFA types calculated for all ecosystem services included in the EFA calculator (Ecosystem Services total) and four specific ecosystem services in the NUTS3 ES618 region

Differences in the scores show how differences in the geographical context (climate, soil, topography) are taken into account by the EFA calculator.

Results are slightly different in the two regional cases, but trends do not change.
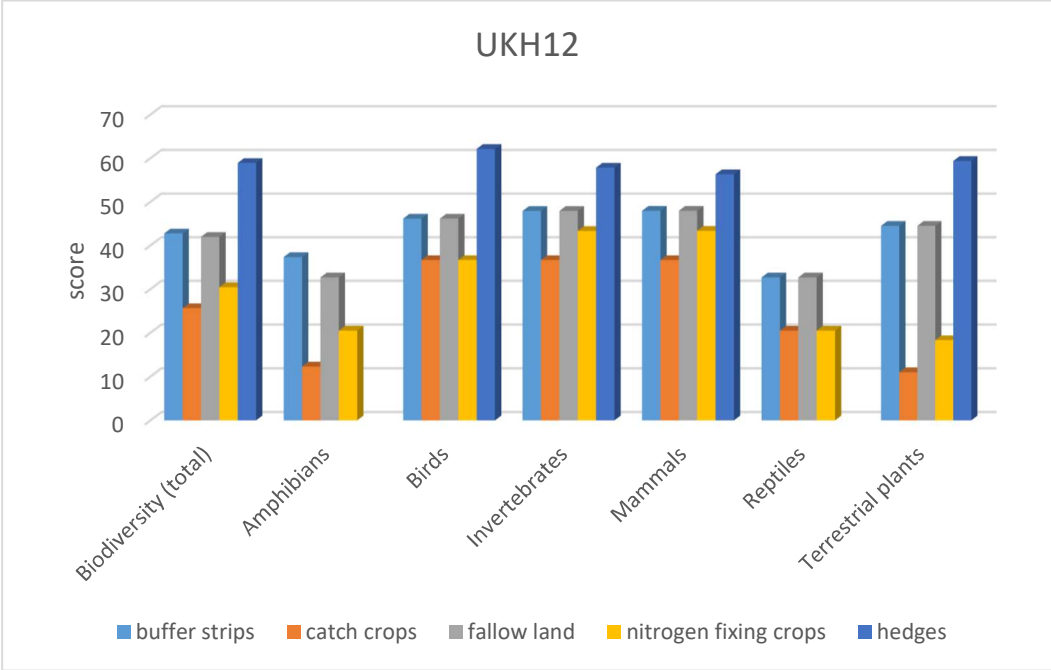
Figure 28 - Impact scores of different EFA types calculated for biodiversity (total) and some EUNIS species groups in the NUTS3 UKH12 region
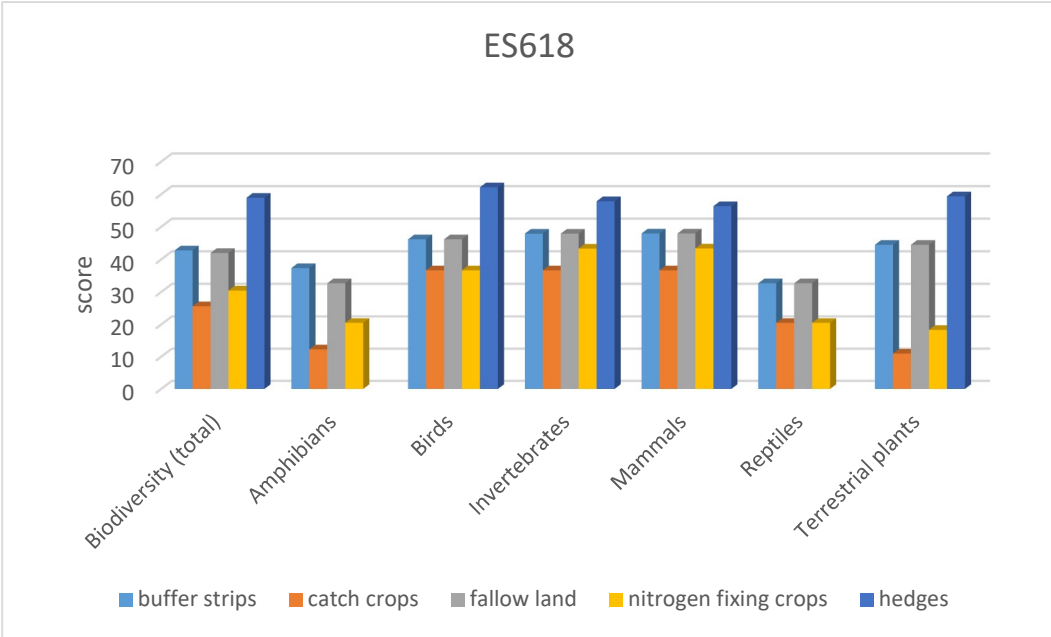
Figure 29 - Impact scores of different EFA types calculated for biodiversity (total) and some EUNIS species groups in the NUTS3 ES618 region

Scores have also been calculated for biodiversity as a total and for EUNIS biodiversity species groups. Results in Figure 28 and Figure **29** show that hedges have by far the most positive effects, followed by fallow land and buffer strips, while catch crops are less significant for biodiversity. Compared to ecosystem services, biodiversity scores are practically unchanged in the two regions. Biodiversity scores seem to vary much less with

location compared to ecosystem services. This is due to the fact that in the EFA calculator biodiversity scores are more dependent on local factors and features (i.e. floral diversity, cutting season) which are not described in the region files where an average value is used, whereas changes in ecosystem services are linked to variables acting at broader spatial scales such as soil and climate (which are defined in the region files).

3.3 Specific characteristics that influence potential impacts of the EFA types

Results shown in the above graphs do not take into account specific characteristics of the EFA features, as these attributes are specific to the feature, and are sometimes related to the feature management and surrounding landscape. The EFA calculator gives the possibility to fine-tune impacts according to these parameters, but this is not currently assessable at the NUTS3 level. We have listed below the main parameters that are not taken into account in the regional application, classified by EFA type. These also give an idea on how to enhance EFA performance on biodiversity and ecosystem services. The text is taken from the final report of the Study on the EFA calculator (Tzilivakis, J., et al. 2015).

3.3.1 Hedges

Floral diversity is one of the most important factors for pollination. Species-rich hedgerows will attract a greater diversity of pollinators. More in general, total richness and insect-pollinated plant richness are important for birds, insects and mammals.

Hedge height affects potential impacts both for ecosystem services and biodiversity. Tall hedgerows offer the greatest benefit for hosting pest predators, and are most effective in reducing pesticide drift and protecting non-target areas, including water bodies. Tall hedgerows offer the greatest benefit in mediating smell, noise and visual impacts. Farmland bird species tend to prefer shorter trees and hedgerows/grassy or scrub type boundaries. Obviously, scrubland bird species tend to prefer trees and hedgerows of intermediate height, and woodland bird species tend to prefer taller trees and hedgerows.

The abundance and diversity of birds will be affected by the density of hedgerow trees. The presence of hedgerow trees has a large positive impact on the abundance and diversity of moths. 60% of species (including butterflies) visiting the hedge are dependent on the tree layer type. The incidence of bats is significantly affected by tree density - the more trees present the greater the population and diversity of bats visiting.

Uncut hedges provide more flowers and berries than cut hedges. Typically, large, wide, bushy hedges support twice as many species of birds than tidy, frequently cut hedges. Hedgerow cutting reduces the number of flowers and the biomass of berries available over winter. Cutting should be undertaken in the winter, and avoided during spring and summer. Moreover, winter cutting can increase the biomass of berries.

Hedgerows with low porosity offer the greatest benefit for trapping pests. Hedgerows with moderate porosity are the most effective in reducing pesticide drift and protecting non-target areas, including water bodies. Hedgerows with low porosity offer the greatest benefit for mediating smell, noise and visual impacts.

The presence of well-grown, dead and decaying trees is beneficial to many species, including pollinators, as they provide nest holes, foraging resources and perches. Invertebrates such as spiders, ground beetles and hoverflies are often found in large quantities in the lower regions of hedges, where deadwood residue accumulates. Deadwood provides nesting opportunities for bees and can enhance the habitat for mosses and liverworts.

3.3.2 Buffer strips

The impact on pesticide drift and on surface run-off increases with <u>buffer width</u> due to the increased opportunity for infiltration (surface run-off) and filtration by vegetation (pesticides drift).

One of the most important factors for reducing overland flow is the <u>vertical hydraulic conductivity of the soil</u>, as higher conductivity allows for higher infiltration rates, and reduces pollution by waterborne pollutants.

Buffer strips may become overwhelmed in the event of <u>excessive sediment delivery</u>, so there is a risk that they may become less effective in locations where soil erosion is high. This can be mitigated if the adjacent field is <u>managed to reduce the risk of soil erosion</u>.

<u>Dense vegetation</u> provides a greater barrier to overland flow (and the pollutants it carries) than more sparsely populated buffer strips, reducing flow velocity and increasing time for infiltration.

In terms of biodiversity, the <u>adjacent vegetation structure</u> can play an important role. Structurally diverse habitats such as rough grassland, scrub, hedgerows or woodland in close proximity provide a favourable habitat. This habitat declines in suitability with a decrease in structure, for example where vegetation is frequently cut and maintained at a uniform low height, or in large areas of bare or frequently disturbed.

Diverse, quality <u>hedgerow or linear features with dense structurally diverse vegetation</u> provide hibernation sites, increase flowering plant species diversity, enhance dispersal and connect habitat fragments. Their ecological quality is reduced with a decrease in hedge structure and the presence of gaps.

3.3.3 Catch crops, fallow land and nitrogen-fixing crops

As for buffer strips, the impact on biodiversity can change in relation to <u>adjacent vegetation structure</u> and <u>adjacent wildlife corridors</u>.

An increase in <u>annual rainfall</u> generally corresponds to an increased risk of nitrate leaching, surface run-off and surface erosion. The analyses have been carried out using an average annual rainfall in the NUTS3 regions, but obviously local variations exist.

For these EFAs, impacts can depend on the different crop species and types of ground cover. This issue is discussed in paragraphs 3.5, 3.6 and 3.7.

3.4 Spatial impact assessment of biodiversity and ecosystem services

One of the aims of the analysis was to compare the performance of different NUTS3 regions. An indication of the different potential impacts on biodiversity and ecosystems services for NUTS3 regions was already discussed in the analysis carried out on the different categories of NUTS3 regions. A clear effect of the composition of EFA types on the potential impacts on biodiversity and different ecosystem services has been identified.

