EBONE: integrated figures of habitat and biodiversity indicators

Quantifying indicators of an integrated biodiversity observation system

Philip Roche and Ilse Geijzendorffer

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Abstract

The EBONE project developed a method to monitor biodiversity over time in the whole of Europe. In this deliverable, a proof of practice for the developed methodology is presented through an analysis of the data collected. Field data have been collected from a sampling pool of 1km squares throughout Europe and three case study regions outside Europe.
The EBONE Habitat Recording Field Protocol allowed the computation of a wide array of indicators from habitat level, pressure and management, life forms and species biodiversity. The protocol ensures the provision of multidimensional and statistically robust estimators of biodiversity for national, environmental strata or any given type of habitats levels. Additionally, it offers new perspectives on both Annex I habitats and semi-natural habitats.

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Summary

The EBONE project aims to develop a method to monitor biodiversity over time in the whole of Europe. For this purpose, field data have been collected in situ from a sampling pool of 1km squares throughout Europe and three case study regions outside Europe.Collected data include information on habitats, environmental conditions and vegetation releves. In this deliverable, an analysis of the data collected is presented in the form of selected indicators. Indicators have been derived from the habitat, species, environment and management data recorded using the EBONE Habitat Recording Field Protocol.

The work presented in this deliverable provides a proof of practice for the developed methodology. The field test of the EBONE protocol has been done in twelve European countries within the WP6 and three more countries in WP9 (Israel, Australia and South-Africa). Although EBONE has been able to cover an impressive number of sample points throughout Europe for an EU FP7 project, the sample size and locations cannot be considered to be a true representation of Europe. Figures in this report are therefore also not indicating statistical values.

Although, the current EBONE dataset is not suitable to draw conclusions on individual indicators, countries or environmental strata, it shows that national or regional monitoring programs could use the approach and collect data using the protocols, tools and data warehouse to generate the biodiversity indicators for their area of interest.

Given the above stated limitations of the dataset, the computation demonstration yielded some very interesting food for thought. The EBONE protocol allowed the computation of a wide array of indicators from habitat level (patch size, patch density, habitat diversity, Annex I), pressure and management (nature and intensity of management), life forms and species biodiversity.
Based on a full sampling protocol, the EBONE protocol can ensure the provision of multidimensional and statistically robust estimators of biodiversity for national, environmental strata or any given type of habitats levels.

The EBONE dataset for one shows that its data provides more biodiversity information than schemes with a larger MMU (e.g. EBONE: 400m^2 versus CLC 25ha). Additionally, this demonstration shows that the EBONE protocol offers new perspectives on both Annex I habitats and semi-natural habitats.

So far no monitoring scheme has been able to provide local and regional knowledge on landscape structure, management and the management timeline in addition to local indicators for the quality of the habitat itself (e.g. plant and life form recordings).

These findings clearly show that the EBONE protocol can be used for habitat monitoring and offers valuable additional information in comparison to existing monitoring schemes.

1   Introduction

The EBONE project aims to develop a method to monitor biodiversity over time in the whole of Europe. In order to realise a real size in-situ test of the protocols, data have been collected in twelve European countries. In this deliverable, an analysis of the data collected is presented. Indicators have been derived from the habitat, species, environment and management data recorded using the EBONE Habitat recording field protocol.

The work presented in this deliverable provides a proof of practise for the developed methodology and it should be stated clearly that the figures presented in this report have does not a statistical value. Although EBONE has been able to cover an impressive number of sample points throughout Europe for an EU FP7 project, the sample size and locations cannot be considered to be a true representation of Europe.

This deliverable is therefore produced with the objective to serve rather as an example of the capabilities of the EBONE protocol to report on the status of habitats and their biodiversity in a standard way than to provide the status itself.

The source: the EBONE field data

The EBONE field data was recorded in 94 1km^2 squares using the EBONE habitat mapping methodology. The EBONE data is composed of two main components. Firstly, a GIS shapes layers that store the locations and shapes of areal, linear and point elements at the landscape level. Secondly, a database in which are recorded the nature and qualifiers for every elements created in the GIS layers. This database is referred as the "field database".

Three main type of information are recorded per element encountered in the field (see the EBONE field recording manual for in depth description of the different typologies[1]):
– Nature of the elements using a comprehensive and flexible typology based on structural elements and plant life forms.
– Plant life form and species recordings using standard protocol and survey methodology.
– Environmental and management qualifiers.

Each of the three main type of information can be used on its own or in combination in order to derive indicators for habitat, species, environment and management status. The spatial information recorded in the GIS layers can also be used to derive landscape scale indicators or/and to compute quantitative indicators by crossing spatial and descriptive data.

The data and indicators derived from the EBONE data can contribute to the following analyses:
– To link habitat information to species data.
– To analyse the habitat composition on the aggregation level of member states and environmental zones.
– To use habitat information on species diversity to explore alpha-, beta-, and gamma-diversity.
– To explore the possible contribution of habitat information to the SEBI indicators selected in Deliverable 1.1.
– Perform multivariate analysis as a sensitivity analysis of the methodology and to illustrate the potential use of the EBONE methodology to our stakeholders.

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[1]http://www.ebone.wur.nl/UK/Deliverables/

2   EBONE Field Protocol

> *The EBONE Field Protocol provides an approach for monitoring ecosystems in the field. The aim is that with this protocol the changes that occur in the ecosystems biodiversity can be monitored over time with a standard quality in space and time.*

Ecosystem monitoring implies the definition of the scale on which the systems are being observed. In general an ecosystem is a community of organisms and their physical environment, and the interactions among them without considering spatial delineation of the ecosystem.
The EBONE protocol focuses on recording the different habitats of which the general landscape is composed as a recording unit. The working definition of 'habitat' developed in the EBONE project is as follows:

> *'A habitat is a discrete patch of community of organisms and their physical environment. The spatial delineation of the habitat is determined by variations in vertical and horizontal structure of the community of organism or their physical environment.'*

2.1   Elements

Following the EBONE definition of a habitat, spatial criteria were defined as part of the mapping rules. The elements are the different types of habitats regarding these spatial criteria.

– If Area > 400m^2 and width > 5m, then it is an AREAL Habitat Element.
– If Area < 400m^2 and 1<width< 5m and length > 30m, then it is a LINEAR Habitat Element.
– If the habitat is smaller than this and the habitats are ecologically significant, then it is a POINT Habitat Element.

The AREAL, LINEAR and POINT Habitat Element are classified into General Habitat Categories (thereafter referred as GHC) that are a list of Habitat Types based primarily on structural life forms with the exception of Cultivated, Sparsely vegetated and Urban Habitats.

The basic survey area is 1km^2 within which areal, linear and point habitats are recorded.

2.2   Habitat typology

A list of GHCs acts as the core of the procedure for recording habitats and linking to extant data. Following this list avoids the multiplicity of categories that would otherwise result from disaggregated recording. Recording GHCs is based on the following set of principles that have been adopted as essential for consistent recording of habitats:
– A GHC has to be determined per individual element in the field, which must be made in an appropriate time window for a given region, i.e. around the period of maximum biomass.

- GHCs are mutually exclusive and together cover the complete land surface of Europe, including water bodies.
- There are explicit rules to define GHCs.
- GHCs are distinctive and recognisable. Photos of all the GHCs can be found on the EBONE website.
- GHCs are a common denominator for comparison between countries using extant data and classes in current use wherever possible.
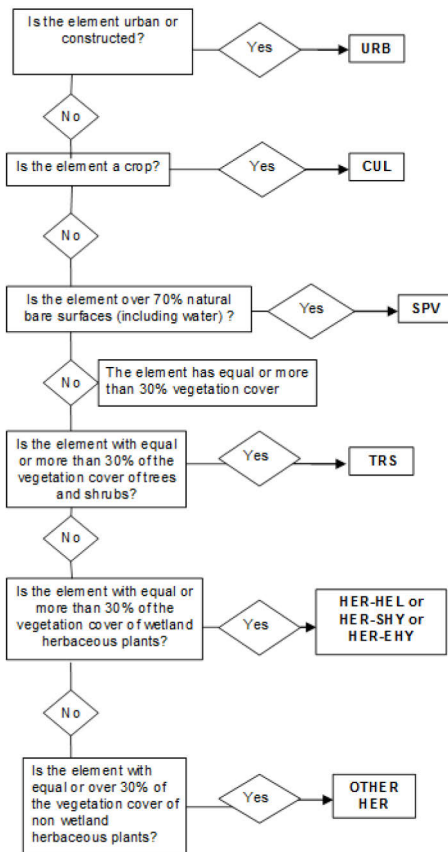
Figure 1

Classification key for determination of the GHC super categories.

The EBONE methodology provides each element with several aggregated levels of the above mentioned main types of information. In this deliverable three levels of information were used in the analysis:
- Level1 - only the very main level of habitat categories comprising of five categories.
- Level2 - habitat level L1 + structural characteristics of life forms and non-life forms.
- Level3 - all habitat L2 categories plus leaf types (photosynthetic component).

Within this report we used the three levels of the GHC typology: GHC L1 = Five super categories, GHC L2 = L1 + Life and non-Life forms, GHC L3 = L2 + Leaf types (photosynthetic component).
There is a restricted list of GHCs acting as the core of the procedure for recording habitats and linking extant data. **There are 140 GHCs, the complete list is being given in Annex I of this document. No other combinations are allowed.**

2.3 Plant Life Forms

Although Life Forms originated in the early nineteenth century, they have been widely used and adopted for many recent studies. The most known life form classification system is the one of Raunkiaer (1934) that is still at the core of the EBONE plant life form classification.

The primary sources for the Life Forms have been various floras (e.g. Clapham et al.,1952; Oberdorfer, 1990). The height categories have been designed to fit in with previous work, especially in the Mediterranean literature. Some widely used habitat terms are not life forms, e.g. halophytes (salt tolerant plants) and chasmophytes (rock crevice plants) Cryptogams are included as a separate category because they occupy extreme environments.
Information on plant life forms can be used for determining the status of the ecosystem and its biodiversity.

2.4 Qualifiers

The recording procedure adds further detail by using various qualifiers relating to Environment, Management and Site characteristics. These qualifiers can be used to refine the status of the habitat.

Global Qualifiers: Global qualifiers refer to the setting of an element (height or scattered trees) or to the accessibility of the element or reference previous data (data missing).

Environmental Qualifiers: Environmental qualifier codes express variation between elements that have the same GHC. Environmental qualifiers include indicators for humidity and acidity. Identifying the right label can take place via substrate identification, direct measuring, Ellenberg values or indicative species. It is essential to note that local use of terms, especially dry, may differ from a European standard. For European projects the European standards should be used for a correct analysis.

Management Qualifiers: The management qualifiers consist of several elements of information. Firstly, the time of the management; secondly, the location of the management is taking place, e.g. forest or urban; and thirdly, specific management activities. A hierarchical structure allows for flexible data analysis.

2.5 GIS Layers

The EBONE field work protocol is based on the exhaustive mapping of a landscape sample of 1km x 1km. Based on a digitising protocol (Annex 2), the spatial data issued from photo-interpretation and recordings from the field work are stored into GIS (Arc SHAPE files) layers; one layer for each of AREAL, LINEAR and POINT Habitat elements.
The GIS Layers are composed of the vector shapefiles and an associated data table with reference coding allowing the linkage with the field data base storing the coding and the description of each habitat element using the EBONE field work protocol.
Ensuring a consistent coding and linkage between the GIS layers and the Database is mandatory for further analysis and based on our field test experience guidelines have been provided.

2.6 What has been sampled?

The objectives of WP6 and the analyses of the data recorded are not to produce representative estimates but to test *in-situ* the EBONE habitat recording protocol from the acquisition of data in field to the processing of the data and production of a set of indicators.

A selection of indicators is presented in this deliverable, but the EBONE protocol allows to record a large number of parameters form habitat, life forms, environment, management, biodiversity and a much large range of indicators presented in this deliverable can be derived in a flexible and controlled way.

The field test of the EBONE protocol has been done in twelve European countries within WP6 and three more countries in WP9 (Israel, Australia and South-Africa). Table 1 summarises the dataset used for the data analysis

Table 1
Number of sample squares used for data analysis per country and per environmental strata.

COUNTRY	Nb Km2	ALN	ALS	ATC	BOR	CON	LUS	MDM	MDN	MDS	NEM	PAN
Austria	8		1			2						5
Belgium	6			4		2						
Estonia	8										8	
Spain	5								2	3		
France	14			4					12	1		
Great Britain	3											
Greece	11								5	6		
The Netherlands	3											
Norway	11	9			2							
Portugal	5						3	1		1		
Romania	9		3									6
Slovakia	11					6						5
Total	94	9	4	8	2	10	3	1	19	11	8	16
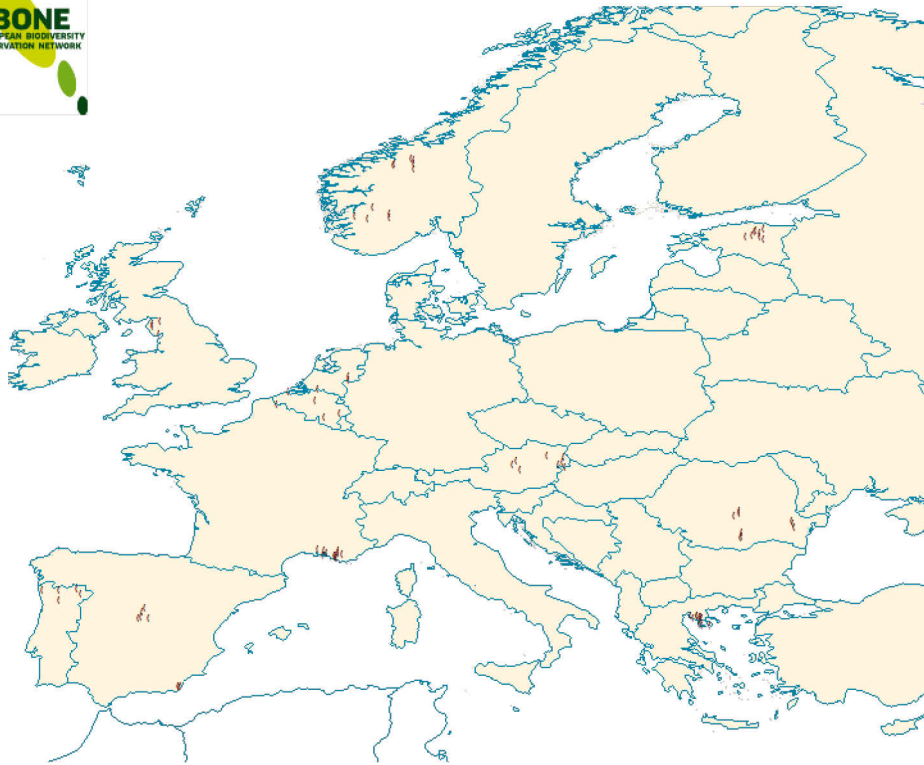
Figure 2
Spatial location of the 94 landscape squares surveyed during the EBONE.

Table 2

Landscape squares surveyed and used in the data analysis. The number of patches is the number of different polygons in the GIS shape file layer. The number of GHC is the number of different GHC recorded. The five last columns give the relative percentage in area of the squares per GHC level 1 classification (CUL: cultivated; HER: Herbaceous; SPV: Sparsely Vegetated; TRS: Trees and Shrubs; URB: Urban). The coloured bars are proportional to the values per columns and allow a graphical reading of the data table.

