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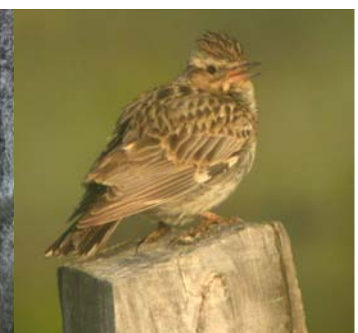

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Institute for Environment and Sustainability

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Analysis of spatial and temporal variations of High Nature Value farmland and links with changes in bird populations: a study on France

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Acronyms list

CLC : Corine Land Cover

ECA : Ecological Compensation Areas

EEA : European Environment Agency

EI : Ecological Infrastructure

FADN : Farm Accountancy Data Network

FSA : Farm System Approach

FSS : Farm Structure Survey

GIS : Geographic Information System

HNV: High Nature Value

IES : Institute for Environment and Sustainability

IFN : Inventaire Forestier National (National Forest Survey)

INSEE : Institut National de la Statistique et des Etudes Economiques

IOBC : International Organisation for Biological Control

IRENA : Indicator Reporting on the Integration of Environmental Concerns into Agricultural Policy

JRC : Joint Research Centre

LFA : Less Favoured Areas

LPIS : Land Parcel Identification System

LU : Livestock Unit

NUTS : Nomenclature d'Unités Territoriales Statistiques (Nomenclature of Territorial Units for Statistics)

PEP : Proof of Ecological Performance

RGA : Recensement Géneral de l'Agriculture

RICA : Réseau d'Information Comptable Agricole (French FADN)

UAA : Utilised Agricultural Area

Executive summary

The aim of this study is to improve the methodology to identify High Nature Value (HNV) farmland and to investigate more thoroughly the link between bird species and farmland habitats.
The focus on France derives from the availability of relevant statistical data concerning agricultural practices both at present and past time periods. In this context, a specific methodology called "**the farming system approach**" could be developed for France, which is different from the one implement at the European level by JRC/EEA (Paracchini *et al.*, 2008), based on land cover and biodiversity data.

"The farming system approach", on which the present work builds, was firstly developed in 2006 (Pointereau and Thomas, 2006) and is based on an aggregated indicator describing three main characteristics of farming systems and practices in relation to biodiversity: the diversity of crops, the extensivity of farming practices and the presence of landscape elements. Furthermore, the scoring system derived offers the possibility to have a variable HNV threshold.

As described in this report, the methodology has been refined and improved and a revised version of the HNV map corresponding to the year 2000 has been produced at the municipality scale (LAU2 scale). According to the new estimates the HNV farmland surface covers in France 7,927,915 ha corresponding to 6,967,745 ha of UAA (25% of the total UAA) plus 960,170 ha of common lands. The minimum score for farmland to be classified as HNV is 14.78 points out of 30.

HNV farmland includes 33.4% of the total livestock units, with 54.9 % of these located in Less Favoured Areas. It also includes 85% of low productive grasslands, 85% of common lands and 47% of productive permanent grasslands. Only 9% of the HNV surface is identified in vulnerable zones confirming the low nitrogen pressure in HNV areas. **63% of the farmed area of Natura2000 sites is classified as HNV farmland**.

FADN data confirm that farms located in HNV areas are **low input farms** compared to the ones located outside. For example the main input costs (fertilizers, pesticides and feedstuffs) are lower by 40% in average. However, FADN shows also that even with lower input costs and more subsidies (+5%), **the family income per working unit is lower for HNV farms** (-15% in 2006 and -38% in 2007).

A historical map based on the year 1970 has also been produced. The loss of **HNV farmland area between 1970 and 2000 is estimated to 14.4 millions of hectares** corresponding to a loss of **68% of the surface**. This evolution matches the loss of biodiversity in farmland observed by scientists. For example, during the time period 1970-2000, the generalist species of butterflies are declining slowly (-1%) compared to specialists of grassland (-19%) (Van Swaay, 2006). The comparison of 2 surveys (1970-2005) concerning weeds realized in Burgundy-France shows that the average specific richness per plot decreased from 16,6 to 9,3 individuals and the average density from 61.5/m2 to 20.2/m2 (Fried, 2007). A hundred of arable plants are now considered threatened or extinct in Europe (Jauzein, 2001; Glemnitz *et al.*, 2006; Byfield and Wilson, 2005; Legast *et al.*, 2008; Holec *et al.*, 2009).

The focus on birds is justified as it is a consistently monitored group of species in many countries of the EU, therefore sufficiently detailed data exist that allow the modellisation of temporal and spatial trends. Furthermore, birds are a robust indicator of changes in agricultural habitats.

The cross-validation of the HNV indicator with the common bird indicators proposed by the French Museum of Natural History revealed some interesting results. The analysis of local abundance showed that populations of species with **unfavourable conservation status** were larger in HNV zones. The results obtained with the **community indices** (species richness, specialist species richness, and community specialisation index) indicated that HNV farmland does **not** hold **more bird species** but **more specialized bird communities** than non-HNV sites.

The EU **Farmland Bird Indicator** (FBI) for HNV and non-HNV sites was also estimated. This indicator is efficient to trace changes over time and thus it is a widely used indicator by the European Commission. Significantly higher trends of the FBI in HNV areas than in non-HNV areas were observed, indicating that the abundances of the 20 most common farmland bird species are higher in HNV farmland. HNV farmland seems efficient to provide favourable conditions for bird populations in France.

The analysis of the evolution of HNV scores between 1970 and 2000 gave also some interesting results. We observed that sites that are presently considered as High Nature Value farmland in France hold indeed more specialist bird communities. We also showed that farmland specialists are **more abundant** in sites where HNV scores increased during the study period of 30 years. For areas with increasing level of **intensification**, we observed a negative trend of the community specialization index, indicating that bird communities are composed more largely of **habitat generalists**. This global negative trend of community specialization levels over the intensification gradient of farming practices was only slightly reversed for actual highly intensive, open field farmland, where only few open-area specialists are present.

A sensitivity analysis was performed to define which threshold (% of UAA) should be fixed for considering an area HNV farmland, based on the Farmland Bird Indicator (FBI). The analysis suggests that depending on the protection purposes possibly applied in each case, both **15% and 30% thresholds may effectively be used for the attribution of the HNV status**. The first threshold is stricter, including less HNV areas of a particularly high nature value. The second threshold is less strict, including more HNV areas but still effectively making the distinction between HNV and non-HNV areas, and respecting the compromise of a relatively high HNV score value. In the present study a threshold of 25% was applied.

In the future, it will be possible to improve again the methodology by including in the analysis data on other species groups such as weed or butterflies. Nevertheless, this national statistical approach will meet its limits unless completed by local approaches based on more precised data collected in the field.

1. Context and objectives

1.1. The concept of High Nature Value farmland

The concept of High Nature Value (HNV) farmland has been evolving over the last fifteen years in Europe. In the European Union this has been closely linked to the aim of integrating environmental concerns into Community policies. The idea that nature values, environmental qualities and even cultural heritage are linked to or depend on farming also underlies and supports the concept of a multifunctional 'European model of farming' which provides other benefits than food. The 'High Nature Value farming' idea thus ties the preservation of the biological diversity of rural areas to the need of safeguarding the continuation of farming in areas where such diversity is higher.

Europe's agricultural landscapes provide highly varied living conditions for many plants and animals. Baldock *et al.* (1993) and Beaufoy *et al.* (1994) described the general characteristics of low-input farming systems in terms of biodiversity and management practices and introduced the term *high nature value farmland*. Typical high nature value farmland areas are the extensively grazed uplands in the UK, alpine meadows and pasture, steppic areas in eastern and southern Europe and dehesas and montados in Spain and Portugal. The more intensively farmed areas in lowland Western Europe can also host concentrations of species of particular conservation interest, such as migratory waterfowl (Paracchini *et al.*, 2008).

The need for measures to prevent the loss of high nature value farmland is widely acknowledged. Conservation of biodiversity on agricultural land is an explicit objective of the pan-European Biodiversity and Landscape Strategy, the Bern Convention, the European Landscape Convention, and, at EU level, the Habitats and Birds Directives and the Rural Development Policy (Community Strategic Guidelines for Rural Development Programming Period 2007-2013). Conserving High Nature Value farmland is a key aspect in achieving future biodiversity targets. In their 2003 'Kyiv' declaration, the European Environment Ministers have set the goal to identify HNV farmland in Europe and take adequate conservation measures. The COM (2010) 4 final "Options for an EU vision and target for biodiversity beyond 2010" recognises the need of preserving and enhancing farming and forestry with a high nature value in the context of the Common Agricultural Policy (CAP).

Furthermore, in 2006 the frame of agri-environmental indicators for monitoring the integration of environmental concerns into the CAP has been formally identified and published in the COM (2006) 508. The High Nature Value farmland indicator is part of the framework, as well as an indicator on Population trends in farmland birds.

1.2. Background

Several activities have been carried out by the JRC on HNV farmland identification:

- the identification and mapping of HNV farmland in EU27, carried out in collaboration with the EEA with the aim of implementing the land cover approach to HNV mapping proposed in the IRENA operation (Paracchini *et al.*, 2008)
- an explorative study (05/1 within the Framework contract n° 380641 F3ED on the provision of expertise in the Field of Agri-Environment) on the possibility of using agricultural statistics and data on farm practices at municipal level to identify HNV farming systems (Pointereau *et al.*, 2007);
- the implementation of a HNV indicator in the CAPRI (CAP Regionalised Impact) modelling system, in order to perform the ex-ante impact assessment of policy scenarios on HNV farmland (Paracchini and Britz, 2010)

The study based on French statistical data included a first analysis of bird data and a characterization of HNV farmland areas. The results showed that there is need for further analysis, in particular concerning the spatial aspects of population trends, their link to specific changes in land cover/ land use, and the distinction between HNV and non-HNV areas in the calculation of the farmland bird indicator.

In the frame of HNV farmland activities the link between agricultural land use and biodiversity was assumed on the basis of: existing and known links between specific land uses and land cover types, spatial organization (structure) of land cover types, intensity of management of agricultural lands and species richness and abundance. However, it is necessary to further investigate this link at a more detailed scale than the one currently available in the EC agrienvironmental indicators framework (national scale for the farmland birds index). Moreover, the evaluation of the impact of present land uses, as well as their spatial and temporal changes on existing farmland biodiversity should be considered at the large scale.

1.3. Objectives

The aim of this study is to improve the methodology to identify HNV farmland areas and investigate in deeper terms the link between bird species and farmland habitats, with specific focus on High Nature Value farmland.

We specifically use data on bird species, as they are often used as an indicator of habitats quality. Additionally, birds are one of the most well documented and monitored groups of species in Europe, permitting us thus to test our hypotheses. Furthermore, as reported in the EEA Report No 2/2006 Integration of environment into EU agriculture policy — the IRENA indicator-based assessment report, "*The trend in farmland birds is a barometer of change for the biodiversity of agricultural landscapes in Europe. The indicator assumes a close link between the bird species and the farmland habitat, and shows that there has been a significant decline in farmland bird populations*".

The focus on France comes from the possibility to access to relevant statistical data and at different periods. In this context we were able to develop a specific methodology named "the farming system approach", based on the analysis of agricultural statistics and data on farming practices.

The goals of the study are the following:

- To present the methodological improvements to identify HNV farmland in France in comparison to the methodology presented in Pointereau *at al.*, 2007, and to provide a historical equivalent HNV map, calculated within the period 1970-2000.

- To assess the relation between land use changes in HNV areas and changes in bird distribution using French data.

- To present an appropriate methodology able to tackle the point above: through specific bird species indicators, aggregated land use indices (i.e. the crop diversity indicator) or other types of land use change indices.

- To do identify indicators and trends, through analysis of temporal data series (i.e. the French Breeding Birds Survey and Farm Structure Survey) that can be used in ex-post and ex-ante assessments. For example for building applications in econometric models (i.e. CAPRI) able to link changes in land use to changes in biodiversity in the analysis of policy scenarios .

- To validate the methodology tested on France using the above assessments.

Figure 1 summarises the different steps of this study.

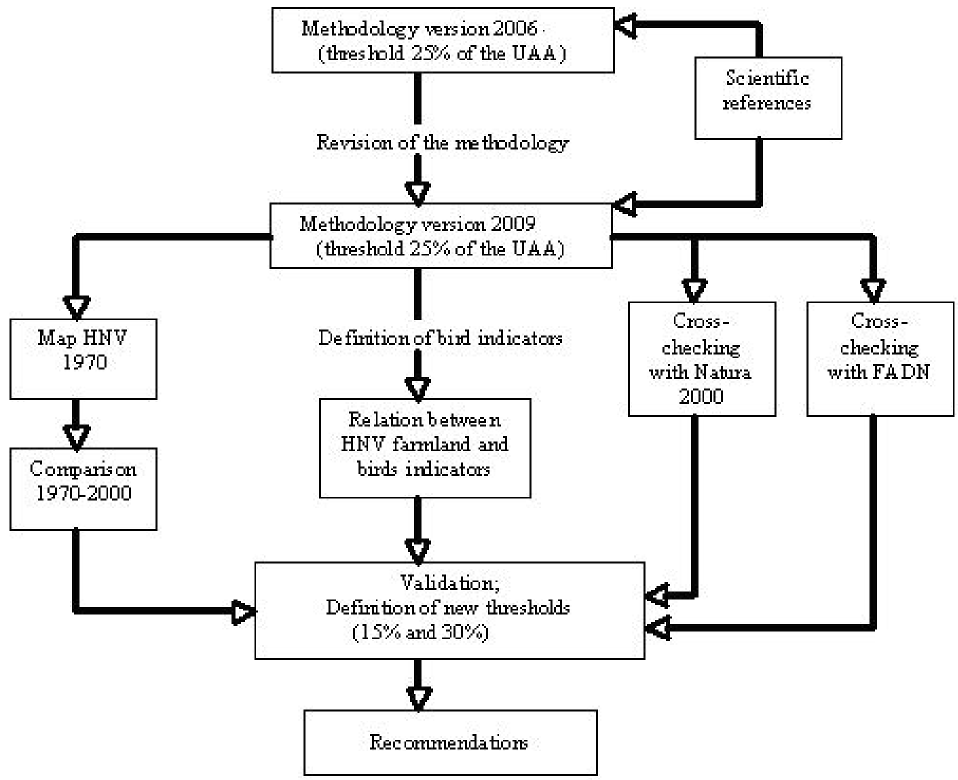


Figure 1: Presentation of the different steps of the study

2. The link between agricultural practices and biodiversity: scientific background

2.1. Biodiversity trends in farmland areas

Threats menacing Europe's wild species have become increasingly important. Almost half of the known species of vertebrates and over one third of birds are in decline (CEC, 2001). It is estimated that 50% of all species in Europe depend on agricultural habitats including a number of endemic and threatened species (Kristensen, 2003). Biodiversity decline in farmland concerns all species groups (plants, birds, insects) but the decline is more important for specialist species. For example, during the time period 1970-2000, generalist species of butterflies declined slowly (-1%) compared to specialists of grassland (-19%) (Van Swaay *et al.*, 2006). Kosior *et al.* (2007) estimated that 80% of bumble and cuckoo bees taxa are threatened throughout their range in 11 countries of Western and Central Europe.

The dramatic decline of biodiversity has been largely attributed to the intensity of land-use practices (Klimek *et al.*, 2006). The main reasons for such a decline are associated to (CEC, 2001): the simplification of crop rotation, the intensification of agricultural practices with increased use of fertilizers and pesticides, and the simplification of landscape (less semi-natural elements as hedges, increase of parcel size and decrease of the field borders).
A wide range of changes to agricultural practices has been blamed for the decline of many arable plant species:

- **The widespread use of herbicides** since 1960
- Efficient seed cleaning techniques
-**The massive increase in use of nitrogen fertiliser** (most of these arable plants are oligotroph)
- The development of high-yielding crop varieties (linked with the use of pesticides and nitrogen)
- **Removal of field boundaries** and the loss of un-intensively–farmed field margins
- Increase of field size (linked with the decrease of field boundary surface)
- Decrease of common plants species providing food for pollinator fauna of rare arable plants

The destruction of semi-naturals habitats, the simplification of crop rotations as well as higher inputs of fertilisers and pesticides are considered to be responsible for the severe decline of biological diversity that has been observed (Aebischer, 1991). Herbicide and insecticide use also result in lower weed-seed and prey-insect availabilities and these again affect seed and insect eating birds, and also raptors and owls indirectly through the decline in insectivorous prey species (for example, RSPB, 1995; Tucker and Evans, 1997).

Making agriculture more sustainable and enhancing biodiversity in agricultural systems can be achieved by reducing the amount of agrochemicals used, by low input and organic farming, appropriate crop rotations, small-scale fields and maintenance of natural areas between agroecosystems (Nentwig *et al.*, 1998). Extensive grazing is very important for maintaining the biodiversity value of permanent semi-natural grasslands (Bignal and McCracken, 2000; Miguel, 1999; Anger *et al.*, 2002; Nagy, 2002). Furthermore, to halt population declines and species extinctions of bumble and cuckoo bees which are important plant pollinators, it is necessary to preserve aspects of traditional farming practices (Kosior *et al.*, 2007).

2.2. Identification of indicators to define HNV farmland areas

The priorities of the Biodiversity Action Plan (2001) for agriculture concern:

- The diversification of types of production with all the aspects related to crop rotation
- The reduction of input uses (fertilizers and plant protection products)

- The extensive methods of production in particular in the stock-farming sector
- The promotion of organic farming
- The conservation of ecological infrastructures (linear features such as –hedges, field margins unfertilised and without use of pesticides, and isolated areas as haymaking meadows, extensive grazing, and old orchards)

These priorities have been integrated in the different agricultural instruments and policies as agrienvironmental measures (AEM), cross compliance and the promotion of HNV farming systems.

Most of the AEM are focused on the reduction of fertiliser use, the maintenance of extensive grasslands and extensive systems, the management of linear and small landscapes features and the management of rotations with the introduction of a new crop to obtain a minimum of 4 crops in the rotation.

The Pointereau *et al.*, 2007 study identified three indicators to describe HNV farmland: crop diversity (rotations), extensive practices and presence of landscape elements.

These three elements are as well the founding characteristics of the three typologies of HNV farmland identified in EEA, 2004 and revised in Paracchini *et al.*, 2008. Furthermore, the study on HNV indicators for evaluation prepared for DG Agriculture (Cooper, 2007) defined HNV systems by the following three parameters:

1) The low intensity of land use management (livestock density, nitrogen and biocide use);
2) The presence of semi-natural features (unimproved grassland, scrub, field margins, ponds);
3) The presence of a land use mosaic (scale and diversity of land cover: crops, fallows, grass, and trees).

There is, therefore, general agreement on the main characteristics of HNV farmland and these have been retained in the current study as well. Reality is much more complex than a relatively simple model can approximate, so a review of main issues to be taken into consideration follows hereafter.

2.3. Crop diversity

Intensive agriculture systems have clearly negative impacts on soil, water quality and on biodiversity conservation. The **reduction of crop diversity** to one or very few species is widely criticized for its negative environmental impacts, among which biodiversity loss (Malézieux *et al.*, 2008). The number of bugs is for example correlated with crop diversity (Billeter, 2008), while Henderson *et al.* (2009) found that crop diversification associated with low pesticide inputs is beneficial for bird populations.

Long rotations favour biodiversity when temporary grasslands are introduced. Moreover, rotations also reduce pesticide use which is beneficial to biodiversity (Le Roux *et al.*, 2008). Diversified crop rotation is linked to a higher diversity of species (Schweiger *et al.*, 2005). Diversified cropping systems including perennial forage contribute to manage weed species (Liebman, 2009). Long rotation is included in Integrated Production Principles developed by IOBC, according to which a minimum rotation of 4 years is suggested (Boller *et al.*, 1997).

2.4. Grasslands and grazing: intensification versus extensification

Grassland ecosystems hold an important part of Europe's biodiversity (Veen *et al.*, 2009). Such man-made grasslands are of great nature conservation interest. They offer ideal conditions for a vast diversity of habitats and species, and are especially important for birds and invertebrates, providing vital breeding areas. Grasslands also provide a habitat for plants and animals – soil microfauna and large mammals alike. Grasslands in Europe are an integrated part of pastoral and mixed-farming grassland systems traditionally used for hay-making, livestock grazing, or both. In broad terms, high biodiversity values coincide with low agricultural inputs, low stocking densities and often labour-intensive management practices (Klimek *et al.*, 2007; Silva *et al.*, 2008).

Temperate grasslands in Europe make an important contribution to biodiversity of agricultural landscapes. The species and community diversity of grasslands is a result of a traditional extensive grassland management interacting with a broad range of site conditions. Until the early decades of the last century, grassland sites were hardly ameliorated and the agronomic potential was generally low, depending on the fertility of the soils. Later on the production from grassland was markedly improved by regular fertilisation, by liming and by artificial drainage of wet sites. Correspondingly, stocking rates and cutting frequency increased (Isseltien *et al.*, 2005).

The nature value of grasslands depends on the level of intensification (N fertilisation/cut number/stocking density). When the intensity of management increases from 0 kgN/ha to 150 kgN/ha the overall species diversity (biodiversity score based on the SALCA Biodiversity method) decreases from 20.1 to 6.2 (Jeanneret *et al.*, 2007). Generally, the most pronounced decline in species richness occurs below 30 kg kgN/ha (Kleijn et al., 2009). The specific richness of the grassland flora decreases up to 30% with a nitrogen fertilization of 50 kg/ha. The impact of phosphorus and potassium is less important compared to nitrogen (Broyer, 2001).

Grasslands and scrub communities are the most important biotopes for butterfly species, including threatened species. Butterflies are highly dependent on man-made biotopes such as dry grasslands and meadows, which are typically maintained by farming management such as livestock grazing and hay-making. The majority of species are affected by agricultural improvement, which includes conversion of unimproved grasslands to arable crops, fertilisation of pastures and drainage of wet grasslands, which is the major threat for wetland butterflies (Van Swaay *et al.*, 2006). Grazing at a low-to-moderate stocking density promotes the β-diversity of all plant species at the local scale due to increased within-habitat heterogeneity. Low application rates of nitrogen fertilisers and abiotic environmental conditions such as steep slopes and soils with a low nutrient status are generally beneficial to local species diversity components (Klimek *et al.*, 2007).

Biodiversity strongly decreased with the increase of stocking rates and cutting frequency, with regular fertilisation and drainage of wet grasslands. Species-rich swards only persisted on a low percentage of the total grassland area and the preservation of the remaining species-rich grasslands is a primary goal of nature conservation (Isselstein *et al.*, 2005). Intensive grazing has a negative impact on specific richness (plants, arthropods and small mammals) of permanent pastures (Le Roux *et al.*, 2008). Klimek *et al.* (2007) studying 117 permanent grasslands show a strong correlation between the increase of nitrogen fertilization and the decrease of species number. No consistent optimal grassland productivity for maximum biodiversity could be found in grassland ecosystems, but a maximum species richness was always found at light grazing regimes. In the case of fertilization of permanent grassland, the ecosystem quality decreases (Reidsma, 2006). When grasslands are fertilized their productivity increases but their plant diversity diminishes. In the last 50 years levels of plant-available nitrogen and phosphorous have doubled worldwide. This additional supply of plant nutrients is predicted to be one of the three most important causes of biodiversity loss this century (Hautier *et al.*, 2009).
In Switzerland direct payments have been conditional on farm producing Proof of Ecological Performance (PEP) to preserve biodiversity. PEP requirements concern diversified crop rotation, Ecological Compensation Areas (ECA), farm nutrient budgets, selective pesticide use and soil conservation. ECA is the main measure and must cover a minimum surface of 7% of the UAA of the farm. ECA concern extensively managed meadows (no mineral nitrogen fertilization and no pesticide use), litter meadows, wild flowers strips, traditional orchards and hedgerows. These semi-natural habitats contribute to enhance the number and the density of species and contain more threatened species. For example extensive meadows contain 36 species per 25 m^2 compared to 21 in intensive meadows. 31% of the spider species and 16% of the carabid species are observed in the ECA (Herzog and Walter, 2005).

2.5. Summer pastures, pastoralism and transhumance

Transhumance is extremely relevant for the maintenance of some biodiversity-rich semi-natural grasslands, since some species directly depend on it (Herzog and Bunce, 2004), and some examples of this are listed hereafter.

In the southern part of France most of the extensive grasslands used in transhumant systems are listed in Annex I of the habitats Directive. Some of them, the semi-arid pseudo-steppe (Crau) are used by a bird fauna unique in France, including the only French population of pintail sand grouse, and the largest populations of species such as lesser kestrel, little bustard or calandra lark. Pastoralism and transhumance hence play a key role in the management of grasslands and benefit to priority bird species as *Pyrrhocorax pyrrhocorax, Neophron percnopterus and Pterocles alchata* (Wolff & Fabre, 2004).

In Germany, recent studies have demonstrated the importance of sheep transhumance in maintaining biodiversity and ecological functioning of semi-natural calcareous grassland fragments (Mertens & Huband, 2004). In Poland transhumance is crucial for semi-natural mountain grasslands preservation and conservation, which will become afforested when extensive grazing stops (Mroz & Olszanska, 2004). In Greece, transhumance landscape is of great importance to wildlife as *Pyrrhocorax pyrrhocorax, Neophron percnopterus, Aquila chrysaetos and Gyps fulvus.* Sick animals represent food for vultures (Ispikoudis *et al.*, 2004). In Spain transhumance support a high proportion of many endangered fauna species and interesting plant communities (Gomez & Iorente, 2004). In Norway summer farming areas are of vital importance for biodiversity of the Norwegian cultural landscape at both vegetation type and species level (Austad *et al.*, 2004).

2.6. Fertilizer use

The higher diversity of plants observed in Ecological Compensation Areas in Switzerland could be the result of lower fertilizer usage. This high diversity of flowering plants increases the diversity of herbivores, arthropods and pollinators (Aviron *et al.*, 2009).

Fertilizing to improve production has also diminished the biodiversity of many semi-natural grasslands and others have been destroyed and transformed into less biodiverse leys (Austad *et al.*, 2004); semi-natural sub-alpine pastures formerly managed as meadows had about twice the number of plant species, 28 per 0.25 m^2 compared to fertilized leys, 15 per 0.25m^2 (Olson, 2004).

The populations of bird species specialists of meadows, as *Vanellus vanellus* or *Crex crex* have decreased a lot since 1970. The main reasons are the drainage of wet grasslands and the intensification (mineral fertilization, and early cut) of the remaining ones. The specific richness of the grassland flora decreases with an increase of the nitrogen fertilization (see paragraph 2.4).

2.7. Pesticide use

In arable lands, pesticide uses, deep ploughing and fertilization are the main factors driving the decline of richness and abundance of species (soil fauna, arthropods, plants, birds and amphibians). Herbicide use has reduced the oligotroph flora as rare arable plants. Birds considered as specialists have been replaced by generalist species (Le Roux *et al.*, 2008). Apple orchards managed in organic farming have 4 times more bird species than those managed in a conventional way with insecticides (Bouvier *et al.*, 2005). In Denmark, the intensive use of herbicides and fertilizers on the surrounding fields appear to be the main causes of the greatly impoverished ground flora (Tybirk *et al.*, 2001).

Birds have declined significantly in the last few decades partly due to a reduction in the food available for their chicks within the arable habitat, consequence of pesticide inputs. The invertebrates found in cereal fields form an important component in the nestling diet of many farmland bird species. The *Perdrix perdrix* chick survival has been correlated to the abundance of invertebrate food. Headland and field boundaries have generally a greatest floral diversity beneficial for birds (Moreby & Southway, 2001).

2.8. Weeds and rare arable plants

Weeds and particularly rare arable plants are a relevant biodiversity indicator of organic and low input cereal fields. Albretch (2003) suggests that weeds are key species in arable fields with strong correlations to total species diversity and suggests there should be a focus on these plant species that have their main habitat in these fields. Among them, the rare arable plants (100 to 150 species)[1] share the same ecological niche as the crop plants among which they grow and can be classified as a specialist species group. As these plants are particularly sensitive to intensive practices, they can be a good biodiversity indicator of extensive practices in cereals fields (wheat, barley and oats mainly, also fallow) but also of the farming system (long rotation, mixed farm consuming their own grains, diversified landscape elements). These plants are used to measure the impact of agricultural practices on biodiversity through different methods concerning:

- Comparison of organic farms versus non-organic farms (conventional farms)
- Comparison during a long time period
- Comparison field edge-field centre (field edge are considered to be more extensively managed)
- Comparison between a field and a control plot without herbicide treatments

Surveys made in some European Countries show that weeds are declining in terms of number of species but also in terms of density. These plants have declined since the sixties with the intensification of agricultural practices (Jauzein, 2001). In Great Britain these plants are considered the most critically threatened group of plants in the British flora and seven species are regarded as extinct (Byfield and Wilson, 2005). 60% of the arable plants of Wallonia are threatened or extinct (Legast *et al.*, 2008). The comparison of two surveys (1970-2005) realised in Burgundy-France shows that the average specific richness per plot decreased from 16,6 to 9,3 individuals and the average density from 61.5 per m^2 to 20.2 per m^2 (Fried, 2007). A survey realised in Aragon from 2005 to 2007 (185 species found) shows that most of the weeds observed were rare, with 63% of the species found in less than 10% of the fields (Cirujeda *et al.*, 2009). From the total of 350 arable weed species of Czech Republic, 80 species are mentioned on the Red list (e. g. *Adonis aestivalis, Agrostemma githago, Bromus arvensis*) (Holec *et al.*, 2009).

