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Biodiversity of European agricultural landscapes

Enhancing a high nature value farmland indicator

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werkdocumenten

WOt Wettelijke Onderzoekstaken Natuur & Milieu

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Biodiversity of European agricultural landscapes

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This document was produced in accordance with the Quality Manual of the Statutory Research Tasks Unit for Nature & the Environment (WOT Natuur & Milieu) and has been accepted by Harm Houweling programme coordinator of WOT Natuur & Milieu.

WOt Working Document **195** presents the findings of a research project commissioned by the Netherlands Environmental Assessment Agency (PBL) and funded by the Dutch Ministry of Agriculture, Nature and Food Quality (LNV). This document contributes to the body of knowledge which will be incorporated in more policy-oriented publications such as the Nature Balance and Environmental Balance reports, and Thematic Assessments.

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Wageningen, juli 2010

Abstract
Wascher, D.M., M. van Eupen, C.A. Mücher & I.R. Geijzendorffer, 2010. *Biodiversity of European agricultural landscapes; Enhancing a high nature value farmland indicator.* Wageningen, Statutory Research Tasks Unit for Nature & the Environment, WOt working document 195. 88 p.; 26 Figs.; 1 Tab.; 33 Refs.; 6 Annexes.

Depending on the amount of semi-natural vegetation, land use intensity, the presence of small landscape elements and of specific species, the biodiversity values of agricultural land can differ substantially across Europe. From the policy perspective, high nature value agricultural landscapes are of large interest in the framework of agri-environmental measures and rural development objectives. This project aims at developing a new indicator for high nature value farming, in other words indicating areas where European agricultural landscapes have a high biodiversity value, integrating state-of-the-art European data sets. European data sets that have been analysed are e.g. CORINE Land Cover, LUCAS Landscape Elements, UTM Farmland Bird statistics, and FADN land use statistics (e.g. intensity expressed in kg N/ha). The developed methodology aimed to identify different levels of biodiversity values for all agricultural landscapes. The European Landscape Classification LANMAP, provided the landscape units at which the different data sources were integrated and analysed. Identification of the extent as well as the quality of high nature value farming areas is of equal importance. The intention is to contribute to the further development of European assessments and monitoring programmes currently ongoing at the EC and EEA.

Keywords: biodiversity, landscape structure, land use change, land use intensity, high nature farmland, farmland birds, indicators, agri-environmental policy

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Preface

The principle motivation for WOT 5.2[1] has been to make use of LANMAP landscape units and associated key attributes (Mücher *et al.,* 2006; Mücher *et al.,* 2010) for building geographic references when assessing agro-biodiversity as part of Eururalis 3.0 (Eickhout and Prins, 2008). The use of landscape units as a geo-spatial aggregation level is being considered as an alternative to the abstractness of both administrative units – e.g. the European NUTS regions – and the grid-cell character of most state-of-the-art land use data sets. When doing so it soon became evident that this research is of great relevance for the development of high nature value farming indicators. We hence decided to build our methodological developments closely upon the current approaches of JRC (European Commission Joint Research Centre) and EEA (European Environmental Agency) thereby offering support to already existing initiatives.

We would like to thank various species experts for their advices in screening the methodological options for selecting adequate fauna and flora indicators, especially Henk Sierdsema from the EBCC Spatial Modelling Group on advising us on the use of farmland bird data; and Stephan Hennekens (Alterra) for helping us to better understand the potential use of the SynBioSys database for Europe's vegetation.

We also would like to thank Arnaud Temme for developing a common conceptual approach and offering methodological support through his Clue-S-based land use intensity assessment.

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Ilse Geijzendorffer

[1] WOT 5.2 is project Estimating biodiversity in Europe

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Summary

For the WOT project ‘Estimating Biodiversity in Europe’ (WOT-04-002-170 / 2009-5.2) the aim is to explore the possibility of quantifying an agro-biodiversity indicator for the whole of Europe at the level of landscape units. Areas where farming practices are associated with high biodiversity are commonly referred to as high nature value (HNV) farmland. The conservation of these often extensively farmed ecosystems is an explicit objective of EU's environment and rural development policies. Unfortunately, spatially explicit information of these farmlands with a high biodiversity value, are hard to find for Europe as a whole, and therefore indicators are needed to identify these areas. This WOT project hence considered to contribute to the wider objectives of the recent CAP reform towards new rural developments and its sustainable use. After an extensive period of data reviewing and communications with the scientific and user community, a series of four essential spatial layers – building upon the HNV methodology - has been produced and reviewed**:**

- A map showing those LANMAP units where semi-natural land use types are of relatively high importance;
- A map showing farmland with a mosaic of low intensity agriculture and structural elements; based on two maps:
    - o Presence of small landscape elements as indication for lower agricultural intensity high biodiversity at the level of LANMAP landscape units;
    - o The first results of WOT 4.4[2] on land use intensity;
- A map for farmland birds[3] on the basis of earlier projects (ENRISK, JRC/EEA EU HNV indicator etc) at the level of LANMAP landscape units;
- A synoptic map integrating the three previous maps.

All individual layers are of utmost importance in understanding why specific areas are highlighted as important for high nature value farming. The results showed substantial differences with the existing JRC/EEA HNV farmland map by bringing forward well-known high-biodiversity/landscape structural diversity areas in NW-France, Spain and other areas. At the same time, the data sources, on which the data layers have been built, have serious limitations that had their impact on the results. Therefore all results should be critically reviewed with the likely goal to further improve their methodological basis.

Extensive testing of the LUCAS data demonstrated that counting crossings in transects is not the proper manner to estimate the amount of linear landscape features at a regional scale. This means, alternative methodologies need to be used. We hence suggest to further develop the existing approaches that derive landscape structure from existing satellite imagery and to further explore the results of WOT 4.4[2]. Both sources of information are likely to generate more accurate results. Another area of improvement is further collaboration with species experts to make more targeted and differentiated use of the farmland bird data base, but is only valuable if the spatial resolution of the species data is improved.

[2] WOT 4.4 is project ‘Modelling of intensive and extensive farming in CLUE’ (Temme en Verburg, 2010)

[3] Final species group and database to be fine-tuned together with PBL

Samenvatting

Voor het WOT project 'Estimating Biodiversity in Europe' (WOT-04-002-170 / 2009-5.2) was het de bedoeling te onderzoeken of het mogelijk is om op het niveau van landschapseenheden een agro-biodiversiteits-indicator voor heel Europa te genereren. Gebieden waar landbouw wordt geassocieerd met een hoge biodiversiteit worden gewoonlijk aangeduid als 'landbouwgrond met een hoge natuurwaarde (HNV)'. Het behoud van deze antropogeen beïnvloede, vaak extensieve, ecosystemen is een expliciete doelstelling van het milieubeleid van de Europese Unie en het beleid voor plattelandsontwikkeling. Dit project tracht bij te dragen aan de bredere doelstellingen van de recente hervorming van het EU-CAP beleid in het kader van nieuwe ontwikkelingen op het gebied van duurzaam landgebruik. Voor Europa als geheel is ruimtelijk expliciete informatie van deze HNV-landbouwgronden helaas moeilijk te vinden, en daarom zijn indicatoren nodig om deze gebieden beter te identificeren. Een uitgebreide periode van inwinning en herziening van de ruimtelijke gegevens, en de daaruit af te leiden indicatoren, heeft geresulteerd in een serie van vier essentiële kaartlagen die voortbouwen op de HNV-methodologie. Deze kaartlagen zijn uitgebreid besproken met het Planbureau voor de Leefomgeving (PBL):

- Een kaart met LANMAP-eenheden met een relatieve score van de Europese semi-natuurlijke landgebruiktypen;
- Een kaart waarop landbouwgrond met een mozaïek van lage intensiteit landbouw en structurele elementen, gebaseerd op twee kaarten:
  - o aanwezigheid van kleine landschapselementen als indicatie voor lagere agrarische intensiteit met een hoge biodiversiteit op het niveau van LANMAP landschappelijke eenheden,
  - o in combinatie met de eerste resultaten van het WOT 4.4[4] project (een indicator voor agrarische intensiteit van het landgebruik).
- Een kaart met het belang van landschapseenheden voor de akker-en weidevogels[5] op basis van eerdere projecten (ENRISK / JRC/EEA EU HNV indicator, enz.
- Een overzichtskaart waarin de voorgaande drie kaarten worden geïntegreerd.

Alle afzonderlijke kaartlagen zijn van groot belang om te begrijpen waarom bepaalde gebieden een hoge agro-biodiversiteitswaarde krijgen. De resultaten toonden aanzienlijke verschillen met de bestaande JRC/EEA EU HNV indicator, vooral door het toevoegen van de kaartlaag met landschapselementen/ -structuur (kaartlaag 2). Onder meer in NW-Frankrijk, Spanje en andere gebieden resulteerde dit in duidelijk hogere agro-biodiversiteitswaarden. HNV Type 2 ontbreekt als ruimtelijk bestand in de JRC-methodologie. Tegelijkertijd is het duidelijk dat beperkingen in de data waaruit de afzonderlijke kaartlagen zijn opgebouwd hun weerslag hebben gehad op de eindresultaten. Het is daarom gewenst dat de resultaten kritisch worden bekeken met als uiteindelijke doel de methodologische basis te versterken.

De LUCAS dataset telt landschapselementen in een transect op een zeer locaal schaalniveau binnen een uitgebreid Europees netwerk van systematische transecten. Uit uitgebreide analyses in dit project is gebleken dat dit niet de juiste manier is om het belang van lineaire landschapselementen te schatten op het regionale schaalniveau. Dit betekent dat alternatieve methoden moeten worden gebruikt. Wij raden daarom aan om de koppeling van agro-biodiversiteit aan landschapsstructuur te benaderen met behulp van satellietbeelden in

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[4] WOT 4.4 is het project 'Modelling of intensive and extensive farming in CLUE' (Temme en Verburg, 2010)

[5] Final species group and database to be fine-tuned together with PBL

combinatie met gegevens over de agrarische intensiteit van het landgebruik (uit o.a. de resultaten van WOT 4.4). Met behulp van beide informatiebronnen zijn waarschijnlijk nauwkeurigere resultaten te genereren dan op basis van de LUCAS-methode. Een ander punt van verbetering is de verdere samenwerking met faunadeskundigen om meer gericht en gedifferentieerd gebruik te kunnen maken van de Europese vogeldata. Dit is echter alleen waardevol als de ruimtelijke resolutie van dit soort gegevens is verbeterd.

1 Introduction

1.1 Problem and background

An important EU biodiversity policy objective is to stop the loss of biodiversity by 2010. This does not seem to be feasible at this moment. Attention is increasingly being focussed on the possible contribution of changes from European agricultural policies after 2013 to reduce the loss of biodiversity. Current assessments of the influence of agricultural policy on biodiversity have mostly been ex post evaluations of current or historical policy on case study scale. The effects of future policy under different scenarios are unknown - yet required to assess effects of proposed policy, or to design alternative policy. Therefore, development of a method to calculate (agricultural) policy effects on agro-biodiversity is crucial.

EURURALIS aims to support the biodiversity debate in the EU by providing facts and figures on the impacts of several autonomous developments and policy options. For that purpose, Eururalis 1.0 and 2.0 included a biodiversity indicator. In Eururalis 1.0 a distinction was made between biodiversity in agricultural areas and biodiversity of nature areas. In Eururalis 2.0 only an indicator for total biodiversity was included, which was based on land use pattern, infrastructure (fragmentation), livestock density and nitrogen deposition. In Eururalis 3.0, we aim to portray how data on agro-biodiversity (EBCC, Natura 2000) is spatially related to landscape units (LANMAP), thereby focussing on the agro-biodiversity assessment of Eururalis.

Reason to use LANMAP is that is the only objective and complete European landscape classification. Landscapes are ideal units to study and analyse spatial-functional relationships (Mücher *et al.,* 2010)

1.2 Objectives and research questions

The goal of this project is to identify farmland nature values at different levels, possibly institutionally acknowledged sites (Natura 2000), farmland bird presence as an indicator for overall high biodiversity of agricultural habitats combined with landscape structure (LUCAS and other sources) as indicator for higher nature values (HNV) in agricultural landscapes. All these data sets will be used to allow an interpretation of the agro-biodiversity per landscape type as defined by LANMAP, thereby offering an alternative to traditional spatial reference systems such as administrative boundaries (NUTS regions) or grid systems.

General questions:

- Is it possible to use landscape type information (e.g. landscape structure) as indicators/ proxy for biodiversity?
- How can currently available data be combined with existing landscape classifications in order to better understand biodiversity of agricultural landscapes?

Research questions:

- Which agriculturally dominated landscape units could be considered as being of special biodiversity values?
- Can existing European data sets on the distribution of habitat and landscape structure improve current methodologies when assessing agro-biodiversity at the European level (e.g. HNV)?
- Do large scale monitoring activities such as the EU's LUCAS or GLOBIO project allow verifying the agro-biodiversity assessments using species and landscape data?

1.3 Envisioned scope

Context

The following components are **not** included in the proposed research:

- Research on what constitutes farmland biodiversity in Europe – off-the-shelf results such as established species lists, indicators and if possible existing maps such as the ENRISK species richness map or JRC/EEA EU HNV indicator will be used.
- The project will not run complex queries of existing species databases in order to arrive at agro-biodiversity profiles.
- The project will not perform comprehensive validation procedures, certainly no field work.

According to PBL, the principle need was a map covering the whole of Europe; the combination of WOT – 4.4 – 5.2 should show intensity- and structure-related dynamics in the agricultural arena that are not yet visible at this moment. If we succeed in that, then we have made a significant step – even while we can think of many more steps.

Figure 1.1 illustrates the overall integration of envisioned activities between WOT 5.2 (Agro-biodiversity) and WOT 4.4 (Land use intensity). As one can see, right from the beginning both assessment have been considered to stand in close relationship with each other. This is especially the case with regard to the role of land use data which is of principle importance for both. At the same time, the projects are hosted in two different data environments: WOT 5.2 explicitly is aggregated at the level of LANMAP units and operates with largely with non-agricultural data sets (e.g. landscape elements, species, designated sites); WOT 4.4 on the other hand is closely linked to agro-economic information which is compiled in LEI's FADN data base and managed in the models LEITAP and CAPRI. Later, Clue-S became the land use model to disaggregate NUTS-based agricultural data to square kilometre grid cells of Eururalis. Please note that the above graph has undergone various changes during the implementation of the project – Natura 2000 for instance has not been taken up (See also Figure 1.2).

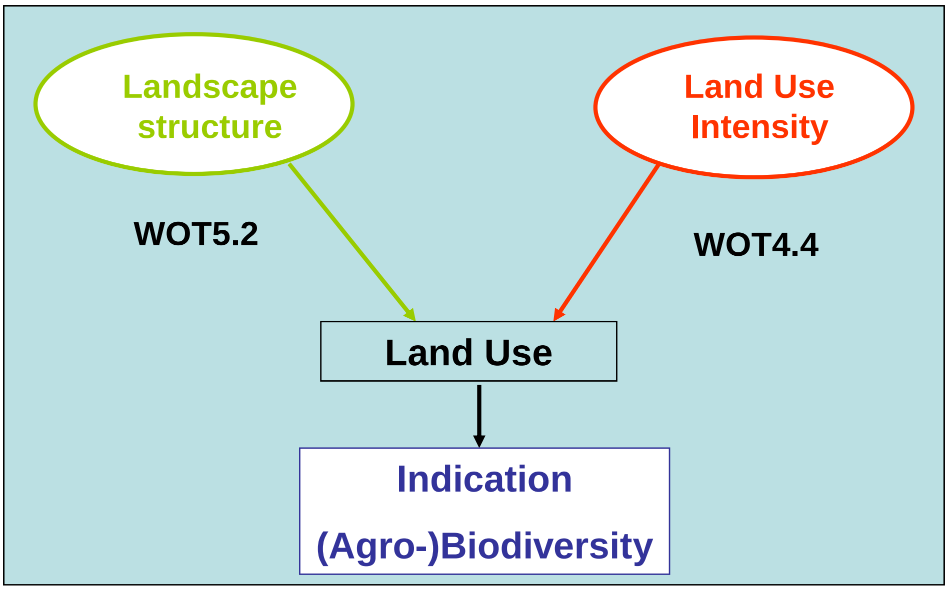

Figure 1.1: Integration of WOT 5.2 into the overall project scheme alongside WOT 4.4

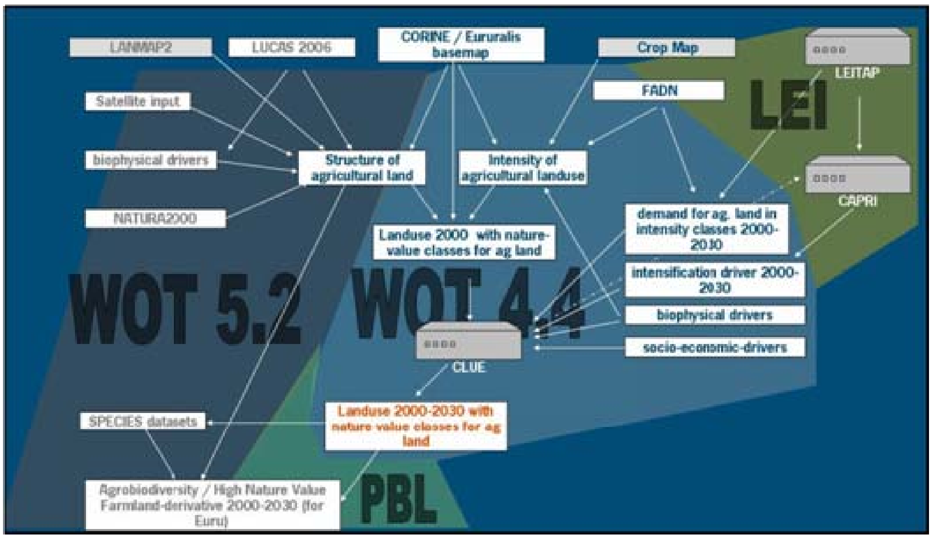

Figure 1.2: Early data management concept for implementation of WOT 5.5 and WOT 4.4

Projected results

A series of four maps summarizing the agricultural related biodiversity as calculated in WOT 5.2:

- A map showing those LANMAP units where semi-natural land use types are of relatively high importance;
- A map showing the presence of small landscape elements as indication for high biodiversity deriving from a structural analysis aggregating LUCAS data at the level of LANMAP;
- Third map is a map with fauna biodiversity as captured by earlier projects (ENRISK/ JRC/EEA EU HNV indicator etc) Farmland Birds[6] to be linked to landscape structure and/or landscape units;
- A cumulative map matching the presence of semi-natural habitats/land use types, high scores of farmland birds and high landscape elements richness.

Tentative objectives:

- Where needed improvement of the LANMAP landscape character map units to be able to coupled/related to EURURALIS land use data at the km^2 level;
- A random (non-representative) comparison of the cumulative map with data from GLOBIO data for examining the results;
- Organise an international workshop in cooperation with other relevant projects such as EUMon (UFZ), HNV (JRC/EEA) or BioScore (ECNC) and others to present and discuss the results;
- Publish an article in the Nature Conservation Journal.

WOT-Application

Application of the generated map is foreseen within the EURURALIS project that informs European citizens and policy makers of the effects of policy decisions for land use patterns and a number of indicator variables. Although targeted at EURURALIS, the project will provide also generic methods that can be used in combination with other models or model assemblages.

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[6] Final species group and database to be fine-tuned together with PBL

2 Concept and Data

2.1 Concept outline

During the early phase of the project, the following consideration where playing a role when building the conceptual approach:

- The project planning scheme required adaptation as the methodological research was evolving. Especially in the beginning time was needed to commonly agree on a proper division between the different activities.

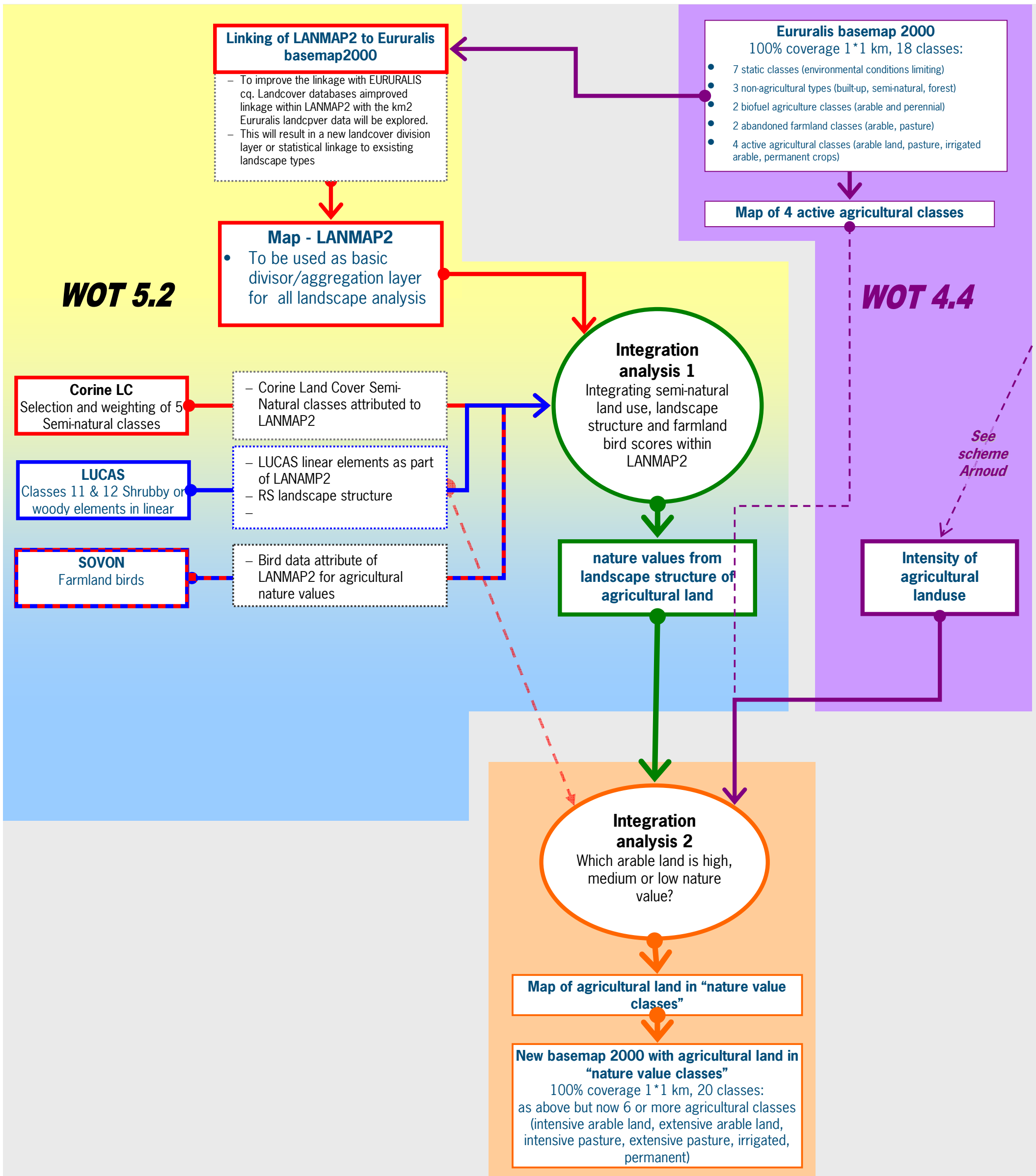


Figure 2.1: WOT 5.2 - Concept using structural and contextual data deriving from LUCAS, SOVON/EBCC and CORINE Land Cover aggregated in LANMAP.

- Already in the beginning the use of Natura 2000 data was considered as problematic because it excludes much agricultural land; therefore, the use of additional datasets – for instance about farmland birds - was envisaged.
- The question was whether we need to look for absolute changes in biodiversity or for relative changes? There are no good datasets for absolute biodiversity, but we would like to be able to distinguish a 10% decrease of biodiversity in Poland from a 10% decrease in biodiversity in the Netherlands.
- One way to deal with this issue is through the use of maximum-functions. Biodiversity indicators may be related to biophysical and other conditions through such function, leading to a max ("absolute") biodiversity under conditions.
- The relative changes of areas where farming practices are associated with high biodiversity are commonly referred to as high nature value (HNV) farmland. Since the HNV concept (see par. 2.2) is a further elaboration of term "agro-biodiversity " as stated in the objective of the project, it was agreed to conform to the HNV concept and terminology to avoid further confusion. See par. 2.2 for further explanation of the HNV concept.

Figure 2.1 shows in more detail how the evolving approach was conceptualized.

2.2 HNV concept

The conservation of the often extensively farmed ecosystems is an explicit objective of EU's environment and rural development policies. In the Kyiv Resolution on Biodiversity the European environment ministers have committed themselves to identify high nature value farmland areas by 2006 and to have favourable management of a substantial proportion of it in place by 2008. The methodology is based on land cover and biodiversity data. A regionally differentiated selection has been made of habitats where HNV farmland may be expected. The high variability of habitats in Europe was taken into account through selection rules, defined by regional experts who identified the link between Corine land cover classes and the corresponding nature value, per country and environmental zone. Available national surveys and relevees on semi-natural grasslands were included in the mapping process. Lists of habitats (Natura 2000) and species (birds and butterflies) indicative of HNV farmland were compiled and corresponding sites in the Natura 2000 network, important bird areas and primary butterfly areas were selected (Paracchini *et al.*, 2008).

Rural development programmes will be subject to a mid term and ex post evaluation in 2010 and 2015, respectively, to assess the extent to which the objectives of the programme have been achieved. The Common Monitoring and Evaluation Framework (CMEF) provides a single framework for the monitoring and evaluation of all rural development interventions through the application of five sets of indicators. For the purpose of developing the CMEF impact indicator, the IRENA definition has been modified to take account of the national and/or regional scale.

In terms of their methodologies and results, both the 2004 as well as the 2008 map of potential HNV areas are exposed to critical reviews by both policy and research. For example, the HNV assessment of pasture / grassland management intensity were not entirely satisfying so that the contribution of pastures/grasslands to HNV farmland has probably been overestimated (Hoogeveen *et al.,* 2006). As a consequence, several corrective measures have been taken such as applying models to distinguish among different grassland management (ESCAPE methodology), identifying vegetation occurring on specific soil types, using information on altitude and slope, and, most relevant, adding national inventories when available. Oppermann (2008) found for the example of Germany, a division into HNV farmland and non HNV farmland leads to strong simplifications. This is echoed by Sjödahl (2008) who compared the national assessments for Sweden with the European HNV mapping approach and found that the overlap between the two methods was only one third, pointing at the low resolution of the European data and unresolved special case of mosaic landscapes. However, the authors of the European approach are aware of the difficulties to take into account small HNV areas when these are located in intensive farmland areas, such as narrow flooding valleys scattered in different farms and municipalities (Pointereau *et al.* 2007).

Due to the increasing interest and debate on HNV farmland (see figure 2.2) we felt encouraged to steer WOT 5.2 towards a further elaboration of the European HNV farming approach, thereby targeting at European policy implementation. Half way through the process, especially after realizing that data sets such as Natura 2000 and other species data sets were not really appropriate at this stage, we decided that our conceptual approach should take up the premises of the three types of HNV indicators as developed by JRC/EEA (Andersen *et al.* 2003; See figure 2.3 and Textbox 1):

Type 1: Farmland with a high proportion of semi-natural vegetation;

Type 2: Farmland that is dominated by either low intensity farmland or a mosaic of semi-natural and cultivated land and small-scale features

Type 3: Farmland supporting rare species or a high proportion of European or World population.