COUNTRY	SQUARE_ID	Square Name	ENV STRATA	Nb Polygons	Nb GHC	CUL	HER	WET	SPV	TRS	URB	UNK
AUSTRIA	AEA5	Freundorf	Pannonian	109	15	36.0%	34.1%	0.0%	0.0%	13.6%	16.3%	0.0%
AUSTRIA	AEA6	Lugauer	Atlantic South	48	14	0.0%	29.8%	0.0%	3.9%	66.0%	0.4%	0.0%
AUSTRIA	AT01	Pamhagen-Grenze	Pannonian	75	9	90.4%	4.4%	0.0%	0.0%	2.9%	2.3%	0.0%
AUSTRIA	AT02	Fasangarten	Pannonian	96	17	48.4%	34.0%	1.3%	0.6%	6.3%	9.4%	0.0%
AUSTRIA	AT03	Jois	Pannonian	127	11	68.1%	18.4%	0.0%	0.3%	12.7%	0.6%	0.0%
AUSTRIA	ATA4	Teichhof	Pannonian	26	11	85.9%	4.6%	0.0%	0.0%	1.5%	8.0%	0.0%
AUSTRIA	ATU1	Steyern	Continental	79	14	0.0%	38.8%	0.0%	3.0%	56.4%	1.8%	0.0%
AUSTRIA	ATU2	Post-Behamberg	Continental	130	16	5.5%	54.2%	0.0%	2.2%	32.4%	5.7%	0.0%
BELGIUM	BE01	Rotselaar	Atlantic Central	66	14	10.6%	28.0%	0.0%	3.1%	48.7%	9.6%	0.0%
BELGIUM	BE02	Zwin	Atlantic Central	21	9	0.0%	42.5%	43.3%	0.0%	14.1%	0.0%	0.0%
BELGIUM	BE03	Marum	Atlantic Central	63	6	2.8%	48.0%	0.0%	0.0%	49.1%	0.0%	0.0%
BELGIUM	BE04	Kalmthoutse Heide	Atlantic Central	43	12	0.0%	20.2%	0.0%	1.6%	72.2%	6.0%	0.0%
BELGIUM	BE05	Ave-et-Auffe	Continental	35	11	8.7%	49.1%	0.0%	0.0%	40.0%	2.2%	0.0%
BELGIUM	BE06	Vielsalm	Continental	47	12	0.0%	3.2%	0.0%	2.5%	93.0%	1.4%	0.0%
ESTONIA	EE01	Jogeva	Nemoral	25	5	47.1%	24.0%	0.0%	0.0%	28.9%	0.0%	0.0%
ESTONIA	EE02	Kareda	Nemoral	27	9	0.0%	87.5%	0.0%	0.0%	8.6%	3.9%	0.0%
ESTONIA	EE03	Koeru	Nemoral	33	13	16.9%	45.9%	0.0%	2.0%	23.7%	11.5%	0.0%
ESTONIA	EE04	Rakke	Nemoral	45	13	66.5%	17.1%	0.0%	0.2%	14.3%	1.9%	0.0%
ESTONIA	EE05	Vaeike-Maarja	Nemoral	13	5	92.8%	0.0%	0.0%	0.0%	6.5%	0.6%	0.0%
ESTONIA	EE06	Assamalla	Nemoral	23	11	10.6%	70.1%	0.0%	0.0%	14.6%	4.7%	0.0%
ESTONIA	EE07	Porkuni	Nemoral	26	12	47.4%	26.9%	0.0%	0.0%	16.5%	9.2%	0.0%
ESTONIA	EE08	Raegavere	Nemoral	41	11	0.0%	87.8%	0.0%	0.0%	5.2%	7.0%	0.0%
SPAIN	ES1853	Mostoles	Mediterranean South	7	6	53.2%	0.0%	0.0%	0.0%	17.1%	29.7%	0.0%
SPAIN	ES2672	Pozuelo de Alarcon	Mediterranean South	6	4	0.0%	1.4%	0.0%	0.0%	70.2%	28.3%	0.0%
SPAIN	ES4051	Colmenar Viejo	Mediterranean North	8	6	0.0%	83.3%	0.0%	0.0%	14.3%	2.4%	0.0%
SPAIN	ES5563	Venturada	Mediterranean North	10	7	3.9%	0.0%	0.0%	0.0%	68.0%	28.1%	0.0%
SPAIN	ES6371	Loeches	Mediterranean South	12	10	88.0%	8.3%	0.4%	0.0%	2.9%	0.4%	0.0%
FRANCE	FR001	Les Basses Selves	Mediterranean North	16	8	0.9%	0.2%	0.0%	0.0%	97.5%	1.2%	0.3%
FRANCE	FR002	Regagnas	Mediterranean North	12	6	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
FRANCE	FR003	Fonblanche	Mediterranean North	9	4	3.9%	0.0%	0.0%	0.0%	96.1%	0.0%	0.0%
FRANCE	FR004	Vallon de Valtrede	Mediterranean South	24	12	7.0%	1.8%	0.0%	0.0%	91.0%	0.2%	0.0%
FRANCE	FR005	La Sambuc	Mediterranean North	10	6	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
FRANCE	FR006	Ste Anne du Castellet	Mediterranean North	8	3	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
FRANCE	FR007	Les Adrechs	Mediterranean North	14	11	2.5%	0.2%	0.0%	0.0%	95.6%	1.7%	0.0%
FRANCE	FR008	Coriolan	Mediterranean North	12	8	4.0%	0.0%	0.0%	0.0%	73.2%	21.9%	0.9%
FRANCE	FR009	La Tauliere	Mediterranean North	21	12	13.1%	23.6%	0.0%	0.0%	53.2%	5.3%	4.8%
FRANCE	FR010	La Couirasse	Mediterranean North	13	6	0.0%	0.8%	0.0%	0.0%	99.2%	0.0%	0.0%
FRANCE	FR011	Le Vallon Rouge	Mediterranean North	11	11	10.2%	0.2%	0.0%	0.0%	83.2%	3.9%	2.4%
FRANCE	FR012	Collet Redon	Mediterranean North	19	10	4.7%	6.3%	0.0%	0.0%	81.2%	1.7%	6.2%
FRANCE	FR051	Mayenque	Mediterranean North	116	29	45.5%	20.0%	0.0%	0.0%	22.6%	2.2%	9.7%
FRANCE	FR99	Bailleul	Atlantic Central	38	9	50.6%	34.7%	0.0%	0.0%	1.8%	12.9%	0.0%
GREAT BRITAIN	GB01		Atlantic North	78	10	0.0%	62.0%	0.0%	0.0%	15.8%	16.0%	6.2%
GREAT BRITAIN	GB02		Atlantic North	69	8	0.0%	58.6%	0.0%	0.0%	30.9%	3.2%	7.3%
GREAT BRITAIN	GB04		Atlantic North	45	7	2.6%	62.7%	0.0%	0.0%	26.0%	2.8%	5.9%
GREECE	GR01	Scholari	Mediterranean South	28	15	17.2%	52.3%	0.0%	0.0%	3.2%	27.3%	0.0%
GREECE	GR02	Triglia	Mediterranean South	14	7	56.5%	0.0%	0.0%	0.0%	40.9%	2.6%	0.0%
GREECE	GR03	Kryopigi	Mediterranean South	12	9	25.9%	0.0%	0.0%	0.0%	69.6%	4.5%	0.0%
GREECE	GR04	Paraskevi	Mediterranean South	22	12	42.5%	0.0%	0.0%	0.0%	53.7%	3.8%	0.0%
GREECE	GR05	Nisi	Mediterranean South	22	12	71.3%	5.1%	1.9%	0.1%	0.1%	21.6%	0.0%
GREECE	GR06	Kalamitsi	Mediterranean South	8	5	2.4%	0.0%	0.0%	0.0%	93.2%	4.4%	0.0%
GREECE	GR07	Ormylia	Mediterranean North	5	3	63.1%	0.0%	0.0%	0.0%	36.9%	0.0%	0.0%
GREECE	GR08	Vrastama	Mediterranean North	4	3	8.2%	13.1%	0.0%	0.0%	78.6%	0.0%	0.0%
GREECE	GR09	Taxiarchis	Mediterranean North	8	4	0.0%	1.3%	0.0%	0.0%	98.0%	0.8%	0.0%
GREECE	GR10	Prodromos	Mediterranean North	9	6	34.5%	0.0%	0.0%	0.0%	65.5%	0.1%	0.0%
GREECE	GR11	Agios	Mediterranean North	4	3	66.2%	0.0%	0.0%	0.0%	33.8%	0.0%	0.0%
THE NETHERLANDS	NL01		Atlantic Central	128	11	24.1%	61.7%	0.0%	0.1%	1.1%	8.4%	4.6%
THE NETHERLANDS	NL03		Atlantic Central	151	12	8.8%	39.7%	0.2%	1.4%	34.9%	5.5%	9.5%
THE NETHERLANDS	NL12		Atlantic Central	74	6	12.7%	73.7%	0.0%	4.2%	0.0%	5.5%	3.9%
NORWAY	NO001	Trastolen	Alpine North	7	6	0.0%	45.8%	0.0%	11.3%	41.2%	1.7%	0.0%
NORWAY	NO002	Kalhovd	Boreal	7	7	0.0%	39.2%	0.0%	2.5%	57.7%	0.7%	0.0%
NORWAY	NO003	Gamlestolen	Alpine North	7	6	0.0%	28.8%	0.0%	3.7%	66.9%	0.6%	0.0%
NORWAY	NO004	Merakkhaugen	Boreal	6	5	0.0%	22.3%	0.0%	1.3%	76.4%	0.0%	0.0%
NORWAY	NO005	Kjelavatn	Alpine North	7	5	0.0%	3.6%	0.0%	17.1%	76.0%	3.3%	0.0%
NORWAY	NO006	Oyan	Alpine North	7	6	0.0%	20.0%	0.0%	5.5%	73.4%	1.1%	0.0%
NORWAY	NO007	Sandvatnet	Alpine North	5	5	0.0%	1.0%	0.0%	40.2%	58.7%	0.0%	0.1%
NORWAY	NO008	Gravhoa	Alpine North	4	4	0.0%	44.8%	0.0%	7.9%	47.3%	0.0%	0.0%
NORWAY	NO009	Rundhaugen	Alpine North	6	6	0.0%	0.3%	0.0%	27.0%	72.0%	0.7%	0.0%
NORWAY	NO010	Tverrfjellet	Alpine North	8	8	0.0%	32.5%	0.0%	1.4%	56.0%	10.0%	0.0%
NORWAY	NO011	Dorremesetra	Alpine North	21	9	0.0%	14.6%	0.0%	0.0%	81.9%	3.5%	0.0%
PORTUGAL	PT001	Alturas do Barroso	Lusitanian	27	11	10.0%	46.8%	0.0%	0.0%	42.0%	1.2%	0.0%
PORTUGAL	PT002	Medroes	Lusitanian	4	9	68.7%	0.7%	0.0%	0.0%	10.5%	6.7%	13.5%
PORTUGAL	PT004	Morais	Mediterranean North	15	9	0.0%	25.4%	0.0%	0.0%	74.6%	0.0%	0.0%
PORTUGAL	PT003	Ousilhao	Mediterranean Mountain	15	7	37.4%	11.6%	0.0%	0.0%	45.6%	5.4%	0.0%
PORTUGAL	PT005	Vitorino de Piaes	Lusitanian	41	19	13.0%	14.0%	0.0%	0.0%	42.3%	30.7%	0.0%
ROMANIA	RO01	Simon Bran	Atlantic South	10	4	0.0%	2.3%	0.0%	0.0%	97.7%	0.0%	0.0%
ROMANIA	RO02	Tohanu Nou	Atlantic South	46	9	17.3%	42.7%	5.1%	0.0%	0.7%	34.1%	0.0%
ROMANIA	RO03	Dragoslavele	Atlantic South	17	9	0.0%	11.8%	0.0%	0.0%	23.5%	64.7%	0.0%
ROMANIA	RO04	Marsa	Pannonian	10	5	99.2%	0.2%	0.7%	0.0%	0.0%	0.0%	0.0%
ROMANIA	RO05	Izvoru	Pannonian	110	6	41.2%	42.9%	0.0%	0.0%	14.1%	1.8%	0.0%
ROMANIA	RO06	Sericu	Pannonian	68	8	53.8%	27.8%	5.4%	0.0%	0.8%	12.2%	0.0%
ROMANIA	RO07	Gropeni	Pannonian	4	2	99.8%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
ROMANIA	RO08	Tacau	Pannonian	6	2	99.6%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
ROMANIA	RO09	Garliciu	Pannonian	55	6	69.1%	22.9%	0.0%	0.0%	0.0%	8.0%	0.0%
SLOVAKIA	SK01	Klin	Continental	90	14	43.4%	38.9%	2.0%	0.6%	8.3%	6.5%	0.2%
SLOVAKIA	SK03	Gotovany	Continental	46	8	9.1%	73.9%	4.5%	0.0%	10.9%	1.6%	0.0%
SLOVAKIA	SK04	Liptovska Teplicka	Continental	73	11	0.8%	47.0%	1.0%	0.0%	51.1%	0.1%	0.0%
SLOVAKIA	SK05	Tisovec	Continental	50	11	0.0%	38.1%	0.0%	0.0%	60.8%	1.1%	0.0%
SLOVAKIA	SK06	Malacky	Pannonian	77	12	24.8%	4.4%	6.7%	0.0%	61.4%	2.7%	0.0%
SLOVAKIA	SK07	Oponice	Pannonian	60	13	66.1%	5.2%	0.0%	0.3%	25.1%	3.2%	0.0%
SLOVAKIA	SK09	Sudovce	Pannonian	88	16	10.3%	40.6%	0.0%	0.0%	38.2%	10.2%	0.7%
SLOVAKIA	SK10	Tachty	Pannonian	81	9	11.6%	14.8%	9.3%	8.3%	53.8%	2.2%	0.0%

3　Data Analysis

The landscapes and the habitats are the results of long terms interactions between practices, land uses, culture, abiotic and biotic components.
The rationale of the data analyses exercise was to compute a range of different categories of indicators and summary tables that could be used to report on the diversity of habitats and biodiversity at EU level, at national level and per environmental strata if the EBONE protocol is to be applied at full scale.

The data and indicators derived from the EBONE data have to contribute to the following analyses:
– To analyse the habitat composition on the aggregation level of member states and environmental zones.
– To link habitat information to biodiversity data.
– To explore the possible contribution of habitat information to the SEBI indicators selected in Deliverable 1.1.

Any of these analyses can only be performed for those units for which information can be obtained from a minimum sample size. **Since the WP6 field testing was not aimed at providing statistically representative estimates of any of the indicators, but of providing an example to show how data from different parts of Europe can be combined, we skipped the constraint of the minimum sample size and focused on the computation of indicators.** For this reason we did not compute any variance estimates for the indicators.
However, any real size implementation of the protocol with a scientifically robust reporting of the indicators at EU, National or Environmental strata should rely on a statically robust data set following probability sampling protocols (see deliverable 3.2 http://www.ebone.wur.nl/UK/Deliverables/

The number of areal habitat patches per landscape squares varies from 4 to 151 and the number of GHC from 2 to 29 (Table 2). A quick overview of the square summary table shows that most of the squares are dominated by Trees and Shrubs GHCs (TRS), predominantly in the Mediterranean area. Most squares comprise a mix of Cultivated (CUL) and Herbaceous (HER) GHCs. Only 16 squares have more than 10% of urban areas.

The dataflow management was realised using the datawarehouse implemented by the Austrian team of Umweltbundesamt GmbH using the open source data warehouse PENTAHO will be tested to establish a common database for the analysis based on the existing and newly created EBONE data.
The data model for the data warehouse will be derived from the common domain data model developed within the EBONE project. This test phase includes the following steps:
– Development of the common data model.
– Set up the ETL process for the selected test data sources.
– Execute the ETL process to populate the data warehouse.

The content of the data warehouse reflects the harmonised data from all the originating data sources.

Based on a preliminary list of indicators and data flows, tables allowing the final production of indicators were extracted by Barbara Magagna (Umweltbundesamt GmbH).

More information see http://www.ebone.wur.nl/UK/Deliverables/

3.1   Indicator Oriented Analysis

I.   Basic indicators

To do the proposed analyses, certain basic indicators for habitat and species diversity need to be computed. In this document these indicators are described at a general level. After having decided that these indicators are indeed the required indicators, we will develop calculation protocols for these indicators. Indicators groups:

− Patch: Habitat Patch Density: the number patches per (km^2), Habitat Patch Area and Perimeter: Mean area of Patches per square.
− Habitat: Habitat Coverage: the surface area (unit m2 or ha) of each GHC (or a coarser habitat level).
− Habitat Richness Density: the number of GHC (or a coarser habitat level) types per (ha or km^2).
− Habitat Diversity: computed from proportional area of each GHC (or a coarser habitat level) types per km^2 (using diversity metrics such as e.g. H Shannon, H Simpson or Evenness).