2.9. Extensive practices and biodiversity in cereal fields

The comparison between organic farms and non-organic farms shows clearly the impact on biodiversity of pesticide use and globally of more extensive practices (long rotation, low nitrogen fertilization). Organic farming, which limits the use of pesticides and mineral fertilizer, favours rare arable plants and also weeds in general (Kay & Gregory, 1999; Romero & Chamorro, 2003; Verschwele & Zwerger, 2004; Gabriel and Tscharntke, 2007; Doreen *et al.*, 2009; Necasova *et al.*, 2009; Maria *et al.*, 2009; Salonen *et al.*, 2009).

According to (Glemnitz *et al.*, 2006), 768 weed plant species were found all over Europe on 210 fields investigated. Nearly two thirds of the species occurred rarely, only on less than 10% of the fields. Weed flora on fallow fields or extensively used fields was characterised by higher species richness.

Organic farms seem to support a substantially higher number of rare and declining arable plant species than conventional farms. Out of 21 "target" species present in England, eleven were found only on organic farms and 8 were found on both, but were more common on organic farms (Kay & Gregory, 1999). In Catalonia region, abundance, species richness and diversity are higher in organic than conventional fields (11.2 species in conventional versus 19.87 in organic in 2003, Shannon index 2.76 versus 3.13) (Cirujeda *et al.*, 2009). Plant species numbers were found to be much higher in organic than in conventional fields and higher in field edge than in field centre. Insect pollinated plants appeared to be related to higher pollinator densities in organic fields (Gabriel and Tscharntke, 2007). Under organic farming, occurrence of some species presented in Black and Red List of Vascular Plants of the Czech Republic were noticed (e. g. *Adonis aestivalis, Stachys annua)*. Many species more sensitive to herbicides (*Myosotis arvensis, Vicia hirsuta, Lycopsis arvensis*) were also found (Necasova *et al.*, 2009). Both number of species and Shannon index showed significantly higher values in organic and herbicide abandoned plots compared to sprayed plots (Maria *et al.*, 2009). The number of weed species and Shannon index were higher for the areas with low input agriculture, which are located at higher altitude (Cirujeda *et al.*, 2009). The average number of weed species was about 25 in organically managed fields and 10 in conventionally managed fields in a Finnish survey (Salonen *et al.*, 2009). Among 107 plots surveyed in Midi-Pyrénées region, 59% were under organic farming which represent only 2% of the farms,

[1] 101 in France, 120 in Britain, 80 in Czech republic, 119 in Wallonia, 150 in Germany

and 79% did not received any herbicide (Pointereau & Thomas, 2006). The abundance and richness of leguminous weeds are significantly higher in organically managed fields (Caballero-Lopez *et al.*, 2009, Romero and Chamorro, 2003). Changes in species richness of leguminous weeds (9.41 species in organic, 6.42 in conventional) can be related to the absence of chemical fertilization (Romero and Chamorro, 2003). More arable plants are generally observed in the field margins and a control plot without herbicide treatments (Fried, 2007, Solé *et al.*, 2009). For example, average species richness found in margins, headlands and crop centres was 15.32, 9.96 and 5.32 respectively (Solé *et al.*, 2009). Seven years after the conversion to organic farming (10 ha), weed species increased from 19 in 1996 to 36 in 2003 in Northern Germany, according to (Verschwele & Zwerger, 2004).

What listed above confirms that rare arable plants are indicators of extensive practices. Field margins and headlands of cereal fields have an important role as refuges for agricultural weeds, especially in non-organic fields.

2.10. Weeds and other taxa

There is a strong relationship between rare arable plants and pollinators as most of these plants are pollinated by insects. According to (Gibson *et al.*, 2006), in the United Kingdom the pollinator fauna of three species of rare plant depends on other plant species. In many cases these other plant species constitute the primary food sources for the shared pollinators. Therefore, long-term survival of rare plant populations is likely to depend on more common plant species in the community.

Wild plants in cropped areas provide seeds and other resources for higher taxa (Fletcher, 2009). Weeds contribute to feed predators. In the field, ground beetles (Carabidae) exert an important seed predation. *Pseudoophonus rufipes* consumes 29.0 seeds per day and *Harpalus affinis* 12.2 seeds per day (Saska *et al.*, 2009).

High nutrient inputs from artificial fertilizers are designed to favour crop growth and hence favour a high crop density which may suppress the growth of other weeds and plants, leading to a loss of plant species diversity which may in turn affect invertebrate abundance and diversity (Wilson and Tilman, 1993; Kleijn and van der Voort, 1997). A high crop density can also impede access to single plants and to the ground to foraging birds and young chicks (Shrubb and Lack, 1991).

Considering weeds as an important part of farmland biodiversity, extensive practices as low herbicide and nitrogen use, and low yields, are important to maintain a high level of biodiversity in arable fields. But other factors can be considered, as efficient seed cleaning. As the commercial seeds do not contain any weed seeds, it is important for certain rare arable plants to maintain traditional seed cleaning which leave in average 7% of the weed seeds in the soil (Loddo *et al.*, 2009). Today, the main farming systems which still apply traditional seed cleaning are mixed farms which use their grains only to feed their animals and try to reduce the seed costs, and organic farms, considering the difficulties to buy traditional varieties and organic seeds. Traditional seed cleaning is in fact sufficient to control the weeds but not to satisfy commercial rules.

2.11. Landscape elements and semi-natural elements

The presence of semi-natural habitats is a defining feature of HNV farmland. In many HNV farmland areas, the majority of the farmed area is semi-natural, comprising various types of grazed vegetation. In addition, the presence of semi-natural elements such as field margins, hedges, grass strips, patches of uncultivated land and other semi-natural vegetation, such as grassland, is an essential ecological complement to low intensity agricultural fields (Cooper *et al.*, 2007).

The diversity of agricultural landscapes has globally a positive effect on biodiversity by increasing the species richness and their abundance. Ecological infrastructures have a role of refuge, corridor and habitat for numerous species, while fragmentation of semi-natural habitats has a negative impact on species richness. Biodiversity response to the percentage of semi-natural elements in the landscape **is not linear** (Le Roux *et al.*, 2008). Duelli (1990) concludes that a mosaic landscape of small-sized crop fields and semi-natural habitats maximises arthropod diversity.

A large study (Billeter, 2008) concerning 25 landscapes located in 7 European countries including France showed that the specific richness (birds, plants, carabids, bees, spiders, hoverflies and bugs) is positively correlated to the proportion of semi-natural habitats and negatively correlated to fertilization.

IOBC recommends a 5% rule for ecological compensation areas (excluding forest). They include areas with no input of fertilisers and pesticides (hedges, natural biotopes, field boundaries, ditches and extensified agricultural surfaces) (Boller *et al.*, 1997).

2.12. Hedgerows: density and connectivity

A minimum surface of hedgerows and wood edges is necessary to connect the different elements of the landscape and increase biodiversity. In particular density and connectivity of hedgerows are important elements to enhance biodiversity, since they connect habitats. A study by Constant *et al.*, 1976 shows that bird density decreases from 99 pairs to 63 and 35 in French landscapes characterised by, respectively, high hedgerow density, low hedgerow density and openfield landscape and the specie richness by 58% between bocage and openfield.

In Norway, Oreszczyn and Lane (2001) show that suitable habitats connected to other habitats by hedges and other margins had twice the probability of supporting a population of the scarce copper (*Lycaena vigaureae*) than unconnected remnants. Hedges are assumed to act as corridors for certain woodland plants as well. Boundaries and hedgerows plots in Britain support relatively higher frequencies of species associated with woodland edges or less shaded parts of woodland (Smart *et al.*, 2001). Connected hedgerows have more woody species present than the unconnected hedgerows with the same range of lengths (Boots, 2001).

There are 54 species of butterfly in lowland Britain, 23 of these breed in hedgerows, 15 commonly showing the importance of hedgerows for butterfly species. Butterfly populations may benefit substantially from consistently low pesticide usage in field margins.

The number of snail species is correlated with the age of the hedge. Hedges can be relatively good reservoirs of forest species in agricultural landscapes and their presence will increase the rate of colonisation of abandoned land (Barr *et al.*, 1995).

Hedgerows contribute biological control of crops. Predator-parasitoïd complexes and a number of beneficial pollinators can benefit from hedgerows and associated vegetation in field margins as the two spotted spider mite in corn-soybean fields (Paoletti *et al.*, 2001). They supply shade, pollen and nectar sources (Moreby and Southway, 2001). Woody edges increase the structural and vegetation diversity in agricultural areas. A higher insect diversity and particularly predacious species are found in hedges if compared to agricultural fields, and in fields situated in landscapes with a higher density of woody edges. So the latter may be beneficial to agriculture by controlling herbivore species, furthermore higher carabid species are found near to the field boundaries in comparison to mid-fields (Holland and Fahrig, 2001).

The importance of hedgerows for breeding birds in farmland is generally accepted. Hedges provide a resource for many birds for nesting, song perches, roosts, food supply, shelter from predators and for movement. A large proportion of the British avifauna is thus to be found in hedges (Barr *et al.*, 1995). Abundance in the majority of species, and therefore also species richness and species diversity, is highest in high, wide hedges with trees and high berry abundance. Only some farmland specialists (Red-Legged Partridge, skylark, House sparrow and Tree sparrow) prefer short treeless hedges (Chamberlain *et al.*, 2001).

2.13. Traditional orchards

Traditional orchards of standard trees comprise a wide range of micro-habitats (herbaceous plants, buds, flowers and fruits, cavities, deadwood and bark) because of their structural diversity. Ecological gradients are a result of climate conditions (humid, dry, sunny, shady, windy or sheltered) and farming practices (whether or not reaping takes place). They have therefore become a refuge for declining or endangered species. Almost 2,400 plant and animal species have been recorded in these habitats in Germany, including 408 endangered species (Rösler, 1996).

Orchard meadows support complex food chains. Little owls, for example, are fond of the cavities in old walnut, apple or pear trees, where they hide during the day and raise their chicks. Bullfinches, whose numbers are declining, are attracted by buds. In winter the orchards shelter a large part of wintering populations of redwings and fieldfares. In England 15% of the population of hawfinch breed on cherry traditional orchards (Coulon *et al.*, 2005). In Alsace, 35 species of breeding birds have been counted, 10 of which can only be seen in these orchards. Half of these birds are cavernicolous, such as wrynecks, hoopoes, green woodpeckers, tree sparrows, starlings and tits. Cherry orchards attract a significant number of hawfinches. Plum orchards are home to a high density of wrynecks and redstarts – 41 species have been observed – along with several species of bats (serotines, noctules, greater horseshoe bats, brown long-eared bats and pipistrelles), garden and fat dormice and stone martens. A total of 75 species of hoverflies have been observed in the Midi-Pyrénées region, including five heritage species (rare at a national scale).

Apple pests, European red mites (*Panonychus ulmi*), provide an interesting example. A survey carried out in 1996 of 19 orchards in the North of France showed that intensive orchards only harboured one species of phytoseidae (mite predators), compared to two in organic orchards and six in orchards of hardy trees. The biological stability of orchard meadows makes it possible to achieve a high yield without using chemicals; the production of dessert apples in intensive orchards of dwarf trees requires in fact an average of 37 chemical treatments (Pointereau, 2005).

In Normandy, the orchard habitat is way the richest because it is set in a bocage context. The complementarities among orchard-meadow-hedge are a major factor in explaining the increased presence of many species in such orchards. The half-standard orchard adopted at the end of the 20^{th} century for industrial considerations does not have a lot in common with the traditional orchard and its bird population remains a lot poorer than that of the latter. At this regard, Colette (2008) proved that the number of cavernicolous birds increases with the size of the orchards.

2.14. Fishing ponds

In France fishing ponds cover 0,5% of the UAA. The main fishing ponds areas (*La Dombes, La Bresse, la Brenne, Sologne, Armagnac*) are included in Natura 2000 sites. They consist of a specific natural habitat for different species of European interest. They are managed extensively for carp and pike production (80 kg/ha to 400 kg/ha) and also for hunting.

In France, The Dombes (site Natura 2000 FR 820 1635) is the main fishing pond region covering 12.000 ha with 1.000 ponds created in the Middle Ages. These ponds are of biodiversity interest with 3 habitats, 3 aquatic plants of European interest and numerous amphibians, bats, fishes, butterflies and mainly birds (as *Chlidonias hybridus*) of European interest (DIREN Rhône-Alpes, 2004). The pond is part of the crop rotation and is cultivated every 3 or 5 years. Sologne is the larger French Natura 2000 site (site FR 240 2001) with a surface of 345,000 ha (Allion, 2007), and contains 3,200 fishing ponds covering 11,500 ha (2% of the UAA).

2.15. Other farming practices

Besides the farming practices mentioned in the above paragraphs, others exist that impact as well on biodiversity and that are not directly taken into account in the three indicators presented in this study. These are listed in Table 1.

Table 1: Agricultural practices which impact biodiversity related to the three main indicators

Indicators	Agricultural practices	Biodiversity impact	Links with the existing indicators
Grassland and grazing	Use of pesticide worming	Coleopteran coprophagous	No direct link
	Phosphorus fertilization	Flora	Mineral fertilization
	Cut date	Breeding birds	Mineral fertilization
Crops	Parcel size	Arthropods	Percentage of landscape elements
	Deep ploughing	Arthropods	No direct link
	Drainage	Specific wet grassland birds	Crop diversity
	Irrigation	Fauna and flora	Crop yield, crop diversity
	Seed cleaning	Some specific rare arable plants	Crop diversity (mixed farming)
Hedgerows	Hedge cutting, trimming, timing, high		No direct link
	Species composition	Arthropods	No direct link
	Tree and hedgerow age	Epiphytic mosses, lichens, birds, woodland plants	No direct link
	Connection	Birds, small mammals, wood land plants	Percentage of landscape elements
	Presence of field margins (width) Management of adjacent fields	Plants	Intensity of practices
Traditional orchards	Parcel size	Birds	Percentage of landscape elements
	Age of the tree	Birds	No direct link
	Management of the grassland under the trees	Flora	Intensity of practices
Ponds	Management: drain pond	Birds, flora	No direct link

2.16. Conclusion

This scientific review shows that the three indicators used in the "Farming system approach" are recognised for their strong links with biodiversity. It shows as well that crop diversity is an important factor, but biodiversity level is highly correlated to the intensity of management and the presence of landscape elements. Very few studies exist concerning the impact of crop diversity on biodiversity and most of the studies are focused on the impact of agricultural practice intensity (mainly fertilization and pesticide use) and semi-natural habitats (landscape elements, ecological infrastructures) located in the farmland. The main effect of long rotations is an indirect effect through pesticide reduction.

Mixed farming and grasslands offer favourable conditions for biodiversity but this objective is achieved when agricultural practices are not too intensive. Extensivity of practices and farming systems offer the best conditions for biodiversity. For example, organic farming has always a higher level of biodiversity compared to conventional farming.

It is clear also that interrelations and synergies exist between these different components. For example, the biodiversity level of a landscape element such as a hedge is enhanced when the crop headland is managed extensively or when a traditional orchard is surrounded by a hedgerow.

3. The HNV indicator: changes in the methodology

3.1. Structure of the indicator

The method used for the estimation of the High Nature Value (HNV) indicator relies on the calculation and combination of three components (see Figure 2):

1) crop diversity
2) extensification of farming practices
3) presence of landscape elements

which are all considered to be favourable to biodiversity. These three components provide information on farming systems, and can be calculated on the basis of the Farm Structure Survey (FSS) and other national databases (Pointereau *et al.* 2007). The three indicators are combined to compute a final score leading to the identification of High Nature Value farmland.

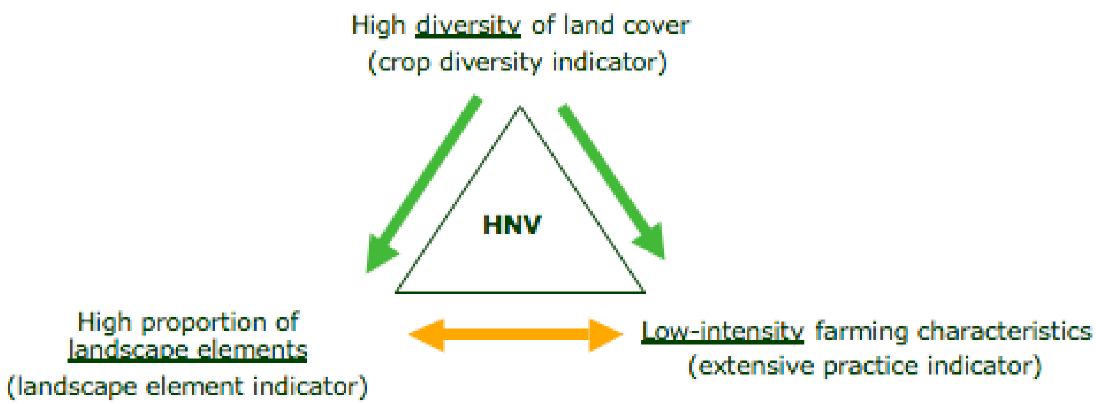


Figure 2: The three components of the HNV indicator

The research work described in this report has the aim to fine tune and implement the methodology described in Pointereau *et al.*, 2007, therefore a critical description follows hereafter of all changes made (summarised in Table 3). The Pointereau et al. 2007 work is referred to as "2006 version" of the methodology.

3.2. Revision of the methodology

3.2.1. Data used

Different data sources have been used to calculate the indicators (see Table 2). The main data source is FSS 2000 (and FSS 1970 for the temporal analysis) which provides data at the farm scale. Data concerning the surface of each crop per farm have been used to calculate the indicator "Crop diversity" at the municipality scale.

Table 2: Overview of information used to characterise HNV in France

Survey	Statistical variables	Administrative Scale and year	Relevant indicators
FSS 2000	Crops and grasslands, farm ponds, farms having common pastures	Municipality, 2000	Crop diversity, % of permanent grassland/UAA, number of farms with fishing ponds, surface of common lands
FSS 2000 "specific regional questions"	Traditional orchards	Municipality, 2000 (see table11)	Number of traditional apple, chestnut, walnut and olive trees
Agricultural Annual Survey 2000	Common land	Department, 2000	Surface of common land per department, grain yields
National Forest Survey (IFN)	Forest borders and hedges	"Department", 1985-2004 (one survey per "department" every 12 years)	Length of borders and hedges /UAA
Grassland survey	Grassland management of productive grasslands	Small grassland region, 1998	Nitrogen units/ha of grassland, % of unfertilised grassland
French LPIS	Agricultural parcel	GIS, 2006	UAA included in Natura 2000 zones
Wetland survey	All wetlands included wet grasslands	GIS, 2009.	Surface of wet grasslands per municipality
Regional data	Traditional orchards	Municipality	Number of traditional apple trees

3.2.2. Weighting of indicator components

The main revision in comparison to the 2006 methodology concerns the change in the weighting system.

The final indicator is obtained by summing up the single scores of the three components. In the 2006 version, the methodology attributes a double weight to the crop diversity component (weighting 2-1-1), i.e. while the values of crop diversity range from 0 to 10, the other two components vary in a scale from 1 to 5, and the final indicator ranges from 0 to 20. The choice of attributing a double weight to crop diversity was made because of the availability of detailed data (LAU2) at national level (Pointereau *et al.* 2007) that allowed a very precise calculation of this component, while this was not the case for the data used in the other two components.
The revised version of the methodology (weighting 1-1-1) considers instead an equal weighting of the three components.

The aim of the comparison presented hereafter is to make a sensitivity analysis and to investigate if there are significant differences between the final scores resulting from the two weighting approaches. If the double weight does not significantly improve the estimation of the HNV score, the simpler aggregation frame i.e. weighting 1-1-1, should be preferred, since there is no real scientific background that justifies the use of a different weighting system.
For comparisons, both indicators are normalized to the same scale (ranging from 1 to 20), and further compared using a Pearson correlation test. Results revealed that the scores of the two indicators are highly correlated ($r = 0.98$, $p << 0.001$). Moreover, the slope estimate of the linear regression is 1.02, which is very close to 1 i.e. indicating a very high similarity between both indicators (Figure 3). These results indicate that there is almost no difference between the values of the two indicators.

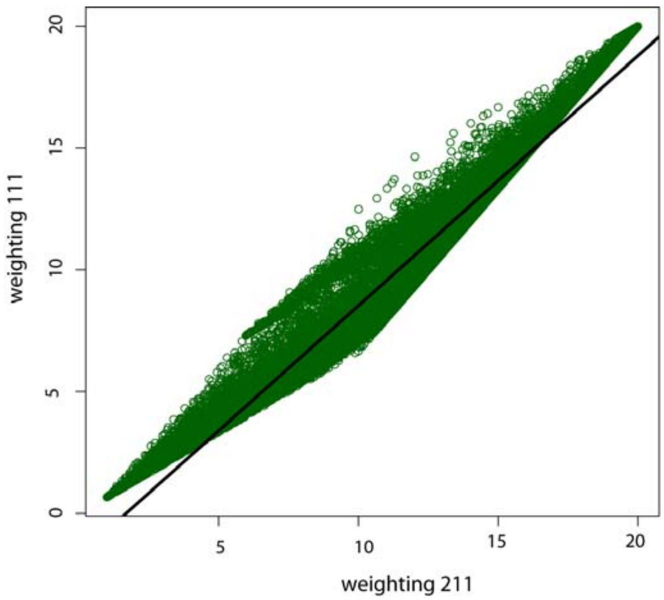


Figure 3: Scores obtained by the two indicators.

The residuals from the linear regression presented in Figure 3 were calculated, to further study the eventual structure of the small differences between the two indicators (=2%). Plotting these residuals against the original indicator value of weighting 2-1-1, we found that for low (<5) and high (>15) HNV scores, the indicator of weighting 1-1-1 gives slightly higher values than the weighting 2-1-1. The difference varies between 0 and 1.5. This means that for the extreme cases of highly intensive farmland areas and the High Nature Value areas, the indicator calculated using an equal weighting for all components provides scores that are slightly higher. These results indicate that weighting 1-1-1 can more effectively discriminate values at the higher range of the scale. For average HNV scores (between 5 and 15), weighting 1-1-1 gives slightly lower scores than weighting 2-1-1. The differences are very small varying from 0 to -0.5. As the threshold for characterizing HNV zones is around 15 (=14.80), the difference between the two indicators is 0 at this threshold. We thus consider that the simpler indicator (weighting 1-1-1) should be preferred over the double weighting for crop diversity component (weighting 2-1-1), as it is highly similar to the weighting 2-1-1 but allows to discriminate more efficiently high nature value areas.

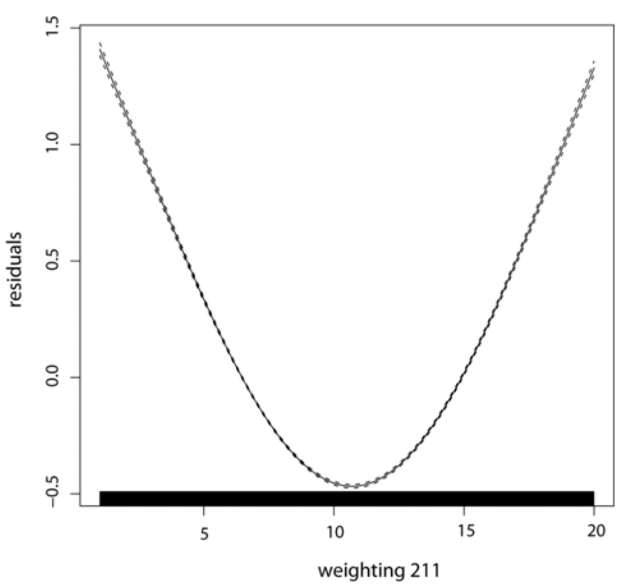


Figure 4: Residuals of the linear regression presented in Figure 3 over the weighting 2-1-1.

3.2.3. Component 1: "Crop diversity"

The method for calculating the crop diversity component was not changed, and is described in 4.1

3.2.4. Component 2: "Extensivity of farming practices"

The improvements of this component concern three points:

1. Fallow lands have been considered as extensive practices as the agricultural practice survey 2001 shows that fallow lands are in majority not fertilized (98%) and do not received any pesticide treatments (80%).

2. The location of common lands is more precise. The disaggregation of the surface of common lands provided at NUTS 3 is now realized on the base of the livestock units of each farm using common lands as reference and not on an average per farm basis. The common lands surface is always considered as extensively managed (this means they get by default the highest score).

3. Mineral nitrogen fertilization of permanent grasslands is not any more based on the average between the fertilized grasslands and the non-fertilized grasslands. These two categories have been considered separately.

3.2.5. Component 3: "Landscape elements"

The improvements of this component concern 5 points:

1. One new landscape element has been integrated in the scoring of this indicator, as statistical data are now available. This concerns wet grasslands.
2. New data on surface of traditional orchards have been added.
3. The location of forest edges is more precise.
4. The disaggregation of forest edges length is now based on the forest surface of the municipality and not on a ratio by department.
5. The weight of the fishing ponds has been increased considering that they represent a rare and important landscape element, which was previously underestimated. Actually, the French FSS survey does not contain data on the number of ponds and pond surface per farm but only if there is at least one.

Table 3: Evolution of the methodology between version 2006 and current version

	Changes	Reasons	Consequences
Indicator 1 "crop diversity"			
Weighting	Same weight to all three components	Difficulty to explain the reason for assigning double weight to the crop diversity component	No real change
Indicator 2: Extensivity of farming practices			
Fallow land	Give the maximum points to fallow land	It was not integrated in the first version. The majority of fallow lands are not fertilized and do not received pesticides.	Limited. Fallow land represents 3% of the UAA. Bonus for the arable areas where set aside is not used for industrial or energy crops
N Fertilization of productive permanent grasslands	In 2006 the average between non fertilized grasslands and fertilized grasslands was used. They are now considered separately	For example in Lorraine, the average for fertilized and not fertilized grasslands is 60 Kg/ha. Consequently the grasslands do not get any point. But 30% of the grassland are not fertilized and should receive some points.	A bonus for the region (small grassland regions) with an average fertilization higher than 50 kg/ha but with a percentage of non fertilized grasslands.
Surface of common land	Calculation of the surface weighted by the number of LU of each farm declaring using common lands.	It is just an improvement. In version 2006 the disaggregation of common lands was based only on the number of farms declaring to use common lands	Very limited (only 14,000 farms use common lands). A bonus for the larger farms (with more animals) and the municipalities with more cattle.
Indicator 3: Landscape elements			
Traditional orchards	Introduce new data	New information coming from surveys of Natural Regional Parks	Very limited: few municipalities (40 to 50)
Forest edges	Change the width of the edge (5 m compared to the previous 10 m).	To be coherent with different policies and reports assigning a width of 5 meters.	Less points to forest edges compared to the other landscape elements
Forest edges	The disaggregation is based now on the percentage of the forest area in the municipality	It is assumed that there is a correlation between the forest surface and its edge length. The shape of forest patches is also important.	A bonus for the municipalities with a higher percentage of forest (--> more edges)
Fishing ponds	Increase the weighting. 1 point per farm. Maximum 5 farms with fishing ponds per municipality	There are very few municipalities with ponds and often farms have more than one pond. Some fishing ponds are not declared in the UAA	More points for municipalities with fishing ponds
Wet grasslands	Introduce a new landscape element	This follows a request of local stakeholders. Wet permanent grasslands can be considered as a landscape element and are often very rich in biodiversity. A large part of them is in Natura 2000 sites	A bonus for the flooding plains.

4. The HNV indicator: updated methodology

4.1. Component 1 “Crop diversity”

Hypothesis: see chapter 2.3 and 2.4. This indicator is a proxy of the rotation system, since the diversity of crops and the presence of permanent and temporary grasslands are favourable to biodiversity. The diversity of crops provides more habitats and more food for fauna and contributes also to a decrease in input uses (pesticides, and nitrogen with legumes crops). Grasslands generally do not receive pesticide treatments. More crops means also more plots offering place to ecological infrastructures (IE) as grassy strips. Woody landscape elements such as hedges, traditional orchards, scattered trees are often linked to grasslands. Longer rotations and the presence of permanent and temporary grasslands are indicative of mixed systems and less intensive agriculture.

Temporary and permanent grasslands are multi-species and cannot be assimilated to one single crop. Temporary grasslands are generally sown for more than 4 years. Generally in grazing systems, the forage surface is distributed in different categories (annual forage, legumes, temporary grassland and permanent grassland) with different species, increasing the diversity of the crops. Leguminous grasslands (alfalfa, clover) represent in France 3% of grasslands and often less than 10% of the UAA (source FSS, 2000) and temporary grasslands represent 25% of grasslands. This means that the majority of grasslands are permanent grasslands. The nature value of fodder surfaces depends on the agricultural practices and their intensity (see Figure 5).

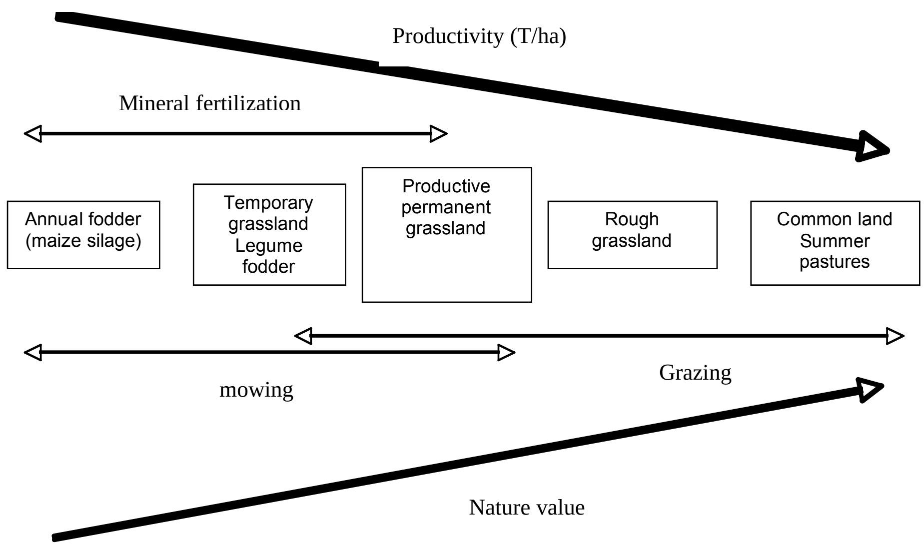


Figure 5: Types of fodder surfaces and agricultural practices

4.1.1. Calculation

The indicator is first calculated for each farm (660,000 farms in France in 2000) and then for each municipality (LAU2) as the sum of results at farm level weighted by the respective farm surface.