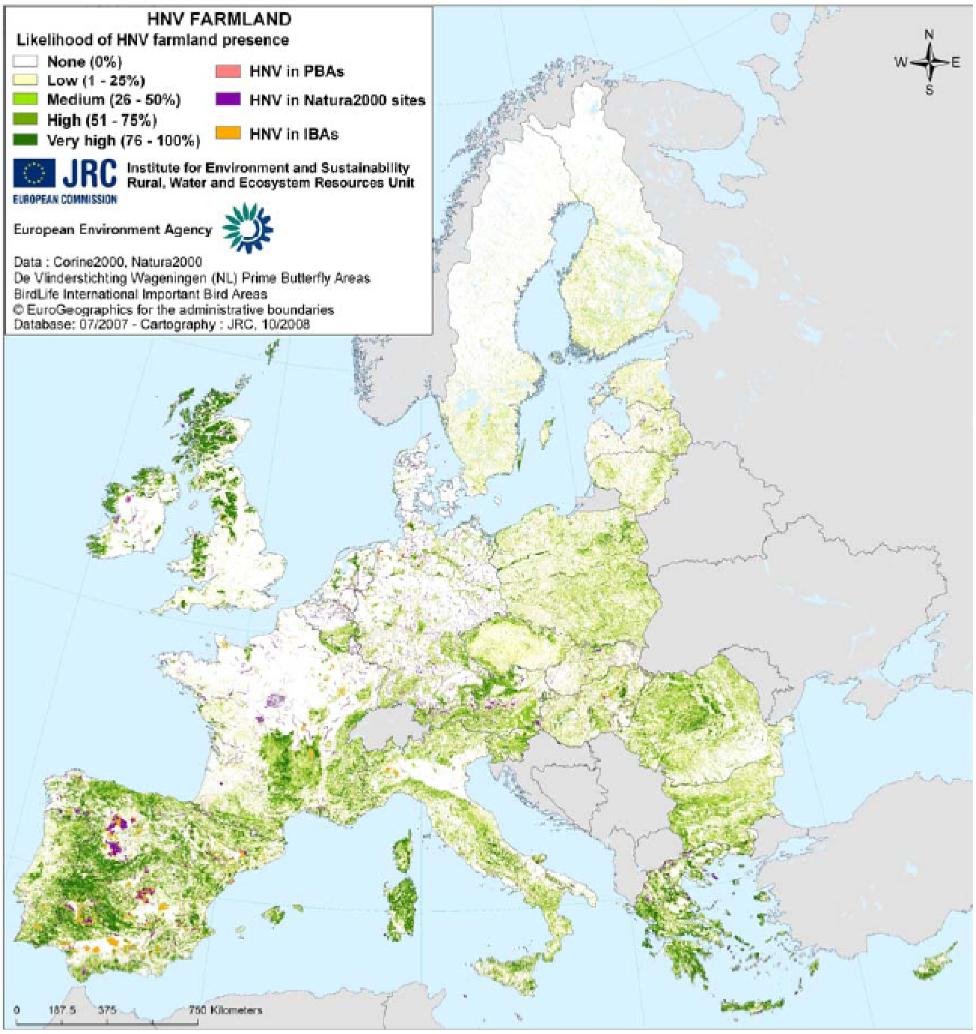


Figure 2.2: Map of high nature value farmland (Paracchini et al. 2008)

Textbox 1: Definition and current known elaboration of the HNV concept in the European context. The HNV concept and definition clearly shows a more precise definition of the term 'agro-biodiversity' and farming practices which could be associated with high biodiversity. In: Elbersen and Van Eupen, 2008

The identification of HNV farmland areas was first done by Andersen *et al* (2003). In this study high nature value farmland was defined as **"those areas in Europe where agriculture is a major (usually the dominant) land use and where that agriculture supports, or is associated with, either a high species and habitat diversity, or the presence of species of European conservation concern, or both".**
From this, three types of HNV farmland were distinguished, with a hierarchical order in terms of biodiversity values:

- Type 1: Farmland with a high proportion of semi-natural vegetation.
- Type 2: Farmland with a mosaic of low intensity agriculture and structural elements, such as field margins, hedgerows, stonewalls, patches of woodland or scrub, small rivers etc.. The description of Type 2 was altered in 2006 by the EEA-JRC. The original formulation by Andersen *et al.* (2003) was: *'Farmland that is dominated by either low intensity farmland or a mosaic of semi-natural and cultivated land and small-scale features'.*
- Type 3: Farmland supporting rare species or a high proportion of European or World population.

In the period 2005-2008 JRC and EEA have carried out a further update of the CLC-based HNV map of Andersen *et al.* (2003) applying an up-dated methodology (Paracchini *et al.*, 2008). It is based on European environmental datasets, including CLC data, and additional spatial data sets such as the environmental zones of Europe (Metzger *et al.* 2005), Natura 2000 sites, important bird areas (IBAs) and primary butterfly areas. The main reason to continue using the European data sets was that they are updated regularly so providing the possibility for also updating the resulting map and helps to produce relatively consistent results throughout Europe. However, for the further improvement national experts and representatives from environment or agricultural ministries were already involved in the exercise. They gave suggestions on how to improve the methodology in order to produce maps that fitted as much as possible to the HNV farmland distribution that was known by them at regional or local level.

This decision is supported by the conclusions of Elbersen & Van Eupen (2008) defining the HNV values for the Netherlands. A key factor in the approach of Elbersen & Van Eupen (2008) was that all three HNV farmland types a first identified separately from each other.

> "*The advantage of this separate identification is that it provides a better understanding of what HNV characteristics need to be identified and what data needs to be used for doing this. Furthermore it also gives a better understanding of data problems in relation to identifying specific HNV features. Finally it should also be mentioned that indicators per HNV farmland type also deliver a better starting point for targeting policy measures (e.g. Agri-environmental measures*). *(Elbersen & Van Eupen 2008)*"

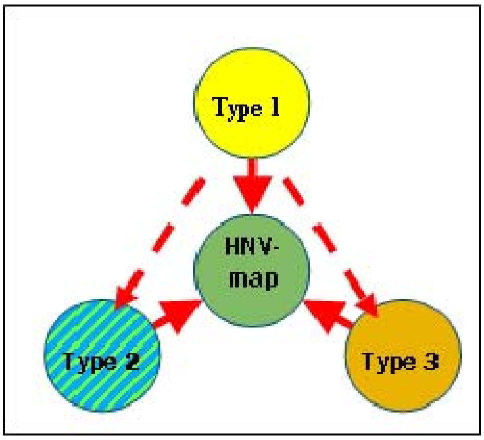


Figure 2.3 Ultimate concept based on HNV definition (Andersen et al. 2003)

The envisioned approach or WOT 5.2 was as follows:

- Characteristic regions in EU (rough location and typical characteristics) → LANMAP;
- Create indicative maps for each HNV farmland type;
- Characterise typical HNV farming systems for 3 types of HNV farmland → WOT 4.4;

Combine integrated indicators to develop final HNV farmland indicator.

For each of the HNV farming area classes it is hence proposed to undertake the following assessment:

Overall goals is to arrive at (a) a generic agricultural landscape score depending on the percentage of agricultural lc-types per LANMAP unit; (b) HNV class score within (a); (c) a Farmland bird score; (d) an IBA or Natura 2000 score[7], and (e) a cumulative score (a-d).

2.3 Data review and methodological choices

2.3.1 Landscape classification

LANMAP

The European landscape map and typology LANMAP (Mücher *et al.,* 2006; Mücher *et al.,* 2010) provides bio-physical profiles of 14,000 mapping units across pan-Europe for 320 different landscape types. Each profile consists of information on the dominant land cover type, mean elevation level and prevailing soil class.

By means of GIS analysis of the underlying data sources – both in terms of landscape structure and past land use changes – this information allows conclusions on agri-environmental aspects of each landscape unit. If supported by additional geo-referenced information such as on the distribution and trends of farmland birds as well as on the presences and threads of important bird areas (IBAs), LANMAP units can become indicative for agro-biodiversity characteristics.

2.3.2 Proportion of semi-natural land

CORINE land cover

CORINE land cover data can - to a certain extent - be interpreted with regard to its potential land use, and hence recognising areas being mainly natural or semi-natural, receiving low human impact. Major habitat types have been defined by aggregating CORINE land cover classes to obtain a representative number of classes, meaningful for nature conservation. The CORINE land cover data converted to 250 m ground resolution are used as basic input data together with the geo-referenced transport infrastructure data provided by Eurostat/GISCO.

Each habitat type is assigned an attribute expressing whether an area is supposed to put pressure (P) to the adjacent area contributing to fragmentation or being sensible (S) to pressure. The latter areas are considered to be potentially semi-natural or natural areas. A number of land cover types are considered 'neutral', which means in this case without a significant pressure on semi-natural or natural areas from human influence (See Figure 2.4).

[7] Step (d) has later been abandoned, see section on species data

level 1	level 2		Code	Level 3 CORINE land cover class	Nr.
1. Artificial surfaces	1.1	urban fabric	1.1.1	continuous urban fabric	1
			1.1.2	discontinuous urban fabric	2
	1.2	industrial, commercial and	1.2.1	industrial and commercial units	3
		transport units	1.2.2	road and rail networks and associated land	4
			1.2.3	port areas	5
			1.2.4	airports	6
	1.3	mine, dump and	1.3.1	mineral extraction sites	7
		construction sites	1.3.2	dump sites	8
			1.3.3	construction sites	9
	1.4	artificial non-agricultural	1.4.1	green urban areas	10
		vegetated areas	1.4.2	port and leisure facilities	11
2. Agricultural areas	2.1	arable land	2.1.1	non-irrigated arable land	12
			2.1.2	permanently irrigated land	13
			2.1.3	rice fields	14
	2.2	permanent crops	2.2.1	vineyards	15
			2.2.2	fruit trees and berry plantation	16
			2.2.3	olive groves	17
	2.3	pastures	2.3.1	pastures	18
	2.4	heterogeneous agricultural are	2.4.1	annual cops associated with permanent crops	19
		agricultural areas	2.4.2	complex cultivation patterns	20
			2.4.3	land principally occupied by agriculture with si	21
			2.4.4	agro-forestry areas	22
3. Forests and semi-natural areas	3.1	forest	3.1.1	broad-leaved forest	23
			3.1.2	coniferous forest	24
			3.1.3	mixed forest	25
	3.2	shrub and/or herbaceous	3.2.1	natural grasslands	26
		vegetation associations	3.2.2	moors and heath lands	27
			3.2.3	sclerophyllous vegetation	28
			3.2.4	transitional woodland-scrub	29
	3.3	open spaces with little or no	3.3.1	beaches, sand, dunes	30
		vegetation	3.3.2	bare rocks	31
			3.3.3	sparsely vegetated areas	
			3.3.4	burnt areas	
			3.3.5	glaciers and perpetual snow	
4. Wetlands	4.1	inland wetlands	4.1.1	inland marshes	
			4.1.2	peat bogs	
	4.2	coastal wetlands	4.2.1	salt marshes	
			4.2.2	salines	
			4.2.3	intertidal flats	
5. Water bodies	5.1	inland waters	5.1.1	water courses	
			5.1.2	water bodies	
	5.2	marine waters	5.2.1	coastal lagoons	
			5.2.2	estuaries	
			5.2.3	sea and ocean	

Formula calculation HNV semi-natural land cover layer:

- % land cover type per landscape unit
- Calculation HNV value (%):
  - (1x21)+(2x22)+(3x23)+
  - (4x24)+(5x32)/15

Figure 2.4: Selection and weighting of CORINE's semi-natural land cover types to arrive at HNV

2.3.3 Landscape structure

The biodiversity of European agricultural landscapes depends to a large extent on the amount of small landscape elements in the landscape. This is translated in the HNV concept (section 2.2) by type 2: farmland dominated by low intensity agriculture or a mosaic of semi-natural and cultivated land and small landscape elements. Low intensity traditional landscapes are often very rich in small landscape elements. Under the pressure of increasing intensification and often associated land consolidation many of the landscape elements got lost, and therefore resulted in a loss of biodiversity. There are a number of countries that have their national inventory of small landscape elements and biotopes. Unfortunately, these data are hardly accessible and a second problem is that national recording strategies differ to a large extent. Projects such as BIOHAB, EBONE and BIOBIO are putting much effort in the collection of consistent information of point, linear and patch habitats across Europe, but are in general based on a very limited amount of sample sites. In amongst others the SENSOR project, Mücher *et al.* (2008, 2009) investigated the use of satellite imagery to estimate the amount of woody linear elements in the wider countryside.

LUCAS

The LUCAS project of EUROSTAT aims at estimating land cover / use areas by direct observations made in the field across the European Union (see Figure 2.5 and see also Annex 1). The LUCAS database contains approximately 10,000 primary sampling units (PSUs) at distances of 18 km and covering 15 EU countries. The LUCAS sampling design is based on a systematic grid. The grid is created as a double level grid with the PSUs at the first level. The second level defines the location of 10 samples (secondary sample units, SSU) divided over two rows. These SSUs are 300 meter apart centred on the PSU. In total there are approximately a 100,000 SSUs.

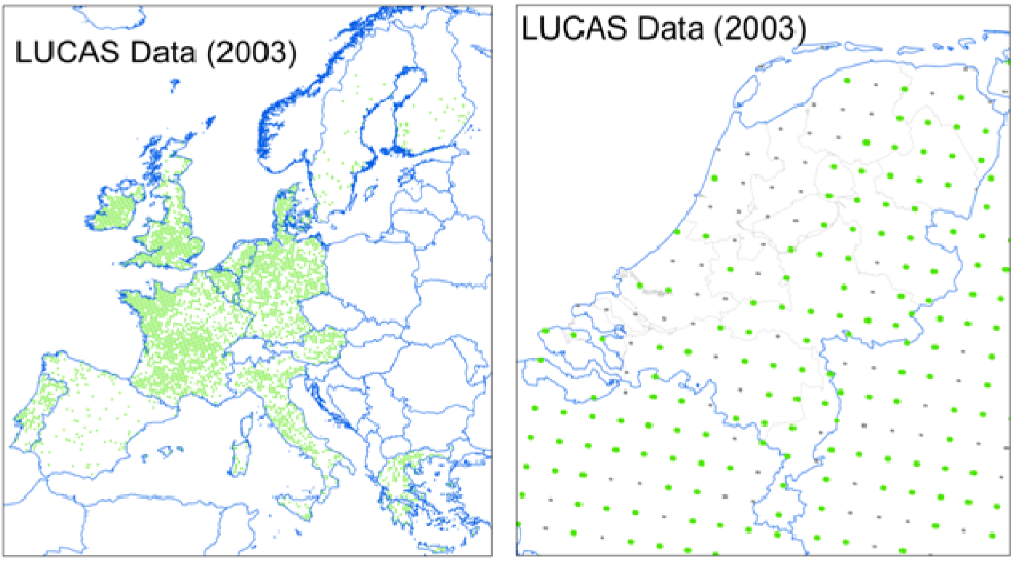


Figure 2.5 The LUCAS field sampling points within Europe (left) and the Netherlands (right).

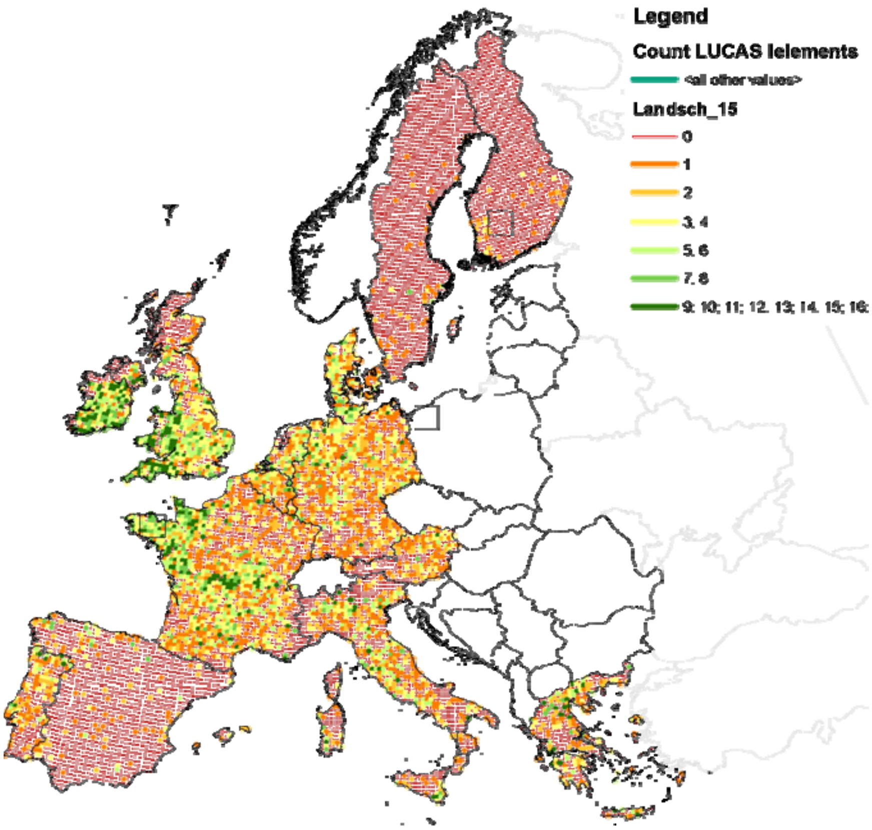


Figure 2.6: The score of LUCAS data for linear landscape elements 'Trees and hedges' (code 11 and 12) as grid.

A specific aspect of the monitoring, is the sampling of a transect in LUCAS which has been defined to estimate the presence of linear features. The transect is defined by joining the 5 northern SSUs of each PSU. Along each transect (east-west) of 1200 meters the number of linear features (> 30 m) that are crossed are counted. Specific linear features of interest are class 11 and 12 (see Figure 2.6): "Shrubby or woody vegetation in a continuous linear shape'. This category includes also line of trees. Shrub or wood margins are found as field boundaries within agricultural land or alongside roads or water courses. The number of intersections reported to the length of the transect is used to estimate the density of linear features per area unit and therefore the total length. Unfortunately, results indicated that the estimation of the total length per region were disappointing (at different scale lengths) in an experiment for the Netherlands. A reason for this could be the spatial complexity of linear elements which are not easy to estimate using a systematic transect methodology. Moreover, large differences were noticed between countries due to different interpretations by the field survey teams which are not related to the real situation (noticed at country border lines). Although for countries, like France and England the regional differences within the country seemed to be quite realistic according to several landscape experts. So a better training of field teams seems to be one option for improvements. Although the authors are convinced that the use of transects are not optimal for assessing linear features throughout the landscape, the method is very suitable for estimating crop acreages. Therefore the use of satellite imagery might be an alternative to estimate the amount of linear elements more consistently throughout the landscape.

Remotely sensed landscape structure

Satellite imagery are an optimal information source to obtain synoptic information on the landscape structure (Mücher *et al.,* 2008, 2009). Nevertheless, landscape elements, such as woody linear elements can only be determined directly by very high resolution satellite images with spatial resolutions of a few meters or higher (e.g. IKONOS, Quickbird) or by aerial photo interpretations. Since these kind of EO images have also very high costs they must be applied on a sample basis. Contrary, high resolution satellite imagery (10-30 m spatial resolution) such as LANDSAT ETM+ and SPOT HRV are available for the whole of Europe and can be used to determine the landscape structure (e.g. amount, size and shape of individual patches). However, these images can not be used to detect directly small landscape elements due to its spatial resolution. Nevertheless, relationships between landscape structure and amount of landscape elements do exist, but these relationships differ per region, and therefore empirical relationships have to be calibrated (to estimate the amount of landscape elements).

From European projects such as SENSOR it has become clear that LANDSAT satellite imagery can be used very well to obtain information about the landscape structure. It is assumed by the authors that information on the landscape structure can used as a proxy to estimate the amount of woody linear elements. The relationship between landscape metrics and amount of woody linear elements had to be determined for that reason. In general, we observe that landscapes with large and regular fields or parcels are in intensive agricultural areas that are often characterized by a low amount of woody linear elements (which have been removed often in the sixties and seventies during the process of land consolidation), while landscapes with smaller and irregular fields are more often less intensive used and are characterized by more small landscape elements. For more details and examples for this remote sensing based approach, please see Annex 2.

Land use intensity

Next to structural diversity, the other second-level criteria for HNV areas is 'low-intensity farmland', hence something closely related to land use management. Until today, such assessments are difficult to make as there only exist farm management information at the level of NUTS-region, e.g. FADN or FSS data. The parallel WOT project 4.4, however, had exactly this objective, namely to identify different levels of land use intensity at the scale of one square kilometre. The project could not be implemented for the whole of Europe, but some countries such as Spain, France and the Netherlands showed interesting results which became available for 'last-minute- integration. The report (Temme & Verburg, 2010) concludes that it is possible to predict the amount and location of intensity of agricultural land in three classes for arable land and in two classes for grassland. As an example, these predictions were made for the Netherlands, Poland, Portugal, Spain and Greece in the year 2000 (using available information) and in the year 2025 (for the SENSOR financial policy reform case). Combination of year 2000 and year 2025 maps of agricultural intensity has allowed classification of transitions into broad categories of intensification, extensification, expansion and abandonment. These combinations and classifications are useful for subsequent quantification of (agro-)biodiversity changes. We have outlined and illustrated the method to achieve such predictions, discussed some of the assumptions that influence its validity and presented tests that could be performed to test that validity (please see examples in Annex 3)

2.3.4 Farmland supporting rare species

Farmland birds

The European farmland bird lidicator (EFBI) has been adopted as a structural and sustainable development indicator by the European Union. It is an aggregated index integrating the population trends of 33 common bird species associated with farmland habitats across 21 countries. We describe a modelling method for predicting this indicator from land use characteristics. Using yearly historical land use data of crop areas derived from the FAO databases (1990–2007) and published population data of farmland birds at the national level for the same period, we developed a series of multiple regression models to predict the trend of the EU state specific indicator, and the EFBI.

Previous studies have shown a significant decline in populations of farmland birds across Europe between 1970 and 1990, which have been attributed to a general process of agricultural intensification. Farmland birds rely greatly on farmland for food and nesting sites. Therefore, changes in farming practices such as increased levels of mechanisation and chemical use or the spread of monocultures, associated with agricultural intensification, are believed to have important impacts on bird populations. Understanding the links between agriculture intensification and biodiversity is important because farmland constitutes the single largest habitat in Europe, covering 45% of the total European land area (Figure 2.7).

Due to the EU-wide coverage of this indicator and because of the possibility to aggregate subsets of this indicator for specific agricultural habitat types (see Annex 4), farmland birds have been considered as superior over Natura 2000 or IBA data. Though the data is considered as useful and has found various applications (Delbaere & Nieto Seradilla 2005), great care must be applied in the application and interpretation.

The definition of HNV type 3 (Farmland supporting rare species or a high proportion of European or world population) is much wider than only farmland birds. However, in existing databases the link to farmland varies from species to species and / or the spatial coverage of the data is clearly fragmented or politically biased (e.g. Natura 2000 PBA, or IBA data). Even for birds, which is considered the best covered species database in Europe, the link to farmland practice and is often disputed and regionally differentiated (Andersen 2003, EEA, 2004). Elbersen & Van Eupen (2008) showed that on the more regional (with a very good species database) interpretation is much easier and therefore of much more added value than on heterogeneous European level (Figure 2.8 and 2.9).

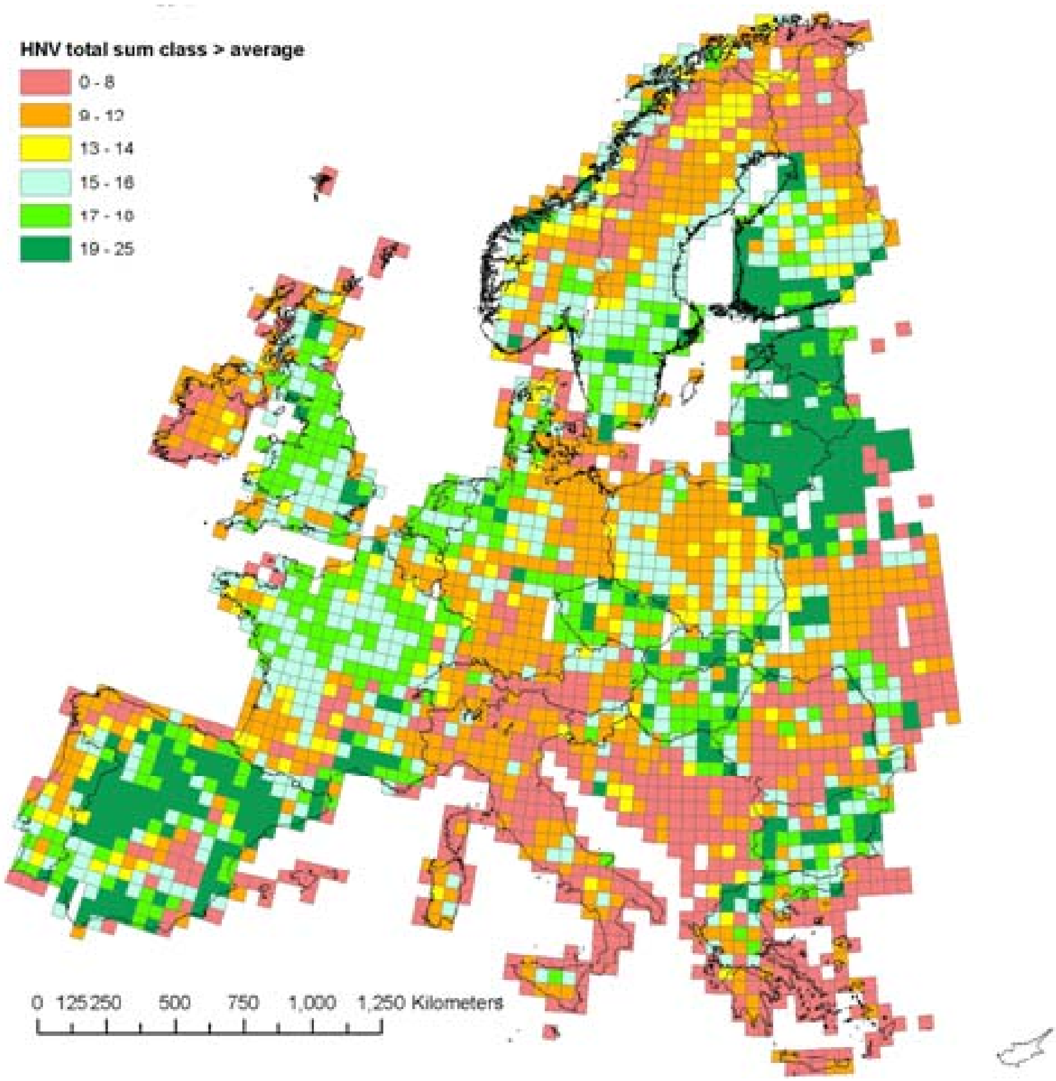


Figure 2.7: Farmland bird richness on the basis of UTM grid cells.

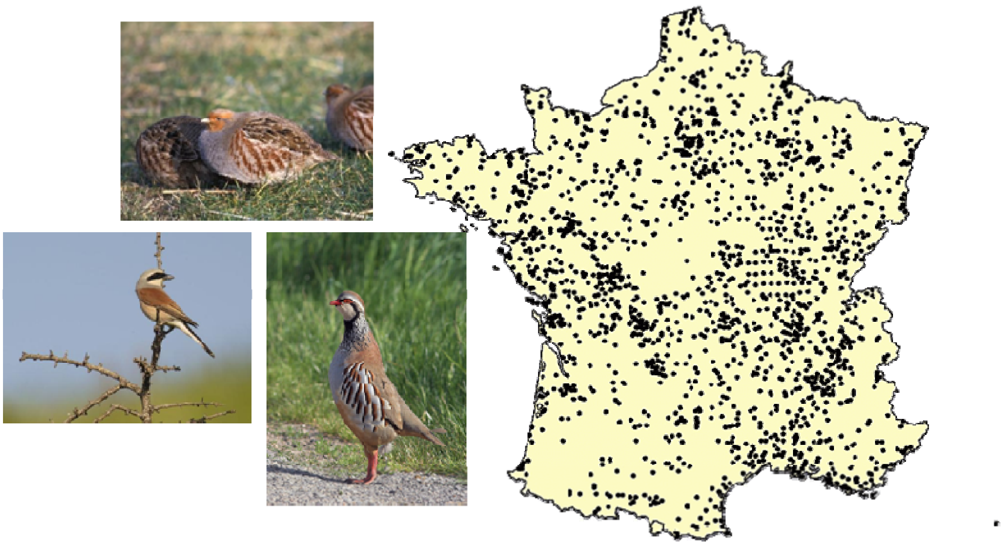


Figure 2.8: Example of farming bird distribution data for France (UTM grid)

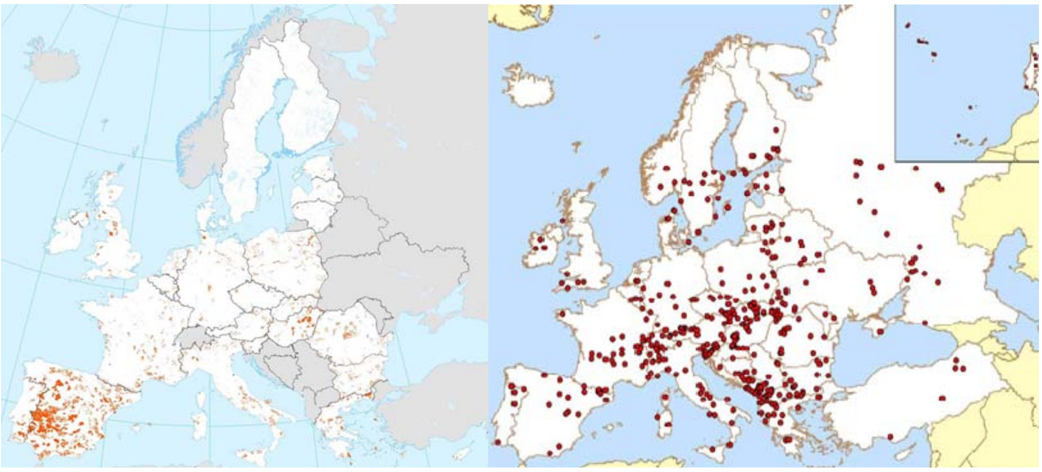


Figure 2.9: Left: Selected important bird areas (Paracchini, 2008); Right: Prime butterfly areas (Swaay & Watten, 2003)

3 Results

3.1 Proportion of semi-natural land use

The assessment of the presence of semi-natural agricultural landscape types (Figure 3.1) shows both confirmations as well as contradicting results regarding prevailing expert knowledge. While the results for Europe's northern, western and southern periphery are largely consistent what can be expected (except the relatively low semi-natural character of the Italian mainland and the high presence in the intensively managed Netherlands), the low semi-naturalness of southern Finland and Sweden (the latter being recognized for the presence of small-scale, mosaic structure of cultural landscapes) comes as a surprise. As an explanation, the data reliability of CORINE land cover, but also the legend units themselves and not to forget the methodological weighting process for generating this assessment should be under consideration.

