Assessing the sensitivity of niche breadth to reflect community specialization.
The case of birds and agricultural land use changes.

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0 ABSTRACT

Global changes forced by human activities are dramatically driving to biotic homogenization. Specialist species are more negatively affected by changes of habitats than generalist species as they are showing little dependency on a certain habitat, therefore we predict that they should be less affected to changes on habitat than specialist ones.

Taking into account that there is the need for large scale indices which reflect human disturbance and biodiversity response, we proposed to develop an indicator based on functional homogenization. This indicator has been applied to the Iberian Peninsula. Due to the good representativeness of birds as indicators of trends for farmland biodiversity, we have decided to focus on them. To build the indicator only free available data has been used as the Vegetation series map for Spain, the National Biodiversity Inventory and the CORINE land cover database. The degree of specialization has been determined by the measure of niche breath.

The study has shown the degree of sensitivity that has the community specialization with respect to changes in land use, particularly for agricultural use in two different temporal stages (1990 and 2000).

Changes from disturbed environments to natural habitats do not always mean an increase on the community specialization. Our results showed specialization impoverishment when land abandonment occurred. In fact, both classes (the managed and the unmanaged) equally reached the highest values at the beginning of the period.

What it is clear is that changes promote a decrease of specialization. This can be due to the capability of communities to cope with a low degree of disturbance, based on the resilience of ecosystems. In any case, both agricultural and forest areas shelter the highest values of specialization, so special care has to be considered when practising changes on them.

Keywords

biotic homogenization, specialization, land-use changes, National Biodiversity Inventory, Spanish Breeding Birds Atlas, niche breath, community, Corine Land Cover, Spain

1 INTRODUCTION

*'**Biological diversity** means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.'*

Quote from UNEP CONVENTION ON BIOLOGICAL DIVERSITY, 5th *of* JUNE *of 1992*

The decline of biodiversity

Biodiversity is decreasing at a faster rhythm than expected by natural processes due to our unsustainable way of life, based on the systematic alteration of the habitats that shelter the natural wealth (Devictor *et al*., 2008a). The protection of these values as natural heritage is linked to our recent common history; this was a powerful motivation for the creation of the first national parks in the late nineteenth century (Kassas, 2002). Thus, disfunctions caused to the ecosystems entails the emergence of an awareness of environmental damage, this fact promotes the need for protection of natural values. In the present context, the UN adopts the global commitment to significantly reduce biodiversity loss by 2010, under the Millennium Declaration Goals (Millennium Declaration, 2000). Following this trend, Europe takes a step further and sets a target of halting biodiversity loss in 2010 (European Council, 2001).

Biotic homogenization

Global changes forced by human activities are dramatically driving to biotic homogenization in all its aspects: genetic, taxonomic and functional (Olden *et al*., 2004). Taxonomic homogenization is well studied and characterised by the increase of species similarity in space over time, for instance as a result of species invasion or extinction. But biodiversity loss is also affecting functional homogenization when an impoverishment of functional diversity of communities occurs, that is to say when a distinct functional role played by certain species within the ecosystem is shifted by another that is common to many species. This process brings to functional redundancy (Olden and Rooney, 2006). Recent studies have shown a trend of specialist species to be more negatively affected by anthropic changes of habitats than generalist species (McKinney and Lockwood, 1999; Julliard *et al.*, 2006; Filippi-Codaccioni *et al*., 2008). Stability in environments whether in space or time favours specialists, while disturbance benefits generalists. The different response to environment changes is a result of an evolutionary trade-off between the ability of species to exploit a wide range of resources versus the capability to use more efficiently some resources (Levins, 1968). For instance, the specialists trade-off entails a lower dispersal ability (Brouat *et al*., 2004), a strong intra-specific competition (Dall and Cuthill, 1997) and a poor adaptability to stochasticity (Sol *et al*., 2002), while generalist species deal better with disturbance and are agile colonizers (Devictor et al., 2008b).

The need for indicators

Nowadays the use of indicators is one of the most useful techniques to analyze trends, progress and responses to environmental management and conservation measures. Indicators are also useful tools to communicate and to make scientific information readily usable for policy makers. At European level, a set of indicators has been established to assess the state of biodiversity, the 'Streamlining European 2010 Biodiversity Indicators' (SEBI 2010), which aims to inform about the progress towards the European 2010 targets. Birds are good representatives of the integrity of ecosystems as well as for its biodiversity. So we can find two of the SEBI indicators focused directly on birds, the abundance and distribution of selected species of birds and the impact of climatic change on bird populations (Schutyser *et al*., 2009).

Among the strengths of the SEBI 2010 set of indicators are ones about the components of biodiversity that have been developed with greater dedication, specifically those that relate to species diversity. In the same line are those associated with the composition of ecosystems, to the detriment of those linked to structural and functional aspects that need further scientific investment. It has also been detected a lower level of study of the indicators that focus on genetic and ecosystem diversity. In order to achieve a robust set of indicators, it is necessary to advance in the investigation of weak points (Schutyser *et al*., 2009).

CSI for Community Specialization Index

'One important goal of community ecology is to understand the origin, maintenance, and consequences of ecological diversity within local communities.' (Morin, 1999)

On this context, the European Topic Centre for Biodiversity is supporting the development of an index containing a clear relation of causality, which aims to reflect the ecosystem integrity. The Community Specialization Index (CSI) manifests the homogenization of communities that are found under some kind of stress. This generalization is based on the progressive loss of specialist species and the increase of generalist species in ecosystems under stress (Marvier et. al, 2004). As a result, it is possible to obtain an idea of the state of biodiversity and the health of the analyzed ecosystems.

Land use and birds

In recent years agricultural territory is gaining interest in protecting the environment, since it is one of the most extensive and changing territories at European level. Moreover, given the wide coverage of agricultural areas a strong interest raised to its multifunctional use: agriculture, landscape and nature protection. The abandonment of arable land, depopulation of rural areas, changes in the types of crops and the replacement of traditional farming techniques are increasing their vulnerability. We must be alert to these changes in order to cause the minimal impact. In that sense, the European Commission has included an index for population of farmland birds in the Structural Indicators set in order to monitor the possible threat to biodiversity due to unsustainable agricultural practises.

Over the last three decades common bird populations have been decreasing, that fact has been observed for both forest and farmland birds, whose populations have continuously been reduced (PECBMS, 2009). Farmland birds have been particularly affected by the negative trend, as their populations have been reduced approximately to a half in 15 years (from 1980 to 2005). The already mentioned changes in land use and agricultural practices may be distinctively relevant when affect nesting or feeding. At present time this decline seems to be levelled off for the whole group of farmland birds, but this stabilization possibly hides individual species trends. If we analyse them separately, we can see that most of specialist farmland species are still declining, while generalists are increasing. One thing is clear, birds are good taxa indicators of trends for farmland biodiversity and there is the need for large scale indices which reflect human disturbance and biodiversity response (Balmford *et al*., 2005).

Objectives and scope

The present study aims to make an approach to biotic homogenization and a proposal to develop an indicator based on functional homogenization. This indicator has to be applied to a wide scope as it is the Spanish territory of the Iberian Peninsula. The indicator has to be validated using some well-known, reference species, and also by comparison with other indicators.

Nowadays, a rich diversity of data can be found on the Internet, published by very different institutions. One of the goals of the study is exploring the viability of producing advanced indicators using this available data. As a consequence, only freely available data has been used in this research. If they are proven useful, they may significantly lower the barriers to entry into research.

