BIO_SOS

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Abstract	To identify appropriate bio-indicators species for BIO_SOS we have used existing datasets (as indicated in D4.1) and we have checked a recent scientific literature in order to provide a scientific consistent selection of bio-indicator species. Our choice is based on (*i*) the possibility to compare niche models with and without GHCs; (*ii*) the usefulness for stakeholders; (*iii*) the possibility to carry out comparison among different sites; and (*iv*) the actual availability of the distributional data.

Keywords	Bio-indicator, surrogate *taxa*, focal species

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1. Executive summary

In task 6.4 the relationship between the GHCs and abundance and composition of some species, both animals and plants, will be investigated by ecological niche modelling. GHCs were selected in D2.1 as surrogate biodiversity measure, whereas D6.6 aims to identify the *taxa*, or functional groups of species, that are most suitable to investigate the relationships with the GHCs, with the pressures and landscape features, and (possibly) with other indicators detected from EO data and selected in D2.1.

Main criteria for this selection are (*i*) the possibility to compare niche models with and without GHCs; (*ii*) the usefulness for stakeholders; (*iii*) the possibility to carry out comparison among different sites; and (*iv*) the actual availability of the distributional data.

The selected bio-indicators are available in existing datasets or, according with deadline of next deliverables, will be collected during spring 2012.

2. Introduction

The main aim of the BIO_SOS project is the development of an operational ecological modelling system suitable for effective and timely multi-annual monitoring of Natura 2000 sites and their surroundings in areas exposed to different and combined type of pressures. The project will:

1. adopt and develop novel operational automatic High spatial Resolution (HR), Very High spatial Resolution (VHR) and hyper-spectral resolution Earth Observation (EO) data pre-processing and understanding techniques for Land Cover (LC) map and LC Change (LCC) map generation eligible for use in biodiversity monitoring. This is tantamount to saying that BIO_SOS is expected to provide improved operational core service products with respect to state-of-the-art satellite-based LC and LCC mapping systems.
2. Develop a modelling framework (scenario analysis) to combine EO and *in-situ* data in support to the automatic provision of biodiversity indicators and provide a deeper understanding, assessment and prediction of the impacts that human induced pressures may have on biodiversity. This means BIO_SOS aims at developing and integrating new and existing models able to evaluate and predict trends in biodiversity issues. This will lead to the development of new downstream services production.

In order to achieve this, the BIO_SOS project will test the integration of existing and new automatic EO data processing techniques to enable better use of observations over different scales and link that with *in situ* information. Focus is on the use of VHR EO data to detect changes to be embedded in innovative ecological modelling.

General Habitat Categories (GHCs; Bunce et al*.* 2008 and 2011) were selected as surrogate measure of biodiversity (D2.1). GHCs are gathered from Remote Sensing (RS) EO data as well as *in situ* data , therefore they represent the link between detailed site-based level measures and habitat assessments from remote sensing. Nevertheless, there is a growing need to assess the relationship between the indicators and the entities they are assumed to indicate, e.g. biodiversity (Wiens et al., 2008; Cushman et al., 2010; Lindenmayer and Likens, 2011).

Moreover, the Habitats Directive (92/43/EEC) requires the monitoring of some species of European importance. Linking these target species (of interest for the end users of BIO_SOS, i.e. Natura 2000 managers) to RS data will help to identify areas where the presence of those species is most likely, and will allow a prompt assessment of the impact of different pressures.

In task 6.4 we will investigate the relationship between the GHCs and the abundance and composition of some *taxa*, both animals and plants. The aim of this deliverable is to identify the *taxa*, or the functional groups of species, that are most suitable to investigate the relationship with the GHCs, with the pressures and landscape features, and (possibly) with other indicators detected from EO data and selected in D2.1.

Taxa will be selected following criteria reported in D2.1, chapter 3. In particular, animal and plant species will be selected on the basis of their policy and biodiversity relevance. In addition, their response to different pressures, both anthropic and natural, will be considered, like the abundance, the conservation status and distribution of a candidate species. Unfortunately, availability of suitable data on species distribution is limited. This is a challenge for the development and use of indicators for biodiversity assessments, as pointed out in D2.1 about the SEBI final choice of indicators. Therefore, the choice of *taxa* to use have to be necessarily highly data constrained.

3. Bio-indicators: terminology and state of the art

3.1 Terminology

In the literature of biological indicators, different definitions have often been applied to the same object, therefore it is essential defining the technical terms. In the next paragraphs we define the terminology we will employ in the full text.

Indicator species. Landres (1988) defines **indicator species** as "an organism whose characteristics (e.g. presence or absence, population density, dispersion, reproductive success) are used as an index of attributes too difficult, inconvenient, or expensive to measure for other species or environmental conditions of interest".

Bio-indicators, or "biological indicators", concern with the identification and monitoring of changes in biota, reflecting environmental changes. They can be categorized in **"environmental"**, **"ecological"** and **"biodiversity indicators"**, corresponding to their main applications (McGeoch, 1998). The first ones respond predictably to a changes in environmental state or to environmental disturbances; ecological indicators demonstrate the effects of environmental changes on biotic systems; and biodiversity indicators are well known *taxa* which number of species can act as proxy for richness in poorly known, but sympatric taxonomic groups (McGeoch, 1998; Caro and O'Doherty, 1999). Nevertheless, in literature, non-biotic components of ecosystem have also been used as biodiversity surrogates: environmental information has been used as a proxy for species distributions, either by itself or in conjunction with species distribution data (Ferrier, 2002).

Surrogate, umbrella and flagship species. Bio-indicators are **surrogate *taxa***, i.e., one or a small number of *taxa* used in conservation biology as short-cut to help managers and biologist tackle conservation problems. Surrogate species include also **"umbrella"** and **"flagship species"** (Caro and O'Doherty, 1999). Umbrella species may be used as surrogates to define size and habitat characteristics of the areas to be preserved, being these species more sensitive than the rest of community in term of area and habitat requirements. Umbrella species are often employed in conservation biology, but their real effectiveness is controversial (e.g., Andelman and Fagan, 2000; Roberge and Angelstam, 2004). Flagship species are employed to attract public attention, in order to raise funding and favour people acceptance of conservation measures. Flagship species do not need to be ecologically relevant, but only popular and charismatic, like as the giant panda or the tiger (Caro and O'Doherty, 1999).

Focal species. Starting from the concept of umbrella species, Lambeck (1997) proposed "a multi-species approach for defining the attributes required to meet the needs of the biota in a landscape and the management regimes that should be applied", calling such species **"focal"**. Nevertheless the term "focal species" does not assume an univocal meaning across the literature, being often used to indicate umbrella, indicators or flagship species (Caro, 2000). Furthermore there are issues in the practical procedure to identify focal species, which is much more labour and data intensive than the identification of umbrella and flagship species (see Lindenmayer et al., 2002; see Ficetola et al., 2007). Actually Heink and Kowarik (2010) included the focal species among the "normative or prescriptive indicators".

Normative indicators. According to Heink and Kowarik (2010) "Normative or prescriptive indicators relate to attributes that are directly affected by management (e.g fire regime, fragmentation) […] They can be used to stipulate the future condition of habitats".

Indicators in ecology and environmental planning. In their review Heink and Kowarik (2010) provided the following definition of a such indicators: "a component or a measure of environmentally relevant phenomena used to depict or evaluate environmental conditions or changes or to set environmental goals. Environmentally relevant phenomena are pressures, states, and responses as defined by the OECD (2003)". Indeed, "indicators can be applied in descriptive, evaluative, and prescriptive contexts" (Heink and Kowarik, 2010). The need for establishment of a causal relationship or a correlation between indicator and a phenomenon of interest (*indicandum*) have been stressed by several authors in the last years (Wiens et al., 2008; Cushman et al., 2010; Lindenmayer and Likens, 2011), but a correlation

between indicator and *indicandum* should be necessarily proved only for descriptive indicators (Heink and Kowarik, 2010).