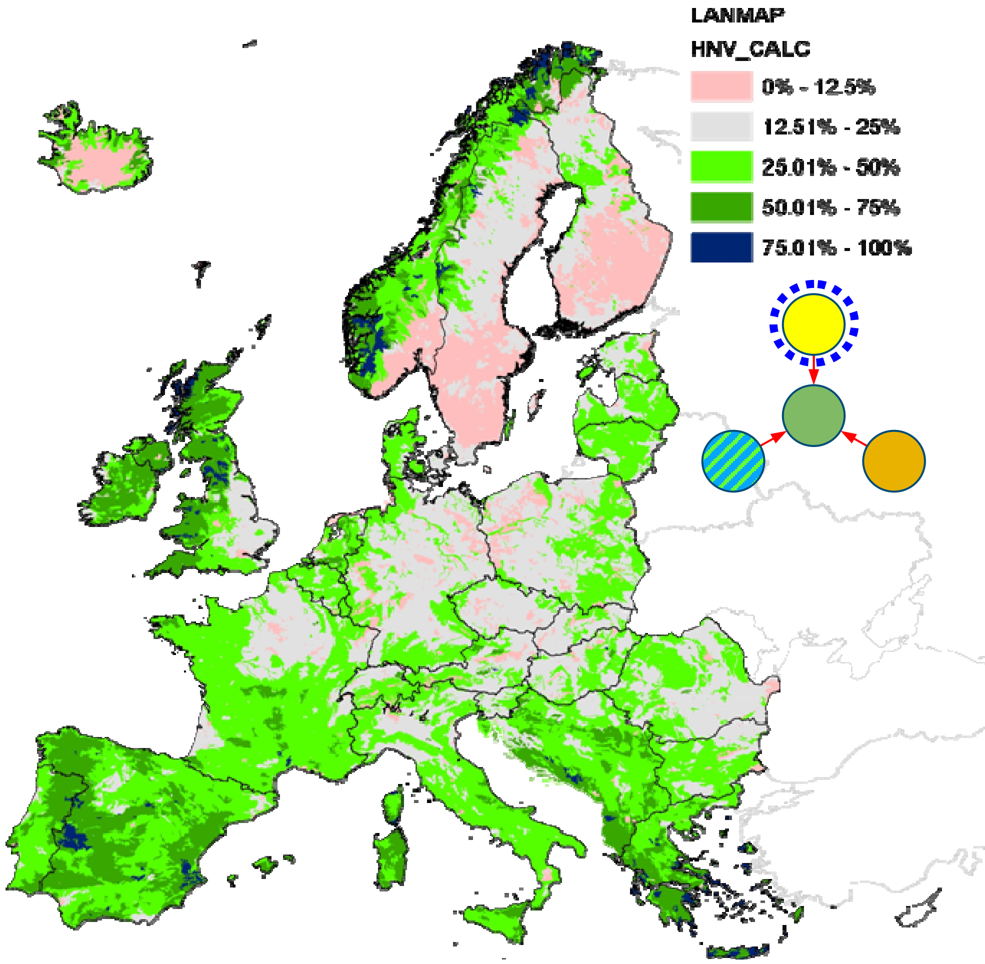


Figure 3.1: Result for semi-natural agricultural landscape types on the basis of CORINE Image 2000 data.

3.2 Landscape structure

Figure 3.2 illustrates that LUCAS data does tell a story and that part of it reflects some of the assumption for high landscape structure – e.g. the high scores for Brittany, an areas that is under-represented in the current EEA-JRC HNV assessment. On the other hand, LUCAS scores extremely low in southern Finland, an area known for its landscape diversity in terms of small lakes and woodlands. A high amount of forest edges and water borders are considered to be of equal importance and functional character as the linear landscape elements covered by LUCAS (tree rows and hedges). Obviously, LUCAS does not capture this type of structural diversity. The two examples show that the use of LUCAS requires additional expert judgment.

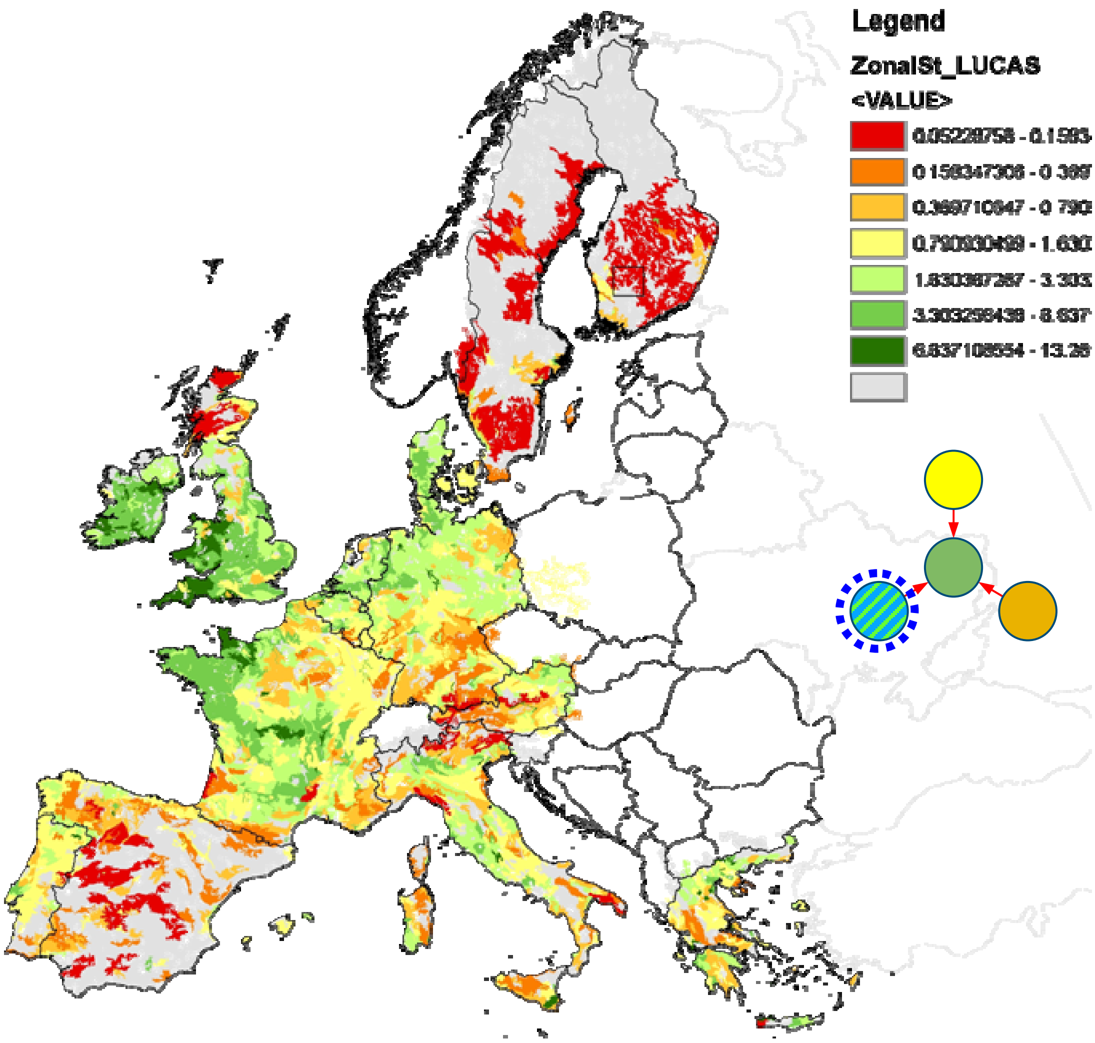
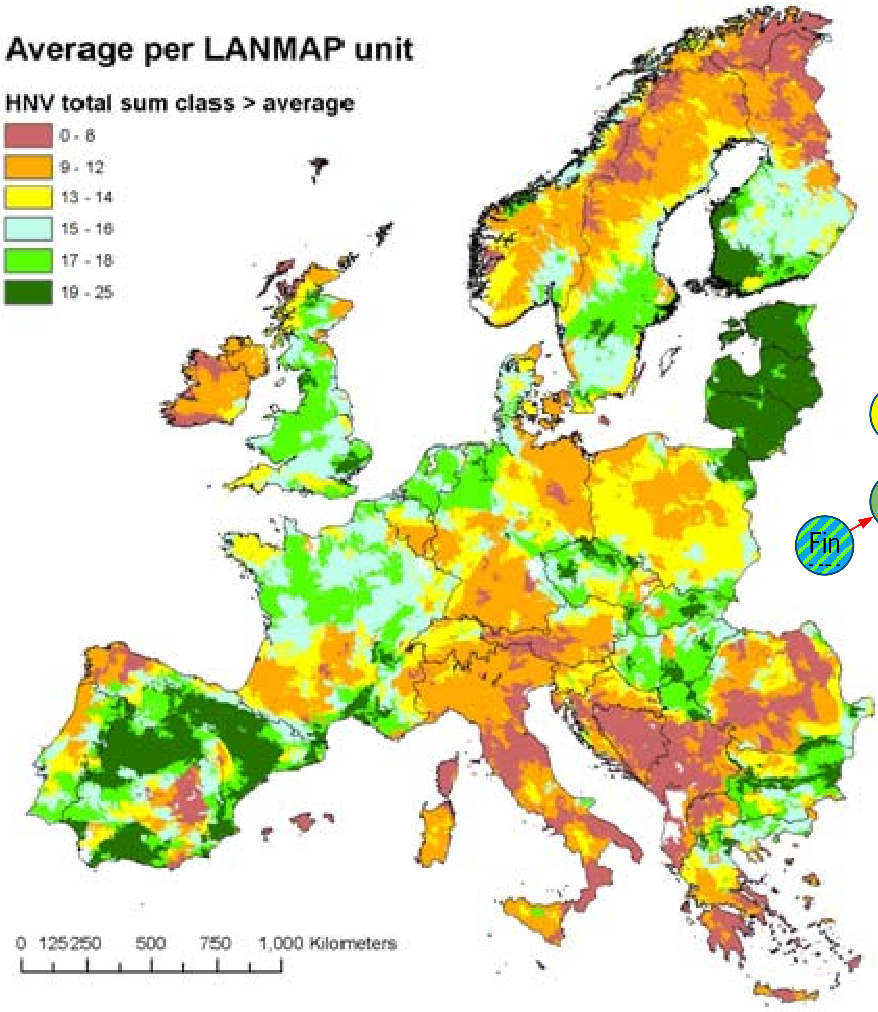


Figure 3.2: The score of LUCAS data for linear landscape elements 'Trees and hedges' (code 11 and 12) aggregated towards LANMAP units.

3.3 Farmland birds

Figure 3.3 shows that very high farmland bird habitats can be found in the Mediterranean areas of Greece, Bulgaria, southern France and particular Spain. Also Hungary and The Czech Republic accommodate a considerable amount of high cumulative HNV values for Farmland birds. The Clear (full) coverage of the Baltic States is expectable, but probably overestimated due to their very good data availability compared to the rest of Europe. The same effect can also be seen in the Netherlands.



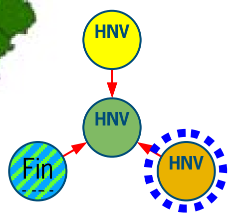


Figure 3.3: Cumulative results from all farmland bird habitat assessments on the basis of EBCC data (see details in Annex 2 and 6). Numbers of farmland bird species per UTM grid cell (Hagemeijer and Blair, 1997); aggregated for LANMAP units.

3.4 Integrated HNV results

For the integration of the HNV results the hierarchical order in terms of biodiversity values between the three HNV types was used to rank all regions according to their combination. Each HNV type was firstly ranked bitwise (0 or 1) to select the very high biodiversity areas according the type (Figure 3.4). The thresholds which were used are derived from taking the average and standard deviations of each type over Europe. Areas which are clearly higher than the European average have been selected. For HNV type 2, the available[8] low intensity farming areas (See WOT 4.4, (Temme & Verburg, 2010) were added to the existing areas with high LUCAS landscape structure (Figure 3.4).

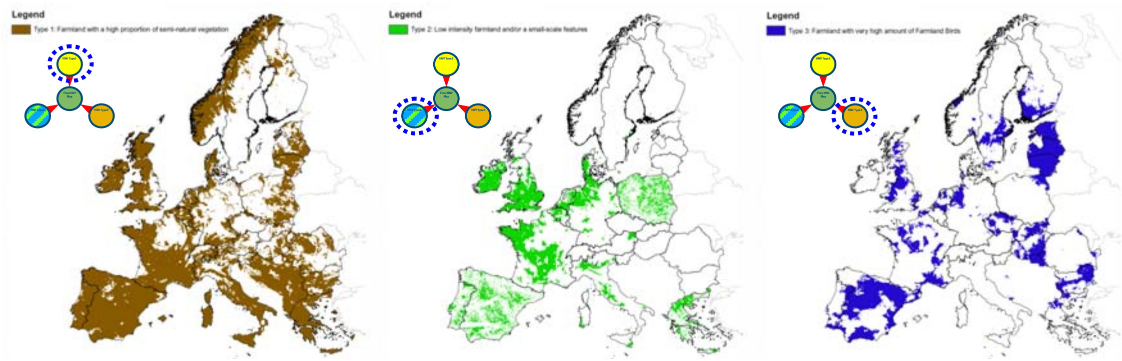


Fig 3.4: Selection of HNV Type 1 Reclassification of Fig.3.1>35%

Selection of HNV Type 2 Reclassification of Fig.3.2>2 or WOT4.4 = medium or low intensity

Selection of HNV Type 3 Reclassification of Fig.3.3>16.5

Next step was the integration of the three types into one agricultural biodiversity map. This was done according to the hierarchical definition of HNV (see Section 2.2). The three bitmaps shown in Figure 3.4. were combined, which results in 8 possible combinations. These combinations where ranked according to their "Chance on Agricultural Biodiversity" (Table 3.1).

Table 3.1: Determination of the chance on agricultural biodiversity based on the three HNV types

Id.	HNV code Total	Chance on agricultural biodiversity	HNV Type1	HNV Type2	HNV Type3
1	111	Very high chance	**Yes**	**Yes**	**Yes**
2	110	High chance	**Yes**	**Yes**	No
3	101		**Yes**	No	**Yes**
4	011	Medium chance	No	**Yes**	**Yes**
5	100		**Yes**	No	No
6	010	Low chance	No	**Yes**	No
7	001		No	No	**Yes**
8	000	Lowest chance	No	No	No

[8] Available were: Poland, Spain, Greece and The Netherlands. Clearly making a real European coverage of HNV type 2 based on WOT 4.4 is impossible. The here presented map should be seen as an example of the possible integration

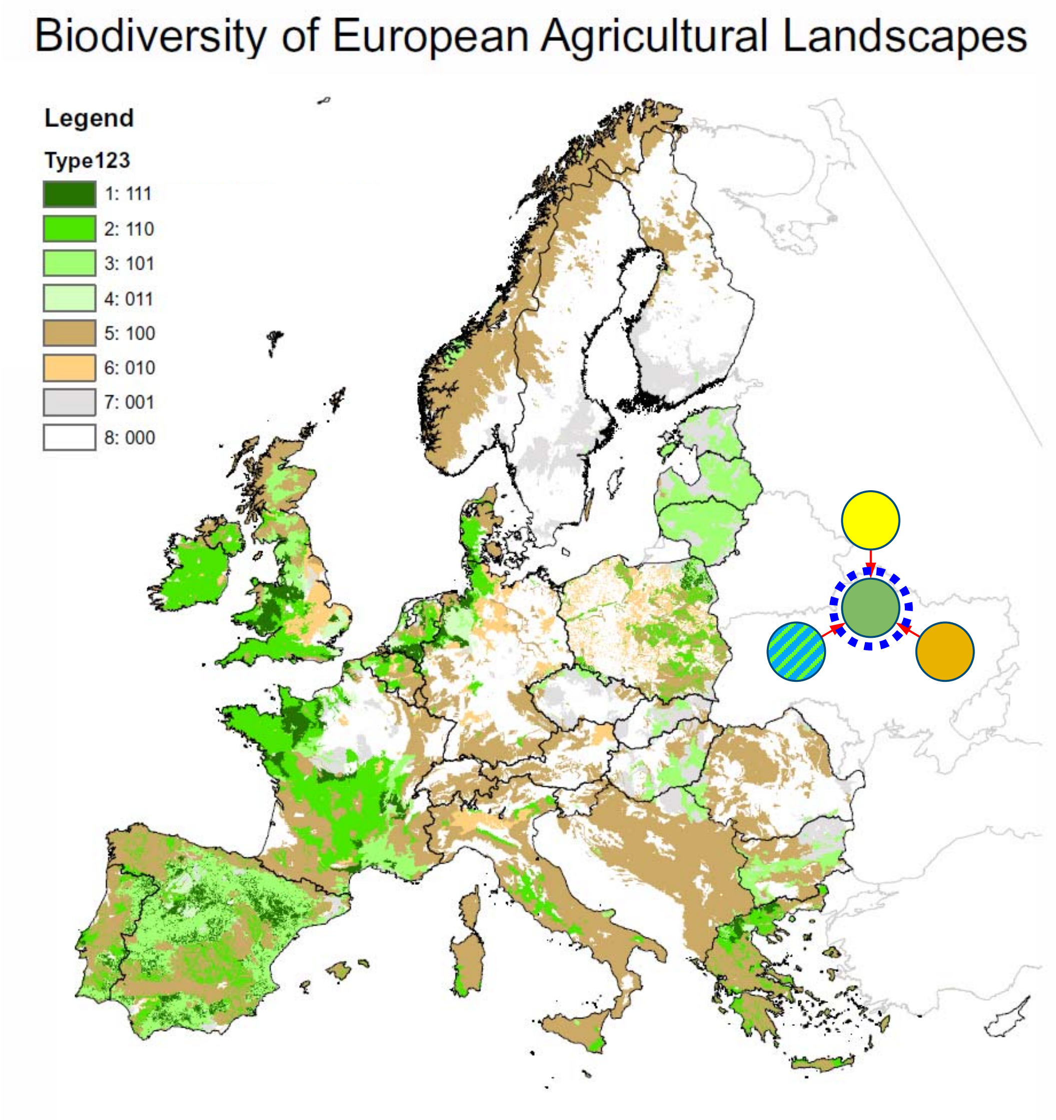


Figure 3.5: Map showing the calculated Chance on Agricultural Biodiversity integrating HNV type 1, 2 (see also footnote 4) & 3.

4 Case studies and discussion

Introduction

European assessments are always posing challenges in terms of data harmonisation, availability and management, but also in term of the role of expert's advice when constructing indicators and weighting the different parameters. The complexity of the underlying operations and modelling exercises, the frequent heterogeneity of the applied data sets and the large variety of natural and cultural attributes that characterise the European landscape make it virtually impossible to satisfy all user needs. 'Users' of high nature value farmland information are themselves forming a rather diverse group as they can include virtually all kind of people from NGOs active in nature conservation, land owners concerned with sustainable farming, policy makers at various levels – from local to European - and of course researchers. The general objective when developing cartographic materials such as on HNV farmland is to satisfy the possibly widest range of users that might be interested. However, due to the European orientation of these and comparable projects, the results are likely to be more valuable to international users than to local users. Any comparison with strictly local data sets deriving from e.g. aerial photography or field sampling will challenge the more generic, large scale assessments results as developed by JRC or in this study. While these maps cannot be expected to provide guidance for local or even regional management plans, the data needs to reflect broadly available common knowledge on some of its key attributes.

We have hence undertaken a closer inspection of data composition that laid 'behind' the results and did so by 'zooming' into five locations for which we present the separate data sets as they have been used. With a size of 15.000 km^2, each of these five 'case study' areas forms itself a rather complex and heterogeneous entity, thus fare from allowing a detailed assessment of the true agro-biodiversity situation. On the other hand, the close up and thematic analysis of the different data layers provides some valuable insights that can guide the further development of such an assessment. The case study areas have been selected by using the principle of the smallest common denominator – in this case the limited availability of data from land use intensity assessment (Temme & Verburg, 2010). So we decided to make use of these land use case studies when selecting the following areas:

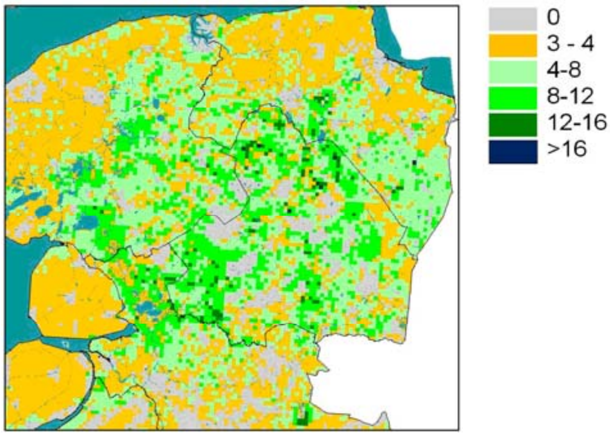
- North-Netherlands region (provinces of Flevoland, Friesland, Groningen, Drenthe, Overijssel & Gelderland)
- Brittany region, France
- Vistula region west of Warsaw, Poland
- Mount Olympus region, Greece
- Castilla La Mancha region, Spain

Due to the size of these areas, but also – admittedly – due to the absence of regional expert knowledge, we will focus on the example of the Netherlands and on only some generic, data-related issues in the remaining case studies. After all, the core research topic is targeted at the European perspective and here we try to deliver advances.

When following the discussion on the results of the other four case studies (France, Poland, Greece and Spain) we need to ask you to consult the thematic maps and legends of Annex 5.

Figure 4.1: HNV JRC-EEA

Figure 4.2: HNV-NL map (Alterra 2006)



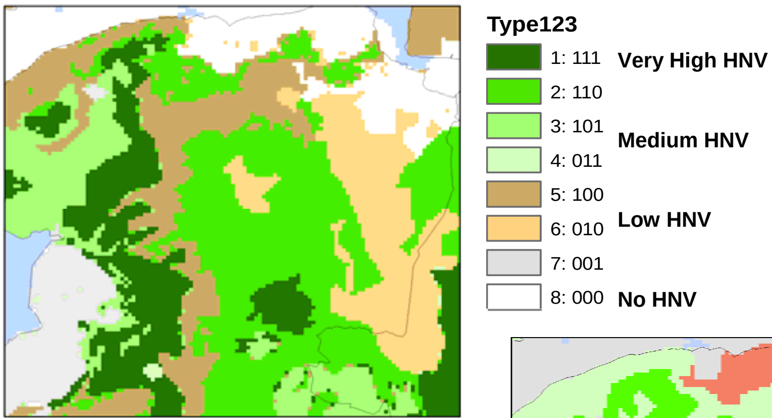
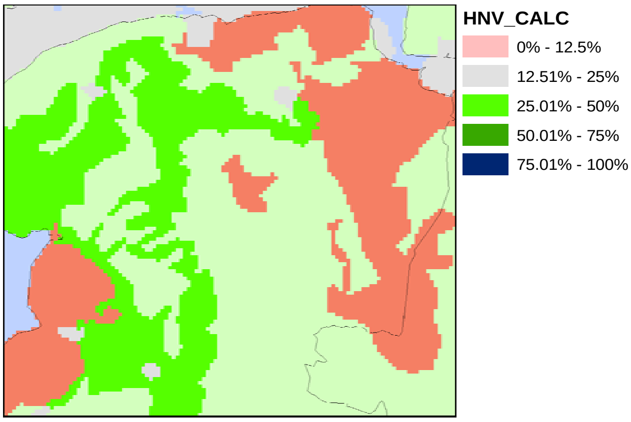


Figure 4.3: HNV Total value this study

Figure 4.4: Type 1 LANMAP Corine Land Cover



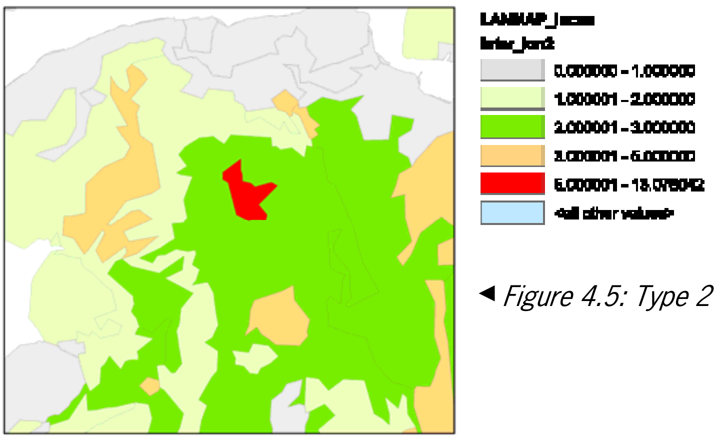


Figure 4.5: Type 2 LANMAP-LUCAS (density)

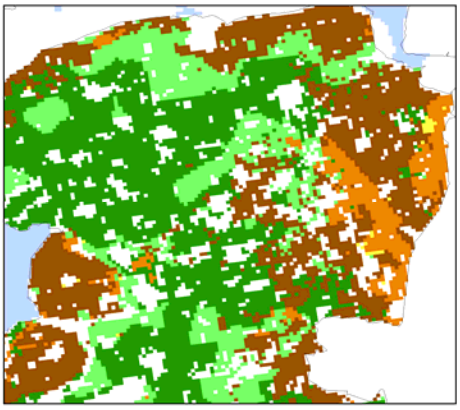
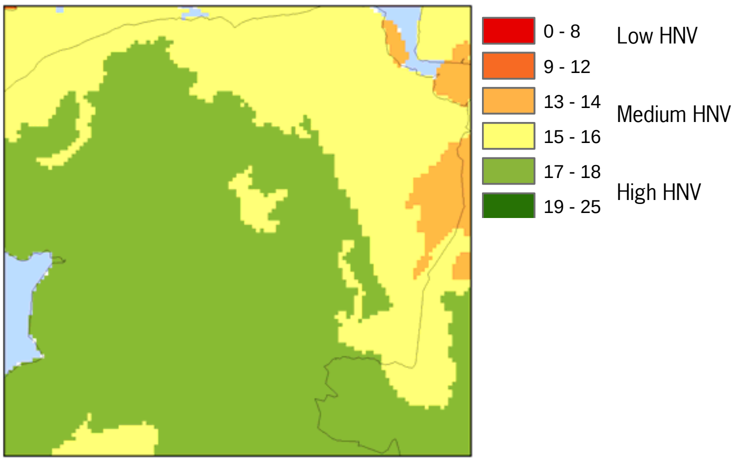


Figure 4.6: Type 2 WOT 4.4 Agricultural Intensity

Figure 4.7: Type 3 Farmland Birds



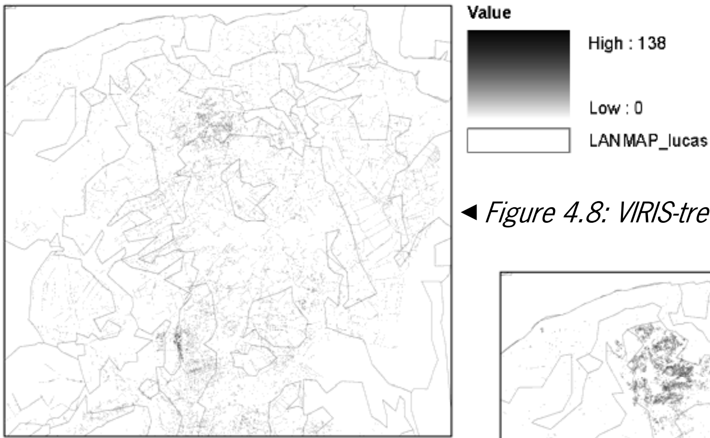
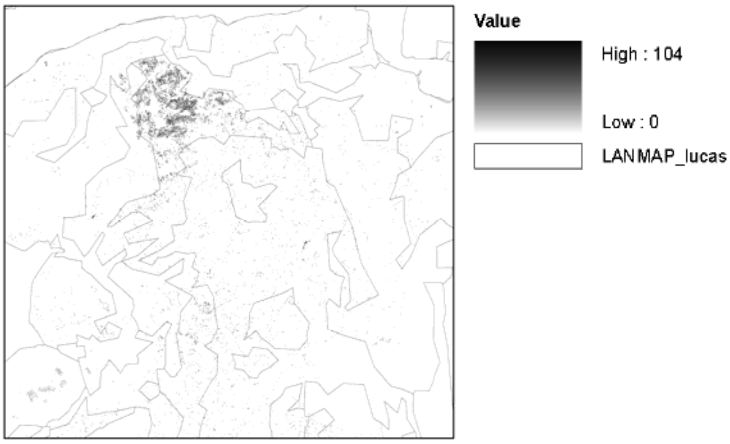


Figure 4.8: VIRIS-tree lines (TOP10 vector)

Figure 4.9: VIRIS-hedgerows (TOP10 vector)



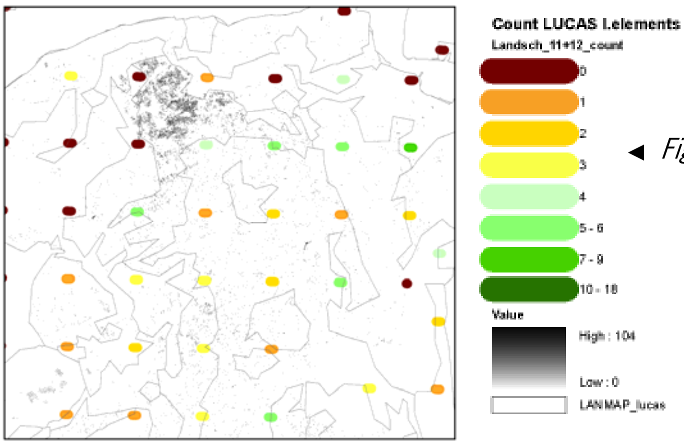


Figure 4.10: VIRIS-hedgerows & LUCAS

The Dutch case study

According to a recent Dutch study on the distribution of HNV farmland in the Netherlands (Elbersen & van Eupen, 2008), Dutch agriculture is still hosting large shares of European populations of farmland breeding birds such as the Lapwing, Black-tailed Godwit, Ruff and Snipe, and they are also important foraging areas for several types of goose. Meadow and wintering birds can be regarded as the most important biodiversity values for which The Netherlands has an international conservation responsibility. From a vegetation perspective there are only very limited habitats of European conservation concern left in Dutch farmland areas, and if present they are only very small patches. Vegetation is therefore not a real factor for delimiting HNV farmland.