Another purpose of the study is to show the degree of sensitivity that has the community specialization with respect to changes in land use, particularly for agricultural use. Two different temporal stages (1990 and 2000) of the CORINE Land Cover database will be used to study the impact of land use changes in community integrity. In summary, our aims are:

- To produce and evaluate an indicator of community specialization
- To asses the viability of making advanced research using freely available data
- To look at the sensibility of community specialization to one of the most dynamic land use: agriculture

Hypothesis

We accept that generalist species use various types of habitat in the matrix showing little dependency on a certain habitat, therefore we predict that they should be less affected to changes on habitat than specialist ones which are tied up to few habitat types (Krauss *et al*., 2003).

2 METHODS

Study design

The study is located on the Spanish territory of the Iberian Peninsula (493.707’8 km^2). Data corresponding to the Balearic Islands, the Canary Islands, and the two autonomous cities of Ceuta and Melilla has been removed from the analyses process. The removal object is to avoid insularity effects when assigning specialization values to communities considering the whole peninsula. The entire study area has been divided into 10 x 10 km squares, using the National Biodiversity Inventory reference grid, which is projected in the UTM coordinate system (Universal Transverse Mercator), zone 30 North and the European 1950 Datum (see Annex I).

To build the niche breath index two data sources have been used, having into account that all the datasets used in this study are independent of each other. First, the Vegetation series map for Spain (Rivas-Martínez, 1987) has been the basis to define habitat classes for birds. Later, the Atlas of breeding birds, from the National Inventory of Biodiversity database published on the Spanish Ministry of the Environment and Rural and Marine Affairs webpage, has been useful to build the specialization index for every bird species. Finally, the same database together with the niche breadth index has provided the framework to calculate the specialization value for every community in the study area, considered as a sample grid.

In a step forward, the CORINE land cover data of changes has been used to analyze the response of the community niche breadth to the changes on the territory.

Defining habitat classes using vegetation maps

We have accepted the approach that the chorology of avifauna is more linked to vegetation structure rather than to floral composition of vegetation communities (Tellería *et al*., 1988; Suárez *et al*., 1991). A rough classification of vegetation has been done considering the potential niche that it may provide to birds. Different aspects of vegetation are acknowledged as the density of foliage, the type of leaves, deciduous or evergreen species, vegetation coverage, trunk structure and hardness, height, fruit production, climatic distribution, phenology, environmental humidity, etc. It seems appropriate to base the classification of habitats on the dominant vegetation species which will give structure to the community as well as it will give homogeneity to the niche supply. According to this, the Vegetation series map has been analyzed (see Annex III for the complete series list). The whole vegetation map for Spain was produced by Rivas-Martínez on 1981 and revised by him 6 years later. Thirty seven vegetation macroseries and about a hundred series or sigmetum were defined and delimited on the national map at the scale 1:400.000. The vegetation series describe the potential vegetation for Spain. We have used the digitalised map for our study area, which is also projected in the UTM zone 30N coordinate system and the European 1950 Datum. We have grouped the series according to the dominant species for the potential vegetation, with the result of fifteen habitat classes derived from climatic vegetation series, while two have been obtained from the geoseries.

GROUPING OF VEGETATION SERIES	HABITAT	id_hab
7a, 16c	abedulares	1
2b, 4a, 4b, 20a, 20b	abetales	2
28	acebuchales	3
23a, 23aa, 23b, 23c, 23ca, 23d, 23da, 23e, 26, 26a, 26b	alcornocales	4
29, 29a, 29b, 29c, 30a	coscojares	5
geoseries II, III	dunas y salinas	6
11a, 11b, 11ba, 11c, 21a, 21b, 21c, 21ca, 21cc, 22a, 22aa, 22b, 22ba, 22c, 24a, 24aa, 24ab, 24b, 24ba, 24bb, 24bc, 24c, 24ca, 24cb, 24cc, 24d, 24da, 24e, 24eb, 24ec, 24f, 27a, 27b, 27ba, 27c, 27ca	encinares	7
6a, 6c	fresnedas	8
5a, 5b, 5c, 5d, 5e, 5f, 5g, 5h, 16a, 16b, 16d	hayedos	9
31a, 31aa, 31b	lentiscares	10
2e, 2f, 13a, 13b, 13c, 13d, 13e, 13f, 14a, 14b, 15a, 15b, 15c	matorrales junipero	11
32a, 32b, 32ba	matorrales áridos	12
1a, 1b, 1c, 1d, 1e, 1f, 1g, 12a, 12b, 12c, 12d, 12e	pastizales	13
2a, 2c, 2d, 3a, 3b, 3c	pinares	14
19a, 19b, 19bb, 19c, 19cc, 19d, 19dd, 19e	quejigares	15
geoseries I, Ia, Ib, Ic, Id, Ie	riparias	16
6b, 6ba, 6d (piso C), 6d (pisoD), 7b, 8a, 8aa, 8b, 8c, 8d, 9a, 9b, 9ba, 10, 17, 18a, 18aa, 18b, 18ba, 18bb, 18c, 18d, 18e, 18f, 18g, 18h, 25	robledales	17

Table1. Description of the vegetation series groups forming habitat classes

First class is 'abedulares', birch forests habitat which comprises all the series dominated by the genus *Betula sp.*, basically speaking about *Betula celtiberica*. Next class is 'abetales', grouping together *Abies alba* and *Abies pinsapo*. The 'acebuchales' is only considerinng *Olea europaea var. Sylvestris*. Cork oaks, 'alcornocales', where the *Quercus suber* prevails. Quercus coccifera forms the class 'coscojares'. While 'Dunas y salinas' is a geoseries that entails salt marshes, dunes and sand habitats. Holm oak group, 'encinares', comprises *Quercus ilex subsp ilex* and *Quercus ilex subsp rotundifolia*. 'Fresnedas' class is dominated by ash trees *Fraxinus excelsior*. Another broadleaved temperate habitat is the 'hayedas' with the preponderance of the beech *Fagus sylvatica*. 'Lentiscares' is the territory of the sclerophyllous *Pistacia lentiscus*. A class is formed by a grouping of different shrubs where drier conditions appear, including 'enebrales', 'sabinares' and 'piornales', that has been named 'matorrales de junipero' which includes *Juniperus sabina, Juniperus nana, Juniperus thurifera* and *Cytisus purgans*. And there is a different class for the habitats that are formed when the conditions turn into extreme, an arid scrubland 'matorrales aridos' group dominated by *Ziziphus lotus* and *Periploca angustifolia*. Pastures are aggregated in a single class 'pastizales'. The entire genus *Pinus* is clustered together in the habitat 'pinares', basically ruled by *Pinus sylvestris* and *Pinus uncinata*. 'Quejigares' is the habitat class for *Quercus faginea*. 'Riparias' is the geoseries associated to riverine environments, the class entails 'alisedas', 'fresnedas', 'choperas' and 'olmedas'. Finally, 'robledales' class agglomerates all the oaks *Quercus robur, Quercus pyrenaica, Quercus petraea, Quercus canariensis* and *Quercus pubescens*. To work with the digitalised map, the polygons have been dissolved by the same habitat type (see Annex IV). Finally, spatial autocorrelation has been measured for the habitat classes.

Birds data

For the present study we have used data from the National Inventory of Biodiversity database. The avifauna data comes from the Spanish Breeding Birds Atlas (Martí and Moral, 2003), which is a compilation of data coming from different sources, mainly from sampling surveys carried out from 1998 up to 2001. Information was completed with auxiliary data from local authorities monitoring programmes for endangered species, national census for several species, and also other regional atlases, only considered when the fieldwork of these atlases was practised from 1985 up to 2002. A standardized survey methodology (Purroy, 1997) was performed to obtain presence/absence information, basically identifying breeding birds either by visual or auditory contact. Fieldwork was executed mainly by skilled volunteers, additionally experienced professional ornithologists covered those grids where no other data was available. First task was to analyze the different environments present in every 10 x 10 km grid in order to efficiently plan the surveys. To carry out the grid sampling, major effort was done on selecting habitats and dates according to facilitate the finding of breeding evidences instead of confirming the species breeding. Every plot was visited at least three times in a monthly interval. An early sample, generally undertaken on May, helped primary to spot conspicuous bird territorial songs. Next one after April, when birds have started the breeding process. And a final one, during May or June, when breeding evidences were clear if spotting family groups or youngsters. With all this presence/absence raw data of every species we could build distribution maps for a particular species (see Annex II). In addition, species richness was measured and represented for every 10 x 10 km plot (see Annex V).