The analysis that follows aims to discuss the spatial impact of policy and identify whether the actual EFA implementation can possibly address specific territorial issues, such as biodiversity decline or soil erosion.

3.4.1 Biodiversity

Within the sample of NUTS3 regions, biodiversity impact scores vary from 25.7 to 54.4. Figure 30 shows the impact scores for biodiversity in the analysed NUTS3 regions; score classes are calculated using quartiles.

In order to identify the possible effect of policy implementation, it is important to consider the percentage of arable land under EFA obligation. It is assumed that, if this percentage

is low, the potential impact is limited to a small area and therefore cannot be representative of the whole NUTS3 region. The percentage of arable land affected by EFAs is displayed using different textures in the map.

This map represents the potential impacts of EFA implementation on the basis of composition of different EFA types declared and the general characteristics of selected NUTS3 regions.
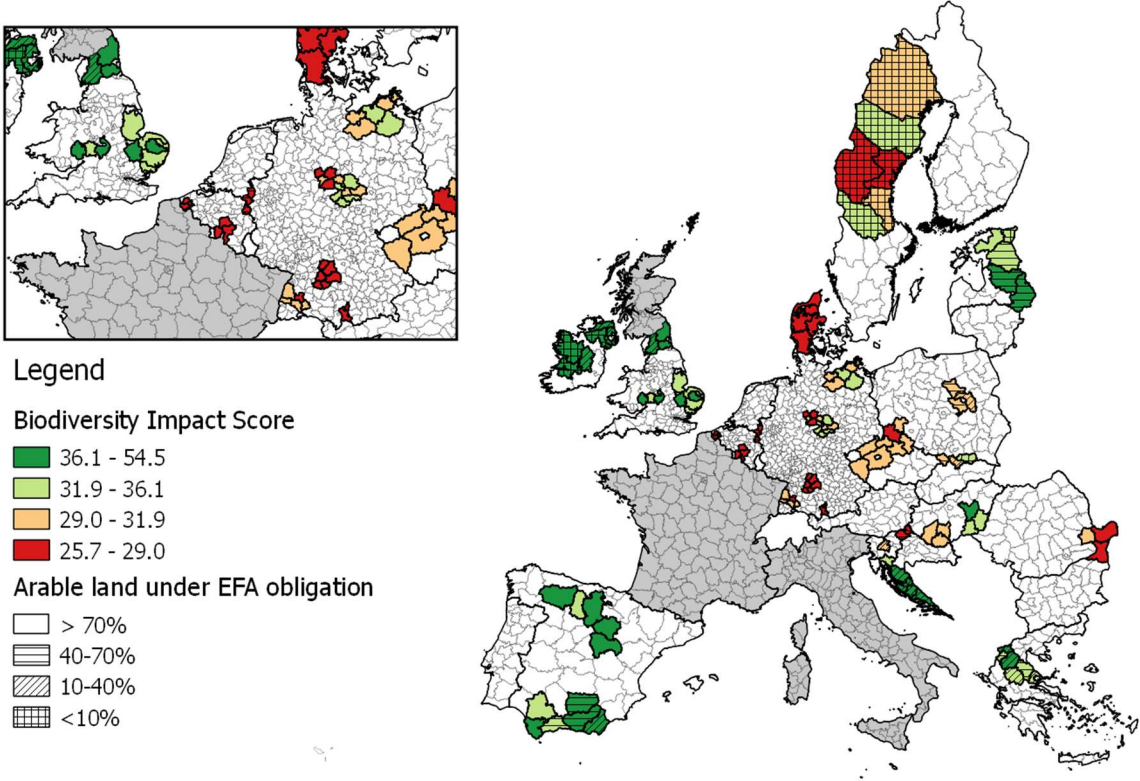
Figure 30 - Biodiversity impact scores and percentage of arable land under EFA obligation in the NUTS3 regions analysed

The analysis of the potential impacts of the different EFA types composition could be further extended through a spatial analysis, where potential impacts are overlaid with specific environmental issues (i.e. biodiversity, soil erosion). This helps understand whether the declared EFA composition can address specific territorial issues.

Biodiversity decline has been considered as one of these territorial issues. As we do not have sufficiently detailed data to calculate the "real" baseline, we used as proxy a descriptor of the green network supporting biodiversity: the map of distribution of semi-natural vegetation in agricultural land (Garcia-Feced et al., 2015) with some JRC elaborations that aim to include the share of tree cover, without considering olive groves and orchards (Figure 31). In this map, macro-structures of semi-natural vegetation are displayed. These are mostly tree lines, hedges, woodlots, patches of semi-natural grassland identifiable from satellite images with 25-m to 250-m resolution. Micro-structures such as field margins are not mapped. The map of semi-natural vegetation is aggregated at the NUTS3 level in order to classify NUTS3 regions in relation to the abundance of semi-natural vegetation in agricultural land. The areas in red represent

regions with a very low presence of the abovementioned types of semi-natural vegetation in agricultural land.
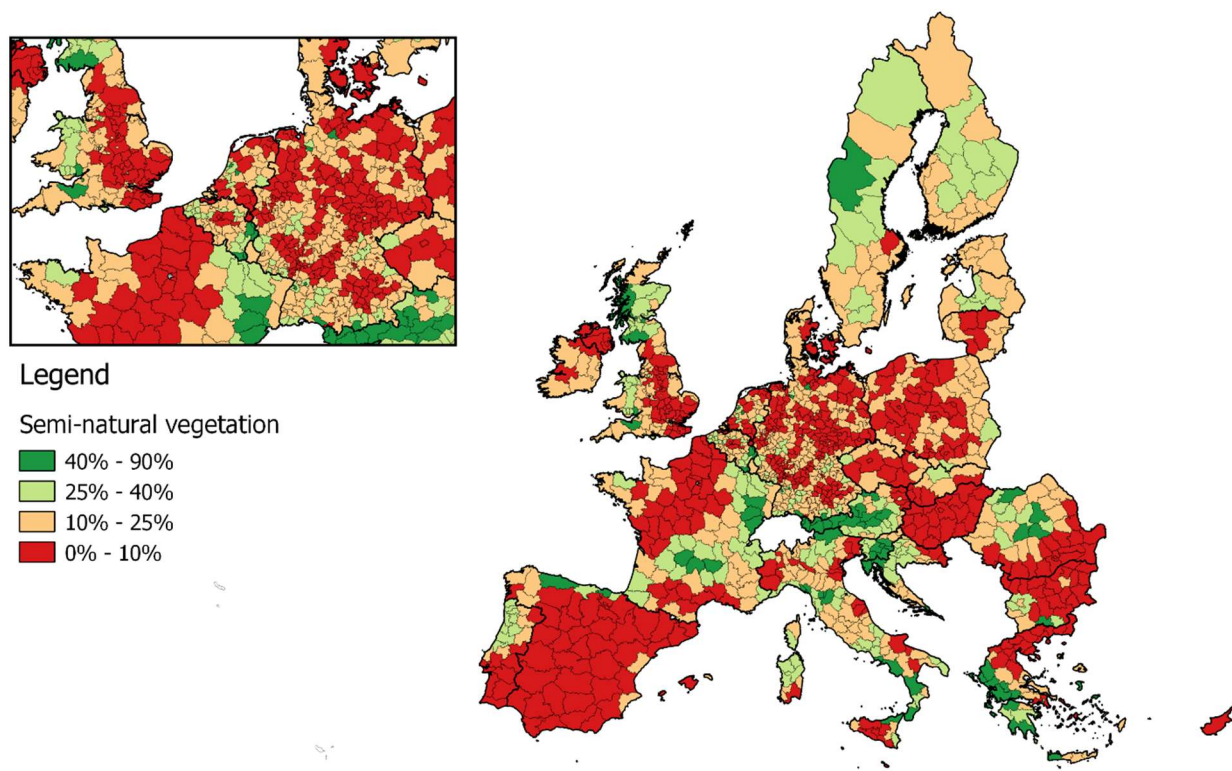
Figure 31 - Maps of semi-natural vegetation aggregated at NUTS3 level; JRC elaboration based on Garcia-Feced et al., 2015

By overlaying the two sources of information (NUTS3 regions with scarce semi-natural vegetation and NUTS3 regions with good scores for biodiversity), it is possible to highlight areas with different potential effects of the EFA-type composition on biodiversity (Figure 32): this is the case in the NUTS3 regions in East England, North of Spain and South-East of Hungary, where semi-natural vegetation is scarce but biodiversity scores are good. In these regions, EFA implementation may contribute to improving the network of semi-natural vegetation that supports biodiversity. The EFA-type composition declared may generate some benefits, even if smaller, also in regions which obtained good biodiversity scores and where semi-natural vegetation is not abundant but less scarce than in the regions mentioned above (North and West of England) or where the percentage of arable land impacted by EFA is not high (South of Spain, Greece, Estonia and Latvia).

In the regions with good scores for biodiversity, EFA features declared are represented by EFA types with higher impacts on biodiversity (landscape features, fallow land).

It is worth noting that landscape features declared as EFAs (e.g. in England) maybe not be newly planted hedges, but rather landscape features that already existed (in fact this information is not known). In the second case, the fact that they are declared as EFAs is likely to avoid them being removed. Where these features are not already protected under cross-compliance, their conservation can represent a positive policy impact in areas where there is a lack of semi-natural vegetation.