A comparison between the Dutch national assessment (Figure 4.2) and the JRC-Map (Paracchini *et al.*, 2008; see Figure 4.1) shows that – with regard to relative land use – there is only a rather little difference between both maps, the HNV share in total utilised agricultural area (UAA) is 13% for the Dutch approach and 15% for the EEA-JRC approach. On the other hand, even a random examination shows that there are quite some clear differences *and* commonalities in the extend and location of these shares. It is obvious that high scores are more pronounced in the JRC assessment, namely along in the inland regions of the Friesland province extending into western Overijssel and northern Gelderland. Also the fragmented HNV farmlands of Drenthe seem to match. However, the Dutch assessment shows many more areas in the middle range (in both cases light green) which probably can be attributed to the high presence of linear elements such as trees and hedges (see Figure 4.8 and 4.9) in many parts of the country. The authors of the Dutch study state themselves, that extensive farming is being perceived entirely differently at the Dutch national level than from the European perspective.

Now finally to the results of this study as shown in Figure 4.3. The first clear difference with the previous results is the representation of HNV farmland aggregated to LANMAP units. Even though fragments of HNV tend to disappear in such aggregations, it is striking how close the high scores match those of JRC. On the other hand, also this study points at more extensive landscapes of the second HNV score (110), this is probably due to the high scores of farmland birds for large proportions of the Dutch inland (Figure 4.7) in combination with fragments of low intensive land use and moderate presence of LUCAS landscape elements (Figure 4.5 and 4.6).

Finally, it can be stated that such regional comparisons provided interesting insights about flaws in the underlying data. When superimposing the original LUCAS sampling data upon the national data on linear landscape elements such as hedges (Figure 4.10), we immediately can recognize the inadequacy of the sampling device: the raster patters at a distance of 18 km between primary Ssmpling units (PSUs) is simply too large to adequately capture the structure of the landscape. The fine-grain texture literally falls between the raster making the results downright misleading (see also Annex 1 and 2).

The French , Spanish, Polish, and Greek case studies

For the comparison of these case studies we point the interested reader to the materials presented in Annex 5. However, we will provide a brief summary of the major findings as part of this section.

Brittany, France

The case study in Brittany is the most striking example for both the need and the opportunity of improving the European HNV assessment. In accordance with wider expert opinion, publications and environmental reporting, Brittany's agricultural lands are potentially rich of HNV. This is especially due to the presence of landscape linear elements which in this case are relatively well captured by LUCAS. Since really high scores are only limited to smaller fractions, the aggregation into landscape units results only in a second rating HNV; but still with a clear difference to JRC's (almost) zero assessment.

Vistula region, Poland

Poland is very much known for its small-scale, traditional agriculture, resulting is fine-grained landscape pattern of rather rectangular structure (lots). Land use is diverse and so is its nature value. The comparison between the JRC results and cumulative map of this study shows a strong resemblance in the upper eastern part where we see low intensive grasslands in landscape units dominated by semi-natural habitats. However, same is true for a finger-like area in the south-eastern section of the study area. The latter is not capture by the JRC map. A plausible explanation is that JRC focuses on farmland birds (very low!), Natura 2000 sites (hardly present) and of national policy guidance. It is interesting to note that the land use intensity data (Temme & Verburg, 2010) allows rather specific representation of likely HNV.

Mount Olympus region, Greece

The comparison between the JRC and the results of this study show that there is general similarity between in terms of the overall distribution patterns of high scoring HNV areas. Detailed comparisons might alter this impression. There is in any case a very close resemblance between Type 1 (semi-natural landscape units) and JRC which points at a possible methodological opportunity of limiting the LANDMAP aggregation to this one type only combined with superimpositions of farmland birds, landscape structure and land use intensity scores. It appears as odd that the high scoring farmland bird results (Mount Olympus?) seem to conflict with patches of low JRC-HNV scores. Results on Farmland Birds and land use intensity are difficult to interpret.

Castella de Mancha region, Spain

In the Spanish example we find substantial differences between the JRC and results of this study. JRC's large central high scoring patch, but also the one at the north-west corner do not or only in fragments come back in our study. According to our study, all landscape units are in the same class, only the superimposition of the land use intensity data introduces structural differences. Interestingly, the higher scores in WOT's Type 1 are entirely compensated by gaps in the Farmland Birds scores. This examples illustrates that further and more detailed studies are required to resolve contradictions and indistinctness.

5 Conclusions and recommendations

Conclusions

This study on the Biodiversity of European agricultural landscapes has provided new and more detailed insights into the development of a high nature value (HNV) farmland assessment. By building upon the conceptual framework of the HNV approach as developed by EEA and JRC (Paracchini *et al.*, 2008), this study undertakes a critical review of all underlying data sets and methodological considerations. We hence do not consider the cumulative final map as the only result, but rather also the implications and observations that have been surfaced during the process. They are summarized here as conclusions and recommendation.

One of the main objectives of our study was to test the potential of LANMAP's landscape units as a main spatial reference framework for the assessment of agricultural biodiversity. This has been done to answer the questions (1) whether certain landscape units host 'inherently' more biodiversity than others, and (2) whether the resulting information can be made directly available to Eururalis in support of future agri-environmental assessments.

The answers to these questions cannot be a simple yes or no since the assessment demonstrated complex data and land use related complexities. However, given the close examination of both the overall result (Figure 3.5) and the comparative analysis undertaken in the five case studies, we come to the conclusion that both a Eururalis and a future HNV mapping effort is not like to find methodological support in a pure landscape aggregation. The reason is that the relatively high variability within most of the landscape units – some of which containing important HNV farmland patches of different proportions – deserve to be methodologically maintained. Given the policy and expert feed-back until now, a partial loss of HNV farmland information due to aggregation is not likely to find acceptance. Nevertheless, aggregation is necessary in a final stage to simplify the many characteristics, but even more to find more simple spatial relationships between the many processes (which can not be done at the pixel level due to spatial inaccuracies).

The second remark shows the current operational part of the answer. The fact is that the omissions in data (E.g. no LUCAS for Eastern Europe, no reliable data for other species groups etc) and the limited coverage of the results from WOT 4.4 makes it is difficult to create an integrated indicator that is usable at this moment. It is clear that the current spatial coverage of the WOT 4.4 results is insufficient for making a reliable integration; directly with the LUCAS data (to create a good HNV type 2 map) and thus indirectly with the other two HNV types. Consequence is also that a good comparison with the EEA-JRC approach for those areas not covered by the WOT4.4 results is limited.

Recommendations

Type 1 (proportion of semi-natural land cover areas) can serve as a valuable spatial reference, especially if supported by additional data on landscape structure, land use intensity and farmland species. However, LUCAS data does not appear to provide yet the necessary information to serve as input for landscape structure. Instead, we suggest to further explore the use of high resolution remote sensing data to model the likely presence of structural diversity in agricultural areas. Such satellite derived synoptic information can be used for many different purposes and in combination with targeted expert advice, such an approach appears as more promising than a continuation with LUCAS results from systematic sampling.

The other promising avenue that we had explored is the assessment of agro-statistical data on land use in order to identify areas of low intensity. Though the approach requires further elaboration, validation and a European-wider coverage, the resulting data is likely to provide important references for HNV.

The third remaining methodological leg of the study is the use of farmland bird data. At this stage and due to limitations in resources and time, we had to confine the assessment to a rather generic scoring system based on 33 selected farmland birds (Hagemeijer *et al.,* 2003). In the future, we propose to favour a regionally and species specific approach which takes into account the real distribution patterns of key species and independent population modelling to arrive at more reliable and detailed results. See also textbox 2.

Textbox 2: Rules and references when building a HNV indicator

For each area to be selected as HNV-farmland:
- Understanding HNV characteristics and what data needs to be used;
- Provides a better understanding of data problems in relation to identifying specific HNV features;
- Results in indicators per HNV farmland type → better starting point for targeting policy (e.g. Agri-environmental measures);
- The identification of HNV farmland is strongly biased by the quality of input data used. To reduce this bias it's better to combine data sources to identify the same HNV feature.

The identification of HNV farmland should be based on a combination of criteria:
- Evidence of HNV farming system (→ link to WOT 4.4);
- Evidence of farmland related indicative high nature value species (birds, vegetation and (not EU wide) butterflies).

So identification of HNV farmland can only be done by combining different sorts of (spatial) information on:
- Land use/land cover;
- Farming systems;
- Biodiversity data.

Use of (bird)count data could be effective → Risks:
- Quality inconsistent between regions/countries.
- Crucial to use counts and not only presence and absence.
- Difficult to make the bird selection. A distinction should be made between:
  - selection of birds for identifying the high quality HNV farmland habitat;
  - selection of birds that need to be targeted in HNV policy because of threat status.

A nested approach should be followed to ensure consistency and EU-wide comparability:
- General identification at EU scale (EU-data sources + expert information);
- More detailed identification at National scale (National + regional data sources);
- Final definite identification at regional scale (local data and localised up-to-date information and involvement).

In the following we would like to make some more specific suggestions regarding the three types of HNV assessments.

HNV Type 2.1: Landscape structural assessment

The estimation can be based on the relationship between the calculated landscapes metrics per CORINE polygon and reference materials. In earlier tests, reference data were obtained for the Netherlands and from the European project Greenveins. Estimation of the amount of woody linear elements can be made directly from satellite imagery based on very high resolution imagery (eg. QuickBird and IKONOS with 1 meter resolution or less) or aerial photography. However, such images are too expensive to obtain for very large areas across Europe. For this reason we used Landsat imagery, available for Europe entirely from the IMAGE 2000 database from JRC. Unfortunately, this imagery has a resolution of 25 meters (multi-spectral) and 10 meters (pan-chromatic), which is not sufficient for the detection of woody linear elements in the landscape. Nevertheless, Landsat satellite imagery can be used very well to obtain information about the landscape structure. It is assumed by the authors that information on the landscape structure can used as a proxy to estimate the amount of woody linear elements. The relationship between landscape metrics and amount of woody linear elements had to be determined for that reason. In general, we observe that landscapes with large and regular fields or parcels are in intensive agricultural areas that are often characterized by a low amount of woody linear elements (which have been removed often in the sixties and seventies during the process of land consolidation), while landscapes with smaller and irregular fields are more often less intensive used and are characterized by more small landscape elements. In order to determine the relationship between the obtained landscape metrics and the amount of woody linear elements in the landscape we used two reference databases: the Dutch VIRIS database and the database from the European project Greenveins.

HNV Type 2.2: Land use intensity

Temme en Verburg (2010) conclude that it is possible to predict the amount and location of intensity of agricultural land in three classes for arable land and in two classes for grassland. As an example, these predictions were made for the Netherlands, Poland, Portugal, Spain and Greece in the year 2000 (using available information) and in the year 2025 (for the SENSOR financial policy reform case). Combination of year 2000 and year 2025 maps of agricultural intensity has allowed classification of transitions into broad categories of intensification, extensification, expansion and abandonment. These combinations and classifications are useful for subsequent quantification of (agro-)biodiversity changes.

Temme en Verburg (2010) have outlined and illustrated the method to achieve such predictions, discussed some of the assumptions that influence its validity and presented tests that could be performed to test that validity.

To make a HNV/agro-biodiversity indicator operational in Eururalis the expansion of the results for the whole of Europe is necessary.

HNV Type 3: Farmland birds

The EBCC monitors the change in the abundance of farmland birds (and many other species) with the Pan-European common bird monitoring scheme (PECBMS). This schemes offers perfect possibilities for the designation and monitoring of HNV areas. Although the current resolution of the output of the scheme (countries or sometimes regions) offers limited possibilities for local or regional spatial analyses, the EBCC aims for producing output on a much finer scale. More detailed information on the driving forces may be also obtained by combining changes in local count data with local information on (changes) in land use with spatial statistical models resulting in distribution and trend maps and information on possible driving forces. The heterogenic nature of the observations and the sparseness of high-quality European environmental data however, make it difficult to model the distribution in detail on a European scale. However, high-quality distribution maps and trend maps could be made by using a multi-scale approach combining national and European environmental data sets in the modelling.

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Annex 1 European landscape structure indicator from LUCAS field transects

Ilse Geijzendorffer, Sander Mücher en Han Naeff

Aim

For the WOT project 'Estimating biodiversity in Europe' (WOT-04-002-170 / 2009-5.2) the aim is to explore the possibility of quantifying an agro-biodiversity indicator for the whole of Europe. How can we quantify the biological value of agricultural landscapes in Europe? The biological value is largely determined by the habitats and species occurring in those landscapes. The richness is on one side determined by the natural environmental conditions and on the other side by its land use history and current intensities in land use. Information on land use and species is already available in many database. Information on European habitats is largely available in the Natura 2000 database. Unfortunately, the Natura 2000 sites are primarily related to protected sites of natural and semi-natural vegetation, which in many occasions were already existing protected sites, and so it does not reflect much of the biodiversity in the wider countryside. The biological value of agricultural landscapes are for a large part determined by its landscape elements. Linear features, such as hedges and lines of trees are important habitats for species in the countryside which are not reflected in the Natura 2000 habitats.

Therefore, our aim here is to estimate the amount of woody linear elements in European agricultural landscapes. This estimation can be used a s part of an agro-biodiversity indicator, to be used in land use scenario's, e.g. CLUE and assessment tools such as Eururalis. As mentioned before, a good agro-biodiversity indicator needs to partially based on the landscape structure in the wider countryside. Aim of the work described in this document is to explore the LUCAS database for this purpose.

Data

Field inventories of landscape elements have been done in different European countries, such as in Austria, Denmark, Sweden, Spain, England and the Netherlands. Unfortunately, these data are hardly accessible and a second problem is that national recording strategies differ to a large extent. Projects such as BIOHAB, EBONE and BIOBIO are putting much effort in the collection of consistent information of point, linear and patch habitats across Europe, but are in general based on a very limited amount of sample sites. In amongst others the SENSOR project, Mücher *et al.* (2008, 2009) investigated the use of satellite imagery to estimate the amount of woody linear elements in the wider country side. Satellite images are an optimal information source to obtain synoptic information on the landscape structure. The shape and size of agricultural fields and semi-natural patches tells us much about the land use intensity. Nevertheless, landscape elements, such as woody linear elements can only be determined by very high resolution satellite images with spatial resolutions around 1 meter (e.g. IKONOS, Quickbird), and must be applied on a sample basis. Satellite images such as LANDSAT ETM+ and SPOT HRV are suitable to cover Europe as a whole and can be used to determine the landscape structure. Nevertheless, the relationship between landscape structure and amount of woody linear elements is not the same for all European regions, and therefore results in estimations.

The LUCAS project of EUROSTAT aims at estimating land cover / use areas by direct observations made in the field across the European Union. The LUCAS database contains approximately 10,000 primary sampling units (PSUs) at distances of 18 km and covering 15 EU countries. The LUCAS sampling design is based on a systematic grid. The grid is created as a double level grid with the PSUs at the first level. The second level defines the location of 10 samples (secondary sample units, SSU) divided over two rows. These SSUs are 300 meter apart centred on the PSU. In total there are approximately a 100,000 SSUs.

A specific aspect of the monitoring, is the sampling of a transect in LUCAS which has been defined to estimate the presence of linear features. The transect is defined by joining the 5 northern SSUs of each PSU. Along each transect (or line) of 1200 meters the crossing linear features are counted. *The number of intersections reported to the length of the transect is used to estimate the density of linear features per area units and therefore the total length.* The field surveys are implemented by national observer teams. For the LUCAS audit, the sample locations are GIS referenced and observers walk along the transect and record all the linear features of 30 m and longer that intersect the transect. The audits have taken place a few times over the last 10 years. See also Figure A1.1.

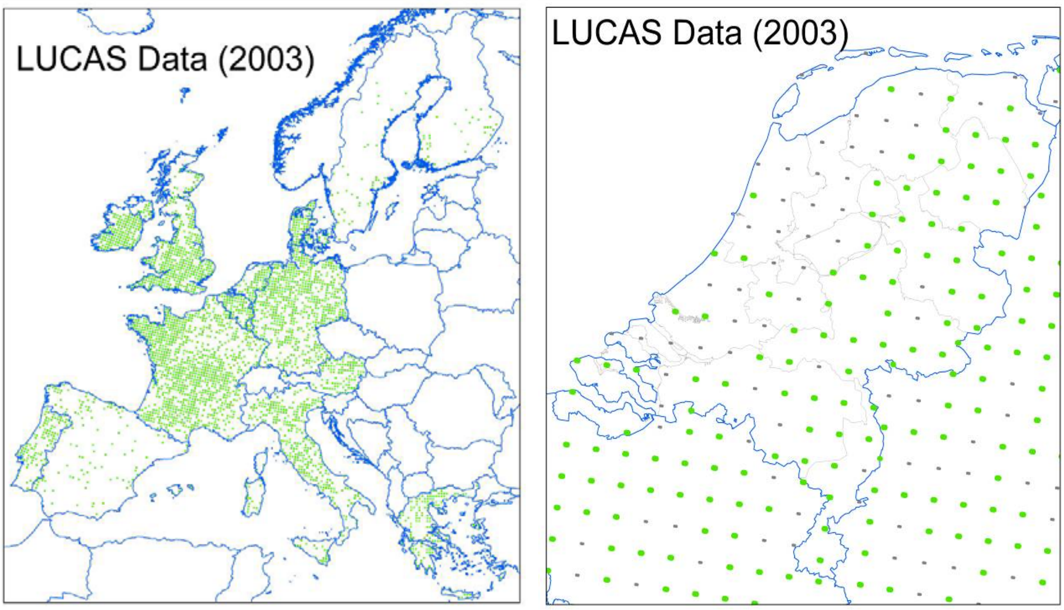


Figure A1.1: The LUCAS field sampling points within Europe (left) and the Netherlands (right).

Field monitoring protocols and specific definitions have changed over time since the start of the project. Definitions for linear features have increased in detail and the number of sampled countries increased. For this project we used the database that was available at that time, i.e. the database of 2003.

For our purpose, we have used the most recent LUCAS data that included the registration of landscape elements. This concerned the LUCAS data from 2003. In 2003, the following European countries were included in the audit:

1. Ireland,
2. England,
3. France,
4. Portugal ,
5. Spain,
6. The Netherlands,
7. Belgium,
8. Luxembourg,
9. Italy,
10. Austria,
11. Germany,
12. Denmark,
13. Greece,
14. Sweden
15. Finland.

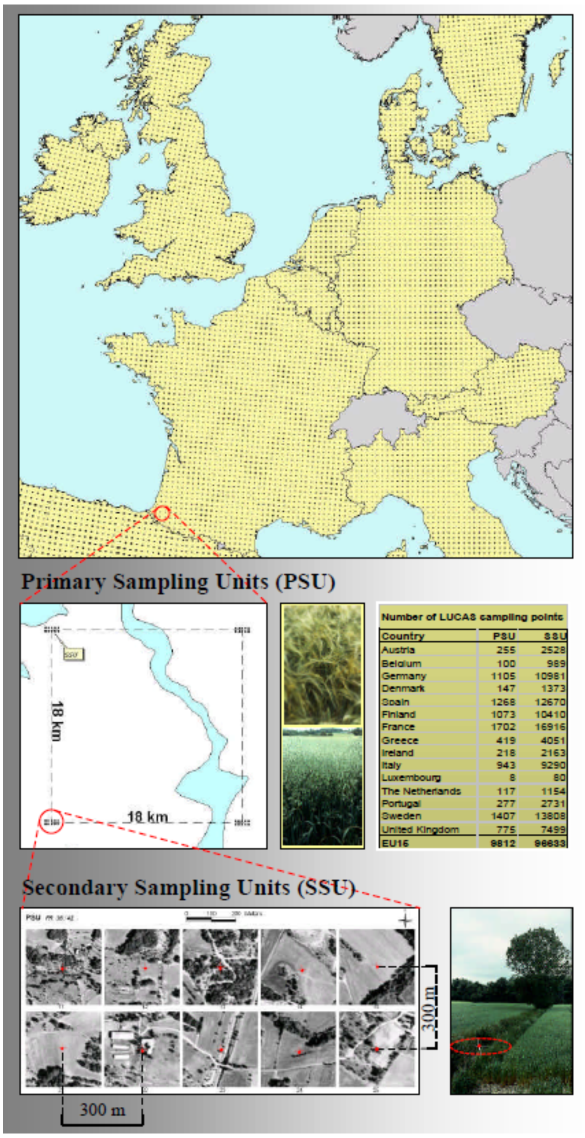


Figure A1.2: The LUCAS double level sampling design.

In the database of 2003, linear elements of shrubby or woody vegetation were only categorized as broad (>3 m in width) or small linear elements (1-3 m in width), while being at least 30 m in length (category 11 and 13 in Appendix 1). Other linear elements such as infrastructure (roads and water bodies) were also recorded in LUCAS, but were considered to be less relevant for an agro-biodiversity indicator. From this point onwards, all linear elements referred to in the text refer to linear landscape elements of shrubby and/or woody vegetation. See also Figure A1.2.

Approach
The first step was to validate the LUCAS registration of linear elements. The LUCAS data was evaluated based on the detailed dataset available for the Netherlands, namely the digital topographical maps 1:10.000 (Top10 vector map).

The second step was to aggregate the landscape structural information (at the level of the LUCAS transects) to spatial units. Examples of spatial units are for example administrative units, hour blocks (5 by 5 km) or landscapes such as defined by LANMAP (Mücher *et al.,* 2009). Since landscapes are a natural entity, LANMAP units has been selected as the most suitable aggregation level (next to the hour blocks) It is assumed here that if the LUCAS data is a good approximation of the landscape elements present at regional scale, the LUCAS data can be used in all European regions (see Figure A1.3).

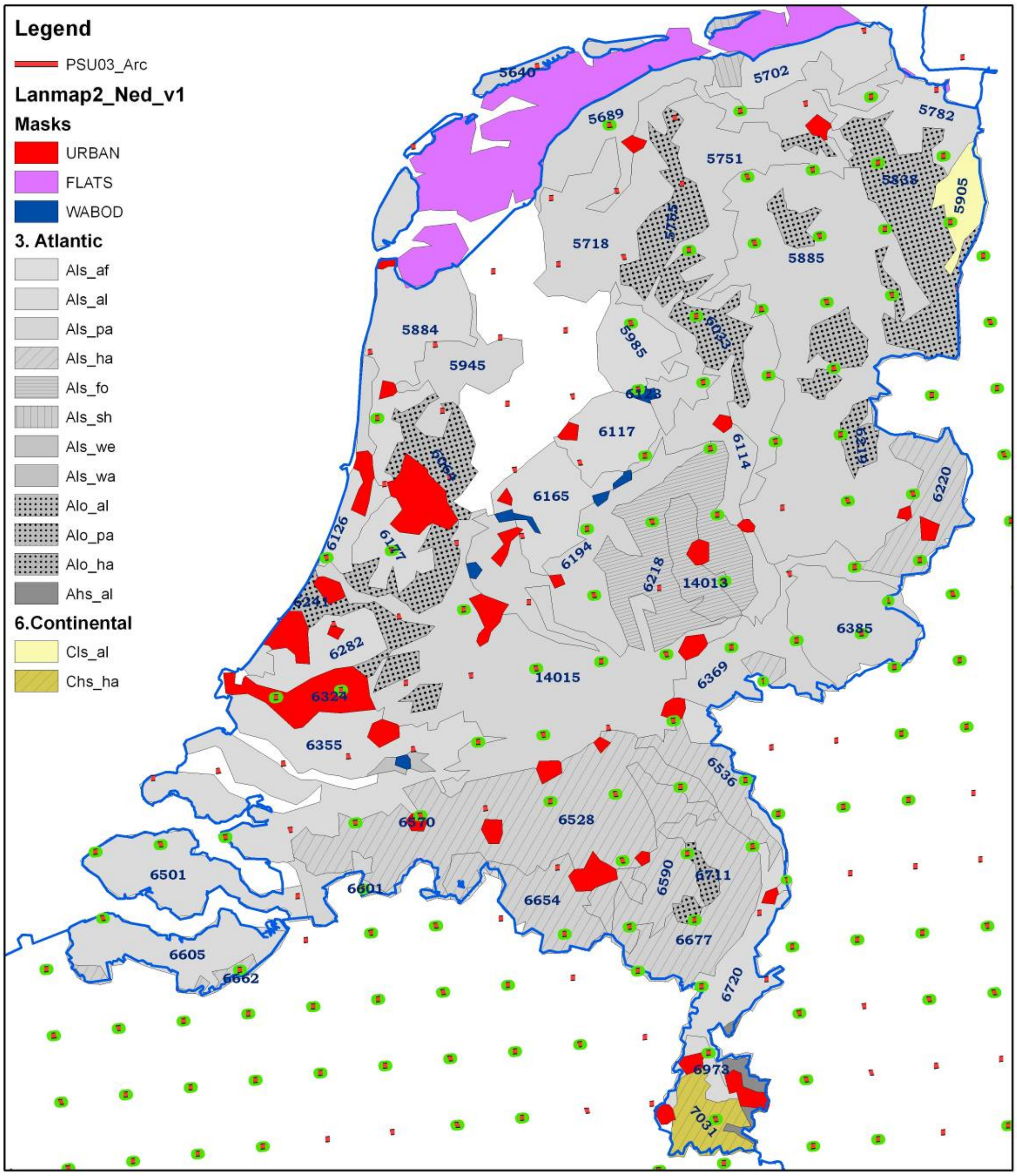


Figure A1.3: The location of LANMAP units (Level 4) and the LUCAS transects in the Netherlands.

LUCAS data were validated for the Netherlands at several spatial levels to identify the proper scale for regional estimates. For that purpose, the LUCAS data were compared with:

- The Top10 vector map. The Top10 vector map allows for a local comparison of landscape elements and is very well documented;
- Length and density of linear element per landscape unit (LANMAP level 4. LANMAP is a hierarchical landscape classification with 4 levels determined by combinations of climate, altitude, parent material and land use. At the lowest hierarchical level there are 350 landscape types, while at the highest level only 8. The LANMAP database has 14,000 landscape units with a minimum area of 11 km^2 (Mücher *et al.,* 2009);

- Length of linear elements in an 'hour block'. These blocks are used in the Netherlands for biodiversity monitoring and a correlation of LUCAS transects and hour block length of linear elements would make it easy to link it with available biodiversity data.

Results

1. LUCAS and the top 10 vector map

Each LUCAS transect was coded to have an intersect with a linear elements or not (1 or 0). For the Netherlands, there are 116 LUCAS sampling points (PSUs). Of these samples, 70 transects recorded linear elements.

When comparing the intersection of LUCAS transect with the expected intersections according to the Top10 vector map, **a correlation of 68% was found**. In 79 of the 116 transects, the registration was verified with the Top10 vector (Table A1.1).

Table A.1.1: Correlation of the LUCAS transect and the Top10 vector map

	Intersect expected based on Top10 vector map	**No intersect expected based on Top10 vector map**	**Total**
LUCAS transect with linear element recorded	**45**	25	70
LUCAS transect without linear element	12	**34**	46
Total	57	59	116

2. LUCAS and the LANMAP units

For each LANMAP unit, the length of linear elements was calculated based on the Top10 vector map. The length of Top10 linear elements was then correlated with the number of intersections of the LUCAS transects located within a LANMAP unit (Figure A1.4). Linear correlation only had an R-square of 0.0037. Additionally, the density of linear elements per LANMAP unit (= length of linear elements per LANMAP unit divided by the LANMAP unit surface) was correlated with the LUCAS intersects yielding a R-square of 0.093 (Figure A1.5).

