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Report on ecosystem services provided by semi-natural habitat from literature

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QuESSA – WP2

Literature review of ecosystem services provided by semi-natural habitats

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Introduction

A systematic map approach was chosen as the appropriate method for this review as it allowed the identification and categorisation of available evidence to form a searchable database. Systematic Maps are methodical overviews of the quantity and quality of evidence in relation to a broad (open) question of policy or management relevance. The process and rigour of the mapping exercise is the same as for systematic review except that no evidence synthesis is attempted to seek an answer to the question (from: http://www.environmentalevidence.org/Instructionsforauthors_maps.html [21/11/2013].

The map allowed us to:

- Identify the plant traits (for which there is sufficient evidence) that could potentially support ecological services so that we can include them in our database
- Identify the evidence for the services provided by SNH
- Identify subject areas where there is sufficient evidence for meta-analysis and review (the whole topic is too large)
- Identify gaps in the evidence for future research and for ourselves to explore with bolt on studies for this project.
- Understand the breadth and depth of evidence available

Method

A literature search was conducted by GWCT that was comprehensive and precise enough to find as much of the relevant literature as is realistically possible whilst avoiding the capture of too much irrelevant literature. Only published, empirical research was included and searches were carried out using the online database: Web of Knowledge (v.5.10). A scoping process was used to refine and select the final search terms that included review by the partners. The final search term was: ((woodland OR "field margin" OR "grass margin" OR hedge* OR "unimproved grass*" OR "field boundary" OR "cover crop" OR fallow OR "semi-natural grass*" OR landscape*) AND ("ecosystem service*" OR pollinat* OR "pest control" OR biocontrol OR "biological control" OR "seed predation" OR "soil erosion" OR "soil organic matter") AND (agricultur* OR farm*)). The search was restricted to research conducted in Europe by adding all European countries to the address option. All results from the search results are reviewed at a title and abstract level to ensure they meet a set of inclusion criteria. If one or more of these criteria are not met, the paper is not included in the final

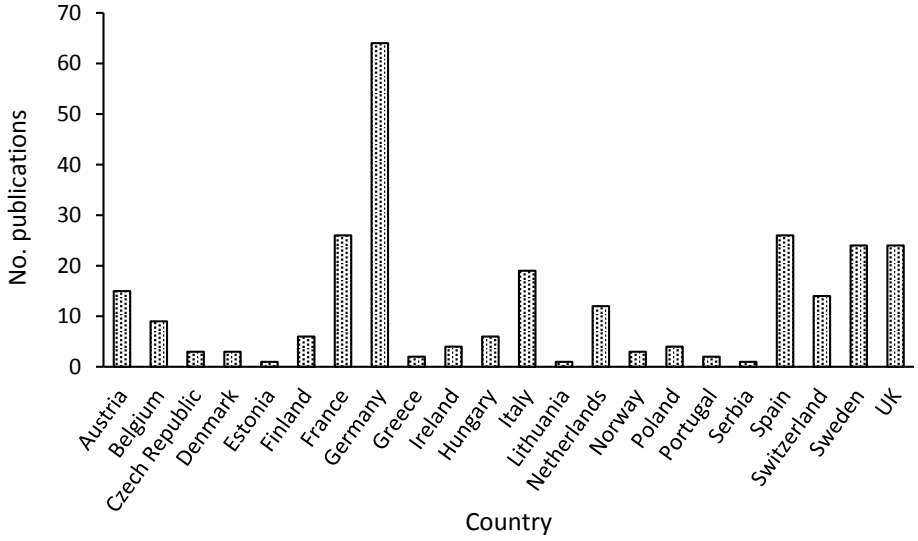
systematic map. Articles that pass the inclusion criteria are then read in full, and coded into the database by extraction of the relevant data.

Results

The search terms returned 2252 publications and these were reviewed for suitability for inclusion. Of these 285 had information that could be entered into the database. A systematic map was created and is in the form of a fully searchable Access database that provides a synopsis of the information contained in the 285 papers in which ES provision (pollination, biocontrol, soil erosion, carbon storage) from SNH was investigated.

The highest number of publications originated from Germany (64), followed by France, Spain, Sweden and the UK (24-26). (Fig. 1). Only 9 publications reported on studies conducted in more than one country.

Figure 1. The number of publications originating from European countries.