Measuring functional homogenization

'A community is an assemblage of different species that coexist in time and space.' (Gotelli, 2001)

The degree of specialization can be determined by the measure of niche breath (Donovan and Welden, 2002). Ecological theory states that the specialization degree of a species varies with the niche breadth, as the result of an evolutionary trade off between the capability of a species to use a certain resource and the ability to exploit a wider range of different resources (McArthur, 1972). A common way to quantify niche breadth is the Levins' proposal (Morin, 1999) which describes the uniformity of the resources use made by a certain species. Applying the equation

$$B = 1 / \Sigma p_i^2 \qquad \textbf{Equation 1}$$

where B is the measure of niche breadth, and p_i is the proportion of the species which is found in environment i, that is to say the proportion of the given species which is using the environment i.

Here we considered habitat as a resource used by the species (Levins, 1968). Accordingly, niche breadth was calculated as a measure of habitat selection, evaluating the proportion of habitat used by a species. To obtain the p_i we have used the map of the different habitat classes (Annex IV) and the area of distribution for every species (Annex II). We have crossed this information, so we obtained the area of every habitat class for every species, which was divided by the total distribution area of the considered species. Following this procedure, we obtained the niche breadth for every species present in the area of study. But we were interested in analyzing the community response to land use changes, so we had to measure the specialization degree at the community level.

Communities can be delimited whether by natural means or by the study needs (Magurran, 2004). In our case, we have defined a community as a sampling plot of 100 km^2 with the identifier of the reference grid field. We have done two approaches to community niche breadth (CNB), the first as the summation of the species niche breadth (equation 2), and the second as the average of B (equation 3), being n the number of species recorded in every plot.

$$CNB_t = \Sigma\ B_i$$ **Equation 2**

$$CNB_{AV} = (\Sigma\ B_i)/\ n$$ **Equation 3**

Community Specialization Index (CSI)

We wanted to compare our approach to other tested measures of specialization as the CSI (Julliard *et al*., 2006). This measure estimates functional homogenization as the average of the species specialization index (SSI).

$$CSI = \Sigma\ SSI/\ n$$ **Equation 4**

for the species present at a certain site, calculated as the coefficient of variation of its densities across 18 defined habitat classes.

$$SSI = \text{standard deviation} / \text{mean}$$ **Equation 5**

This index has been analyzed for different taxonomic groups (birds, reptiles, amphibians and mammals), and previous studies have shown that the SSI was not biased by taxonomic autocorrelation (Devictor *et al*., 2008b).

The SSI has already been calculated for the 100 most frequent terrestrial bird species in France. This measure allows ordering species in a specialization gradient from generalists with low values, occurring in many habitats, up to specialists with the highest values as they occur in few habitat classes. We have used the SSI values and have calculated the CSI for the Iberian Peninsula.

Land use change

We used the CORINE Land Cover change data to assess the land use changes during the period of 1990 to 2000. CORINE is an European programme initiated in 1985 by the European Commission, which provides the best land cover data European wide for three time shots (1990, 2000 and 2006). We have used the digitalised map of the changes on the land cover, which were projected in the Lambert Azimuthal Equal Area coordinate system with the datum ETRS 1989. CORINE is divided in 5 main classes (artificial areas, agricultural land, forests and semi natural, wetlands and water bodies). The data is coded with the land use class corresponding to the year 1990, and the land use class at 2000, which describes the change or no-change information. To carry out the analyses, we have crossed this data with the community niche breadth index and observed which was the evolution through the changes. The areas with no change on agricultural land have been used as control points.

3 RESULTS AND DISCUSSION

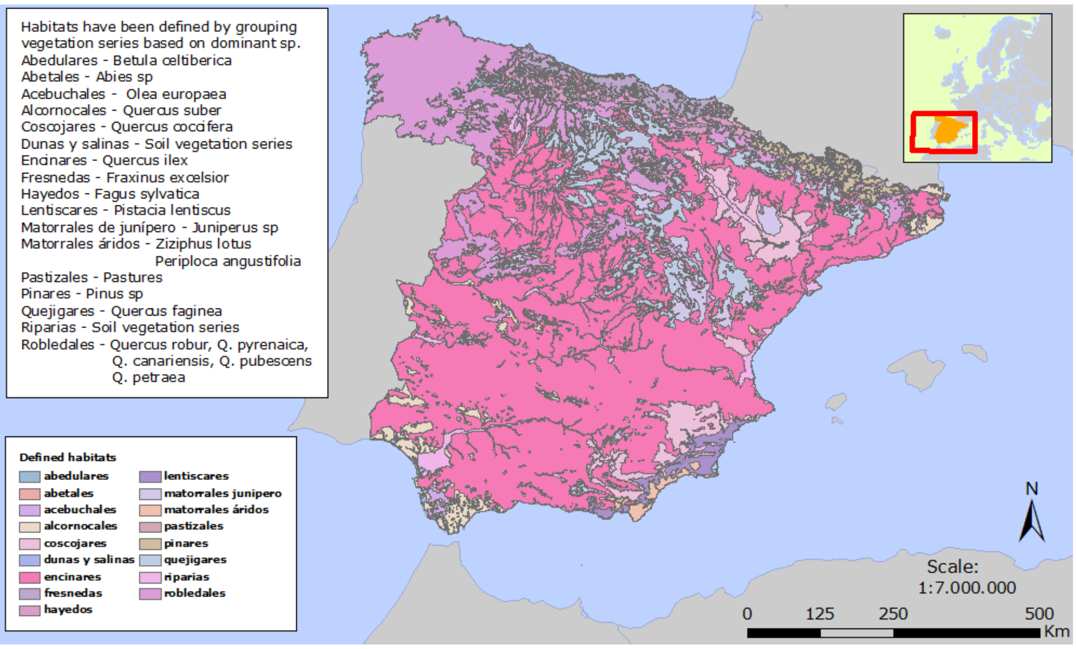
From vegetation maps to habitat classes

Vegetation is not evenly distributed on the territory. The major habitat is 'encinares' with an area of 272.393,66 km^2 , representing more than a half of the study area (55,17%). It is followed by 'robledales' with 75.745,37 km^2 (15,34%). The rest of the habitats classes is disseminated more homogeneously.

habitat_classes	id_habitat	dominant_sp	area_km2
abedulares	1	b. celtiberica	2109,37
abetales	2	abies sp	406,91
acebuchales	3	olea europaea	1553,68
alcornocales	4	q. suber	14591,35
coscojares	5	q. coccifera	24199,77
dunas y salinas	6		811,64
encinares	7	q. ilex - q rotundifolia	272393,66
fresnedas	8	f. excelsior	9321,01
hayedos	9	fagus sylvatica	11019,79
lentiscares	10	p. lentiscus	6547,99
matorrales junipero	11	juniperus sp	13658,48
matorrales áridos	12	espinal-cornical	2662,22
pastizales	13	pastures	847,59
pinares	14	pinus sp	6558,11
quejigares	15	q. faginea	31263,24
riparias	16		20017,62
robledales	17		75745,37

Statistics	habitats_area
N	18
Min	406,91
Max	261649
Sum	493708
Mean	27428,2
Std. error	14399,1
Variance	3,73E+09
Stand. dev	61090,2