In order to avoid misunderstanding, Heink and Kowarik suggest to distinguish between **"ecological indicators"** and **"environmental policy indicators"**, the former being used in scientific framework, and the latest in decision-making processes. Many authors underline the role of the biodiversity indicators as bridge between science and policy (Gregory et al., 2005; van Strien et al., 2009).

Keystone species and ecosystem engineers. Keystone species are species that have a disproportionately large effect on their environment relative to their abundance (Mills et al., 1993); such species play a critical role in maintaining the structure of an ecological community. Furthermore, a species is considered as an ecosystem engineer if it creates or modifies habitats (Jones et al., 1994). For example, species, like beavers, can modify the environment by mechanically changing materials from one form to another. Keystone species do not represent a shortcut to describe processes and patterns in conservation biology, nevertheless they may be suitable as surrogates, e.g. umbrella species; furthermore, multiple species are affected by their distribution pattern (Caro and O'Doherty, 1999).

Figure 3-1 summarizes relationships and definitions for surrogate types used in conservation biology.

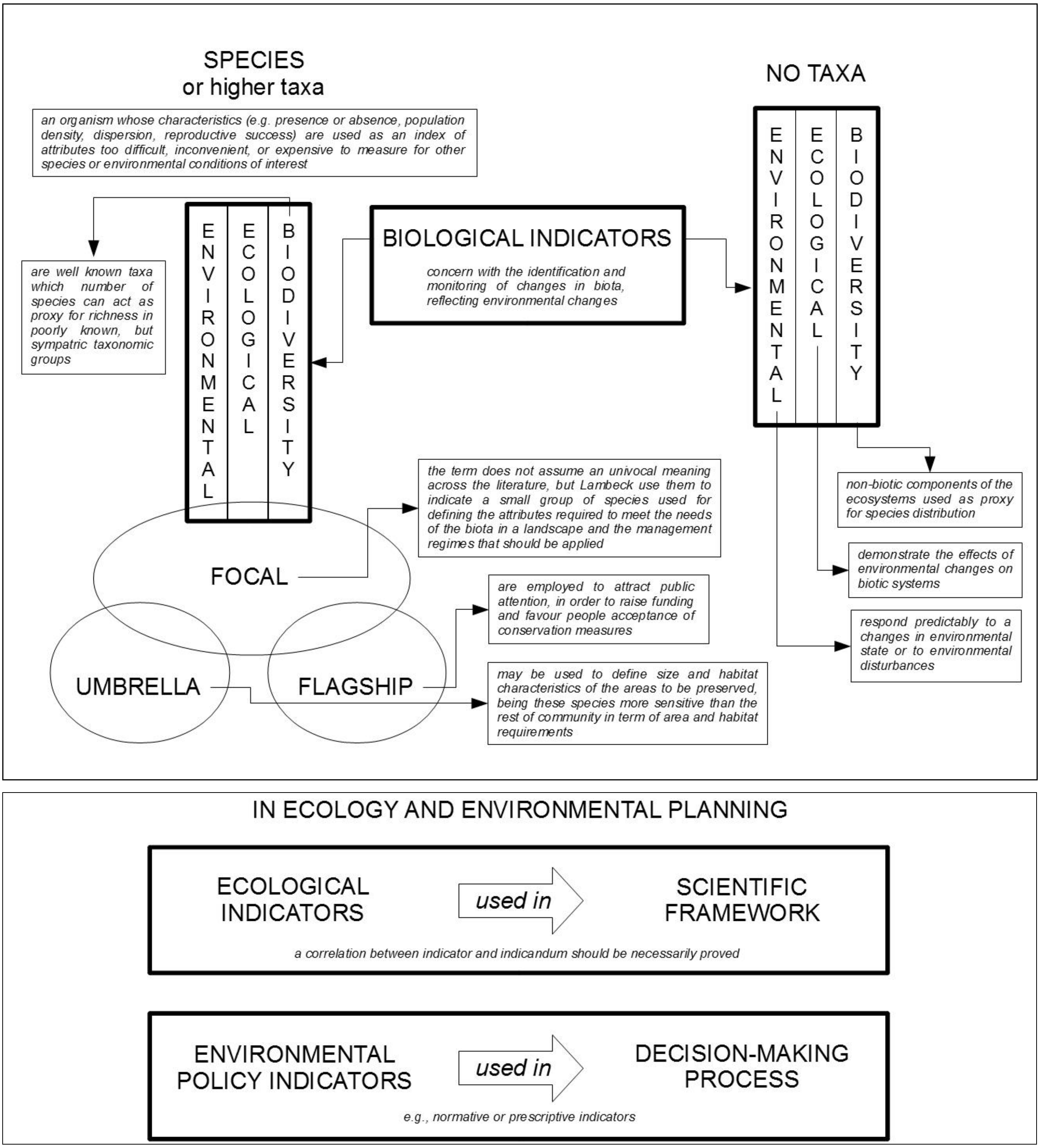

Figure 3-1 *Surrogate used in conservation biology: conceptual relationships and definitions.*

3.2 State of the art

Although surrogate species are increasingly employed in many management and conservation fields (e.g., see Lindenmayer and Likens, 2011), several papers criticized and discussed limitations of that approach (Andelman and Fagan, 2000; Lindenmayer et al., 2002; Wiens et al., 2008; Lindenmayer and Likens, 2011). The main advantage of this approach is that measuring surrogate species is faster and

cheaper than measuring the original environmental quantity. That is why this approach has been used for the study of many environmental attributes ranging from biodiversity to pollution. And it found many applications in conservation from reserve site selection and management to monitoring freshwater quality. The main criticism deals with their efficacy, seldom rigorously investigated and often only assumed. Lindenmayer and Likens (2011), in particular, compare the surrogate and the direct measurement approaches in monitoring environmental and/or biodiversity changes. The focus of the direct measurement approach is on one entity or on a small group of entities in a target ecosystem, without to assume any surrogacy relationship with unmeasured entities. This characteristic makes it simpler and faster to prove a causal relationship between the key attributes of the ecosystem of interest and the entity to be measured, rather than using the surrogate approach, because the step concerning the demonstration of the surrogacy relationship is missing. However, in many cases it is difficult and often even impossible to characterize the functioning of a complex system, such as an ecosystem, or to measure a complicated multifaceted attribute, such as biodiversity, even by means of direct measurements. The size of the system, the complexity of the interactions involved, or the difficulty and cost of the measurements needed are often prohibitive. In the case of biodiversity, furthermore, which encompasses the variation of life forms from genes to species to ecosystems, it is not specified what constitutes a direct measurement. The focus on a small group of species is therefore a necessity.

Nevertheless, the debate of what is the most efficient biodiversity indicator is still going on and many different approaches have been proposed in the literature. Trying to categorize these approaches we could distinguish them to cross-taxon and within-taxon approaches. Cross-taxon approaches use the biodiversity of one taxon to infer the biodiversity of other taxa in the same area (among others Wolters et al., 2006; among others Billeter et al., 2008; Cushman et al., 2010). Within-taxon approaches try to substitute full species inventories with simpler measures of biodiversity. Several proposed indicators fall within this approach including the higher taxon surrogacy, the diversity of common or rare species, the diversity of endemic or threatened species.