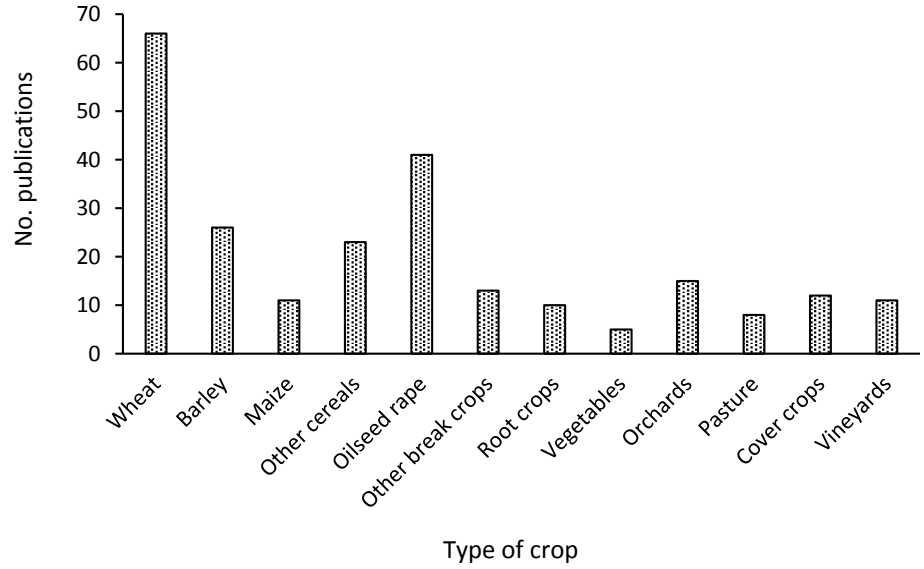


A high proportion of studies investigated the landscape structure (117) or were specific to semi-natural habitats (94). There were 42 publications comparing the effects of different farming systems such as conventional and organic or those with different levels of inputs. The type of ground management which included levels of fertiliser inputs, grazing intensity and seed mix, was investigated in 31 publications. There were 31 publications on cover crops.

The experimental design used in each study was appraised. In 110 publications the experimental approach was manipulative whilst 173 used a correlative design. The latter may be expected for habitats that take many years to establish. Only 35 used a control whilst 214 did not. 126 had a randomised design, 271 had spatial replication and 227 had temporal replication (study was repeated over more than one year). 203 publications reported on studies conducted on more than one farm (site), whilst 81 were of a single study site. Most publications originated from studies conducted on arable farming (220), 29 were of orchards and 15 on livestock farms.

The most studied crops were wheat (66) and oilseed rape (41), followed by barley (26) and other cereals such as triticale, rye, spelt and oats (23) (Figure 2).

Figure 2. The number of publications on each crop type.



The most extensively studied semi-natural habitats were hedgerows/field margins (163), woodland, shrubland (115) and grassland (138) (Fig. 3). Investigations of fallows were reported in 39 publications whilst the other habitats had 12 or fewer publications. Half of the publications (143) investigated more than one habitat type. The most frequently sampled locations were woodland/shrubland (43), hedgerows or field margins (38) and within the crop (36) (Fig. 4).

Figure 3. The number of publications for each type of semi-natural habitat.