For the analysis, habitat categories can be used as coarse as the first level in the GHC and as detailed as combinations of qualifiers and full level GHC's. Analysis should start at the lowest level and continue towards more details. To clarify the computations of the indicators, the queries are represented using a flow chart (Figure 3). The computation base remains the same; it's merely based on database queries at the element level, only the fusion phase change.
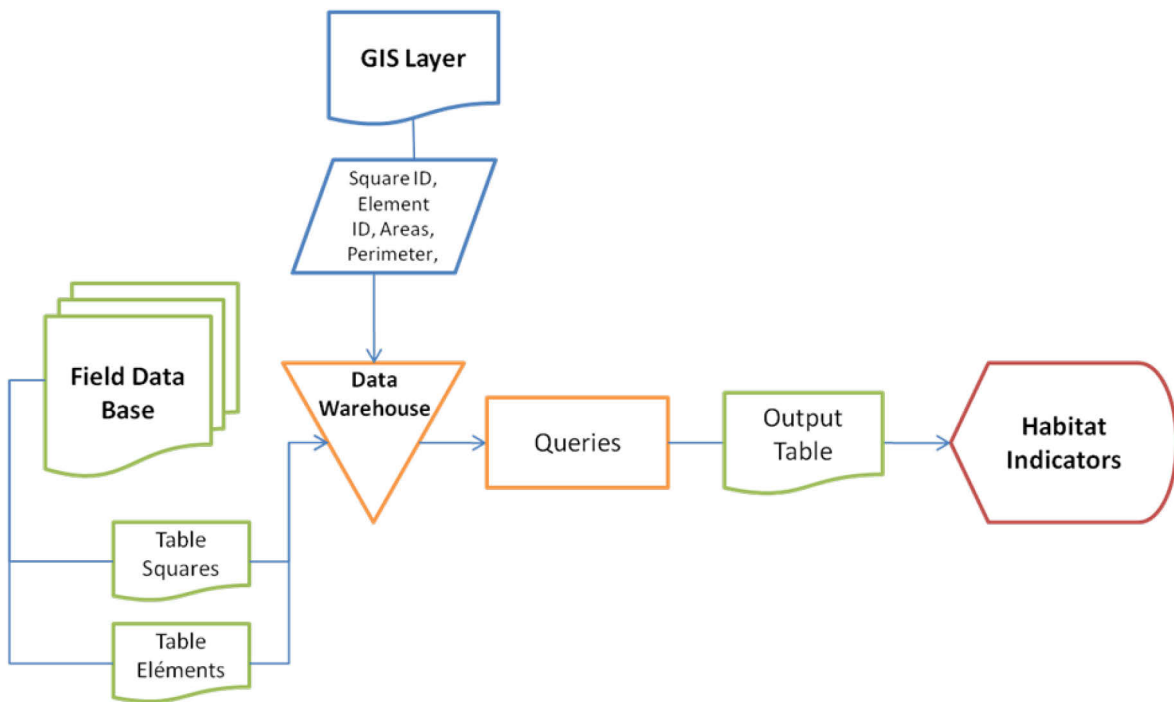
Figure 3
*Query flow from database and GIS attribute table to habitat coverage indicators.*

II.   Indicator 1: Habitat Patch Density

The Habitat Patch Density (HPD) is defined as the total number of areal elements within a sampled km^2. It is related to landscape grain and the composition of the landscape: the higher number of patches for a given

area, the higher is the landscape grain. Interactions exist with Patch area, Patch Perimeter and Patch Shape Index.

The HPD can be related to fragmentation. The increase in HPD indicates an increase of the number of discrete elements in the landscapes and could lead to patch isolation when considering patches of the same habitat. According to metapopulation theories, the increase in fragmentation and isolation may cause a reduction in the flows of individuals and genes between habitat patches and threaten viability of population (Hanski, 1998). The interpretation of HPD should be associated with the nature of the habitats since sensitivity to fragmentation and changes in connectivity associated with isolation are dependent on habitats and species.
For all our case studies, the mean patch density is 72.5 patches per squares with a standard deviation of 58.6. Hence, there was a huge variety over all the km^2 sampled

At country level, HPD the Austrian samples appears to be very high, while Estonia and Spain have low HPD (Figure 4). Generally, higher HPD are associated with increase in land use intensity-; therefore this is in agreement of what could be expected.
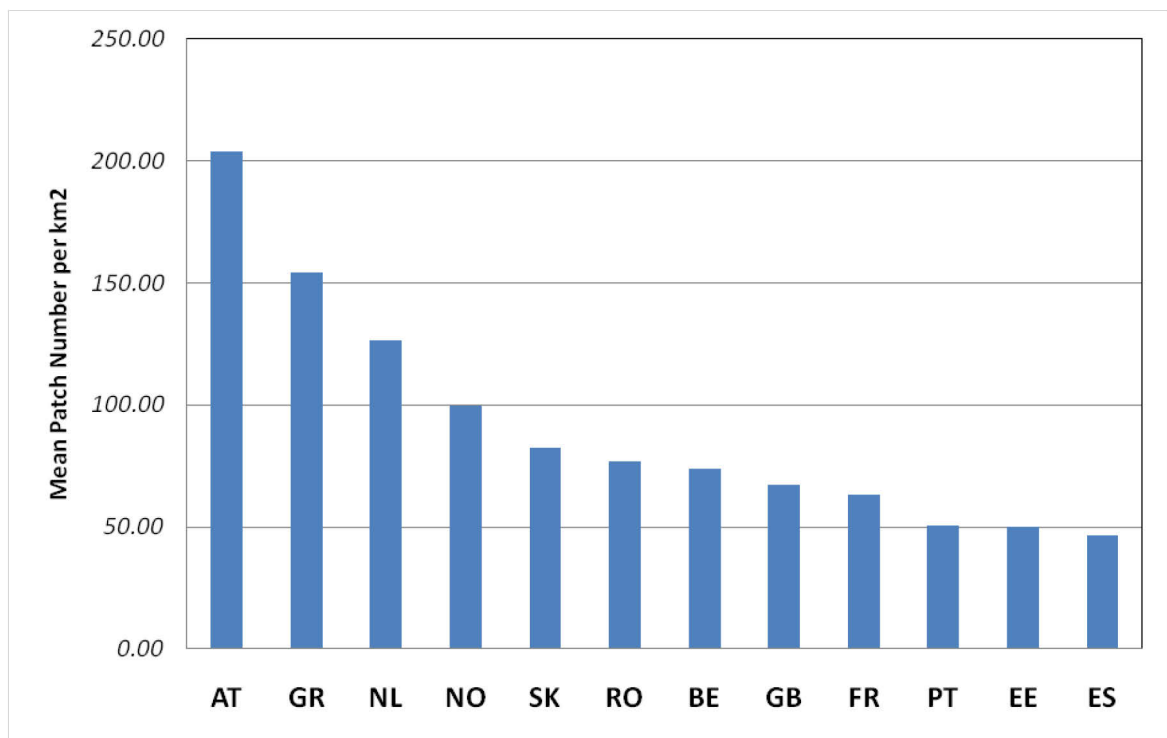
Figure 4

Mean Habitat Patch Density per country per 1km². For Portugal, the area of the sample sites was 0.25km².

At Environmental strata level[2], the values are also very variable with the higher values for Pannonian which are very influenced by Austrian data and the lowest for Mediterranean Mountains.

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[2]Environmental strata refer the environmental stratification of Metzger et al., 2005 (Deliverable 3.1: http://www.ebone.wur.nl/UK/Deliverables/. They result from a bioclimatic analysis at European level.
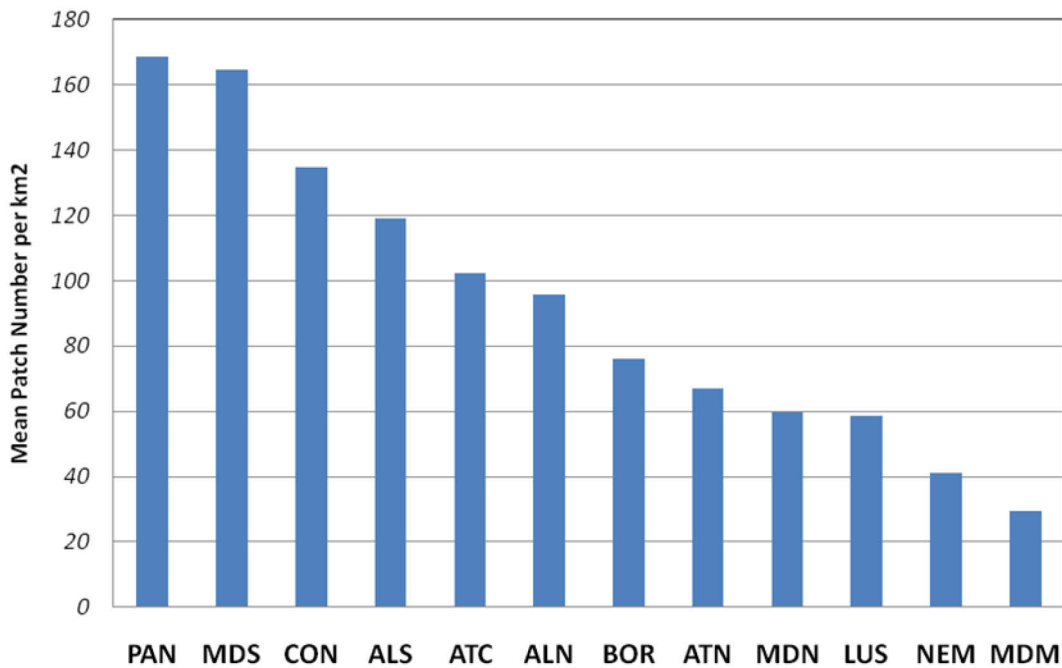
Figure 5
Mean Habitat Patch Density per Environmental strata (EnS) per 1km².

III. Indicator 2: Habitat Patch Size

Habitat Patch Size (HPS) is defined as the average size of a patch. Following the data flow (Figure 3), it's easy to compute habitat coverage per a large set of grouping factors (GHC, Country, EnS, Squares …). As stated previously the Habitat Patch Size is linked to the number of patches within a given area. Although the link between the two is not simple, when the number of patches within a given area increase it results in a reduction of the average patch area.

Habitat Patch Size is an indicator related to fragmentation since a decrease in HPS is related to habitat shrinkage and could results in loss of core habitat and favour edges. It has a negative impact on the abundance of habitat specialist species, particularly for forested habitats. It could be interesting to differentiate the HPS by habitat types in order to follow time trends and compare between regions. Some animal species, including birds, mammals and reptiles prefers large habitat patches that provide enough area to provide them all the resources needed and breeding territories. A decrease in HPS will very likely results in a reduction of biodiversity (Lindenmeyer and Franklin, 2002). At landscape level the effect could be counterbalanced by habitat diversity and connectivity.

As expected the country (Austria) with the highest HPD appears to have the lowest HPA (Figure 6).
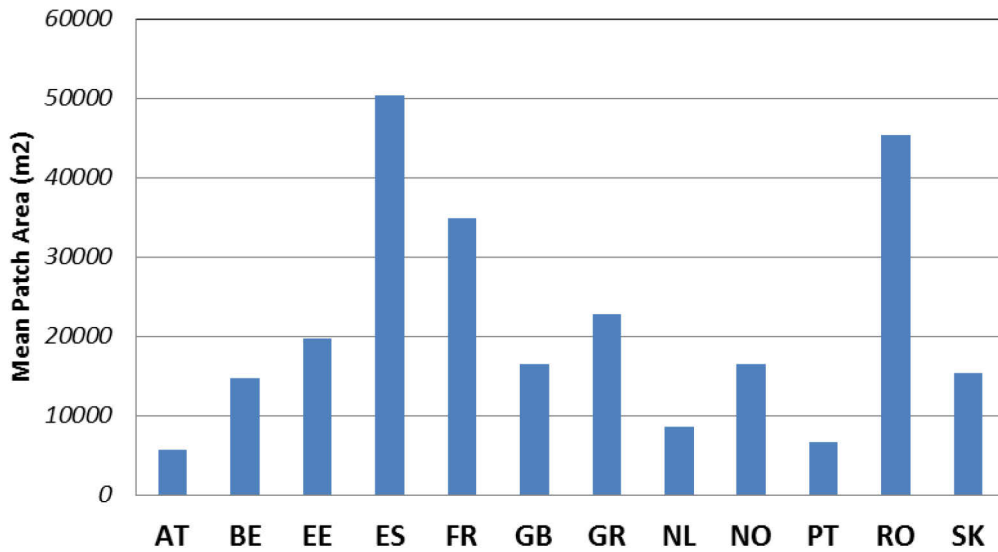
Figure 6

Habitat Patch Size per country.

HPS can also be estimated for GHC types (Fig. 7). If we consider the CHC Level 1 typology (super categories) we observe that the TRS habitats have the highest mean Patch size while the other remains around a mean value of 1 ha. It appears that Spain and France are coarse grained landscapes compared to Austrian and Portugal which are fine grained landscapes.
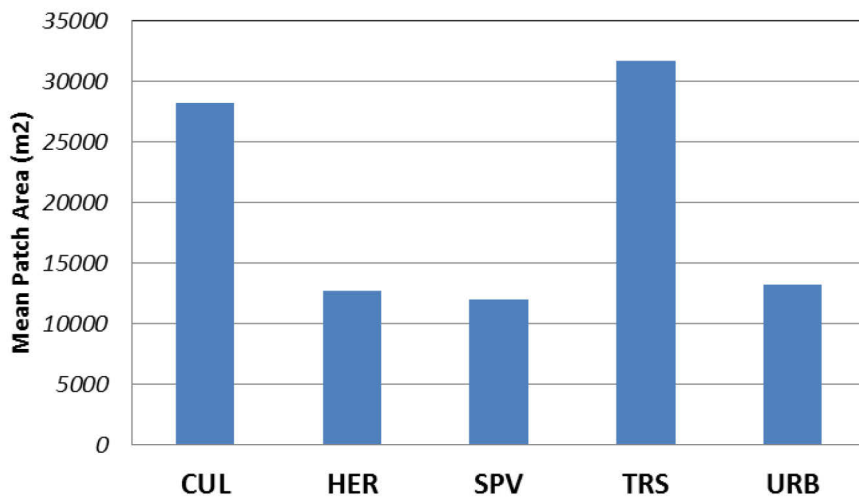
Figure 7

Habitat Patch Size per GHC level 1.

This average value is very low when compared with what could be estimated from global data layers like CLC were the MMU is fixed at 25 ha! This indicates the added value of the EBONE protocol. The spatial resolution

of the EBONE data which have a MMU of 400m2 allows to better provide information on the finer grained landscapes.

Changes in area and isolation of habitats are particularly important for habitat specialist species.

IV. Indicator 3: Mean Patch Shape Index (PSI)

The mean patch perimeter of a patch is related to its area and the complexity of its shape. A patch that is perfectly circular has the smallest perimeter relatively to its area. More complex patches have a longer perimeter (ex: fields and hedges). From Patch Area and Perimeter the Shape Index could be computed by relating the Area/Perimeter ratio with a reference ratio (usually a disc or a square). Lower values indicate are frequent in cultural dominated landscapes with squared or simply shaped fields. Nevertheless, some cultural practices involves narrow and elongated fields resulting in intermediate PSI.

The PSI indicator should be used in conjunction with HPS. For the same habitat patch size, the importance of edge and thus the impact on core habitat availability would be higher for high patch shape index that indicates elongated or dissected patches. The impact would be negative on the biodiversity of habitat specialist species and positive on edge species. The magnitude of the impact on biodiversity could be very variable between habitats and species.