The higher taxon surrogacy proposes predicting species richness based on the richness of a limited number of families, genera or orders (Gaston and Williams, 1993; Williams and Gaston, 1994; Mazaris et al., 2008b). Studies performed at various regions, habitat types and scales placing emphasis to different taxa demonstrated that this surrogacy method performed adequately well, providing a reliable estimation of species richness (Cardoso et al., 2004; Larsen and Rahbek, 2005; Villasenor et al., 2005). It has also been tested in both aquatic and terrestrial ecosystems and for various taxa like plants, algae, invertebrates, mammals, birds, amphibian and reptiles. This approach has also been proposed for monitoring trends in biodiversity and not only the spatial pattern of biodiversity (Kallimanis et al., 2012). Even though several studies support the reliability of this surrogacy there are few caveats raised in the literature. The surrogacy is more reliable as the taxonomic distance between indicator and *indicatum* is smaller, i.e. genera outperform families, while families outperform classes, etc. And after a point it does not work, for example there are many document cases that order richness is a poor indicator for species richness. A second caveat is that this approach works best for taxa that have a well-established taxonomy.

Several studies provide empirical support regarding the concurrence between the distribution of rare species and patterns of overall species richness (Lawler et al., 2003; Warman et al., 2004). Recently, more attention has been drawn to the contribution of common species in determining spatial patterns of species richness, suggesting that spatial patterns of biodiversity are mainly defined by the more widespread species, and thus common species are better biodiversity indicators than rare ones (Jetz and Rahbek, 2002; Lennon et al., 2004; Mazaris et al., 2008a). A major limitation of this approach is the definition of commonness and rarity, with many species being classified as common in one case and rare in another.

Rare and common may be defined either based on abundance estimates or on the size of their geographic range. One special case in the later is endemism. Endemism originally referred to being restricted to a particular area irrespective of its size, but following an influential paper by Terborgh and Winter (1983), the term was extended to species restricted to a small area (so-called narrow endemics). Endemism has been used as a biodiversity indicator. In a seminal and often cited paper Myers et al. (2000) used endemism as a main criterion to define global biodiversity hotspots. This approach performs

best at coarse scales with continental or wider extent. At fine scales, the adequacy of the method remains debatable.

Another often used biodiversity indicator are threatened species, which are also a conservation priority ***per se***. Threatened species are often defined at a global scale (based on the definition of “vulnerable,” “endangered,” or “critically endangered” using IUCN criteria) or at more local scales using national red data books were available. One difficulty with using threatened taxa as an indicator is that poorly studied groups will incorporate fewer threatened species for artificial reasons, since common species tend to be recorded first and they are necessarily less prone to extinction, so less-studied taxa that are just starting to be researched will contain fewer threatened species. Additionally, less studied groups will be less well evaluated for threat than well-studied taxa.

Several studies combined such approaches. Mazaris et al. (2010) combined the higher taxon surrogacy and the common to rare approach in order to predict vascular plant species richness in the Greek Natura 2000 network of protected areas. They found that the knowledge of all higher order taxa is not necessary in order to predict species richness. If we know how many out of the 30 most common orders are present, we can reliably predict the number of species. Similar results were obtained if we know how many of the 60 most common families or 200 most common genera are present.

Many studies applied simultaneous several of these approaches and compared their efficiency. Trindade-Filho and Loyola (2011) evaluated the effectiveness of nine indicator groups of mammals (Carnivora, Chiroptera, Primates, Rodentia, and Didelphimorphia, species-poor orders -i.e. those with less than 17 species-, threatened species, endemic species and restricted-range species) as surrogate for the whole mammalian species, using IUCN public occurrence maps, in two Brazilian hotspots. They conclude that priority sites selected through the indicator groups considered can include an important proportion of the whole mammal richness. In addition, restricted-range species expressed an efficient and consistent representation of mammalian fauna in both the hotspots. Nevertheless, two critical shortcomings were highlighted by the authors themselves: the very small conservation goal, easy to achieve, and the use of IUCN range maps as proxy for geographic distribution of the species.

Cross *taxon* approaches rely on measuring the diversity of one easily identifiable *taxon* in order to predict the diversity of one or more different *taxa*. In this debate, some papers dealt with the effectiveness of the surrogate approach and with its extrapolation, analysing the relationships hypothesized. Surrogacy relationship for biodiversity indicators and the performances in selecting conservation areas were often investigated, in different contexts and for several *taxa*.

Wolters et al. (2006) reviewed a large number of studies on biodiversity indicators, and assessed whether investigations focusing on well-known groups allows to concurrently predict the changes in the richness of poorly known *taxa*. They gathered a very heterogeneous data set, including 237 richness correlations for 43 different *taxa*. The most represented of them were beetles, vascular plants, butterflies, birds, ants, and mammals. Using meta-analysis, they showed positive but weak correlations between the diversity of *taxa* ($r = 0.37 \pm 0.068$ 95% CI), and concluded that no one resulted a particularly good predictor for the other one richness. Moreover, in studies conducted in temperate regions the explanatory power was lower than that in researches performed in the tropics.

Grantham et al. (2010) compared different measures of biodiversity surrogates for conservation planning, investigating the effect of four key factors. Factors tested were: choice of surrogate; *indicanda* (mammals, birds, reptiles, frogs, plants and all of these combined); study area; and testing method considered in evaluating the surrogates. Results highlighted that all the tested factors influence the effectiveness of the surrogates.

Cushman et al. (2010) investigated the effectiveness of the abundance of individual **bird** species to infer the abundance of the other species or groups of species, at two spatial scales and for different typologies of species grouping (*a priori* or empirical). Results were not encouraging: only few significant surrogate relationships were identified, at either spatial scale or under either grouping rule. Moreover, the few significant relationships observed did not explain a large enough portion of the variation of abundance of the other species.

Across seven European countries, Billeter et al. (2008) examined biodiversity of seven *taxa* (vascular plants, birds and five groups of arthropod: Apoidea, Heteroptera, Carabidae, Syrphidae, Araneae). They evaluated both the possibility to predict the richness of all the other *taxa* at a continental scale, and the links with features and management of the agricultural landscape. Also in this research, some significant predictive relationships were found, but no single *taxon* resulted as a consistent good indicator for the rest of the biodiversity considered at such a large scale. This occurred, in particular, where biogeographic variation in species richness was large (country effect significant in the models for most *taxa*). Finally, the diversity in all groups was positively related to the size of semi-natural habitat patches in the landscape.

Using a large database (1449 species) in two USA regions, Lawler and White (2008) investigated whether there are distinctive features of good taxonomic-based indicators of biodiversity. In particular, they studied the performance consistency of such indicators and tested five hypotheses proposed in literature to explain this surrogate performance: taxonomic diversity; nested species distribution; hotspots of biodiversity; species range size; environmental diversity. Species groups examined as surrogates were: birds, butterflies, amphibians, freshwater fish, mammals and at-risk species. The results of analyses showed that the indicators performance was poorly consistent in the regions considered, but also that surrogate performance presents only weak association with the tested characteristics of the species.

In Northern Greece, Kati et al. (2004) applied two techniques to evaluate the efficiency as biodiversity indicators of six groups of *taxa*: woody plants, aquatic and terrestrial herpetofauna, small terrestrial birds, orchids, and Orthoptera. Both the techniques showed that woody plants are the best biodiversity indicator, but the authors also pointed out a low general congruence in the species richness patterns across the considered groups. In addition, none of the optimal complementary networks of the examined groups resulted to protect all the species of the other groups. Nevertheless, woody plant complementary network preserved adequately the other groups, except orchids. The authors highlighted the importance of integrating the complementary principle into the analyses aiming at evaluating the performance of indicators.

In a similar way, Ricketts et al. (2002) assessed the effectiveness of a *taxon* to provide as biodiversity indicator for another *taxon.* In particular, they investigated whether “true butterflies” (superfamily: Papilionoidea), a well-known *taxon,* could act be used as biodiversity surrogate for moths (i.e., Leidoptera excluding Papilionoidea) at a local scale. The two groups are taxonomically related, but moths are less known. Across all 19 sites sampled, no correlation between moth and butterfly number of species was found, therefore, in this case, butterflies did not proved as useful biodiversity surrogate for moths. Phylogenetic relatedness, furthermore, cannot be considered a reliable criterion to select effective biodiversity indicator *taxa*. Finally, authors claimed that a habitat-based approach would be preferable in those situations - often numerous - where the surrogate relationships between *taxa* are not investigated yet.

