Effects of woodland islets introduced in a Mediterranean agricultural landscape on local bird communities

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This study assesses whether the afforestation approach consisting in the introduction of woodland islets in 'agricultural seas' can reconcile the restoration of woody vegetation and the persistence of open-habitat bird populations, providing further opportunities for other forest species to enrich bird diversity at the landscape level. We compared the species richness and abundance of bird communities in a field with 16 introduced woodland islets and in a nearby abandoned field located in central Spain during spring and winter time. The woodland islets presented higher accumulated species richness as well as a higher probability of finding new species if sampling effort were increased only in winter time. These trends were the opposite during spring time. Mean species richness and mean bird abundance were lower at the woodland islets than at the abandoned field in both seasons. We found a higher abundance of open-habitat specialist species in the abandoned field. Woodland islets favoured the wintering of chiffchaff *Phylloscopus collybita*. We did not find any effects on the only forest specialist species (blue tit *Parus caeruleus*) in spring. Bird richness and abundance were higher in edge islets than in inner islets. The introduction of larger and mixed plantations connected by hedgerows and a management that favoured the development of big trees, a lower tree density and a diverse shrub layer could promote bird diversity, allowing forest specialists and open-habitat species to coexist at the landscape scale.

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Agriculture is controversial in the debate about conservation and exploitation of ecosystems (Green et al. 2005, Matson and Vitousek 2006). Widespread deforestation to provide agricultural land has resulted in major environmental problems, and croplands and pastures have become the largest terrestrial biome, accounting for ca 40% of the planet's land surface (Foley et al. 2005). Farming practices in many areas have become intensified, and many traditional agricultural landscapes have been lost or severely degraded as a result. Agricultural intensification and deforestation to create farmland can occur alongside extensive farmland abandonment which, in turn, can lead to succession back to the forest (Tellería et al. 1988, Díaz and Tellería 1994, Rey Benayas 2005).

Some agricultural and agro-forestry systems are recognized for their conservation merit, including bird diversity and habitat values (Bignal and McCracken 1996, Kleijn et al. 2006, Gómez Sal and Gonzalez Garcia 2007). Indeed, agriculture has a long history in the Mediterranean basin and it has enabled the evolution of diverse, highly and uniquely adapted bird communities (Potts and Aebischer 1991, Blondel and Aronson 1999). Traditional extensive systems, which have often integrated agriculture, stockbreeding and forestry, are especially valuable. Such

multifunctional systems are common in southern Europe and many bird species depend on them (Tucker and Heath 1994, Hagemeijer and Blair 1997, Suárez 2004, Suárez et al. 2004). However, their conservation is threatened by the rapid transformation and degradation of their habitats, i.e. farmland abandonment or intensification (Donald et al. 2001, Gregory et al. 2005, Kleijn et al. 2006).

Previous studies have consistently found negative consequences of agricultural intensification on bird diversity and population abundance (Chamberlain et al. 2000, Stoate et al. 2000, 2001, Söderström et al. 2003, Suárez 2004, Laiolo 2005). The effects of farmland abandonment on bird community structure are less consistent (Rey Benayas et al. 2007). While in the Mediterranean region land abandonment is a main cause of avian diversity decline, in northern Europe species diversity often increases with successional age (Suárez-Seoane et al. 2002). Old fields are open spaces subjected to secondary succession, being more or less rapidly colonized by natural vegetation. If abandonment occurs simultaneously on large tracts of land, it results in the homogenization of vegetation and in a reduction in landscape heterogeneity (Höchtl et al. 2005, Lasanta-Martineza et al. 2005, Rey Benayas et al. 2007). Some studies have found detrimental effects of land abandonment on bird diversity (Moreira and Russo 2007, Sirami et al. 2007) and on species populations that are characteristic of open spaces (Yosikawa et al. 1998, Firbank et al. 2003, Russo 2004, Viedma et al. 2006). Thus, Suárez-Seoane et al. (2002) found in the bird community of agricultural land in northern Spain that the trend in avian diversity with successional stage differed little between Mediterranean and Eurosiberian species in winter time. However, there was an increase in diversity with stage in abandonment for Eurosiberian birds, but not for Mediterranean species during the breeding season.