The indicator per each farm is calculated as follows:

$$\text{CropDiversity(i, j)} = 10 + \sum_{\text{i,C(i)}>\frac{\text{UAA(i,j)}}{10}} \left\lfloor 1 - \frac{\text{C(i)} \times 10}{\text{UAA(i, j)}} \right\rfloor$$

Where:

i : farm

j : municipality

CropDiversity(i,j): crops diversity indicator of farm i in municipality j

C(i): crop area of farm i (referring to each group of crops as listed in Table 18, Appendix I)

UAA (i,j) : Utilised Agricultural Area of farm i in municipality j

Crops are aggregated to simplify the calculation (small surfaces) and because from an ecological point of view they can in specific cases be considered as being the same crop (see Table 17, Appendix I).
The scoring of temporary and permanent grasslands is considered to be what remains after the scoring of each group of crops has been calculated and subtracted from the initial maximum scoring of 10.
NB: The surface of common pastures is not taken into account in the calculation of the indicator because not included in the UAA.

The indicator 'Diversity of crops' is then calculated at municipality level (LAU 2) as the sum of individual farm indicators weighted by the UAA of the farms. The equation is as follows:

$$\text{CropDiversity(j)} = \frac{\sum_{\text{i}} [\text{CropDiversity(i, j)} \bullet \text{UAA(i, j)}]}{\text{UAA(j)}}$$

Where:

i : farm

j : municipality

CropDiversity(j): crop diversity indicator of municipality j

CropDiversity(i,j): crop diversity indicator of farm i in municipality j

UAA (i,j) : Utilised Agricultural Area of farm i in municipality j

UAA (j) : Utilised Agricultural Area of municipality j

Examples of farming systems:

In practice, the indicator is built in a way that it gives 1 point to each crop, including annual forage, covering at least 10% of the UAA (plus decimals), while for grasslands (temporary and permanent) it gives one point per each 10% of its surface. Grasslands are considered as different crops (different categories of grasslands and different species sown or present) and are weighting more since they bring a higher nature value when extensively managed.
The minimum score of 1 is achieved, for example, in a monoculture of vineyard or maize (example E); and the maximum score of 10 is achieved either when there is a high presence of grasslands (example A), or a high number of crops covering each more than 10% of the UAA (example B). Between these two extremes the score will depend on the share of crops which cover more than 10% of the UAA. The score will decrease as this share increases (examples C and D). The score will increase as the share of permanent and temporary grasslands and/or the number of crops increases.
The crops that cover less than 10% of the UAA are accounted for in the indicator proportionally to their surface converted in decimals (i.e. 8% of UAA corresponds to 0.8 in the scoring system). The formula does not directly calculate these scores, but they result from the subtraction of the index score for crops covering more than 10% of the UAA.

Example A: total surface 100 ha, out of which 100 ha of grassland.
→ No crop, so : $CropDiversity(A) = 10 + 0 = 10$

Example B: total surface 100 ha, out of which 10 crops covering 10 ha each.
→ No culture exceeds 10% of the UAA, so : $CropDiversity(B) = 10$

Example C: total UAA is of 100 ha, out of which 50 ha of grassland, 25 ha of wheat, 20 ha of sunflower and 5 ha of peas.
→ $\text{CropDiversity(C)} = 10 + \left(1 - \frac{25 \times 10}{100}\right) - \left(1 - \frac{20 \times 10}{100}\right) = 10 - 1.5 - 1.0 = 7.5$

Example D: total UAA 100 ha, out of which 35 ha of grassland, 25 ha of wheat, 15 ha of sunflower, 5 ha of rapeseed, 5 ha of sugar beet and 10 ha of rye

→ Only wheat and sunflower are considered, so:

$$CropDiversity(D) = 10 + \left(1 - \frac{25 \times 10}{100}\right) - \left(1 - \frac{15 \times 10}{100}\right) = 10 - 1.5 - 0.5 = 8$$

Example E: total surface 100 ha, out of which 100 ha of maize
→ $\text{CropDiversity(E)} = 10 + \left(1 - \frac{100 \times 10}{100}\right) = 10 - 9 = 1$

Data sources: FSS census

Range :
- The score ranges from 1 to 10. Zero is not possible because at least one crop is always present.

Weighting : 1

Evolution version 2006 / current version
- No change

Weaknesses
- in average 18% of the UAA of a farm is not located in the municipality where it is declared (generally the neighbouring municipalities). This affects the real UAA of the municipalities but not so much the final value of the indicator. It is assumed that the impact is limited by the fact that farming systems are normally very similar along municipality borders.

Strengths
- very precise data provided per farm at the municipality scale and weighted with the UAA of each farm

4.2. Component 2 “Extensive farming practices”

Hypothesis: see chapters 2.5 to 2.10. Extensive practices are generally considered to be favourable to biodiversity. Extensive practices consist in a low pesticide input, a low amount of irrigation and a low mineral fertilizer use. These extensive practices are often linked to long rotation including legumes and controlling weeds. Low yields can often be considered as indicators of extensive practices.

4.2.1. Considerations

It is considered that extensive practices do not exist (in France) for the following crops (see Table 4):

- Industrial crops (sugar beat, potato, etc.) because of high level of fertilization, very high level of pesticide treatments, irrigation use; these crops are cultivated in spring with low soil cover in winter;
- Maize: very high level of fertilization, very high level of irrigation (maize grain), medium level of pesticide treatments, low rotation or monoculture, and low soil cover (spring crop);
- Oil seed rape and peas because of high level of pesticide treatments;
- Temporary grassland because of high level of fertilization;
- Conventional fruit trees because of very high level of pesticide treatments, very high level of irrigation;
- Vegetables because of high level of pesticide treatments and very high level of irrigation;
- Vineyards because of very high level of pesticide treatments and low soil cover.

Table 4: Practice intensity per crop (intensive practices are highlighted in grey) – average values for France (source : Practice Surveys – SCEESS)

Crop	Number of pesticide treat-ments*	Mineral fertilization (kgN/ha)	Organic fertilization(kgN/ha)	Irrigation in %	Rotation length	Spring crop	Source	Remarks
Wheat	6,45	172	8	0,3	Medium		Main Crop practices 2001	Link between yield, N fertilization and pesticide treatment
Durum wheat	4,07	168	3	5,5	Low		Idem	idem
Barley	4,41	125	11	3,8	High		Idem	idem
Grain maize	3,11	159	36	41,8	Very low	yes	Idem	
Silage maize	2,54	75	115	7,1	Low	yes	Idem	
Oil seed rape	7,21	44	14	0	High		Idem	
Peas	6,25	0	0	16,2	Very high		Idem	
Sunflower	2,81	44	10	1,6	Medium	yes	Idem	Mainly herbicide
Sugar beet	12,5	127	22	8,4	High	yes	Idem	
Potato	16,2	155	34	35,9	Very high	yes	Idem	
Fallow land	0,27	0	0	2	ND		Idem	32% more than 5 years old. 95% with soil cover (41% is natural cover)
Temporary grassland	0,13	65	91		ND		Idem	28% with organic N input and 85% grazed (79 kgN/ha in average)
Productive permanent grassland	0,10	55	94		Not concerned		Idem	11% with organic N input and 95% grazed (72 kgN/ha in average)
Apple trees	32	ND	ND	86	Not concerned		Orchard practices 1997	High tree density
Pear trees	23	ND	ND	85	Not concerned		Idem	High tree density, irrigation
Peach tree	16	ND	ND	94	Not concerned		Idem	High tree density, irrigation
Plum tree	13	ND	ND	57	Not concerned		Idem	High tree density, irrigation
Apricot tree	ND	ND	ND	58	Not concerned		Idem	High tree density, irrigation
Cherry tree	8	ND	ND	39	Not concerned		Idem	High tree density, irrigation
Vineyard	15	ND	ND		Not concerned		Vineyard practices 2006	With 2 herbicide and 2 insecticide treatments on average. 37% are covered with grass.

** The seed treatment is not taken into account*

Organic farming in France is covering only 2% of the UAA and it is spread all over the territory. Given these premises it is not possible to include this extensive system in the methodology, so it is not taken into account.

Extensive practices are considered to be existing for the following crops:

- wheat, barley, triticale, sun flower with low yield
- oat
- mixed cereals and other cereals (buckwheat)
- fallow land
- fodder legumes (i.e. alfalfa)

- productive permanent grassland with low level of fertilization
- low productive permanent grassland
- common land

For wheat and barley (Figure 6), there is a direct relation between the yield of the crop and input (N mineral and pesticides). This is not true for rapeseed and maize (Figure 7).

With a threshold at 4.3 T/ha for barley (30 % below the average national yield), nitrogen consumption is under 105 kg and the number of treatments under 3.6 (1.7 herbicides, 0.1 insecticides, 1.5 fungicides and 0.3 for chemicals used to limit the height of the straw). But the assumption can be made that nitrogen fertilization and use of pesticides corresponding to the lowest yield classes are overestimated, because the Agricultural Practices Survey does not concern the extensive regions where barley is cultivated in mixed farms. 19% of barley surfaces are in fact excluded from the survey. Often in these systems no pesticides are used. The results presented for lower yields are more the consequences of climatic problems, than a real strategy. This is also true for the wheat cultivated in the Massif Central and in the South-East.

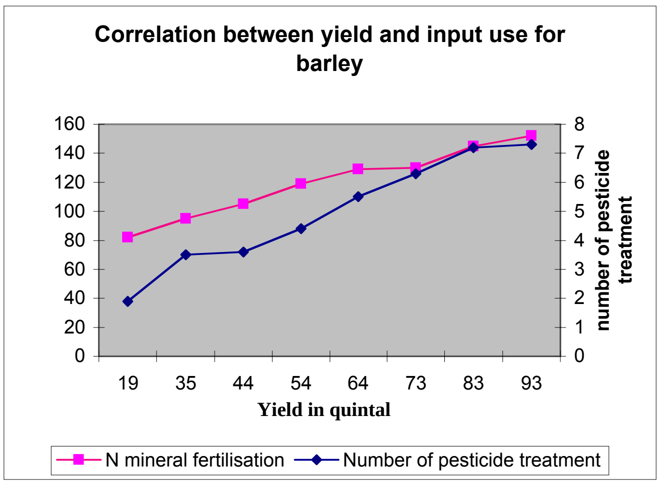


Figure 6: Correlation between barley yield and the N fertilizer quantity and pesticide treatments (Source: Agricultural practices Survey 2006 – SCEES)

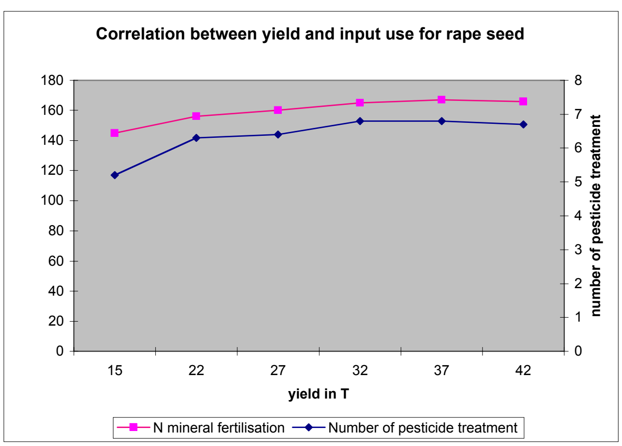


Figure 7: Correlation between oil seed rape yield and the N fertilizer quantity and pesticide treatments (Source: Agricultural practices Survey 2006 – SCEES).

4.2.2. Calculation

The indicator is addressing separately crops and grasslands.

4.2.2.1. Revised calculation of the indicator for extensively managed crops

In the applied methodology, the following crops have been considered as being extensively managed:
- wheat, barley and triticale, when the departmental average yields are under 30% of the national average
- all surfaces of oats, rye, other grains and mixed grains
- all surfaces of legume fodders (i.e. alfalfa)

In the updated method, fallow lands (FL) are considered to be also extensively managed.

The equation to calculate the indicator for extensive managed crops is as follows:

$$EMC(i) = 10 \times \frac{ECM(i) + FL(i)}{UAA(i)}$$

Where:

ECM(i): indicator for extensive crops management in municipality i

ECM(i): Extensive managed crops area in municipality i

FL (i) : fallow lands area in municipality i

UAA (i) : Utilised Agricultural area of municipality i

4.2.2.2. Revised calculation of the sub-indicator for extensively managed pastures

As in the 2006 version of the methodology, the following pastures are considered to be extensively managed:
- All extensive permanent grasslands,
- Common grasslands.

- Revised calculation of common grazings

The surface of common grazings of each municipality is calculated by taking into account the number of livestock units using common grasslands (data source: FSS 2000 at LAU2 level), and disaggregating the datum on common grazings available at the level of *department*:

$$CG(i) = LU_{CG}(i) \times \frac{CGd(i)}{LUd_{CG}(i)}$$

Where:

CG (i) : Common grasslands area of municipality i

CGd (i) : Common grasslands area in the departement of municipality i

LUCG (i) : Livestock Units of municipality i using common grazings

LUdCG (i) : Livestock unit of the departement of the municipality i using common grazings

- Revised calculation of the "extensive grassland management" sub-indicator

In the updated method, the surface of productive permanent non fertilized grasslands is included in extensive pastures. This unfertilized surface is estimated using the Grassland survey (1998), which provides the percentage of unfertilized surface of productive permanent grassland for each fodder natural region.

As in version 2006 of the methodology, a coefficient was applied to the surface of productive permanent fertilized grasslands which is inversely proportional to the fertilisation rate; the coefficient is meant to give a score which decreases from 1 to 0 for corresponding levels of mineral fertilisation ranging from 0 kg/ha to 50 kg/ha; above the threshold of 50 kg/ha a 0 score is assigned. The coefficient is calculated as follow:

$K_{PPGF}(r) = 1 - \frac{MF(r)}{50}$, if the average level of mineral nitrogen MF(r) of the fodder natural region is below 50 kg/ha ;

$K_{PPGF}(r) = 0$ if the average level of mineral fertilization MF(r) of the fodder natural region is above 50 kg/ha.

The "extensive grassland management" indicator is then calculated by applying the following equation:

$$EMG(i) = 10 \times \{[K_{PPGF}(r) \times PPGF(i)] + PPGnf(i) + LPPG(i) + CG(i)\} \times \frac{1}{UAA(i) + CG(i)}$$

Where:
K_{PPGF} (r) : extensive management coefficient of productive permanent grasslands fertilized in the natural region r of municipality i
PPGF (i) : Surface of Productive permanent grasslands fertilized in the municipality i
PPGnf (i) : Surface of Productive permanent grasslands not fertilized in the municipality i
LPPG (i) Low productive permanent grasslands area of the municipality i
UAA (i) : Utilised Agricultural Area of the municipality i
CG (i) : Common grasslands area of municipality i

4.2.2.3. Calculation of the final indicator of 'Extensive Agricultural Practices'

The final indicator of 'Extensive Agricultural Practices' indicator is the sum of the results obtained for extensive crops and extensive grasslands.

The equation is as follows:

$$I_2(i) = EGM(i) + ECM(i)$$

Where :
I_2(i) : indicator of 'extensive agricultural practices' for municipality i
EGM(i) : sub-indicator 'extensive crops management' of municipality i
ECM(i) : sub-indicator 'extensive grassland management' of municipality i

Data sources:

The available statistical data concern: type of crops, crop yield, stocking density (for ruminants), organic farming, irrigation.
For France different surveys are available: the Grassland Survey (1982, 1998), the Orchard Practices Survey (1997, 2002), the Main Crop Practices Survey (1994, 2001, 2006)[2], the Vineyard Practices Survey (2006)
The data sources used to calculate this indicator are: the Annual Agricultural Survey for crop yields, FSS for crop types and their surfaces, the Grassland Survey for the fertilization of permanent grasslands.

Range :
- The indicator ranges from 0 to 10

Weighting : 1

[2] concerns in 2001 and 2006 the following crops: common wheat, durum wheat, barley, maize, rapeseed, sun flower, pea, sugar beet, potato, temporary grasslands and fallow land (only in 2001) and the following practices: tillage, fertilization, pesticide use, irrigation, yield

Evolution version 2006 / current version

- Integration of fallow land as extensive crop (not taken into account in 2006).
- Concerning productive permanent grasslands, grasslands which are not fertilized have been differentiated from fertilized grasslands (the average of both was used in 2006).
- The surface of common lands affected by farm is weighted by the number of livestock units using common lands (FSS)

Weaknesses

- Yields are only provided at the department scale.
- Organic farming is not taken into account

Strengths

- Relevant data concerning the management of permanent grasslands are introduced in the methodology

4.3. Component 3 "Landscape elements"

4.3.1. Hypothesis

See chapters 2.12 to 2.14. Landscape elements, semi-natural habitats or ecological infrastructures (EI) contribute to biodiversity enhancement. The diversity of landscape elements provides more habitats, more food for wild fauna, a higher species richness. EI contribute to the biological control of the crops and limit insecticide use. Landscape elements are not farmed and do not received any pesticide and fertilizer. Their surfaces are limited compared to the UAA.

Landscape elements can differ from one region to another due to historical reasons and ecological situation, e.g. in mountains, forest edges are more important than hedgerows. Traditional orchards are often mixed with hedgerows.

It is considered that a minimum surface of landscape elements is necessary to conserve a minimum level of biodiversity and to guarantee a connection between the different semi-natural elements. For example, Integrated Production considers that the width of a field should not exceed 300 meters in order to conserve predators and parasitoids into the field. In average this corresponds to a parcel size ranging from 18 ha to 25 ha depending on the shape of the parcel. In this case the surface occupied by a 10 meters width hedgerow surrounding the parcel may vary from 4% to 5% of the UAA. Figure 8 shows clearly that a low (under 4%) percentage of landscape elements corresponds to very large parcels.

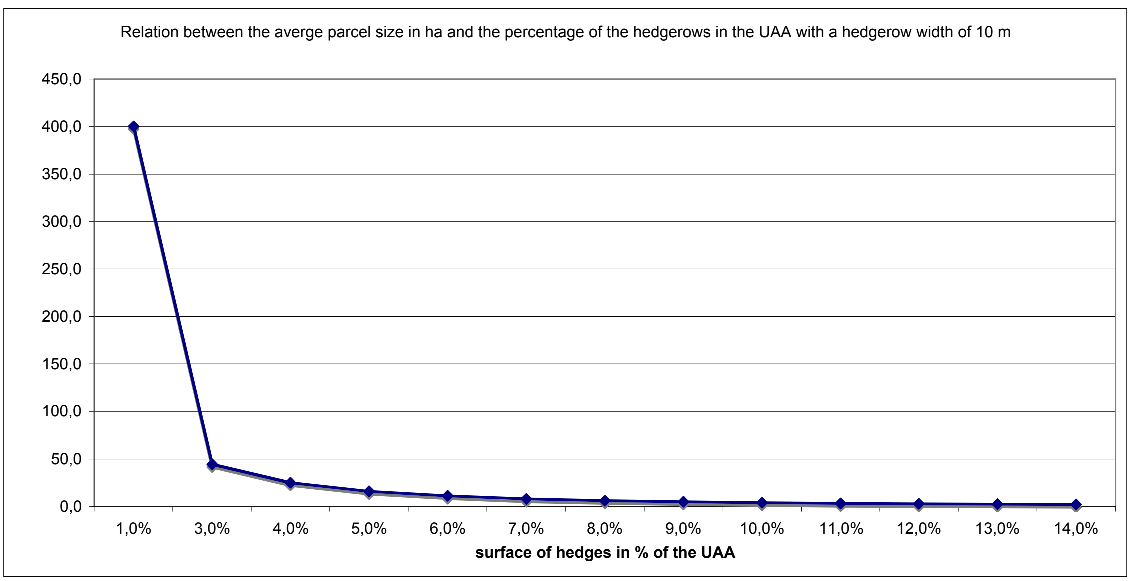


Figure 8: Relation between the parcel size and the percentage of hedgerows in the UAA (source: IFN)

On the basis of this, the minimum threshold has then been defined equal to 4% of the UAA for wooded elements.

4.3.2. Evolution of the method in comparison to 2006 methodology

Three components are considered:

- Wooded elements (hedgerows, forest edges and traditional orchards)
- Fishing ponds
- Wetlands

Each component is scored separately and all scores are added to obtain the final indicator of 'Landscape Elements'.
The evolution of the scoring method in comparison to 2006 methodology is summarised in Table 5.

Table 5: Evolution of the landscape elements scoring system

Landscape elements	**Version 2006**	**Current version**
Fishing ponds	1 345 farms have declared fishing ponds, and 978 municipalities. Underestimation (some fishing ponds are not declared by the farmer which is not the owner)	Increased weighting. 1 farm per municipality: 1 point, 2 farms: 2 points, …. and/or more than 3 farms : 5 points
Hedgerows	Width: 10 m	No change
Forest edges	Width: 10 m	Width: 5 m
Forest edges	Same density per municipality of a department	Disaggregation based on the forest surface of each municipality
Traditional orchards	Limited to a maximum score of 2,5 points. Reason: traditional orchards are already included in permanent grassland	Limited to 50% of the maximum score (5 /10) for orchards representing 4% or more of the UAA.

4.3.2.1. Hedgerows

In this case the 2006 methodology is applied and data are disaggregated from the department to the municipality scale, assuming that, in a department, the density of hedges is related to land use as follows:
- hedges density is 10 times higher in permanent grasslands than in crops
- hedges density is 5 times higher in temporary grasslands than in crops
- hedges density is 2 times higher in legume forages than in crops

The width of hedges has been considered equal to 10 meters, in order to transform the length of hedges (IFN data) into a surface. A comparison of the results with the new methodology results of IFN is presented in appendix II.

4.3.2.2. Changes concerning forest edges

a) Disaggregation

To improve the results, the disaggregation is based in the current methodology on the forest surface of each municipality, considering that the forest edge length is proportional to the forest surface. The forest surface at municipality level comes from the Municipality Survey 1998 (source INSEE).

The equation is:

$$FEA(i) = FEL_{DEP}(i) * \frac{FA(i)}{FA_{DEP}(i)}$$

Where:
FEA(i) : forest edges area in municipality i (ha)
FEL_{DEP}(i) : forest edges length of the department to which municipality i belongs (km)
FA(i) : forest area of municipality i (ha)
FA_{DEP}(i) : forest area of the department to which municipality i belongs (ha)

b) Change in the forest edge width

The length of forest edges provided by the national Forestry Survey at NUTS3 is converted in surface by fixing an average width. This width was fixed to 10 meters in the 2006 version. It is now fixed at 5 m, given the lower importance of the forest edge component in the total score of the indicator and also to be coherent with policy measures as the Ecopoint Programme in Lower Austria which takes into account a 5m width of forest edges to calculate the surface of landscape elements.

4.3.2.3. Calculation of the "Tree outside forest" score

There is no change between 2006 and the current version. The methodology is presented in Table 6.

"Trees out of forest" include hedges, forest edges and traditional orchards. The sub-indicator ranges from 0 to 10, with a linear evolution between trees out of forest covering 4% to 14% of the UAA. The threshold of 14% corresponds to an average parcel size of 2 ha (see figure 8) and a density of hedgerows and forest edges of 140 m/ha of UAA which is quite high compared to the French situation (average of 54m/ha of UAA[3]), where only 2% of the UAA has a density higher than 140 m/ha.

Table 6: Calculation of the score for trees outside forest (hedges, forest edges, traditional orchards)

Surface of TOF elements / UAA	**Score**
Less than 4% of UAA	0
More than 14% of UAA	10
Between 4 and 14%	Linear evolution

This score of trees outside forest (TOF) is corrected if the result is zero and the surface of traditional orchards over 0.5% of the UAA, considering that even small patches of traditional orchards are favourable to biodiversity (see appendix III). In this cases points may be given to orchards surface exceeding 0.5% of the UAA.

4.3.2.4. Fishing ponds

Fishing ponds are underestimated in terms of number and surface. They generally cover several hectares[4], therefore a new scoring increasing the weight of this indicator has been established and is presented in Table 7.

The sub-indicator for fishing ponds (FP) ranges from 0 to 10.

Table 7: Calculation of the score for fishing ponds (FP)

Number of farms having fishing ponds, by municipality	Score in version 2006	Score in current version
5 and more	5 pts	10 pts
4	4 pts	8 pts
3	3 pts	6 pts
2	0 pts	4 pts
1	0 pts	2 pts
None	0 pts	0 pt

[3] the linear hedgerow is 705,000 km and the forest edges 843,000 km

[4] Fishing ponds are located in France in limited areas where they cover between 2 (Sologne) and 10% (La Dombes) of the territory. This percentage is therefore higher if referred to the UAA only. Their surface is estimated to be 153,000 ha (source: SAA 2002). Their average size is 10 ha. Considering that the number of municipalities having fishing ponds is very low (978) and the nature value of fishing ponds very high, it is necessary to include this element in the metodology. Overall, 1345 farms have declared having fishing ponds, the analysis of results shows that there are only 460 municipalities (see table 8) in which fishing ponds are classified HNV.

4.3.2.5. Wet grasslands

a) Methodology to take into account wet grasslands

No statistical or GIS data exist to localise wet grasslands in France. The Wetlands GIS[5] does not cover only wet grasslands but includes also other parts of the UAA, such as rivers, lakes and salt marshes.
The hypothesis is that wet grasslands of ecological interest are classified in Natura 2000.

The surface of wet grasslands is considered to be the minimum surface of:

- UAA located in Natura 2000 area[6]
- The surface of permanent grasslands including common lands
- Wetland areas

UAA in Natura 2000 can include other agricultural surfaces than wet grasslands. Permanent grasslands can include non-wet grasslands and wetland area includes rivers and lakes. A more precise result could be obtained by intersecting the two GIS layers UAA in Natura 2000 and wetland area but this was not possible for the present study.

The estimation obtained is 195 000 ha.

b) Scoring of wet grasslands

The score is calculated on the basis of the ratio: wet grasslands per municipality / UAA + common grasslands in the municipality (see Table 8).

As for fishing ponds the surface of wet grasslands is very limited as they cover only 0,6% of the UAA. In a municipality they generally cover small areas bordering water courses, but their nature value is very high considering species richness, i.e. birds, flowers or butterflies. This natural habitat is threatened and its surface has severely decreased in the past[7]. 5% of the UAA can therefore be considered as already a high threshold.

The sub-indicator value ranges from 0 to 10 and has a linear evolution for wet grasslands covering 0 to 5% of the UAA.

Table 8: Calculation of the score for wet grasslands

Surface of wet grasslands /UAA	Score
None	0
More than 5%	10
Between 0% and 5%	Linear evolution

[5] managed by the Minsitry of Ecology (version May 2009). The wetland area covers 742,000 ha

[6] calculated by intersecting the LPIS (version 2005) which provides the location of the parcels receiving CAP payments with the Natura 2000 GIS managed by the Ministry of Ecology (version 2008). This surface covers 2.47 millions of ha.

[7] IFEN considered that between 1960 and 1990, 68% of the main wetland areas have lost more than 10% of their surface , and 16% have lost more that 50% of their surface. In the "Marais Poitevin" area the wet grasslands have decreased by 1600 ha/year between 1973 and 1990, by 1300 ha/year between 1992 and 1995 and by 500 ha/year between 1992 and 1997.

The equation can be written as follows:

$$WGL(i) = 10 * Min\left[1; \left(\frac{\frac{WG(i)}{(UAA(i) + CG(i))}}{(5\% - 0\%)}\right)\right]$$

Where:
WGL(i) : score for wet grasslands of the municipality i
WG(i) : wet grasslands area of the municipality i
CG (i) : Common grasslands area of municipality i
UAA(i) : Agricultural Area of the municipality i (in ha)

4.3.2.6. Indicator of landscape elements

The final score for the landscape elements is the sum of the 3 components (trees outside forest, fishing ponds and wet grasslands), that cannot exceed 10 points.

The equation is as follows:

$$LNE(i) = Min[10; WGL(i) + TOF(i) + FP(i)]$$

Where:
LNE(i) : sub-indicator for Landscape Natural Elements of the municipality i
WGL(i) : sub-indicator for wet grasslands of the municipality i
TOF(i) : sub-indicator for trees outside forest of the municipality i
FP(i) : sub-indicator for fishing ponds of the municipality i

The function Min() prevents that the final score exceeds the maximum of 10 points. Indeed, in some municipalities very rich in landscape elements and that host fishing ponds, hedgerows and or wetlands, this threshold could be exceeded.

Data sources: National Forestry Inventory (IFN) for hedgerows and wood edges, FSS census for traditional orchards, number of farm ponds and forest density, IFEN for wetlands data.

Range :

- The score ranges from 0 to 10

Weighting : 1

Evolution version 2006/current version

- integration of wet grasslands
- mitigation of the weighting of forest edges compared to the other landscape elements

Weakness:

- some data (hedgerows and forest edges) are provided at NUTS3. But hedgerows directly linked to grassland can be disaggregated at LAU2 taking into account grassland surfaces, forest edges and forest surfaces
- The calculation of landscape element surfaces is limited by the data provided by statistical survey or inventories.