The interpretation of the Shape index is not straight forward since elongated shapes like the field in Austria and Slovakia have high shape index values that could be compared to complex topographically induced shapes of Spain and Norway (Figure 8). Lower values indicate a mean shape close to a square and are frequent in cultural dominated areas with square or simply shaped fields.
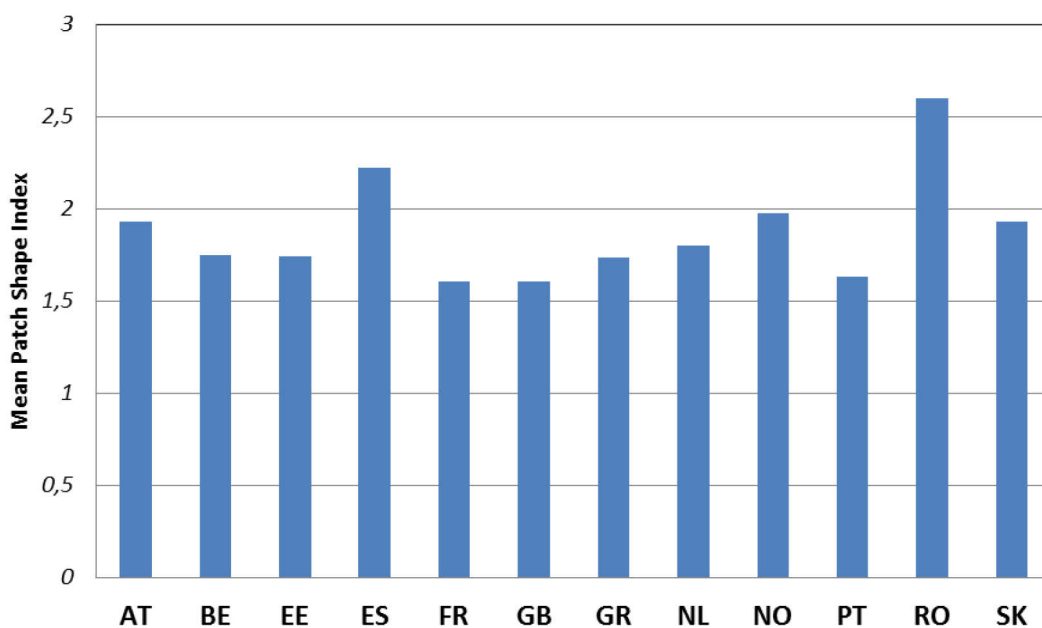
Figure 8

Mean Patch Shape Index per km² per country.

V. Indicator 4: Habitat Richness Density (HRD)

The Habitat Richness Density could be defined as the total number of different habitats within a sampled area.

The range of Habitat Richness Density is related primarily to habitat typology; the coarser the habitat typology is (few types) the smaller is the range of Habitat Richness Density.

The habitat richness can to be related to biodiversity, the total biodiversity at landscape level (gamma) is positively related to the number and range of habitat types (Weibull et al., 2003). The relation between HRD and biodiversity is highly dependent on the habitat types and species biodiversity could be correlated with HRD and the area of important habitat types (Dauber et al., 2003).

In order to explore the dependency of HRD on values to the typology, we used three levels of the GCH typology (see EBONE field manual).

– Level 1: GHC Super-categories (Max. Nb = 5)
– Level 2: GHC without leaf type (more structural; Max. Nb = xxx)
– Level 3: GHC with leaf type (Max. Nb = 140)

Level 1 is related to the diversity of the major categories of habitats and a high value will indicate a very diverse landscape in type of habitat and management types.
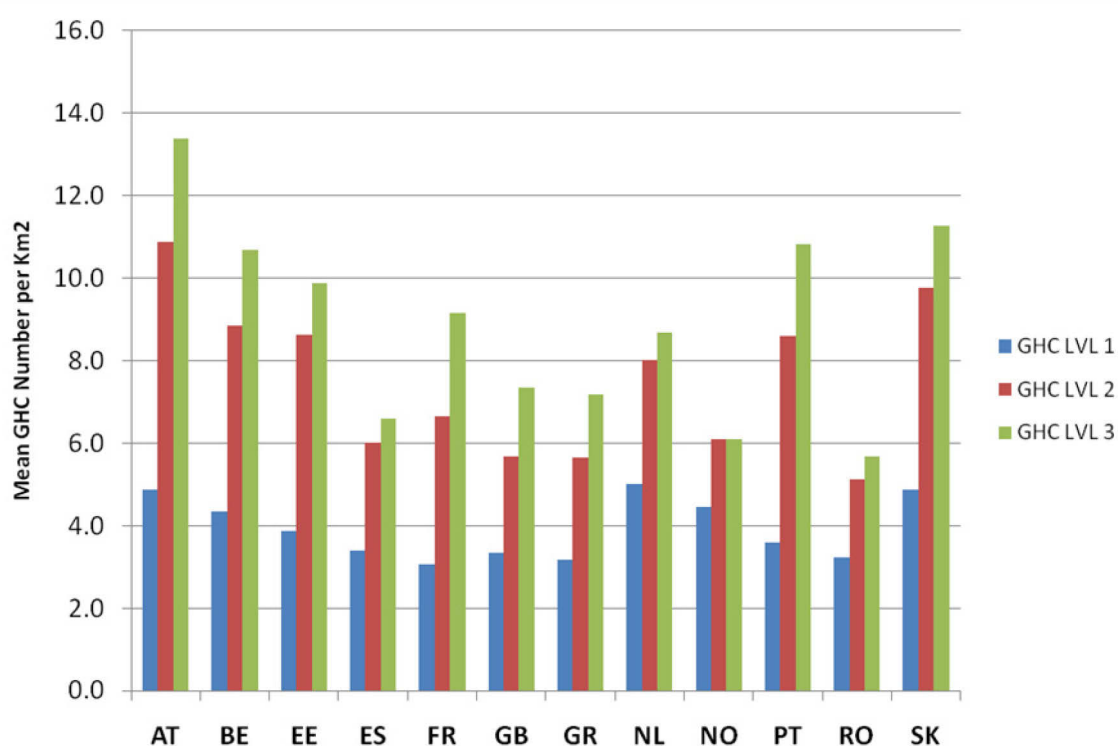
Figure 9
Average Habitat Richness Density per country for three levels of precision of habitat typology.

The levels 2 and 3 are related to structural variability of habitat types and a can reach high values even in landscape that were not very Habitat Rich at level 1 (ex. A natural landscape can be composed of only two GHC super-categories (Herbaceous and Tree/Shrubs)) and have a high Habitat Richness at GHC level 2 and 3 indicating the occurrence of many different subtypes of habitats.

As expected the value of the HRD increases as the number of types increases per level (Figure 9). A higher HRD number indicates that the km^2 sampled in that country has a higher diversity in their patch types when looking with a more detailed typology. GHC L3 is related to the photosynthetic type of leaves of TRS and countries with a higher variability in the vegetation leaf types increase the most in their HRD from Level 2 to Level 3.
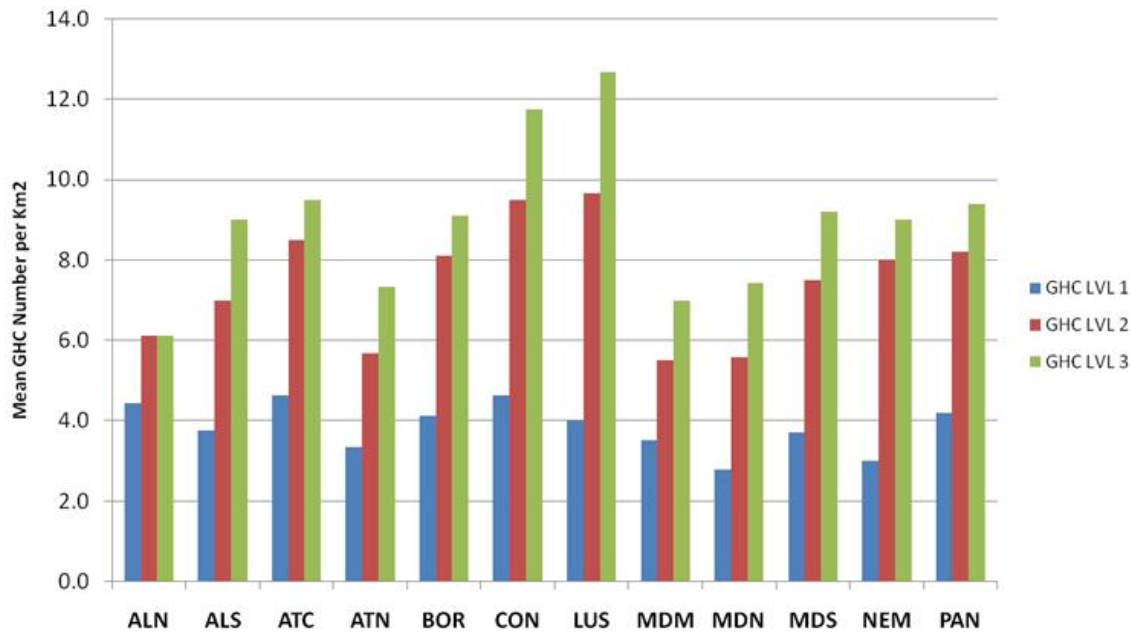
Figure 10

Average Habitat Richness Density per EnS.

The countries with the highest values HRD are Austria and Slovakia, while the lowest values are for Romania, Spain and Norway (Figure 9). This indicates more homogeneous landscapes.

Patches in Portuguese dataset appear to be of only two types (i.e. TRS and HER) at level 1 detail of the GHC typology but to be habitat rich when the structural variability among TRS GHC are considered. The patches from the Greek dataset, despite being from a Mediterranean country, appear to be quite low in habitat variability; this is certainly to be related to a dominance of Cultivated GHC and little variability in cultivation types within the sampling set.

The pattern observed at country level is maintained at the EnS level; the major increment being between the GHC L1 and GHC L2.

The three environmental strata with the highest Habitat Richness Density were the Alpine South, the Pannonian and the Mediterranean South. The lowest values were found for the Boreal, Atlantic North and Mediterranean North strata (Figure 10).

VI. Indicator 5: Habitat Diversity (HD)

We computed the Habitat Diversity using two diversity index: the Shannon index and the Simpson reciprocal index. The frequencies used to compute the diversity values represent the proportion of the square area occupied by a given habitat.

The diversity index allows taking into account dominance beside richness. The Shannon index is widely used in ecological literature although it is less informative compared to HRD than the Simpson index. The Shannon index is more correlated to the number of habitats (Magguran, 1988).
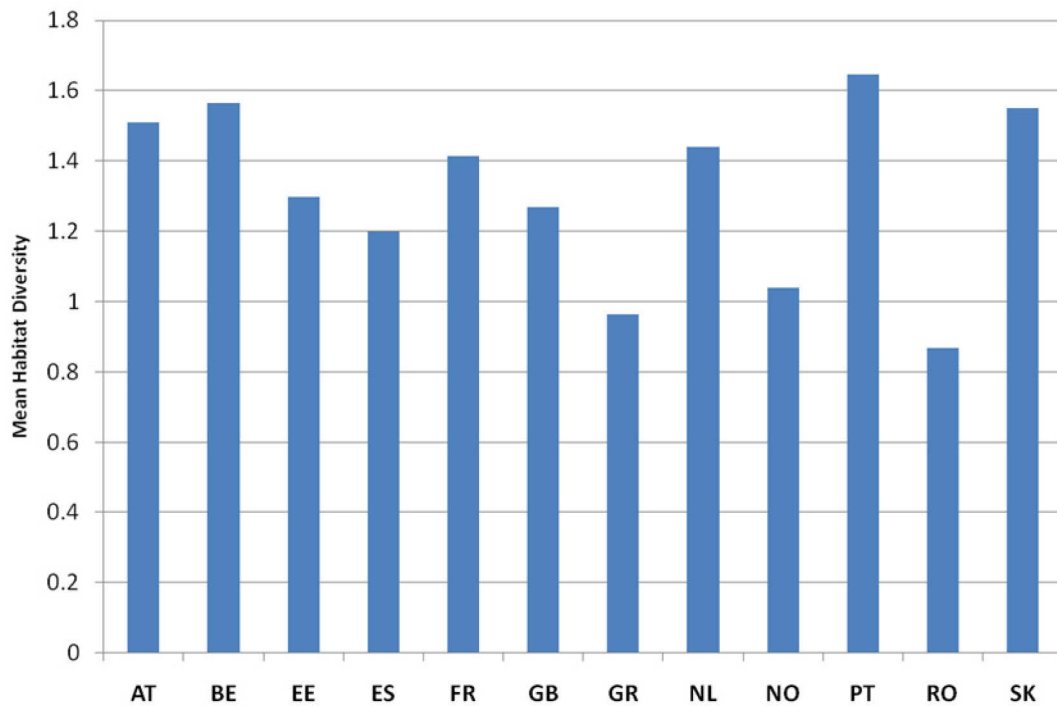
Figure 11

Mean Habitat Diversity at Square level per country.
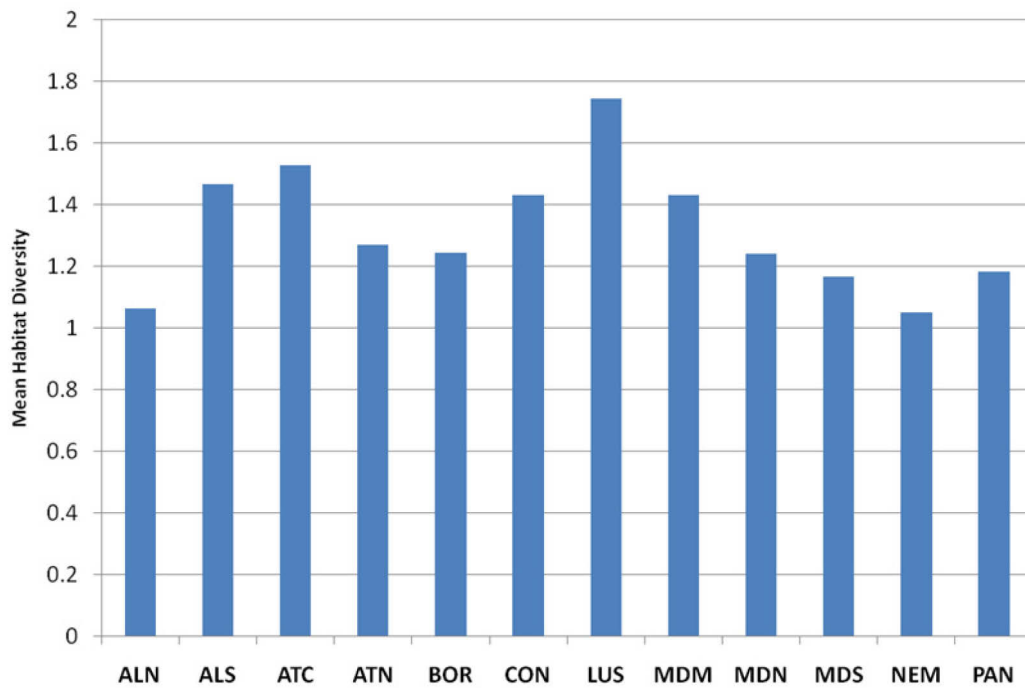
Figure 12

Mean Habitat Diversity at Square level per EnS.

VII. Indicator 6: Life Forms Richness Density (LFRD)

Life Forms can be used as functional proxies to species biodiversity by grouping plant species into groups with similar strategies regarding life duration, resources acquisition and space occupancy (Sahu et al., 2012)). The Life Form Richness Density would then be a good proxy for the plant species diversity.

The life forms serve primary key within the EBONE field protocol to identify elements as General Habitat Categories, but also to record information about vegetation structure and diversity. In general, for each habitat element all the life forms with more than 10% cover are recorded as well as TER components (i.e. rocks, gravel, soil, sand…).

The analysis of the life form data of elements provide a lot of information on the composition variation between elements of similar GHC and can also be used for more detailed ecological and biodiversity analyses.

The LFRD is a first estimate of biodiversity variability grouped at country or EnS level. We used the square averaged LFRD that is less dependent on the number of squares sampled than the total Life Form Richness. As a matter of comparison, we provided the mean number of GHC per square for Country level (Figure 13) and for EnS level (Figure 14).