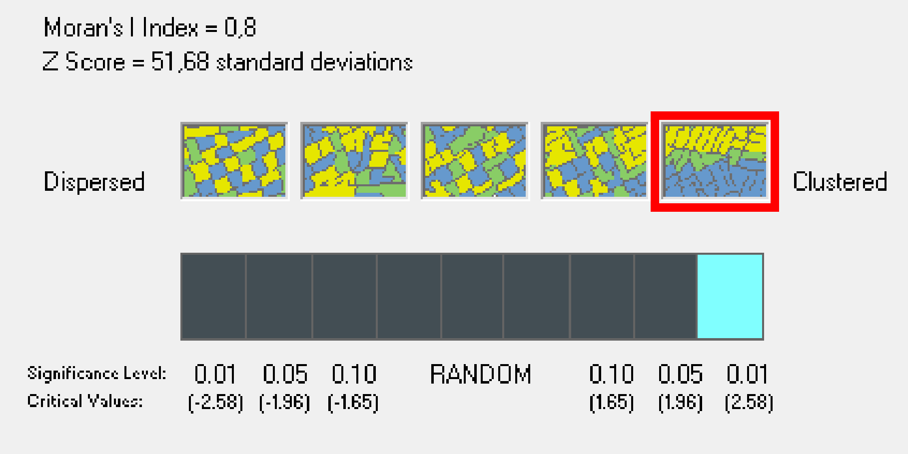
Table 2. Summary of the statistics for the 17 habitat classes considering the area (km^2)



Habitats have been defined by grouping vegetation series based on dominant sp.
Abedulares - Betula celtiberica
Abetales - Abies sp
Acebuchales - Olea europaea
Alcornocales - Quercus suber
Coscojares - Quercus coccifera
Dunas y salinas - Soil vegetation series
Encinares - Quercus ilex
Fresnedas - Fraxinus excelsior
Hayedos - Fagus sylvatica
Lentiscares - Pistacia lentiscus
Matorrales de junípero - Juniperus sp
Matorrales áridos - Ziziphus lotus
Periploca angustifolia
Pastizales - Pastures
Pinares - Pinus sp
Quejigares - Quercus faginea
Riparias - Soil vegetation series
Robledales - Quercus robur, Q. pyrenaica,
Q. canariensis, Q. pubescens
Q. petraea

Figure 1. Defined habitats for the study area considering the vegetation series (see Annex IV)

To analyze the distribution pattern of the vegetation series, a spatial autocorrelation using Moran's Index was ran with Arctoolbox in ArcMap (ArcGIS 9.3). The result was that there is high clustered distribution pattern assured by a Moran's Index of 0'8. Moreover, it obtained a high signification as there is less than 1 % likelihood that this pattern could be the result of random chance. So there is a high dependency of vegetation to spatial variables, as it could be expected.



Moran's I Index = 0,8
Z Score = 51,68 standard deviations

Figure 2. Spatial autocorrelation analyses for the vegetation series (Global Moran's index)

The vegetation series map has been helpful to give a framework to analyze a continuous distribution pattern. But to base habitat classes only on the potential vegetation is too much simplifying. These environments which do not present vegetation, as for instance bare rocks or cliffs or even urban areas, are included in a vegetation class. Even if it happens in few occasions, this fact is introducing an error to the index calculations and has to be taken into account.

The niche breadth index

Focusing on the results obtained with the niche breadth index (B) for the Spanish breeding birds, the species with lower values are the common murre *Uria aalge* and the Black-legged Kittiwake *Rissa tridactyla*, with the minimum value of 1'00. Both species, share the same breeding locations, only two in Costa da Morte (A Coruña). These are the most specialists breeding birds in the study area. They are followed by the osprey *Pandion haliaetus,* which only breeds in Cádiz, on quiet cliffs, with a niche breadth value of 1'21. It is closely followed by the sandwich tern *Thalasseus sandvicensis,* niche breadth of 1'22, which is only breeding in the Ebro delta and the Albufera of Valencia. For nesting it prefers sedimentary banks in the littoral. All of them have a very located spatial distribution, only breeding in few areas, just a couple of grids (10 x 10 km) of the study area. But this is not the case of the next species, the great bustard *Otis tarda* (niche breadth of 1'43). Its potential habitat is all the non irrigated labour land, open spaces in the steppes and natural pastures.

It is remarkable that some species very much linked to the human presence are found in the middle of the list. We could previously expect they would score a marked generalist value, but they do not. The group of pigeons with *Columba domestica* (2'69), *Columba livia* (2'59), *Columba oenas* (2'73) and *Columba palumbus* (2'90). The same happens with the house sparrow *Passer domesticus* (2'91), the blackbird *Turdus merula* (2'99), the magpie *Pica pica* (3'04) and the European robin *Erithacus rubecula* (3'77).

On the other end, with the higher values we can find the Eurasian woodcock *Scolopax rusticola*, with a niche breadth of 5'69. It is found in deciduous forests with a heterogeneous structure. It goes next the alpine accentor *Prunella collaris* and the alpine chough *Pyrrhocorax graculus,* which both live in high mountains and breed in rock crevices, cracks and caves. And finally, with the highest values two forest fringillids, the Eurasian siskin *Carduelis spinus* and the citril finch *Serinus citrinella*, which show an opportunistic breeding linked to the fruit production of coniferous forests and obtain a niche breadth value of 6'36 and 6'64 respectively.

Generally speaking, the niche breadth index fits with the biology of the species. We must take into account that the species data is based on presence / absence in 10 km squared grids, so some disadjustments could be occasioned by this poor precision. However, the present study has shown that for most of the species this scale is proved to be enough to assess their niche ecology.