Strength

- Five types of landscape elements are considered, which cover a large diversity of the farmed landscape

5. Results HNV 2000 – map version 2009

5.1. HNV area 2000 (version 2009)

The final HNV indicator is calculated by summing up the results of the three components: crop diversity, extensive farming practices and landscape elements. The final score ranges from 1 to 30.

A first minimum threshold to qualify as HNV farmland was decided by selecting the 25% percentile best LAU2 scores. This indicative threshold is taken from the previous work described in (Pointereau et al., 2007), however the scoring system allows establishing alternative thresholds and therefore testing different values or scenarios for identifying the HNV farmland area (see chapters 5.4 and 5.5).

Under this assumption the HNV farmland surface covers 7,927,915 ha (see Figure 9) corresponding to 6,967,745 ha of UAA plus 960,170 ha of common lands. The corresponding threshold for a municipality to qualify as HNV is 14.78 points.

This result can be compared with the JRC/EEA approach (Paracchini *et al.*, 2008) which estimates that the farmland area covers in France 7,797,145 ha.

The comparison of the results per region with the JRC/EEA methodology is presented in appendix IV. Even if the final surface is not considerably different (3%), the comparison per region shows some differences:

- an underestimation of the grasslands in the Atlantic Central zone of *Bourgogne*, *Basse-Normandie* and *Limousin*,
- An overestimation of cropland area in the South East

Such differences reflect the differences in data and methodologies applied: on one hand the "farming system approach" assigns one score to the whole farmed surface of a municipality, on the other hand the JRC/EEA methodology is based on a land cover approach (therefore on a stratified selection of land cover types) that includes CORINE2000 and biodiversity data. CORINE2000 data are characterised by a certain degree of generalisation (i.e. 25 ha minimum mapping unit) and therefore results cannot be directly referred to the UAA (see appendix X in Paracchini *et al.*, 2008). Figure 29 in Appendix IV shows the relation between the two methodologies in more detail.

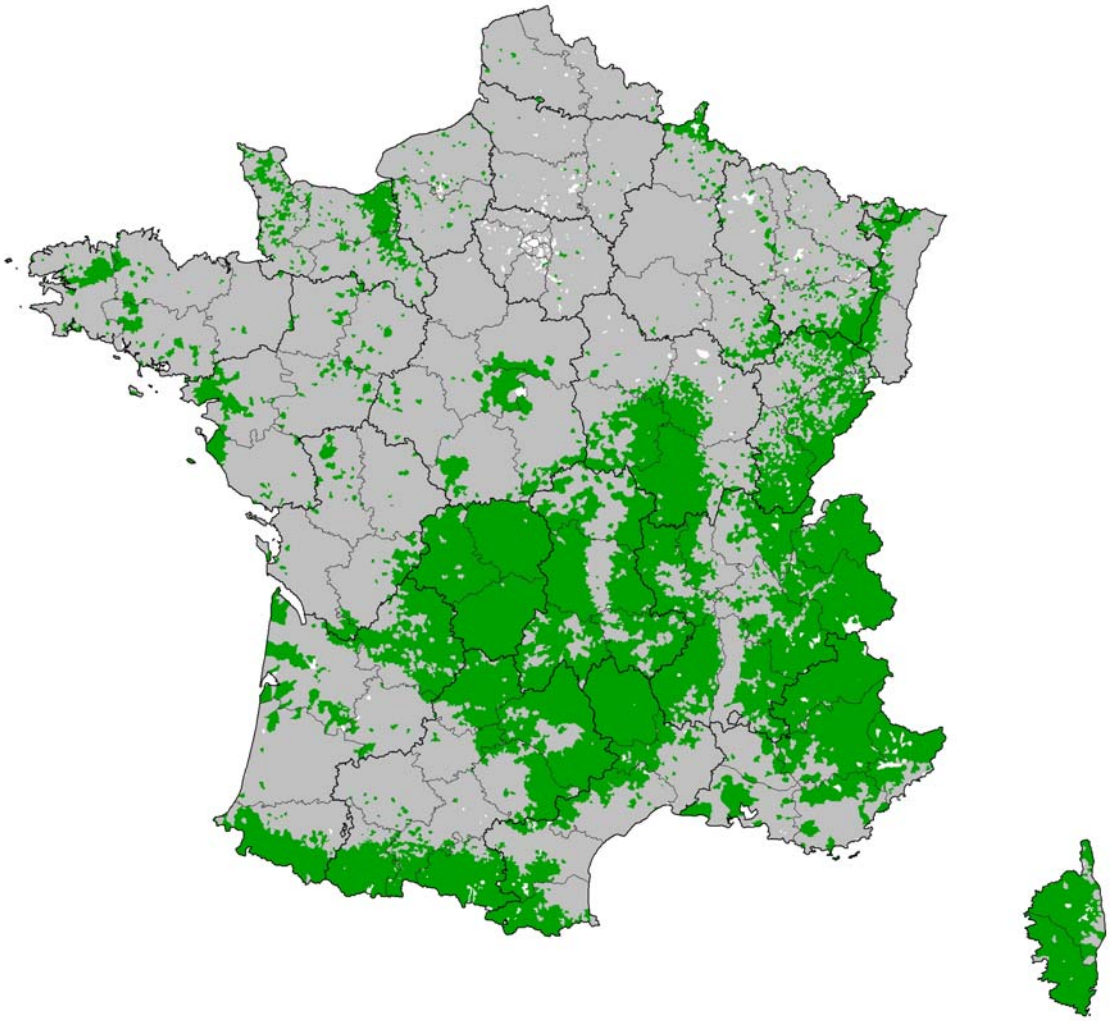


Figure 9: HNV farmland in 2000 (version 2009)

HNV farmland includes 33.4% of the total LU, but 54.9 % of the LU located in LFA. The identified HNV areas also include 85% of the low productive grasslands, 84.9% of common lands and 46.5% of productive permanent grasslands (see Table 9). Only 8.7% are classified in vulnerable zones which is in general a good indicator of a low nitrogen pressure in HNV areas.

Table 9: Percentage of grassland, LU and landscape elements located in HNV farmland

	Results	**Percentage of the total in HNV areas**
HNV UAA	6,967,745 ha	25.0
Total HNV farmland (UAA+ common lands)	7,927,915 ha	28.3
Productive permanent grasslands	3,213,062 ha	46.5
Low productive grasslands	1,193,922 ha	85.0
Common lands	960,170 ha	84.9
Livestock unit	4,651,496 LU	33.4
Livestock unit in LFA	3,842,905 LU	54.9
Wet grasslands	176,494 ha	90.6
Hedgerow surface	307,435 ha	43.6
Traditional orchards	29,840 ha	55.0
Municipalities with fishing ponds	460 municipalities	47.0
UAA in vulnerable zone	1,325,479	8.7
Natura 2000 in farmland	1,567,800	63.3
National parks	311 municipalities	98

5.2. Composition of the scoring

The average contribution of the three components does not vary much if three different thresholds (15%, 25% and 30%) are applied to identify HNV farmland (see Table 10) .

Table 10: Contribution of the three components to the final score in HNV areas, according to variable HNV thresholds

	Minimum threshold	Crop rotation	Extensive practices	Landscape elements	
HNV15%	17.8	41%	26%	33%	**100%**
HNV25%	14.8	43%	25%	32%	**100%**
HNV30%	13.5	45%	24%	31%	**100%**

Figure 10 shows that the contribution of each component varies with the final score (HNV25%). The scoring of component 2 is decreasing gradually from the higher score to the lowest score. The score of indicator 1 decreases only when the final indicator value is very low (below 7 points) and at this stage contributes to more than 80% of the final result. The score of component 3 is high until it reaches 11 points but decreases substantially after that.

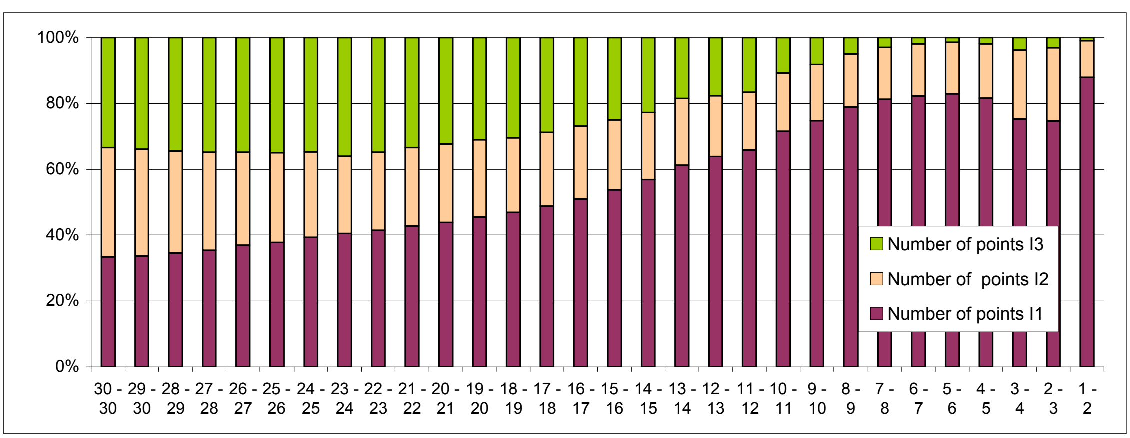


Figure 10: Contribution of the three components to the final HNV indicator

5.3. HNV farmland and Natura 2000

According to the results **63.3% of farmed Natura 2000 is located in HNV areas**. A large part of the UAA of the municipalities characterised by higher indicator values are classified in Natura 2000, e. g. 90% of the UAA of the municipalities with a score of 30 points.

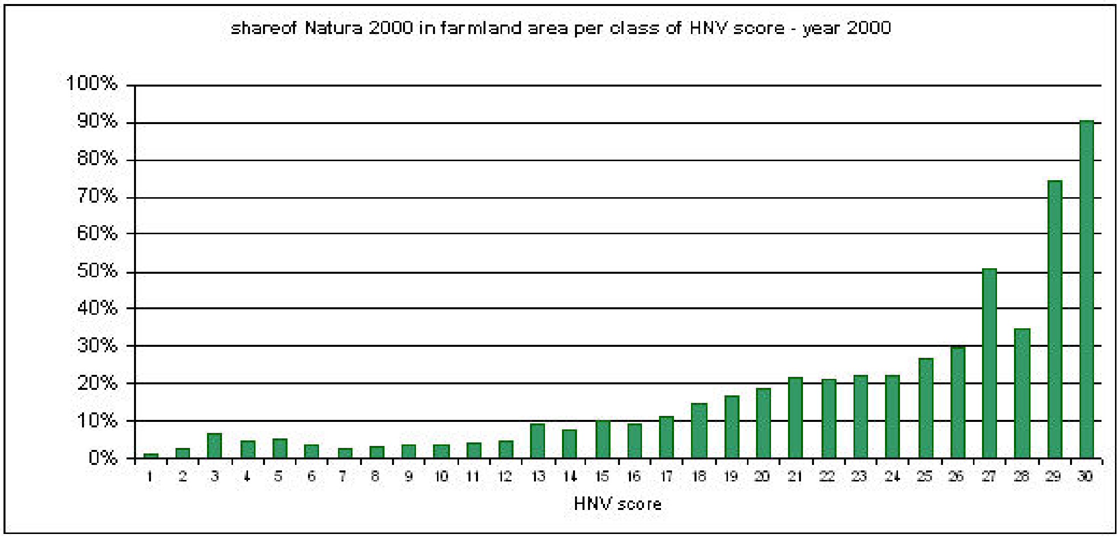


Figure 11: Share of Natura 2000 in farmland area in relation to the HNV score of the municipality

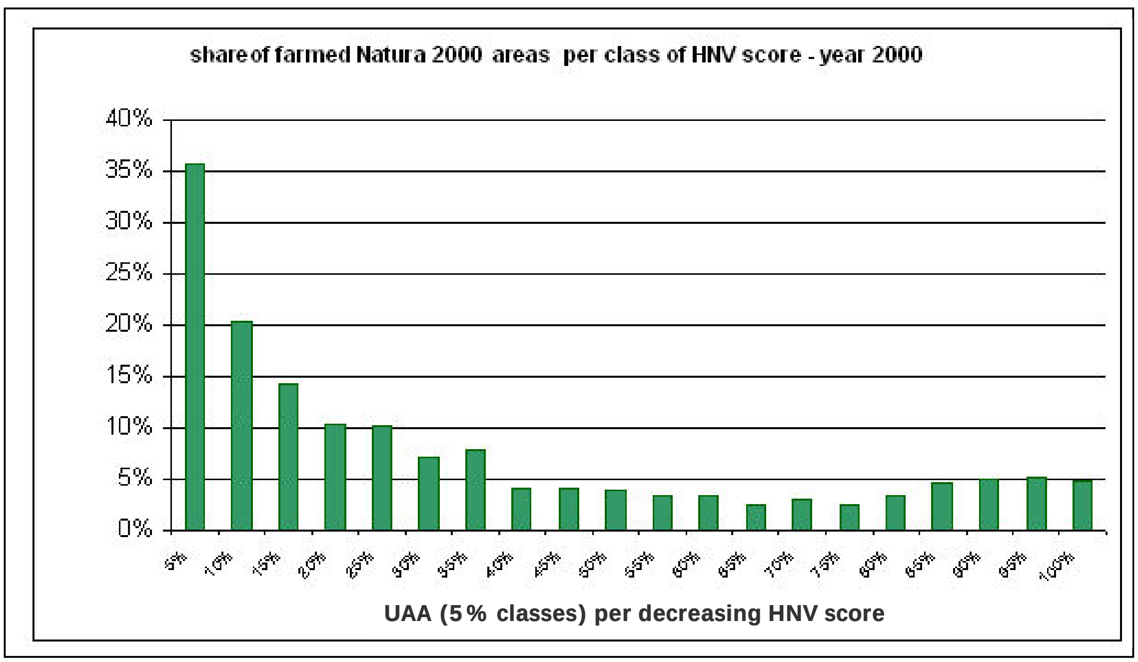
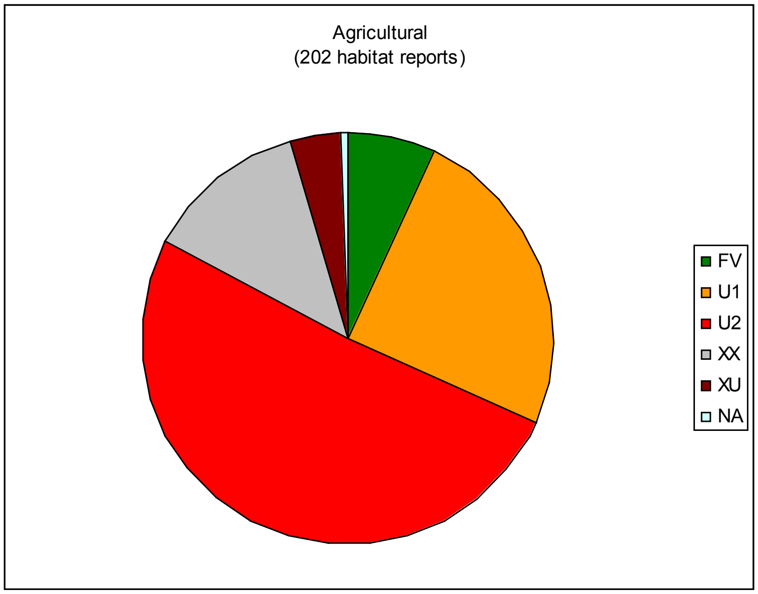


Figure 12: Share of Natura 2000 in farmland area per decreasing class of HNV score ((i.e. 5% of the UAA with the highest scores contains 36% of farmed Natura 2000 areas; 10% of the UAA with the highest scores contains 20.2% of farmed Natura 2000 areas etc.)

A statistical analysis (see appendix VI) indicates that for a HNV value higher or equal to 13, we are placed in the part of the curve where, with increasing HNV values, we get increasing shares of Natura 2000 areas classified as HNV. Thresholds higher than 13, such as 30% or even 25% of the UAA can be thus considered as reasonable thresholds when Natura 2000 sites are concerned.

The first assessment of the Habitat directive (under the article 17) shows that the majority of farmland habitats are on a bad state of conservation (see Figure 13). This situation can explain why some farmland areas, classified in Natura 2000, are not classified as HNV. In these regions, the farming system and its intensity level cannot be considered favourable for the conservation of the habitats (and the species).



** FV= favourable, U1= Unfavourable-inadequate, U2 = unfavourable-bad, XX=unknown,* XU = unknown but not favourable, NA : not possible to assess

Figure 13: Conservation status of agricultural habitats (source: ETC/BD)

5.4. Indicator 3: landscape elements

Figure 14 presents the share of the different landscape elements in relation to the total score of the indicator (accumulated points)

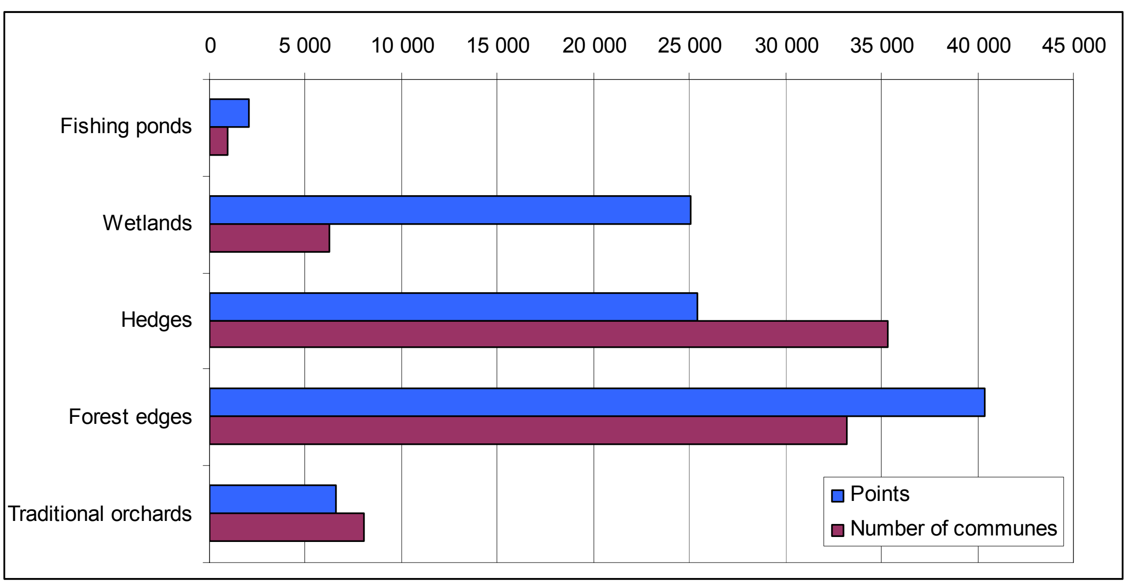


Figure 14: The share of the different landscape elements in relation to the final HNV score

5.5. FADN data analysis

The Farm Accountancy Data Network (FADN) data allows comparing the economical situation of professional farms located in HNV areas with the ones outside HNV areas for different thresholds and for the last 2 years.

5.5.1. Characteristics of HNV farms

The number of farms is directly correlated to the percentage of the UAA. For example by setting a threshold of 15% of the UAA the percentage of HNV farms is 14% and for a threshold of 30%, it raises to 29%.

The average size of the HNV farms is 80 ha in 2006, higher than non-HNV farms (76 ha). This can be explained by the extensivity of HNV farms with more rough grasslands. The size of the farms increases by 4 ha between 2006 and 2007 in both cases (HNV and non-HNV) This is the general trend in France as most of the farmers try to increase the size of their farm.
HNV farms have also more livestock units: 77/81 compared to 64/68 in 2006. As for the size of farms, the livestock increases between 2006 and 2007 and more in HNV than outside HNV.
The number of family work is lower (-13/15%) in HNV farms compared to non-HNV farms.

Table 11: Comparison of the economical situations of the professional farms in HNV versus non HNV in 2006 and 2007 (source: RICA/ FADN)*

2006	With a threshold of 15%			With a threshold of 25%			With a threshold of 30%		
	HNV Farms	Non HNV Farms	Difference	HNV Farms	Non HNV Farms	Difference	HNV Farms	Non HNV Farms	Difference
Number of sample farms	948	6 398	13%	1 640	5 706	22%	1 987	5 359	27%
Number of sample farms	49 100	297 100	14%	83 300	263 000	24%	100 200	246 000	29%
UAA (in ha)	80	76	5%	80	75	6%	78	76	3%
Livestock (in LU)	77	68	14%	81	65	25%	80	64	25%
Number of Family Work Unit	1,75	2,02	-13%	1,74	2,05	-15%	1,78	2,06	-14%
Subsidies in Ū	31 300	29 200	7%	31 700	28 700	10%	31 000	29 000	7%
Family Farm Income in Ū	28 000	38 300	-27%	26 400	28 800	-8%	29 800	39 700	-25%
Family Farm Income/WU in Ū	16 000	18 960	-16%	15 172	14 049	8%	16 742	19 272	-13%
Fertlisers in Ū/ha	59	112	-47%	64	117	-45%	68	119	-43%
Crop protection in Ū/ha	26	99	-74%	31	108	-71%	34	112	-70%
Animal feed	153	186	-18%	165	187	-12%	170	187	-9%
Sub-total input in Ū/ha	238	398	-40%	260	412	-37%	271	418	-35%
Energy in Ū/ha	46	66	-31%	47	68	-30%	49	69	-28%

2007	With a threshold of 15%			With a threshold of 25%			With a threshold of 30%		
	HNV Farms	Non HNV Farms	Difference	HNV Farms	Non HNV Farms	Difference	HNV Farms	Non HNV Farms	Difference
Number of sample farms	980	7 377	12%	1 683	5 964	22%	2 031	5 346	28%
Number of sample farms	46 000	280 000	14%	78 300	247 700	24%	94 600	231 400	29%
UAA (in ha)	84	79	6%	84	79	7%	82	79	4%
Livestock (in LU)	81	71	15%	87	67	29%	87	66	31%
Number of Family Work Unit	1,78	2,04	-13%	1,76	2,07	-15%	1,80	2,08	-13%
Subsidies in Ū	29 600	29 000	2%	29 900	28 700	4%	29 400	28 800	2%
Family Farm Income in Ū	26 400	50 100	-47%	26 400	50 100	-47%	29 800	53 600	-44%
Family Farm Income/WU in Ū	14 831	24 559	-40%	15 000	24 203	-38%	16 556	25 769	-36%
Fertlisers in Ū/ha	60	117	-49%	66	123	-46%	69	125	-45%
Crop protection in Ū/ha	27	108	-75%	32	117	-73%	35	121	-71%
Animal feed	157	218	-28%	181	187	-3%	186	218	-15%
Sub-total input in Ū/ha	243	443	-45%	279	428	-35%	291	465	-37%
Energy in Ū/ha	44	67	-34%	47	69	-32%	49	69	-30%

** a comparison for the year 2004 is presented in appendix*

5.5.2. Comparison of the input costs

The results show clearly that HNV farms can be considered as low input farms.

The input costs of HNV farms are always lower than for non-HNV farms.
- Whatever the threshold and the year, the fertilizer cost is 43-49% lower, the pesticides cost is 70-75% lower and the energy cost is 28-34% lower in HNV farms comparing to non-HNV farms.
- The inputs costs increase when the HNV threshold increases.

- The costs of buying feed in HNV farms are 3 to 28% lower than in non-HNV farms. This is linked to the fact that a large part of HNV farms are located in mountains where crop production is limited. In these areas most of the farms have to buy grains and straw.
The distribution of the three main input costs (fertilizers, pesticides and feedstuffs) is presented in appendix IV.
The comparison between the farms located inside and outside HNV areas shows that the methodology is not perfect and that is possible to find some low input farms outside HNV areas and, vice versa, to find some intensive farms inside HNV areas. This can be explained by the methodology which calculates an average per municipality. This allows including some intensive farms in a municipality if there are enough extensive farms to maintain an adequately high HNV indicator score.

5.5.3. Comparison of subsidies and farm income

Even with more subsidies (+7/10% in 2006 and +2/4% in 2007 in comparison to non-HNV farms) and lower input costs, the family income is lower for HNV farms (except in 2006 for a threshold of 25%): -13 to -16% in 2006 and -36 to -40% in 2007 in comparison to non-HNV farms. The situation in 2007 is due to high prices of the cereals which have increased the income of cereal crop farms, mainly located outside HNV areas.
Therefore it can be concluded that the high nature value of HNV farms does not contribute via lower expenditures for inputs or subsidies to maintain their income at the same level of the other farms. The main reasons are connected to their lower production (yields) and differences in the production system.

5.6. Stocking density vs mineral fertilisation

In some European countries, there are no statistics concerning the mineral fertilization of grasslands while data on stocking density are always available.

The indicator "level of N mineral fertilization" of permanent grasslands of component 2, could therefore be replaced by the level of stocking density per environmental zone (see Table 12), by setting a threshold corresponding to extensive management and below which the indicator gets the maximum score.

Table 12: Livestock density thresholds per environmental zone corresponding to extensive grazing systems (Source: UASE/EEA)

Environmental zone	Threshold LU/ha
Lusitanian	1.2
Atlantic central	1.1
Pannonian	1
Continental	1
Alpine South	1.1
Mediterranean Mountains	1.1
Mediterranean North	1.1
Mediterranean South	0.6

The final map is presented in appendix V (see Figure 30) and shows a high level of similarity with HNV farmland identified on the basis of mineral fertilisation of grasslands.

The stocking density can therefore be used as an indicator to measure the extensivity of the practices but it is necessary to define appropriate thresholds per environmental zone.

6. Cross-validation of the HNV indicator with the Common Bird Indicators

6.1. Farmland birds species used

The number of farmland bird species used to calculate the different indicators is presented in Table 13 and in detail in appendix VIII.

Table 13: Number of species used for the different indicators

Indicator	***Number of species***
Species richness	144
Species abundances related to species specialization	101
Species abundances of species under unfavourable status	44
Specialist species richness	37
Community specialization index	144
French - EU farmland bird indicator	20
Europe - EU farmland bird indicator	23

6.2. Analysis at the species level: species specific responses to HNV scores

To test whether the species abundances in areas of various HNV scores were related to species specialization, we performed the following analysis, based on 101 generalist and specialists farmland species (see Table 13). We selected those species as the ones that are most commonly accounted in this type of habitat. We first ran generalized linear models (GLM) using the abundance of each species as the dependent factor and as independent factors the HNV score as continuous parameter, the site and year as factor parameters, accounting also for the spatial autocorrelation. The spatial autocorrelation was modelled by the following equation: $S = x+y+x*y+x^2+y^2$, where x and y are the geographical coordinates of each monitored site. We considered the regressions slopes for the HNV parameter as the species responses to HNV. These responses are estimated with variable precision according to the species presence in farmland areas. We then tested the responses of each species in relation to the species specialization index, using generalized linear models (GLM) weighted by the SE of each response. For more complex patterns we tested non-linear models through general additive models (GAM), analogous to the weighted GLM (Siriwardena *et al.*, 1998; Guisan *et al.*, 2002; Devictor *et al.*, 2008). The results revealed a significant linear effect between the response to HNV and the SSI (slope = 0.054, t = 2.003, p = 0.048). This result indicates that specialist farmland species are more abundant in HNV areas.

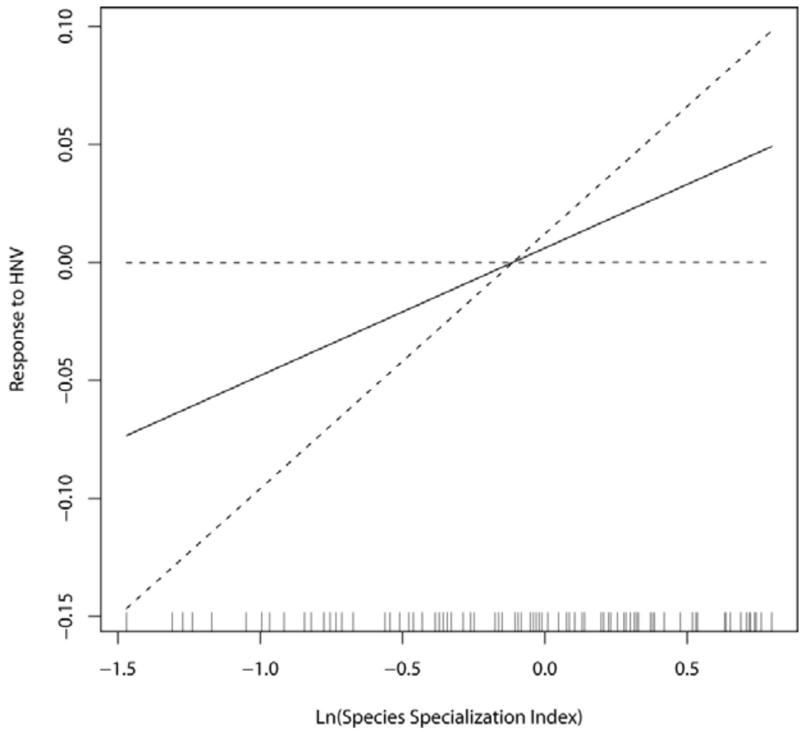


Figure 15: Non-Linear regression of the response to HNV (shown in y axis), against the ln of the Species Specialization Index (SSI) (shown in x axis, confidence intervals are shown in dotted lines).