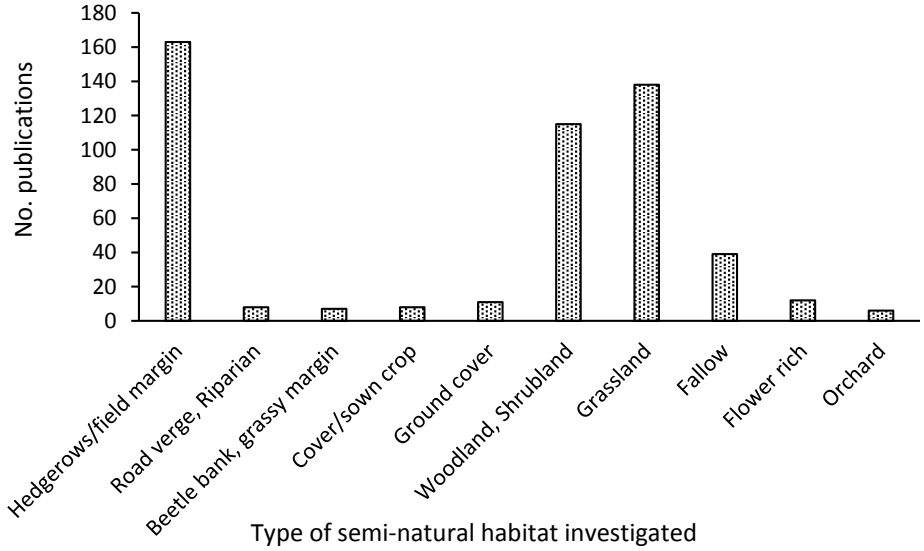
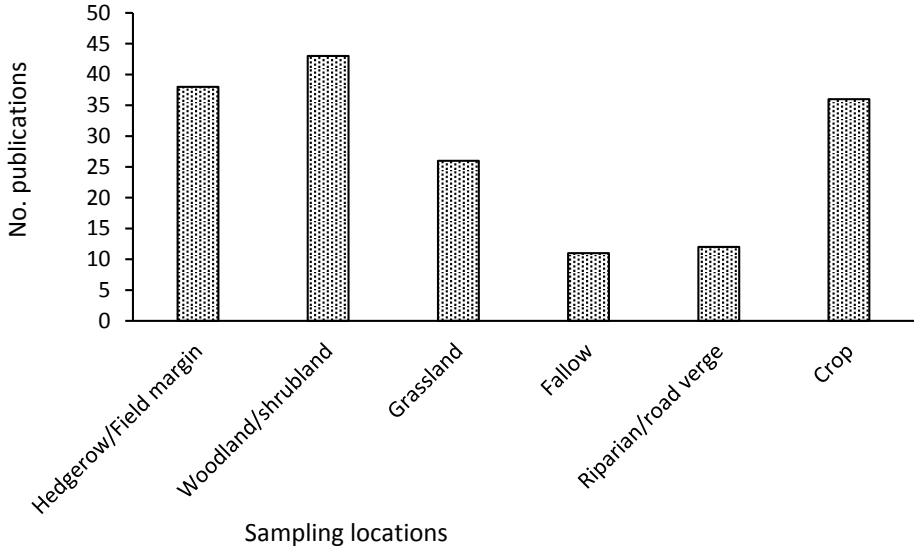
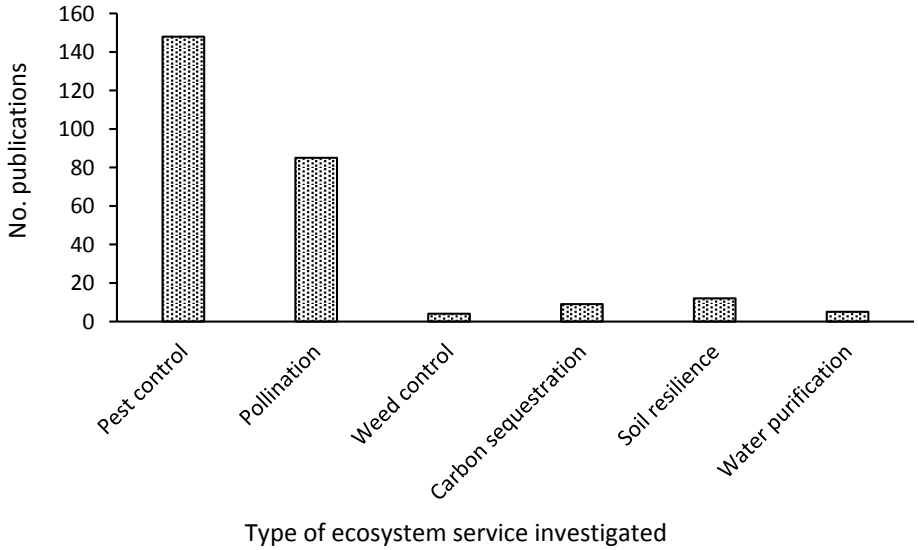


Figure 4. The number of publications in which each type of semi-natural habitat was sampled.



The majority of publications looked at regulating ecosystem services (256), 28 investigated supporting services and there were three publications for each of cultural and provisioning services. The most commonly investigated regulating ecosystem services were pest control (148) and pollination (85), with the other ecosystems services having 12 or less publications (Fig. 5).