One of the alternatives proposed for abandoned farmland is the recovery of forest ecosystems by planting woody species, especially where the lack of propagules, their dispersers or environmental constraints reduce the potential for natural regeneration. This is the case of large expanses of croplands, olive groves and vineyards in central Spain, where plantations subsidized by the Common Agricultural Policy are increasingly frequent since 1993. With regards to bird conservation, the aim of these programs could be to promote forest species diversity in areas where open-habitat species have declined. However, this is not always easy. Firstly, the different structure of plantations compared to that of natural forests condition their functionality for forest species. In addition, increase in area availability of a given type of habitat only triggers colonization by specialist species when the connectivity at the landscape and biogeographic scales is enough to allow the dispersal of individuals. If plantations cannot attract forest species and exclude open-habitat species, we may conclude that their spread will lead to a decline of overall bird diversity. Thus, it is necessary to find a proper design and management

of plantations that optimises their value for forest species, while making them compatible with the maintenance of open-habitat bird populations.

Rey Benayas et al. (2008) proposed a new afforestation model called 'Woodland Islets in Agricultural Seas' (the Woodland Islets Model from here on). This model involves small-scale active restoration of woody vegetation as a driver of secondary succession in broader areas if they are abandoned. If abandonment does not occur, the introduced woodland islets are compatible with the persistence of agricultural uses. The model consists of planting small woodlots (some tens or hundreds of m²) of dense woody vegetation scattered (separated tens or hundreds of meters) on agricultural land. Another advantage that has been pointed out for this model is the provision of forest habitat that can act at the landscape scale increasing woodland connectivity and having an important role in meta-population sustaining of certain animal species.

The Woodland Islets Model is a recent proposal whose potential long term benefits are largely untested, especially for vertebrates with large home ranges. The importance of these islets as forest habitat for birds is one of the aspects which still require in-depth assessment, and it is the aim of this study. We wonder whether this model could reconcile the restoration of woody vegetation and the persistence of open-habitat bird populations, providing further opportunities for other forest species to enrich regional diversity. We focused on two main objectives: 1) to analyse the influence of woodland islets on local bird communities as compared with non-afforested abandoned cropland, and 2) to study the structural characteristics and landscape design that condition the utilization of the islets by birds.

Material and methods

Study area

We surveyed the bird community at two sites in an agricultural landscape of flat relief located in central Spain. One site is La Higueruela Experimental Farm (ED_1950_UTM_Zone_30N; x: 377839; y: 4435048), where we took advantage of an exemplary experimental Woodland Islets Model that was implemented 15 years ago (Rey Benayas et al. 2008). The other site was a 20-km away abandoned field in Santa Cruz de Retamar (ED_1950_UTM_Zone_30N; x: 391724; y: 4440393). Both sites are ca 1 ha in size. Our sampling design lacked independent spatial replicates because the woodland islet site is a genuine experiment and a similar scenario does not exist in the region (Data analysis, below). The surveyed sites are small in size but representative of the woodland islets model – intended for the introduction of small patches of native vegetation in vast deforested landscapes – and of many abandoned croplands in the region.

This region represents the situation of many Mediterranean less-productive agro-systems. Originally, the landscape was mostly covered with large holm oak forests. This vegetation was cleared to obtain land for agriculture and livestock grazing, and only a few remnants of the original vegetation remain at present time. The environmental and social conditions permitted the coexistence of traditional agriculture, low-intensity sheep farming and conservation of valuable populations of birds for a long time. Nevertheless, current trends are intensifying agricultural productions in suitable farmland while low productivity farmland is abandoned.