We also tested whether species under unfavourable conservation status respond positively in terms of abundances in HNV farmland. More than 30% of all most common bird species (or n = 44 out of 144) are under an unfavourable conservation status (BirdLife International, 2004)). The analysis of the local abundance showed that populations of species under a particular conservation status were larger in HNV farmland than predicted from random. Most interestingly, while HNV farmland covers around 25% of the national farmed territory, 73% of these species had more than 25% of their national populations in farmland included in HNV zones. The evaluation of the proportion of national farmland population included in HNV (HNV ratio) per species is presented in Table 20 of the appendix VIII. Only two species with a conservation status (representing 4% of the total number) had less than 15% of their population in HNV areas. We also observed that 15% of the species used for this analysis are wetland related species. Most of them have an important part of their relative abundances inside HNV areas (Appendix VIII). This was expected as the used methodology considers wet meadows and wet grasslands within the landscape elements contributing to the global HNV scores.

6.3. Analysis at the community level : Bird community indices

6.3.1. Species richness

Here we present the analysis of species richness over the HNV score (see Figure 16 a,b). We observe no significant relationship between the HNV indicator and the total species richness based on 144 species (-0.03, p=0.6; slope of the linear regression accounting for the year effect as a factor parameter). A positive but not significant relationship (0.012, p=0.6; idem) was revealed between the HNV indicator and the specialists species richness based on 37 species (Fig. 16b), with an increase for highest values of HNV score, though associated with a large confidence interval.

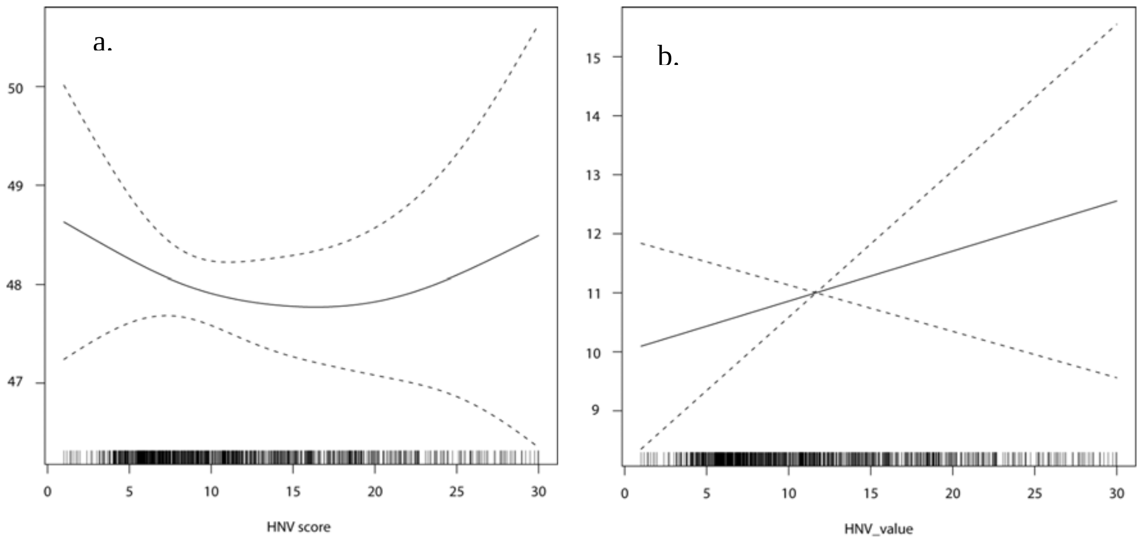


Figure 16: Species richness over the HNV score a) for all common species (N = 144) and b) for specialist farmland species (N = 37).

6.3.2. Community specialization index

Non-linear regression of the community specialization index (measured by the CSI) against the continuous HNV indicator revealed a high level of community specialization for high HNV values. This is explained by the presence of numerous sensitive species in high nature value areas (e.g. *Anthus campestris, Lanius colurio, Saxicola rubetra*). The lowest levels of community specialization were obtained for mean HNV scores (between 10 and 15), while slightly higher values are observed for low values (<10) of the HNV indicator. This is explained by an over domination of three open-area specialists (*Alauda arvensis, Emberiza calandra* and *Motacilla flava*) in open field intensive farmland with no trees.

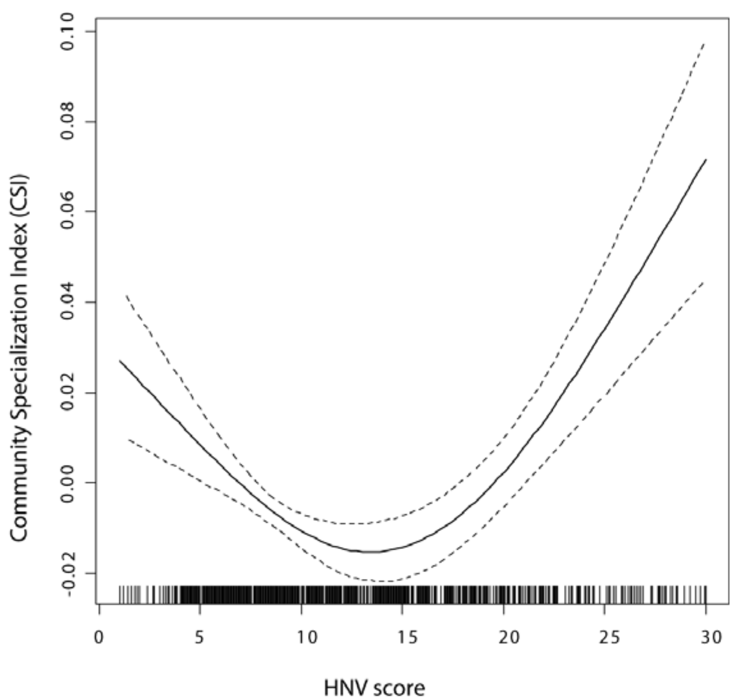


Figure 17: Non-Linear regression of the community specialization index (shown in y axis), against HNV indicator (shown in x axis, confidence intervals are shown in dotted lines).

6.4. Analysis over time (2001-2008): EU Farmland Bird Indicator

The EU Farmland Bird Indicators for HNV and non-HNV sites, are presented in Figure 18. We use monitoring data on 20 species from 2001 to 2008. During this time period, the indicator increased by 6.5% in HNV zones, but was stable in non-HNV zones (1%). In a linear model testing for an eventual difference in temporal trend of species indices (20 species) between HNV and non-HNV, the interaction between year and HNV-status was almost significant ($t = 1.83$, d.f. = 298, $p = 0.07$). This result indicates that the species included in the indicator have a higher increase rate in HNV than in non-HNV farmland.

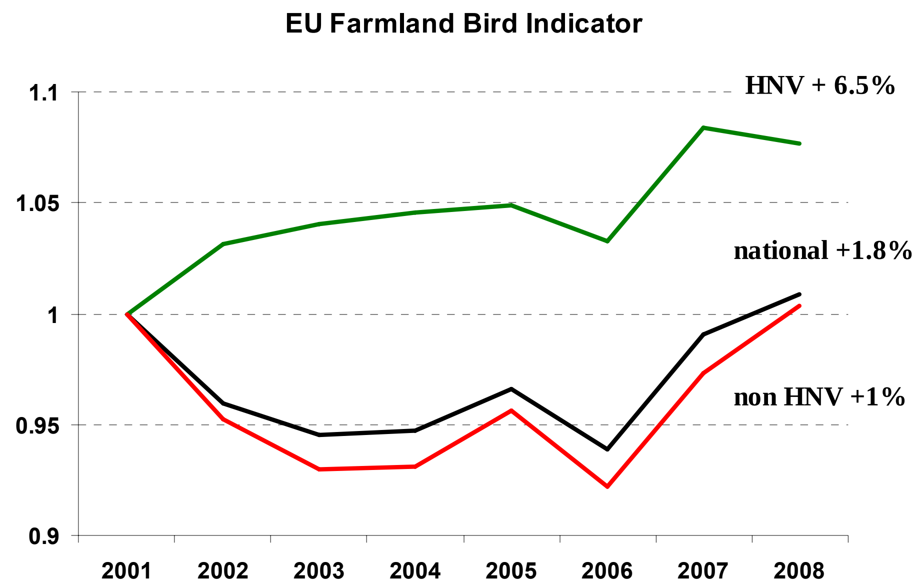


Figure 18: The EU Farmland Bird Indicator for HNV and non-HNV sites surveyed by the French Breeding Bird Survey. The indicator is calculated as a geometric mean of yearly population indices of 20 species across the country. The national indicator for farmland birds in France refers to the same period.

6.5. Sensibility analysis of the HNV threshold

At the previous analysis, we used the minimum threshold to qualify an area as HNV farmland by selecting the 25% percentile of the best NUTS5 scores. We applied this threshold in order to remain consistent with the analysis described in chapt.5. However, the scoring system allows establishing alternative thresholds and therefore testing different values or scenarios for identifying the HNV farmland area. We thus made a sensitivity analysis of the HNV threshold by using the EU Farmland Bird Indicators (FBI). This analysis will permit us to identify more clearly a threshold that reflects ecological differences between the areas classified as HNV, expected thus to support higher levels of biological diversity than the non-HNV farmland areas.

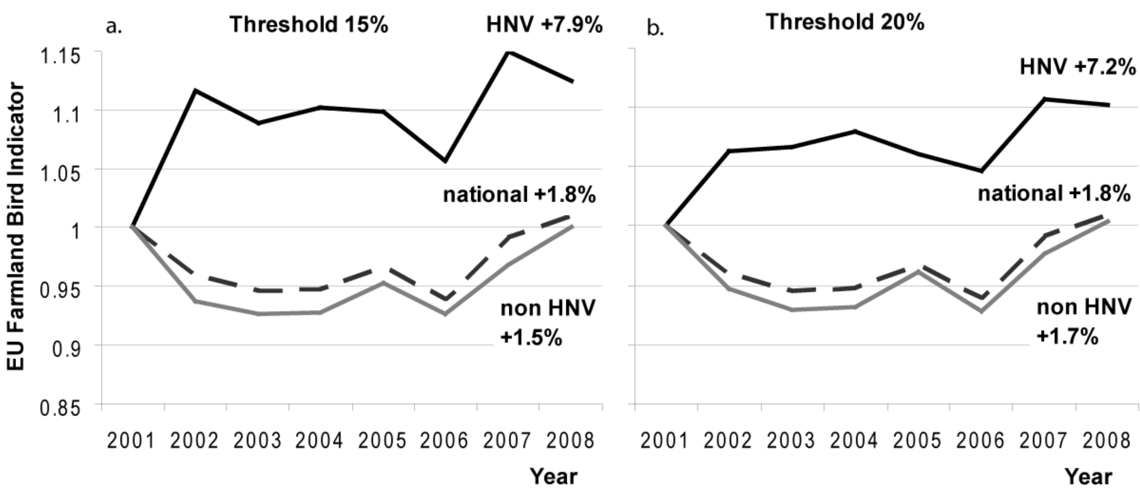
We estimated the EU Farmland Bird Indicators (FBI) for HNV and non-HNV sites, using various thresholds of the HNV indicator. The FBI is estimated using monitoring data on 20 farmland species from 2001 to 2008. We tested the temporal trends of species indices in HNV and non-HNV sites, through linear models using species as a factor parameter, the HNV status as a binomial parameter and the interaction between year and the HNV status.

The threshold of 15% of the UAA designed as HNV corresponds at an HNV score equal to 17.85 (Figure 19a). For this threshold, the interaction between year and HNV status was significant ($t = 2.07$, $p = 0.04$). For the thresholds 20% and 25% of the UAA designed as HNV (HNV scores: 16.32

and 14.80 respectively), the interaction between year and HNV status were at the limit of being significant (p = 0.06 and p = 0.07 respectively).

For a threshold of 30% of the UAA designated as HNV, the interaction between year and HNV-status was significant (t = 2.21, p = 0.03; Figure 19d), showing that species included in the indicator have more negative trends in non-HNV than in HNV farmland. The interaction year-HNV status was also highly significant for thresholds higher than 30% (threshold 35% - HNV score [12.48] : t = 2.46, p = 0.015 and 40% - HNV score [11.47] : t = 2.75, p = 0.006; Figure 19e and Figure 19f respectively). However, as the percentage of UAA designed as HNV increases, the minimum scores for assigning an HNV area decreases. For instance, the HNV score that corresponds to the 30% threshold is equal to 13.54, thus lower than that of the 15% threshold (see above). Considering also our results of the community specialization index (Figure 17), we observe that for average HNV scores (between 10 and 15) we obtain the lowest levels of community specialization. Higher HNV scores are attributed to areas with higher presence of specialist species.
If we consider thresholds higher than 40% then we diminish the difference between HNV and the national curve, whereas the difference between non-HNV and the national curve increases. In other words, considering very high thresholds is not only unrealistic from a political and management point of view but also from a biological one. By considering thresholds 50% or higher, we could eventually identify Low Value Farmland, but this is not the purpose of the present analysis.

We thus suggest that depending on the protection purposes possibly applied in each case, both 15% and 30% thresholds may effectively be used for the attribution of the HNV status. The first threshold is stricter, including less HNV areas of a particularly high nature value. The second threshold is less strict, including more HNV areas but still making effectively the distinction between HNV and non-HNV areas, and respecting the compromise of a relatively high HNV score value.



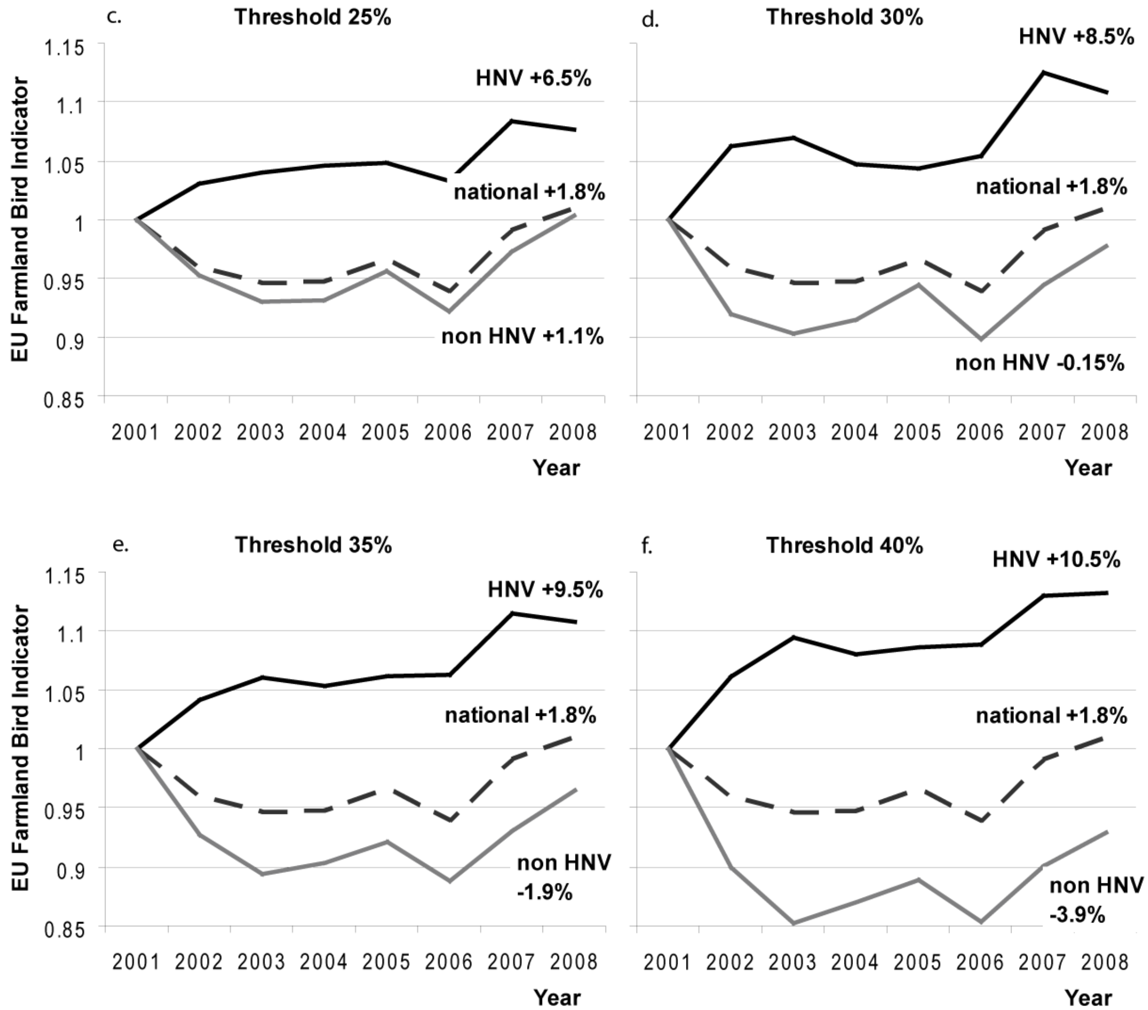


Figure 19: The EU Farmland Bird Indicator for HNV and non-HNV sites surveyed by the French Breeding Bird Survey. a) the threshold for HNV areas is fixed at 15% of the UAA, b) HNV threshold at 20% of the UAA, c) HNV threshold at 25% of the UAA, d) HNV threshold at 30% of the UAA, e) HNV threshold at 35% of the UAA, f) HNV threshold at 40% of the UAA

Black line : HNV sites, grey line : non-HNV sites, dashed line : all sites considered.

7. Revised HNV farmland maps for France

The analysis of bird indicators suggests taking into account two thresholds: 15% and 30% of the UAA as HNV farmland.

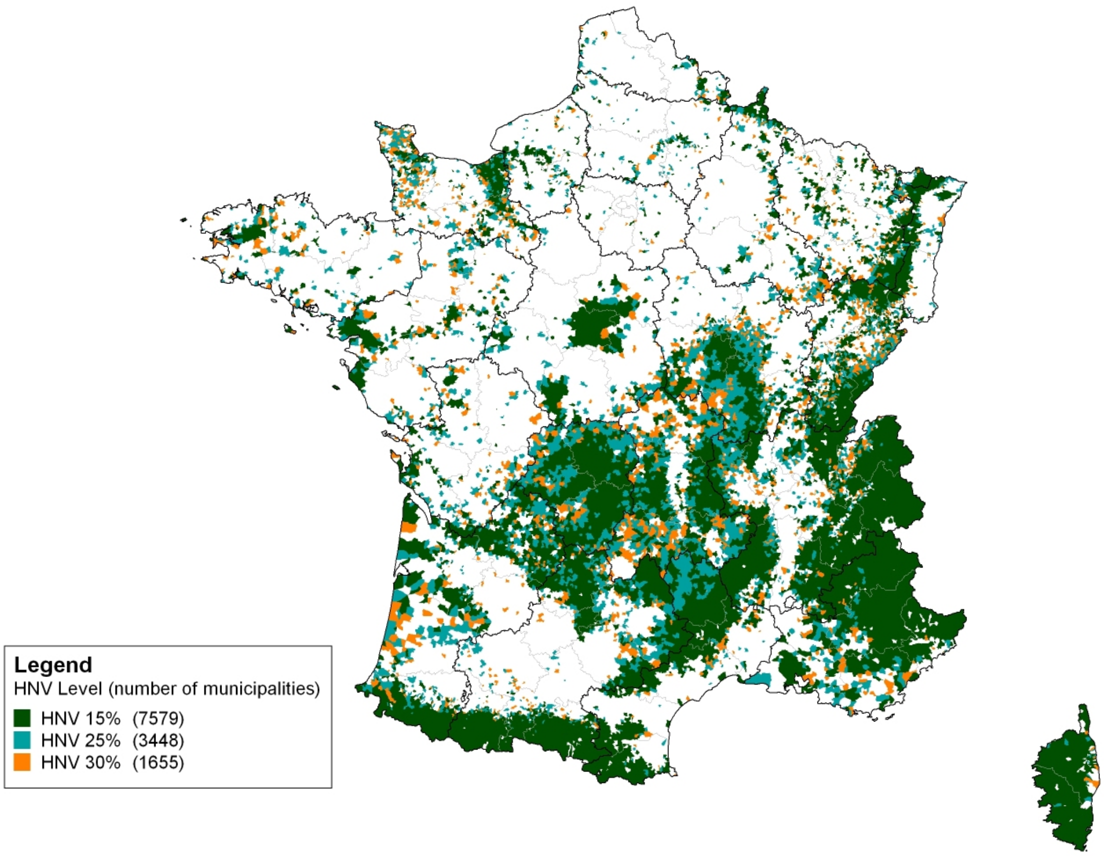


Figure 20: Final map with the HNV threshold set at 15%, 25% and 30% of the UAA

The map in Figure 20 shows that the surfaces adding up with increasing HNV threshold are always located next to existing HNV areas.

8. HNV farmland in 1970

8.1. Hypothesis

The objective is to investigate the evolution of HNV farmland in France between 1970 and 2000. In order to do so, the same indicators are estimated, using the same thresholds and the same weighting, for the two reference years i.e. 1970 and 2000, in order to be able to compare HNV evolution on a common basis.

Most of the data used to produce the map of HNV farmland in 1970 are provided for that same year. The data not directly available are: fishing ponds, forest, grassland fertilisation and wet grasslands. Changes in forest area in the period 1970-2000 are limited therefore the edge length is considered unchanged. Data on grassland fertilization are provided by the 1982 grassland survey, we can consider thus that the fertilization is slightly overestimated (meaning that the HNV score is underestimated). It is also known that the surface of wet grasslands was larger in 1970 than in following years. Given these constraints we consider thus that the 1970 HNV map provides an underestimation of HNV farmland for that year.

Table 14: Available data to calculate the HNV farmland areas in 1970

Indicator	Data sources
Indicator 1 "crop diversity"	FSS 1970
Indicator 2 "extensive practices"	- Annual Agricultural Statistic (yield) and FSS 1970 (type) for extensive permanent grassland and common lands. - Grassland survey 1982 concerning the N fertilization level of the permanent grassland
Indicator 3 "landscape elements"	- surface of traditional orchards in 1970 - surface of hedgerows based on the first Forestry survey (IFN) – average date 1975 and retrapolated to 1970 - unchanged forest edge length considering that forest evolution between 1970 et 2000 is limited - unchanged number of fishing ponds (no data available in 1970) - wet grasslands area in 2000 (no data available in 1970)

8.2. Results

8.2.1. Evolution of the HNV scores (1970-2000) with a threshold of 25% of the UAA

According to the procedure described in 8.1 the **HNV farmland area is estimated to 21.3 millions of hectares in 1970 compared to 6.9 millions in 2000**. The HNV farmland area has thus decreased by 68% in 30 years corresponding to a loss of 14.4 millions of ha (see Figure 21).

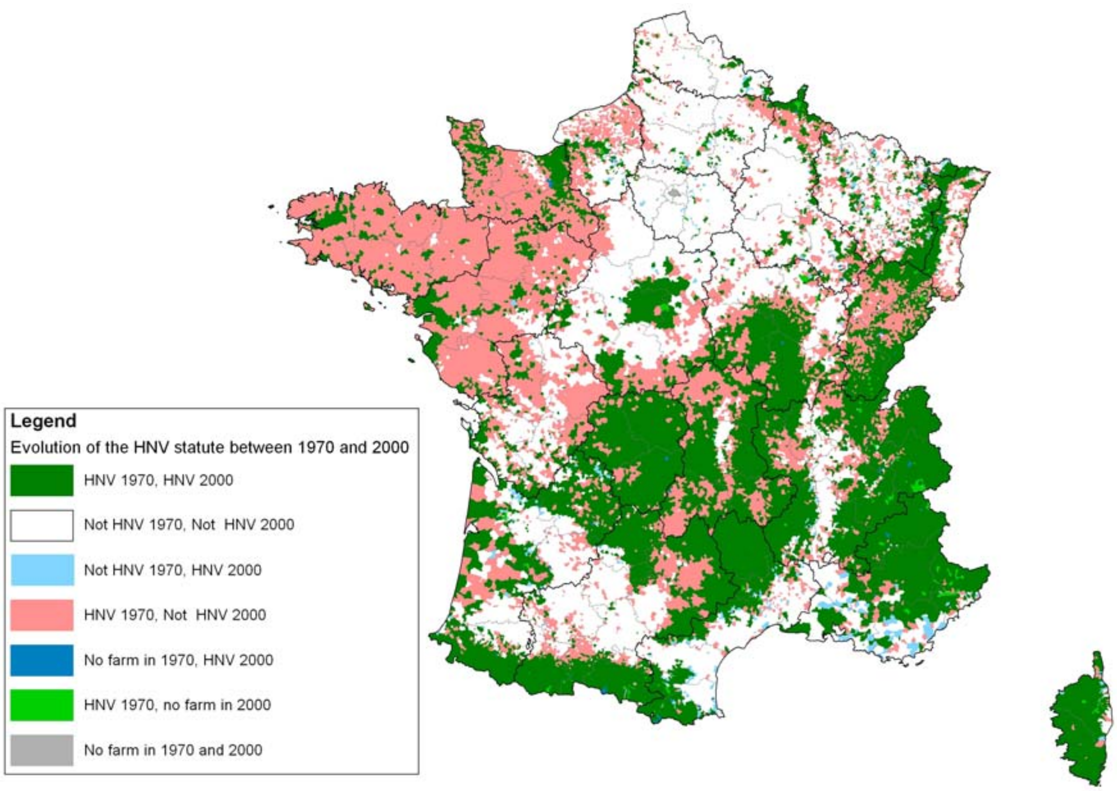


Figure 21: Evolution of the HNV farmland area between 1970 and 2000

For the majority (90%) of municipalities the HNV score has decreased between 1970 and 2000 (see table 15). For the municipalities classified in HNV in 2000 the score evolution is -9,1% compared to non HNV (-46%) (see table 16).
27% of the municipalities classified HNV in 2000 have increased their score between 1970 and 2000 (see table 15 and figure 22), but only 2.4% for the non HNV municipalities. Only 288 municipalities have changed category by increasing their HNV score between 1970 and 2000[8].

Table 15: Evolution of the score between 1970 and 2000

	HNV status in 2000		Non HNV status in 2000	
	Number of communes	%	Number of communes	%
Increase or equal	2 921	26.6%	594	2.4%
Decrease	8 043	73.4%	24 274	97.6%
	10 964	**100%**	**24 868**	**100%**

[8] In 2000, the average UUA of these municipalities is very small (309 ha), The median surface is only 160 ha. 82 municipalities have less than 50 ha of UAA in 2000 (representing 28% of these municipalities). Their average score was 12.19 in 1970 and 19.28 in 2000. They are located mainly in the Mediterranean area. One hypothesis could be the reduction of the vineyard area and the increase of the share of the olive trees in the UAA which is considered as a landscape element.

Table 16: Evolution of the HNV score between 1970 and 2000

	Average HNV score in 1970	Average HNV score in 2000	Evolution
HNV areas 2000	22.82	20.73	-9,1%
Non HNV areas 2000	15.55	8.42	-45,9%
All	17.77	12.19	-31.4%

In 2000, the average UUA of these municipalities is 309 ha, but the median surface is only 160 ha. 82 municipalities (representing 28% of municipalities) have less than 50 ha of UAA in 2000.

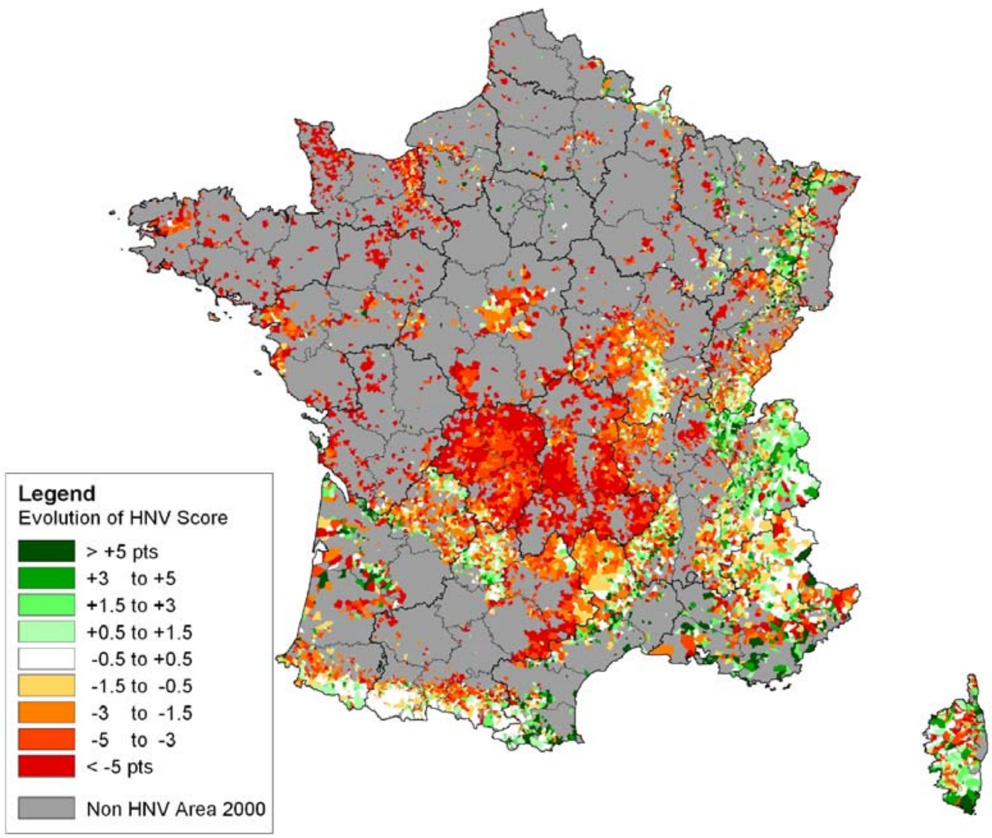


Figure 22: Evolution of the HNV score between 1970 and 2000

In Figure 23 we compare the distribution of the surfaces per class of HNV score in 1970 and 2000.