The same reasoning can be applied to land laying fallow (e.g. in Spain), even if in this case it is more likely that this may represent a change from an existing land use.
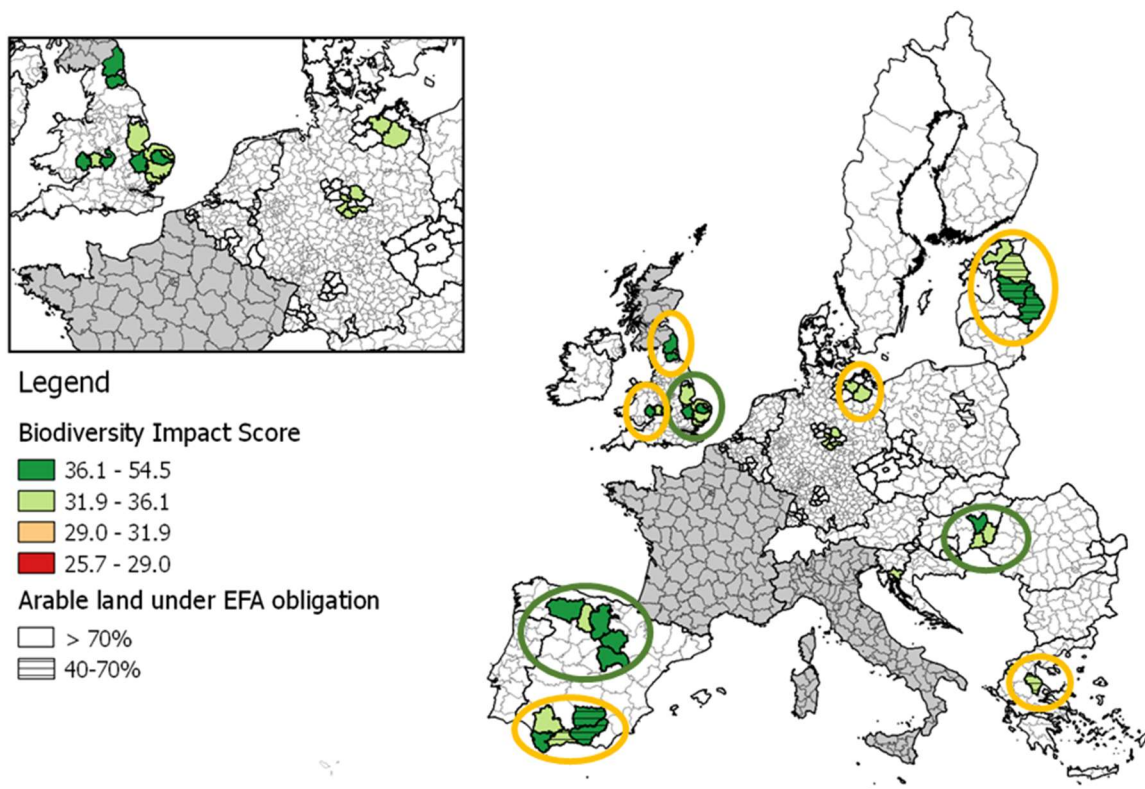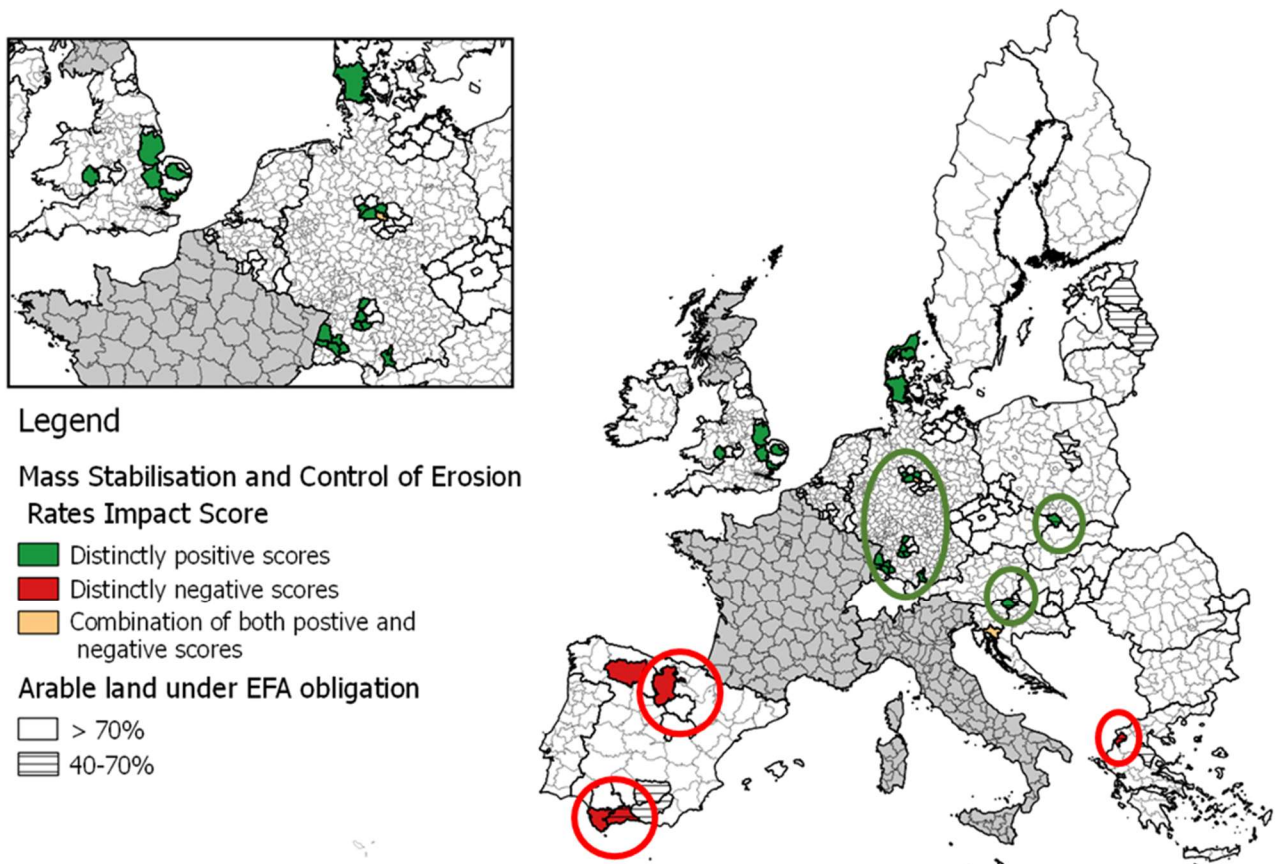
Figure 32 - Biodiversity impact scores in NUTS3 regions with more than 40% of arable land under EFA obligation. The areas highlighted with green and yellow circles are those where the EFA-type composition could generate, respectively, a very positive effect (good scores for biodiversity in areas where the current level of semi-natural vegetation is very low) and a positive effect (good scores for biodiversity in areas where the current level of semi-natural vegetation is low, or the area under EFA obligation is between 40 and 70%)

By overlaying NUTS3 regions with scarce semi-natural vegetation and NUTS3 regions where EFA implementation scores low for biodiversity, it is possible to highlight areas where the EFA-type composition declared seems unlikely to provide benefits in terms of biodiversity (Figure 33). In this case, EFA features declared are represented by EFA types with low impacts on biodiversity (mainly catch crops) in areas where the presence of semi-natural vegetation is scarce (e.g. in Denmark, some regions in of Netherlands and Belgium, South-West of Hungary and Romania).
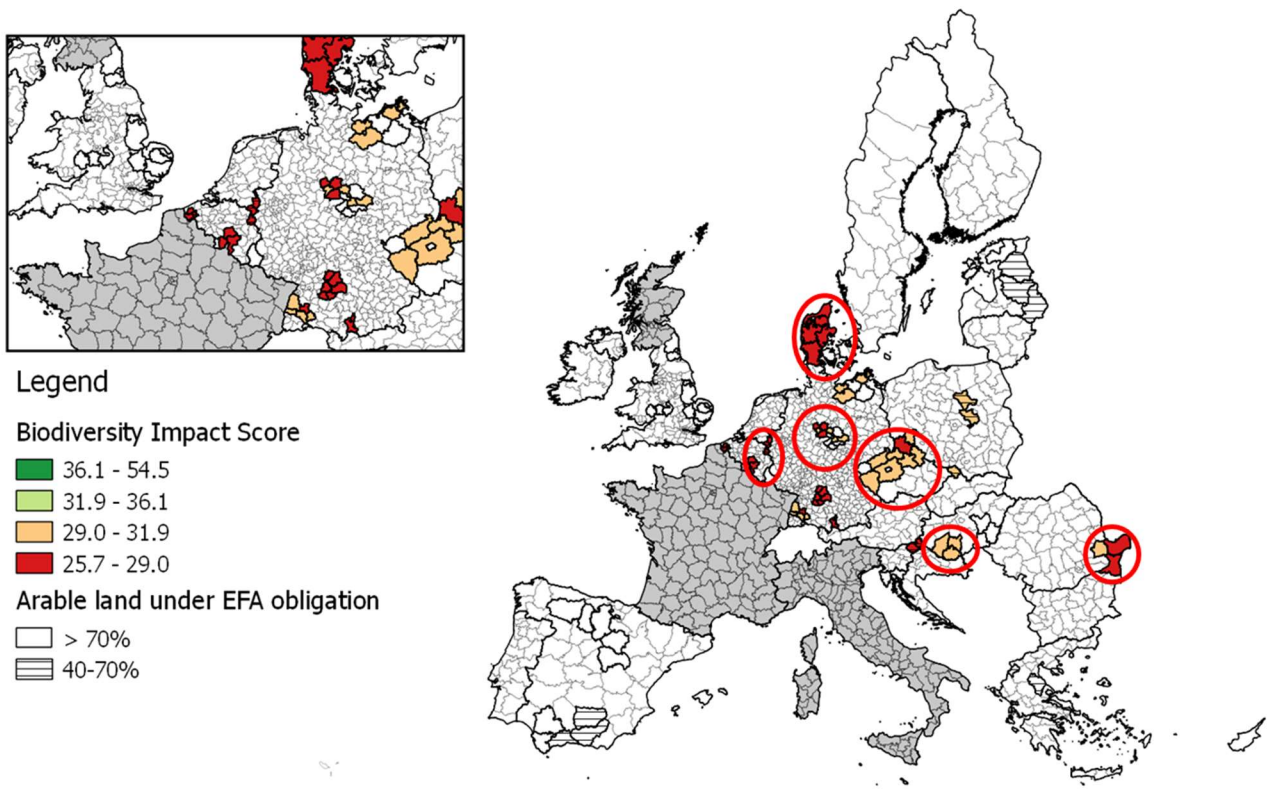
Figure 33 - Biodiversity impact scores in NUTS3 regions with more than 40% of arable land under EFA obligation. The areas in red circles are those where the EFA-type composition declared seems unable to provide benefits for biodiversity (low scores for biodiversity in areas where the current level of semi-natural vegetation is very low or low)