For the figures 13 and 14, it can be observed that the LFRD is generally higher than the HRD. This means that patches were recorded as the same GHC type, but the composition of the Life Forms with the patches showed a higher diversity. There is a correlation between the GHC typologies and the Life Form Richness because the GHC typology relies on life forms (i.e. CHE, LHE, LPH…) and pseudo life forms such as land uses (i.e. CUL, URB). This relation gives a functional relation between habitat diversity and biodiversity (Figure 15).
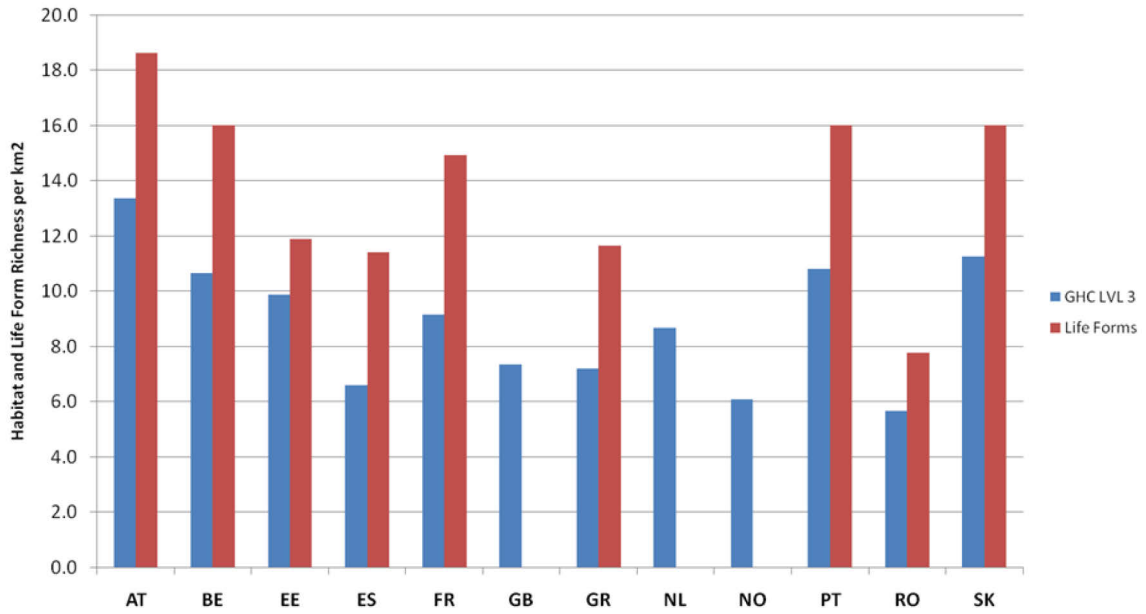
Figure 13

Habitat and Life Form Richness per km² squares averaged per country. Data are missing for GB, NL and NO.
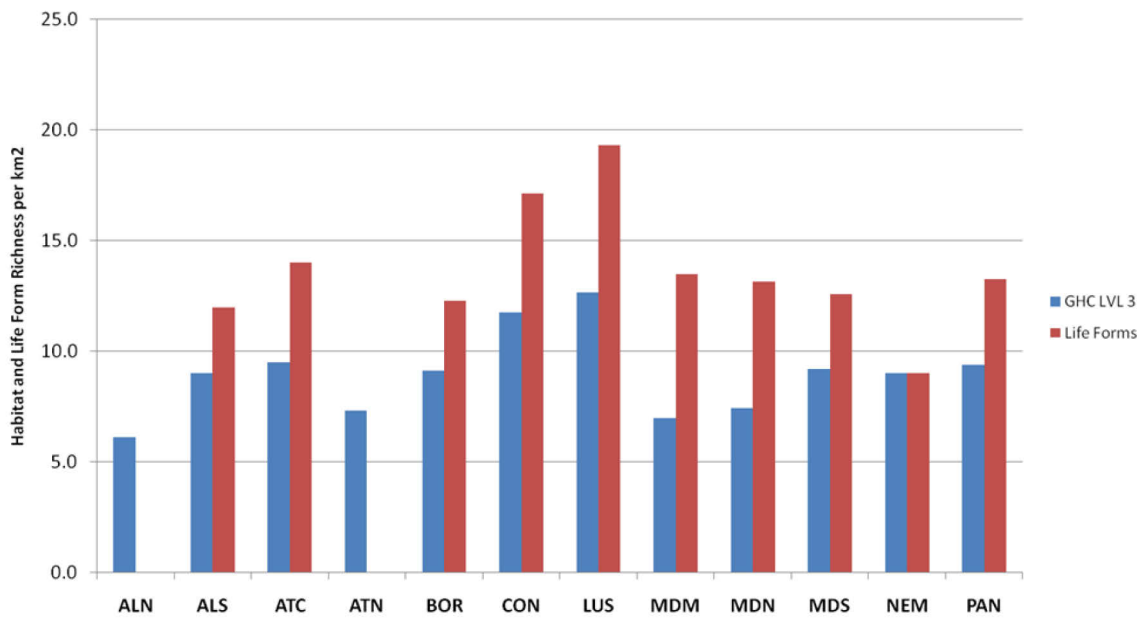
Figure 14

Habitat and Life Form Richness per km² squares averaged per EnS. Data missing for ALN and ATN.
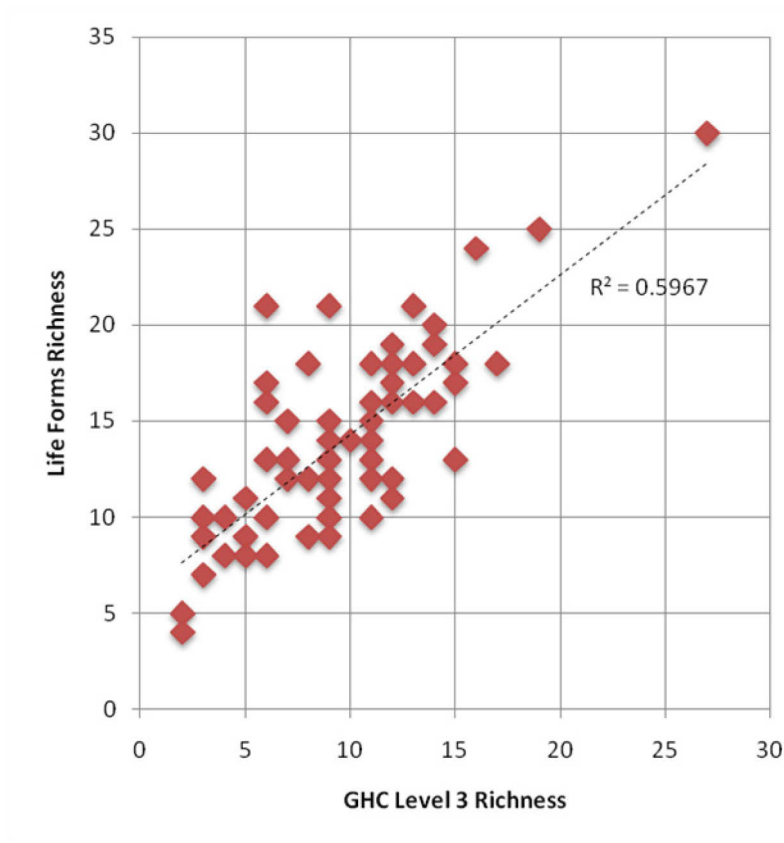
Figure 15
Relation between Number of GHC and Number of Life Forms.

3.2 Pressure Indicators

Pressure indicators represent an ongoing impact the biodiversity over time. Pressure indicators include for instance the application of fertilizer, the soil disturbances, stocking density, use of pesticides. Some of these pressure indicators can be derived from the analysis of land use. The EBONE protocol uses a hierarchical system of coding for different types of land uses that allows separating the broad land use types, the precise land use types and the degree of activity on a time scale (Bunce et al., 2011). A fourth level of information concerns the species involved in the agricultural and forestry managements.

I. Indicator 7: Time Frame of management activity

The Time Frame of the management activities makes it possible to get an indication of the intensity of land use in a sample set (Figure 16). This can be a very important explanatory factor in biodiversity differences between samples in the same regions. Also it can help to understand differences between countries.
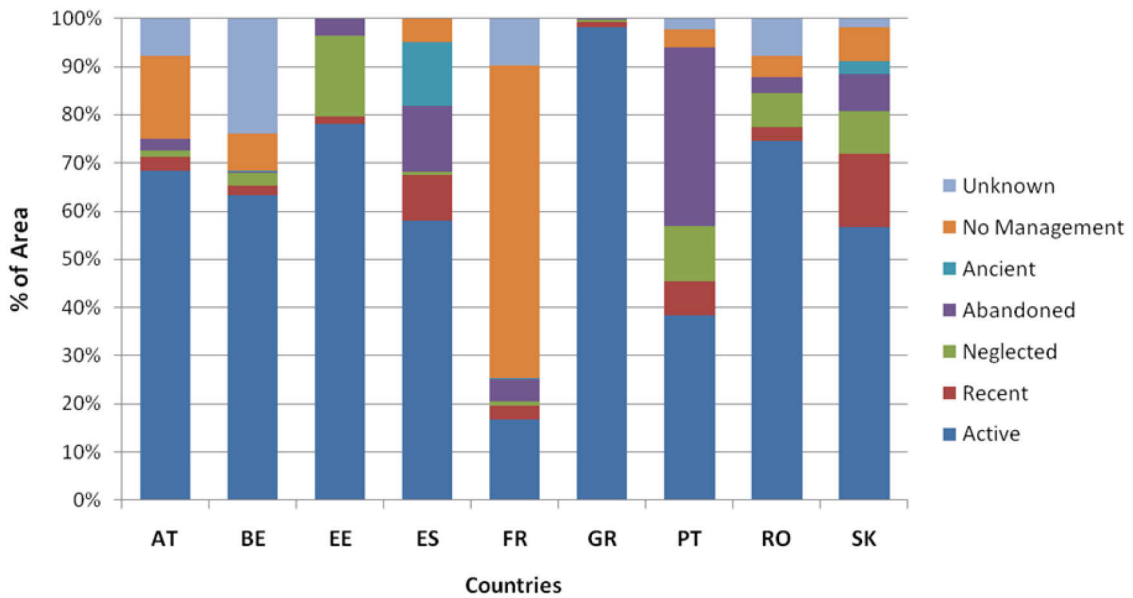
Figure 16

Time of activity profile for management per countries.

An illustrative indicator for what is going on in a region could be the ratio of land management time between active and recent versus Neglected, Abandoned and Ancient:

$$Indicator\ of\ Management\ Activity = \frac{Area\ (Active\ +\ Recent)}{Area\ (Active\ +\ Recent)\ +\ Area\ (Neglected+Abandoned+Ancient+No\ Management)} *100$$

If this percentage reduces over time, it is clear that either abandonment is taking place with positive effect on the species associated with undisturbed environments. If it reduces, it means that more land is taken into use again which can have a positive or a negative effect on biodiversity depending on the management introduced.
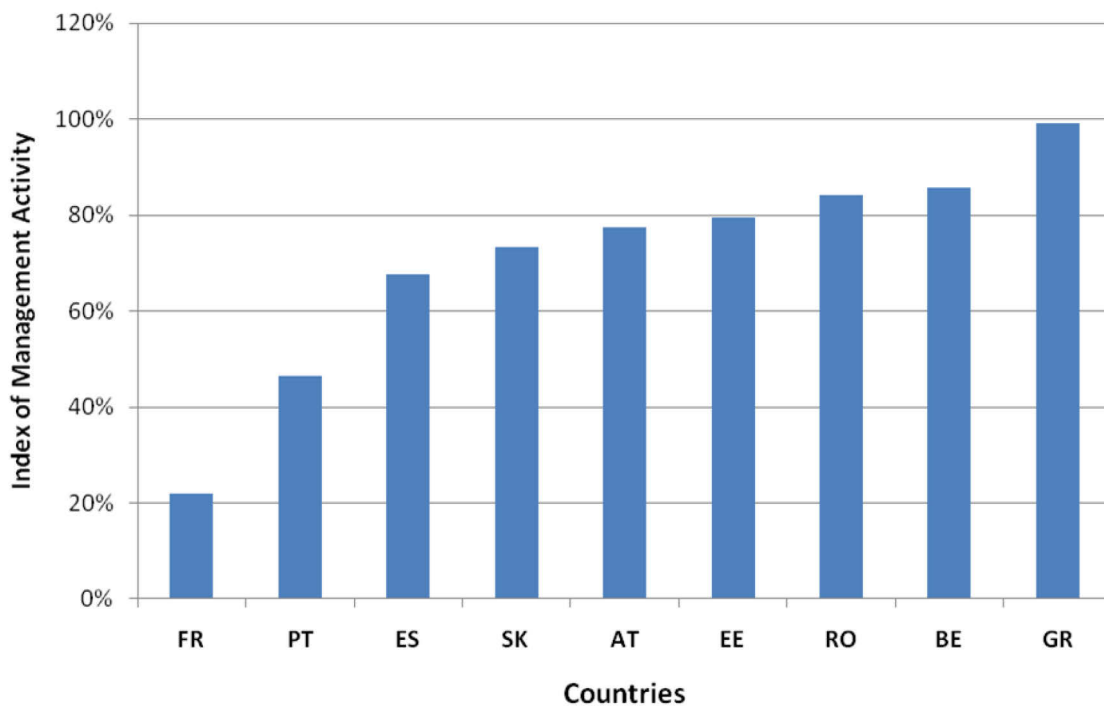
Figure 17

Index of management activity per countries.

The Index of management activity clearly shows differences in management activity between the countries based on the current dataset (Figure 17). France and Portugal appear to have the lowest values of the index indicating dominance of unmanaged or undermanaged habitats while Belgium and Greece have the highest values indicating that most of the sampled landscape are actively managed. The French sampled km^2 show a majority of forested areas which are predominantly unmanaged except for fire protection. In Portugal, the data set indicates a landscape with agricultural activities at different stages of extensive management and abandonment. The Greek dataset shows actively managed rural landscapes.

II.   Indicator 8: Analysis of the land cover/land use profile

From the dataset, we can observe a range of different land use profiles between different countries with countries like Estonia, Romania and Austria showing a dominance of agricultural management and countries like Spain, Greece and Belgium with a more complex mixture of land cover and use. It can be observed that usually a less agriculture dominated profile is not replaced by a single dominance of a different land cover and land use category (Figure 18).

A pressure indicator for biodiversity could be the % of Urban, Agricultural and Recreational land use and land cover within a landscape.
This indicator could be combined with the indicator of Management Intensity to derive a pressure indicator on the landscape structure and biodiversity. However, some components of the management intensity are not recorded in the EBONE protocol such as the intensity of use of herbicides or pesticides. This kind of information may be collected through questioning landowners or making use of agricultural databases such as FADN (the Farm Accountancy Data Network).
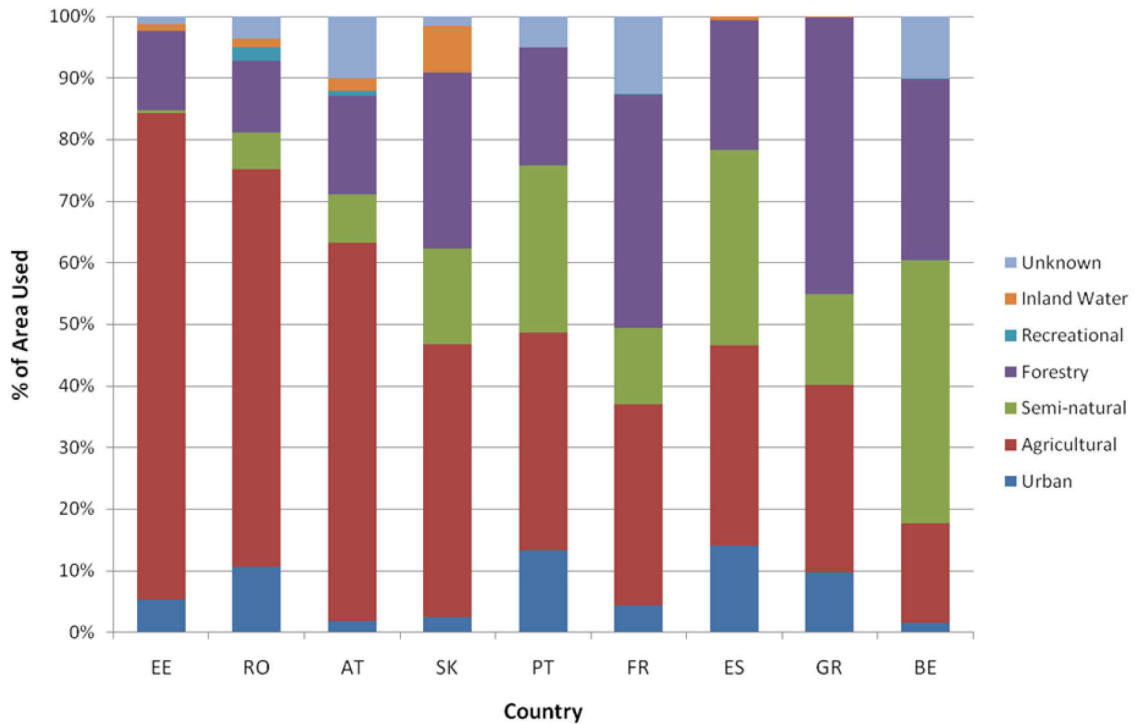
Figure 18

Percentage of area used by the different land cover types from the management codes.