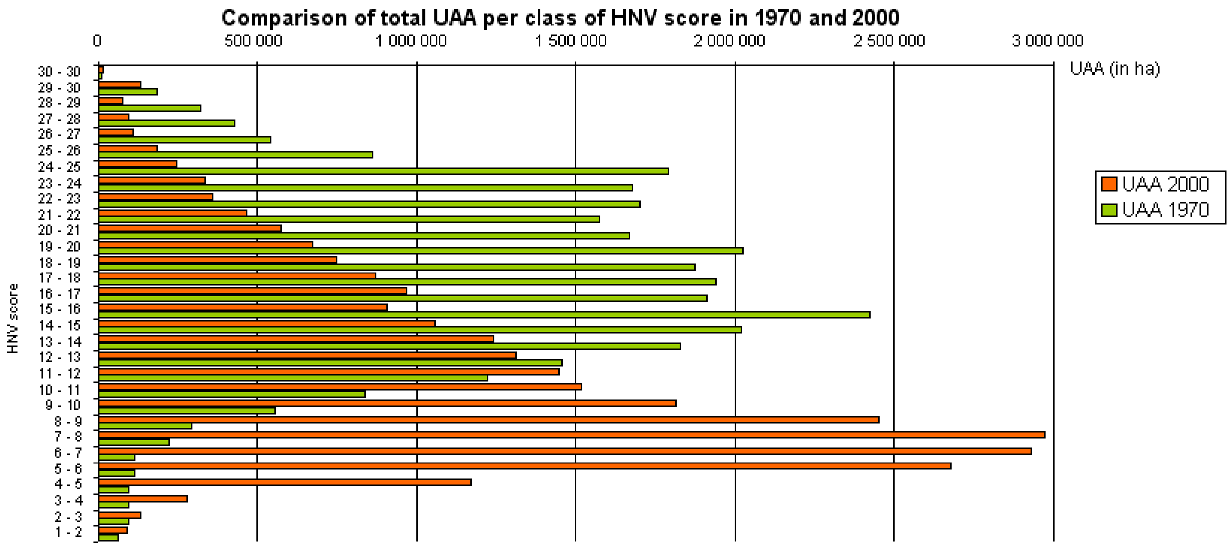


Figure 23: Comparison of the total UAA per class of HNV score in 1970 and 2000.

Figure 23 shows a clear shift of HNV scores to a lower median value. This means that on the average HNV areas are losing their nature value, even when remaining above the HNV threshold.

8.2.2. CSI and Evolution of the HNV scores (1970 – 2000)

Here we calculated the difference of HNV scores estimated at the national level in 1970 and 2000. Positive differences between the two scores indicate that concerned zones decreased their value of HNV indicator during the period 1970-2000, indicating an intensification of agriculture production. Similarly, negative score differences indicate sites that increased their HNV score during the period 1970-2000, containing actually more extensive farmland zones. In absolute values, the higher is the difference between the two indicators, the more important are the modifications of land use over time. We tested the community specialization index (CSI) over the difference of HNV scores from 1970 to 2000 (Figure 24).

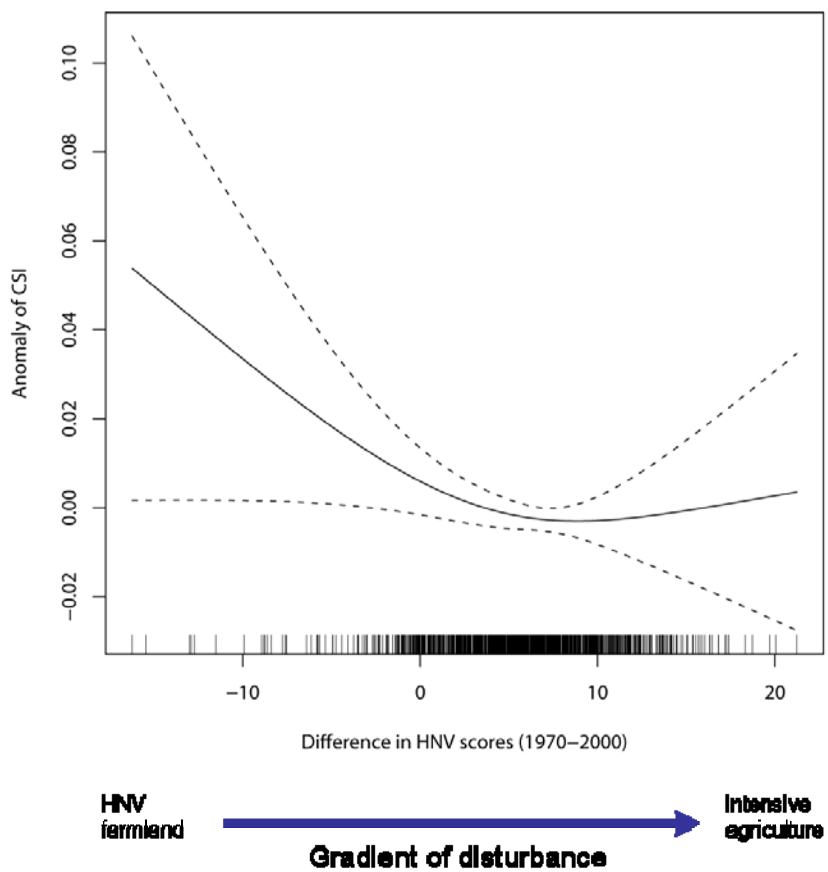


Figure 24: Community specialization index over the difference of HNV scores between 1970 and 2000. All sites are being considered.

This parameter "Difference in HNV scores" should be considered as an index of increasing intensification of practices during the considered period. Starting from the negative differences between the two indicators, we observe that those sites that increased their HNV value in this period of 30 years are actually composed more by specialist communities. While the difference of the two indicators gets smaller, the community specialization index also decreases indicating that for those sites that decreased their HNV score, communities are more composed by generalist species. Only for high positive differences of the HNV scores, we observe a small increase of the CSI index, which is due to the presence of few specialist species in highly intensive farmland.
We also conducted similar analyses, by considering only those sites that changed HNV status passing from non HNV zones to HNV zones and vice versa (therefore refer to also as gain and loss respectively). The threshold for attributing the HNV status was set for both indicators equal to 14.78, which corresponds to the 25% threshold. The evolution of the HNV status is presented in Figure 21.

We observe that we gained very few HNV sites during the period 1970 and 2000, situated mainly in the South-Eastern part of France (presented in light blue). On the contrary, we observe an important loss of HNV areas, mostly in the North-West and less in central France. Finally, in green and white are presented the sites that have not changed HNV status, remaining HNV and non-HNV respectively.
We conducted separate analyses for each one of these three cases:

a) for sites that were not considered HNV in 1970 and they passed the threshold in 2000 (gain) ;

b) for sites that were HNV in 1970 and that they have passed below the threshold in 2000 (loss) ;

c) for sites that have not changed HNV status between 1970 and 2000 (no change).

The results of the CSI indicator for each of these three cases are presented in Figure 25 (a,b,c).

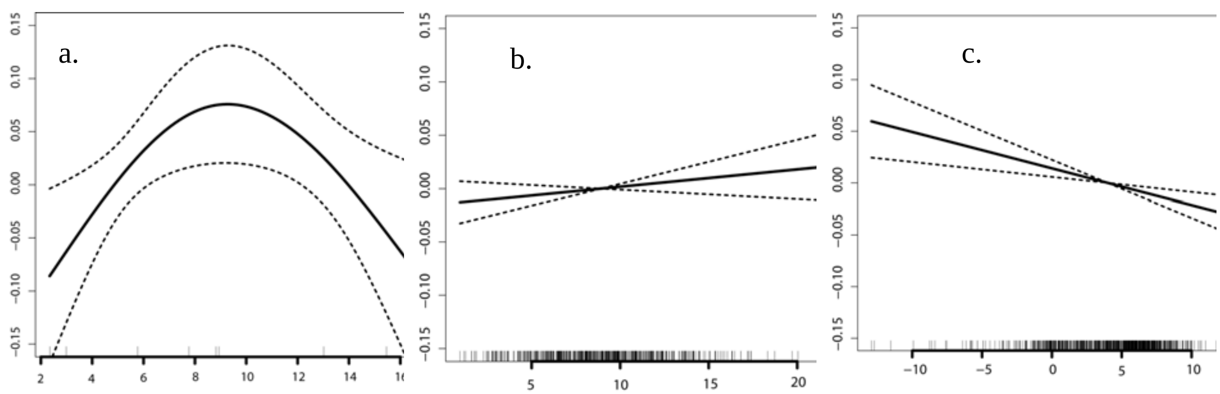


Figure 25: Community Specialization Index (CSI) (shown in y axis) over the difference of HNV scores between 1970 and 2000 (shown in x axis, confidence intervals are shown in dotted lines) *for a) gain of HNV sites; b) loss of HNV sites; c) sites that have not changed HNV status.*

For those sites that became HNV areas between 1970 and 2000 (gain), we revealed a quadratic but not significant effect between the CSI and DHNV, here presented in absolute values (t_8=1.75, p = 0.1; t_8=1.63, p = 0.1). Communities with low differences in HNV scores are composed by more generalist species and the highest community specialization values are obtained for mean difference of HNV scores. Concerning only those sites that were HNV in 1970 but are not anymore (loss), we observe no significant trend over the difference of HNV scores (t_{496}=-0.68, p = 0.5). However, for those sites that have not changed HNV status, we observe a significant negative trend (t_{726}=-2.22, p = 0.03). This result is consistent with the one obtained when all the sites are considered (see Figure 24).

8.2.3. FBI and Evolution of the HNV scores (1970 – 2000)

We also tested the response of species abundances to the evolution of HNV scores between 1970 and 2000 (also noted as DHNV). We use monitoring data on the 20 specialist farmland species of the EU Farmland Bird Indicator from 2001 to 2008. In a linear model testing for an eventual difference in temporal trend of species indices (20 species), the interaction between year and DHNV score was highly significant (p << 0.001). This result indicates that temporal trends of species abundances are significantly lower with an increase of DHNV. The increase of DHNV values indicates an increasing gradient of perturbation in the farming practices leading to more intensively cultivated farmland areas. Farmland specialists are thus significantly less abundant in sites that have currently a lower HNV score than that of 1970.

We also tested non-linear regression models between the abundance of the 20 specialist farmland species and the DHNV. This analysis revealed indeed a negative response of species abundances with the increase of DHNV (going from negative values towards 0). However, additionally to previous results, we also observed a positive response for positive values of the DHNV, explained by an over domination of open-area specialists in open field intensive farmland.

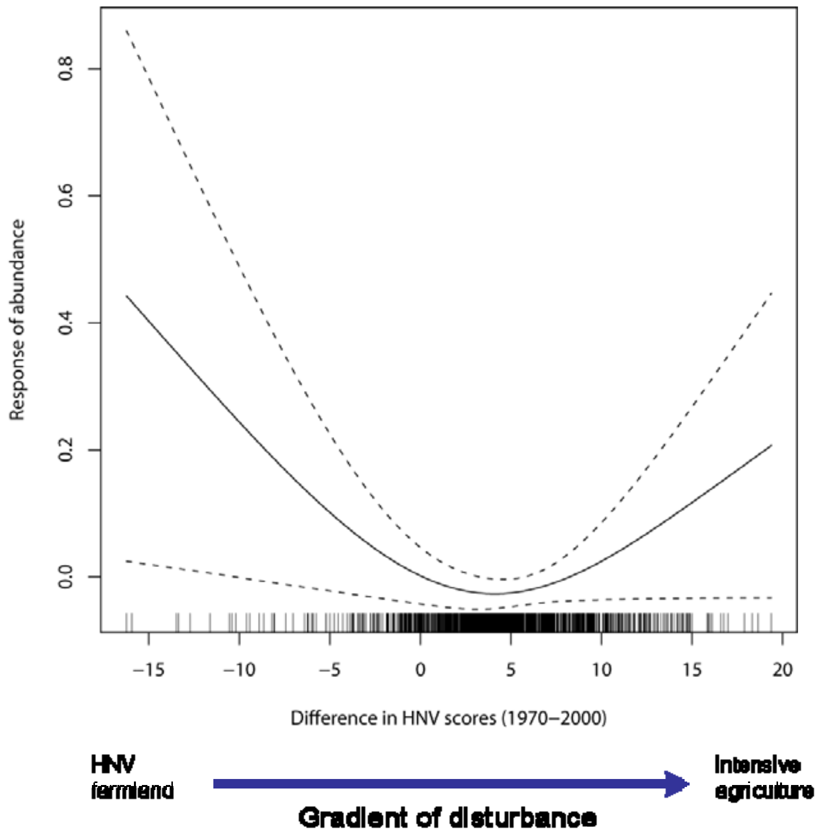


Figure 26: Non-Linear regression of the response of species abundance (shown in y axis) of the 20 specialist farmland species, against the difference in HNV scores (DHNV) between the years 1970 and 2000 (shown in x axis, confidence intervals are shown in dotted lines).

9. Conclusions and Perspectives

Several conclusions can be drawn from the analyses presented in this report:

1. The negative evolution observed in the surface of HNV farmland area between 1970 and 2000, confirms the trend observed in farmland biodiversity during the same period by scientists. Additionally, the maps show that in France the intensification of the farming systems and agricultural practices do not occur at the same level everywhere. The Atlantic region was highly intensified as the Alsace flood plain, while in some regions with a lower agronomic potential the intensification was limited. These regions are dominated by grazing systems and low input levels.

2. The FADN confirms that the size of professional farms located in HNV areas is smaller than the size of those located in HNV areas (-5%) and the difference in working units is also negative (-14%). Reflecting the general trend, the size of HNV farms is increasing (+4% per year) over years. But the main differences between the two categories concern the farm income per WU which is lower by 13% for HNV farms in 2004, 15% in 2006 and 38% in 2007 even if the level of subsidies per farm is slightly higher.

3. A large proportion (63%) of the farmland located in Natura 2000 is located in HNV areas. For increasing HNV values, we get increasing shares of Natura 2000 included in HNV farmland. For example, 90% of the UAA of the municipalities with the maximum score of 30 points is located in NATURA 2000.

4. The analysis of local abundances shows that populations of bird species with unfavourable conservation status are larger in HNV areas: for a HNV threshold set at 25% of the UAA, 73% of these species have more than 25% of their national populations included in HNV areas. We also observed that most of the wetland related species considered in this study (n=22) had an important part of their relative abundances inside HNV areas (Appendix VIII). This indicates that wet meadows and wet grasslands seem to be an important element of HNV farmland in France.

5. The results obtained with the community indices (species richness, specialist species richness, and community specialisation index) indicate that HNV farmland does not hold more bird species but more specialized bird communities than non-HNV sites. Under the global trends of biotic homogenization and biological simplification through the replacement of specialist species by generalists ones, High Nature Value farmland seems to constitute an efficient spatial network for conservation needs and goals and should provide guidelines on agricultural practices for adaptive management scenarios and policies.

6. Calculating the EU Farmland Bird Indicator for HNV and non-HNV sites, we observe that bird population trends are higher in HNV than in non HNV. In the unfavourable context of global farmland bird declines facing agriculture intensification in Europe (Donald *et al.*, 2001; 2006, Gregory *et al.*, 2005) and also in France (cf. national FBI here), HNV farmland seems efficient to provide favourable conditions for bird populations in France. This indicator is efficient to trace changes over time and thus it is a widely used indicator in European-wide indicator frameworks. Moreover, the efficiency of the EU Farmland Bird Indicator to track changes over time and space justifies, if necessary, its use as a major tool for management and policy decisions at the European scale.

7. The analysis of the evolution of HNV scores between 1970 and 2000 gives also some interesting results. Sites that increased their HNV value between 1970 and 2000 are actually composed by specialist communities. Specialist farmland species are also more abundant in sites that became HNV areas during this period of 30 years. For areas with small differences in the HNV scores between the two periods, we observe a certain homogenization, with bird communities being composed principally by generalist species. We finally observe higher abundances for some specialists species present in zones that were HNV in 1970 and are not in 2000, explained by the presence of few open-area specialist bird species in extensive farmlands.

The national French approach seems suitable to identify HNV areas at national level and with a high level of detail. The presented methodology could be applied in other European countries if the access to FSS data at farm scale is available. If the data concerning the nitrogen mineral fertilization of permanent graslands are not available, this indicator could be replaced by the stocking density after building a specific scale per environemental zone or agri-environmental region. The selection of landscape elements should be adapted to each country taking into account available data. As for the stocking density, the thresholds, the scales and the weigthing of each element should be redefined according to the local conditions. The FBI and other biodiversity indicators could help to validate the results.

The methodology and the calculation of the HNV threshold could also be improved by analysing the HNV data together with other biodiversity indicators. Taxa as weeds or butterflies could have a different response to the intensity of agricultural practices (see appendix IX). The interrelation between the three indicators should also be studied. The scientific review shows for example that species richness is higher in traditional orchards surrounded by a hedge or in a grassy strip closely located to an extensive field headland.

We observed some differences between the analysis of 2006 and the present analysis. The most important one concerns the trends of Farmland Bird Indicator in HNV and non-HNV farmland. Adding two years of data in a database of a relatively recent existence (8 years) can change the shape and significance of statistical tests. Moreover, as for the FBI, an additional reason may explain the observed differences, which is related to the way this indicator is now estimated. In newly breeding bird surveys, we expect that first-time observers will gradually increase their capacities of counting all present individuals and bird species. We thus expect that observers will count more accurately present birds in subsequent years than during the first year of their participation at the survey. This effect is also known as "the first-time observer effect" (Kendall *et al.*, 1996). This effect was taken into account in the estimation of the Farmland Bird Indicator in France for the analysis of 2006. However, a recent analysis by Jiguet (2008) revealed that this bias is small for the French data and thus needs not to be considered in French indicators. Moreover, the new estimation of the French FBI has also an additional advantage, as it is now estimated in the same way as the Pan-European Indicator. As it becomes increasingly important to produce national indicators that can be easily compared among countries, such methodological homogenization can be only beneficial for analyses at larger scales.

The community specialization index may also be a potentially sensitive indicator to changes in the agricultural areas. An analysis similar to the one presented in terms of abundances at the species level, may also be made at the community level. The purpose of this analysis would be to check whether the composition of communities changes over time and whether we observe a pattern linked to the HNV score of each area concerned. The level of community specialization is an important indicator of the quality of habitat. In general, communities composed by specialists species indicate a higher quality of the habitats in which they are present. In cases where the community specialization index is indeed sensitive to changes of the HNV indicator over time, it could be used as a new tool for tracing ecological changes over time and potentially contribute to a new indicator.

10. References

Aebischer, N.J. 1991. Twenty years of monitoring invertebrates and weeds in cereal fields in Sussex. Pages 304-331 in *The Ecology of temperate Ce real Fields*. Blackwell Scientific Publications, Oxford.

Albretch, H., 2003. Suitability of arable weeds as indicator organisms to evaluate species conservation effects of management in agricultural ecosystems. *Agriculture Ecosystems and Environment* **98**:201-211.

Allion Y., 2007. Natura 2000: documents d'objectif du site d'importance communautaire Sologne Fr 2402001. Institut d'écologie appliquée.

Anger, M., Malcharek, A. and Kuhbach, W., 2002. An evaluation of the fodder values of extensively utilised grasslands in upland areas of Western Germany. I. Botanical composition of the sward and DM yield. *Journal of Applied Ecology* **76**:41-46.

Austad I. and Al, 2004. An overview of Norwegian summer farming. Transhumance and biodiversity in European Moutains. *Iale and Alterra*.

Aviron S. and Al, 2009. Ecological cross compliance promotes farmland biodiversity in Switzerland. Frontiers in Ecology and the Environment. The Ecological Society of America

Baldock, D., G. Beaufoy, G. Bennett, & J. Clark., 1993. Nature conservation and new directions in the common agricultural policy. *IEEP* London.

Barr C.J., Britt C.P. and Sparks T.H., 1995. Hedgerow management and wildlife. A review of research on the effects of hedgerow management and adjacent land on biodiversity. Institute of Territorial Ecology.

Beaufoy, G., Baldock, D. and J. Clark., 1994. The Nature of Farming: Low Intensity Farming Systems in Nine European Countries. *IEEP*, London.

Bignal, E.M. and McCracken, D.I., 2000. The nature conservation value of European traditional farming systems. *Environmental Reviews* **8**:149-171.

Billeter, R., J. Liira, D. Bailey, R. Bugter, P. Arens, I. Augenstein, S. Aviron, J. Baudry, R. Bukáček, F. Burel, M. Cerny, G. De Blust, R. De Cock, T. Diekötter, H. Dietz, J. Dirksen, C. Dormann, W. Durka, M. Frenzel, R. Hamersky, F. Hendrickx, F. Herzog, S. Klotz, B. Koolstra, A. Lausch, D. Le Coeur, J. P. Maelfait, P. Opdam, M. Roubalova, A. Schermann, N. Schermann, T. Schmidt, O. Schweiger, M. J. M. Smulders, M. Speelmans, P. Simova, J. Verboom, W. K. R. E. van Wingerden, M. Zobel, and P. J. Edwards (2008). Indicators for biodiversity in agricultural landscapes: a pan-European study. Journal of Applied Ecology 45:141–150.

BirdLife International, 2004. Threatened birds of the world 2004. Cambridge, UK: BirdLife International (www.birdlife.org).

Boller E.F., Malavolta C. and Jörg E., 1997. Guidelines for Integrated Production of Arable Crops in Europe. *IOBC wprs Bulletin*

Boots A.J., 2001. The effect of connection to woodlands on the woody species composition of hedgerows. Hedgerows of the world : their ecological functions in different landscapes. *Proceedings of the 2001 annual IALE Conference*.

Bouvier J.-C., Toubon J.-F., Boivin T. and Sauphanor B., 2005. Effects of apple orchard management strategies on great tit (Parus major) in Southern France. Environmental Toxicology and Chemistry, Vol. 24, **11**:2846–2852

Broyer J., 2001. Plaidoyer pour une politique européenne en faveur des ecosystems prairiaux. *Courrier de l'environnement de l'INRA n°43*.

Byfield A. and Wilson P., 2005. Important arable plant areas. Identifying priority sites for arable plant conservation in the United Kingdom. Plantlife, Salisbury.

Caballero-López B., Blanco-Moreno J.M., Pérez N., Pujade-Villar J., Ventura D., and F.-X. Sans, 2009. Effect of farming management on plant and arthropods community in dryland wheat fields. *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity,* Lleida 12-13 March 2009.

Chamberlain De, Vickery Ja, Marshall Ejp, Tucker Gm, 2001. The effect of hedgerow characteristics on the winter hedgerow bird community. *Hedgerows of the World: Their Ecological Functions in Different Landscapes*, 197-206.

Cirujeda A., Aibar J. and C. Zaragoza, 2009. The weed composition in cereal fields reflects the agricultural intensity level in Aragón. *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity*, Lleida 12-13 March 2009

Colette J., 2008. The birds of orchards in Normandy. Le Cormoran Tome 16 N°67.

Commission of the European Communities, 2001. Communication from the commission to the Council and the European parliament. Biodiversity action plan for agriculture. COM(2001) 162 final.

Commission of the European Communities., 2006. Handbook on Common Monitoring and Evaluation Framework - Guidance document and Annexes. Accessed 30 October 2009 at http://ec.europa.eu/agriculture/rurdev/eval/index_en.htm

Commission of the European Communities., 2006. EU environment-related indicators 2006. Directorate General for Environment, European Commission, Brussels. Accessed 30 November 2007 at http://ec.europa.eu/environment/indicators/pdf/leaflet_env_indic_2006.pdf.

Constant P., Eybert M-C. and Maheo R., 1976. Avifaune reproductrice du bocage de l'ouest. Les bocages: histoire, écologie et économie. *CNRS-ENSA et Université de Rennes*

Cooper, T., K. Arblaster, D. Baldock, M. Farmer, G. Beaufoy, G. Jones, X. Poux, Davy McCracken, E. Bignal, B. Elbersen, D. Wascher, P. Angelstam, J.-M. Roberge, P. Pointereau, J. Seffer, & D. Galvanek. , 2007. Final report for the study on HNV indicators for evaluation. Contract notice 2006 – G4-04. *Report prepared by the Institute for European Environmental Policy for DG Agriculture.*

Coulon, F., Pointereau, P. and Meiffren I. , 2005. Le pré-verger, pour une agriculture durable. Editions Solagro

Devictor, V., R. Julliard, & F. Jiguet., 2008. Distribution of specialist and generalist species along spatial gradients of habitat disturbance and fragmentation. *Oikos* **117**:507-514.

DIREN Rhône-Alpes, 2004. Documents d'objectifs Natura 2000: Etangs des Dombes.

Donald, P. F., Green R.E. and M. F. Heath., 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. *Proceedings of the Royal Society of London Series B-Biological Sciences* **268**:25-29.

Donald, P. F., F. J. Sanderson, I. J. Burfield, & F. P. J. van Bommel., 2006. Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990-2000. *Agriculture Ecosystems & Environment* **116**:189-196.

Doreen G., Sait S., Kunin W. and T. Benton, 2009. Effects of organic farming on plant diversity in crop and grass fields at different spatial scales. 3rd Workshop of the European Weed Research society, Working Group: Weeds an Biodiversity, Lleida 12-13 March 2009.

Duelli P., 1990. Population movements of arthropods between natural and cultivated areas; *biological conservation* **54**:193-207

EEA/UNEP, 2004. High Nature Value Farmland: Characteristics, Trends and Policy Challenges. *EEA Report* No. 1/2004, Copenhagen.

EEA, 2005. Agriculture and Environment in EU-15 – the IRENA indicator report. *EEA Report* No 6/2005. European Environment Agency, Copenhagen.

European Communities, 2009. Guidance document - The Application of the High Nature Value Impact Indicator 2007-2013. Accessed 30 October 2009 at http://ec.europa.eu/agriculture/rurdev/eval/hnv/guidance_en.pdf

EU, Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD)

Fried G., 2007. Variations spatiales et temporelles des communautés adventices des cultures annuelles en France. Thèse Université de Bourgogne, INRA

Gabriel D. and T. Tscharntke, 2007. Insect pollinated plants benefit from organic farming. Agriculture, Ecosystems & Environment, Vol.18, Issues 1-4, pp.43-48

Gibson Rh, Nelson Il, Hopkins Gw, Hamlett Bj, Memmott J, 2006. Pollinator webs, plant communities and the conservation of rare plants: arable weeds as a case study. *Journal of Applied Ecology* **43**:246-257.

Glemnitz, M., Czimber G., Radics L. and J. Hoffmann, 2006. Weed flora composition along a north-south climate gradient in Europe. Acta Agron. Óváriensis **42**:155–169.

Gomez A. and lorente I., 2004. The present status and ecological consequences of transhumance in Spain. Transhumance and biodiversity in European Moutains. *Iale and Alterra.*

Gregory, R. D., A. van Strien, P. Vorisek, A. W. G. Meyling, D. G. Noble, R. P. B. Foppen, & D. W. Gibbons., 2005. Developing indicators for European birds. *Philosophical Transactions of the Royal Society B-Biological Sciences* **360**:269-288.

Guisan, A., T. C. Edwards, & T. Hastie., 2002. Generalized linear and generalized additive models in studies of species distributions: setting the scene. *Ecological Modelling* **157**:89-100.

Hautier Y., Niklaus P. A and Hector A, 2009. Competition for Light Causes Plant Biodiversity Loss Following Eutrophication. *Science* **324**, Issue 5927

Henderson I.G., Ravenscroft N., Smith G. and Holloway S., 2009. Effects of crop diversification and low pesticide inputs on bird populations on arable land. *Agriculture, Ecosystems and Environment* **129:**149–156

Herzog F. and Bunce R.G.H., 2004. Conclusions from the policy Workshop. Transhumance and biodiversity in European Moutains. *Iale and Alterra*.

Herzog F. and Walter T., 2005. Evaluation des mesures écologiques , domaine biodiversité. *Agroscope-FAL*.

Holland J.D. and Fahrig L., 2001. Landscape woody border increases insect diversity in alfafa fields. Hedgerows of the world : their ecological functions in different landscapes. *Proceedings of the 2001 annual IALE Conference*.

Holec, J., Necasova, M., Soukup, J. and P. Hamouz, 2009. Changes of the weed flora during 20th century – a case study on the area of the Czech Republic. *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity,* Lleida 12-13 March 2009

Ispikoudis I., Siouliou M.K. and Papanastasis V.P., 2004. Transhumance in Greece: past, present and future prospects. Transhumance and biodiversity in European Moutains. *Iale and Alterra.*

Isselstein J., Jeangros B. and Pavlu V., 2005. Agronomic aspects of biodiversity targeted management of temperate grasslands in Europe : A review . *Agronomy research*. **3**:139-151

Jauzein P., 2001. Biodiversité des champs cultivés: l'enrichissement floristique. In: Agriculture et biodiversité des plantes – dossier de l'Environnement de l'INRA, Vol.21. , 43-64, INRA, Paris, France

Jeanneret Ph., Huguenin-Elie O., Baumgartner D., Freiermuth Knuchel R., Gaillard G., Nemecek Th. and P. Weibel, 2007. Estimation of grassland management impact on biodiversity. Grassland Science in Europe, 12, 382-385.

Jiguet, F., 2008. Suivi Temporel des Oiseaux Communs. Bilan 2007 pour la France. *Ornithos* **15**: 73-83.