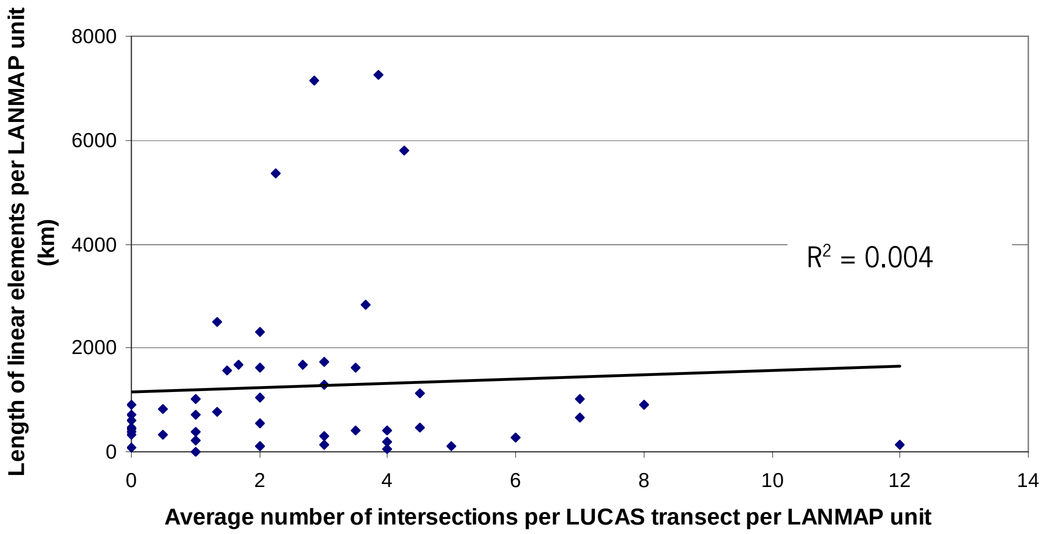


Figure A1.4: Correlation of the length of linear elements per LANMAP units and the number of intersects per LUCAS transect.

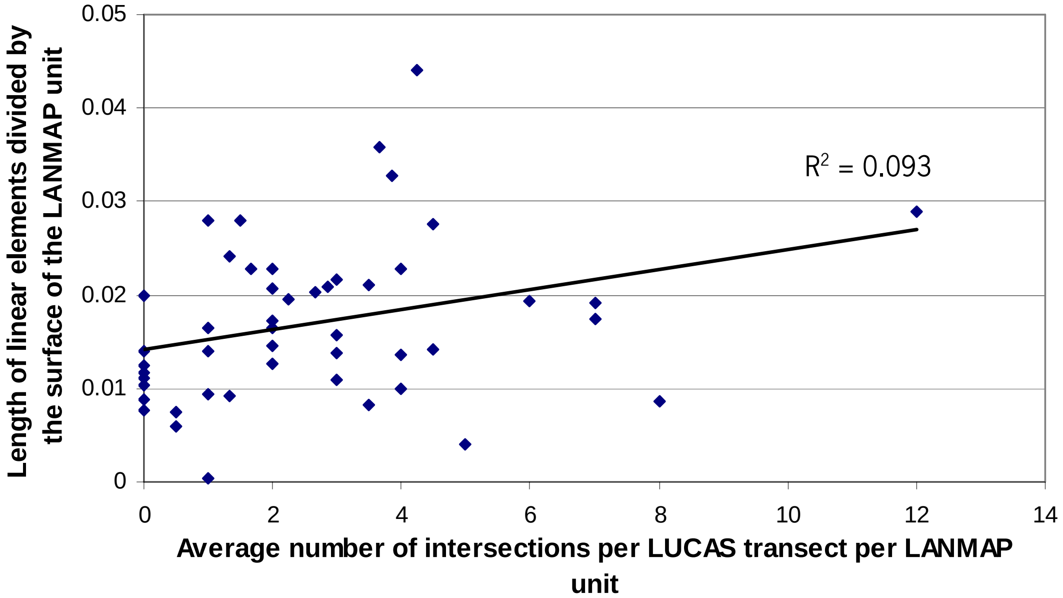


Figure A1.5: Correlation of the linear element density of LANMAP units (at level 4) y3 and the number of intersects per LUCAS transect.

3. LUCAS and the 'hour block'

For each hour block, the length of linear elements was calculated based on the Top10 vector map. An hour block is 25 km^2. The length of linear elements of an hour block was correlated with the number of intersections the LUCAS transect located within that hour block (see Fig. A1.6). Linear correlation only had an R-square of 0.088 and a polynomial correlation had an R-square of 0.141.

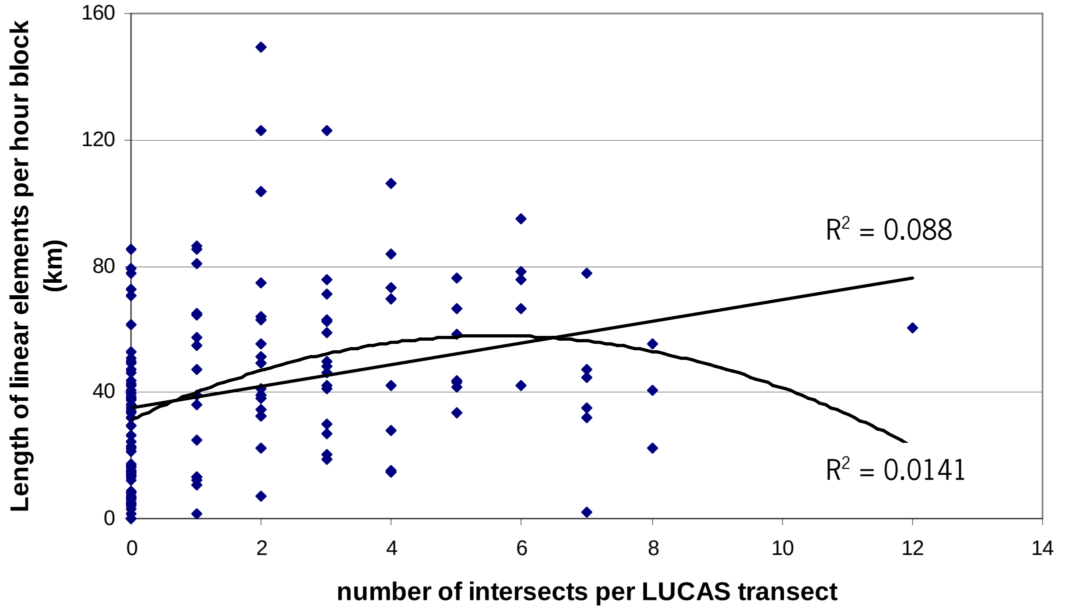


Figure A1.6: Correlation of LUCAS transects with the length of linear elements in hour block s.

Table A1.2: Definitions for recording linear features in LUCAS transect (taken from 2001 Lucas Nomenclature, Eurostat; linear features definitions changed in 2005)

Linear Feature	Width	New code	Definition/Observation
Grass margin	>1 - < 3 m	01	Strip of mainly uncultivated (not agriculturally used) vegetation, dominated by grasses, grass-like plants, forbs or herbs. Often located at the edge of fields, between cropped areas (beetle banks) or bordering roads and tracks (roadside verge) as well as associated with water courses.
	> 3 m	02	
Shrub or wood margin including line of trees	>1 - < 3 m	11	Shrubby or woody vegetation in a continuous linear shape, often managed (hedge) but also without evidence of recent management. This category includes also line of trees. Shrub or wood margins are found as field boundaries within agricultural land or alongside roads or water courses.
	> 3 m	12	
Cultural, man made features	>1 - < 3 m	21	Various man made built structures e.g. walls, dams or terraces etc. of different material such as dry stones or bricks but also mortared walls. All walls are to be recorded, independently from their width.
	> 3 m	22	
Ditches, channels	>1 - < 3 m	31	"Artificial" drainage or irrigation line, usually straight, temporary or permanently wet, often as standing water. Ditches are frequently found in agricultural land for lower the water table or drainage. They are often associated with roadside verges used to drain the runoff from the associated road. Ditches are to be recorded independently from their width. Edges or banks along the small water body are to be recorded separately as grass, shrub or wood margin.
	> 3 m	32	
Rivers and streams	>1 - < 3 m	41	A linear body of water, often flowing in its naturally shaped bed through the land into a body of water such another stream, a lake or the ocean. Banks or edges (riverside vegetation) have to be recorded separately as grass, shrub or wood margin.
	> 3 m	42	
Electric lines		50	Power supply line mounted on pylons used to transport electricity, including telephone lines.
Tracks	>1 - < 3 m	61	Usually rough tracks, mainly used to access agricultural land or forests, in most cases unpaved. They are not part of the public road network thus often closed for public transport. This category includes all type of paths and cycle tracks. Roadside vegetation has to be recorded separately.
	> 3 m	62	
Roads	>1 - < 3 m	71	Mainly part of the official traffic road network composed of roads of different levels (urban streets to highways). Roadside vegetation has to be recorded separately.
	> 3 m	72	
Railways		80	A set of rails on which trains run. Green linear features bordering the railway track are to be recorded separately.
other		90	Anything not specified in other classes. Description is to be given in the "Remarks".

Conclusion
Based on all available datasets for the Netherlands, The LUCAS transects seem to correlate only reasonably well on a very small spatial level. Correlations at a higher aggregation level (LANMAP or hour blocks) are not significant. This suggests that the variations in landscape structures is thus high that the resolution of the LUCAS sampling points can not be assumed to be representative for the amount of landscape features at a regional level. The more recent audit of landscape elements has not increased the sample resolution, so it will face the same problem.

The question is whether the sampling resolution can be increased to the point where it is representative for regional landscape structure. This may lead to very costly and voluminous monitoring. However, it might be possible to only increase the sample resolution in specific regions (e.g. LANMAP units), that are characterized by a high variability of landscape elements. Or representative regions of specific LANMAP units may be monitored in detail and the findings extrapolated to the whole of Europe (as was attempted in SENSOR).

Annex 2 Remotely sensed landscape structure and assessment of landscape elements

Sander Mücher, 2009

The biodiversity of European agricultural landscapes depends to a large extent on the amount of small landscape elements in the landscape. This is translated in the hierarchical HNV concept (section 2.2) by type 2: farmland dominated by low intensity agriculture or a mosaic of semi-natural and cultivated land and small landscape elements. Low intensity traditional landscapes are often very rich in small landscape elements. Under the pressure of increasing intensification and often associated land consolidation many of the landscape elements got lost, and therefore resulted in a loss of biodiversity. There are a number of countries that have their national inventory of small landscape elements and biotopes. Unfortunately, these data are hardly accessible and a second problem is that national recording strategies differ to a large extent. Projects such as BIOHAB, EBONE and BIOBIO are putting much effort in the collection of consistent information of point, linear and patch habitats across Europe, but are in general based on a very limited amount of sample sites.

The LUCAS project of EUROSTAT aims at estimating land cover areas by direct observations made in the field across the European Union. The LUCAS database contains approximately 10,000 primary sampling units (PSUs) at distances of 18 km and covering 15 EU countries. The LUCAS sampling design is based on a systematic grid. The grid is created as a double level grid with the PSUs at the first level. The second level defines the location of 10 samples (secondary sample units, SSU) divided over two rows. These SSUs are 300 meter apart centred on the PSU. In total there are approximately a 100,000 SSUs. A specific aspect of the monitoring, is the sampling of a transect in LUCAS which has been defined to estimate the presence of linear features. The transect is defined by joining the 5 northern SSUs of each PSU. Along each transect (east-west) of 1200 meters the number of linear features (> 30 m) that are crossed are counted. Specific linear features of interest are class 11 and 12: "Shrubby or woody vegetation in a continuous linear shape". This category includes also line of trees. Shrub or wood margins are found as field boundaries within agricultural land or alongside roads or water courses. The number of intersections reported to the length of the transect is used to estimate the density of linear features per area unit and therefore the total length. Unfortunately, results indicated that the estimation of the total length per region were disappointing (at different scale lengths) in an experiment for the Netherlands. A reason for this could be the spatial complexity of linear elements which are not easy to estimate using a systematic transect methodology. Moreover, large differences were noticed between countries due to different interpretations by the field survey teams which are not related to the real situation (noticed at country border lines). Although for countries, like France and England the regional differences within the country seemed to be quite realistic according to several landscape experts. So a better training of field teams seems to be one option for improvements. Although the authors are convinced that the use of transects are not optimal for assessing linear features throughout the landscape, the method is very suitable for estimating crop acreages. Therefore the use of satellite images might be an alternative to estimate the amount of linear elements more consistently throughout the landscape.

Satellite images are an optimal information source to obtain synoptic information on the landscape structure (Mücher *et al.,* 2008, 2009). Nevertheless, landscape elements, such as woody linear elements can only be determined directly by very high resolution satellite images with spatial resolutions of a few meters or higher (e.g. IKONOS, Quickbird) or by aerial photo interpretations. Since these kind of EO images have also very high costs they must be applied on a sample basis. Contrary, high resolution satellite images (10-30 m spatial resolution) such as LANDSAT ETM+ and SPOT HRV are available for the whole of Europe and can be used to determine the landscape structure (e.g. amount, size and shape of individual patches). However, these images can not be used to detect directly small landscape elements due to its spatial resolution. Nevertheless, relationships between landscape structure and amount of landscape elements do exist, but these relationships differ per region, and therefore empirical relationships have to be calibrated (to estimate the amount of landscape elements).

Within the SENSOR project a methodology (Mücher *et al.,* 2007, 2008, 2009) has been developed to estimate the amount of woody linear elements based on land cover information in combination with information on the landscape structure. Concerning landscape structure information about characteristics of individual patches will play a central role. Patches are defined by Forman & Godron (1986) as a nonlinear surface area differing in appearance from its surrounding and, normally, patches in a landscape are plant and animal communities.

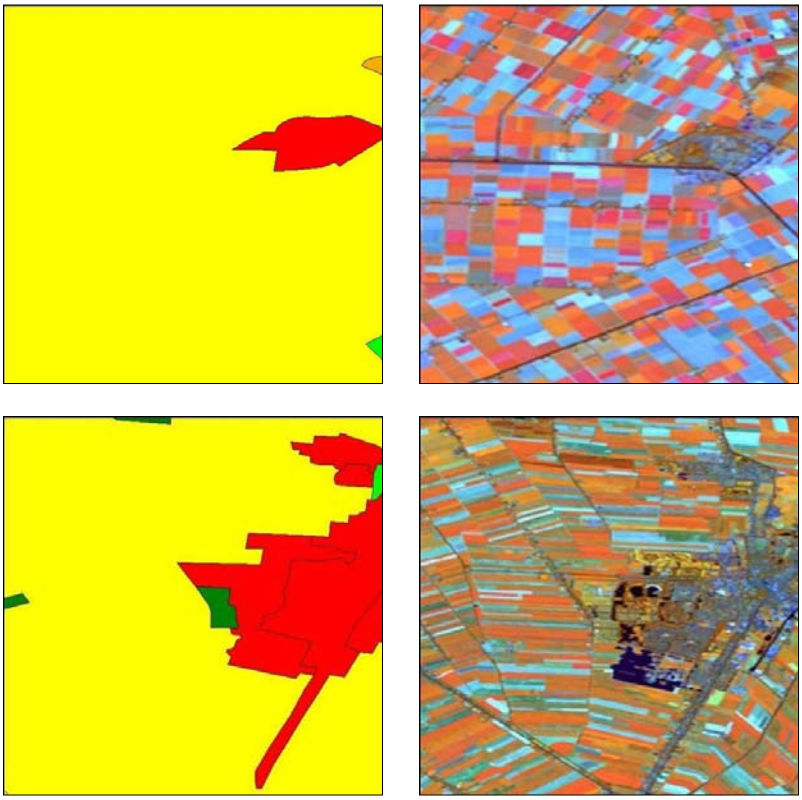


Figure A2.1 Above left (CORINE land cover) and right (Landsat TM image) an example (scale ~ 1: 80.000) for an arable land region in the Flevopolders where the agricultural fields are relative large and rectangular in shape. The agricultural production on this reclaimed clayey land from the sea (polders) has a high production and generates higher incomes for the farmers. Below left (CORINE land cover) and right (Landsat TM image) an example for arable land in the Groningse "Veenkolonieën", a reclaimed peatland area near Veendam where the agriculture fields are small and rectangular due to the history of land reclamation. The farmers in this region have always been relatively poor and there is a high unemployment in the region.

From the example below, see Figure A2.1, it must be clear that CORINE land cover does not provide much information about the landscape structure but it is a major source of information next to the original satellite images. So, a combined use yielded the highest benefit for the SENSOR project. Above left (CORINE land cover) and right (Landsat TM image) an example (scale ~ 1: 80.000) for an arable land region in the Flevopolders where the agricultural fields are relative large and rectangular in shape. The agricultural production on this reclaimed clayey land from the sea (polders) has a high production and generates higher incomes for the farmers. Below left (CORINE land cover) and right (Landsat TM image) an example for arable land in the Groningse 'Veenkolonieën', a reclaimed peatland area near Veendam where the agriculture fields are small and rectangular due to the history of land reclamation. The farmers in this region have always been relatively poor and there is a high unemployment in the region.

The methodology

The SENSOR method for the regional assessment of woody linear elements on basis of remotely sensed landscape structure had the following steps (Figure A2.2):

1. Segmentation of the satellite images;
2. Calculation of the dominant land cover type per segment (SID);
3. Dissolving adjacent segments with the same land cover type, resulting in newly established CORINE polygons (CPID)with a more detailed borders;
4. Calculating landscape metrics per Corine polygon (CPID);
5. Estimate the amount of linear features (m/ha) based on the indentified relationship between landscape metrics and reference data from the Netherlands and Greenveins database.

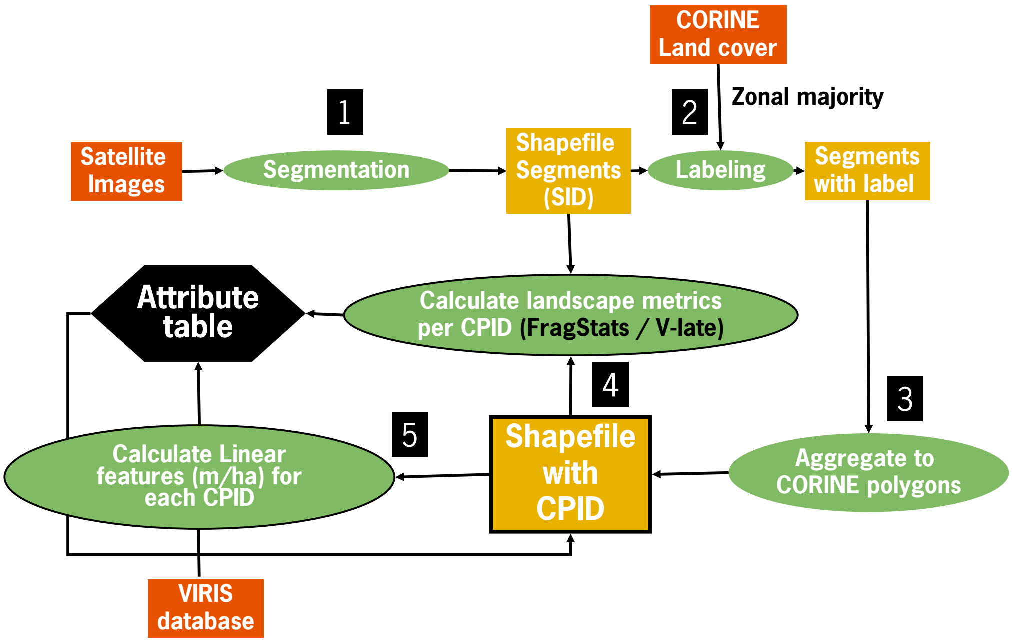


Figure A2.2: Flowchart of the methodology to estimate the amount of wooded linear elements (m/ha) per CORINE polygon (CPID)

The estimation is based on the relationship between the calculated landscape metrics per CORINE polygon and reference materials. Reference data were obtained for the Netherlands and from the European project Greenveins. Estimation of the amount of woody linear elements can be made directly from satellite images based on very high resolution images (eg. QuickBird and IKONOS with 1 m resolution or less) or aerial photography. However, such images are too expensive to obtain for very large areas across Europe. For this reason we used LANDSAT images, available for Europe entirely from the IMAGE 2000 database from JRC. Unfortunately, these images have a resolution of 25 meters (multi-spectral) and 10 meters (pan-chromatic), which is not sufficient for the detection of woody linear elements in the landscape. Nevertheless, LANDSAT satellite images can be used very well to obtain information about the landscape structure. It is assumed by the authors that information on the landscape structure can used as a proxy to estimate the amount of woody linear elements. The relationship between landscape metrics and amount of woody linear elements had to be determined for that reason. In general, we observe that landscapes with large and regular fields or parcels are in intensive agricultural areas that are often characterized by a low amount of woody linear elements (which have been removed often in the sixties and seventies during the process of land consolidation), while landscapes with smaller and irregular fields are more often less intensive used and are characterized by more small landscape elements. In order to determine the relationship between the obtained landscape metrics and the amount of woody linear elements in the landscape we used two reference databases: the Dutch VIRIS database and the database from the European project Greenveins.

- Landscape structure: large & regular fields
- Land use intensity: high
- Low amount of green linear elements
- Low landscape permeability

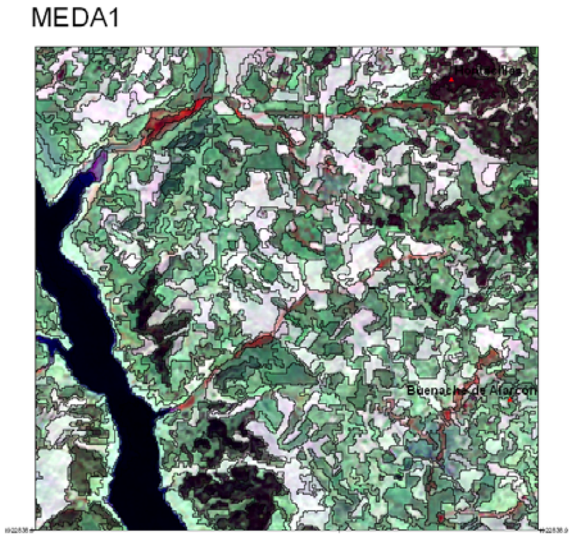
- Landscape structure: smaller & irreg. fields
- Land use intensity: medium
- High amount of green linear elements
- High landscape permeability

Figure A2.3: Case of aerial photographs demonstrating that areas with large and regular field have often small amount of linear feature, while less intensive agricultural areas with smaller and more irregular fields have a higher amount of woody linear elements.

Results

The result of the developed methodology is shown here for two sample areas, each of 50 by 50 km, of which one is located in Central Spain and one in Western France. The predicted amount of woody linear elements is only calculated for agricultural land cover classes. All other classes are masked.

Sample CATM1 (FRANCE)



Detail central area sample (10x10 km) CATM1 with segmentation

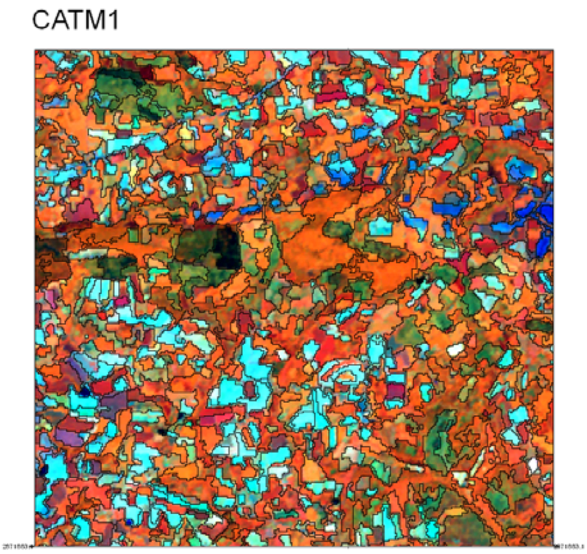
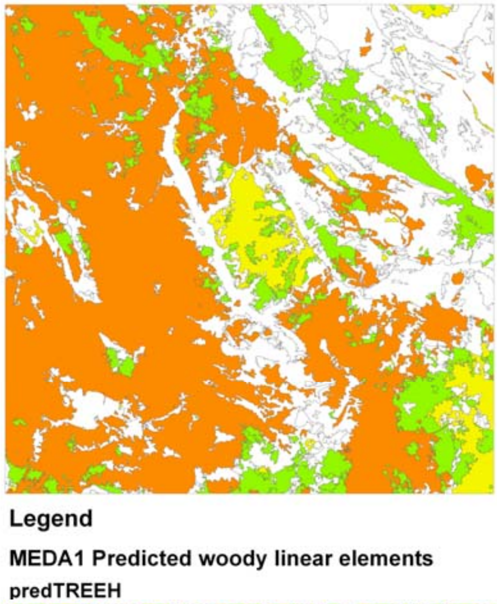
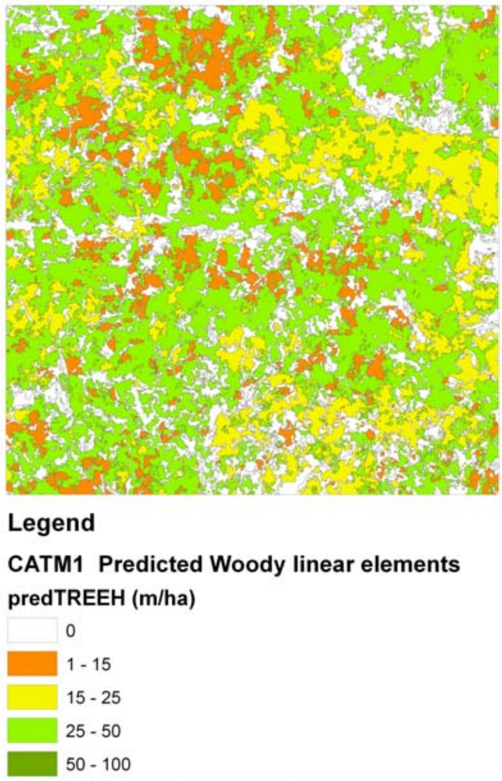


*Figure A2.4: Detail central area sample (10 km * 10 km) MEDA1 with segmentation with an area of 2500 km²*

Sample MEDA1 (SPAIN) with an area of 2500 km²





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Annex 3 Allocated agricultural land use intensity

Temme & Verburg, 2010

Allocation resulted in maps of agricultural intensity for the five countries for the year 2000 and for the year 2025. These 10 maps are in Annex 3 . To introduce these maps, an example is given in Figure A3.1 for an area in the South East of Spain.

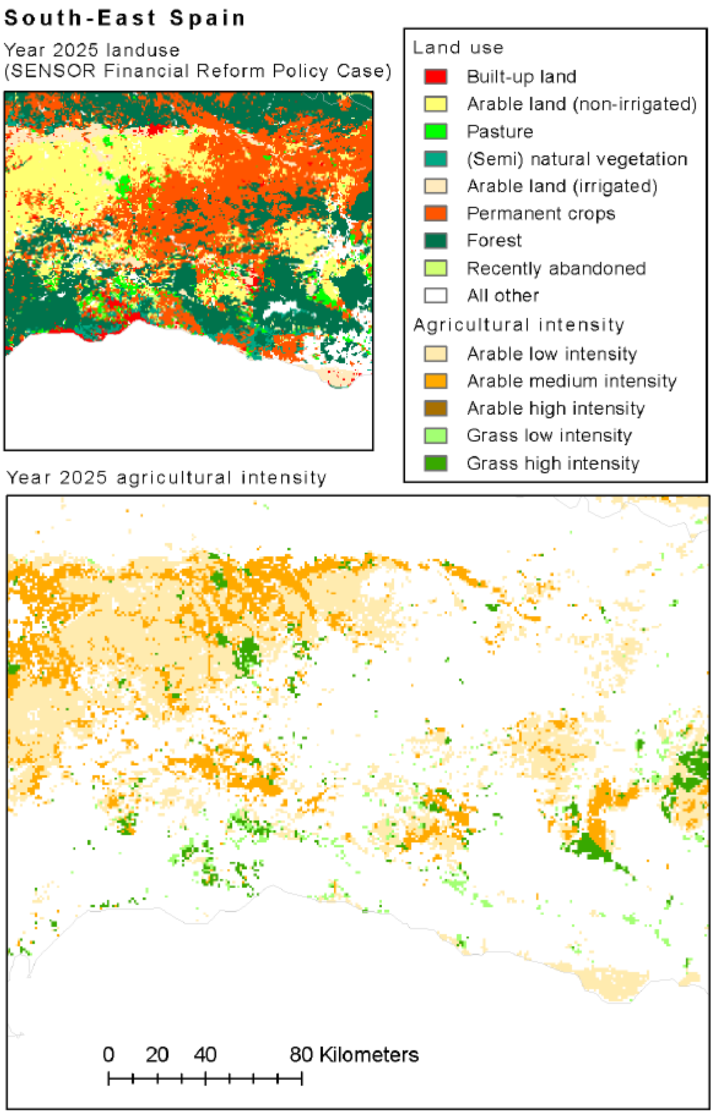


Figure A3.1: Example map of year 2025 agricultural intensity allocation for the South.East of Spain

Figure A3.1 illustrates that the five maps for year 2000 and the five maps for year 2025 have in common. First, arable or grassland in intensity classes are only predicted in locations that have arable or grassland respectively in the land use map. No prediction is made for other areas. Second, the pattern of different intensities within areas of arable or grassland is independent of the location of other land uses. In other words, the probability of a location for each intensity class is only dependent on the underlying driving factors, not on the proximity of other land uses.