The Woodland Islets Model stems from an introduction of holm oak seedlings into 16 100-m² plots, 10–20 m apart from each other, on former cropland in 1993 (Rey Benayas 1998). Woodland islets showed a marked heterogeneity in their vegetation structure due to differential establishment treatments. The land surrounding the woodland islets consist of an agricultural mosaic with some olive groves and cereal croplands. There is an additional patch of planted holm oak trees ca 30 m away from the closest woodland islet (Fig. 1). In the abandoned field, agriculture production was interrupted seven years before our bird survey.

Bird sampling

To sample bird communities, we used point counts set at the centre of both fields, each count lasting for 15 min. We defined a circular plot of 50-m radius (Bibby et al. 2000) for each point count, and noted the presence and abundance of every bird species detected visually or auditorily, except if target individuals were clearly over-flying the plot. This method does not provide absolute densities but rather relative abundances.

Counts were conducted in 2006/2007 during six days in winter (15 Dec–15 Feb) and five (at Santa Cruz) or nine (at La Higueruela) days in spring (1 May–15 Jun). They started at sunrise and ended at sunset. Recording always started five min after the arrival of the observer to discard possible disturbances. Poor weather conditions (rain, strong wind or fog) and central hours of day were avoided to reduce detectability problems. We repeated the counts several days to obtain representative data of bird communities using these habitats, as there are not spatial replications for each type of field.

To study the different utilization of the planted woodland islets by birds, we conducted 15-min observation surveys at each islet. We recorded all birds perching or forag-
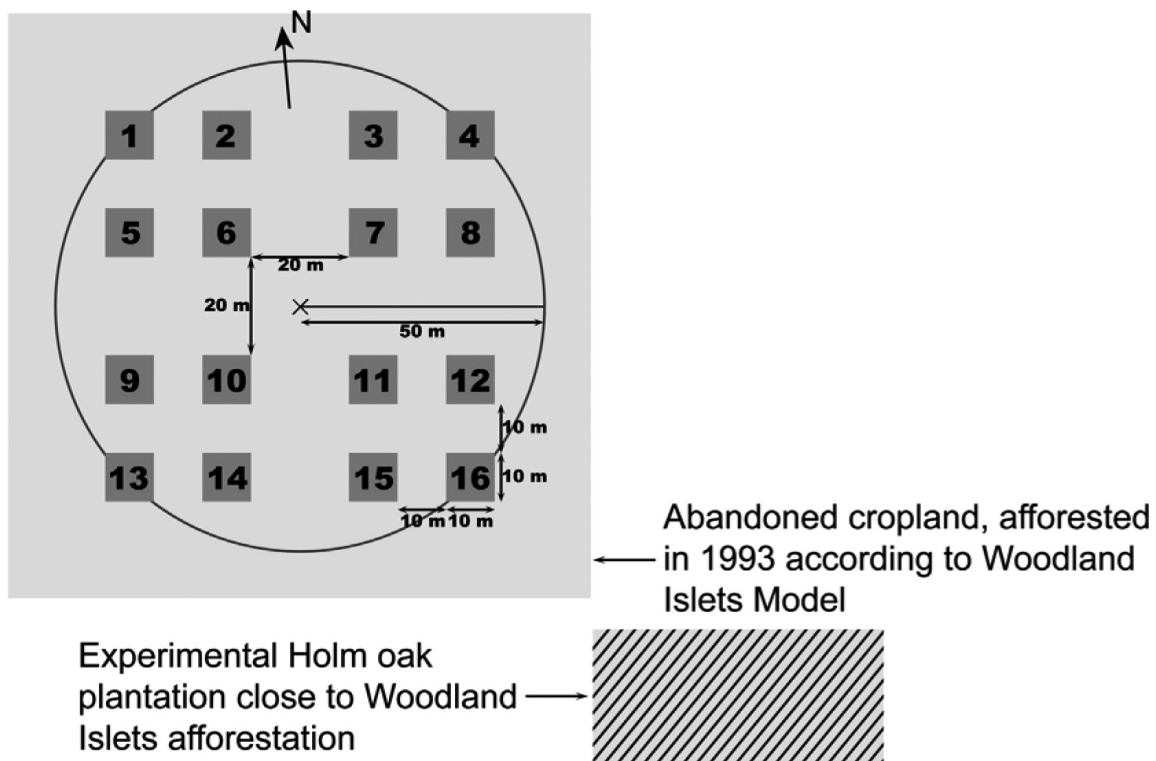