Jiguet, F., A. S. Gadot, R. Julliard, S. E. Newson, & D. Couvet., 2007. Climate envelope, life history traits and the resilience of birds facing global change. *Global Change Biology* **13**:1672-1684.

Jiguet, F., O. Renault, & A. Petiau., 2005. Estimating species richness with capture-recapture models: choice of model when sampling in heterogeneous conditions. *Bird Study* **52**:180-187.

Julliard, R., J. Clavel, V. Devictor, F. Jiguet, & D. Couvet., 2006. Spatial segregation of specialists and generalists in bird communities. *Ecology Letters* **9**:1237-1244.

Julliard, R., & F. Jiguet., 2002. Integrated monitoring of common bird species in France. *Alauda* **70**:137-147.

Kay S. and S. Gregory, 2000. The comparative biodiversity benefits of organic and conventional farming systems. In: The Biodiversity Benefits of Organic Farming. The Soil Association. Available on line at: http://www.wwf.org.uk/filelibrary/pdf/biodiversity_benefits.pdf

Kleijn, D. and van der Voort, L.A.C., 1997. Conservation headlands for rare arable weeds: the effects of fertilizer application and light penetration on plant growth. *Biological Conservation* **81**:57-67.

Klimek, S., Marini, L., Hofmann, M. and J. Isselstein, 2008. Additive partitioning of plant diversity with respect to grassland management regime, fertilisation and abiotic factors. *Basic and Applied Ecology* **9**:626-634

Klimek S, Kemmermann Arg, Hofmann M, Isselstein J, 2007. Plant species richness and composition in managed grasslands: The relative importance of field management and environmental factors. *Biological Conservation* 134:559-570

Kosior A, Celary W, Olejniczak P, Fijal J, Krol W, Solarz W, Plonka P, 2007. The decline of the bumble bees and cuckoo bees (Hymenoptera : Apidae : Bombini) of Western and Central Europe. *Oryx* **41**:79-88.

Le Roux X., Barbault R., Baudry J., Burel I., Doussan I., Garnier E., Ferzog F., Lavorel S., Lifran R., Roger-Estrade J., Sarthou J.-P., and M. Trommetter (eds), 2008. Agriculture et biodiversité. Valoriser les synergies.
Expertise scientifique collective, rapport, INRA (France). Available at : http://www.resogm.org/IMG/pdf/Agriculture-Biodiversite.pdf

Legast M., Mahy G. and bodson B., 2008. Les messicoles, felurs des moissons. Ministère de la region wallonne – Direction générale de l'agriculture.

Liebman M., 2009. Biodiversity and the management of weeds and other non-crop vegetation in arable farming systems. 3rd Workshop of the European Weed Research Society Working Group: Weeds and Biodiversity, Lleida 12-13 March 2009

Loddo D., Russo A. and S. Benvenuti, 2009. Influence of traditional crop seed cleaning techniques on the presence of cornflower (*Centaurea cyanus* L.) and corn cockle (*Agrostemma githago* L.) in winter cereal fields. *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity*, Lleida 12-13 March 2009.

Malézieux E., Crozat Y., Dupraz C., Laurans M., Makowski D., Ozier-Lafontaine H., Rapidel B., de Tourdonnet S., Valantin-Morison M., 2008. Mixing plant species in cropping systems: concepts, tools and models. A review. *Agronomy for sustainable development* 2008/3/7.

Maria J. and Gerowitt B., 2009. Diversity measures of weed communities regarding crop type and management. *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity*, Lleida 12-13 March 2009

Mertens A. and Huband S., 2004. Romanian transhumance – the past, the present and future scenarios. Transhumance and biodiversity in European Moutains. *Iale and Alterra*.

Miguel, J.M. de, 1999. Nature and configuration of the agrosilvopastoral landscape in the conservation of biological diversity in Spain. *Revista Chilena de Historia Natural.* **72**:547-557.

Moreby S.J. and Southway S., 2001. The importance of hedgerow field boundaries to densities of beneficial invertebrates in cereals. Hedgerows of the world : their ecological functions in different landscapes. *Proceedings of the 2001 annual IALE Conference*.

Mroz W. and Olszanska A., 2004. traditional pastoralism and biodiversity in the Western and the Eastern Carpathians. Transhumance and biodiversity in European Moutains. *Iale and Alterra.*

Nagy, G., 2002. The multifunctionality of grasslands in rural development in a European context. *Acta Agronomica Hungarica* **50**:209-222.

Nentwig W. Frank T. and Lethmayerand C., 1998. Sown weed strips: artificial ecological compensation areas as an important tool in conservation biological control. Pages 133-153 in Conservation Biological Control. Edited by Pedro Barbosa. Academic Press.

Necasová M. Tyšer L. and Soukup. J., 2009. Differences between weed communities under conventional and organic management. 3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity, Lleida 12-13 March 2009.

Olson E.G.A., 2004. Summer farming in Jotunheimen, Central Norway. Transhumance and biodiversity in European Moutains. Iale and Alterra.

Oreszczyn S.M. and Lane A.B., 2001. Hedgerows of different cultures: implications from Canadian and English cross-cultural study. Hedgerows of the world : their ecological functions in different landscapes. *Proceedings of the 2001 annual IALE Conference*.

Paoletti M.G., Dreon A.L. and Lorenzoni F.C., 2001. hedgerows in the Mediterranean region: a multifunctional system which links diversity with the history of cultivated plants. Hedgerows of the world : their ecological functions in different landscapes. *Proceedings of the 2001 annual IALE Conference.*

Paracchini M.L. and Britz W., 2010. Quantifying effects of changed farm practices on biodiversity in policy impact assessment – an application of CAPRI-Spat. OECD Workshop on Agri-Environmental Indicators, Leysin, Switzerland, 23-26 March 2010. Available at: http://www.oecd.org/dataoecd/51/58/44802327.pdf

Paracchini M.L., J.-E.Petersen, Y.Hoogeveen, C.Bamps, I.Burfield, & C.van Swaay., 2008. High Nature Value Farmland in Europe - An estimate of the distribution patterns on the basis of land cover and biodiversity data. Luxembourg: Office for Official Publications of the European Communities. EUR 23480 EN.

Pointereau P., 2005. Agroforestry and Bocage Systems, Local Knowledge and Biodiversity. *In Biodiversity and Local Ccological Knowledge in France – CIRAD/IDRI/IFB/INRA.*

Pointereau P. and Thomas F., 2006. Pratiques agricoles et plantes messicoles. Solagro – Conservatoire botanique des Pyrénées.

Pointereau P. and Coulon F., 2008. Compilation of data sets for improved agro-economic modeling of HNV farming systems- French case study. Task 2b. UASE/EEA

Pointereau, P., M. L. Paracchini, J.-M. Terres, F. Jiguet, Y. Bas, & K. Biala., 2007. Identification of High Nature Value farmland in France through statistical information and farm practice surveys. Luxembourg: Office for Official Publications of the European Communities. EUR 22786 EN. Available at: http://agrienv.jrc.ec.europa.eu/publications/pdfs/JRC_HNV_France.pdf

Recensement Agricole, 2000. Vue d'ensemble 2001. Agreste Cahiers Spécial RA 2000 n 3 / 4.

Regulation, C. No 79/65/EEC. Council of 15 June 1965 setting up a network for the collection of accountancy data on the incomes and business operation of agricultural holdings in the European Economic Community.

Reidsma P, Tekelenburg T, Van Den Berg M, Alkemade R, 2006. Impacts of land-use change on biodiversity: An assessment of agricultural biodiversity in the European Union. *Agriculture Ecosystems & Environment* **114**:86-102.

Romero A. and Chamorro L., 2003. Weed vegetation of organic and conventional dryland cereal fields in the Mediterranean region. Researching Sustainable Systems - International Scientific Conference on Organic Agriculture, Adelaide, Australia September 21-23, 2003

Rösler M., 1996. Erhaltung und Förderung von Streuobstwiesen. Bad Boll Ôkologie im Dorf.

RSPB (Royal Society for the Protection of Birds), 1995. The farmland waders of Scotland. Edinburgh.

Salonen J. and Hyvönen T., 2009. Repeated surveys in Finland follow the changes of weed flora in spring cereal fields. *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity,* Lleida 12-13 March 2009

Saska P. Martinkova Z. and Honek A., 2009. Temperature and seed predation rate in ground beetles (Carabidae). *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity*, Lleida 12-13 March 2009

Schweiger O., Maelfait J.P., van Wingerden W., Hendrickx F., Billeter R., ,Speelmans M., Augenstein I., Aukema B., Aviron S., Bailey D., Bukacek R., Burel F., Diekotter T., Dirksen J., Frenzel M., Herzog F., Liira J., Roubalova M. and R. Bugters, 2005. Quantifying the impact of envi¬ronmental factors on arthropod communities in agricultural landscapes across organizational levels and spatial scales. Journal of Applied Ecology **42**: 1129-1139.

Siriwardena, G. M., S. R. Baillie, S. T. Buckland, R. M. Fewster, J. H. Marchant, & J. D. Wilson., 1998. Trends in the abundance of farmland birds: a quantitative comparison of smoothed Common Birds Census indices. *Journal of Applied Ecology* **35**:24-43.

Smart S.M. Bunce R.G.H. and Stuart R.C., 2001. an assessment of the potential of British hedges to act as corridors and refuges for ancient woodland species. Hedgerows of the world: their ecological functions in different landscapes. *Proceedings of the 2001 annual IALE Conference*.

Shrubb, M. and Lack, P.C., 1991. The numbers and distribution of Lapwings *V. vanellus* nesting in England and Wales in 1987. Bird Study **38**:20-37.

Silva J. P., and All., 2008. Life and Europe's grasslands: restoring a forgotten habitat. European commission Life III.

Solé X., Torra J. Royo A. Pedrol J. Conesa J. and Recasens J., 2009. Additive partitioning of weed species richness and diversity in rainfed cereal systems across multiple spatial scales. *3rd Workshop of the European Weed Research society Working Group : Weeds an Biodiversity*, Lleida 12-13March 2009.

Tucker, G.M. and M.I. Evans, 1997. Habitats for Birds in Europe: a conservation strategy for the wider environment. *BirdLife Conservation Series* No. 6. BirdLife International, Cambridge, Great Britain.

Tybirk k. Aude E. Rjrnaes R. Reddersen J. Hald A.B. Riberholdt L. Jönsson C. Jorgensen J.E. Gramstrup M. Andreasen P.R; Vind L.R. Dalsgarrd A. Jensen N.V. Odderskaer P. and Sell H., 2001. Botanical conservation values in Danish hedgerows. Hedgerows of the world: their ecological functions in different landscapes. Proceedings of the 2001 annual IALE Conference.

Van Swaay C. Warren M. and Loïs G., 2006. Biotope use and trends of European butterflies. *Journal of Insect Conservation* **10**:189-209.

Veen P., Jefferson R., de Smidt J., van der Straaten J. (eds.), 2009 Grasslands in Europe of high nature value. KNNV Publishing, Zeist, NL. 319 pp.

Verschwele A. and Zwerger P., 2004. Effects of organic farming on weed abundance – long term results from a site in Northern Germany.

Wilson, S.D. and Tilman, D., 1993. Plant competition and resource availability in response to disturbance and fertilization. *Ecology* **74**:599-611.

Wolff A. and Fabre P., 2004. Transhumant sheep systems of South-eastern France. Transhumance and biodiversity in European Moutains. *Iale and Alterra*.

Appendices

Appendix I: Crop aggregation

Table 17: Crop aggregation used to calculate the crop diversity score

Aggregated type of crops listed in the FSS questionnaire*	Heading number (EU)*	Heading number French FSS	Reason for aggregating
Common and durum wheat	D 1, 2	01,02	Same plant from an ecological point of view
Maize for grain, maize for seeds and green maize	D 6, 18bi	07,30	Same plant from an ecological point of view
Other cereals than wheat, barley, oats, triticale, rye, sorghum for the production of grains : mixed cereals, buckwheat	D 8	10	Very small surfaces
Other industrial crops: tobacco, hops, cotton, linseed, other oil seed crops, flax, hemps, other textiles crops, aromatic plants, medicinal and culinary plants, others	D 23, 24, 25, 29, 30, 31, 32, 33, 34, 35	16,17,18,19,20,21,22,23	Small surfaces and rarely at the same time in the same municipality.
Other annual forages (green sorghum)	D 18biii	32	Green sorghum is different from sorghum for the production of grains
Fresh vegetables	D 16,17	45,46,47,48	Small surfaces
Floriculture (indoor and outdoor)	D 14,15	50,51	Small surfaces
Vineyard	G 4,b,c,d	53 to 59	Same plant from an ecological point of view
Fruit production (apple, pear, plum, cherry, peach, apricot trees only) Others fruit trees and nurseries (fruit and berry species of subtropical climate zones, nuts, citrus plantations, olive plantation Fallow land	G 1a G 1b,c 2, 3, 5, 6 D 21,22	61 to 66 67 to 77 79 and 80	Same plant from an ecological point of view Small surfaces and rarely at the same time in the same municipality. Administrative difference (fallow land with or without subsidies)

** : Commission Regulation (EC) No 143/2002 concerning the organization of the Community surveys on the structure of agricultural holdings*

Appendix II: Disaggregation of hedgerows

These two figures show the degree of similarity between the disaggregation procedure applied in this study (Figure 27) where the disaggregation of the departmental hedgerow length is based on the grassland surface, and the new methodology of IFN (see Figure 28). Even if the units are not the same, the two figures identify the same hot spots of hedge density.

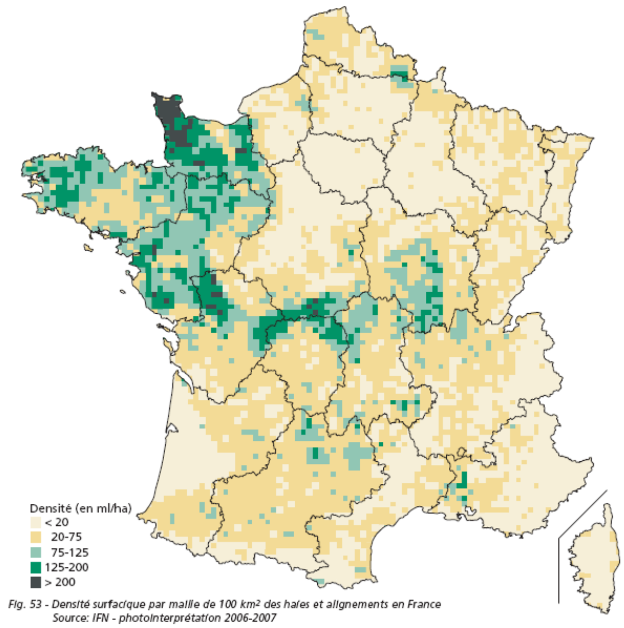


Figure 27: Density of hedgerows and trees lines (Source IFN 2005-2006)

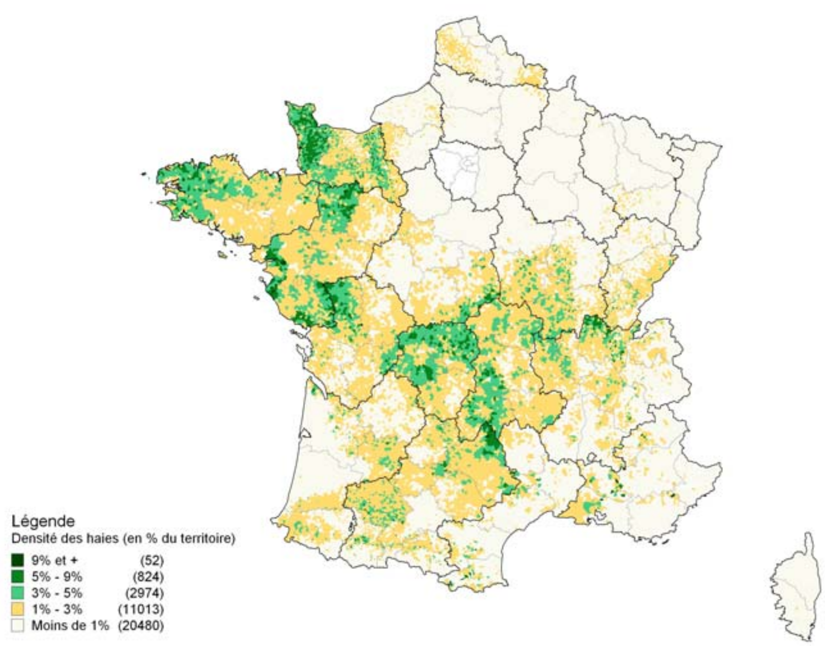


Figure 28: Density of hedgerows (Source : Solagro-JRC).

Appendix III: The case of traditional orchards

Scoring of traditional orchards

Traditional orchards are typical of specific French regions: apple trees in *Normandy* and *Pyrénées*, pear trees in *Savoie*, chestnuts in Mediterranean mountains, plum trees in *Lorraine*. Even if their local density is low, traditional orchards are productive agricultural areas able to maintain a high level of biodiversity.

On the average, the areas with more than 3% of traditional orchards in the UAA are very limited, but host a very high level of biodiversity. For this reason they are given a high HNV score.

The problem arises for areas where traditional orchards cover less than 3% of the UAA (set as maximum threshold) and where hedgerows are not traditional landscape elements (Mediterranean areas: *Cévennes* and *Corse*, part of *Lorraine* and *Alsace* etc.) and therefore do not concur in adding points to the final HNV score, which is low if compared to the level of biodiversity maintained by traditional orchards.

So, we propose to apply specific thresholds for traditional orchards (see Table 18) (the scoring of traditional orchards has been corrected in comparison to the 2006 methodology in order to take into account the new weighting of the "landscape elements" indicator).

Table 18: Calculation of the score for traditional orchards (TO score)

% of traditional orchards in the UAA	Score (in % of the weighting)	Score with the 2006 method	Score with the 2009 method
Less than 0.5%	0%	0 pt	0 pt
0.5% to 1.5 %	10%	0.5 pt	1 pt
1.5% to 2.5%	20%	1.0 pt	2 pts
2.5% to 3.5%	30%	1.5 pt	3 pts
More than 3.5%	40%	2.0 pts	4 pts

In a consistent number of municipalities the density of traditional orchards is below 0.5%, and according to Table 18 they would get 0 points. Nevertheless their contribution to biodiversity maintenance should not be neglected, so we propose treating them as Trees out of Forest (TOF – Table 6), and, in order to avoid double counting, compare their TOF score to the traditional orchards score (TOscor), and retain the maximum value between the two (see ScoreTOF below).

The equation can be written as follows:

$$\text{ScoreTOF(i)} = \text{Max}\left\{0; \text{TOScor}; 10 * \text{Min}\left[1; \left(\frac{\frac{\text{TofA(i)}}{\text{UAA(i)}} - 4\%}{(14\% - 4\%)}\right)\right]\right\}$$

Where:
ScoreTOF(i) : score of trees outside forest of the municipality i (km)
TOScor(i) : score for traditional orchards of the municipality i
TofA(i) : Trees outside forest Area of the municipality i (ha)

Appendix IV: Comparison of the results with the JRC/EEA methodology

Table 19 and Table 20 present the difference in the estimate of HNV farmland between the JRC/EEA approach (Paracchini et al., 2008) and the current study. Such comparison is not straightforward, due to the fact that the study on France has a precise focus on the UAA and includes an estimate of the distribution of common lands, while the EU study is based on CORINE land cover data, which shows a consistent overestimation of agricultural land in comparison to the UAA, for obvious reasons linked to the mapping methodology and scale. The comparison of the results in percentage terms, though, shows a correlation in estimates at NUTS2 level, that increases from 0.54 to 0.77 if one outlier (Languedoc-Roussillon) is excluded. Such result suggests that (in the French case) there is convergence between the two methods; furthermore it also suggests that the JRC/EEA results provide information for a relative assessment of the share of HNV farmland at regional level (last column in the table in Appendix X in Paracchini et al., 2008), but absolute estimates (nr. of ha, fourth column in the table in Appendix X in Paracchini et al., 2008) must be used with the full awareness of the above-mentioned limitations.

Table 19: HNV statistics per region with the farming system approach (threshold 25%)

NAME_REGION	Common lands area in 2000 (in ha)	UAA 2000	HNV in UAA	ComonLands in HNV	Total HNV	HNV% (UAA + common lands)
ILE-DE-FRANCE	2 551	583 246	2 646	150	2 796	0,5%
CHAMPAGNE-ARDENNE	18 043	1 560 325	110 362	656	111 017	7,0%
PICARDIE	11 228	1 341 461	33 515	990	34 505	2,6%
HAUTE-NORMANDIE	26 927	794 026	43 529	5 328	48 857	6,0%
CENTRE	50 320	2 365 694	247 443	14 404	261 847	10,8%
BASSE-NORMANDIE	104 984	1 264 133	284 694	10 138	294 832	21,5%
BOURGOGNE	81 984	1 775 182	647 559	22 741	670 300	36,1%
NORD-PAS-DE-CALAIS	15 093	838 166	21 887	1 130	23 017	2,7%
LORRAINE	21 378	1 132 531	111 511	3 667	115 177	10,0%
ALSACE	2 020	336 229	56 885	836	57 721	17,1%
FRANCHE-COMTE	71 789	667 674	274 249	41 895	316 143	42,8%
PAYS-DE-LA-LOIRE	146 043	2 169 981	275 474	30 895	306 369	13,2%
BRETAGNE	88 340	1 701 566	146 399	11 213	157 612	8,8%
POITOU-CHARENTE	21 815	1 761 867	205 232	2 108	207 340	11,6%
AQUITAINE	139 129	1 473 396	441 915	92 853	534 768	33,2%
MIDI-PYRENEES	229 802	2 361 914	762 577	174 748	937 325	36,2%
LIMOUSIN	21 176	861 021	732 077	18 831	750 908	85,1%
RHONE-ALPES	140 849	1 526 724	800 723	117 991	918 714	55,1%
AUVERGNE	31 871	1 510 577	748 369	23 315	771 684	50,0%
LANGUEDOC-ROUSSILLON	102 404	981 459	456 399	81 791	538 190	49,7%
PROVENCE-ALPES-COTE-D'AZUR	363 515	693 252	428 633	293 113	721 746	68,3%
CORSE	152 017	155 888	135 669	130 973	266 642	86,6%
	1 843 278	**27 856 313**	**6 967 745**	**1 079 765**	**8 047 510**	**27,1%**

Table 20: HNV statistics per region with EEA/JRC approach

NAME_REGION	HNV farmland. EEA/JRC	UAA (CLC)	HNV% (UAA)	Difference between the 2 methods	Difference in %
ILE-DE-FRANCE	3 682	665 172	0,6%	-886	-32%
CHAMPAGNE-ARDENNE	221 286	1 765 960	12,5%	-110 269	-99%
PICARDIE	32 068	1 495 380	2,1%	2 437	7%
HAUTE-NORMANDIE	18 711	917 207	2,0%	30 146	62%
CENTRE	142 594	2 904 770	4,9%	119 253	46%
BASSE-NORMANDIE	109 705	1 551 940	7,1%	185 127	63%
BOURGOGNE	207 131	2 084 130	9,9%	463 169	69%
NORD-PAS-DE-CALAIS	22 475	983 301	2,3%	542	2%
LORRAINE	137 238	1 331 670	10,3%	-22 061	-19%
ALSACE	52 025	410 106	12,7%	5 696	10%
FRANCHE-COMTE	318 756	823 687	38,7%	-2 613	-1%
PAYS-DE-LA-LOIRE	226 572	2 753 690	8,2%	79 797	26%
BRETAGNE	88 212	2 248 250	3,9%	69 400	44%
POITOU-CHARENTE	153 094	2 087 360	7,3%	54 246	26%
AQUITAINE	336 458	2 076 750	16,2%	198 310	37%
MIDI-PYRENEES	1 153 950	3 022 540	38,2%	-216 625	-23%
LIMOUSIN	436 078	1 050 090	41,5%	314 830	42%
RHONE-ALPES	1 215 200	2 165 080	56,1%	-296 486	-32%
AUVERGNE	996 491	1 759 920	56,6%	-224 807	-29%
LANGUEDOC-ROUSSILLON	747 924	1 468 600	50,9%	-209 734	-39%
PROVENCE-ALPES-COTE-D'AZUR	806 850	1 306 110	61,8%	-85 104	-12%
CORSE	370 645	440 147	84,2%	-104 003	-39%
	7 797 145	**35 311 860**	**22,1%**	**250 365**	**3%**

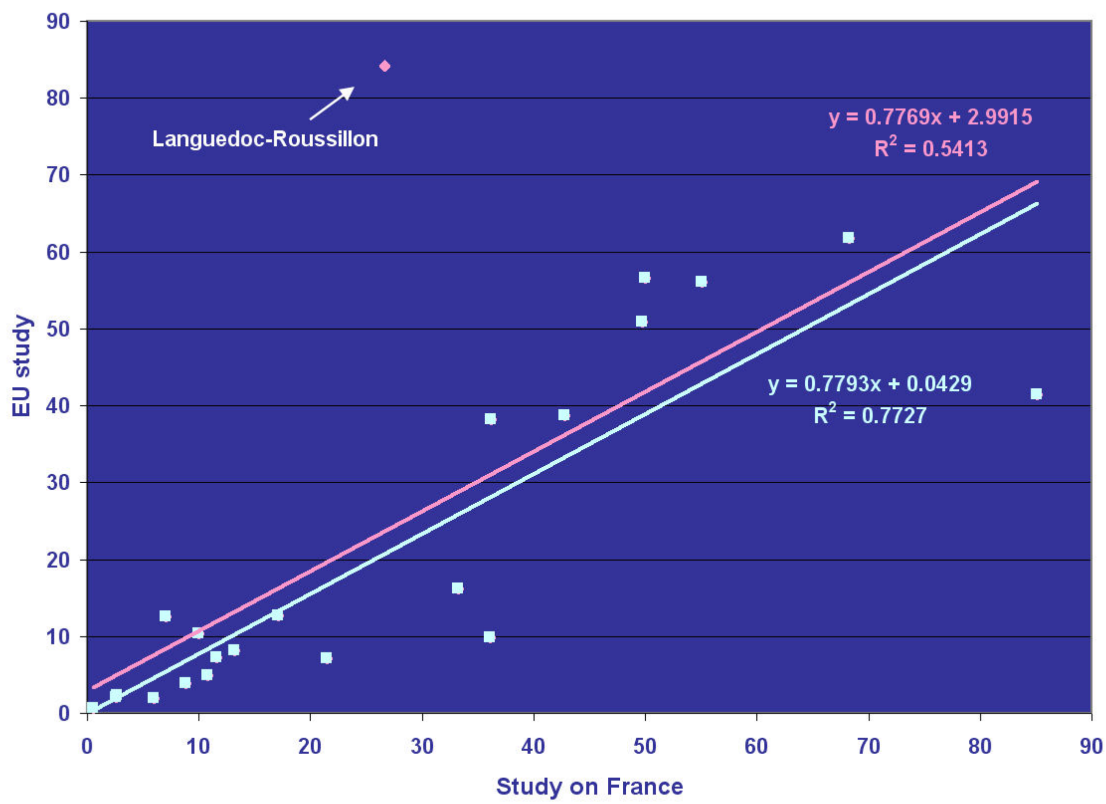


Figure 29: Fit between HNV estimates at NUTS2 level provided by the present study and the JRC/EEA EU study (Paracchini et al., 2008)

Appendix V: Stocking density vs mineral fertilisation

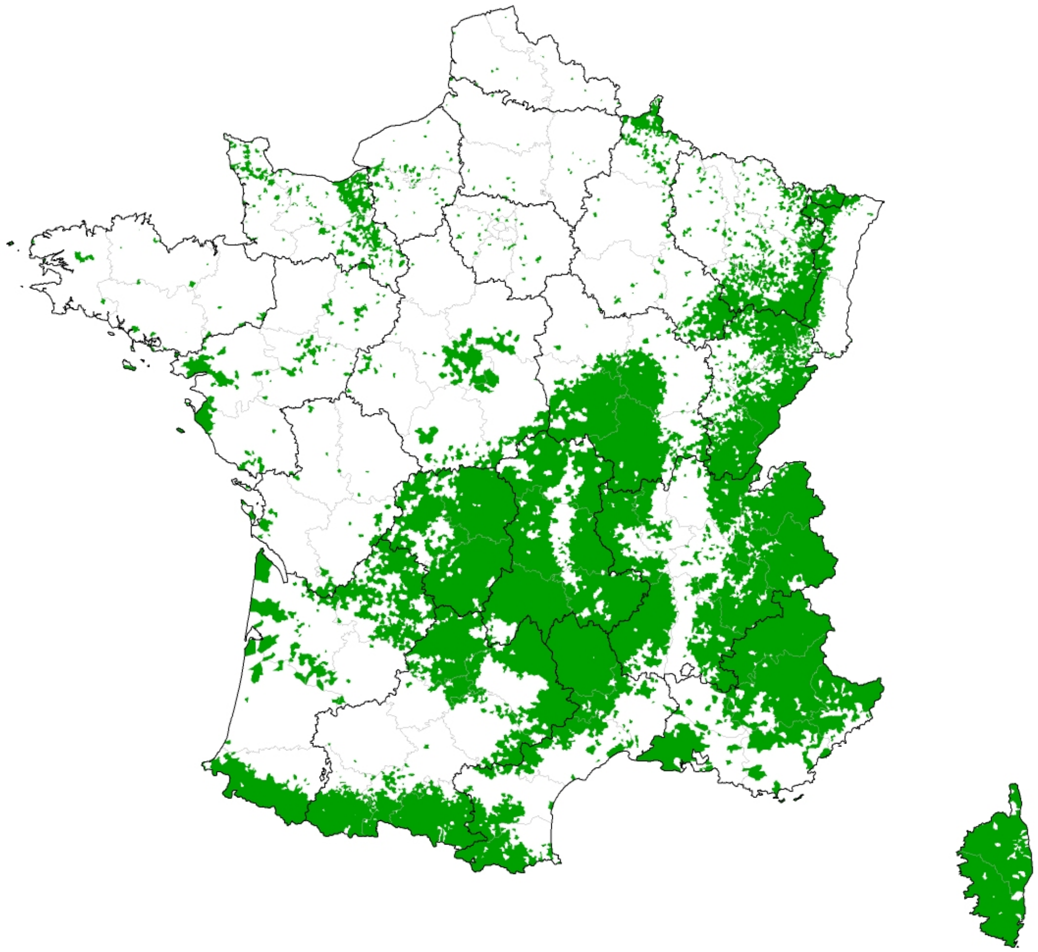


Figure 30: HNV farmland areas (threshold 25%) identified using the indicator of stocking density instead of N mineral fertilization of the permanent grasslands

Appendix VI: HNV and Natura 2000

As we can see in Figure 31, the share of Natura 2000 area is substantially low in farmland areas with a low HNV score, it is maintained low for median scores and it substantially increases for very high scores. As one of the main concerns of our analysis is fixing a threshold for the French HNV indicator, we also considered this distribution of the share of Natura 2000 sites to identify a potential limit, above which the percentage of Natura 2000 gets higher. We did our analysis in two steps: first we tested the fit of three types of models to our data i.e. linear, quadratic and exponential models. For this first step we used all HNV scores (1 to 30, see Figure 31). Secondly, we repeated the same analysis considering only parts of the distribution that correspond to potential thresholds (25%, 30%, 35% of the UAA). To choose between models, we used the Solver optimisation function, according to which the model that fits best the data is the less parameterised model that minimises the error between the predicted and the observed distribution.