3.4.2 Ecosystem services

As already discussed in previous paragraphs, EFA types with low impact scores for biodiversity can nevertheless have positive scores in terms of ecosystem services. Figure 34 and Figure **35** show total positive and negative scores, respectively, for ecosystem services in the NUTS3 regions in the sample. Ecosystem service scores are the combined scores obtained for the different ecosystem services. As negative scores are produced for some of these ecosystem services, this is reflected in the maps with total scores.
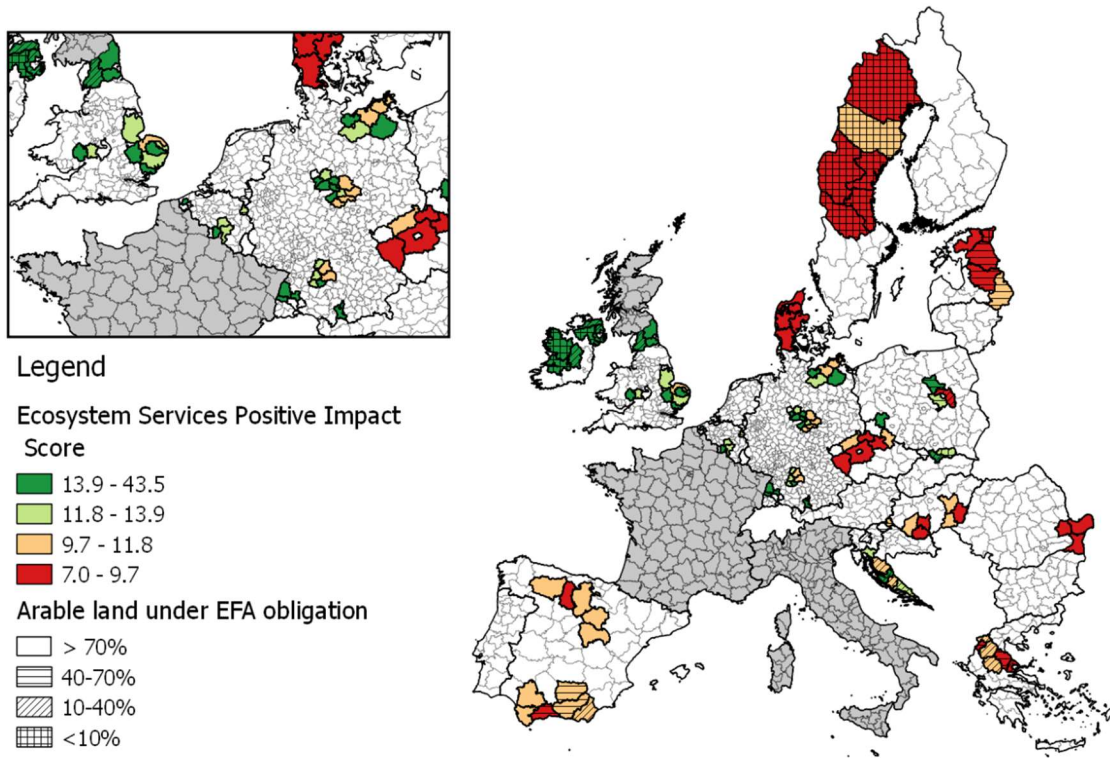
Figure 34 - Positive scores for ecosystem services and percentage of arable land under EFA obligation in the NUTS3 regions analysed
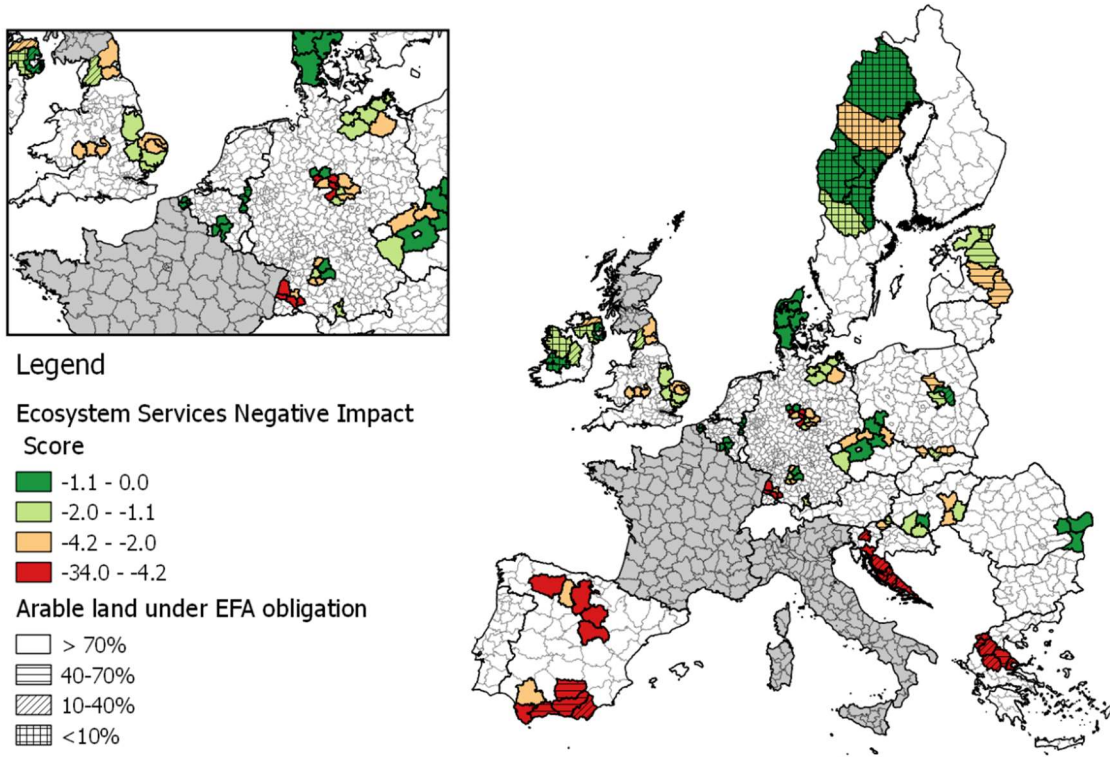
Figure 35 - Negative scores for ecosystem services and percentage of arable land under EFA obligation in the NUTS3 regions analysed

3.4.3 Soil erosion

Figure 36 and Figure **37** show positive and negative scores of NUTS3 regions for the ecosystem "Mass stabilisation and control of erosion rates". As already discussed in section 3.1.2, scores are too small and uniform to draw conclusions about the impacts of different categories of NUTS3 regions. Only in some limited areas do positive scores seem to be significant (NUTS3 regions in England, Ireland, the Netherland and Belgium). NUTS3 regions in Spain, Croatia and Greece present higher negative scores, due to the presence of land laying fallow (which might be bare soils).

Results from the analysis of the potential impacts of the different EFA-type compositions on ecosystem services could be spatially examined to understand whether specific environmental issues could be addressed according to the EFA types declared. Soil erosion by water has been considered as one of these environmental issues. Results obtained for the ecosystem service "Mass stabilisation and control of erosion rates" were overlaid with a map of soil erosion by water in the European Union produced by the JRC Soil Bureau (Panagos et al., 2015) aggregated at NUTS3 level (Figure 38). NUTS3 regions where the percentage of arable land under EFA obligation is less than 40% are not considered in the analysis. The overlay highlights NUTS3 regions with high and moderate risk of water erosion where the analysis produces the highest positive and negative scores (highest and lowest quartiles, respectively) for erosion (Figure 39). The first case occurs in some NUTS3 regions in Germany, Slovenia and South of Poland. The second case occurs in some NUTS3 regions in Spain and Greece.
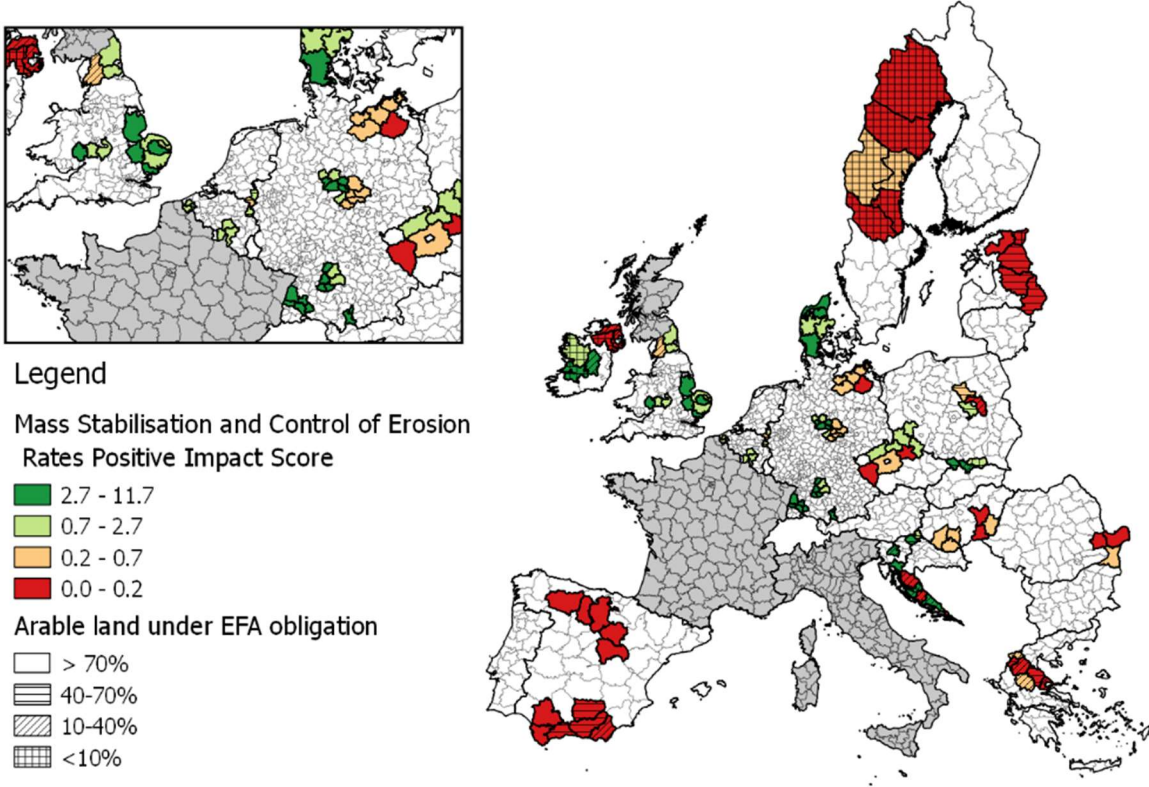
Figure 36 - Control of erosion rates - positive scores and percentage of arable land under EFA obligation in the NUTS3 regions analysed
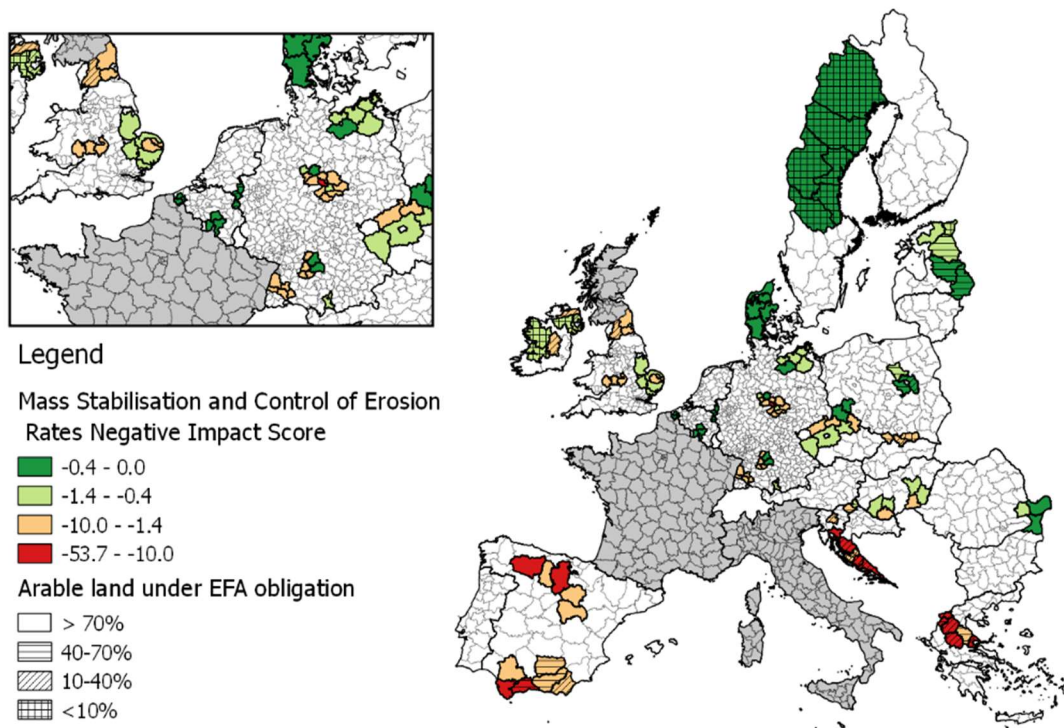
Figure 37 - Control of erosion rates - negative scores and percentage of arable land under EFA obligation in the NUTS3 regions analysed
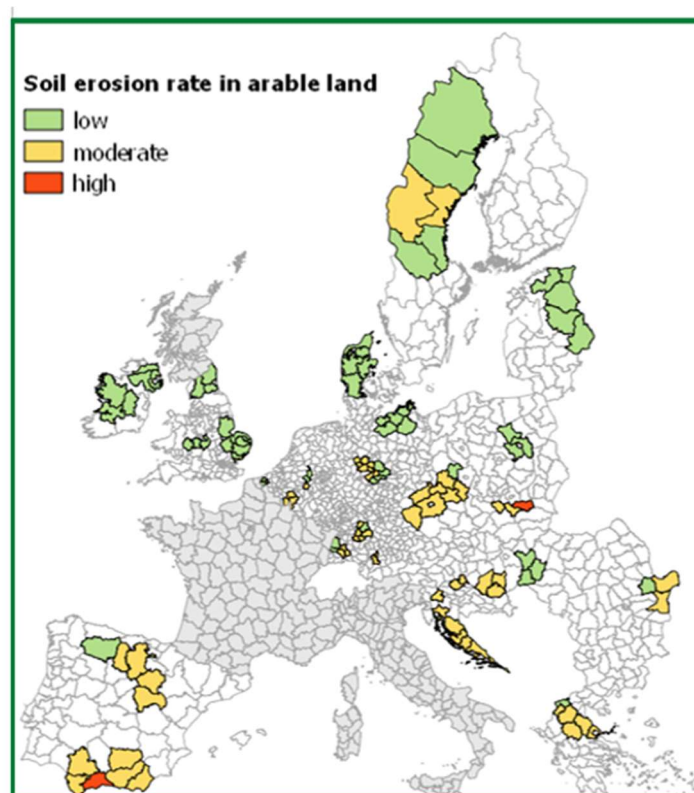
Figure 38 - Soil erosion rate by water in the European Union produced by the JRC Soil Bureau (Panagos et al., 2015) aggregated at NUTS3 level