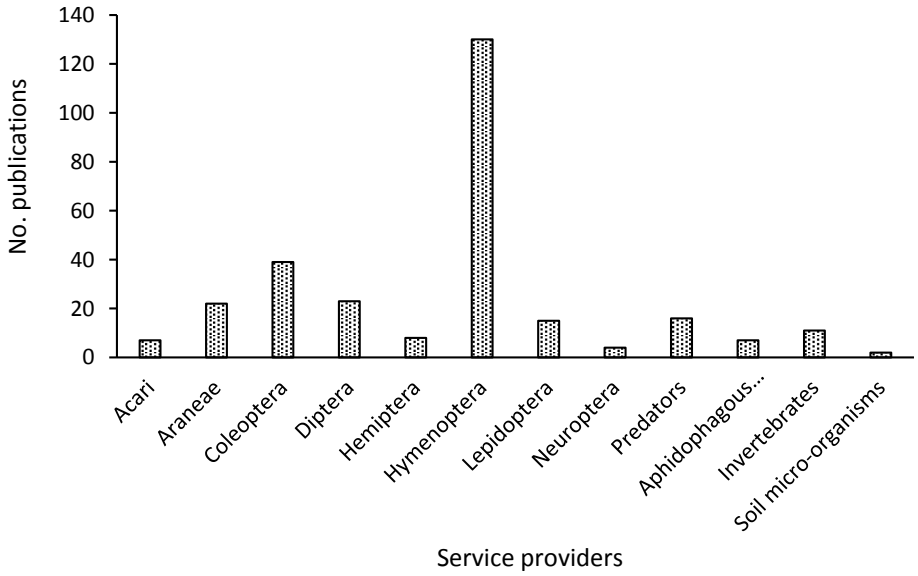
Figure 5. The number of publications for each regulating ecosystem service.



The most extensively studied ecosystem service provider were invertebrates (232) of which there were 140 publications on pest natural enemies, 79 of pollinators but only 5 of both groups and only two of organisms responsible for nutrient recycling.

Of the invertebrates the Hymenoptera were studied in the most publications (130) because this order includes bees and parasitic wasps (Fig. 6). Coleoptera (beetles) were investigated in 39 studies. Some studies only assessed functional groups such as predators or aphidophagous predators.

Figure 6. The number of publications for each type of service provider.

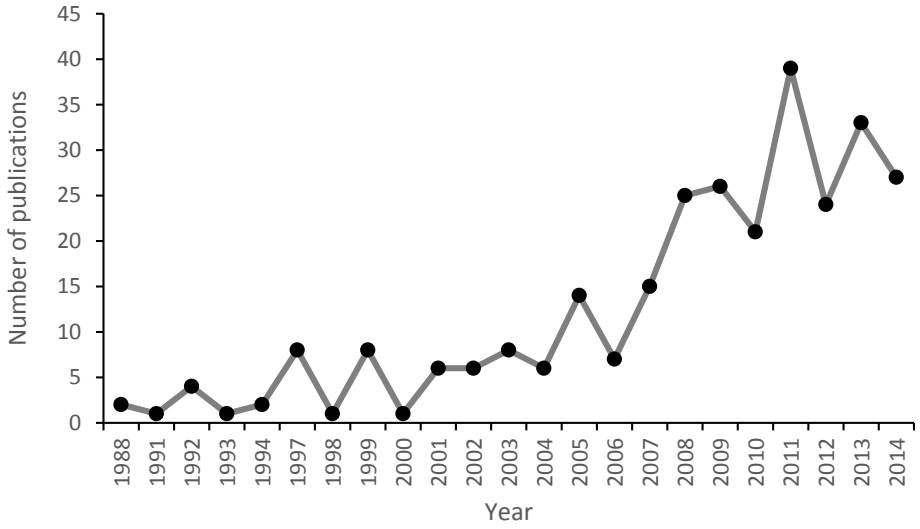


For pest control 33 publications reported pest levels, 91 levels of pest predators, 36 on parasitism rates and four measured the arthropod community composition. Only two publications reported on yield with one finding a positive and the other a negative effect of SNH. However, in 54 publications there was a positive effect of SNH on pest control although sometimes abundance of predators was used as a proxy for pest control, a negative effect in three and eight reported no effect. Of the 60 publications that provided a recommendation as to the best SNH for enhancing pest control, 26 recommended field boundary habitats such as hedgerows, hedgebase or field margins with 13 specifically mentioning hedgerows. Woodland or forest was recommended in 7 publications and grassy habitats in 5 publications.

For pollination in six publications pollen transfer or pollinator foraging activity was measured, pollinator levels were examined in 73 publications whilst 14 investigated seed or fruit set. 27 publications reported a positive effect of SNH, one found a negative effect and five no effect on pollination. None of these publications provide a recommendation on the best habitat to increase pollination, with 22 providing a recommendation only whether pollinators were more abundant in the studied habitats. Of these nine recommended field boundary habitats such as hedgerows, hedgebase or field margins with some mentioning that floral abundance within these was important. Five recommended flower-rich strips or margins, a further three recommended flower-rich meadows.