Figure 1. Distribution of woodland islets in the plantation at La Higueruela Experimental Farm (edge islets: 1–4, 5, 8, 9, 12–16; inner islets: 6–7, 10–11; islets close to the nearby Holm oak patch: 11–12, 15–16; distant islets: 1–10, 13–14; islets with artificial perches: 1–2, 5–6, 9–16; islets without artificial perches: 3–4).

ing at them. In order to maximize detection, the observer moved slowly around the plot during the observation period. All bird counts were done by the same experienced researcher.

Vegetation structure and spatial arrangement of woodland islets

Vegetation structure of each woodland islet was measured according to the following variables: canopy cover at 1 m height intervals estimated as 5% ranges. The estimation was repeated on three different days and averaged the values; mean and maximum height of trees in each islet; mean volume of trees in each islet (volume was calculated as tree height by the area of the ellipse whose axes are the maximum and minimum diameters of the tree crown; Table 1). Woodland islets were also classified according to their position within the experimental plantation (edge or inner islets).

Data analysis

To test the influence of woodland islets on bird communities with respect to farmland abandonment, we compared patterns of accumulated species richness as well as mean species richness, mean total abundance and mean species abundance per sampling unit at each site (sampling unit is the 15-min count in a 0.785 ha plot) in the two different seasons.

To build the species accumulation curves, we used Microsoft Excel to randomise the order of sampling units. This process was repeated 100 times. The Morgan–Mercer–Flodin model was the best fitting model to the cumulative curves of number of species – number of sampling periods ($y = \dfrac{\left(a \cdot b + c \cdot x^d\right)}{b + x^d}$; Morgan et al. 1975). We used Curve expert 1.3 software (<www.ebicom.net/~dhyams/cftp.htm>) for fitting of the model. Species accumulation patterns for each site and season were compared using 95% confidence intervals of the accumulation curve. We also compared the stabilization degree of the cumulative curves (i.e. probability of finding new species

with higher sampling effort) by calculating the first derivative of the function (i.e. the slope) at points of equivalent sampling effort.

Differences in mean species richness, mean total abundance and mean species abundance per sampling unit between sites and seasons were statistically tested by means of Monte-Carlo simulation procedures (bootstrapping with replacement, Davison and Hinkley 2006) as we did not have true spatial replications of each site. Two thousand randomisations were made in Monte Carlo analyses, testing for an observed difference against random differences (null hypothesis). We used the percentile approach to obtain the confidence intervals for the null differences in the Monte Carlo analyses (2.5% and 97.5% percentiles of the 2000 estimations to give the 95% confidence interval, 0.5% and 99.5% percentiles for 99% confidence interval). An observed difference was considered significant when it was outside the estimated confidence intervals (e.g. significant at $p < 0.05$ if it was larger than the upper 97.5% score, or it was below the lower 2.5% figure). When the number of sampling units for between-site or season comparisons was different, we first ran a balance procedure that made data comparable.

Woodland islets use by birds was compared according to the spatial position of the islets within the experimental plantation (edge/inner) and to vegetation structure. Utilization of islets was characterized by means of species richness, total abundance and mean species abundance per sampling unit (15 min, 100 m²). We also correlated vegetation structural variables with bird species richness, total bird abundance and species abundance. We again used Monte-Carlo simulation procedures (1000 randomisations) to test statistical significance of differences between means and correlation coefficients.