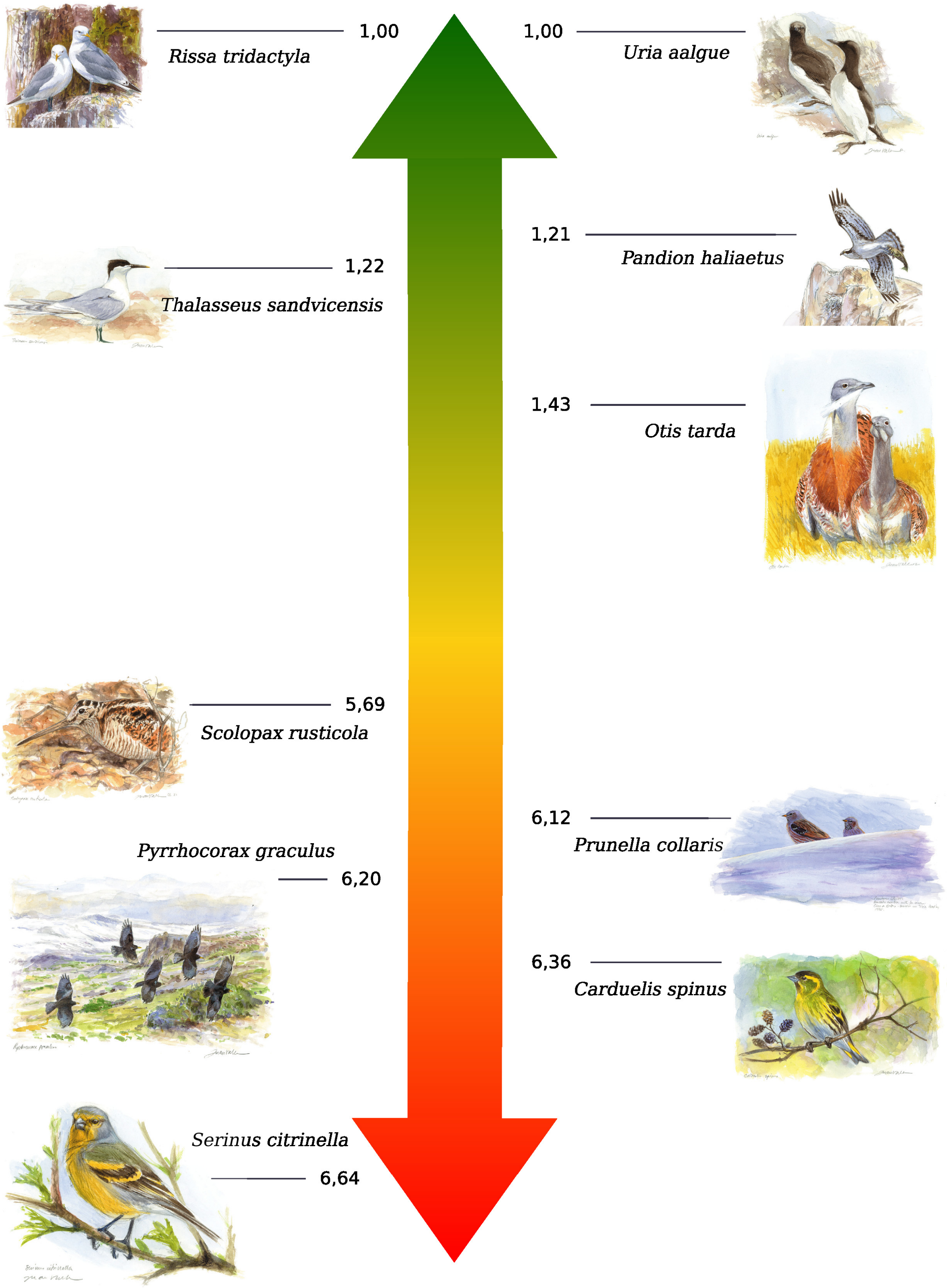


Figure 3. Niche Breadth extreme values for the Spanish breeding birds, with low values corresponding to most specialists species and high values to most generalists ones (paintings from Juan Varela published on the Spanish Breeding Birds Atlas, Martí and Moral, 2003).

The niche breadth versus species specialization index

The correlation between both indices was calculated for the 93 coinciding species for which we had both values. Low relationship was obtained, both for linear regression with a squared correlation coefficient of 0'0103 and for the polynomial one with a R^2 of 0'0935.

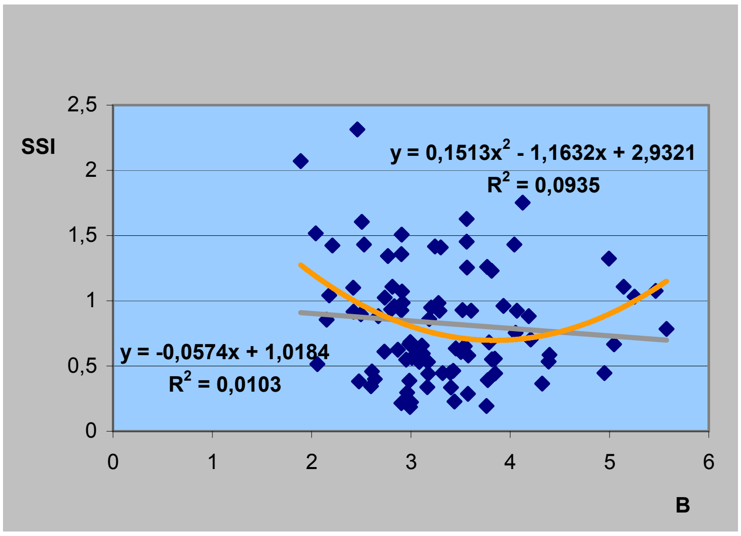


Figure 4. Correlation between the two types of specialization indexes SSI and niche breadth for the 93 commonest terrestrial bird species in France, for the values calculated in Spain.

It has to be taken into account that the SSI values have been computed for the 100 most common terrestrial bird species in France (Julliard *et al.*, 2006). But only 93 of them are found in the Iberian Peninsula, this is the reason why the analysis has been done considering these species for the SSI. This data has a narrow range of values, comprised between 0,18587, for the most generalist species, and 2,31385. In contrast, Niche Breadth has a wider range going from the lowest 1, for the most specialists, up to 6,638.

	SSI	B
N	93	294
Min	0,18587	1
Max	2,31384	6,63799
Sum	76,9416	843,565
Mean	0,827329	2,86927
Std. error	0,0455554	0,0621657
Variance	0,193002	1,13618
Stand. dev	0,43932	1,06592

Table 3. Summary of the statistics for both indexes, the Species Specialization Index (SSI) and for the species niche breadth (B)

Relationships between the indicators were analyzed. It was found a strong correlation between the Species Richness and the average of the Community Niche Breadth with values over 0'391, for both lineal and polynomial.

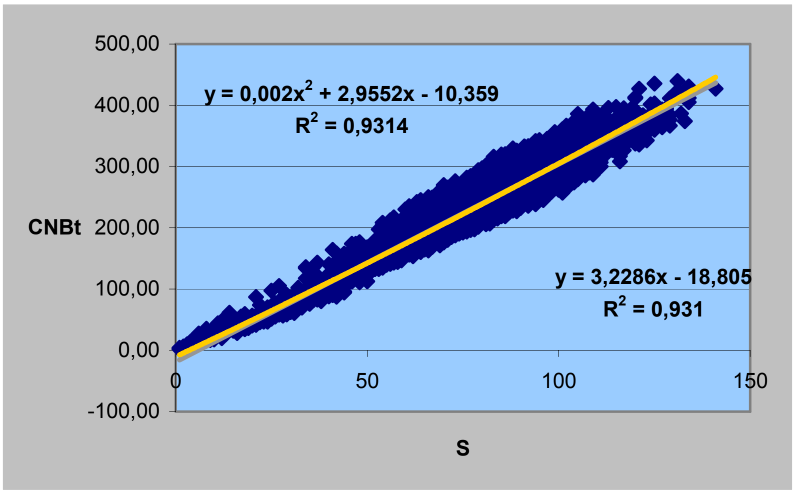
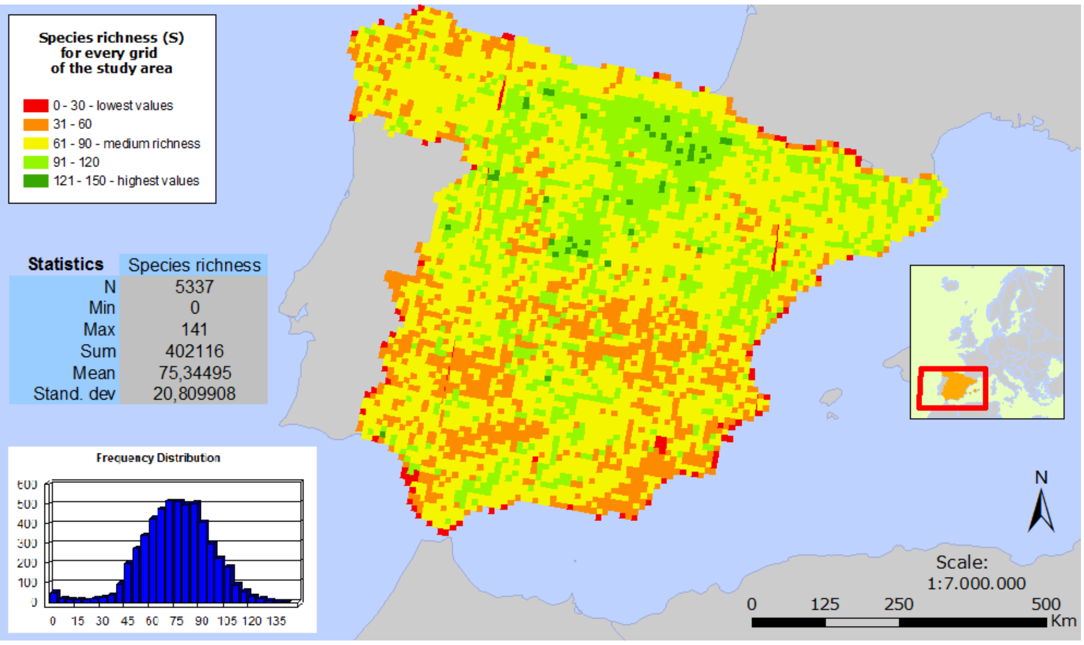


Figure 5. Correlation between the Species richness (S) and the Community Niche Breadth total

The result for the Species richness calculation got the highest value of 141 species in a grid, while the mean value was 75'35. On the map, the distribution of the richest grids looks quite clustered, as it is mainly located on the northern half of the Peninsula and middle way from the ocean influences. Another remarkable fact is that the coastline has low values for the whole study area.