Figure 39 - Erosion control rates impact scores in NUTS3 regions with more than 40% of arable land under EFA obligation. The areas circled in green are those where the EFA-type composition may provide benefits in terms of erosion control (good scores in areas with moderate soil erosion). In areas circled in red, issues related to water erosion do not seem to be addressed by the EFA-type composition declared in the region (low scores in areas with a moderate or high level of erosion).

3.5 **Potential impacts of different ground-cover types for land laying fallow**

Impact scores calculated by the EFA calculator are derived from the characteristics of the EFA element itself. In the analysis carried out at NUTS3 level, only general characteristics related to the whole NUTS3 region were taken into account (prevalent soil texture, annual rainfall, etc.). However, some specific attributes associated with each specific EFA element are used in the EFA tool to calculate the impact scores. Some additional simulations were carried out to assess how scores can vary according to some of these specific characteristics.

Simulations were performed for some NUTS3 regions in Belgium, Poland and Spain.

A first simulation concerned <u>land laying fallow</u>: impact scores were calculated specifying different typologies of vegetation cover (sown bird seed mix, sown grass only, natural regeneration, bare soil, sown wildflowers). Impact scores for biodiversity and for some ecosystem services were calculated both for the specific feature (land laying fallow) and for the "average NUTS3 farm".

Average score from	BE252, BE253, BE256
Distribution EFA types	5. Catch crop > 70%
Percentage fallow land	1.7%
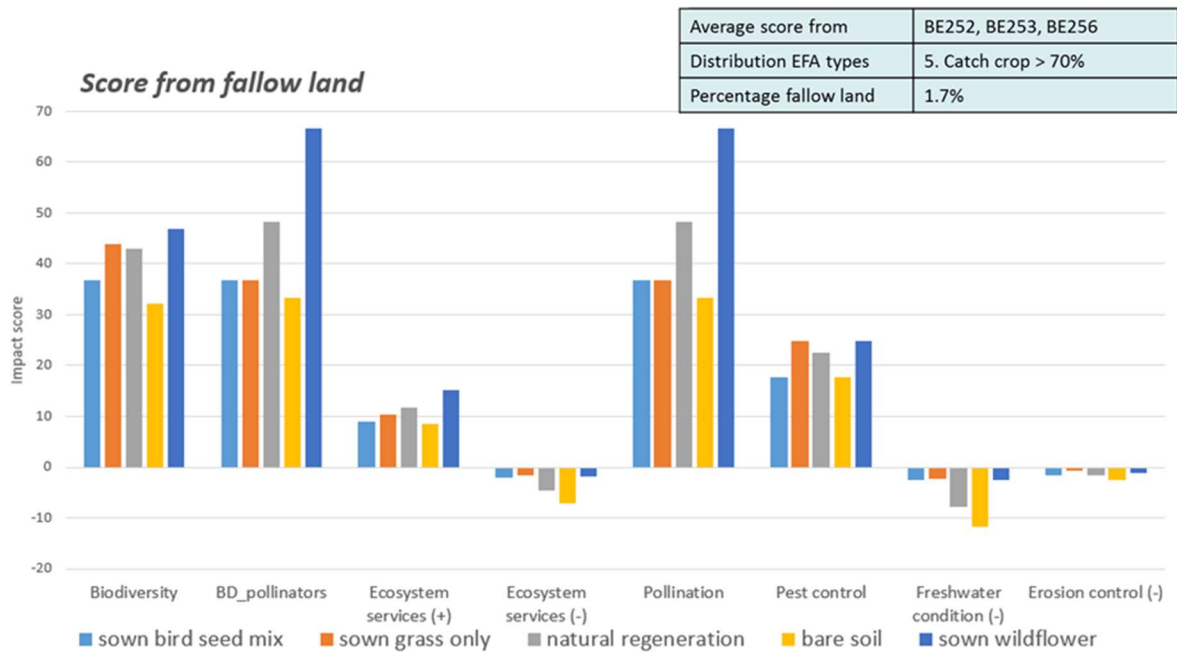
Figure 40 - Effects on biodiversity and ecosystem services of different types of land laying fallow in some Belgian NUTS3 regions

Average score from	ES612, ES616, ES618
Distribution EFA types	4. LLF > 70%
Percentage fallow land	61.7%
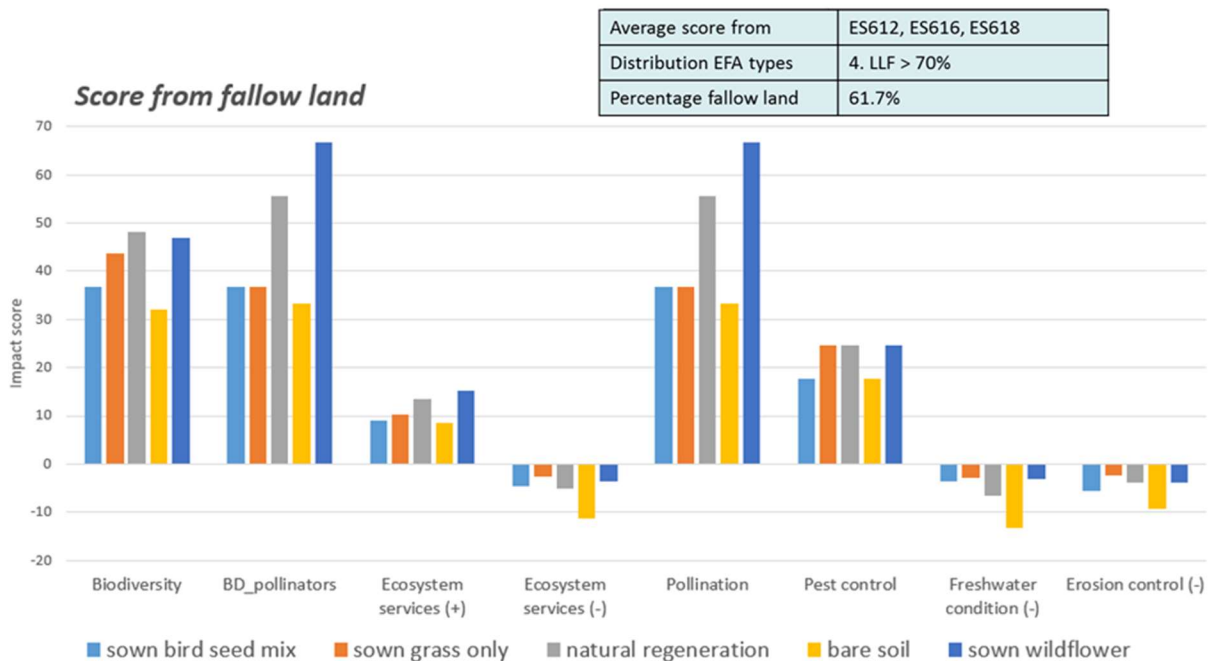
Figure 41 - Effects on biodiversity and ecosystem services of different types of land laying fallow in selected Spanish NUTS3 regions

When one considers impact scores for the fallow land feature, results show that for pollinators (and therefore also for the ecosystem service of pollination), sown wildflowers provide the highest scores, and bare soil the lowest. Bare soil also performs less well in terms of supply of ecosystem services. Natural regeneration is also a good option for

fostering biodiversity and pollination. The performance of the different ground-cover types are similar in Belgium and Spain, with some little differences, e.g. natural regeneration seems to be more effective for pollinators in Spain than in Belgium. This is probably due to the smaller size of the Spanish field. Bare soil has a more negative impact on soil erosion in Spanish NUTS3 regions than in the Belgium ones (Figure 40 and Figure 41).