Results

Influence of woodland islets on local bird communities

The woodland islet site contained 13 species in the winter sampling period, whereas the abandoned field contained only ten species. In spring, the total number of species was the same for both locations (seven species), although the

Table 1. Habitat structure of the woodland islets (Cov = Canopy cover).

	Cov 0–1 (m, %)	Cov 1–2 (m, %)	Cov 2–3 (m, %)	Cov 3–4 (m, %)	Mean tree volume (cm²)	Mean height (cm)	Maximum height (cm)
Mean	61.41	68.75	26.78	15.63	155.63	177.66	84.56
SD	17.56	16.38	15.40	9.65	66.11	27.50	43.60
Range	20–85	30–90	5–50	0–35	50.07–342.52	138.58–253.95	228–404

Table 2. Morgan–Mercer–Flodin model fitting coefficients for the species accumulation curves.

Species accumulation curves MMF Model: $y = \dfrac{(a \cdot b + c \cdot x^d)}{b + x^d}$.		
	Winter	Spring
Woodland Islets Model (La Higueruela)	a = 0.4321 b = 17.5302 c = 36.0045 d = 0.9101	a = –0.7680 b = 10.9800 c = 18.4667 d = 0.6865
Abandoned field (Santa Cruz)	a = –0.7364 b = 5.7356 c = 22.8626 d = 0.6289	a = 0.0271 b = 12.1486 c = 30.0042 d = 0.5899

sampling effort was higher in the afforested field than in the abandoned field (18 vs 9 sampling units). Taking into account both seasons together, 18 species were observed in the afforested field and 11 species were observed in the abandoned field. Bird species richness was compared by means of the Morgan–Mercer–Flodin model coefficients (Table 2) of the species accumulation curves for each site and season (Fig. 2). All differences between every pair of curves were significant at a 95% confidence level for any number of sampling units for the spring curves. The winter curves of both sites differed significantly only if four or more sampling units were considered. Between seasons, the cumulative species richness was higher in winter than in spring at both sites. Between sites, the woodland islet site had higher species richness for an equivalent number of sampling units than the abandoned field in winter (Fig. 2). In addition, the slope of the curve at the woodland islet site was twice as large as the slope of the curve at the

abandoned field (0.617 and 0.307, respectively, for 12 sampling units at both sites), meaning a higher probability of finding new species at the afforested site. The converse pattern was observed during the breeding season, as more species were found in the abandoned field than in the afforested field for an equivalent number of sampling units. Species richness curves at both sites showed a similar slope (0.303 for the afforested site and 0.349 for the abandoned field when nine sampling units were considered).

Mean species richness per sampling unit was significantly higher for wintering birds than for breeding birds at both sites (Monte Carlo analysis testing for an observed difference against random differences –null hypothesis: p < 0.01). The woodland islet site had a lower mean species richness in both seasons, but the differences were statistically significant only in spring (Fig. 3a). Seasonal patterns of mean total abundance (Fig. 3b) were similar to those of mean species richness.

Red-legged partridge *Alectoris rufa* and thekla lark *Galerida theklae*, both in winter and spring, and skylark *Alauda arvensis* in winter, were more abundant in the abandoned field (Table 3). However, the woodland islets favored chiffchaff *Phylloscopus collybita* in winter (Table 3). Blue tit *Parus caeruleus*, the only true forest specialist detected in this study, was not favoured by woodland islets in spring (Table 3). Some ubiquitous species such as the magpie *Pica pica* actively used the habitat created by the woodland islets. We also observed magpie nests and a continuous presence of Spanish sparrows *Passer hispaniolensis* during the spring sampling period.
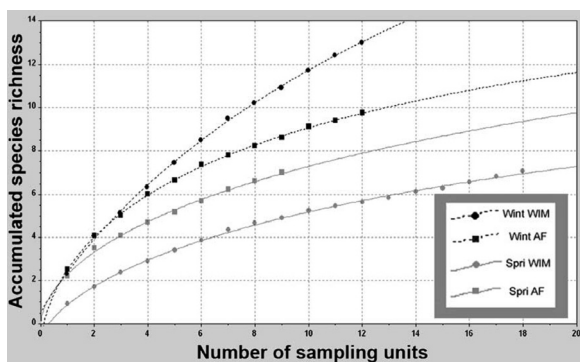