Other researchers, on the other hand, found encouraging results about the reliability of surrogacy relationship in biodiversity indicators. Fleishman et al. (2005), for example, tested if individual or combined species from birds and butterflies (unrelated *taxa*) can act as reliable biodiversity indicators for both or only one of the two *taxa*. They modelled, at the site scale, the species richness of birds, butterflies, and both the groups as functions of the presence or absence of small subsets of species, to test if they could act as indicators. Indicator species are most effective within taxonomic groups, however the study results indicate that it is possible to identify sets of species whose patterns of occurrence explain a large portion of variability -even more than 80%- in biodiversity of multiple taxonomic groups. A small common suite of species, therefore, could be used to predict separately biodiversity of multiple *taxa*.

Sauberer et al. (2004) tested the quality of eight potential indicator *taxa* (bryophytes, vascular plants, gastropods, ants, carabid beetles, spiders, orthopterans, birds) in the agricultural landscape of eastern Austria. Using a multi-*taxa* approach and the principle of complementarity in site selection, each of the investigated *taxa* resulted able to capture a large portion of the overall species richness variability, being each *taxon* significantly correlated with the combined biodiversity of all other groups. In particular

vascular plant and bird diversity showed the highest correlations with the rest of the species richness, whereas carabid beetles and the gastropods were the most idiosyncratic groups.

Lund and Rahbek (2002) tested whether a single *taxon* can effectively drive the setting of conservation priority areas in Denmark, a temperate region, so that biodiversity in other groups is likewise represented. Data employed came from species distribution atlas of six *taxa*: elateridae, butterflies, large moths, chiroptera, birds, herpetofauna, for 434 species overall. Some of these groups represented effectively the other *taxa*; furthermore there was a high cross-*taxon* congruence in priority sets derived by complementarity analysis. In particular, in representing biodiversity of the other *taxa,* butterflies showed to perform rather better than the other tested groups. The relationship between birds and biodiversity was significant, but not excellent, while, bats predicted relatively well biodiversity.

Overall, results of the above examined papers suggest that any generalization of surrogacy tests needs caution, both in regions, *taxa*, temporal and spatial scales, ecosystems.

As pointed out by Lindenmayer and Likens (2011), across the literature almost all components of biotic systems have been proposed as indicators. They reported a long list of these *taxa*, including viruses, unicellular organisms, lichens, fungi, algae, ferns, vascular plants, and many groups of invertebrate and vertebrate. In order to provide a measure of the use of different biodiversity indicators in the scientific literature, in the following paragraphs we will report graphically the number of the papers published for each *taxon*. In all the cases, the last five years are the period with the highest number of scientific papers on the topic Researches were made among papers available in Web of Science (ISI) database. Terms and categories imposed for each search are reported in Appendix 1.

At this point we should also point out the use of non-biotic components of the ecosystems as biodiversity indicators. Given the fact that species' distributional survey data are often restricted to small regions along with the onerous task of collecting data on surrogate taxon species distributions over extended areas, there is a strong argument for using environmental information as a proxy for species distributions, either by itself or in conjunction with species data (Ferrier, 2002). In this sense several environmental variables have been studies including: Climatic attributes (such as temperature and precipitation) Physicochemical variables (such as soil quality and water chemistry), Habitat types (obtained from ground-based or sometimes aerial surveys and include landform-vegetation classes such as coastal vegetation, wetlands, or subalpine vegetation), Landscape structure variables (such as fragmentation or connectivity).

Environmental diversity has been shown to perform adequately well for the selection of reserve sites (Faith and Walker, 1996; Lobo et al., 2001). Another abiotic environmental surrogate for the distribution of biodiversity used for conservation planning is landscape heterogeneity (Lombard et al., 2003). Oliver et al. (2004) showed that each type of land system supported components of biodiversity either not found, or found infrequently, on other land systems. And they suggested that land systems function as surrogates for biodiversity, and that conservation-area networks representing land-system diversity will also represent biological diversity.

3.2.1 Plants

Plants are the organisms the most employed as biodiversity indicators: 988 overall records (Figure 3-2).

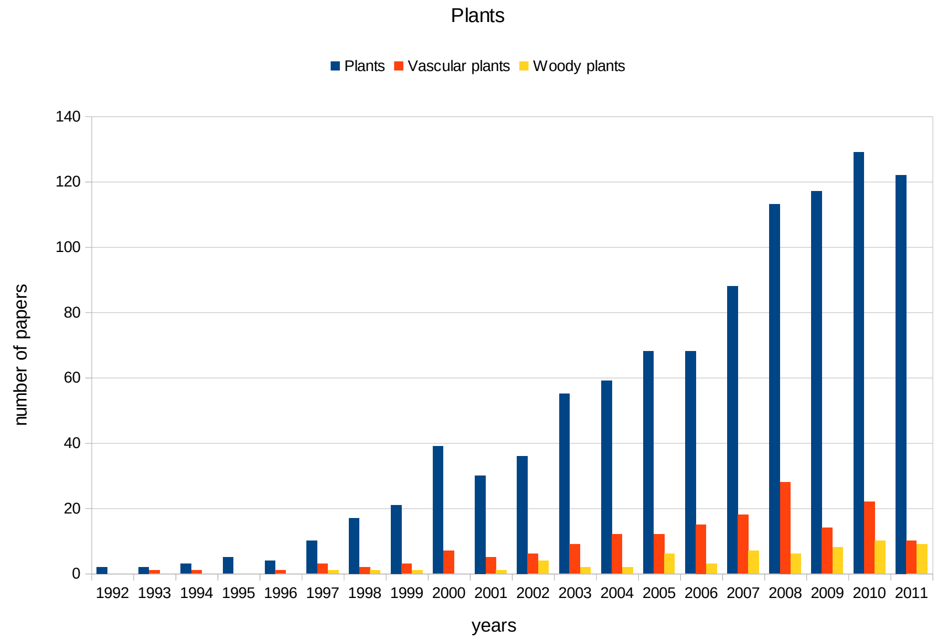

Figure 3-2. *Number of papers published about the plants and two categories of them: vascular and woody.*

3.2.2 Vertebrates

Among the vertebrates, birds are the class the most instigated, with 402 overall records, reptiles are the less studied *taxon*, 46 records only (Figure 3-3).

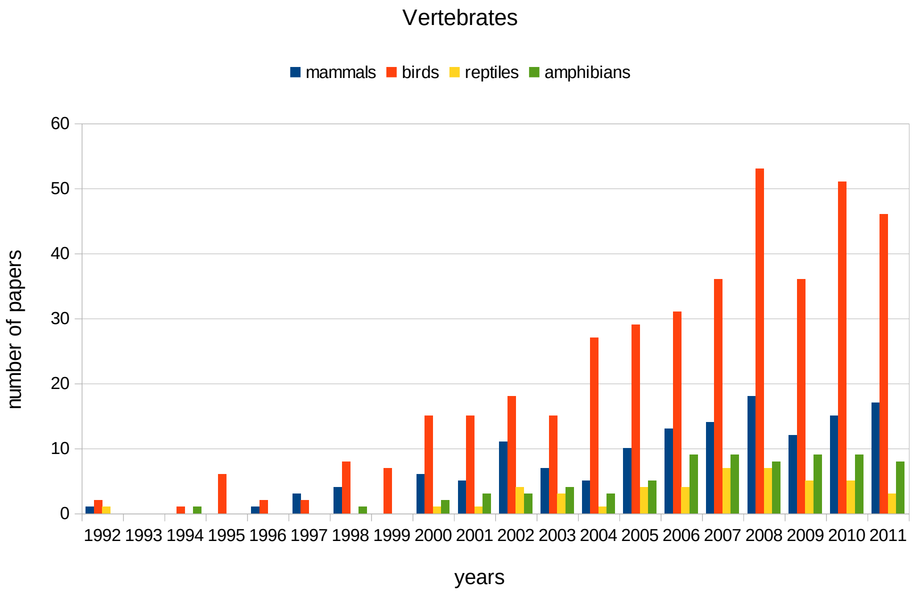

Figure 3-3. *Number of papers published about the classes of vertebrates, but fishes.*

3.2.3 Invertebrates

Among the invertebrates, insect are the most employed *taxon* in biodiversity indicator context (277 records), and butterflies are the most used insects (Figures 3-4 and 3-5).