When considering the scores for the "average NUTS3 farm", different types of fallow land do not generates significant differences in Belgium. This is because the average percentage of fallow land in the analysed NUTS3 is very low (1.7%). For the Spanish NUTS3 regions, where the average incidence of fallow land reaches 61%, the impact scores of the "average NUTS3 farm" show the same trends as those calculated for the specific feature.

The scores calculated for the different ground-cover types are the result of the literature findings that constitute the core of the EFA calculator. Some findings in relation to biodiversity impacts of the different ground-cover types are summarised hereafter.

Tussock grasses within <u>sown grass mixtures</u> and <u>mixtures with flowering plants</u> provide: potential nest sites for some species of bumblebee, or the presence of nests of small mammal that may also be utilised by bumblebees; favourable habitat for insects, and insectivorous birds and small mammals (a potential food source for birds of prey); good winter cover and hibernation sites for a number of insect species (source of food for insectivorous birds) and surface-active insect predators of crop pests; suitable foraging areas; and nest sites, and a source of food for grass-eating and insectivorous species. The limited cultivation and re-establishment frequency favours predator populations. Mixtures that require more frequent tillage, or areas where bare ground persists, are not as favourable to predators, although they will be present. Frequent tillage decreases suitability as favourable habitats.

<u>Mixtures that contain appropriate flowering plants</u> potentially attract pollinating insects (source of food for insectivorous birds). Wild bird seed mixtures are designed specifically to provide a source of food for seed-eating birds. Sown grass or wildflower mixtures, or natural regeneration, may contain small seeded plant species that are also suitable. Wildflower mixtures that contain species with a long corolla and light-coloured flower are favourable to moths, which are a source of food for bats that feed at night. A greater frequency of tillage, for example the annual sowing of wild bird seed mixture, decreases habitat favourability.

<u>Bare soil</u> does not represent a quality habitat for amphibians. Habitat quality is enhanced by the presence of vegetation that enhances structural diversity, such as tussock grasses in a sown grass mixture with minimal cutting, or natural regeneration once the vegetation has become established. Bare soil provides potential basking areas for reptiles, but must be located in close proximity to vegetated areas that provide shelter and shade; large areas of purely bare ground do not provide a favourable habitat.

<u>Natural regeneration</u> may offer potential for the growth of arable flora that will also favour pollinating invertebrates. Natural regeneration favours the development of rare arable flora from the local seedbank. Sown wildflower mixtures also provide a source of flowering plants, determined by the mixture content.

3.6 **Potential impacts of catch crop species**

As the catch crop species used at NUTS3 level were not part of the data notified by the Member States, the calculation of the impact scores of NUTS3 regions in the sample was based on the crop species that were offered to farmers by almost every Member State: *Sinapis alba* and *Lotus spp.*

Simulations were performed specifying the actual <u>crops cultivated by the farmers for the EFA-type catch crops.</u>

Calculations were performed for a NUTS3 region in Flanders (BE253), as the crops mostly used in the mixture in Flanders were known:

- Italian and Perennial ryegrass (*Lolium multiflorum* and *Lolium perenne*)
- White mustard (*Sinapis alba*)
- Fodder radish (*Raphanus sativus subsp. oleiferus*)

The EFA calculator was run with different combinations of these species. Scores obtained for three ecosystem services and biodiversity with the different mixtures are shown in Figure 42. They are compared with the results obtained for the mixture *Sinapis alba* and *Lotus spp*, which was used for the analysis in all NUTS3 in the sample (first blue bar in the graph).
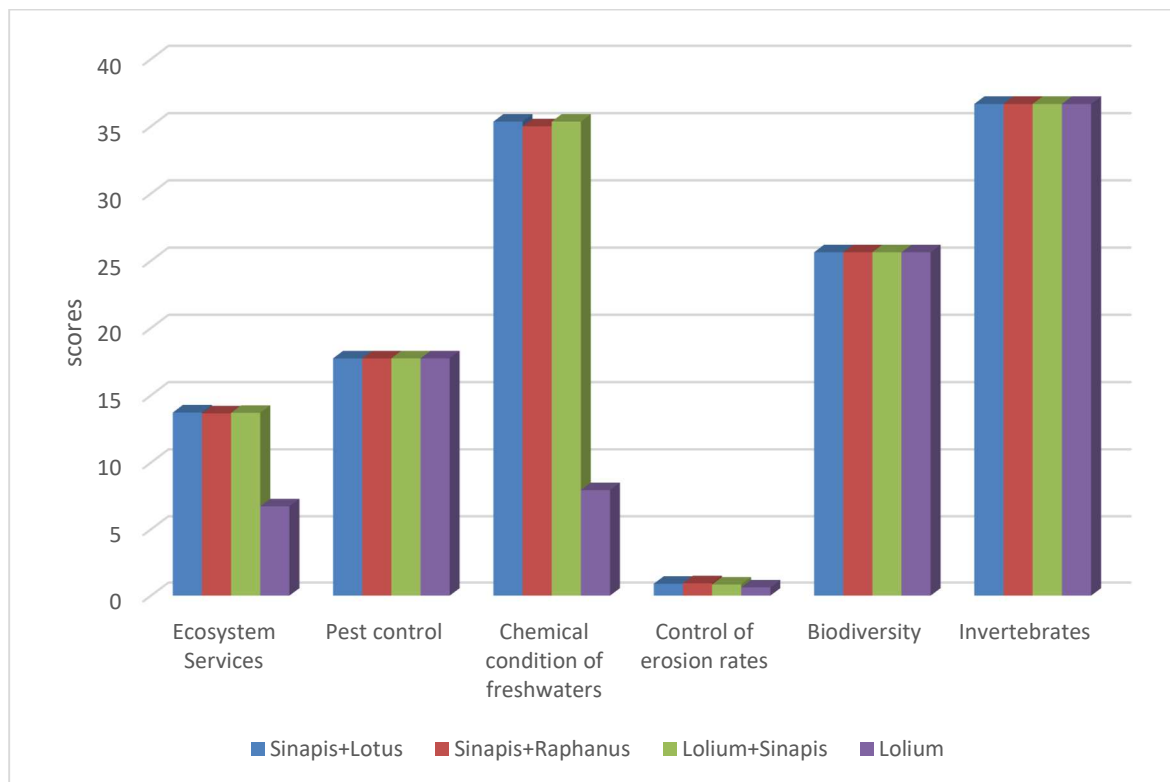
Figure 42 - Impacts of different catch crop mixtures on all ecosystem services included in the EFA calculator (Ecosystem Services), three ecosystem services, biodiversity total and invertebrates species group

The scores obtained using the most common species do not vary compared to those used in the analysis carried out on all NUTS3 regions in the sample, except for the ecosystem service "Chemical condition of freshwater" with *Lolium* mixture.

Similar results are also confirmed by some simulation runs carried out using the species most used in Poland, where *Sinapis alba* (white mustard) is frequently used in combination with *Avena sativa* (oats); in some Polish regions, *Brassica napus* (rapeseed), *Brassica rapa* (turnip rape) and *Hordeum vulgare* (spring barley) are also used.

This confirms that results obtained on the basis of general assumptions about catch crop species would not change much even if crop species were known. This depends on the level of detail of the calculator for this specific issue. In fact, due to the large number of catch crop species used across the Member States, and in order to keep the number of possible combinations of crops down to a practical number, the impacts derived by the EFA calculator are based on plant families and not individual species (also, in many instances the data in the literature is for plant families). Thus, for the example in Flanders region, the crop *Raphanus sativus subsp. oleiferus* (fodder radish) is a member of the *Brassicaceae*

family and, using the Defra RB209 fertiliser manual for oilseed rape, members of the *Brassicaceae* were allocated as removing more nitrogen during the autumn. The *Lolium* is assigned a value from *Poaceae* (grass) which is lower, although some nitrogen is removed.

In general, impacts of catch crop species are calculated taking into consideration the following literature findings.

Species that utilise more nitrogen during the autumn, for example winter oilseed or forage rape (*Brassica napus*), or species that rapidly establish extensive roots, such as winter cereals (of which winter rye, *Secal cereale*, is a good example), are effective at removing nitrogen from the soil and reducing the risk of leaching during winter, especially in soils with a high percentage of sand content. Maintenance of ground-surface cover during winter therefore reduces the risk of soil erosion, phosphate run-off and sedimentation.

Two species groups with different nutrient requirements and rooting systems are likely to utilise more soil nitrogen during the autumn and winter due to differences in plant functional types and nutrient resource exploitation.

In terms of biodiversity, all species may provide some shelter during winter to soil-surface active predatory beetles compared to bare soil, although the impact is likely to be small. All species have a limited effect on amphibians, birds of prey, insectivorous birds, seed-eating birds, small mammals, reptiles, and flowering plants when present as winter cover crops.

The impacts of catch crop species is an area in which the EFA calculator could be improved in the future as more data become available.

3.7 Potential impacts of nitrogen-fixing crop species

As the nitrogen-fixing crop species used at NUTS3 level were not part of the data notified by the Member States, the calculation of the impact scores of NUTS3 regions for nitrogen-fixing crops were obtained using *Vicia faba* as nitrogen-fixing crop species (crop species offered to farmers by almost every Member State).

Simulations were performed specifying the <u>actual crops planted by the farmer as nitrogen-fixing crops and comparing scores</u> with those obtained using *Vicia faba* as nitrogen-fixing crops.