Figure 2. Species accumulation curves for each locality and season. Curves show the average number of species that is expected to be found as a function of the number of sampling units. (Wint = winter, Spri = spring, WIM = Woodland Islets Model, AF = abandoned field).

Habitat use of woodland islets by birds

There were not significant correlations between species richness or abundance and woody vegetation cover, height or volume (correlation coefficients ranged between
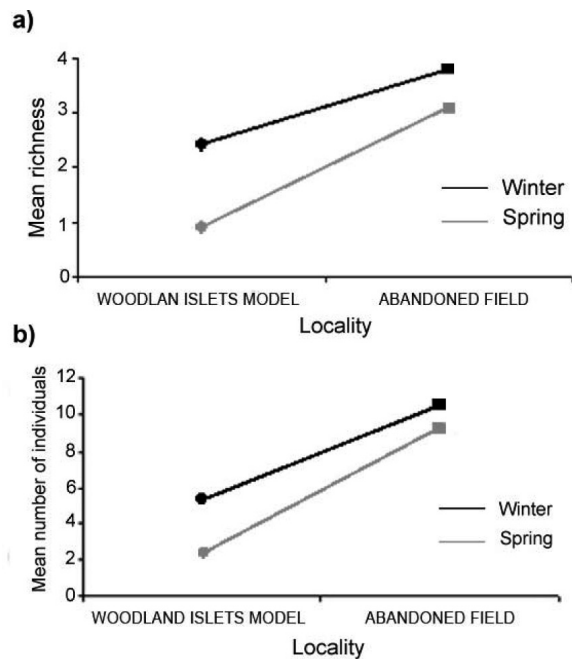
Figure 3. a) mean bird richness per sampling unit in each locality and season. b) mean bird abundance per sampling unit in each locality and season. Differences between seasons for each separated locality were significant for a 99% confidence level, except for mean abundance at the woodland islets site, which was only significant for a 95% confidence level. Differences between sites during winter were not significant; in spring, both mean richness and mean abundance were different for a 99% confidence level. Interaction between factors (site and season) was not significant in any case. Significance of these differences were obtained by means of Monte Carlo analyses building null-hypotheses (random differences between means being compared).

0.03 and 0.39 in winter and between –0.05 and –0.47 in spring).

Edge woodland islets were more actively utilized than the inner islets by a higher number of species (1.25 vs 0.25 species per sampling unit; Monte Carlo analysis testing for an observed difference against random differences – null hypothesis: $p < 0.05$) and individuals (0.43 vs 0.04 individuals per sampling unit; Monte Carlo analysis: $p < 0.05$) and by the chiffchaff in particular (0.25 vs 0.00 individuals per sampling unit; Monte Carlo analysis: $p < 0.05$) during winter, but these trends were not maintained in spring.

Discussion

Bird communities of high ecological value that depend on extensive farming systems can be adversely affected by the progressive abandonment of low production farmland and the subsidies to plant woody species in former farmland in the European Union (EEC Regulation 2080/92,

1257/99 EC and EC 1783/2003). Thus, it is necessary to make proposals aimed at reconciling forestation policies and the conservation of open-habitat bird populations. We assessed one such proposal for a case study, the 'Woodland Islets in Agricultural Seas' (Rey Benayas et al. 2008). The results indicate that the introduced woodland islets excluded open-habitat species at the local scale and that breeding of forest species was not favoured, but they tend to promote some forest species' wintering. We propose a set of measures to improve the design of the Woodland Islets Model. Our results should be interpreted cautiously for two reasons. First, the lack of spatial replicates for the surveyed scenarios, yet our statistical inference is correct with the data at hand. And secondly, the small size of surveyed sites for the sampled organisms, yet this size is representative of the novel woodland islets model as well as of many abandoned croplands.