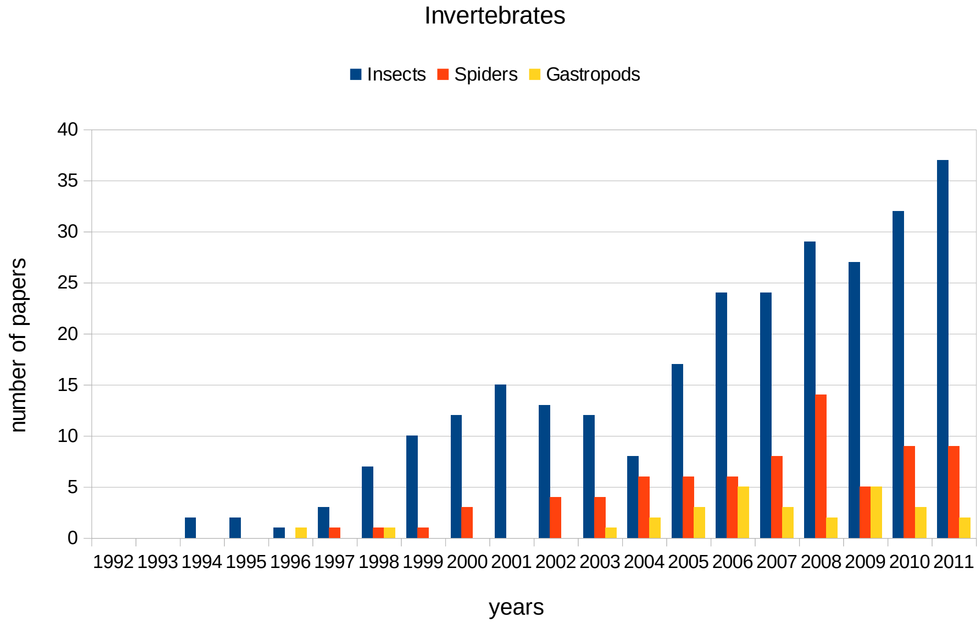

Figure 3-4. *Papers published about biodiversity indicators and three groups of invertebrates: insects, spiders, and gastropods.*

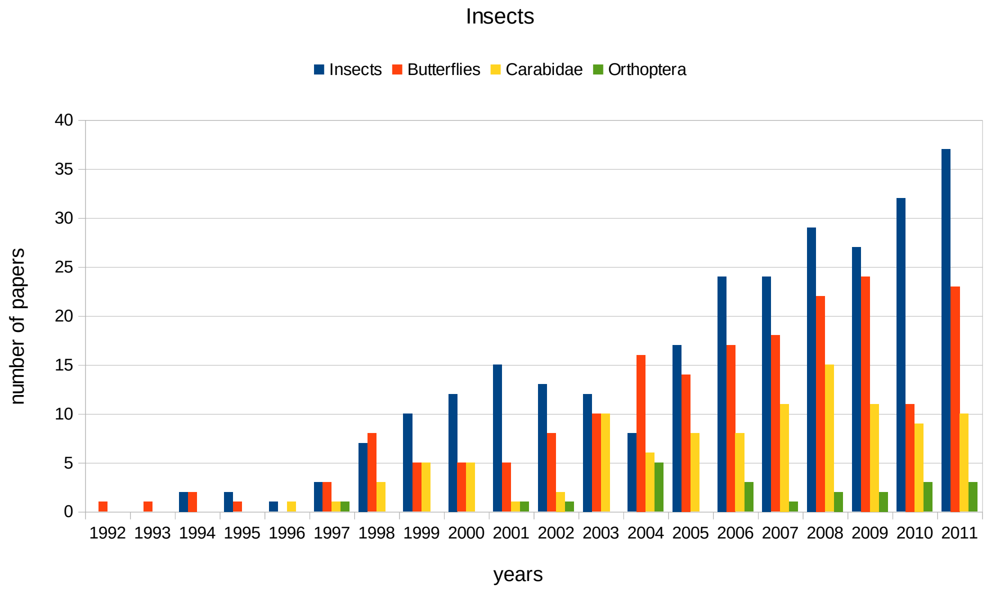

Figure 3-5. *Papers published about the insects and three* taxa *of them: butterflies, Carabidae, and Orthoptera.*

4. Selection of bio-indicators for the BIO_SOS project

4.1 Introduction: existing information

The deliverable 4.1 is the starting point to select bio-indicator species for BIO_SOS program. Each study site of the program (see Table 4-1) has some pre-existing data set and in D4.1 all data sets are listed.

Table 4-1 *Test sites*.

BIO_SOS CODE	N2KCode		N2K Name
	(SCIs/SACs, Habitats Directive)	(SPAs, Birds Directive)	
IT1	IT9110008	IT9110039	Valloni e steppe pedegarganiche
IT2	IT9110005	IT9110038	Zone umide della Capitanata-Paludi presso il Golfo di Manfredonia
IT3	IT9120007	IT9120007	Murgia Alta
IT4	IT9150032	IT9150014	Le Cesine
GR1	GR2120001	GR2120005	Ekvoles Kalama
GR2	GR2120002	GR2120006	Elos Kalodiki
GR3	GR2120004		Stena Kalama
NL	NL9801023	NL3009017	Veluwe. Dutch case study concentrates on part N2K, namely Ginkelse and Ederheide, a heathland area and Weekeromse Zand an inland sand dune area
PT1	PTCON0021	PTZPE0037	Rios Sabor e Maçãs
PT2	PTCON0001	PTZPE0002	Peneda-Gerês
UK			Cors Fochno
BR			Brazilian site in the Amazon

For each site we summarize here the available information on biodiversity, according with the information described in D4.1.

Tables reported in Appendix 2 describe the details for the study sites. Description of the resource, temporary extension, property of data are particularly important.

4.2 Criteria for selection of bio-indicators

On the basis of previous pages we can follow different ways to select bio-indicators. We need to select a group of bio-indicators following 4 criteria:

- possibility to compare niche models with and without GHCs

- usefulness for stakeholders
- possibility to carry out comparison among different sites
- availability of data

Comparison of Niche Models with / without GHCs. The possibility to compare niche models with and without GHCs will depend mostly on the real availability of different maps with and without GHCs. On the basis of previous reports (D4.1, D5.1, and D6.1) we suppose that this kind of analysis can be carried out in a few sites only. The possibility to build a Niche Model can be carried out using presence only data (with the help of programs like MaxEnt – Elith et al., 2011). MaxEnt is considered one of the most efficient approaches to ecological niche modelling using presence-only data (Elith et al., 2006; Elith et al., 2011). The program assesses the probability of presence in a given cell on the basis of environmental features in that cell; MaxEnt establishes flexible relationships between the dependent and independent variables, and is therefore well suited to evaluate the potential distribution of species also in presence of complex or non-linear relationships. Furthermore, it is possible to identify the relationships between GHCs and the species richness of specific target groups. They may be both taxonomic groups (e.g., birds, insects) and functional groups (e.g., species affected by fragmentation, woody plants). These relationships will be assessed through spatially-explicit generalized linear models (Beale et al., 2010).