Statistics	Species richness
N	5337
Min	0
Max	141
Sum	402116
Mean	75,34495
Stand. dev	20,809908

Figure 6. Resulting map for the Birds Species richness (S) in the study area (see Annex V)

It seemed interesting to compare the two approaches to niche breadth. In one hand, the accumulated niche breadth for every grid, which has the strong relation with the species richness. On the other we had the average of the niche breadth that could be compared to the CSI.

	CNB total	CNB average
N	5572	5572
Min	1,79483	1,79483
Max	439,349	4,62524
Sum	1222070	16491
Mean	219,324	2,95962
Std. error	0,97809	0,00363318
Variance	5330,5	0,0735504
Stand. dev	73,0103	0,271202

Table 4. Summary of the statistics for both calculations of the Community Niche Breadth, by the summation (CNB total) and by the average (CNB av)

Here again there was obtained a marked gradient north-south, but in this case, the specialization goes to the southern half of Spain. Generalist communities seem to be concentrated on the central area of the northern Peninsula.

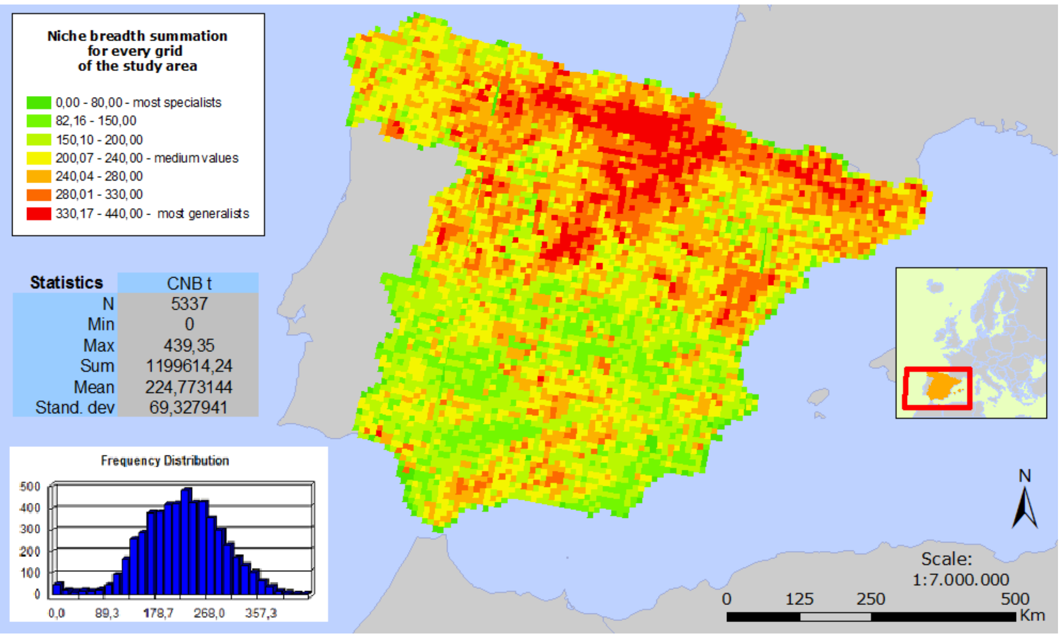
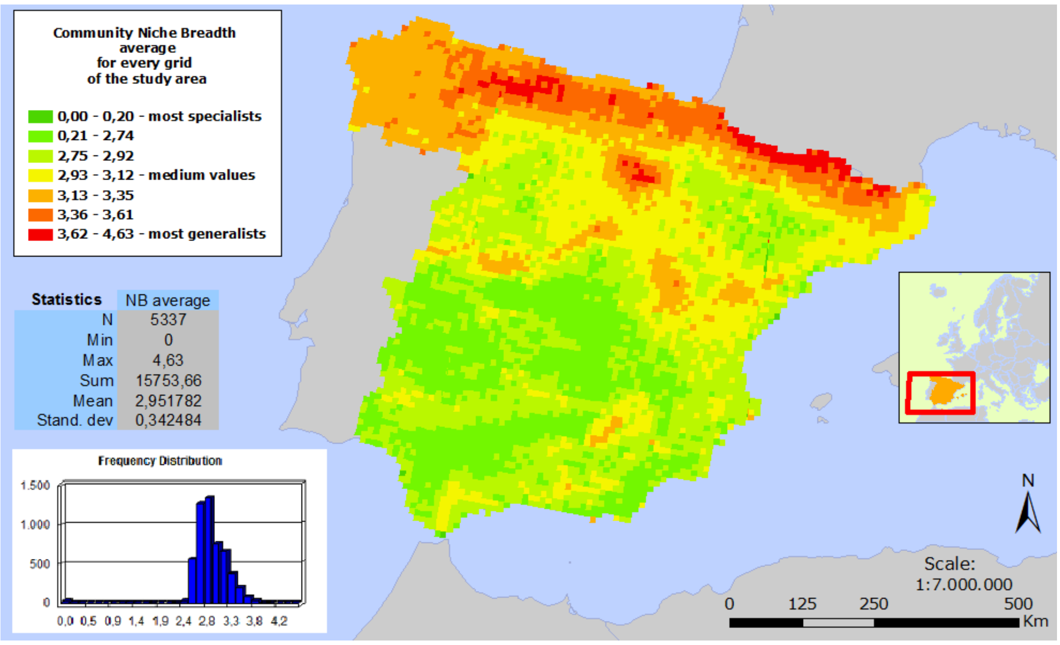


Figure 7. Resulting map for the accumulated Community Niche Breadth in the study area (for major detail see Annex VI)

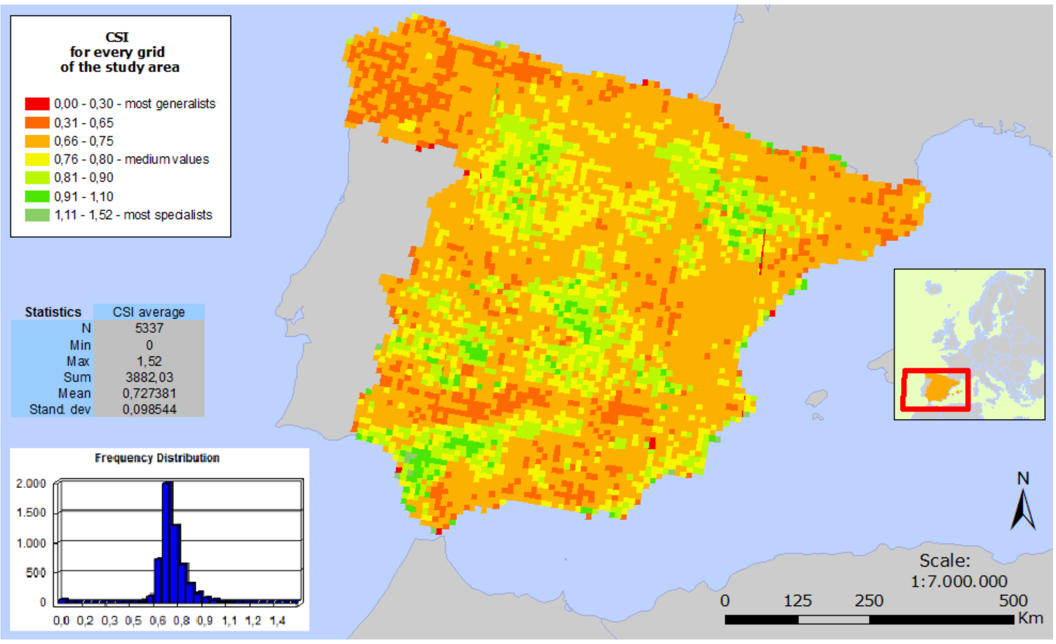
In this Community Niche Breadth map, we can appreciate the main river basins in the Peninsula, as well as the highest mountain chains. There is a clear line of high values crossing the country on the northern boundary, from west to east.