III. Indicator 9: Occurrence of Annex I Habitats

During the EBONE field work the occurrence of Habitats according to the Annex I list have been recorded. This allows to return figures about the areas covered by Annex I Habitats but also to make cross queries to analyse the occurrence of these habitats regarding management indicators (tables 3 and 4) or environmental strata (table 5) of where these habitats are.

Per Land USE TYPE

The results from the EBONE dataset show that some Annex I habitats seem to be restricted to a given type of management (Table 3). As an example are Annex I habitat 5330 being entirely semi-natural or the habitat 6230 that is entirely within agricultural management. But other habitats seem to occur over a large range of management types, i.e. Annex I Habitat 4030 (European dry heath) is encountered in Agricultural, Semi-natural, Forestry and no management situations).

The same can be found for the history of management (Table 4). Some habitats are mainly found in one time category (e.g. habitat 6160) and other are found in a wider time frame of magement (e.g. 91E0).

The link between land use and occurences of Annex I Habitats can provide information regarding the current status and the type of specific management that apparently maintains them.

Table 3

Percentage of Annex I Habitats by main land use types.

Annex I Habitats	Name	Agricultural	Forestry	Semi-natural	Unmanaged
1140	Mudflats and sandflats not covered by seawater at low	0,0%	0,0%	0,0%	100,0%
1310	Salicornia and other annuals colonizing mud and sand	0,0%	0,0%	0,0%	100,0%
1330	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	0,0%	0,0%	0,0%	100,0%
2120	Shifting dunes along the shoreline with Ammophila arenaria (white dunes)	0,0%	0,0%	0,0%	100,0%
2330	Inland dunes with open Corynephorus and Agrostis grasslands	0,0%	0,0%	100,0%	0,0%
4010	Northern Atlantic wet heaths with Erica tetralix	29,9%	0,0%	21,1%	49,0%
4030	European dry heaths	12,7%	35,5%	43,6%	8,3%
5330	Thermo-Mediterranean and pre-desert scrub	0,0%	0,0%	100,0%	0,0%
6160	Oro-Iberian Festuca indigesta grasslands	0,0%	0,0%	100,0%	0,0%
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco Brometalia)(*important orchid sites)	5,2%	0,0%	90,9%	3,9%
6220	Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea	0,0%	0,0%	100,0%	0,0%
6230	Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas in Continental Europe)	100,0%	0,0%	0,0%	0,0%
6310	Dehesas with evergreen Quercus spp.	0,0%	100,0%	0,0%	0,0%
6410	Molinia meadows on calcareous, peaty or clayey-silt laden soils (Molinion caeruleae)	68,9%	0,0%	0,0%	31,1%
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	0,0%	35,6%	64,4%	0,0%
6510	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	74,8%	0,0%	25,2%	0,0%
6520	Mountain hay meadows	76,1%	2,0%	21,9%	0,0%
7110	Active raised bogs	0,0%	100,0%	0,0%	0,0%
7120	Degraded raised bogs still capable of natural regeneration	0,0%	100,0%	0,0%	0,0%
7140	Transition mires and quaking bogs	0,0%	17,4%	39,2%	43,4%
7230	Alkaline fens	71,5%	0,0%	28,5%	0,0%
8120	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)	0,0%	0,0%	100,0%	0,0%
9120	Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion)	0,0%	100,0%	0,0%	0,0%
9130	Asperulo-Fagetum beech forests	0,0%	100,0%	0,0%	0,0%
9190	Old acidophilous oak woods with Quercus robur on sandy plains	0,0%	100,0%	0,0%	0,0%
91E0	Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	0,0%	91,5%	8,5%	0,0%
91H0	Pannonian woods with Quercus pubescens	0,0%	95,7%	4,3%	0,0%
9230	Galicio-Portuguese oak woods with Quercus robur and Quercus pyrenaica	0,0%	12,9%	87,1%	0,0%
9240	Quercus faginea and Quercus canariensis Iberian woods	0,0%	100,0%	0,0%	0,0%
92A0	Salix alba and Populus alba galleries	0,0%	100,0%	0,0%	0,0%
9340	Quercus ilex and Quercus rotundifolia forests	0,0%	99,2%	0,8%	0,0%
9410	Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	18,7%	75,2%	6,2%	0,0%

Per Management Timeline

Table 4

Percentage of Annex I Habitats by Management Timeline.

Annex I Habitats	Name	Active	Recent	Neglected	Abandoned	Ancient	No Management
1140	Mudflats and sandflats not covered by seawater at low	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1310	Salicornia and other annuals colonizing mud and sand	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1330	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2120	Shifting dunes along the shoreline with Ammophila arenaria (white dunes)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2330	Inland dunes with open Corynephorus and Agrostis grasslands	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
4010	Northern Atlantic wet heaths with Erica tetralix	72.57%	0.00%	0.00%	0.00%	0.00%	6.58%
4030	European dry heaths	35.10%	0.00%	0.00%	0.00%	24.70%	34.45%
5330	Thermo-Mediterranean and pre-desert scrub	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
6160	Oro-Iberian Festuca indigesta grasslands	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco Brometalia)(*important	85.24%	0.00%	0.00%	13.05%	0.00%	1.44%
6220	Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%
6230	Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas in Continental	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6310	Dehesas with evergreen Quercus spp.	56.14%	0.00%	0.00%	43.86%	0.00%	0.00%
6410	Molinia meadows on calcareous, peaty or clayey-siltladen soils (Molinion caeruleae)	68.91%	0.00%	0.00%	0.00%	0.00%	0.00%
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	73.39%	0.00%	0.00%	0.00%	0.00%	26.61%
6510	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	75.58%	11.85%	10.91%	0.00%	0.00%	1.65%
6520	Mountain hay meadows	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
7110	Active raised bogs	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%
7120	Degraded raised bogs still capable of natural regeneration	0.00%	0.00%	48.44%	0.00%	0.00%	51.56%
7140	Transition mires and quaking bogs	0.00%	0.00%	7.99%	0.00%	0.00%	72.05%
7230	Alkaline fens	42.69%	0.00%	16.65%	0.00%	0.00%	40.66%
8120	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
9120	Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
9130	Asperulo-Fagetum beech forests	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9190	Old acidophilous oak woods with Quercus robur on sandy plains	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
91E0	Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	18.29%	40.87%	21.96%	0.00%	0.00%	18.88%
91H0	Pannonian woods with Quercus pubescens	0.00%	0.00%	0.00%	88.00%	0.00%	12.00%
9230	Galicio-Portuguese oak woods with Quercus robur and Quercus pyrenaica	15.67%	0.00%	0.00%	59.09%	0.00%	25.24%
9240	Quercus faginea and Quercus canariensis Iberian woods	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%
92A0	Salix alba and Populus alba galleries	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
9340	Quercus ilex and Quercus rotundifolia forests	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%
9410	Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	74.52%	0.00%	0.00%	0.00%	0.00%	25.48%

Per Environmental Stratum

Table 5. Annex I Habitats are predominantly occurring according to environmental strata and thus bioclimatic conditions

Table 5
Annex I Habitats Occurrence per Environmental Strata.

Annex I Habitats	Name	ALS3	ATC2	ATC4	CON2	CON6	LUS4	MDM2	MDN3	MDN6	MDS1	PAN2
1140	Mudflats and sandflats not covered by seawater at low	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
1310	Salicornia and other annuals colonizing mud and sand	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
1330	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
2120	Shifting dunes along the shoreline with Ammophila arenaria (white dunes)	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
2330	Inland dunes with open Corynephorus and Agrostis grasslands	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%
4010	Northern Atlantic wet heaths with Erica tetralix	0%	77%	23%	0%	0%	0%	0%	0%	0%	0%	0%
4030	European dry heaths	0%	40%	60%	0%	0%	0%	0%	0%	0%	0%	0%
5330	Thermo-Mediterranean and pre-desert scrub	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
6160	Oro-Iberian Festuca indigesta grasslands	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%
6210	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco Brometalia)(*important orchid sites)	0%	0%	0%	0%	1%	0%	0%	0%	98%	0%	1%
6220	Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%
6230	Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas in Continental Europe)	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6310	Dehesas with evergreen Quercus spp.	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
6410	Molinia meadows on calcareous, peaty or clayey-silt laden soils (Molinion caeruleae)	0%	0%	0%	0%	0%	100%	0%	0%	0%	0%	0%
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	64%	0%	36%	0%	0%	0%	0%	0%	0%	0%	0%
6510	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	0%	23%	0%	0%	0%	40%	20%	0%	0%	0%	16%
6520	Mountain hay meadows	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
7110	Active raised bogs	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
7120	Degraded raised bogs still capable of natural regeneration	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
7140	Transition mires and quaking bogs	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
7230	Alkaline fens	23%	0%	0%	77%	0%	0%	0%	0%	0%	0%	0%
8120	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9120	Atlantic acidophilous beech forests with Ilex and sometimes also Taxus in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion)	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
9130	Asperulo-Fagetum beech forests	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%
9190	Old acidophilous oak woods with Quercus robur on sandy plains	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%
91E0	Alluvial forests with Alnus glutinosa and Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	0%	25%	12%	0%	0%	3%	0%	0%	0%	0%	60%
91H0	Pannonian woods with Quercus pubescens	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
9230	Galicio-Portuguese oak woods with Quercus robur and Quercus pyrenaica	0%	0%	0%	0%	0%	13%	87%	0%	0%	0%	0%
9240	Quercus faginea and Quercus canariensis Iberian woods	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
92A0	Salix alba and Populus alba galleries	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%
9340	Quercus ilex and Quercus rotundifolia forests	0%	0%	0%	0%	0%	0%	0%	1%	99%	0%	0%
9410	Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

3.3 Diversity Analysis Based On Life Forms

Implementation of the EBONE field protocol generates data that offers a broad range of indicators and proxies of biodiversity from habitat diversity to species diversity. Plant life forms can be used as a proxy for species diversity.

Plant Life Forms can be seen as sets of aggregated groups of plant species that respond similarly to the environment and have similar effects on ecosystem functioning.

Adaptations to specific environmental constraints are reflected in the life traits of each species such as morphology, physiology or life history. Such traits can be suitable to determine niche of plant species and analyse species responses to pressures and environmental gradients.

We based our grouping on the sharing of common attributes by plant species. We used traits such as woodiness (herbs vs trees and shrubs), life span (Annual vs Perennials), size (from DCH to FPH), leaf types (deciduous, conifers, sclerophyllous, etc.).

The Diversity Analysis of the Life Forms itself can therefore be used as an indicator or a proxy to taxonomic species diversity (Olsvig-Whittaker et al,, 2011).

It is relatively easy to calculate the number and abundance of species or life forms within a sample plot. However, to estimate the number of species or life forms in a larger area based on a restricted number of samples is less straight forward. Species richness (or other level of biodiversity) cannot be accurately measured or estimated because samples always underestimate the real species richness (Gotelli and Colwell, 2001). Fortunately, special protocols and methods have been developed for estimating species richness (Agosti et al., 2000).For comparing species richness among different assemblages sample-based accumulation curves and non-parametric estimators have often been recommended (Gotelli and Colwell, 2010).

For demonstration purposes, two common approaches were applied to the life forms data in EBONE dataset:
1. The species area accumulation curves
2. The species richness estimators

I. Life form Accumulation Curves

Life Forms Accumulation Curves present a visualisation of the increase of the recorded Life Form richness with increasing sample numbers. These curves are based on average pooled richness when 1, 2,…, all samples are combined together.

Sample based Accumulation Ccurves depend on many factors such as the sample size, the sample number, the patterns of sampling, the spatial patterning of species and communities.

Species or Life Form Richness is determined by both the sample surface and the landscape diversity (Figure 19). When the sample surface increases two associated aspects increase likewise. Firstly, the probability of finding new species increases (Habitat Area Effect) and this results in higher species richness per sampled area. Secondly, the sampled landscape diversity increases (Habitat Diversity Effect) which leads to higher species richness through the addition of the species associated with new habitats (Figure 19). Both mechanisms are non linearly interacting and depend on many scale dependent patterns and processes.

Despite their inherent complexities, the main interest of species accumulation curves is to compare different sample sets using standardised sampling efforts. It also enables comparison of sample sets that have high small grained species richness[3] (i.e. curve B in Figure 19) with samples sets that are more coarse grained (i.e. curve A in Figure 19).

When the curves start to level out this is where each additional sample still captures additional species richness, but not as much as the previous sample. When the inclination of a curve declines an asymptotic estimation of the total species richness can be made for the sampled region.
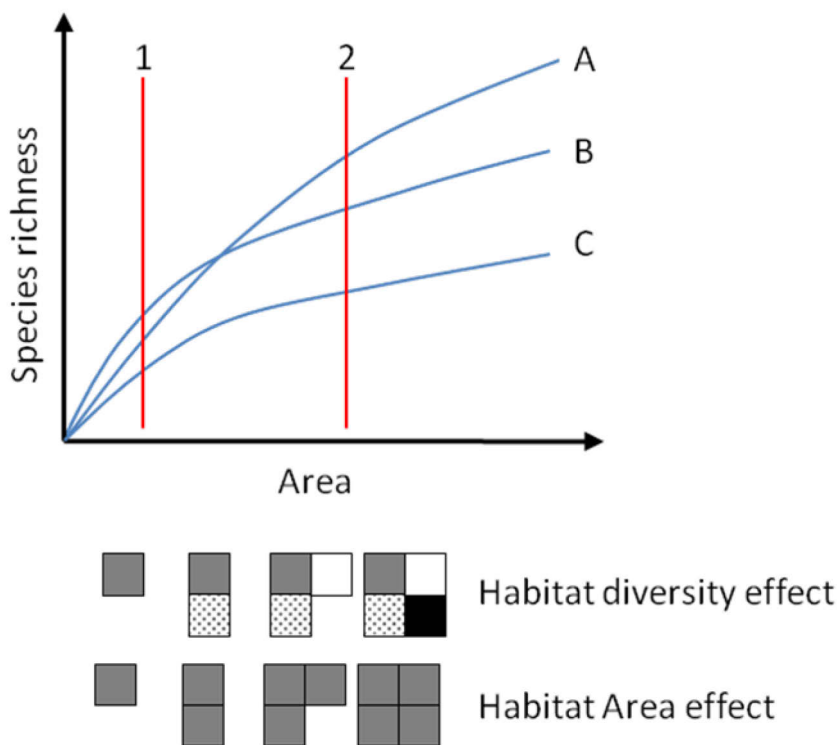
Figure 19

Theoretical species accumulation curves depend on both habitat area effect and habitat diversity effect. Given three sampled communities or regions (A,B,C) the species accumulation curves allows to compare species densities at different sampling efforts (line 1 and 2).

As an example it can be seen from Figure 20, the Life Form Density Curve of Portugal seems to be levelling out, indicating that nearly all life forms were captured in the recorded samples. This indicates a small grained pattern of life form richness and an asymptotic life form richness at regional scales.