Seasonal differences in local bird communities

In our study, the accumulated species richness for equivalent sampling efforts was higher during winter in the Woodland Islet site than in the abandoned field, but the result is the opposite in spring, both for the cumulative and mean species richness. Bird behaviour in different seasons and migration–dispersion can explain this pattern.

Our observation is also in agreement with the characteristics of the local forest birds that are likely to use the woodland islets and of the Iberian forest birds in general. Palaearctic forest bird species seem to have their optimum in deciduous forests of central Europe, from where they diminish their abundance and diversity (Carrascal and Díaz 2003, de la Montaña et al. 2006). In the forests of south-western Europe, there is hence an apparent deterioration in the optimum conditions for these birds, which tend to diminish or to take refuge in mountainous areas as we move southwards in the Iberian Peninsula (Tellería and Santos 1993, 1994). During winter time, many birds from Iberian forests, as well as from central and northern Europe, move towards the warmer and more productive regions of the Iberian Peninsula. Many Mediterranean trees and shrubs with a winter fruiting phenology become prominent feeding resources for this mass of overwintering birds. Tellería and Santos (1997) found that small forests in the lowest lands of central and southern Iberian Peninsula, generally dominated by an agricultural matrix, are very highly occupied by wintering European individuals of species such as chiffchaff or robin *Erithacus rubecula*. We can attribute the higher accumulated species richness found in our study in winter to the abundant transients that were chiefly surveyed in the afforested site because woodland islets attract some ubiquitous and forest generalist species (in our case mainly the chiffchaff *Phylloscopus collybita*, Santos 2004). This interpretation is consistent with the higher species richness in edge woodland islets, as

Table 3. Mean abundance of every recorded bird species per sampling unit at the Woodland islet site (WIM) and at the abandoned field (AF) in winter and in spring. Black asterisks represent the species with significant higher abundance in the afforested field. Grey asterisks represent the species with significant higher abundances in the abandoned field (*p < 0.05, **p < 0.001). The table also shows the preferred habitat for each species. (a) open-habitat species, (b) ubiquitous species, (c) forest generalist species, (d) forest specialist species.

	Winter			Spring		
	mean HG	mean SC	HG–SC	mean HG	mean SC	HG–SC
Alectoris rufa (b)		2.083	–2.083 **		2.778	–2.778 **
Columba palumbus (b)					0.111	–0.111
Upupa epops (b)	0.083		0.083			
Alauda arvensis (a)	0.083	1.833	–1.750 **		0.333	–0.333
Galerida cristata (a)	0.167	0.083	0.083			
Galerida theklae (a)		0.583	–0.583 *		2.333	–2.333 **
Lullula arborea (c)		0.333	–0.333			
Melanocorypha calandra (a)	0.083	0.083			0.111	–0.111
Anthus pratensis (a)		0.250	–0.250			
Anthus campestris (a)					0.111	–0.111
Motacilla alba (b)	0.167	0.167				
Saxicola torquata (b)				0.056		0.056
Phylloscopus collybita (d)	2.000		2.000 **			
Parus major (d)	0.167		0.167			
Parus caeruleus (d)				0.389		0.389
Lanius meridionalis (b)	0.083		0.083			
Pica pica (b)	0.333		0.333	0.994		0.994
Sturnus unicolor (b)				0.167		0.167
Passer hispaniolensis (b)				0.444		0.444
Fringilla coelebs (c)	0.167	0.583	–0.417			
Carduelis cannabina (b)	0.083		0.083		0.111	–0.111
Carduelis carduelis (b)	1.667		1.667			
Serinus serinus (c)				0.056		0.056
Emberiza calandra (b)	0.250	0.167	0.083			

they constitute the first meeting point for transient individuals reaching the plantation. Thus, woodland islets can also play an important role in the connectivity of forest habitat in these systems and their spatial arrangement can be designed to facilitate this connectivity.