Most used species for catch crops and nitrogen-fixing crops were known for Belgium (*Medicago sativa*) and some Polish NUTS3 regions (*Ornithopus spp.*, Bird's foot). The EFA calculator was consequently run again using these species as input; results were compared with those obtained in the previous analysis. This fine-tuning exercise shows that scores vary for nitrogen-fixing crops, especially with regard to biodiversity (in fact, for pollinators, *Vicia faba* gave better scores than the species cultivated in reality), Figure 43. The differences can be seen in the impact scores for the whole "NUTS3 average farm" when nitrogen-fixing crops represent an important percentage of the EFA types.

Score from nitrogen fixing crop in PL129, PL12A, PL12B

Score from nitrogen fixing crop in BE252, BE253, BE256
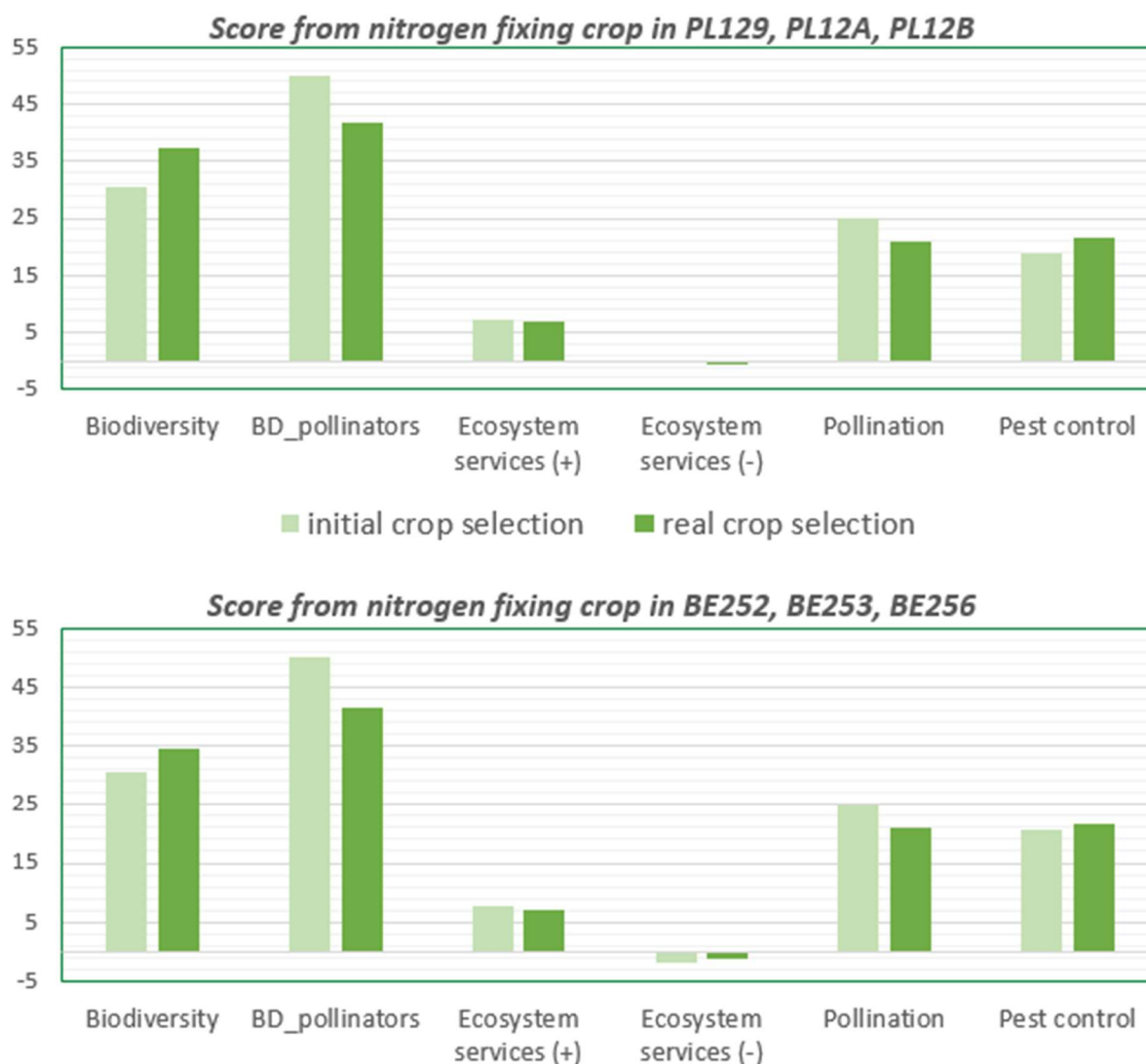
Figure 43 - Comparing impact scores for nitrogen-fixing crops between crop species used in the NUTS3 EU-wide analysis (initial crop selection) and crop species mostly used by the farmers in specific NUTS3 regions (real crop selection) where the uptake is known (some NUTS3 regions in Poland and Belgium)

The impacts of nitrogen-fixing crop species are based on the following literature findings.

A decrease in cultivation frequency reduces the quantity of nitrogen returned to the soil within plant residues via mineralisation, and reduces the risk of soil erosion and phosphate loss in surface run-off. Species that may only require re-establishment and tillage every few years, such as *Lotus spp.* (Birds foot-trefoil) or *Anthyllis* (Kidney vetch), have a lower risk of nitrate leaching, soil erosion and phosphate run-off.

Vicia faba (Faba bean), *Lotus spp.* (Birds foot-trefoil) and *Trifolium spp.* (Clover species) are of value to pollinating insects, for example bees. They are favoured by solitary bees, short- and long-tongued bumblebees, and honeybees. Species such as *Cicer spp.* (Chickpea) and *Glycine spp.* (Soybean) may act as a potential food sources for seed-eating birds. Species with a long corolla and light-coloured flower are potentially favourable to moths, which are a source of food to bats that feed at night. Suitable foraging areas for amphibians and reptiles are provided by structurally diverse habitats with, for example,

tussock grasses. Bare soil provides potential basking areas for reptiles but must be located in close proximity to vegetated areas that provide shelter and shade, large areas of purely bare ground do not provide favourable habitat. A single sown crop species will be of low floral diversity.

A higher frequency of tillage decreases habitat favourability to many soil-surface active invertebrates, including predatory beetles. Benefit is provided by species that may only require re-establishment and tillage every few years, for example *Lotus spp.* (Birds foot-trefoil), *Anthyllis* (Kidney vetch) and *Trifolium spp.* (Clover species).

4   Conclusions

This study consisted of a first attempt to use the EFA calculator as a tool to help assess the impacts on biodiversity and ecosystem services of the implementation of EFAs at the European level. The EFA calculator has been developed as a farm-level tool with the scope of raising farmers' awareness about the implementation of EFA, and providing guidance to farmers with regard to the selection and management of EFAs. The use of this tool with data aggregated at NUTS3 level implies some assumptions and constraints that should always be kept in mind when analysing results obtained. The first assumption is that the region is populated by an average farm. Furthermore, specificities that are taken into account when using the tool at farm level, such as practices and attributes linked to the EFA elements, cannot be considered. This makes the results of this analysis less specific than in a farm-level application. The scores calculated for NUTS3 regions should be taken as the potential impact on the environment of the EFA-type composition that was declared in the region. It should be also noted that the feature impacts calculated by the tool are based on the scientific evidence collected. Other potential impacts may be associated with the EFA land management and landscape features, but a lack of evidence and/or a lack of scientific consensus in the evidence collected led to their exclusion from the tool. Indeed, there is scope for the assessment framework to be further expanded as scientific knowledge and understanding grows.

Taking into account these limitations, a first estimation of impacts of the EFA implementation on biodiversity and ecosystem services at NUTS3 level has been made. As there is a relationship between impacts and EFA types declared, it has been possible to identify geographical areas with different potential impacts on ecosystem services and biodiversity according to the declared EFA-type compositions. Though some specific attributes of the EFA elements (e.g. hedge-cutting periods) or of surrounding landscape (connectivity) are not considered in this analysis due to lack of information, they can be modelled in the calculator impact matrix. This gives the opportunity to simulate impacts of different conditions of EFA implementation and produce evaluation elements to be used for policy fine-tuning.

In the analysis it was also not possible to discriminate between newly created EFA elements and those that already existed, due to lack of information. Nevertheless, the effectiveness of the EFA policy should be considered not only in relation to the changes induced but also with regard to its the success in ensuring the application of good practices. Furthermore, the "greening" is not the only policy instrument related to environmental objectives, as other CAP instruments promote good practices with the same objective, such as cross compliance or agri-environmental climate measures.

This analysis describes the potential impacts of EFA implementation in 2015. There is scope to fine-tune the analysis when new data will become available (e.g. nitrogen-fixing crops species actually used). Improvement in the knowledge base, which represents the foundation of the EFA calculator, could be expected. It would be useful in the future to analyse changes in the EFA types declared by farmers and how these changes modify the impact scores. EFA implementation data 2016 could be used to carry out a similar analysis and compare results. For practical reasons, it would be interesting in the longer term to review the structure of the EFA calculator and upgrade it in order to automate the input process and the extraction of results. With such an update, the EFA calculator could be used to perform regular assessments for the entire EU territory using reported EFA implementation data, not limited to a sample of NUTS3 regions, and to monitor trends in the potential performance of the policy.

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ANNEX - Impact scoring approach in the EFA calculator

Summary of existing approach to knowledge structuring and impact scoring in EFA Calculator

Each land and feature component has been described by a set of parameters and associated parameter classes. These are variable attributes or properties that are likely to affect the potential performance of the land or feature with respect to its impact. For example, 'soil texture' would be a parameter that would influence the impact of 'fallow land' on the ecosystem service of 'mass stabilisation and control of soil erosion' rates. Classes within this parameter (e.g. 'coarse', 'medium', 'medium fine', 'fine' and 'very fine') can then be used, in combination with other parameters and classes (e.g. 'ground cover' with classes of: 'none', 'natural regeneration', 'sown bird seed mix', 'sown wildflowers', and 'sown grass only') to differentiate between degrees of impact. Different combinations of parameters and classes are scored in the impact assessment to provide a means of assessing the relative impact of land and feature components, and their corresponding EFAs, for different spatial and management contexts.