The smallest sample number per region in the EBONE dataset is 5 and the curves show that at this point species richness is still greatly increasing with each additional sample in nearly each region. All in all the figure

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[3]The grain of species richness refers to the spatial patterns of species. Small grained species richness means that a lot of different species occur on small areas but the same species diversity are found at all scales, while coarse grained species richness means that at small scale there is not a high species richness but that new species are found when scale increases.

indicates that the samples in the EBONE data base are not yet sufficient to come up to a representative average of species richness for the respective region, as we already indicated in the introduction.
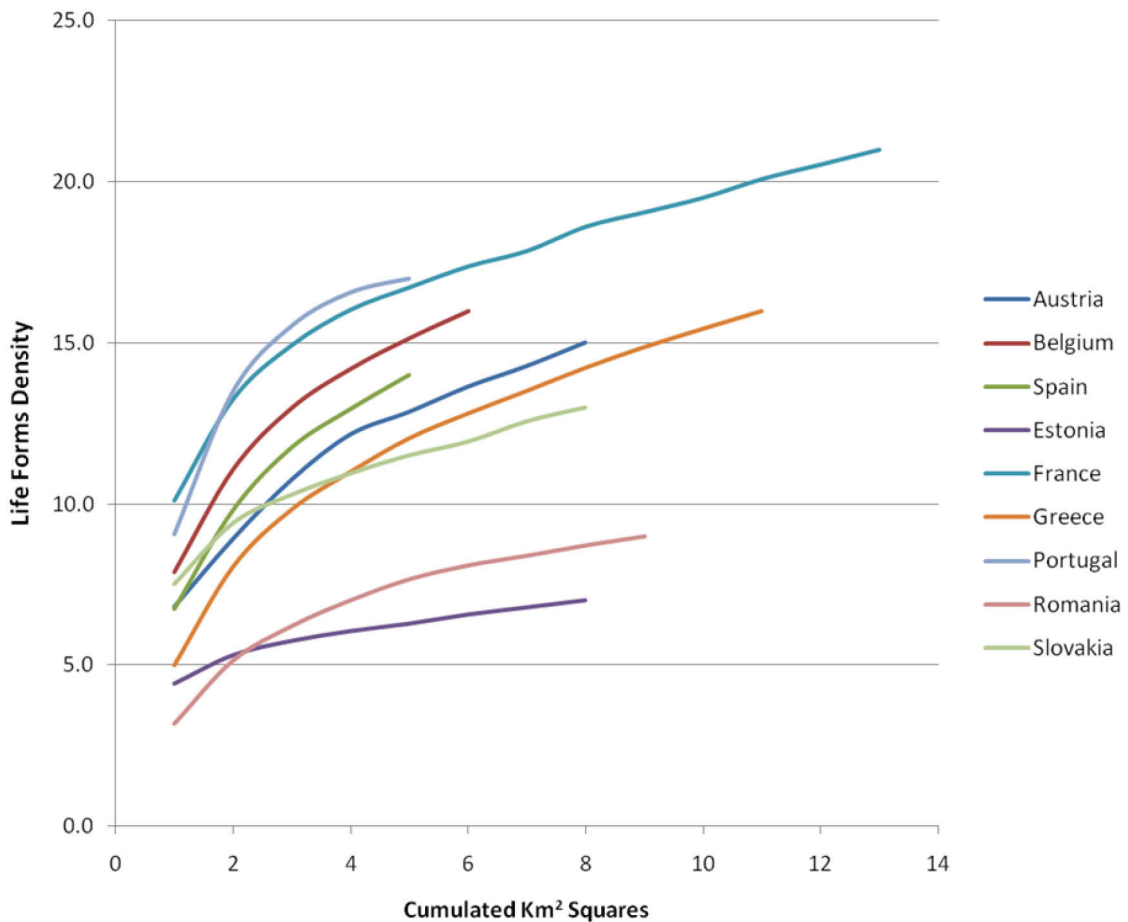
Figure 20
Observed Life Form Accumulation Curves per country.

II. Life Forms Richness Estimators

There are several indicators that can be used to estimate the richness of a community based on samples. Each of the samples provide a biased under estimation of the total richness due to species patterns, sample size, species unseen or undetected, etc. Some statistical procedures have been produced in order to produce an unbiased estimator of the total richness of a community taking into account abundances (number. of individuals) or incidence (presence or absence) of each species based on replicated samples, by doing this the richness indicator allows to estimate the total number of species (Chao, 2004).

Among the indicators, the non-parametric Richness Indicators proved to be very efficient in providing estimates and require no underlying assumptions regarding species abundance or incidence distributions (Walther and Morand, 1998; Chao, 2004).

Many different indicators have been proposed, we used here the four having the best overall performance (Walther and Morand, 1998). All these indicators correct the observed richness by taking into account the number of unique or duplicate species (species present in exactly one or two samples) within the sample set.

Which are the indicators used?
–   The Chao 2 is a robust estimator for incidence data like the life form data from the EBONE protocol and it can be also used to estimate the number of samples required to adequately sample biodiversity.
–   The Jacknife 1 and 2 are based on resampling subsets of samples out for each permutation. They provide an unbiased estimation of species richness. Jacknife 1 takes into account the unique species and Jacknife 2 includes also the duplicate species.
–   The Bootstrap estimator is based on resampling a subset with replacement taken at each permutation, It computes an estimate of the missed species to correct the observed species.

These indicators have been computed using the 'vegan' package in R2.15 with the function specpool used for incidence data and 200 bootstraps (Oksanen et al., 2012). The data that have been used is the incidence of species life forms (as a surrogate of species) within each of the areal elements of each km^2 squares.

It can be observed that the estimated species life form richness is always higher than the observed richness (Figure 21). As an example, 16 life forms have been observed and the estimators produce a range of 16 to 28 species life forms in total. The differences between the estimators differs in the way they take into account rare (non abundant or infrequent) species.

Based on a full sampling protocol, the approach by indicator would allow us to provide statistically robust estimators of biodiversity at national, environmental strata or any given type of habitats.
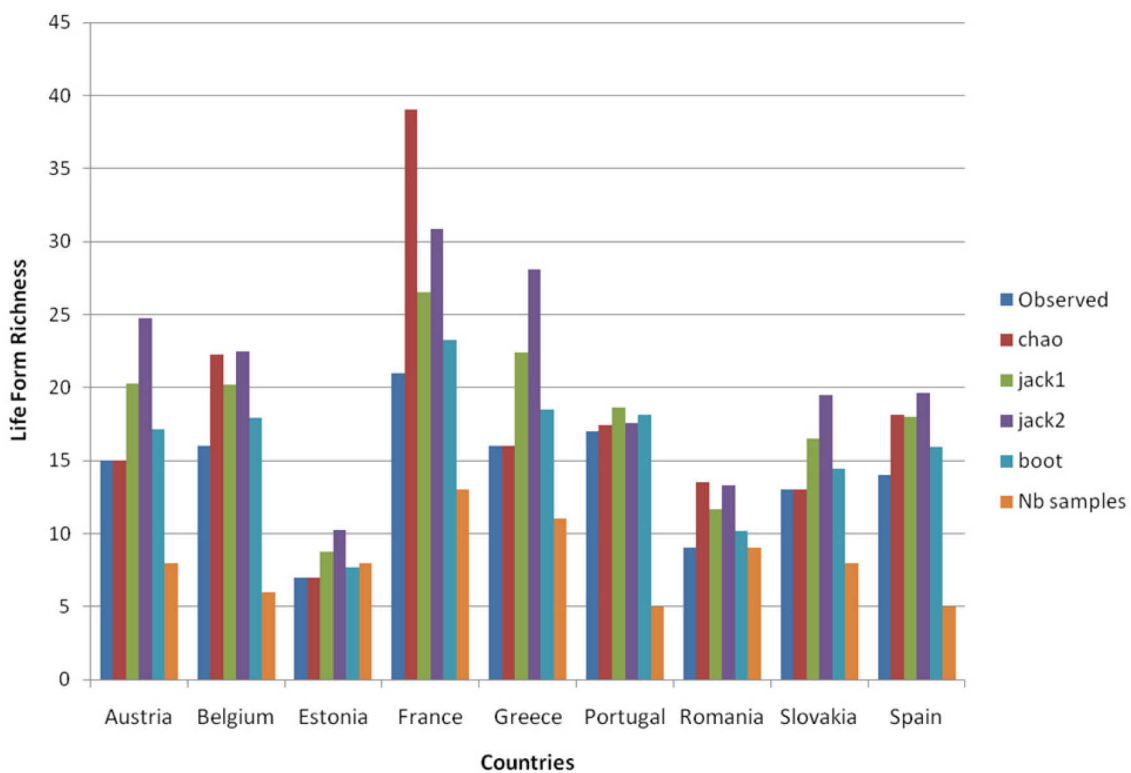
Figure 21
Life Forms Richness Estimators.

4   Conclusions

The main goal of the EBONE field protocol is to measure and provide indicators for biodiversity. This report shows that the data generated by using this protocol offers a broad range of indicators and proxies of biodiversity from habitat diversity to species diversity. More indicators are possible than could be presented in this deliverable.

As mentioned in the introduction, the current EBONE dataset is not suitable to draw conclusions on individual indicators, countries or environmental strata, but it shows that national or regional monitoring programs could use the approach and collect data using the protocols, tools and data warehouse to generate the biodiversity indicators for their area of interest.

Given the limitations of the dataset, the computation demonstration yielded some very interesting food for thought. The EBONE dataset for one shows that its data provides more biodiversity information than schemes with a larger MMU (e.g. EBONE: $400m^2$ versus CLC 25ha). Additionally, this demonstration shows that the EBONE protocol offers new perspectives on both Annex I Habitats and Semi-natural habitats. So far no monitoring scheme has been able to provide local and regional knowledge on landscape structure, management and the management timeline in addition to local indicators for the quality of the habitat itself (e.g. plant and life form recordings).

These findings clearly show that the EBONE protocol can be useful for habitat monitoring and offers interesting added value on top of existing monitoring schemes.

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Annex 1   List of general habitat categories

GHC (vernacular name)	Primary code
URBAN	URB
Artificial	ART
Non Vegetated	NON
Crops	VEG
Herbaceous	GRA
Woody vegetation	TRE
Artificial / Non-Vegetated	ART/NON
Artificial / Crops	ART/VEG
Artificial / Herbaceous	ART/GRA
Artificial / Woody	ART/TRE
Non Vegetated / Crops	NON/VEG
Non Vegetated / Herbaceous	NON/GRA
Non Vegetated / Woody	NON/TRE
Crops / Herbaceous	VEG/GRA
Crops / Woody	VEG/TRE
Herbaceous / Woody	GRA/TRE
CULTIVATED	CUL
Bare Ground	SPA
Herbaceous Crops	CRO
Woody Crops	WOC
Herbaceous/Woody Crops	CRO/WOC
SPARSELY VEGETATED	SPV
Sea	SEA
Tidal	TID
Aquatic	AQU
Ice and Snow	ICE
Terrestrial	TER
Sea/Tidal	SEA/TID
Sea/ice	SEA/ICE
Sea/Terrestrial	SEA/TER
Tidal/Aquatic	TID/AQU
Tidal/ Terrestrial	TID/TER
Aquatic/Terrestrial	AQU/TER
TERRESTRIAL	TER
Bare Rock	ROC
Boulders	BOU
Stones	STO
Gravel	GRV
Sand	SAN
Earth, Mud	EAR
Rock/Boulders	ROC/BOU

GHC (vernacular name)	Primary code
Rock/Stones	ROC/STO
Rock/Gravel	ROC/GRV
Rock/Sand	ROC/SAN
Rock/Earth	ROC/EAR
Boulders/Stones	BOU/STO
Boulders/Gravel	BOU/GRV
Boulders/Sand	BOU/GRV
Boulders/Earth	BOU/EAR
Stones/Gravel	STO/GRV
Stones/Sand	STO/SAN
Stones/Earth	STO/EAR
Gravel/Sand	GRV/SAN
Gravel/Earth	GRV/EAR
Sand/Earth	SAN/EAR
HERBACEOUS WETLAND	HER
Submerged Hydrophytes	SHY
Emergent Hydrophytes	EHY
Helophytes	HEL
Submerged Hydrophytes / Emergent Hydrophytes	SHY/EHY
Submerged Hydrophytes / Helophytes	SHY/HEL
Emergent Hydrophytes / Helophytes	EHY/HEL
HERBACEOUS	HER
Leafy Hemicryptophytes	LHE
Caespitose Hemicryptophytes	CHE
Therophytes	THE
Geophytes	GEO
Chamaephytes	HCH
Cryptogams	CRY
Leafy Hemicryptophytes / Caespitose Hemicryptophytes	LHE/CHE
Leafy Hemicryptophytes / Therophytes	LHE/THE
Leafy Hemicryptophytes / Geophytes	LHE/GEO
Leafy Hemicryptophytes / Herbaceous Chamaephytes	LHE/HCH
Leafy Hemicryptophytes / Cryptogams	LHE/CRY
Caespitose Hemicryptophytes / Therophytes	CHE/THE
Caespitose Hemicryptophytes / Geophytes	CHE/GEO
Caespitose Hemicryptophytes / Herbaceous Chamaephytes	CHE/HCH
Caespitose Hemicryptophytes / Cryptogams	CHE/CRY
Therophytes / Geophytes	THE/GEO
Therophytes / Herbaceous Chamaephytes	THE/HCH
Therophytes / Cryptogams	THE/CRY
Geophytes / Herbaceous Chamaephytes	GEO/HCH
Geophytes / Cryptogams	GEO/CRY
Chamaephytes / Cryptogams	HCH/CRY
TREES/SHRUBS	TRS
Dwarf Chamaephytes Winter Deciduous	DCH/DEC
Dwarf Chamaephytes Evergreen	DCH/EVR
Dwarf Chamaephytes Coniferous	DCH/CON

GHC (vernacular name)	Primary code
Dwarf Chamaephytes Winter Deciduous / Evergreen	DCH/DEC/EVR
Dwarf Chamaephytes Winter Deciduous / Coniferous	DCH/DEC/CON
Dwarf Chamaephytes Evergreen / Coniferous	DCH/EVR/CON
Shrubby Chamaephytes Winter Deciduous	SCH/DEC
Shrubby Chamaephytes Evergreen	SCH/EVR
Shrubby Chamaephytes Coniferous	SCH/CON
Shrubby Chamaephytes Non-Leafy Evergreen	SCH/NLE
Shrubby Chamaephytes Summer Deciduous and/or Spiny Cushion	SCH/SUM
Shrubby Chamaephytes Winter Deciduous / Evergreen	SCH/DEC/EVR
Shrubby Chamaephytes Winter Deciduous / Coniferous	SCH/DEC/CON
Shrubby Chamaephytes Winter Deciduous / Non-Leafy Evergreen	SCH/DEC/NLE
Shrubby Chamaephytes Winter Deciduous / Summer Deciduous	SCH/DEC/SUM
Shrubby Chamaephytes Evergreen / Coniferous	SCH/ EVR/CON
Shrubby Chamaephytes Evergreen / Non-Leafy Evergreen	SCH/EVR/NLE
Shrubby Chamaephytes Evergreen / Summer Deciduous	SCH/EVR/SUM
Shrubby Chamaephytes Coniferous / Non-Leafy Evergreen	SCH/CON/NLE
Shrubby Chamaephytes Coniferous / Summer Deciduous	SCH/CON/SUM
Shrubby Chamaephytes Non-Leafy Evergreen / Summer Deciduous	SCH/NLE/SUM
Low Phanerophytes Winter Deciduous	LPH/DEC
Low Phanerophytes Evergreen	LPH/EVR
Low Phanerophytes Coniferous	LPH/CON
Low Phanerophytes Non-Leafy Evergreen	LPH/NLE
Low Phanerophytes Summer Deciduous	LPH/SUM
Low Phanerophytes Winter deciduous / Evergreen	LPH/DEC/EVR
Low Phanerophytes Winter deciduous / Coniferous	LPH/DEC/CON
Low Phanerophytes Winter deciduous / Non-Leafy Evergreen	LPH/DEC/NLE
Low Phanerophytes Winter Deciduous Summer	LPH/DEC/SUM
Low Phanerophytes Evergreen / Coniferous	LPH/ EVR/CON
Low Phanerophytes Evergreen / Non-Leafy Evergreen	LPH/EVR/NLE
Low Phanerophytes Evergreen / Summer Deciduous	LPH/EVR/SUM
Low Phanerophytes Coniferous / Non-Leafy Evergreen	LPH/CON/NLE
Low Phanerophytes Coniferous / Summer Deciduous	LPH/CON/SUM
Low Phanerophytes Non-Leafy Evergreen / Summer Deciduous	LPH/NLE/SUM
Mid Phanerophytes Winter Deciduous	MPH/DEC
Mid Phanerophytes Evergreen	MPH/EVR
Mid Phanerophytes Coniferous	MPH/CON
Mid Phanerophytes Non Leafy Evergreen	MPH/NLE
Mid Phanerophytes Summer Deciduous and/or Spiny Cushion	MPH/SUM
Mid Phanerophytes Winter Deciduous / Evergreen	MPH/DEC/EVR
Mid Phanerophytes Winter Deciduous / Coniferous	MPH/DEC/CON
Mid Phanerophytes Winter Deciduous / Non-Leafy Evergreen	MPH/DEC/NLE
Mid Phanerophytes Winter Deciduous / Summer Deciduous	MPH/DEC/SUM
Mid Phanerophytes Evergreen / Coniferous	MPH/EVR/CON
Mid Phanerophytes Evergreen / Non-Leafy Evergreen	MPH/EVR/NLE
Mid Phanerophytes Evergreen / Broadleaved / Summer Deciduous	MPH/EVR/SUM
Mid Phanerophytes Coniferous / Non-Leafy Evergreen	MPH/CON/NLE
Mid Phanerophytes Coniferous / Summer Deciduous	MPH/CON/SUM