Statistics	NB average
N	5337
Min	0
Max	4,63
Sum	15753,66
Mean	2,951782
Stand. dev	0,342484

Figure 8. Resulting map for the average Community Niche Breadth (see Annex VII)

For the Community Specialization Index applied to Spain, the resulting frequency distribution is highly concentrated on the medium values of the range, between 0’7 and 0’8. It is interesting to comment that it follows the same spatial pattern for the river basins as the CNB average. Although, a difference with the previous one is that the mountain ranges are not identifiable in this map.



Statistics	CSI average
N	5337
Min	0
Max	1,52
Sum	3882,03
Mean	0,727381
Stand. dev	0,098544

Figure 9. Resulting map for the Community Specialization Index (CSI) calculated for the 93 matching species (see Annex IX)

When we analyze these maps comparing the land uses on the territory, we can identify that the highest values of specialization for all the indexes analyzed correspond with the main agricultural areas in the peninsula. There is the exception of the area of Cabo de Gata (Almería) with a peak of specialization values not related to agriculture; probably due to its extreme natural conditions.

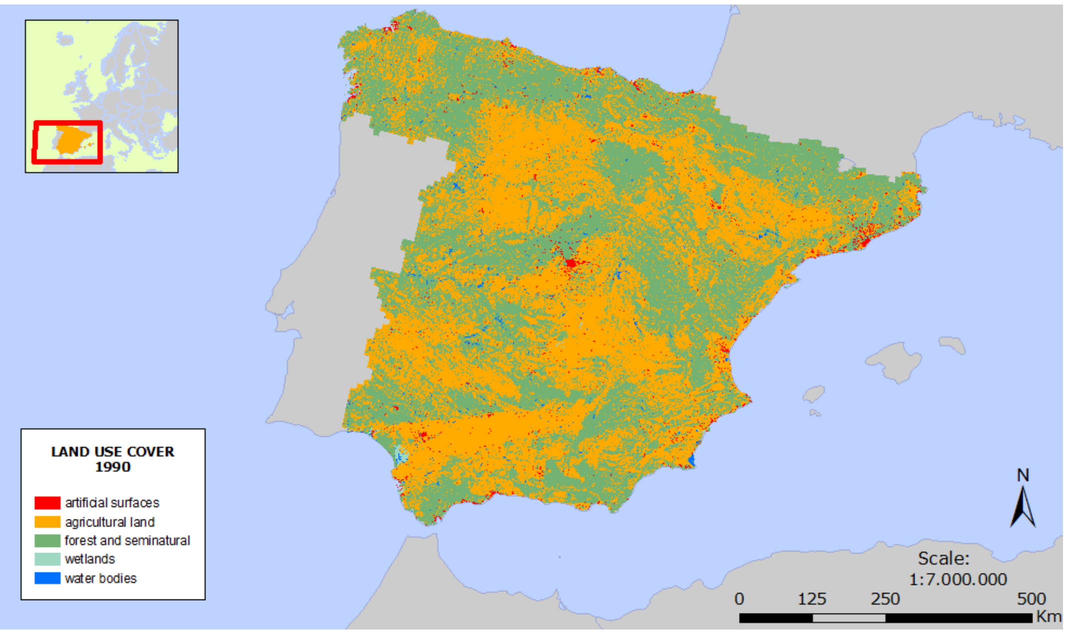


Figure 10. Land use cover of the Spanish peninsula in 1990 from the CORINE database (source: EEA, www.eea.europa.eu)

Community specialization and land use change

To analyze the functional homogenization, through the community niche breadth, first it has been explored the distribution frequency of each land use class at the beginning of the period. It has been seen that maximum values correspond equally to agricultural and to forest areas.

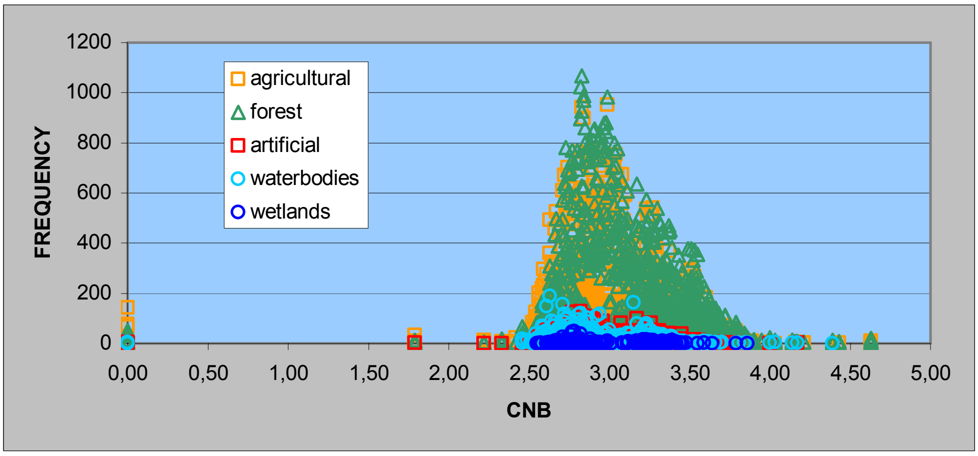


Figure 11. Frequency distribution of the CNB along the different CORINE classes at the beginning of the analyzed period (1990).

Finally, the community niche breadth has been used to assess the changes on the territory. First, analyzing the distribution of CNB where no change has occurred on agricultural land for the analyzed period (1990-2000).

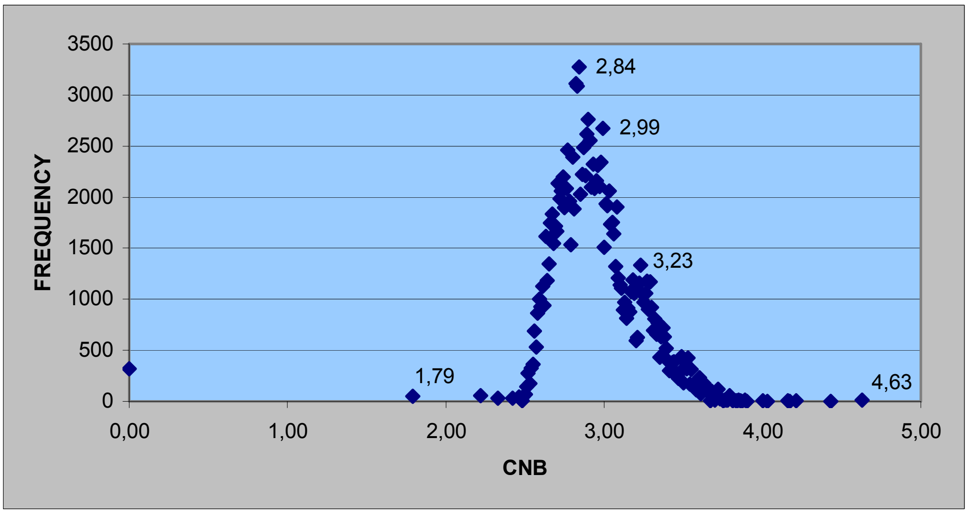


Figure 11. Frequency distribution of the CNB over the permanent agricultural land during the studied period (1990 – 2000).