These analyses do not require time series, but just accurate georeferenced presence records of the species of interest. It will be therefore straightforward performing the analyses when presence records are available.

Usefulness for stakeholders. One of the aims of this project is to have a link with stakeholders, and both in previous pages and in D2.1 usefulness for stakeholders was underlined as a key criterion for the selection of bio-indicators.

According to SEBI report (EEA, 2007), in D2.1 the key criteria to select an indicator were:

- Policy relevant and meaningful
- Biodiversity relevant
- Progress towards 2010 target
- Well founded methodology
- Acceptance and intelligibility
- Routinely collected data
- Cause-effect relationship
- Spatial coverage
- Temporal trend
- Country comparison
- Sensitivity towards changes

In this project, we want to build niche models using species that have a conservation value. Considering that the test areas are Natura 2000 sites, we will probably choose species that are inserted into Habitats and Birds Directive Annexes or in international red lists.

Invasive alien species are one other group of species that can be useful for stakeholders. In this case we get an indicator of pressure over the environment.

Comparison among different sites. If the list of species (not yet available, see later) shows some overlap on species distribution among different sites, we will choose some of those species (assuming they have the same quality of data).

Availability of data. The real availability of data is an essential condition. We operate our selection choosing among the existing data set described in D4.1 and reported in Appendix 2. In particular we will mostly focus on use data that not require any further license.

4.3 Selected bio-indicators

We propose to use the distribution of species richness and the distribution of ecological groups to investigate if GHC can be useful to predict their distribution. This approach will be used for the Italian sites that have both GHC and non-GHC maps. Data on both species distribution and species richness are based on species in Annex I of the Birds Directive (2009/147/EC) and Annexes II and IV of Habitats Directive (92/43/EEC), therefore our analyses will be useful also for the stakeholders.

From Portugal sites there is a species of high conservation value: *Geomaculus maculosus*, declared present in both sites. We propose to use this species to work with a species relevant for stakeholders and with the possibility to carry out a comparison among those sites.

Birds and insects can have a very relevant value for biodiversity, as our analysis of the literature (PAR. 3.2) showed that birds and insects are the most often used bio-indicators in biodiversity studies. If data are available, birds and insects will be the *taxa* of choice for our analyses.

We must consider that at 20 November 2011 no data set (although declared available) has been provided for data inspection, so we cannot provide complete details on the *taxa* and areas on which focusing analyses. Nevertheless, when the data will be available, it will be easy identifying the most appropriate species, on the basis of guidelines identified in this deliverable.

Considering that no revised dataset has been provided for Italian sites, the selection of bio-indicators in IT3 could be supported by data derived from the field activity planned in task 6.2 for 2012. Two animal classes (Aves and Hexapoda) will be considered, namely, breeding birds, butterflies (Lepidoptera) and grasshoppers (Orthoptera). Field surveys will be carried out in areas of the IT3 site covered by both GHC and non GHC maps, according to the protocols defined in D4.3. These groups are well known to be useful environmental and diversity indicators (see chapter 3.2) especially in managed grasslands, which are the most important habitats in IT3 site (D6.3). Grasshoppers are even more associated with grass communities. Many species can be considered as “keystones” as they represent the majority of insect biomass of herbaceous layer and are very important for the preservation of grassland food web structure (Ryszkowski et al., 1993). These data will allow to build diversity and evenness profiles (Hill, 1973; 1997) for the considered communities and therefore provide indicators useful to make comparisons across space and/or time. Diversity and evenness profiling are gaining momentum in ecology. Evenness profiling in particular, seems very promising to provide deeper insights into community structure, revealing the contributions of both rare and common species to biodiversity trends (Studeny et al., 2011). Multivariate analyses, in connection with landscape pattern analysis at landscape-class-patch levels, will be applied to identify those species capable of indicating changes in land use/land cover related to human pressures.

According to D4.1 and D4.3 invasive species (e.g. *Lantana camara* and *Chromolaena odorata* in India, or wild boar –*Sus scrofa* – in IT3) can be important, and we will consider the possibility to build models using the known distribution of invasive species (both animals or plants) in test sites, and linking those species with GHC and LCC. In the Netherlands *Campylopus introflexus* is an invasive species in the Wekeromse Zand and purple moor grass (*Molinia caerulea*), brambles (*Rubus fruticosus spp.)* and tree encroachment (*Pinus sylvestris* and *Betula pendula)* are invasive on the Ginkelse and Eder heath

Any other additional field data collected during the field activity, or now available (i.e., additional data from Indian sites) may be taken into account, considering deliverables deadlines (D 6.7 deadline is month 18).

Biodiversity indicators (according to D2.2)

Despite the wide range of biodiversity indicators identified by CBD and by SEBI2010, consistently with the indicators selected for BIO_SOS (D2.1), in almost all test sites of the BIO_SOS project there is a core of three key biodiversity indicators identified as appropriate and critical to monitor. More specifically, these key indicators will be related to the state and trend of: (*i*) habitats of European interest (extent and change), (*ii*) abundance and distribution of selected species, and (*iii*) fragmentation of natural and semi-natural areas. These indicators are valuable to address the effects of processes and drivers such as land use change (e.g., agricultural extensification or abandonment, urban sprawl, vegetation dynamics) and natural disturbance regimes (e.g., wildfires, floods). Even though the pressures and threats are not identical in all sites, and consequently all the processes and drivers are not applicable in all sites, the same key indicators seem to be effective in almost all cases.

On a secondary basis, other indicators will be considered in specific sites when developing specific studies. These include: (*i*) state and trends of ecosystem function (e.g., productivity, phenology), of landscape diversity and spatial structure and function, and of species diversity (e.g., species richness); (*ii*) intensity of pressures and threats e.g., land use and land use change, fire regimes, invasive species distribution/coverage; (*iii*) response/adaptation (indicators related to e.g., land use planning, nature protection inside and outside protected areas, allocation of conservation resources/funding and environmental compensatory measures).

These indicators can contribute to build more informative models of ecological niche for the selected *taxa*.

5. Appendix

5.1 Appendix 1: Parameters for bibliographic research in the ISI Web of Science

Parameters used for a bibliographic research carried out in November 2011 and total number of obtained records.

5.1.1 Plants

TS=(biodiversity and bio-indicator* and plant*) or TS=(biodiversity and indicator* and plant*)
Refined by: Web of Science Categories=(ECOLOGY OR ENVIRONMENTAL SCIENCES OR BIODIVERSITY CONSERVATION OR REMOTE SENSING OR FORESTRY OR ORNITHOLOGY OR PLANT SCIENCES OR AGRICULTURE MULTIDISCIPLINARY OR ENTOMOLOGY OR ENVIRONMENTAL STUDIES OR SOIL SCIENCE OR MARINE FRESHWATER BIOLOGY OR BIOLOGY OR AGRONOMY OR ZOOLOGY OR GEOGRAPHY OR MULTIDISCIPLINARY SCIENCES OR URBAN STUDIES)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 988

VASCULAR PLANTS
TS=(biodiversity and bio-indicator* and vascular plant*) or TS=(biodiversity and indicator* and vascular plant*)
Refined by: Web of Science Categories=(ECOLOGY OR BIOLOGY OR ENVIRONMENTAL SCIENCES OR GEOGRAPHY OR BIODIVERSITY CONSERVATION OR FORESTRY OR MARINE FRESHWATER BIOLOGY OR PLANT SCIENCES OR MULTIDISCIPLINARY SCIENCES OR REMOTE SENSING OR MYCOLOGY OR AGRICULTURE MULTIDISCIPLINARY OR URBAN STUDIES OR ENVIRONMENTAL STUDIES OR ZOOLOGY)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records:169