Annex 4 Selection of farmland birds for assessing high nature value farmland areas

M. van Eupen & W. Hagemeijer

For European Breeding birds, as indicated by the 'EBCC Atlas of European Breeding Birds, their distribution and abundance' (Hagemeijer & Blair 1997), an attempt was made to select species that are characteristic for high nature value (HNV) farming areas.

A list of habitats used by European breeding birds was compiled by EBCC in the autumn of 2003. This was done using the EUNIS habitat classification. The resulting data file was modified for use in the definition of high nature value farming areas. EUNIS habitat codes that correspond with high nature value agricultural habitats (as provided by B. Elbersen) were selected. Subsequently birds were selected from the overall list, using the identified EUNIS habitats.

Defining habitat use of European breeding birds using the EUNIS habitat classification
The section below (after v. Kleunen 2003) describes the methods that EBCC applied to describe the habitat use of European Breeding birds using EUNIS habitat classification.

A. Status of breeding birds in bio-geographical regions
As a first step the status of breeding birds in eleven European bio-geographical regions was determined, using the geographical map with bio-geographical regions (Roekaarts, 2002) and reference books on the distribution of European breeding birds: *The EBCC Atlas of European Breeding Birds* (Hagemeijer & Blair, 1997) and *An Atlas of the Birds of the Western Palearctic* (Harrison, 1982).

B. Habitat use
Secondly an extensive literature search to habitat use of breeding birds was done using preferably regional breeding bird atlases with a view to specify habitat use per bio-geographical region (table 1). Unfortunately some useful sources like Scandinavian atlases, covering the Boreal and Arctic bio-geographical areas and South-eastern European reference works (especially Steppe region), could not be used in the time available for this study as they were written in native languages. Additional data were extracted from ornithological reference works on European birdlife like *The EBCC Atlas of European Breeding Birds* (Hagemeijer & Blair 1997), *Birds of the Western Palearctic* (Cramp *et al.* 1997-1994), *Handbuch der Vögel Mitteleuropas* (Glutz von Blotzheim *et al.* 1966-1997), *Handbook of the Birds of the World* (del Hoyo *et al.* 1992-2003) and *Europese Vogels. Alle vogels van Europa, Noord-Afrika en het Midden-Oosten* (Mullarny *et al.* 1999).

The habitat-descriptions preferably specified per bio-geographical region and in order of importance were listed in a draft-data matrix. Finally they were translated to EUNIS habitat types as described in section 1.3.

Habitats were defined for all European breeding bird species as described in the *EBCC Atlas of European Breeding Birds* (Hagemeijer & Blair, 1997), except for invasive species. Habitats are not described for irregular or rare breeders in a bio-geographical region and species who's distribution is limited to the edges of a bio-geographical region and are thus not representative for that region.

C. Conversion to EUNIS habitat classification
EUNIS is the European Nature Information System, developed and managed by the ETC for the European Environmental Agency (EEA) and the European Environmental Information Network (EIONET). It includes a habitat-classification and is used for studies and reporting activities related to environmental issues concerning the European Union (EU), in this case the development of indicators for biodiversity.

The EUNIS habitat classification covers all types of habitats (natural and artificial) occurring in Europe and is based on characterising elements of the biotic environment together with abiotic factors operating together at a particular scale. Up to five levels of habitat types are distinguished. Level 1 is the most global classification and level 3-5 are the most refined. In this study the habitat types generally are expressed in level 2 codes. However in some cases level 3 classification is mentioned.

Conversion to EUNIS habitats
A criteria based key for EUNIS-habitats was used to convert the habitat descriptions from literature to EUNIS habitats (Davies & Moss 2002a or on the internet at: http://mrw.wallonie.be/dgrne/sibw/EUNIS/). A geographical map with EUNIS-habitats would have been useful for this purpose. Unfortunately it does not exist. The CORINE Land Cover Map, a different habitat-classification, put available for this study by the EEA, was used to clarify the geographic distribution of some habitat types. This approach could not be applied in all cases because the CORINE habitats as expressed on the geographical map often encompass several EUNIS-level 2 habitats (Davies & Moss2002b).

In this study the breeding habitat is defined as all habitats used and required by a bird in the breeding period. In many cases breeding birds use a complex of EUNIS level 2 habitats. This especially applies to species with large home-ranges, like most non-passerines. For these species different breeding and feeding habitats can be distinguished. For example: many raptor-species nest in forest habitats but use open habitats for hunting. Therefore in the data matrix distinction is made between EUNIS-habitats used for nesting, foraging and both.

Generally breeding habitats are described in EUNIS-level 2 codes. A minority of the records is as a consequence of lack of good information described (partially) in EUNIS-1 codes or a cluster of EUNIS-level 2 codes (appendix). EUNIS level 3 codes are used only if the habitat in question is at variance with the other habitats in the same EUNIS-level 2 category (appendix).

Sorting habitats in order of importance
Ranking of the habitats in three categories: primary, secondary and others, was at first instance done on the basis of qualitative or quantitative information on breeding bird densities from literature, on the condition that the habitat in question is relevant for the bio-geographical region. In reality it appeared not always to be possible to sort habitats in order of importance on the basis of concrete data and a ranking was made by expert-judgement. In cases of doubt several habitats were placed in the same category.

Modification of EUNIS data file for use in the definition of high nature value farming areas
The habitat use of European breeding birds using the EUNIS habitat classification was compiled by EBCC into a spreadsheet file. This file did not allow easy querying for specific habitat types. The spreadsheet file was converted into a database file with records describing one habitat per species/biogeographic area combination, with an indication of habitat preference (primary, secondary, other) and of use of the habitat (nesting, foraging, both). (This data conversion was at the same time also done by A. van Kleunen at SOVON, for EBCC. Comparison of the results shows that results are similar.)

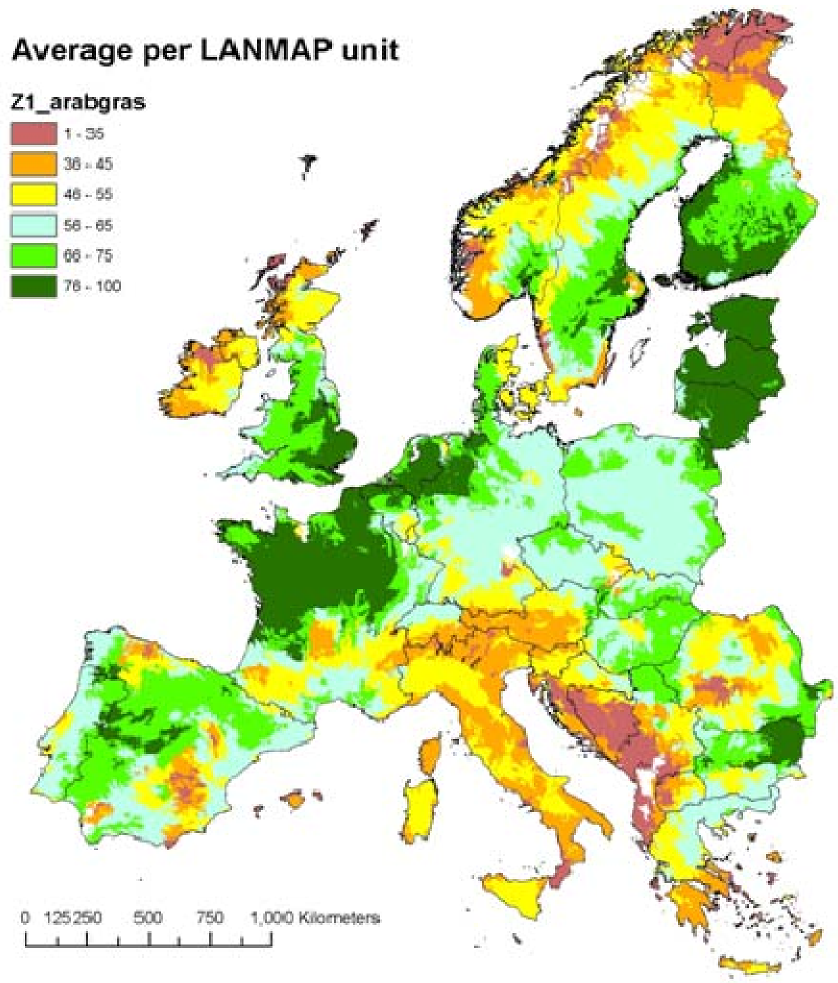
This database provided the basic data source from which species were selected that are characteristic for HNV farming areas.

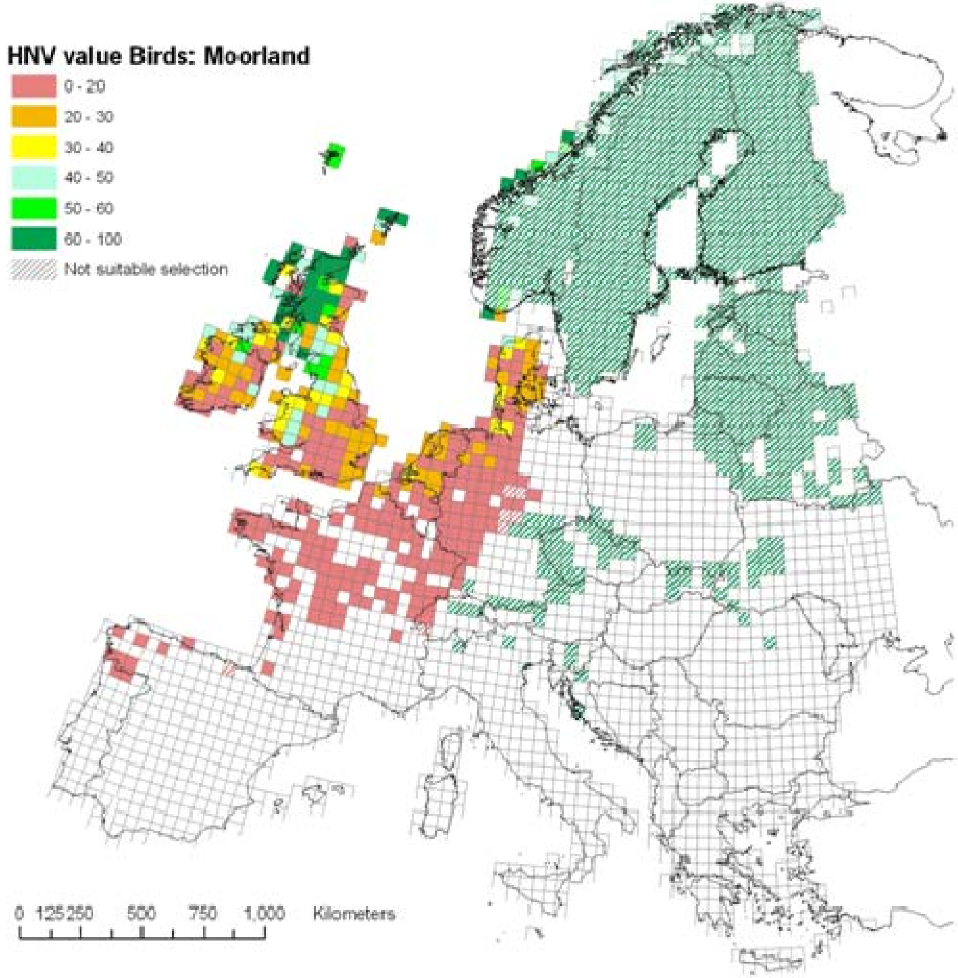
Identification of EUNIS habitat codes that correspond with high nature value farmland area classes
In the Eunis habitat classification matches were identified for the HNV area classes as shown in Table A4.1.

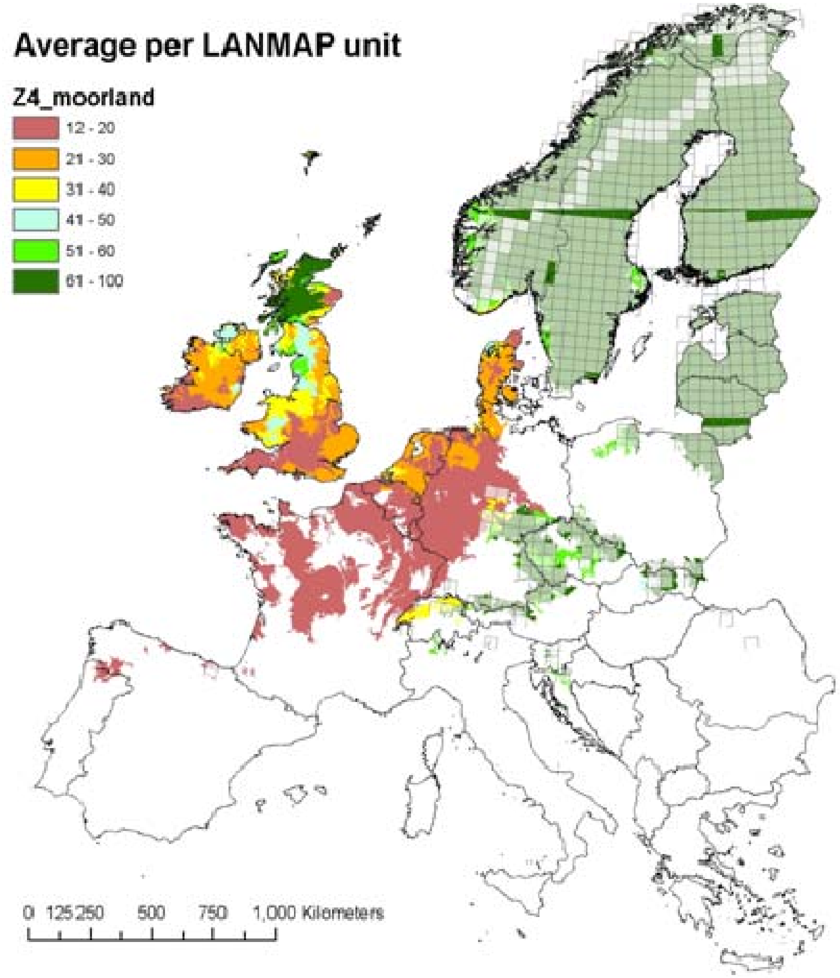
Farmland bird assessment per habitat type

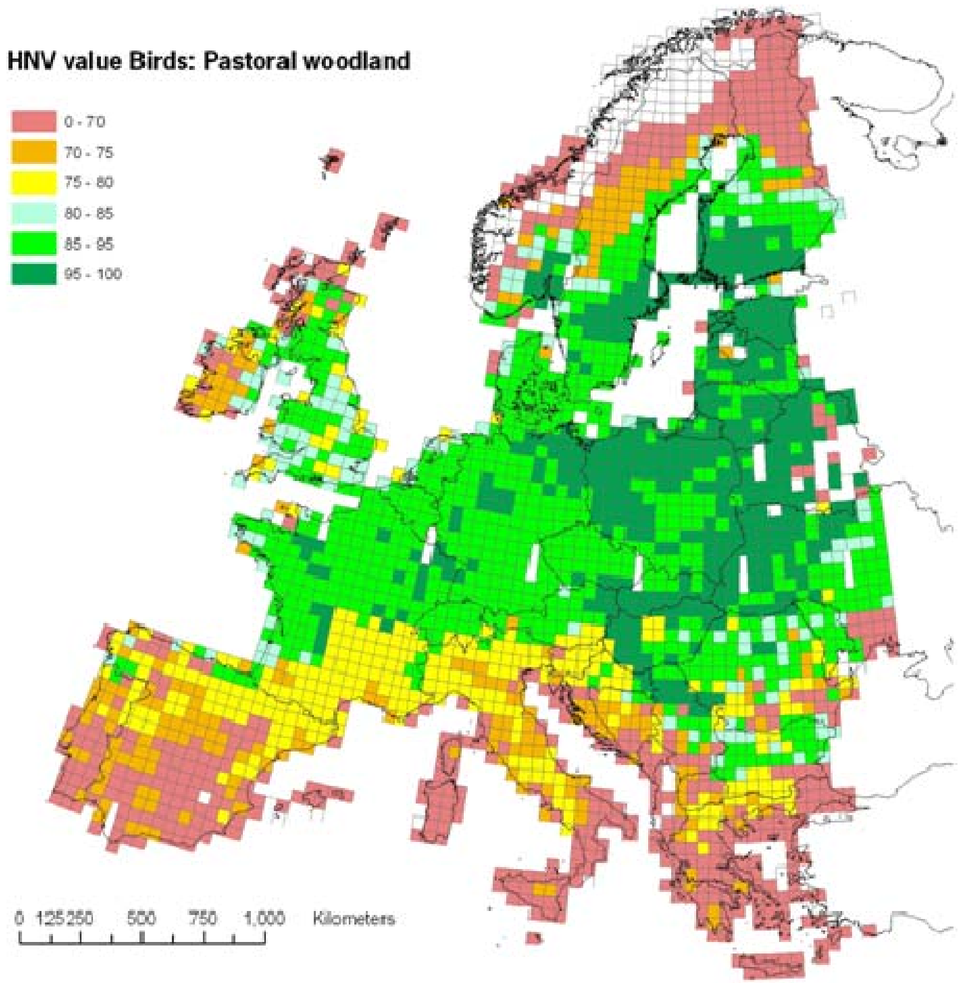
Table A4.1: Eunis habitat classification linked to HNV farming area classes

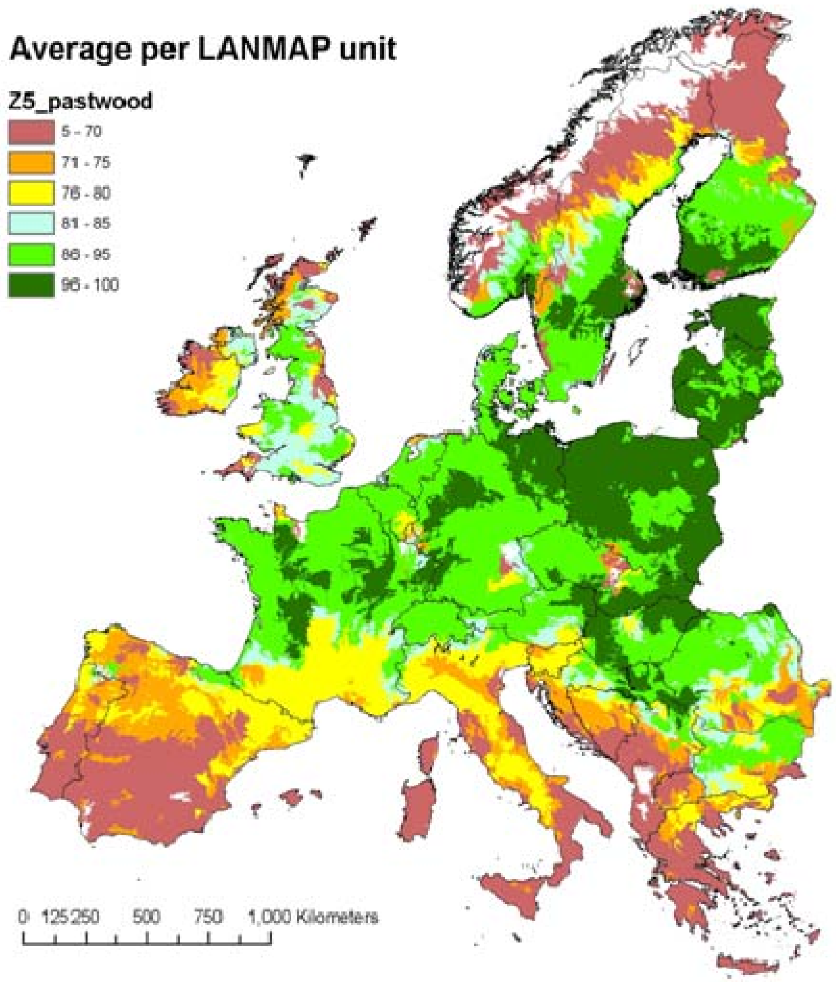
EUNIS		**HNV farmland area**	
Code	**Class name**	**code**	**Class name**
A2.6	Coastal salt marshes and saline reed beds	7	**Sand Dune and salt marsh**
B1.5-7	Coastal dune heath, scrub and wood	7	**Sand Dune and salt marsh**
D1	Raised and blanket bogs	4	**Moorland**
E1	Dry grasslands	8	**Steppe Habitats**
E3	Seasonally wet and wet grasslands	9	**Wet Grassland**
E4	Alpine and subalpine grasslands	3	**Montane Grassland**
E7	Sparsely wooded grasslands	5	**Pastoral Woodland**
F5	Maquis, matorral and thermo-Mediterranean brushes	1	**Mediterranean Shrub**
F6	Garrigue	1	**Mediterranean Shrub**
F7	Spiny Mediterranean heaths (phrygana, related coastal cliff vegetation)	1	**Mediterranean Shrub and hedgehog-heaths**
G5	Lines of trees, small anthropogenic woodlands,	5	**Pastoral Woodland recently felled woodland, early-stage woodland and coppice**
I1	Arable land and market gardens	10	**Arable and improved grassland**
I1.4	Inundatable croplands, including rice fields	6	**Rice Cultivation**
X04	Raised bog complexes	4	**Moorland**
X08	Rural mosaics, consisting of woods, hedges, pastures and crops	5	**Pastoral Woodland**
X09	Pasture woods (with a tree layer overlying pasture)	5	**Pastoral Woodland**
X28	Blanket bog complexes	4	**Moorland**

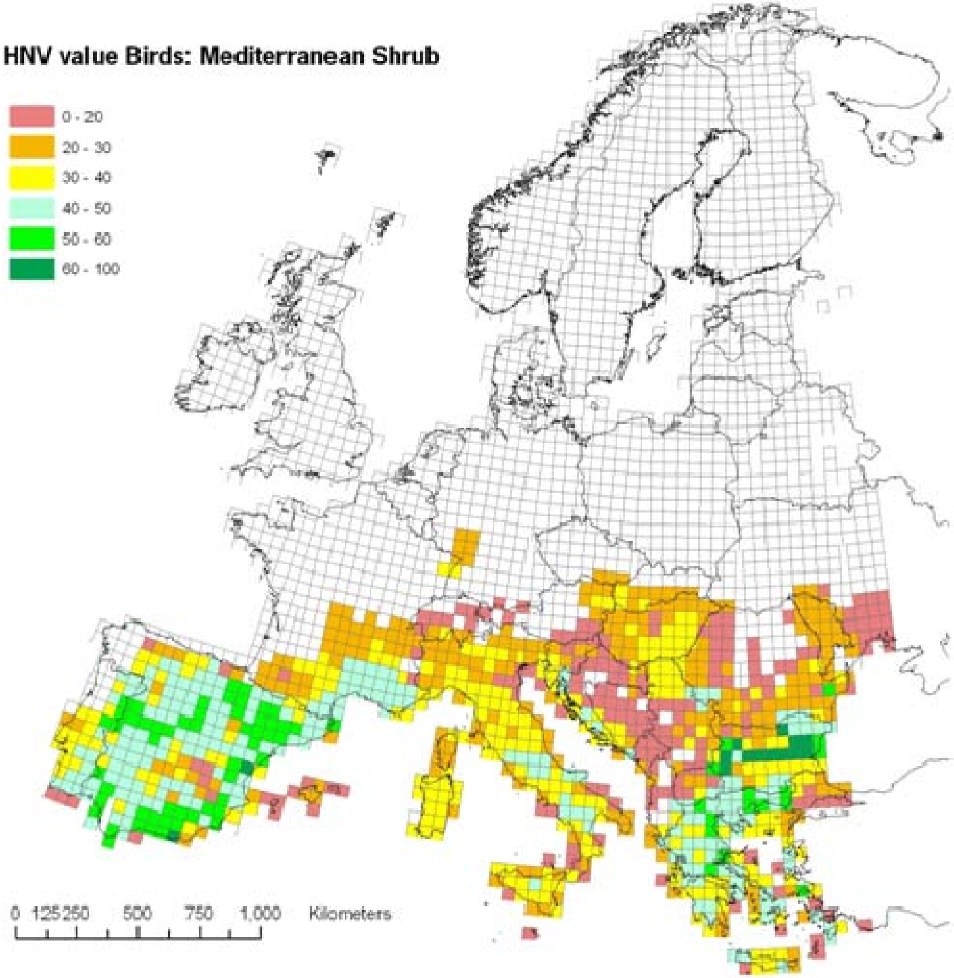



HNV value Birds: Moorland
0 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 100
Not suitable selection
0 125 250 500 750 1,000 Kilometers

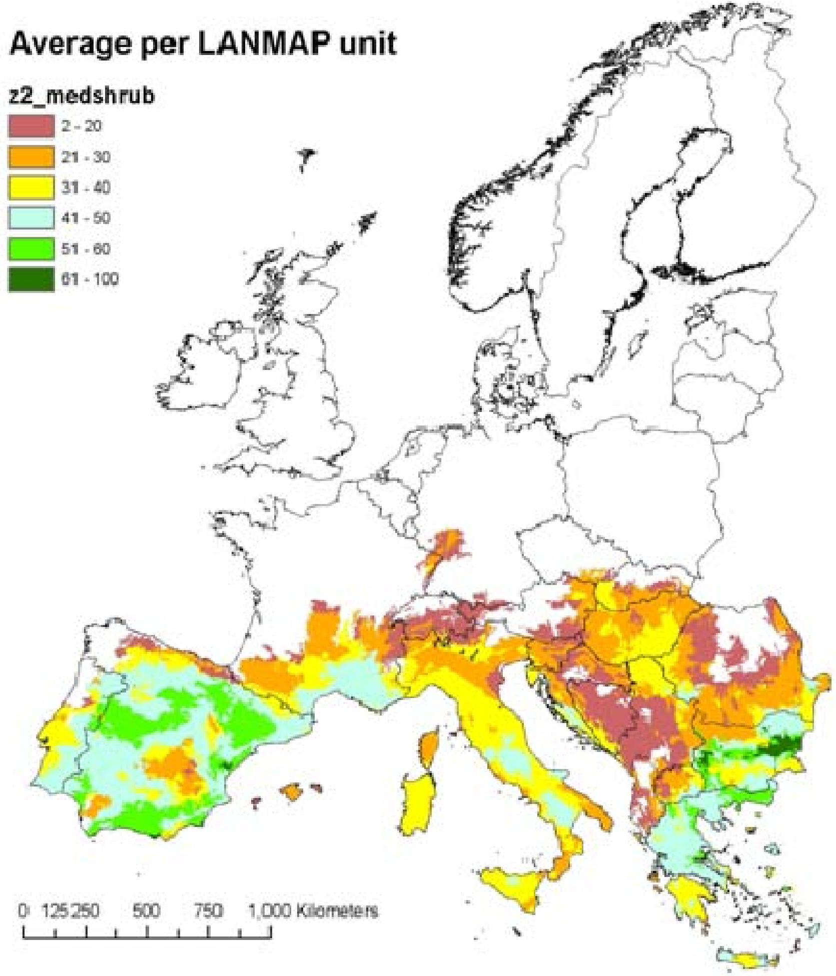

Average per LANMAP unit
Z4_moorland
12 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 100
0 125 250 500 750 1,000 Kilometers


HNV value Birds: Pastoral woodland
0 - 70
70 - 75
75 - 80
80 - 85
85 - 95
95 - 100
0 125 250 500 750 1,000 Kilometers

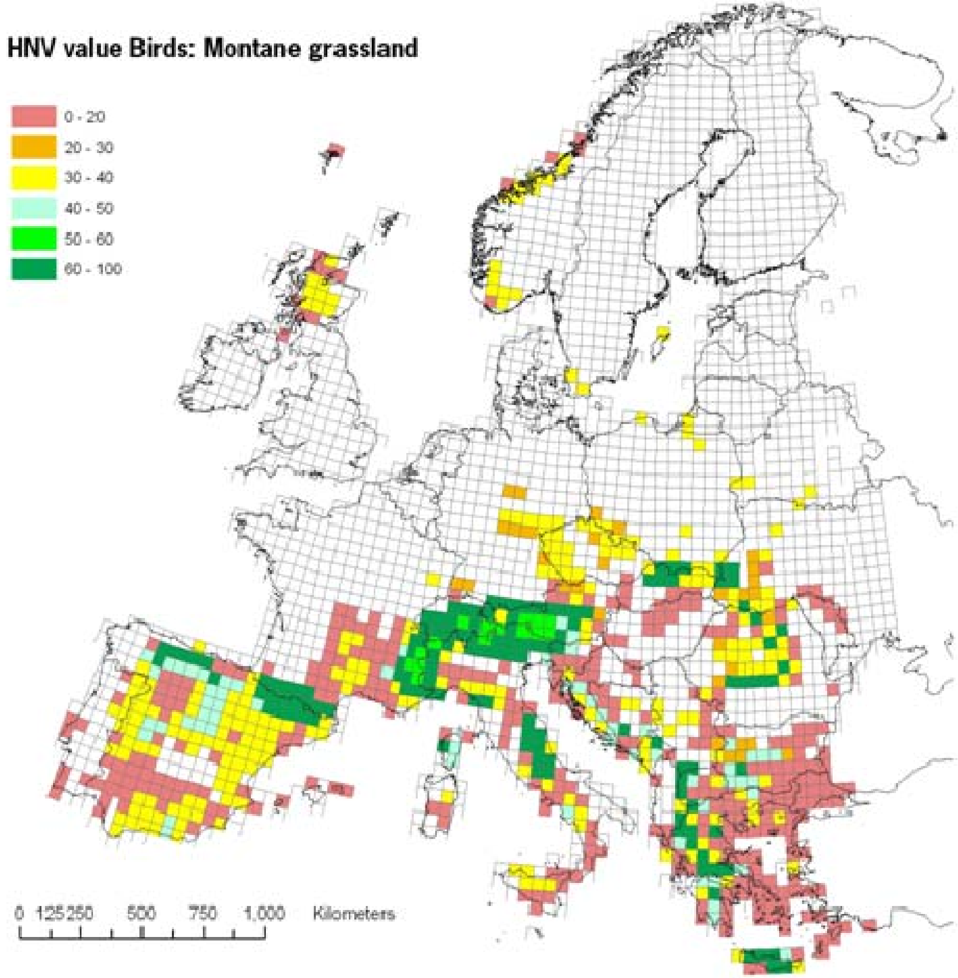

Average per LANMAP unit
Z5_pastwood
5 - 70
71 - 75
76 - 80
81 - 85
86 - 95
96 - 100
0 125 250 500 750 1,000 Kilometers