We can observe that distribution concentrates around value 2'84. And that highest value corresponds to 4'63, while the minimum scores 1'79. When we compare the range with one for the urbanization process, we can observe that the amplitude is narrower, with values comprised between 2'51 and 3'72. Here most of the values clusters around 2'80.

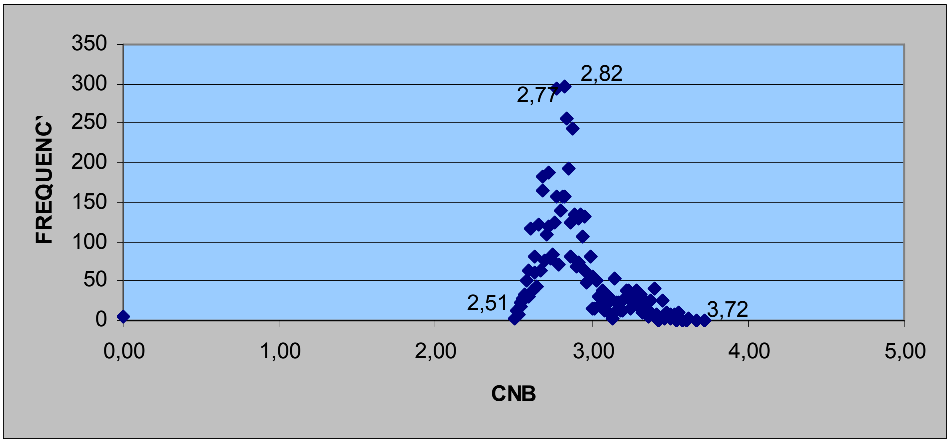


Figure 12. Frequency distribution of the CNB where agricultural land has evolved to artificial areas

The range for the land afforestation is a bit moved to the specialization values of the chart. Highest niche breadth values do not pass 3'66 when land abandonment occurs, but we have to look at the lowest values, which reach 2’22. So we can see that there is a specialization impoverishment, comparing agricultural and forest land changes, this pattern agrees with recent biotic homogenization studies (Clavero and Brotons, 2009). However, the decrease of specialization is less marked in land abandonment than in urbanization of former agricultural areas.

Something remarkable is that there is a common pattern of clustering around community niche breath values of 2’84, which occurs in all the land use classes.

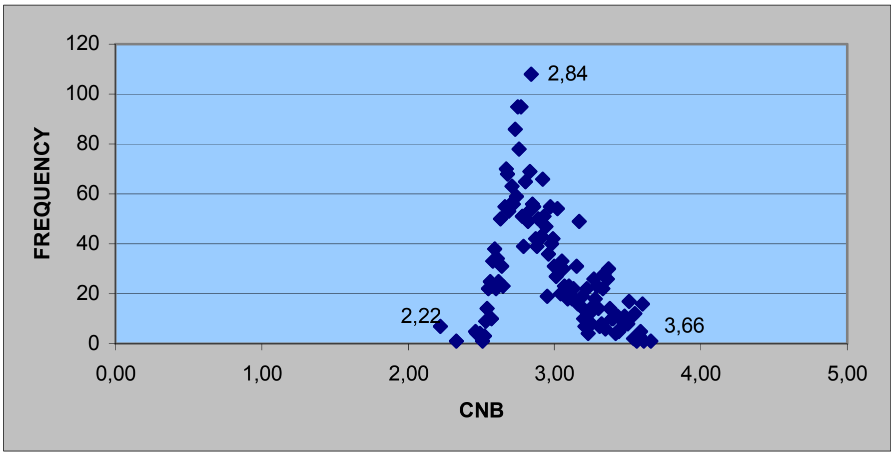


Figure 13. Frequency distribution of the CNB where agricultural areas have evolved to forest or semi natural land

To finish, the results seem to go against the proposed hypothesis. In one hand, it has been tested that a change from a disturbed environment to a natural habitat, as it is the case of agricultural area to forest land, does not mean an increase on the community specialization. As it is shown by the result of specialization impoverishment when land abandonment occurs. In fact, both classes (the managed and the unmanaged) equally reach the lowest values at the beginning of the period, in 1990. What it is clear is that changes on land use promote a decrease of specialization. This can be due to the capability of communities to cope with a low degree of disturbance, based on the resilience of ecosystems. It is also possible that agricultural land is more patchy distributed, and so, more affected by the edge effect. With a higher diversity of environments, it gets also higher specialization communities. And the last thing is that both agricultural and forest areas shelter the highest values of specialization, so special care has to be considered when practising changes on them.

4 CONCLUSIONS

First of all, we succeed with the building of a consistent indicator for the specialization of communities. Our community niche breadth has been validated with other accepted indices as the CSI proposed by Julliard (2006). It has also been checked with the species richness for the whole area of Spain.

The niche breadth indicator can be used to monitor large scale changes on the territory, giving response to the need of an index applicable to a large scale (Clavero and Brotons, 2009). It has been checked a good amount of data free accessible on the internet.

And, finally, although the proposed hypothesis could not be accepted it has been proved the utility of the community niche breadth, which can be used to assess trends of community responses to land use changes.

5 FURTHER RESEARCH

It would be interesting to calculate the niche breadth index based on the CORINE land cover classes. Considering that CORINE is already characterised in 5 main classes (artificial surfaces, agricultural land, forest and semi natural areas, wetlands and water bodies), it would not be difficult to calculate again the index, and then compare the results.

There is also another interesting approach, already done by Clavero and Brotons (waiting for publishing, 2009) who accounted functional homogenization of bird communities with the multidimensionality of niche. It would be possible to consider different landscape variables as the mentioned land use, but also the slope of the territory, the temperatures (maximum, mean, minimum), rainfall. All these variables could be applied through the Digital Climatic Atlas of the Iberian Peninsula (Ninyerola *et al*., 2005). Another variable could be the degree of land protection, a possible data source could be Natura 2000 designated areas and Natural parks, the compilation on the Habitats Atlas, all them available in the Spanish Ministry of the Environment and Rural and Marine Affairs webpage. Human influence should be also assessed through population density areas or considering main roads and other infrastructures. I would also like to compare the results from the present study with the community niche breadth calculated on a smaller extent, with regional atlases which also give presence / absence data but in a more precise sampling area (maybe a 1 km square grid).

The land use changes were analyzed on the first level of land use classification, but for sure there are interesting different responses to change between the different sub-classes of agricultural land (arable land, permanent crops, pastures and heterogeneous agricultural areas).

Finally, I would like to publish the results of this study on the internet as a payback for having used so many different data sources in that open condition, and to keep feeding the amount of available data freely accessible which helps to further develop our general knowledge.

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ANNEX I – REFERENCE GRID FOR BIRDS DATA

ANNEX II – EXAMPLE OF A DISTRIBUTION MAP.

THE COMMON BLACKBIRD *TURDUS MERULA*

ANNEX III – VEGETATION SERIES CONVERSION TABLE

ANNEX IV – DEFINED HABITATS FOR THE STUDY AREA

ANNEX V – SPECIES RICHNESS FOR GRID OF THE STUDY AREA

ANNEX VI – COMMUNITY NICHE BREADTH (TOTAL)

ANNEX VII – COMMUNITY NICHE BREADTH (AVERAGE)

ANNEX VIII – SPECIES SPECIALIZATION INDEX (SSI)

ANNEX IX – COMMUNITY SPECIALIZATION INDEX (CSI)