WOODY PLANTS
TS=(biodiversity and bio-indicator* and woody plant*) or TS=(biodiversity and indicator* and woody plant*)
Refined by: Web of Science Categories=(ECOLOGY OR GEOGRAPHY PHYSICAL OR MULTIDISCIPLINARY SCIENCES OR ENVIRONMENTAL SCIENCES OR AGRONOMY OR FORESTRY OR BIODIVERSITY CONSERVATION OR ENTOMOLOGY OR URBAN STUDIES OR PLANT SCIENCES OR WATER RESOURCES OR AGRICULTURE MULTIDISCIPLINARY OR GEOGRAPHY OR ZOOLOGY OR ENVIRONMENTAL STUDIES OR MARINE FRESHWATER BIOLOGY)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 61

5.1.2 Vertebrates

MAMMALS
TS=(biodiversity and bio-indicator* and mammal*) or TS=(biodiversity and indicator* and mammal*)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 142

BIRDS
TS=(biodiversity and bio-indicator* and bird*) or TS=(biodiversity and indicator* and bird*)

Refined by: Web of Science Categories=(ECOLOGY OR PLANT SCIENCES OR ENVIRONMENTAL SCIENCES OR WATER RESOURCES OR BIODIVERSITY CONSERVATION OR ENTOMOLOGY OR FORESTRY OR BIOLOGY OR GEOGRAPHY PHYSICAL OR ENGINEERING ENVIRONMENTAL OR ENVIRONMENTAL STUDIES OR ORNITHOLOGY OR AGRICULTURE MULTIDISCIPLINARY OR REMOTE SENSING OR MULTIDISCIPLINARY SCIENCES OR GEOGRAPHY OR ZOOLOGY OR URBAN STUDIES OR LIMNOLOGY OR MARINE FRESHWATER BIOLOGY OR AGRONOMY)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 402

REPTILES
TS=(biodiversity and bio-indicator* and reptile*) or TS=(biodiversity and indicator* and reptile*)
Databases=SCI-EXPANDED, SSCI, A&HCI Timespan=All Years
Lemmatization=On
Total records: 46

AMPHIBIANS
TS=(biodiversity and bio-indicator* and amphibian*) or TS=(biodiversity and indicator* and amphibian*)
Databases=SCI-EXPANDED, SSCI, A&HCI Timespan=All Years
Lemmatization=On
Total records: 74

5.1.3 Invertebrates

INSECTS
TS=(biodiversity and bio-indicator* and insect*) or TS=(biodiversity and indicator* and insect*)
Refined by: Web of Science Categories=(ECOLOGY OR ENVIRONMENTAL STUDIES OR ENVIRONMENTAL SCIENCES OR BIODIVERSITY CONSERVATION OR ENTOMOLOGY OR FORESTRY OR URBAN STUDIES OR MARINE FRESHWATER BIOLOGY OR GEOGRAPHY PHYSICAL OR GEOGRAPHY OR BIOLOGY OR MULTIDISCIPLINARY SCIENCES OR AGRICULTURE MULTIDISCIPLINARY OR ORNITHOLOGY OR ZOOLOGY OR PLANT SCIENCES OR AGRONOMY)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 277

BUTTERFLIES
TS=(biodiversity and bio-indicator* and butterfl*) or TS=(biodiversity and indicator* and butterfl*)
Refined by: Web of Science Categories=(ECOLOGY OR ZOOLOGY OR BIODIVERSITY CONSERVATION OR ENVIRONMENTAL STUDIES OR ENVIRONMENTAL SCIENCES OR MULTIDISCIPLINARY SCIENCES OR ENTOMOLOGY OR FORESTRY OR BIOLOGY OR GEOGRAPHY OR MARINE FRESHWATER BIOLOGY OR ORNITHOLOGY OR URBAN STUDIES OR REMOTE SENSING OR AGRICULTURE MULTIDISCIPLINARY)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 194

CARABIDAE
TS=(biodiversity and bio-indicator* and carabid*) or TS=(biodiversity and indicator* and carabid*)
Refined by: Web of Science Categories=(ECOLOGY OR ZOOLOGY OR ENVIRONMENTAL SCIENCES OR BIOLOGY OR BIODIVERSITY CONSERVATION OR ENTOMOLOGY OR ENVIRONMENTAL STUDIES OR FORESTRY OR GEOGRAPHY OR AGRICULTURE MULTIDISCIPLINARY OR URBAN STUDIES OR MARINE FRESHWATER BIOLOGY)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 106

ORTHOPTERA
TS=(biodiversity and bio-indicator* and orthopter*) or TS=(biodiversity and indicator* and orthopter*)
Databases=SCI-EXPANDED, SSCI, A&HCI Timespan=All Years
Lemmatization=On
Total records: 22

SPIDERS
TS=(biodiversity and bio-indicator* and spider*) or TS=(biodiversity and indicator* and spider*)
Refined by: Web of Science Categories=(ECOLOGY OR BIOLOGY OR ENVIRONMENTAL SCIENCES OR BIODIVERSITY CONSERVATION OR AGRONOMY OR ENTOMOLOGY OR GEOSCIENCES MULTIDISCIPLINARY OR MARINE FRESHWATER BIOLOGY OR AGRICULTURE MULTIDISCIPLINARY OR ZOOLOGY OR FORESTRY)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 77

GASTROPODS
TS=(biodiversity and bio-indicator* and gastropod*) or TS=(biodiversity and indicator* and gastropod*)
Refined by: Web of Science Categories=(ENVIRONMENTAL SCIENCES OR BIOLOGY OR ECOLOGY OR FORESTRY OR BIODIVERSITY CONSERVATION OR ZOOLOGY OR GEOSCIENCES MULTIDISCIPLINARY OR MARINE FRESHWATER BIOLOGY OR AGRICULTURE MULTIDISCIPLINARY OR MULTIDISCIPLINARY SCIENCES OR WATER RESOURCES)
Timespan=All Years. Databases=SCI-EXPANDED, SSCI, A&HCI.
Lemmatization=On
Total records: 29

5.2 Appendix 2: Available information on biodiversity in the study sites

ITALIAN SITES (IT1, IT2, IT3, IT4)

Resource title	Resource abstract	Resolution	Spatial scale	Temp. ext.	Date of pub.	File type	Author	Property
Species richness	Map of the species richness in Puglia based on the composite of known breeding areas of Annex II and IV of The 93/42/CE Directive and of Annex I of the 79/409/CE Directive			2006	2009		RP	need to request licensing
Ecological group	Map of the distribution of ecological groups in Puglia based on the composite of both known breeding areas of Annex II and IV of The 93/42/CE Directive and of Annex I of the 79/409/CE Directive and niche their niche requirements			2006	2009		RP	need to request licensing

Greek Sites (GR1, GR2, GR3)

Resource title	Resource abstract	Resolution	Spatial scale	Temp. ext.	Date of pub.	File type	Author	Property
Species of Annex II of Directive 92/43/CE distribution maps	Map of species distributions based on the composite of known breeding areas of Annex II and IV of the 93/42/CE Directive and of Annex I of the 79/409/CE Directive		100k		2000	ESRI Shapefile	Ministry of Environment, Energy and Climate change	need to request licensing

Portuguese sites (PT1 & PT2)

Resource title	Resource abstract	Resolution	Spatial scale	Temp. ext.	Date of pub.	File type	Author	Property