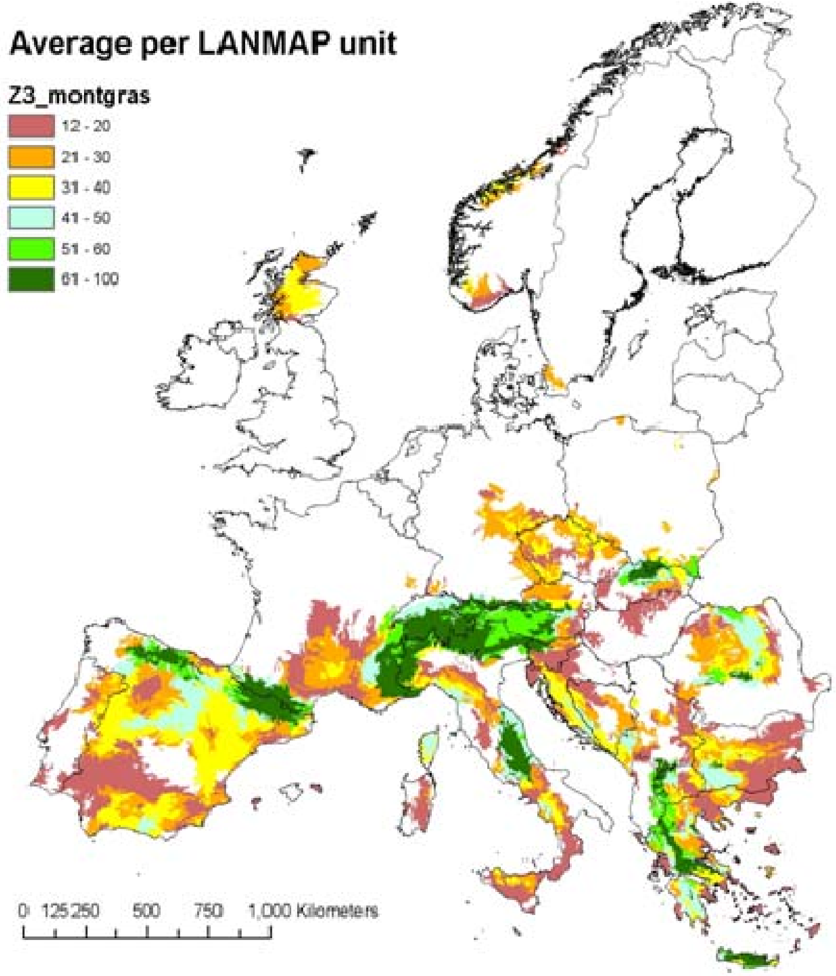


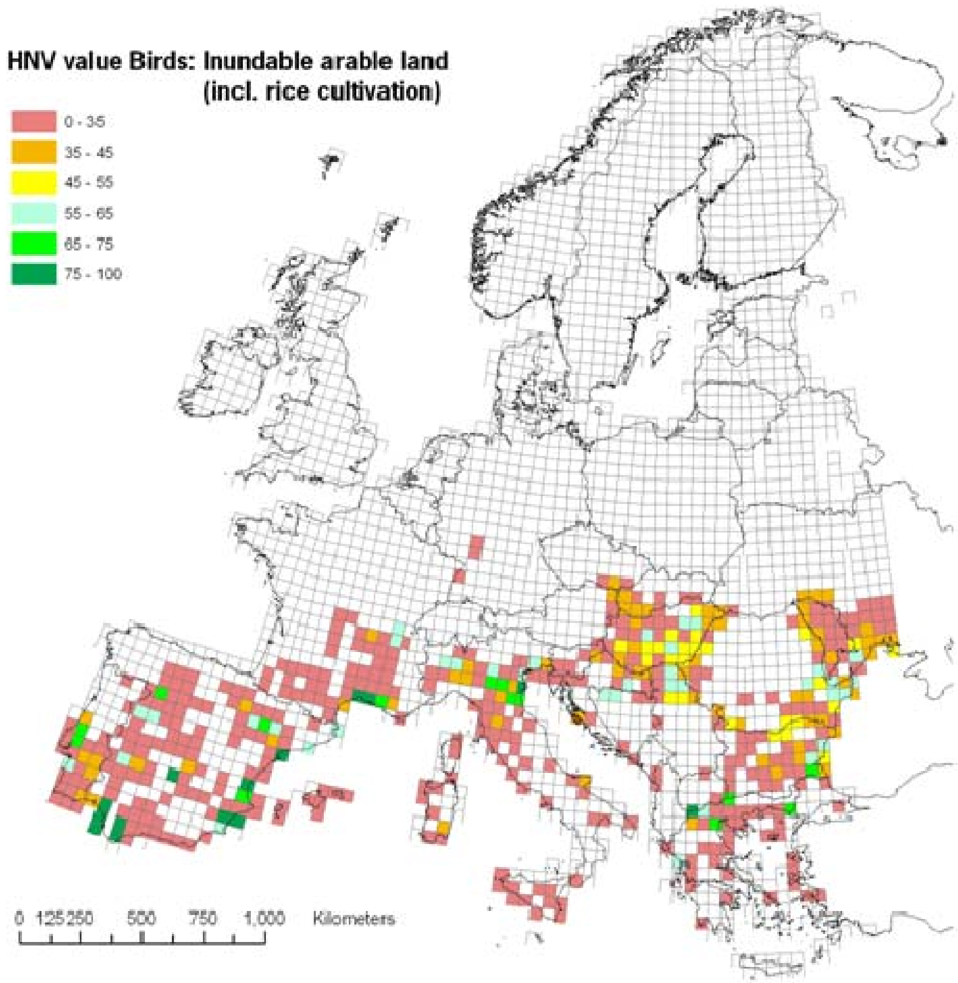
HNV value Birds: Mediterranean Shrub
0 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 100
0 125 250 500 750 1,000 Kilometers

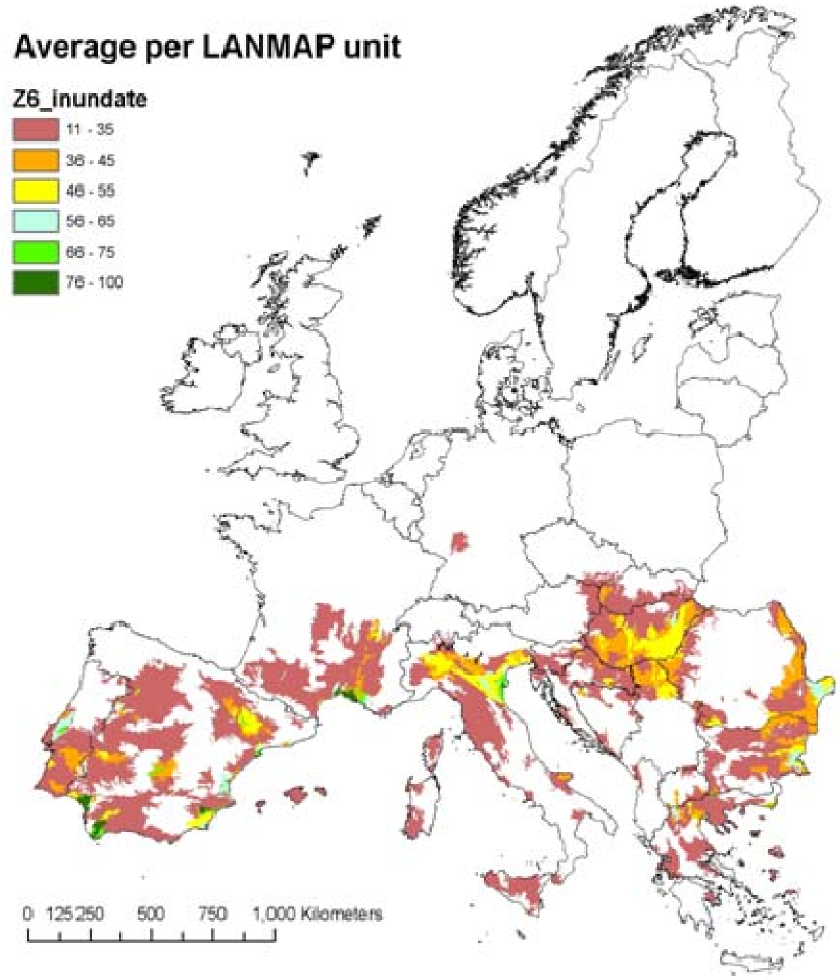


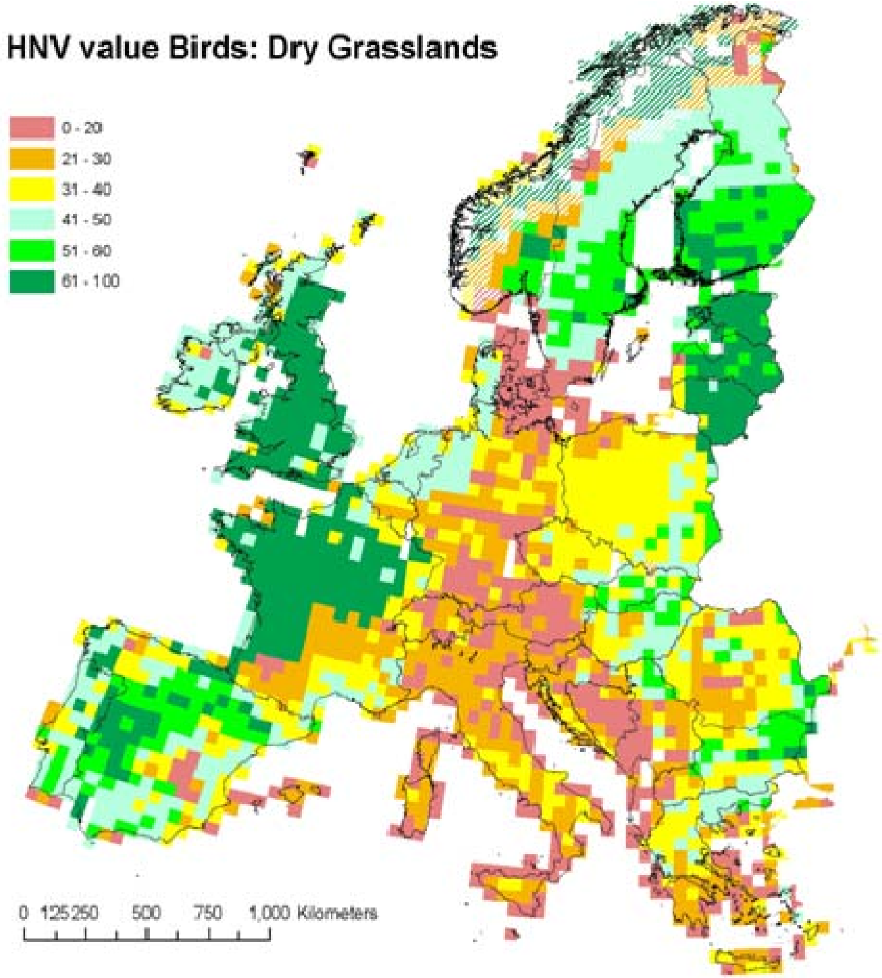
Average per LANMAP unit
z2_medshrub
2 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 100
0 125 250 500 750 1,000 Kilometers

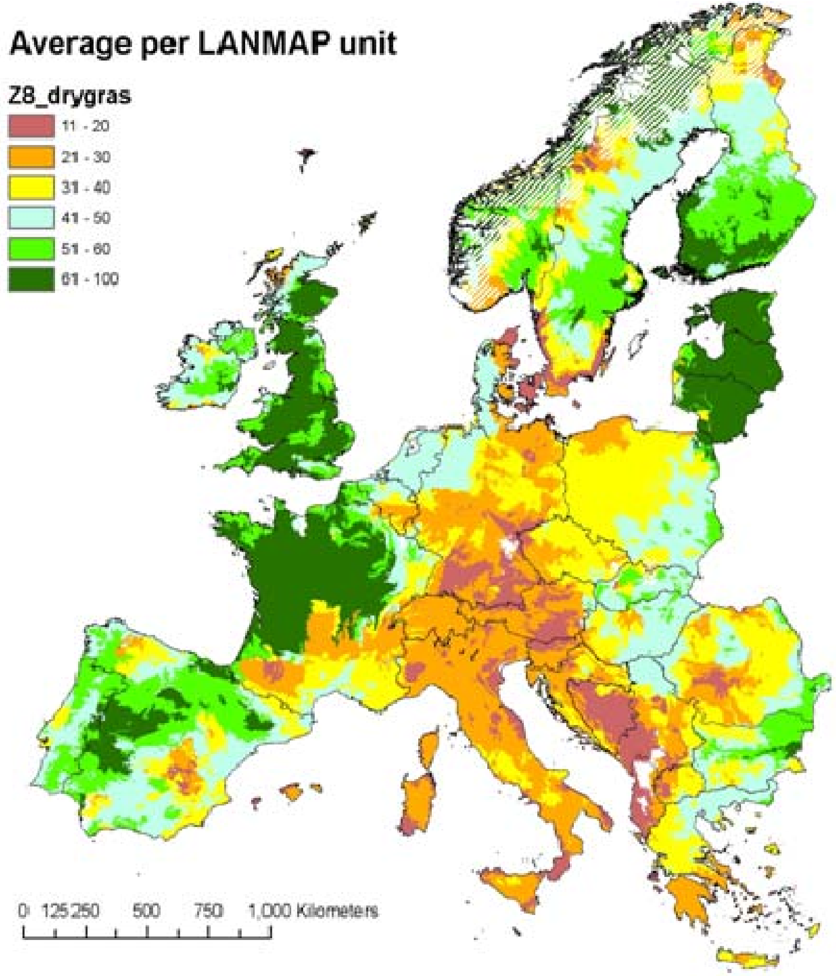

HNV value Birds: Montane grassland
0 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 100
0 125 250 500 750 1,000 Kilometers

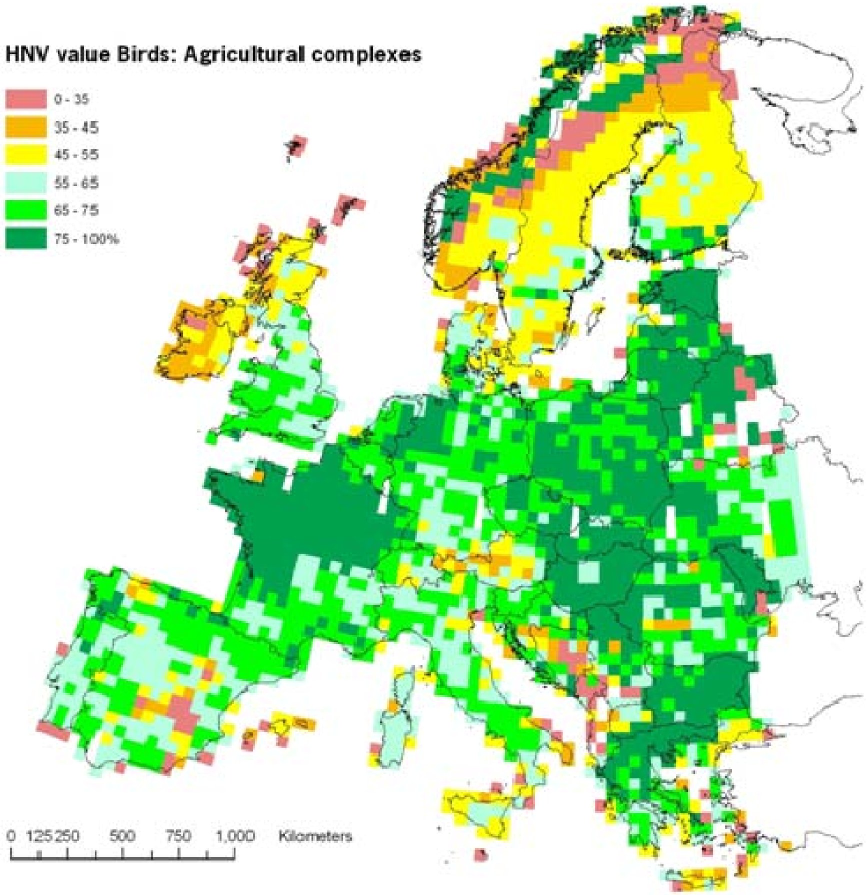

Average per LANMAP unit
Z3_montgras
12 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 100
0 125 250 500 750 1,000 Kilometers

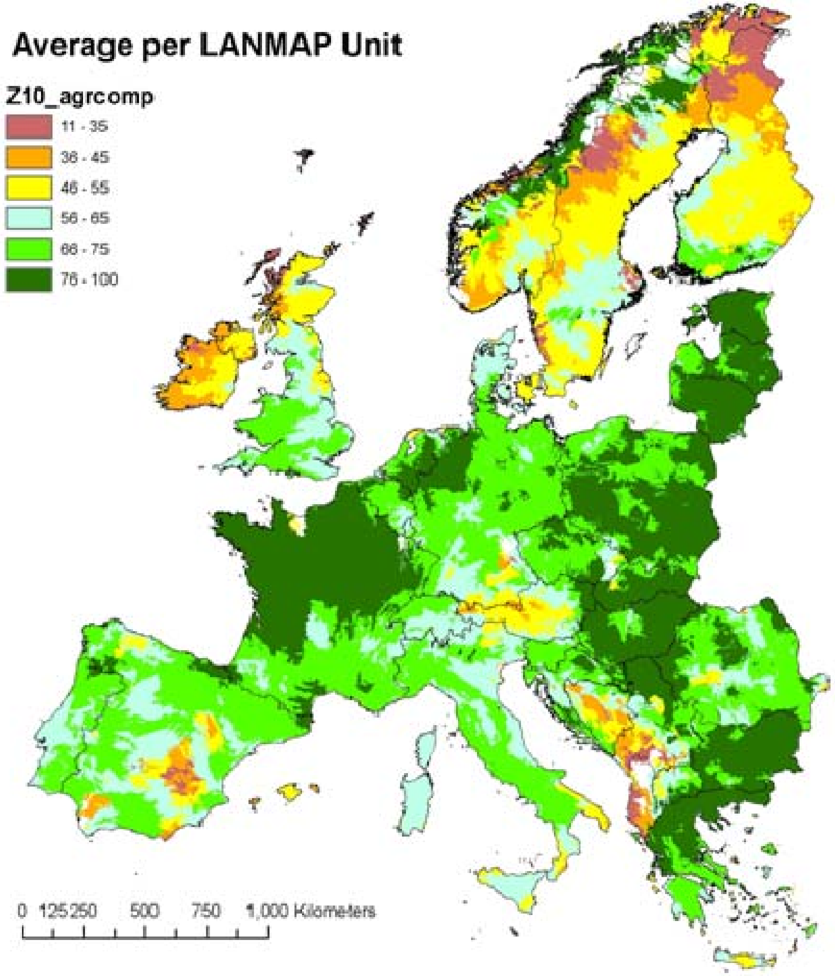

HNV value Birds: Inundable arable land
(incl. rice cultivation)
0 - 35
35 - 45
45 - 55
55 - 65
65 - 75
75 - 100
0 125 250 500 750 1,000 Kilometers


Average per LANMAP unit
Z6_inundate
11 - 35
36 - 45
46 - 55
56 - 65
66 - 75
76 - 100
0 125 250 500 750 1,000 Kilometers


HNV value Birds: Dry Grasslands
0 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 100
0 125 250 500 750 1,000 Kilometers


Average per LANMAP unit
Z8_drygras
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60
61 - 100
0 125 250 500 750 1,000 Kilometers


HNV value Birds: Agricultural complexes
0 - 35
35 - 45
45 - 55
55 - 65
65 - 75
75 - 100%
0 125 250 500 750 1,000 Kilometers


Average per LANMAP Unit
Z10_agrcomp
11 - 35
36 - 45
46 - 55
56 - 65
66 - 75
76 - 100
0 125 250 500 750 1,000 Kilometers

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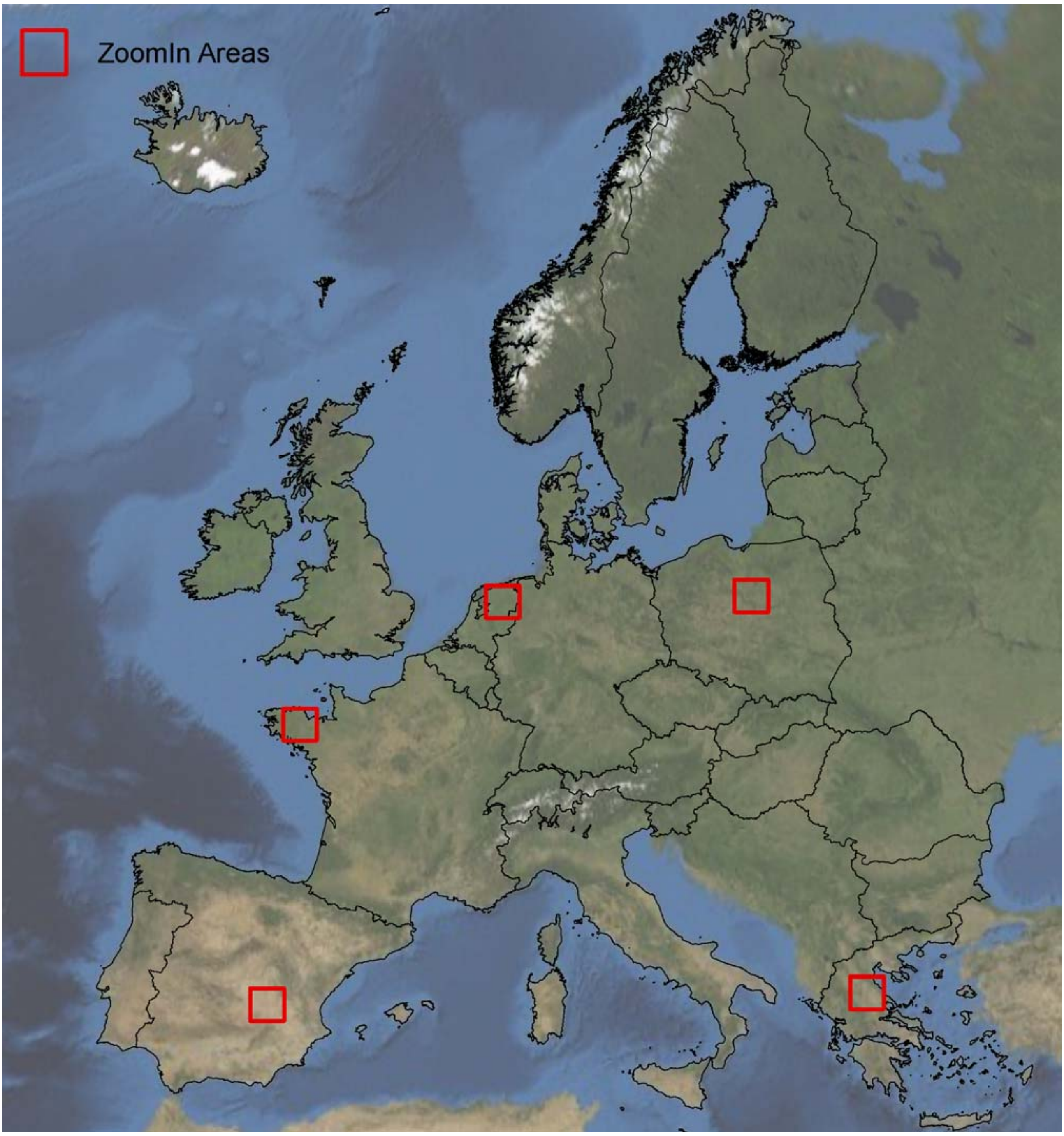
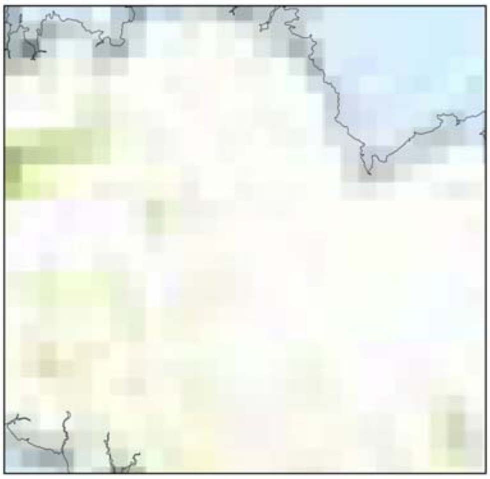
Annex 5 Results case study areas

M. van Eupen



Case Study Brittany, France

HNV JRC-EEA



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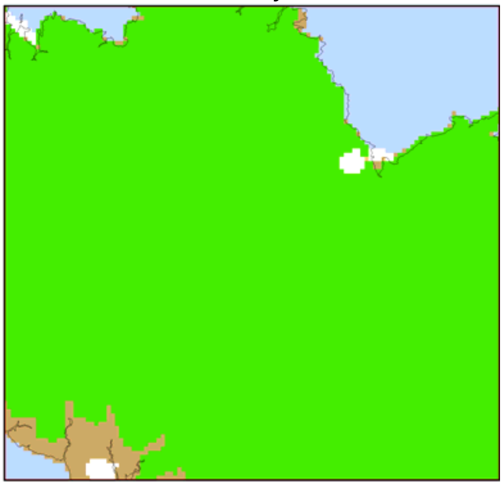

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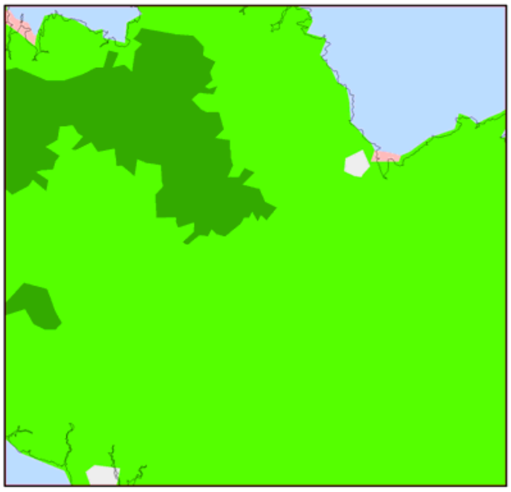

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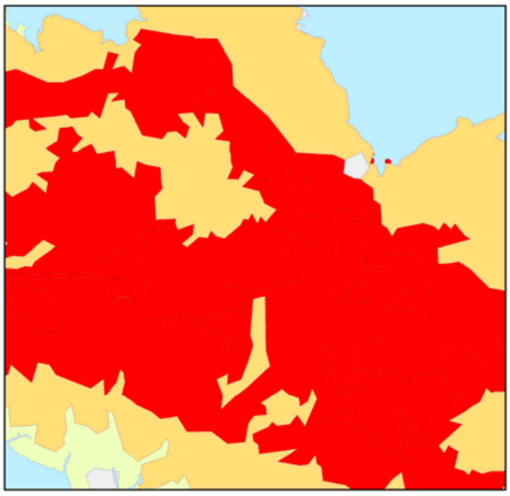