Each feature-impact was scored on a scale of -100 to +100, for negative and positive impacts, respectively. Two techniques were developed to score impacts:

- A semi-quantitative approach, which utilises quantified data and calculations (similar to meta-modelling). A score is awarded for each possible combination of parameters, based on the quantified data.
- A qualitative approach, where scores are awarded for each class, then the scores for the classes selected are summed and weighted for each parameter

The semi-quantitative approach has the advantage that all impacts are comparable across features and tends to be less subjective than the qualitative approach. The disadvantage is there are limited number of robust models or methods available to derive quantitative data, therefore this approach can only be applied to a few impacts. The following substances were quantified:

- Water based on data from Farley et al. (2005) and Sahin & Hall (1996) - impacts on provision of water as a material and for nutrition and flood protection.
- Carbon sequestered using the IPCC (2006) methodology - impacts on global climate regulation by reduction of greenhouse gas concentrations.
- Nitrate leaching and phosphate run-off calculated using the methods and data in Briggs et al. (2015); Defra (2010); Panagos et al. (2012 & 2015); and van der Knijff et al. (2000) - impacts on chemical condition of waters.
- Soil erosion calculated using the methods and data in Defra (2010); Panagos et al. (2012 & 2015); and van der Knijff et al. (2000) - impacts on mass stabilisation and control of soil erosion.

Calculations were derived for all the possible combinations of relevant parameters, then converted into the scale of -100 to +100 using a calibration table. For example, Table 1a shows the calibration data for mass stabilisation and control of soil erosion, and Table 2a shows some example scores for fallow land. The calibration data used to convert the quantitative data are consistent for all features with these impacts (note: in this example, all the data are negative as it is a case minimising a negative impact). The feature with the greatest impact defines the calibration range, and thus the impact of each feature is directly comparable.

Table 1a: Calibration data for mass stabilisation and control of soil erosion

Score	t ha^{-1} yr^{-1}
-100 to -51	>100
-50 to -46	91 to 100
-45 to -41	81 to 90
-40 to -36	71 to 80
-35 to -31	61 to 70
-30 to -26	51 to 60
-25 to -21	41 to 50
-20 to -16	31 to 40

-15 to -11	21 to 30
-10 to -6	11 to 20
-5 to -0.5	1 to 10
-0.4 to 0	0

Table 2a: Impact of fallow land on mass stabilisation and control of soil erosion (data extract)

Slope	Soil texture	Annual rainfall	Ground cover (fallow)	Value
Flat	Coarse	Very high (>765 mm)	None (bare soil)	-1.1
Moderate	Coarse	Very high (>765 mm)	None (bare soil)	-6.3
Steep	Coarse	Very high (>765 mm)	None (bare soil)	-26.3
Flat	Medium	Very high (>765 mm)	None (bare soil)	-2.8
Moderate	Medium	Very high (>765 mm)	None (bare soil)	-17
Steep	Medium	Very high (>765 mm)	None (bare soil)	-71
Flat	Medium fine	Very high (>765 mm)	None (bare soil)	-4
Moderate	Medium fine	Very high (>765 mm)	None (bare soil)	-24
Steep	Medium fine	Very high (>765 mm)	None (bare soil)	-100
Flat	Fine	Very high (>765 mm)	None (bare soil)	-3.1
Moderate	Fine	Very high (>765 mm)	None (bare soil)	-18.6
Steep	Fine	Very high (>765 mm)	None (bare soil)	-77.4
Flat	Very fine	Very high (>765 mm)	None (bare soil)	-1.6
Moderate	Very fine	Very high (>765 mm)	None (bare soil)	-9.3
Steep	Very fine	Very high (>765 mm)	None (bare soil)	-38.8

The qualitative approach has been used for a greater number of feature-impacts. There are two variations:

- Automated: scores are awarded for each parameter class, each parameter is given a weight to account for its relative significance, and thus an overall score for any particular combination of parameter classes can be automatically calculated.
- Manual: all possible combinations of parameter classes are generated, then each combination awarded a score. Used when a parameter or parameter class changes the impact score in way which cannot be accounted for using Equation 1 (e.g. the impact switches from positive to negative or is limited by a parameter class).

The automated approach uses Equation 1 to determine the overall impact score. Each parameter is given a weight between 0 and 100 and each class is given a score between -100 and +100. When the classes have been selected, the score for each class is then weighted using the parameter weight as a proportion of the sum of all the parameter weights, resulting in an overall score between -100 and +100. Table 3a shows an example of the parameter weights and class scores that have been assigned for the impact of fallow land on reptiles.

$$Impact\ Score = \sum \left(class\ score_n \times \left(\frac{Parameter\ weigh_n}{\sum(Parameter\ weights)} \right) \right) \qquad \text{[Equation 1]}$$

Summary of existing approach to knowledge structuring and impact scoring in EFA Calculator

Table 3a: Parameter weights and class scores for the impact of fallow land on reptiles

Parameter	Weight	Class	Score
Adjacent vegetation structure	100	Large area (>1ha) of rough grassland, scrub, hedges or woodland	100
		Small area (<1ha) of rough grassland, scrub, hedges or woodland	67
		Short closely grazed grassland or arable crops	10
		Large areas of bare ground	0
Adjacent wildlife corridors	100	Diverse and complete linear features	100
		Uniform linear features with gaps	50
		No linear features	0
Ground cover (fallow)	100	None (bare soil)	0
		Natural regeneration	67
		Sown bird seed mix	5
		Sown wildflower	35
		Sown grass only	67
South aspect	100	>75% faces South	100
		50-75% faces South	67
		25-50% faces South	25
		<25% faces South	0
Topography	100	Banks, ridges, hollows or hummocks	100
		Mostly uniform	0

The qualitative approach can be more subjective (compared to the quantitative approach) with increased reliance on expert judgement. The protocol below was used to systematically derive the scores and weights:

1. Identification of any existing scoring techniques, indicators or indices in the literature, especially those with documented practical field based application, and adaptation of these to the scoring system outlined above.
2. Identification of any established relationship (e.g. linear or sigmoidal) in the literature for the specified parameters, classes and impacts, and allocation of scores accordingly.
3. Identification of any critical parameters or thresholds and allocation of scores accordingly.
4. In the absence of any of the above, equal distribution of scores across the parameters and classes.

The first option, and/or a combination of options 1-3, is the most ideal as it aims to incorporate the most established and robust evidence into the indicator framework. For example, many of the biodiversity impact scores are largely based on the Habitat Suitability Index (HSI) method (Oldham et al., 2000; ARG, 2010), to rapidly assess the suitability of environmental conditions for the great crested newt (*Triturus cristatus*). The index, based on empirical evidence, uses 10 habitat feature specific variables indicative of quality for *T. cristatus* populations, then combined and averaged to provide an overall score of suitability. The scoring system was then expanded further to incorporate criteria and features applicable to other biodiversity groups, based on indicators of habitat quality derived from the published literature. Oldham et al. (2000) and ARG (2010) assign each habitat feature an index of between 0 and 1, with a score closer to one corresponding to

a feature with greater habitat suitability (Figure 1a). Adaptation of these scores for use in the indicator framework is shown in Table 4a for the parameter 'density of adjacent water bodies'.
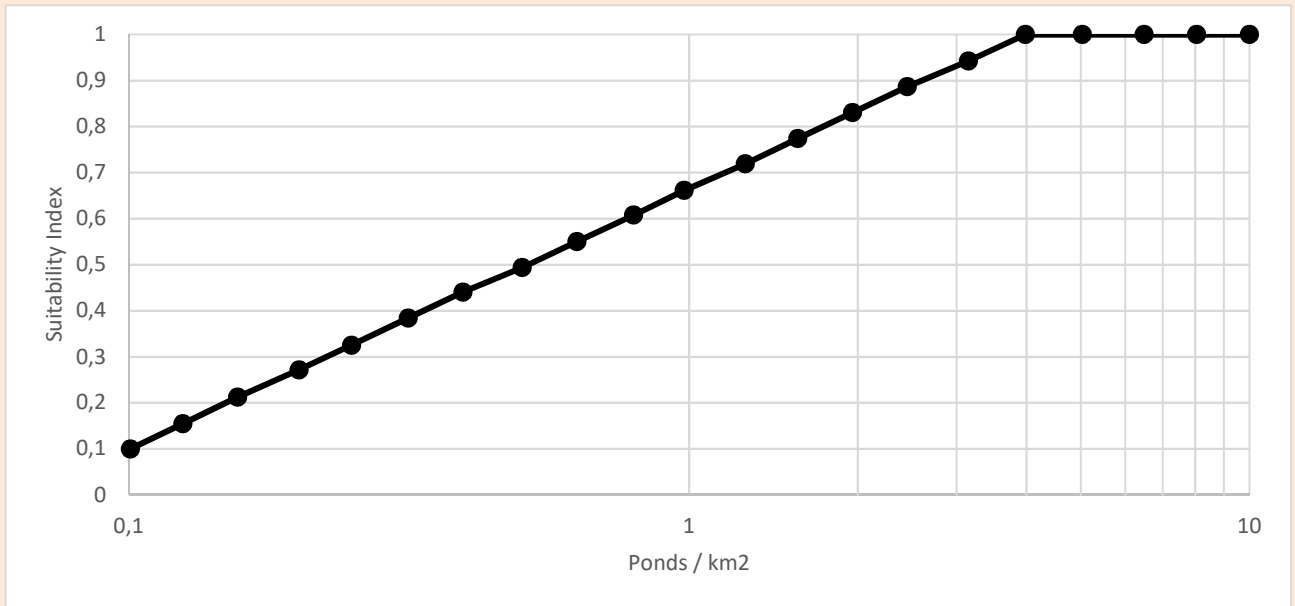
Figure 1a: Habitat Suitability Index for density of adjacent water bodies for *Triturus cristatus*

(Reproduced from ARG, 2010)

Table 4a: Impact scores for density of adjacent water bodies

Density of adjacent water bodies (ponds/km^2)	Score
>1.3	100
1	67
0.5	50
0.1	10
0	0

List of abbreviations and definitions

<u>Abbreviations</u>:

ANOVA analysis of variance
BS   buffer strips
CAP   Common Agricultural Policy
CC   catch crops
CICES   Common International Classification of Ecosystem Services
BIA   Baseline impact assessment
EEA   European Environment Agency
EFA   Ecological Focus Area
EUNIS   European Nature Information System
FIA   Functional impact assessment
IQR   interquartile range
LLF   land laying fallow
LF   landscape features
MS   Member State
NFC   nitrogen-fixing crops
NUTS   Nomenclature of territorial units for statistics

<u>Definitions</u>:

Feature impact   Potential impact of an EFA feature on ecosystem services and biodiversity
Impact categories   Ecosystem services and/or biodiversity groups on which the potential impact of EFA features is calculated

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