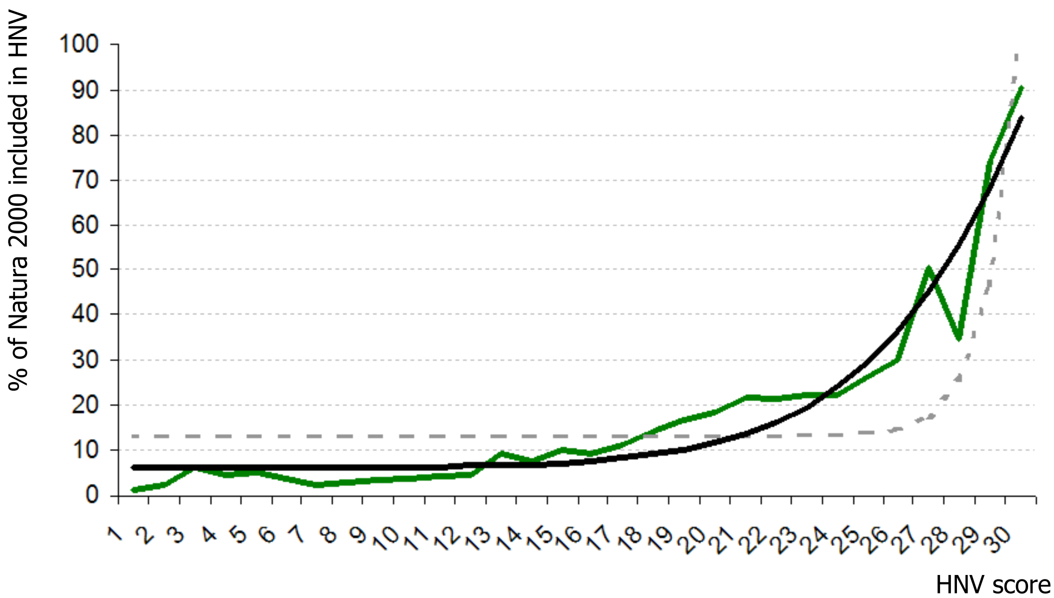


Figure 31: The distribution of the percentage of Natura 2000 (in green line) according to the HNV score. The quadratic model is presented in black line and the exponential model in grey dashed line.

As expected, the linear model did not fit well the data (and thus it is not presented at the Figure 31), as we see clearly that there is a range of low to median HNV scores for which the percentage of Natura 2000 seems more or less stable and this percentage is getting higher for increasing HNV scores. The quadratic model fits best the data (presented in solid black line). We observe that the curve is flat for low to median HNV scores and its curvature increases after a certain level. We wanted thus to identify this kind of 'inflection point'.

The threshold of 25% of the UAA corresponds to a HNV value equal to 14.8. For 30% and 35% of the UAA, the corresponding HNV values are 13.5 and 12.5 respectively. So we repeated the same analysis for the four subsets of HNV scores i.e. [1-15], [1-14], [1-13] and [1-12]. For a value of 15, we observed that the best model was still a quadratic one, indicating that the flat section of the curve ends before this value (Figure 32a). We subsequently tested for lower values. For a value of 12, we finally obtained a better fit to the data from the linear model (Figure 32b).

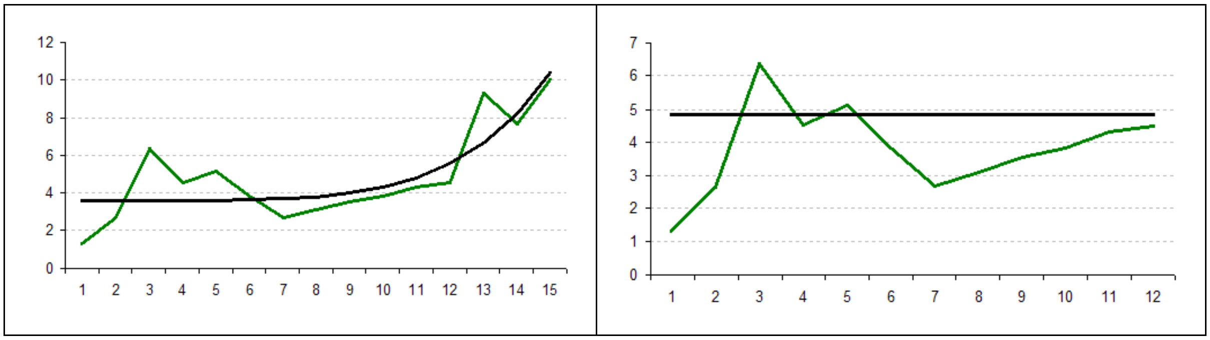


Figure 32: The distribution of the percentage of Natura 2000 (in green line) according to the HNV score. a. The quadratic model fitted best the data (in black line), b. The linear model fitted best the data (in black line).

These results indicate that for a HNV value higher or equal to 13, we are placed in the part of the curve where with increasing HNV values, we get increasing part of Natura 2000 included in HNV. A threshold higher than 13 of the HNV score corresponds to a HNV share between 25% and 30% of the UAA. These two thresholds can be thus considered reasonable according to this criterion.

Appendix VII: FADN results in detail

Table 19: Comparison of the economical results of HNV farms and non-HNV farms in 2004 – Version 2006 Of the HNV (Source: RICA/FADN 2004)(source : RICA/FADN)

	HNV Farms	non HNV Farms	Difference in %
Number of sample farms	1 555	5 777	
Number of farms	94 400	288 600	
UAA (in ha)	68	69	-2%
Livestock in LU	69	60	14%
Number of Family Working Unit	1,62	1,94	-19%
Subsidies in €	25761	24701	4%
Family income in €	25	34	-36%
Farm income per FWU in €	16	18	-13%
Fertlilisers in €/ha	59	112	-89%
Crop protection in €/ha	23	110	-381%
Animal feed in €/ha	165	285	-72%
Total input per ha in €	247	506	-105%

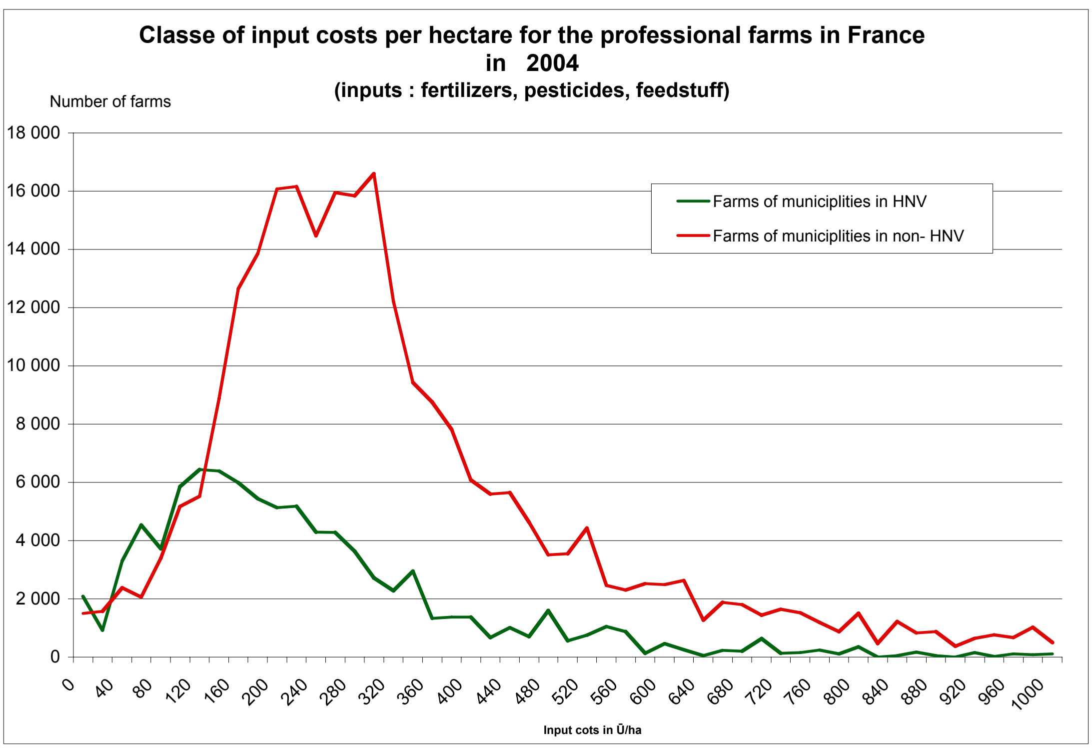


Figure 33: Distribution of the input costs (fertilizers, pesticides, feedstuff) per hectare for all professional farms located in HNV areas (source : RICA/FADN - 2004)

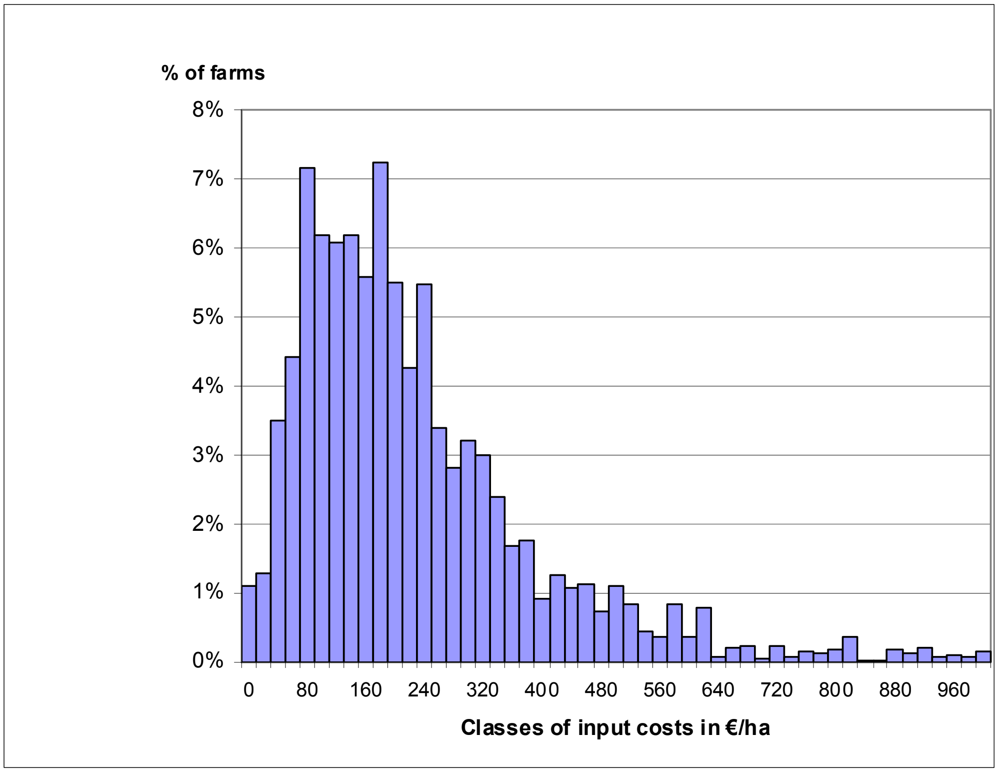


Figure 34: Distribution of the input costs (fertilizers, pesticides, feedstuff) per hectare for all professional farms located in HNV areas (source : RICA/FADN - 2006)

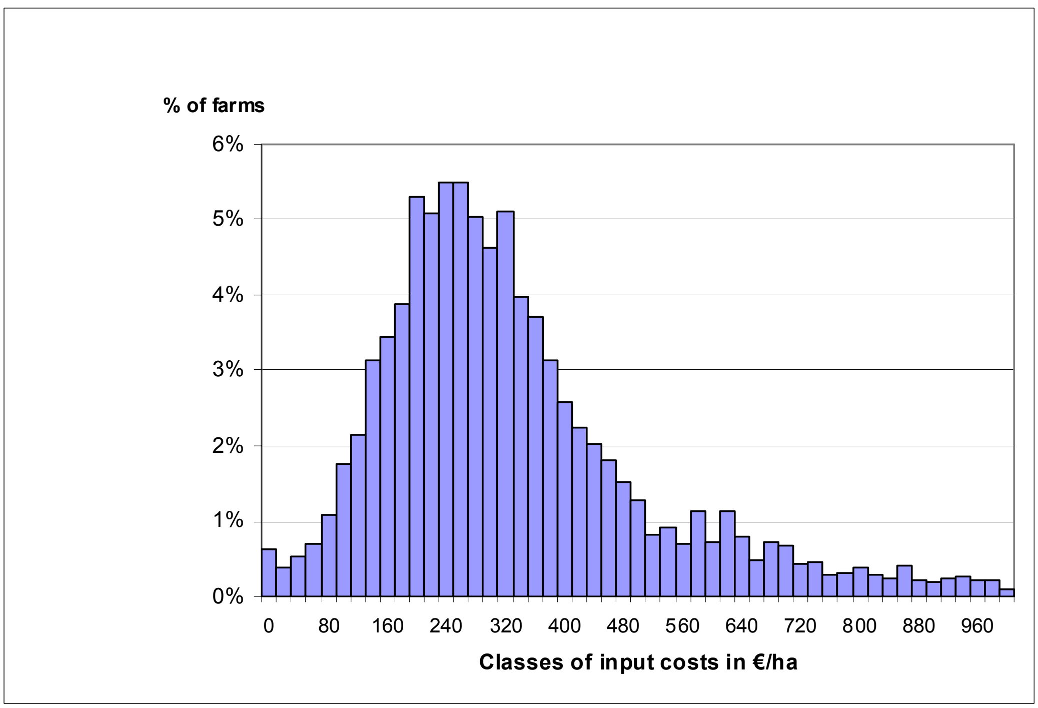


Figure 35: Distribution of the input costs (fertilizers, pesticides, feedstuff) per hectare for all professional farms located outside the HNV areas (source : RICA/FADN - 2006)

Appendix VIII: List of farmland bird species

Table 20: Farmland bird species considered in the analyses, their proportion of national population included in HNV farmland (threshold 25%) and their European conservation status. Species with an asterisk are those used at the species-specific responses analysis. Underlined species are those contributing to the specialist species richness index. Species noted in bold are those contributing to the EU Farmland Bird Indicator.

Species	HNV ratio	European Conservation Status	European Bird Directive Status
Sylvia conspicillata	89%	Non-SPEC	
*Emberiza cia**	87%	SPEC 3	
Nycticorax nycticorax	86%	SPEC 3	Annex I
Larus melanocephalus	86%	Non-SPEC	Annex I
Anthus spinoletta	86%	Non-SPEC	
Podiceps cristatus	80%	Non-SPEC	
Acrocephalus arundinaceus	77%	Non-SPEC	
*Certhia familiaris**	52%	Non-SPEC	
Nucifraga caryocatactes	50%	Non-SPEC	
*Emberiza hortulana**	48%	SPEC 2	Annex I
Luscinia svecica	46%	Non-SPEC	Annex I
Emberiza schoeniclus	45%	Non-SPEC	
Larus ridibundus	44%	Non-SPEC	
Fulica atra	43%	Non-SPEC	
Riparia riparia	42%	SPEC 3	
Sterna hirundo	41%	Non-SPEC	Annex I
*Periparus ater**	40%	Non-SPEC	
Carduelis spinus	40%	Non-SPEC	
Lanius senator	39%	SPEC 2	
Charadrius dubius	39%	Non-SPEC	
Bubulcus ibis	39%	Non-SPEC	
*Poecile montanus**	38%	Non-SPEC	
Ficedula hypoleuca	38%	Non-SPEC	
*Galerida cristata**	37%	SPEC 3	
*Cisticola juncidis**	37%	Non-SPEC	
*Cettia cetti**	37%	Non-SPEC	
*Turdus pilaris**	35%	Non-SPEC	
Gallinula chloropus	35%	Non-SPEC	
*Corvus monedula**	35%	Non-SPEC	
Acrocephalus scirpaceus	35%	Non-SPEC	
Himantopus himantopus	34%	Non-SPEC	Annex I
Lanius collurio*	33%	SPEC 3	Annex I
*Sylvia curruca**	32%	Non-SPEC	
*Poecile palustris**	32%	SPEC 3	
*Phylloscopus bonelli**	32%	SPEC 2	
Alcedo atthis	32%	SPEC 3	Annex I
Actitis hypoleucos	32%	SPEC 3	
Corvus frugilegus*	31%	Non-SPEC	
Anas platyrhynchos	31%	Non-SPEC	
*Hippolais polyglotta**	30%	Non-SPEC	
*Fringilla coelebs**	30%	Non-SPEC	
Emberiza citrinella*	30%	Non-SPEC	

*Dendrocopos minor**	30%	Non-SPEC	
*Cyanistes caeruleus**	30%	Non-SPEC	
*Anthus trivialis**	30%	Non-SPEC	
<u>*Vanellus vanellus**</u>	29%	SPEC 2	
*Turdus philomelos**	29%	Non-SPEC	
*Streptopelia turtur**	29%	SPEC 3	
*Sitta europaea**	29%	Non-SPEC	
<u>***Saxicola torquatus****</u>	29%	Non-SPEC	
*Prunella modularis**	29%	Non-SPEC	
Egretta garzetta	29%	Non-SPEC	Annex I
<u>*Circus pygargus**</u>	29%	Non-SPEC	Annex I
*Certhia brachydactyla**	29%	Non-SPEC	
<u>***Buteo buteo****</u>	29%	Non-SPEC	
Ardea cinerea	29%	Non-SPEC	
*Apus apus**	29%	Non-SPEC	
*Aegithalos caudatus**	29%	Non-SPEC	
Upupa epops*	28%	SPEC 3	
Turdus torquatus	28%	Non-SPEC	
*Turdus merula**	28%	Non-SPEC	
*Sylvia cantillans**	28%	Non-SPEC	
*Sylvia borin**	28%	Non-SPEC	
<u>***Saxicola rubetra****</u>	28%	Non-SPEC	
*Phylloscopus collybita**	28%	Non-SPEC	
Motacilla flava*	28%	Non-SPEC	
Larus argentatus	28%	Non-SPEC	
*Hirundo rustica**	28%	SPEC 3	
*Garrulus glandarius**	28%	Non-SPEC	
<u>***Falco tinnunculus****</u>	28%	SPEC 3	
*Erithacus rubecula**	28%	Non-SPEC	
*Delichon urbicum**	28%	SPEC 3	
<u>***Coturnix coturnix****</u>	28%	SPEC 3	
*Troglodytes troglodytes**	27%	Non-SPEC	
*Sylvia atricapilla**	27%	Non-SPEC	
*Regulus ignicapilla**	27%	Non-SPEC	
*Picus viridis**	27%	SPEC 2	
*Pica pica**	27%	Non-SPEC	
*Phylloscopus sibilatrix**	27%	SPEC 2	
*Parus major**	27%	Non-SPEC	
*Muscicapa striata**	27%	SPEC 3	
*Dendrocopos major**	27%	Non-SPEC	
<u>***Alectoris rufa****</u>	27%	SPEC 2	
*Accipiter nisus**	27%	Non-SPEC	
*Turdus viscivorus**	26%	Non-SPEC	
<u>***Sylvia communis****</u>	26%	Non-SPEC	
*Pyrrhula pyrrhula**	26%	Non-SPEC	
*Pyrrhocorax pyrrhocorax**	26%	SPEC 3	Annex I
*Phoenicurus ochruros**	26%	Non-SPEC	
*Motacilla alba**	26%	Non-SPEC	
<u>*Milvus migrans**</u>	26%	SPEC 3	Annex I
*Luscinia megarhynchos**	26%	Non-SPEC	
<u>*Larus fuscus*</u>	26%	Non-SPEC	
<u>***Emberiza calandra****</u>	26%	SPEC 2	
*Cuculus canorus**	26%	Non-SPEC	
*Columba palumbus**	26%	Non-SPEC	
*Carduelis chloris**	26%	Non-SPEC	

*Carduelis carduelis**	26%	Non-SPEC	
Carduelis cannabina*	26%	SPEC 2	
Alauda arvensis*	26%	SPEC 3	
*Sturnus vulgaris**	25%	SPEC 3	
*Streptopelia decaocto**	25%	Non-SPEC	
Recurvirostra avosetta	25%	Non-SPEC	Annex I
Phasianus colchicus*	25%	Non-SPEC	
*Passer domesticus**	25%	SPEC 3	
*Oriolus oriolus**	25%	Non-SPEC	
Motacilla cinerea	25%	Non-SPEC	
*Merops apiaster**	25%	SPEC 3	
Lullula arborea*	25%	SPEC 2	Annex I
Emberiza cirlus*	25%	Non-SPEC	
*Corvus corone**	25%	Non-SPEC	
*Corvus corax**	25%	Non-SPEC	
*Burhinus oedicnemus**	25%	SPEC 3	Annex I
Acrocephalus schoenobaenus	25%	Non-SPEC	
*Regulus regulus**	24%	Non-SPEC	
Perdix perdix*	24%	SPEC 3	
*Lophophanes cristatus**	24%	SPEC 2	
*Dryocopus martius**	24%	Non-SPEC	Annex I
*Coccothraustes coccothraustes**	24%	Non-SPEC	
*Circus cyaneus**	24%	SPEC 3	Annex I
Anthus pratensis*	24%	Non-SPEC	
Anthus campestris	24%	SPEC 3	Annex I
*Circus aeruginosus**	23%	Non-SPEC	Annex I
Tachybaptus ruficollis	22%	Non-SPEC	
*Sylvia undata**	22%	SPEC 2	Annex I
*Serinus serinus**	22%	Non-SPEC	
*Phylloscopus trochilus**	22%	Non-SPEC	
*Phoenicurus phoenicurus**	22%	SPEC 2	
*Locustella naevia**	22%	Non-SPEC	
Athene noctua	22%	SPEC 3	
Strix aluco	21%	Non-SPEC	
*Columba livia**	21%	Non-SPEC	
*Oenanthe oenanthe**	20%	SPEC 3	
*Jynx torquilla**	19%	SPEC 3	
Dendrocopos medius	19%	Non-SPEC	Annex I
*Passer montanus**	18%	SPEC 3	
*Columba oenas**	18%	Non-SPEC	
Cygnus olor	17%	Non-SPEC	
Serinus citrinella	15%	Non-SPEC	
*Sylvia melanocephala**	12%	Non-SPEC	
Petronia petronia	5%	Non-SPEC	
Sylvia hortensis	4%	SPEC 3	
Loxia curvirostra	4%	Non-SPEC	
Ciconia ciconia	4%	SPEC 2	Annex I

SPEC categories: SPEC 1 – Species of global conservation concern, ie. classified as globally threatened, Near Threatened or Data Deficient (Birdlife International 2004, IUCN 2004); SPEC 2 – Concentrated in Europe and with an Unfavourable Conservation Status; SPEC 3 – Not concentrated in Europe but with an Unfavourable Conservation Status; Non-SPEC – with a Favourable Conservation Status.

Appendix IX: Test on the relation between weeds and HNV farmland

The relation between weed indicators (species richness – Figure 36 and Shannon index – Figure 37) and NHV scoring has been tested with Sup-Agro/INRA (Guillaume Fried) using a weed survey realized in Burgundy in 2005 and 2006.

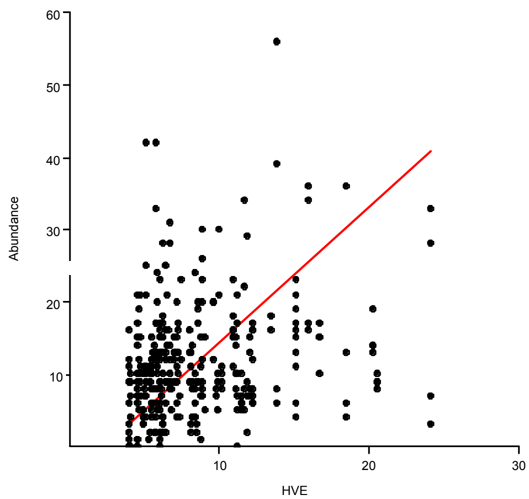


Figure 36: Correlation between the sum of the species abundances per parcels and the HNV score N=316 parcels (2005 and 2006). Linear model. results : r = 0.22, p< 0.001

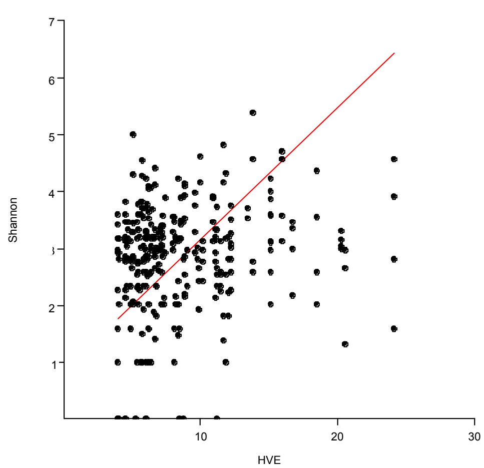


Figure 37: Correlation between the Shannon index (calculated on plant density and number of species) and the HNV scores
N=316 parcels (2005 and 2006) . Linear model. Results : r = 0.18, p= 0.0015

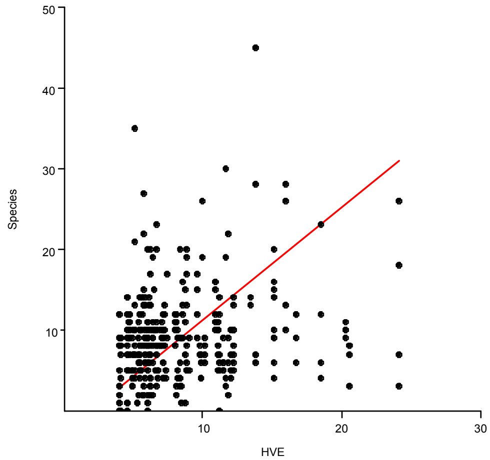


Figure 38: Correlation between the specie richness and the HNV scores
N=316 parcels (2005 and 2006). Linear model. Results : r = 0.20, p<0.001

The relation between weeds and HNV farmland areas could be improved by using only rare arable plants as indicators and by weighting the plants based on their status. The French national action plan on rare arable plants will provide a national survey. The weed survey "Biovigilance Flore" could also provide data at the national scale. This survey has been set up in France in 2002 and is carryed out across a large number of fields selected to represent the diversity of cultural practices and environmental conditions present in arable fields in France.

European Commission

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Abstract

The 'High Nature Value farming' idea connects the preservation of biodiversity with the need to safeguard the continuation of farming in certain areas and the maintenance of specific farming systems associated with a long-term management approach. The need for measures to prevent the loss of High Nature Value farmland is widely acknowledged. Conservation of biodiversity on agricultural land is an explicit objective of the pan-European Biodiversity and Landscape Strategy, the Bern Convention and, at EU level, the Habitats and Birds Directives and the Rural Development Policy (Community Strategic Guidelines for Rural Development Programming Period 2007-2013). Conserving High Nature Value farmland is a key aspect in achieving future biodiversity targets. In their 2003 'Kyiv' declaration, the European Environment Ministers have set the goal to identify HNV farmland in Europe and take adequate conservation measures. The COM(2010) 4 final "Options for an EU vision and target for biodiversity beyond 2010" recognises the need of preserving and enhancing farming and forestry with a high nature value in the context of the CAP. Furthermore, in 2006 the frame of agri-environmental indicators for monitoring the integration of environmental concerns into the common agricultural policy has been formally identified and published in the COM (2006) 508. The High Nature Value farmland indicator is part of the framework, as well as indicators on Population trends in farmland birds. JRC/IES is one of the EC services that are developing such indicators.

The aim of this study is to improve the methodology to define HNV farmland areas and investigate more thoroughly the link between bird species and farmland habitat. The French case study is presented in high detail; relevant statistical data were available regarding agriculture practices both at present and past time periods, which provided the information for the development of a national HNV indicator. Data from the French Breeding Bird Census have been used to seek for links between bird species and bird indices, and spatial and temporal distribution of HNV farmland.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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