Notable trees	Notable trees for the north region of Portugal. Information from the Portuguese Atlas of the Environment (Portuguese Environment Agency)		100k		1997	ESRI Shapefile	Atlas do Ambiente/APA	available to use without licensing
Raptors-high sensitive	Species distribution for the north region of Portugal. Information from de ICNB					ESRI Shapefile	ICNB	available to use without licensing
Geomalacus maculosus species distribution data	Geomalacus maculosus species distribution data for the NUTS II north / SIMBion region of mainland Portugal	5m		2010	2010	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing
Bat species richness	Model led (maxent) bat species richness for the SIMBioN/NUTS II north region of mainland Portugal.	0,002778 degree		2010	2010	ESRI Grid	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	unknown limitations
Bird species distribution for the NUTS II north (PT11) /SIMBioN region	Bird spatial distribution data for the NUTS II north / SIMBioN region. Recording conditions are mentioned as metadata.	10000m		2010	2010	MS Excel 2007 (xls) / ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	unknown limitations
Rupiculous bird species for the NUTSII north (PT11) /SIMBioN region	Rupiculous birds distribution data for the NUTS II north / SIMBioN region.	1000m		2010	2010	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	unknown limitations
Bats-other shelters						ESRI Shapefile		
Bats-important shelters						ESRI Shapefile		
Raptors-sensitive						ESRI Shapefile		
Esteparias-high sensitive						ESRI Shapefile		
Other species-sensitive						ESRI Shapefile		
Other species-high sensitive						ESRI Shapefile		

PT2

Resource title	Resource abstract	Resolution	Spatial scale	Temp. ext.	Date of pub.	File type	Author	Property
Phytosociological associations / vegetation types distribution		1000m		1998 - 2006	2010	MS Excel 2010 (xlsx) - ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing

Flora distribution data - Minho	Flora distribution data for the Minho valley. The dataset contains several prioritary species concerning the habitats and birds directive.		25k	2007	2007	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing
Geomalacus maculosus species distribution data	Geomalacus maculosus species distribution data for the NUTS II north / SIMBion region of mainland Portugal	5m		2010	2010	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing
Invertebrate species distribution data I	Invertebrate species distribution data from UTAD - SIMBioN data collection task	5m		2010	2010	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing
Micromammals distribution data - 2010 SIMBioN campaign	Micromammals distribution data recorded in the 2010 SIMBioN campaign coordinated by UTAD	5m		2010	2010	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing
Odonata species distribution data 2010 SIMBioN campaign	Odonata species distribution data recorded/collected in the 2010 SIMBioN campaign coordinated by UTAD. Records are reported at 10km ED50/UTM grid.	5m		2010	2010	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing
Plant species records / distribution data for mainland Portugal		1000m		2000-2010	2010	MS Excel 2007 (xls)	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	available to use without licensing
Plant species records / distribution data for mainland Portugal from phytosociological inventories		1000m		1998-2006	2010	MS Excel 2010 (xlsx) - ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	
Notable trees	Notable trees for the north region of Portugal. Information from the Portuguese Atlas of the Environment (Portuguese Environment Agency)		1000k		1997	ESRI Shapefile	Atlas do Ambiente/APA	
Raptors-high sensitive	Species distribution for the north region of Portugal. Information from de ICNB		1000k			ESRI Shapefile	ICNB	
Bryophyte species distribution data	Bryophyte species distribution data reported at 1/10 km ED50/UTM grids.	1000m		2000-2010	2010	MS Excel 2007 (xls)	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	need to request licensing
Fish species distribution	Fish species/ ichtyofauna distribution data from the Article 17 Habitats directive dataset reported at 1/10 km ED50/UTM grids.	1000m		2000-2010	2010	MS Excel 2007	ICNB	need to reque

data						(xls)		st licensing
Invertebrate species distribution data	Invertebrate species distribution data from the Article 17 Habitats directive dataset reported at 1/10 km ED50/UTM grids.	1000m		2000-2010	2010	MS Excel 2007 (xls)	ICNB	need to request licensing
Mammalian species distribution data	Mammalian species distribution data from the Article 17 Habitats directive dataset reported at 1/10 km ED50/UTM grids.	1000m		2000-2010	2010	MS Excel 2007 (xls)	ICNB	need to request licensing
Reptile and amphibian atlas for mainland Portugal	Reptile species distribution data from the "Atlas de répteis e anfíbios" reported at 1/10 km grid	1000m		2000-2010	2010	MS Excel 2010 (xlsx)	ICNB	need to request licensing
Bat species records / distribution data	Bats species chorological records / distribution data	1000m		1873 - 2009	2010	MS Excel 2007 (xls)	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	
Bat species richness	Modelled (maxent) bat species richness for the SIMBioN/NUTS II north region of mainland Portugal.	0,002778°		2010	2010	ESRI grid	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	
Bird species distribution for the NUTS II north (PT11) /SIMBioN region	Bird spatial distribution data for the NUTS II north / SIMBioN region. Recording conditions are mentioned as metadata.	10000m		2010	2010	MS Excel 2007 (xls) - ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	
Fauna distribution data - Minho	Fauna distribution data for the Minho valley. The dataset contains several prioritary species concerning the habitats and birds directive.		25k	2007	2007	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	
Rupiculous bird species for the NUTS II north (PT11) /SIMBioN region	Rupiculous birds distribution data for the NUTS II north / SIMBioN region.	1000m		2010	2010	ESRI Shapefile	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	
Trees and shrubs distribution data	This dataset contains trees and shrubs distribution data compiled from the Porto Herbarium	10000m		1853-2004	2007	MS Excel 2007 (xls)	Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	
Veronica micrantha maxent distribution model	Maxent spatial distribution model for the rare plant species Veronica micrantha for the SIMBioN / NUTS II north region of mainland Portugal.	1000m		2010	2010		Centro de Investigação em Biodiversidade e Recursos Genéticos - CIBIO	

Bats-other shelters						ESRI Shapefile		
Bats-important shelters						ESRI Shapefile		
Raptors-sensitive						ESRI Shapefile		
Esteparias-high sensitive						ESRI Shapefile		
Other species-sensitive						ESRI Shapefile		
Other species-high sensitive						ESRI Shapefile		

Netherlands site

No data available from this site

UK site

Resource title	Resource abstract	Resolution	Spatial scale	Temp. ext.	Date of pub.	File type	Author	Property
BAP Invertebrate Species	Point data of key BAP invertebrate species		10k			MapInfo .TAB	Recorder	need to request licensing
BAP marsh fritilary	Point data for marsh fritillary butterflies with latest year recorded and maximum abundance (1990-2002) for adult and larval stages		10k			MapInfo .TAB	Recorder	need to request licensing
Distribution data for Great Crested Newts	Great Crested Newts		2,5k		2007	MapInfo .TAB	CCW	need to request licensing
HEP Sensitive Bryophytes & Lichens	Bryophytes and Lichens sensitive to HEP schemes		10k		2010	MapInfo .TAB	CCW	need to request licensing
Distribution data for Lichens	Rare Lichens		1		2010	MapInfo .TAB	CCW	need to request licensing
LRC - Priority and Protected Species	Priority and Protected Species		2,5k		2010	MapInfo .TAB	CCW	need to request licensing
Distribution data for Stoneworts	Rare Stoneworts		10k			MapInfo .TAB	CCW	need to request licensing

Priority and Protected Species	Priority and Protected Species supplied from the LRCs.		10k		2010	MapInfo .TAB	LRC	need to request licensing

Brazil site

Resource title	Resource abstract	Resolution	Spatial scale	Temp. ext.	Date of pub.	Geog.	File type	Author	Property
BR_extinction_species	List of species endangered of extinction in Brazil			2011	2011	Brazil	web site	ICMBio	available to use without licensing

5.3 Appendix 3: Acronym list

CI Confidence Interval

EO Earth Observation

GHC General Habitat Category

HR High Resolution

IUCN International Union for Conservation of Nature

LC Land Cover

LCC Land Cover Change

RS Remote Sensing

SEBI Streamlining European 2010 Biodiversity Indicators

VHR Very High spatial Resolution

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