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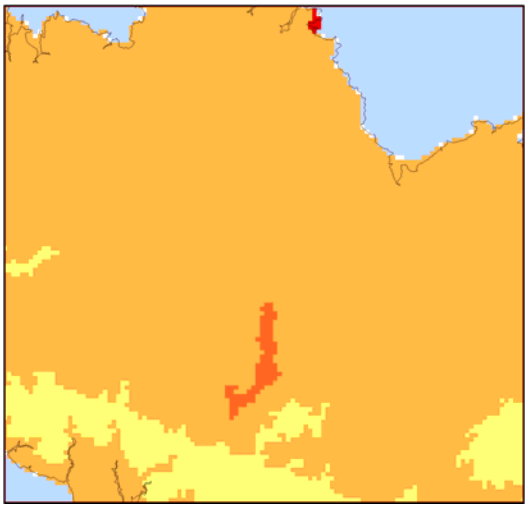
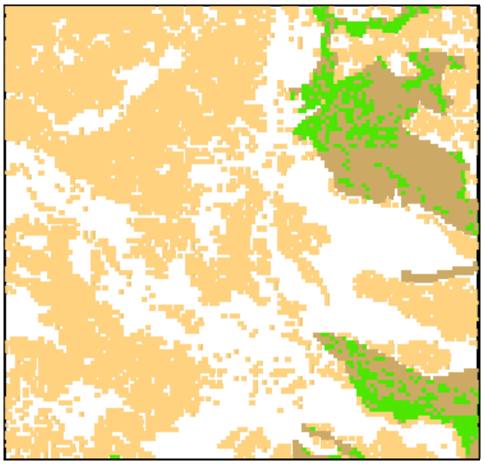
Type 3 Farmland Birds



Case Study Vistula region west of Warsaw, Poland

HNV JRC-EEA

HNV Total value his study



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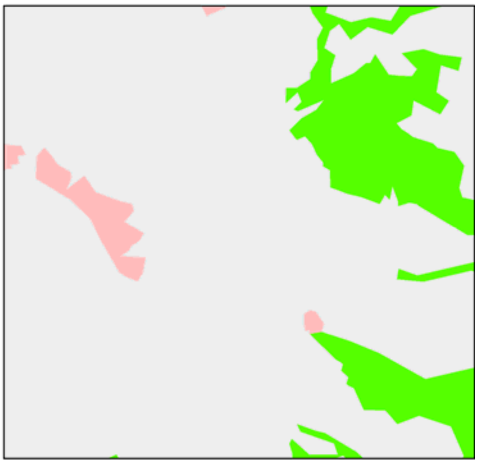

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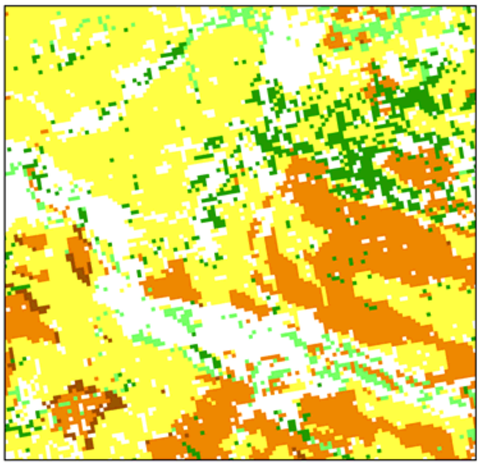

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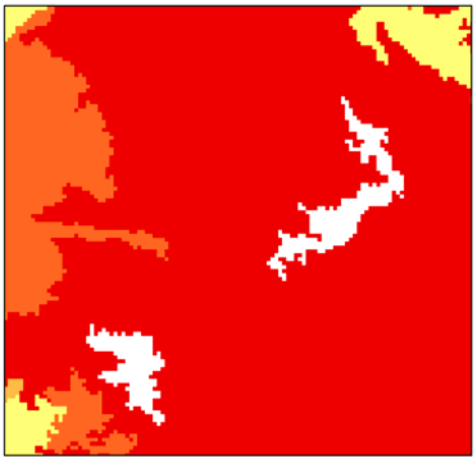
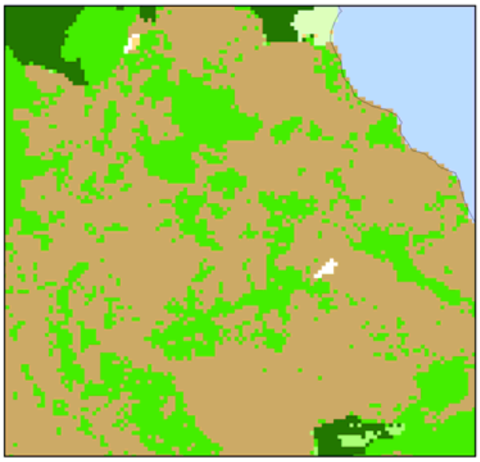


Case Study Mount Oplympus region, Greece

HNV JRC-EEA

HNV Total value his study



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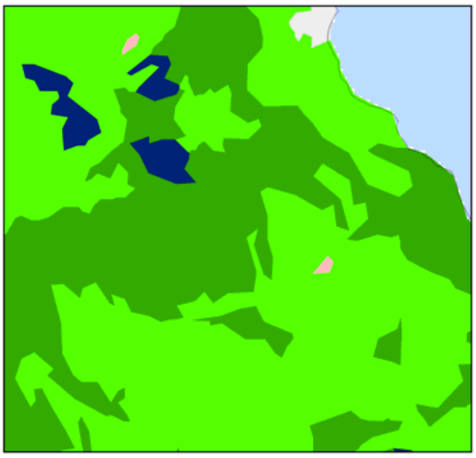

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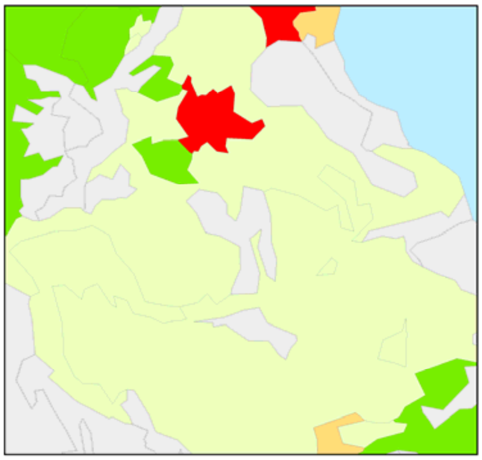

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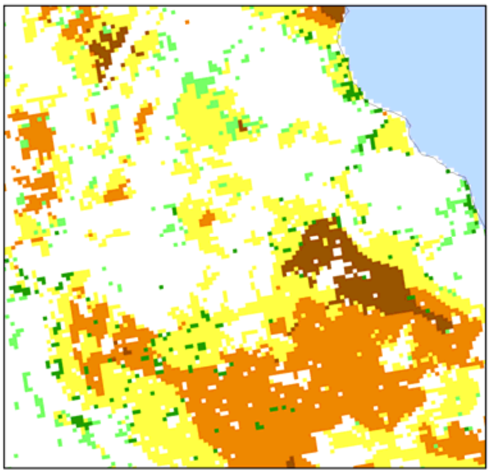

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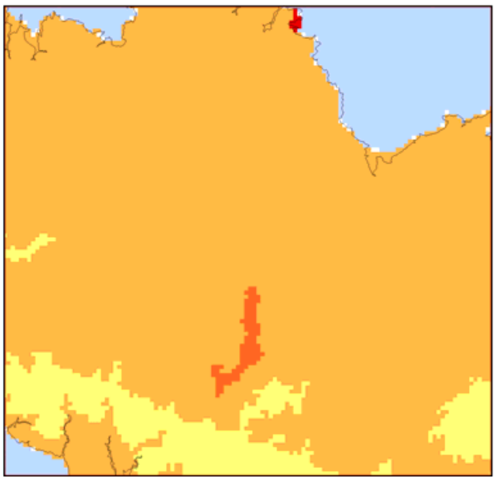

Case Study Castilla La Mancha region, Spain

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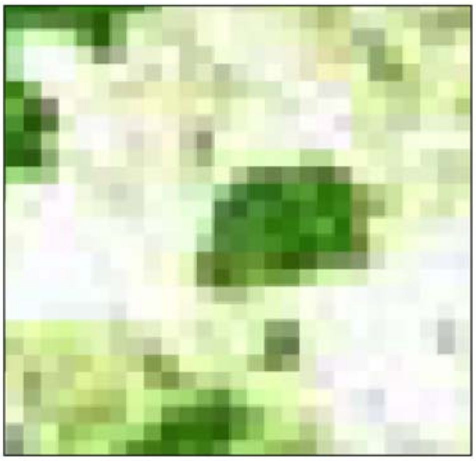

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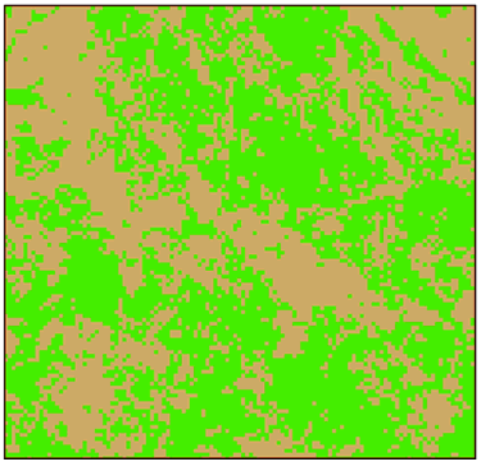

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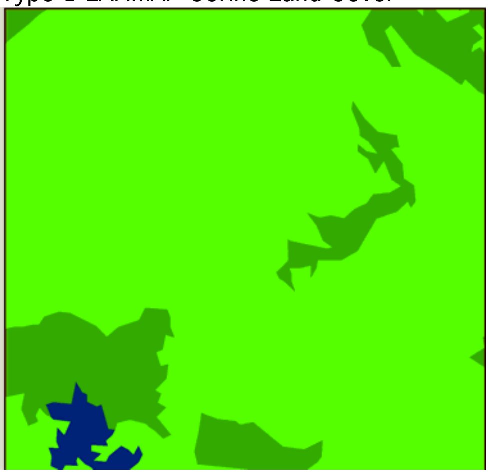

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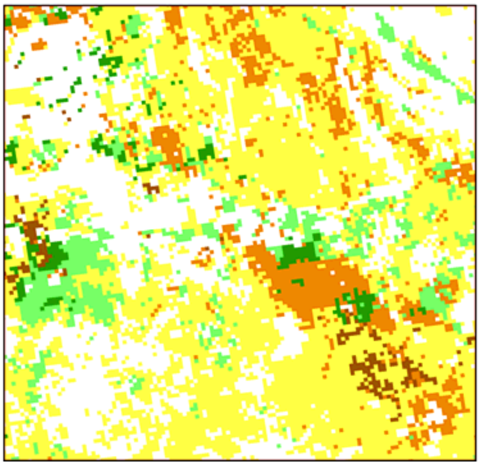

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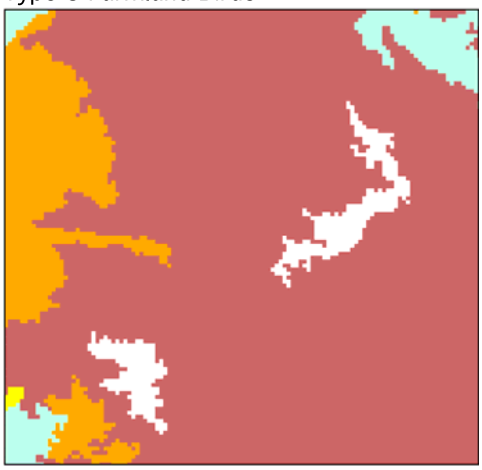

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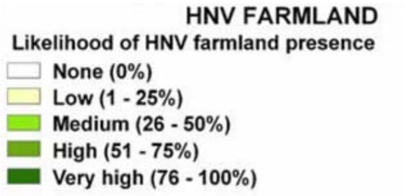

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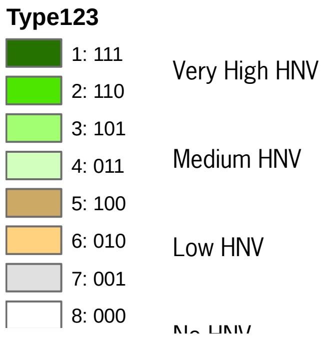

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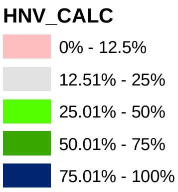

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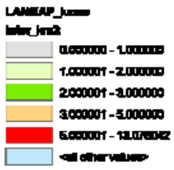

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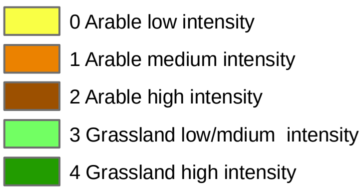

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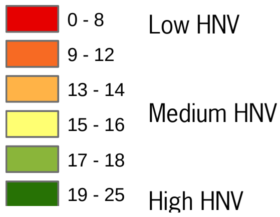

Annex 6 Mapping biodiversity with breeding bird monitoring data

H. Sierdsema, L. Brotons, F. Jiguet, and S. Newson

Information on the biodiversity of farmland has mainly been inferred from land use characteristics instead of distributions and trends of priority species. The data set of the European breeding bird atlas (EOA) (Hagemeijer and Blair 1997) offers many possibilities to analyse the species composition at the scale of 50x50 km, as shown in this report. The EOA data set however, offers limited possibilities to take bird numbers into account, let alone changes in numbers.

The EBCC monitors the change in the abundance of farmland birds (and many other species) with the Pan-European common bird monitoring scheme (PECBMS). This schemes offers perfect possibilities for the designation and monitoring of HNV areas. Although the current resolution of the output of the scheme (countries or sometimes regions) offers limited possibilities for local or regional spatial analyses, the EBCC aims for producing output on a much finer scale. More detailed information on the driving forces may be also obtained by combining changes in local count data with local information on (changes) in land use with spatial statistical models resulting in distribution and trend maps and information on possible driving forces. The heterogenic nature of the observations and the sparseness of high-quality European environmental data however, make it difficult to model the distribution in detail on a European scale. However, high-quality distribution maps and trend maps could be made by using a multi-scale approach combining national and European environmental data sets in the modelling.

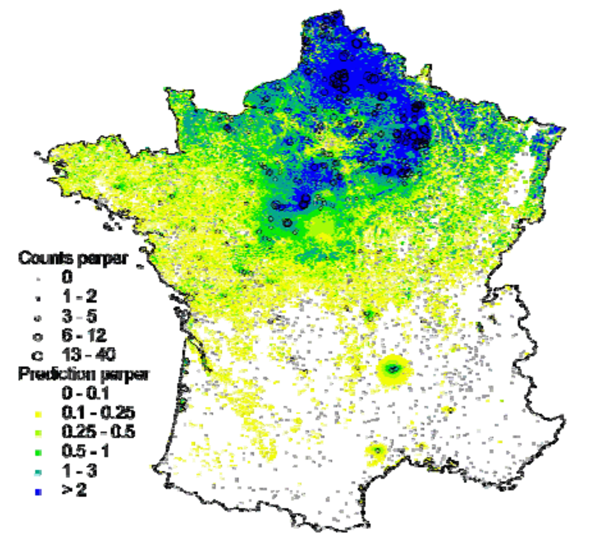

Fig A6.1: Observed numbers per sample site ('counts') and predicted distribution of Grey Partridge (Perdrix perdrix) in France

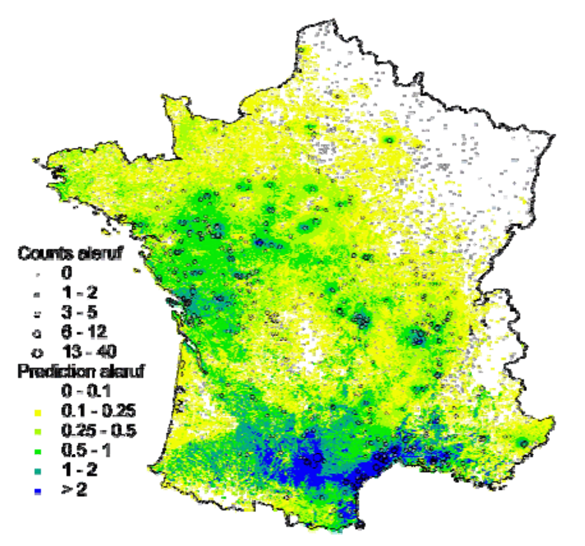

Fig A6.2: Observed numbers per sample site ('counts') and predicted distribution of Red-legged Partridge (Alectoris rufa) in France

In 2009 we carried out a small pilot project combining French breeding bird monitoring data of 24 farmland bird species. We extended the pilot to the UK, Netherlands, France and Catalonia combining bird monitoring data on 8 farmland species. Species distribution maps were made with spatial models combining regression techniques and spatial interpolation of the residuals (Sierdsema and Loon 2008). An example of two distributions for French partridge species is shown in Figures A6.1 and A6.2.

The distribution maps of the different species were combined by adding up the log of the predicted numbers. This ensures that both scarce and abundant species play a comparable role in the final diversity map (Fig A6.4). When we compare the combined breeding bird map with the HNV map published by Paracchini *et al.* (2008), it becomes evident that the breeding bird data are an important additional source of information to delineate HNV farmland areas.

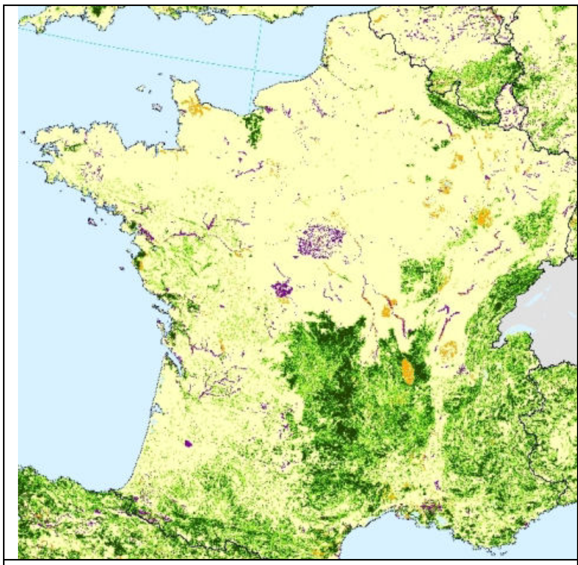

Fig. A6.3: HNV map of France published by Paracchini et al (2008)

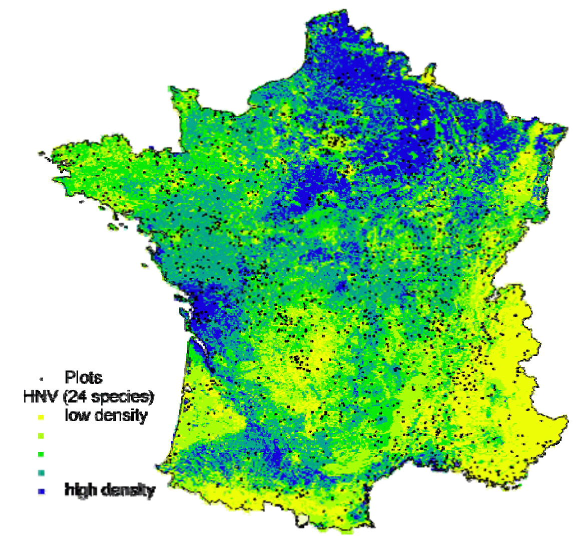

Fig. A6.4: Combined distribution abundance maps of 24 farmland bird species

The French regression models were extended to other countries by adding the type of monitoring scheme to the models. This allows for the prediction of the international distribution maps using the unit of one schemes (like numbers per point) as unit for the whole map. We made international models and predictions for 8 species (Wood Pigeon, Turtle Dove, Skylark, Red-backed Shrike, Starling, Tree Sparrow and Corn Bunting) and combined them into one map analogue to French maps (Fig. A6.5). The general pattern in France is the same as the French map although the map is based on less species.

Trend maps

The monitoring scheme of the EBCC can also be used to make maps of the trends of breeding bird species. This allows us to monitor the changes in HNV as depicted by breeding bird biodiversity. Figures A6.6 and A6.7 shows the trend map for a farmland bird (Redbacked Shrike) and the combined trend map for 8 species over the period 2000-2005.

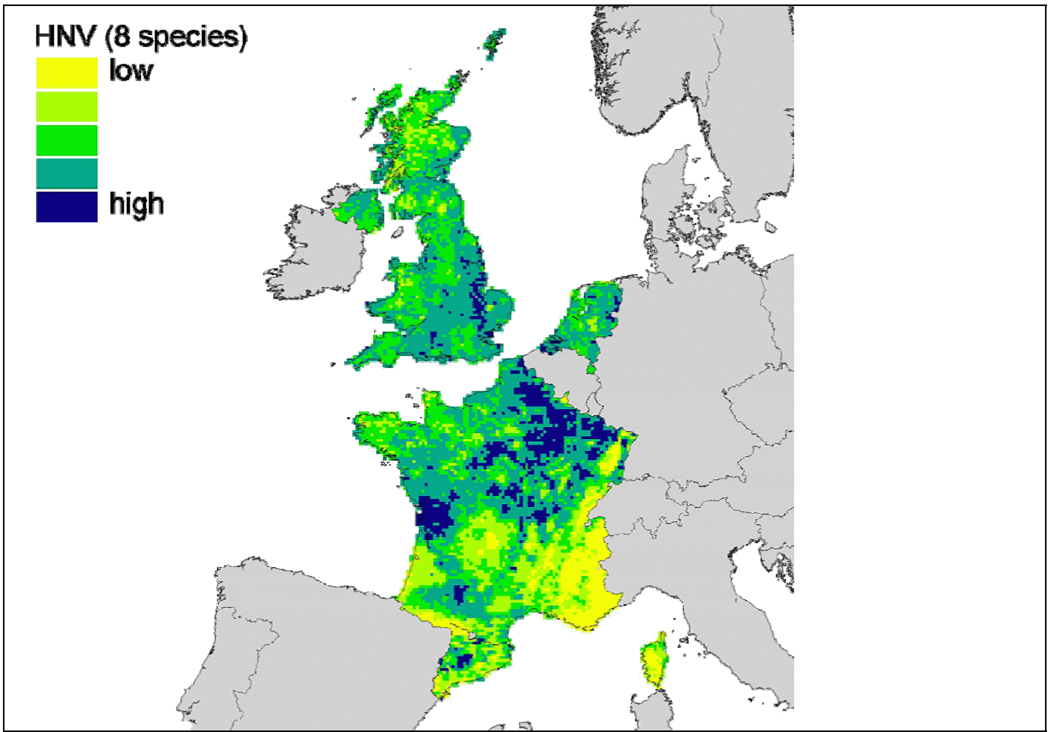

Figure A6.5: HNV map based on the combined distribution of 8 farmland bird species.

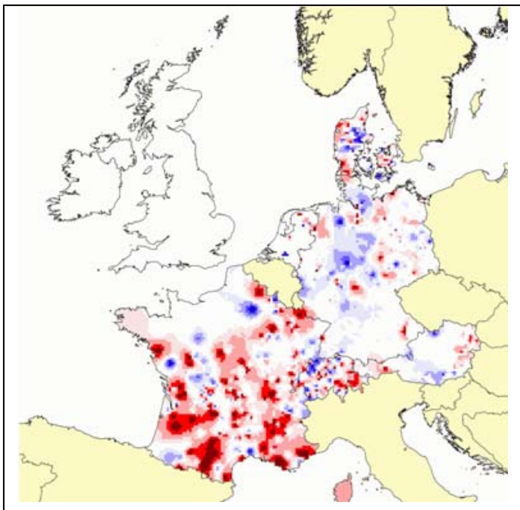

Fig. A6.6: Provisional trend map of Redbacked Shrike (Lanius collurio) over the period 2000-2005.

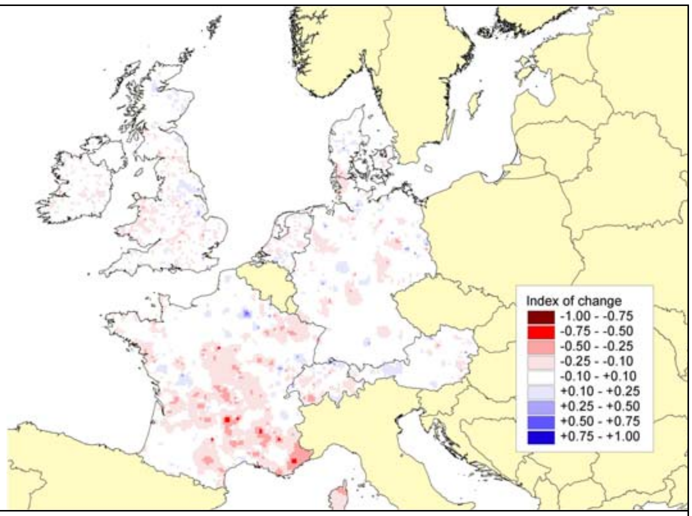

Fig. A6.7. Provisional combined trend map of 8 farmland bird species over the period 2000-2005.

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Hagemeijer, E. J. M. and Blair, M. J. 1997. The EBCC Atlas of European Breeding Birds: their distribution and abundance. - T & AD Poyser.

Sierdsema, H. and Loon, E. E. v. 2008. Filling the gaps: using count survey data to predict bird density distribution patterns and estimate population sizes. - Revista Catalana d'Ornitologia 24.

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De werkdocumenten zijn ook te downloaden via de WOt-website www.wotnatuurenmilieu.wur.nl

2007

47 *Ten Berge, H.F.M., A.M. van Dam, B.H. Janssen & G.L. Velthof.* Mestbeleid en bodemvruchtbaarheid in de Duin- en Bollenstreek; Advies van de CDM-werkgroep Mestbeleid en Bodemvruchtbaarheid in de Duin- en Bollenstreek

48 *Kruit, J. & I.E. Salverda*. Spiegeltje, spiegeltje aan de muur, valt er iets te leren van een andere plannings-cultuur?

49 *Rijk, P.J., E.J. Bos & E.S. van Leeuwen.* Nieuwe activiteiten in het landelijk gebied. Een verkennende studie naar natuur en landschap als vestigingsfactor

50 *Ligthart, S.S.H.* Natuurbeleid met kwaliteit. Het Milieu- en Natuurplanbureau en natuurbeleidsevaluatie in de periode 1998-2006

51 *Kennismarkt 22 maart 2007; van onderbouwend onderzoek Wageningen UR naar producten MNP in 27 posters*

52 *Kuindersma, W., R.I. van Dam & J. Vreke.* Sturen op niveau. Perversies tussen nationaal natuurbeleid en besluitvorming op gebiedsniveau.

53.1 *Reijnen, M.J.S.M.* Indicators for the 'Convention on Biodiversity 2010'. National Capital Index version 2.0

53.3 *Windig, J.J., M.G.P. van Veller & S.J. Hiemstra.* Indicatoren voor 'Convention on Biodiversity 2010'. Biodiversiteit Nederlandse landbouwhuisdieren en gewassen

53.4 *Melman, Th.C.P. & J.P.M. Willemen.* Indicators for the 'Convention on Biodiversity 2010'. Coverage protected areas.

53.6 *Weijden, W.J. van der, R. Leewis & P. Bol.* Indicatoren voor 'Convention on Biodiversity 2010'. Indicatoren voor het invasieproces van exotische organismen in Nederland

53.7a *Nijhof, B.S.J., C.C. Vos & A.J. van Strien.* Indicators for the 'Convention on Biodiversity 2010'. Influence of climate change on biodiversity.

53.7b *Moraal, L.G.* Indicatoren voor 'Convention on Biodiversity 2010'. Effecten van klimaatverandering op insectenplagen bij bomen.

53.8 *Fey-Hofstede, F.E. & H.W.G. Meesters.* Indicators for the 'Convention on Biodiversity 2010'. Exploration of the usefulness of the Marine Trophic Index (MTI) as an indicator for sustainability of marine fisheries in the Dutch part of the North Sea.

53.9 *Reijnen, M.J.S.M.* Indicators for the 'Convention on Biodiversity 2010'. Connectivity/fragmentation of ecosystems: spatial conditions for sustainable biodiversity

53.11 *Gaaff, A. & R.W. Verburg.* Indicators for the 'Convention on Biodiversity 2010' Government expenditure on land acquisition and nature development for the National Ecological Network (EHS) and expenditure for international biodiversity projects

53.12 *Elands, B.H.M. & C.S.A. van Koppen.* Indicators for the 'Convention on Biodiversity 2010'. Public awareness and participation

54 *Broekmeyer, M.E.A. & E.P.A.G. Schouwenberg & M.E. Sanders & R. Pouwels.* Synergie Ecologische Hoofdstructuur en Natura 2000-gebieden. Wat stuurt het beheer?

55 *Bosch, F.J.P. van den.* Draagvlak voor het Natura 2000-gebiedenbeleid. Onder relevante betrokkenen op regionaal niveau

56 *Jong, J.J. & M.N. van Wijk, I.M. Bouwma.* Beheerskosten van Natura 2000-gebieden

57 *Pouwels, R. & M.J.S.M. Reijnen & M. van Adrichem & H. Kuipers.* Ruimtelijke condities voor VHR-soorten

58 Niet verschenen/ vervallen

59 *Schouwenberg, E.P.A.G.* Huidige en toekomstige stikstofbelasting op Natura 2000-gebieden

60 Niet verschenen/ vervallen

61 *Jaarrapportage 2006.* WOT-04-001 – ME-AVP

62 *Jaarrapportage 2006.* WOT-04-002 – Onderbouwend Onderzoek

63 *Jaarrapportage 2006.* WOT-04-003 – Advisering Natuur & Milieu

64 *Jaarrapportage 2006.* WOT-04-385 – Milieuplanbureaufunctie

65 *Jaarrapportage 2006.* WOT-04-394 – Natuurplanbureaufunctie

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