GHC (vernacular name)	Primary code
Mid Phanerophytes Non-Leafy Evergreen / Summer Deciduous	MPH/NLE/SUM
Tall Phanerophytes Winter Deciduous	TPH/DEC
Tall Phanerophytes Evergreen	TPH/EVR
Tall Phanerophytes Coniferous	TPH/CON
Tall Phanerophytes Non-Leafy Evergreen	TPH/NLE
Tall Phanerophytes Summer Deciduous	TPH/SUM
Tall Phanerophytes Winter Deciduous / Evergreen	TPH/DEC/EVR
Tall Phanerophytes Winter Deciduous / Coniferous	TPH/DEC/CON
Tall Phanerophytes Winter Deciduous / Non-Leafy Evergreen	TPH/DEC/NLE
Tall Phanerophytes Evergreen / Coniferous	TPH/EVR/CON
Tall Phanerophytes Evergreen / Non-Leafy Evergreen	TPH/EVR/NLE
Tall Phanerophytes Evergreen / Summer Deciduous	TPH/EVR/SUM
Tall Phanerophytes Coniferous / Non-Leafy Evergreen	TPH/CON/NLE
Tall Phanerophytes Coniferous / Summer Deciduous	TPH/CON/SUM
Forest Phanerophytes Winter Deciduous	FPH/DEC
Forest Phanerophytes Evergreen	FPH/EVR
Forest Phanerophytes Coniferous	FPH/CON
Forest Phanerophytes Summer Deciduous	FPH/SUM
Forest Phanerophytes Winter Deciduous / Evergreen	FPH/DEC/EVR
Forest Phanerophytes Winter Deciduous / Coniferous	FPH/DEC/CON
Forest Phanerophytes Evergreen / Coniferous	FPH/EVR/CON
Forest Phanerophytes Evergreen / Summer Deciduous	FPH/EVR/SUM
Forest Phanerophytes Coniferous/ Summer Deciduous	FPH/CON/SUM
Mega Forest Phanerophytes Deciduous	GPH/DEC
Mega Forest Phanerophytes Evergreen	GPH/EVR
Mega Forest Phanerophytes Conifer	GPH/CON
Mega Forest Phanerophytes Summer deciduous	GPH/SUM
Mega Forest Phanerophytes Winter Deciduous / Evergreen	GPH/DEC/EVR
Mega Forest Phanerophytes Winter Deciduous / Coniferous	GPH/DEC/CON
Mega Forest Phanerophytes Evergreen / Coniferous	GPH/EVR/CON
Mega Forest Phanerophytes Evergreen /Summer Deciduous	GPH/EVR/SUM
Mega Forest Phanerophytes Conifer /Summer Deciduous	GPH/CON/SUM

Annex 2 Data standardisation

1. Time window for survey

For monitoring, the recording of the GHCs should be made in a time window as close as possible to the height of the growing season. This window is likely to be before maximum biomass in the Mediterranean, but after in Scandinavia. The latter can be determined by snow cover and in which case recording would need to be postponed in a late season. The extent of the window must be set by region, using local phenological information.

Repeat surveys should be carried out in the same time span as the baseline surveillance with squares being surveyed as close as possible to the same date of the original survey. This time differs between Environmental Zones, Strata and Countries and will have to be determined before any major survey is carried out.

Metadata records are required of the date and location of the square as well as ownership where required. This information should be included in the field computer database.

2. Quality control and assurance

Quality control is essential and involves regular liaison with staff in the field, and direct supervision and consultation. Modern communication means that regular contact can be made and new decisions or clarifications conveyed immediately to the surveyors.

The Manual must be referred to continually in order to optimise field performance, especially when working in landscapes that have contrasting elements, e.g. polyculture landscapes with many small patches.

It is recognised that there is a problem with learning all the rules. Experience in EBONE has shown that at the European level local training courses are probably more efficient than central sessions. The level of experience of surveyors is also a critical parameter

Quality assurance involves repeated recording by independent observers of previously surveyed squares. The Countryside Survey of Great Britain (GB-CS) has used grids of points from random squares to check on the quality of data from different surveyors to identify errors.

In EBONE a further compromise was used because of the time and cost constraints that included limited quality control and assurance in the same exercise. A report is available at www.ebone.wur.nl

3. Database checks

In order to ensure data quality some database management work have been carried out. Data was checked thoroughly using automatic checking, manual checking and identification of specific frequent errors.

- Automatic checking: removal of overlapping parcels, duplicate recordings.
- Manual checking: ensure that the data are as consistent as possible (e.g. for the removal of impossible combinations such as a salt marsh at the top of a mountain). Such checks must be done manually, because it has been shown in the GB CS that it is not possible to develop an automatic procedure to identify such ecologically impossible situations. Another guideline is to look for any code which stands out as being different from the others in the square. Some mistakes will be common and recognised in the Quality Control e.g. putting the Life Forms as a GHC.

- Specific frequent errors: lack of consistencies between GIS layers and Database, where ID codes could differs or some records present in one data set and not the other. The linkage between the GIS tables and Database Tables points out the discrepancies and help correcting them.

4. Field work preparation

Map and aerial photo information.

For the scanning of the area and the following field work, one or more of the following sources should be used: the most recent 1:10,000 scale (or at least 1:25,000 scale if of sufficient quality) base map including topographic and/or cadastral information, enlarged to 1:5,000 scale.

Aerial Photography (AP) prints at a scale of 1:5,000. Aerial photographs should preferably be ortho-photos or else geometrical properties need to be assessed.

Digital outlines of the AP interpretation held on a field computer and the information in the field recorded directly.

Maps derived from satellite imagery. Image segmentation offers a further option for preparation before going into the field.

5. First scan

Preparatory work on delineation of the major elements within the survey area from the aerial photograph, map or satellite images is strongly recommended.

6. Equipment

Mapping of elements in the field should be made in one or a combination of the following ways:

in pencil, on sheets that are copied from the most recent 1:10,000 scale base map including topographic and/or cadastral information, enlarged to 1:5,000 scale or

in pencil, on transparent overlay sheets placed on Aerial Photography (AP) prints at a scale of 1:5,000. Aerial photographs should preferably be ortho-photos or else geometrical properties need to be assessed.

Elements can be determined by photo-interpretation and used directly in the field as a basis for mapping GHCs.

Digital outlines of elements can be held on the field computer.

Following the field visits the procedures for validation and finalisation of the data vary according to the recording method used.

Separate sheets or overlays are to be used for the mapping of areal and of linear elements. Points are to be mapped on the linear sheet, either as individuals, or groups. The data for mapped elements are recorded on standard forms or on a field computer.

7. Photographs

It is strongly recommended that during field work a photograph of each GHC is taken including a GPS position for the following reasons:

illustration of the local conditions at the time of recording,

as input for later quality assessment,

as a record for later recording.

8. Use of field computers

Since the first version of the Manual was produced major advances have taken place in the application of field computers for the recording of habitat data. Various options are now available and, except in GB, the spatial data is not yet stored in a fully integrated way within a GIS environment. It is important to note that all systems involve previous interpretation of different types of aerial photographs to produce parcel outlines which are then validated in the field. The following systems are available within the EBONE consortium, but others are also available:

1. The GB-CS has a fully integrated system in which spatial data are held, modified in the field and then directly placed into a database management system. The system has been proven in the GB survey in 2007 but the resources required both in terms of software and hardware are beyond the capacity of most organizations.

2. The NICS has a partially automated system, with boundaries available in the field linked to GIS but not linked directly to a server and records have to be transferred manually.

3. The National Inventory of Swedish landscapes (NILS) records field records that are currently manually downloaded into the database system. A system is under development that will link field computers to a PC in the field for downloading directly into the database.

4. The Flemish Institute for Nature and Forest Research (INBO) has developed a system for recording GHCs and associated data on qualifiers and species in the field which is transferrable to other machines. The system developed by INBO has been adopted for EBONE for input into a PDA. The PDA also includes the key to Annex I Habitats developed by Alterra. A manual and software are available for application of the system.

Within the EBONE consortium Cemagref has developed a system for tablet PC within an MS Access environment that was used for the current report. The Access database is available and can be downloaded from the project website.

Annex 3 Field Work Quality Control and Field Work Harmonisation Report

1. The Quality control team

The quality control team consists of the following persons: Bob Bunce, Philip Roche, Geert de Blust, Ilse Geijzendorffer and Rob Jongman. The following countries were visited by the indicated people.

Visit schedule

Person	Austria	Estonia	France	Greece	Norway	Romania	Slovakia	Spain	Portugal
Bob Bunce		x			x				x
Geert de Blust			x					x	
Ilse Geijzendorffer						x			
Philip Roche				x					
Rob Jongman	x						x		

2. Preparation

The team contacted the partners concerned and asked them to send scan of the maps and records of areal and linear elements for initial desk study for obvious errors and recordings which are not clear. Arrangements were made to travel with the partners to the squares to have an immediate explanation of why a certain decision was made and to provide immediate feedback in case of corrections.

3. Areas covered

The squares were chosen as close as possible to the starting point saving travel time. Tracks and roads were followed to cover as large an area as possible. It was not necessary to cover the whole square. The objective was to do two squares a day and have at least two days in the field per country.

4. Major points checked

The priority was to cover GHCs and the use of qualifiers in determining boundaries of areal and linear features. If possible checks were made to both areal and linear elements. The boundaries of the elements were checked if they were in the right place. Qualifiers were only considered in relation to the boundaries between mapped elements. In the quality check the identification of boundaries had to be interpreted in a broad sense:
check the boundaries for their right position (so we may propose to move a boundary),
correctness of a boundary, does it make sense (if there no argument to distinguish between elements, we may decide to remove that boundary). In case a boundary been forgotten, we have to add a new one.

5. Summary report

General

A number of additional qualifiers were proposed and they have all been added to the Handbook. There is also the option of adding qualifiers for each survey, but these should be agreed by the coordinator and communicated in the whole team.

– A global code 'COM' has been added to represent many small patches below 400 m^2 within a large element.
– Many of the problems were due to interpretation of the Handbook. Text has been altered and added where relevant to allow for these comments. Therefor it is recommended to use the latest version of the Manual.
– Some points would be picked up in larger training courses, but also in Quality Control in any given survey.

Other problems in consistency can be sorted out by database management and manual checking.

Specific points that have been updated after quality control check

– The codes for management age have been converted into separate definitions for forestry and agriculture.
– Attention needs to be paid to the scale of maps because large scale maps tend to lead to mapping of small patches below 400 m^2. A recommendation is now included.
– The recording of forest layers is difficult in extensive forests with variable understorey. A recommendation is now included.
– The application of GHCs to linear features has been emphasized.
– Linear complexes have been removed because of difficulties in interpretation and replaced by describing the width of the linear feature.
– A short version of the handbook will be prepared to improved consistency in the field.
– Longer training courses are required, but also should be in separate countries because of local difficulties.
– Two codes for linear features have been added: annual vegetation and banks
– Canopies of forests do not overlap roads.
– Canopies of tree lines are not included in the width.
– Some grasses may be annual or perennial depending on local conditions.
– After ten years with no management urban land and woody crops becomes semi-natural vegetation.
– A series of qualifiers e.g. stone heaps and demolished houses have been added to the various lists.
– Because of lack of internationally accepted classifications geological and soil qualifiers have been omitted, but can be added for regional surveys.
– Vegetation plots which extend outside the boundary of the areal patch should change to a shape that fits within the element. Vegetation plot in linear patches can go outside the patch.
– Tidal has been added as a qualifier to sea/marine.
– The recording of multiple linear elements has been made more explicit.
– The recording of vegetation layers in scrub categories is optional.
– The recording of trees/scrub in urban areas as TRE has been clarified.
– Subsequent data screening may be necessary to ensure that there are not too many unique code introduced.
– Mosaics are not valid. A new option for small patches has been introduced; otherwise the full representation of all GHCs is recorded in column five and available for analysis if required.
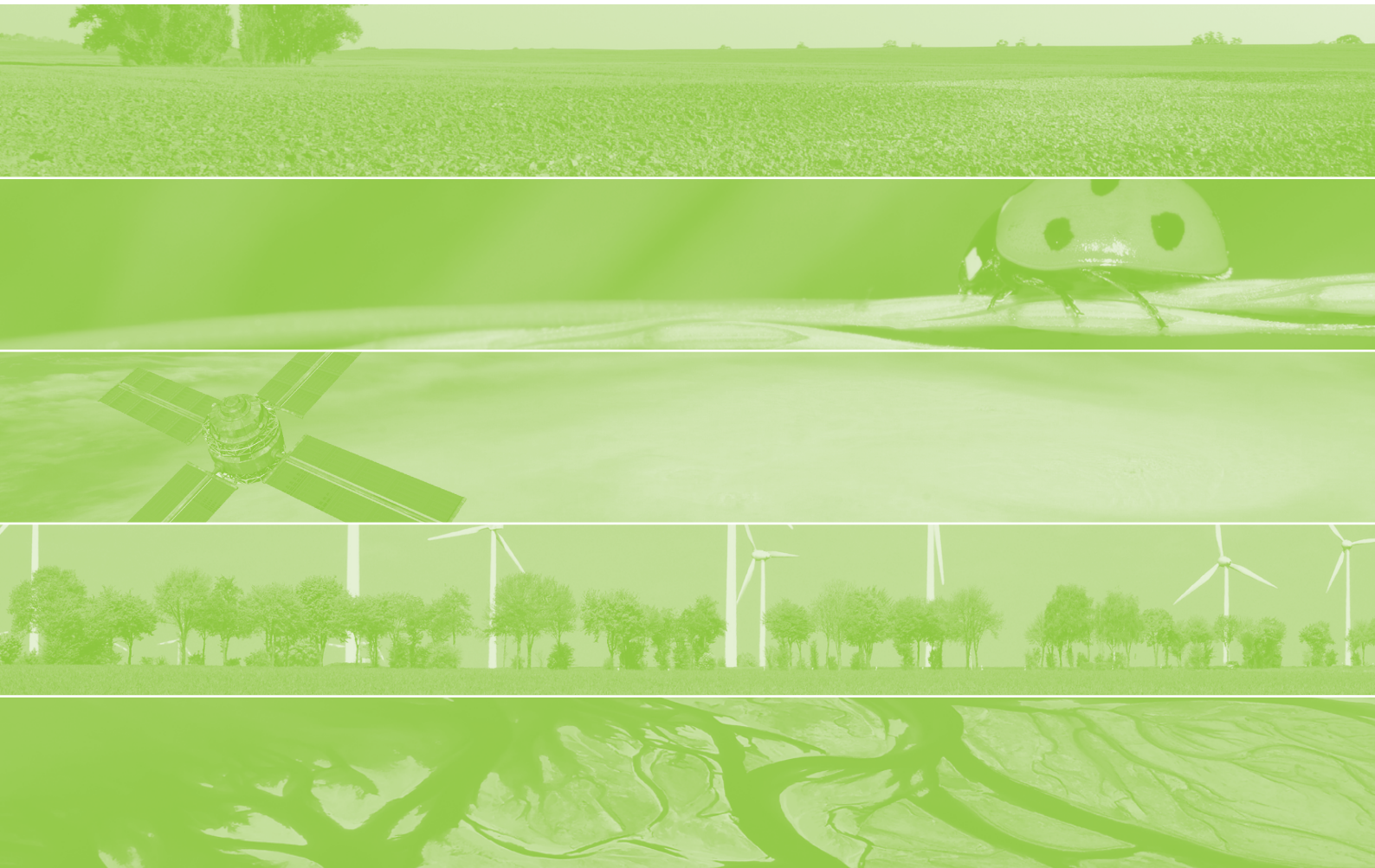
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