The lower mean species richness and abundance per sampling unit at the woodland islets site as compared with the abandoned field in spring indicates that the introduced woodland islets are of poor habitat quality for potential breeding bird species, probably due to the very small size of the woodland islet; specialist forest species did not use them as breeding habitat (Santos 2004). One of the most constantly observed patterns in the structure of forest bird assemblages is the positive relationship between the physiognomical diversity of vegetation and the number of species that find adequate resources for their life activity (Wiens 1989). Our woodland islets are small and young. If habitat patches are very small, there is not a significant structural heterogeneity for birds. Several forest bird species are troglodyte and hollow abundance may become a limiting factor in too small or too young patches (Tellería 1992, Camprodon et al. 2008). Nests on the ground or on tree branches are more accessible to predators, and nest predation risk increases with higher edge effect (Santos and Tellería 1991, 1992, Tellería and Santos 1992).

Implications of the Woodland Islets Model for the conservation of forest and steppe-land birds

The importance of small patches of natural habitat has been repeatedly emphasized in the literature as a way to maintain biodiversity in humanized landscapes (Duelli and Obrist 2003, Bennett et al. 2004). Many forest species can obtain resources from forest fragments if appropriate design and management measures are implemented in plantations (Lindenmayer and Hobbs 2004). Our results indicate that the woodland islets did not favour open-habitat species. One forest specialist was clearly favoured by the woodland islets, but only in winter time (the chiffchaff). We propose that the following features should be considered to increase the utilization of woodland islets in agricultural landscapes by forest bird species.

1) Size of woodland islets. Several studies have recommended that forest plantations should be as large as possible (Diaz et al. 1998, Brotons and Herrando 2001, Santos et al. 2002, Bennett et al. 2004, Santos et al. 2006). However, the Woodland Islets Model implies a tradeoff between the area devoted to tree planting and the remaining area left to agricultural use. In addition, agriculture in Spain is characterized by a small-holder ownership structure, which is against the existence of large plantations. Islets size would be particularly important when conifers are used in plantations (Díaz et al. 1998, Santos et al. 2006).

2) Spatial arrangement of the woodland islets. A spatial design that provides high habitat connectivity for birds is desirable. This turns out being especially important if woodland islets cannot be large. Contrary to what happens in the central European forests, connectivity in Mediterranean forests is a secondary factor for plantation design aimed at achieving a high diversity of birds. This result can be attributed to the relative scarcity of forest specialist species in the Mediterranean area (Blondel and Aronson 1999, Santos et al. 2002, Carrascal and Díaz 2003, Ramírez and Tellería 2003).

3) Structure and composition of vegetation. Structural heterogeneity of the islets may not be relevant for birds due to the young age of the plantation, the absence of different age classes, the small islet size and the lack of a proper management. This is backed up by our results, since we found no significant relationships between any of the structural measures of vegetation and values of richness and abundance of birds. Promoting structural heterogeneity along with an appropriate islet size may allow the coexistence of a higher number of bird species with different requirements (Wiens 1989, Tellería 1992, Benton et al. 2003). The assessed woodland islets in their initial stage of growth involves a complete absence of tall and old trees with hollows (Vesk et al. 2008), therefore excluding all forest species that require these features for nesting or feeding (Santos 2004). An adequate management that favoured the development of big trees with lower plantation density and a shrub layer should also be promoted (Camprodon and Brotons 2006). It would be also desirable to use mixed plantations, as some Mediterranean bird species are specialist in the exploitation of certain tree species such as pines and junipers (e.g. the coal tit *Parus ater* or the crested tit *Parus cristatus*) or oaks (e.g. the long-tailed bushtit *Aegithalos caudatus*, the blue tit *Parus caeruleus*).

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