Only three publications were found in which cultural ecosystem services (recreational experience and cultural inspiration) were investigated. There were 28 publications of supporting services of which 27 investigated nutrient cycling or levels of soil organic matter and one publication each on seed dispersal and soil formation. Of the publications investigating soil erosion, 8 reported a positive effect of SNH, one a negative effect and another no effect. In 17 publications a positive effect on soil organic matter was found whilst two reported no effect. In the 15 studies that provided a recommendation on ways to increase soil organic matter, seven recommended using grassland, two using fallows and four using cover crops. Woodland and hedgerows were also found to have high soil organic matter.

Figure 7. The number of publications per annum.



Overall the number of publications investigating the selected ES covered by the systematic map has risen steadily in the last 10 years.

Conclusions

The systematic map revealed that these ecosystem services are relatively poorly investigated in most European countries with only five having more than 20 publications. Arable crops, predominantly cereals and oilseed rape, were the most studied whilst those for which pests and pollination are more important (orchards and vegetable crops) were less frequently studied. There may be several reasons for this bias. Horticultural crops occupy less land and are economically less important in the countries conducting most of the research, less research is conducted on these crops or the development of integrated pest management is more problematic for high value crops with stringent cosmetic quality targets.

A large proportion (41%) of the publications reported on investigations that included consideration of surrounding landscapes, whilst a further 33% examined specific SNHs. Given the mobility of some service providers such as bumblebees and hoverflies, it is important to consider the surrounding landscapes that may provide additional service providers to those of a local SNH. Studies investigating manipulation of landscapes to enhance ES are, however, rare because of the logistics and cost of implementing and monitoring such studies.

The heavily investigated SNHs were hedgerows or other field margin habitats, woodland and grassland, these representing the main areas of non-crop land on farmland. The detailed landscape mapping currently being conducted as part of WP3 will help identify if there are further SNH that have not been considered. Sampling for ES providers was also conducted in crops, usually as a comparison to SNH rather than as a source of service providers. The majority of studies examined supporting ES, notably pest control and/or pollination which is to be expected as most SNH occur outside of the crop and it mostly only those services that rely on mobile agents that will benefit. Provisioning and cultural services were only examined in 10% of the publications. The impact of SNH in preventing the movement of soil and water was identified as a knowledge gap as it is seldom investigated. Also the potential of SNH to sequester carbon has rarely been measured.

The most frequently investigated ES providers were invertebrates, especially Hymenoptera, Coleoptera and other predatory invertebrates because the majority of studies were on pest control and pollination. The role of soil organisms in pest control, carbon sequestration, nutrient cycling and erosion was rarely investigated.

Of the 148 studies that investigated insect pest control, 61% measured the abundance of service providers, but only 22% measured pest levels and 24% parasitism rates. Yield was only measured in two studies yet 54 publications made recommendations on the value of SNH for pest control. Yield is effected by many other inputs including levels of agrochemicals and water, therefore the measurement of SNH provision in field studies is difficult. This, however, is the most compelling evidence for farmers and is needed if wider adoption of SNH for pest control is to be advocated. In Quessa, the use of artificial prey items (sentinel systems) is being used as a surrogate for pest control because pest infestations cannot always be guaranteed nor created. Hedgerows and similar field margin habitats were considered to benefit pest control, although there is evidence that the effects do not extend far into the field, but landscapes also contribute with higher levels of pest control in complex landscapes. Both these aspects are also investigated in Quessa. Seed predation was only investigated in five studies and will also be measured in Quessa.

Pollination was investigated in 88 publications of which only six measured pollen transfer or pollinator foraging activity on flowers, with a further 14 measuring seed or fruit set. Most measured pollinators as a surrogate for pollination. There is consequently a knowledge gap for measurement of pollination and its effect on yield with respect to the value of SNH, an area that Quessa is investigating.

Few other ES have been investigated in relation to SNHs but included levels of soil organic matter or carbon storage that reflect carbon sequestration, soil erosion that impacts on water quality, nutrient levels as a measure of nutrient cycling and the aesthetic value of SNH. There was evidence that SNH stored carbon and helped prevent soil erosion. However, all of these areas require further investigation and of these the aesthetic value is being investigated by six Quessa partners, with four also examining levels of soil organic matter in SNH.