Distribution and habitat preferences of Eurasian woodcock Scolopax rusticola in S. Miguel island (Azores) during the breeding season

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SHORT COMMUNICATION

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Distribution and habitat preferences of Eurasian woodcock *Scolopax rusticola* in S. Miguel island (Azores) during the breeding season

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The Eurasian woodcock *Scolopax rusticola* is a sedentary bird in the Azores archipelago, where it is an important game species. In S. Miguel island, hunting has been forbidden for at least two decades, but this measure seems to have failed in its purpose of increasing population size. Our work aims to determine woodcock distribution and relative abundance during the breeding season in S. Miguel, identify the proximate habitat factors related to the species occurrence and evaluate the role of reminiscent natural Azorean forest for the conservation of its populations. We conducted censuses at 71 observation points, systematically distributed along the island using UTM 1 $\times$ 1 km grid cells. During the breeding season, male woodcock performs display (roding) flights. Census consisted in recording the number of contacts with roding birds, during the evening roding period. The species was detected in only 30% of the points and its relative abundance was generally low. The species was mainly distributed in the most mountainous regions of the Eastern part of the island. Several habitat variables were measured at each observation point and their relationship with species occurrence was determined with logistic regression. The presence of roding birds was negatively correlated with the distance to natural vegetation and positively correlated with arboreal vegetation surface. The model had a high prediction success (88.9% for presences, 83.3% for absences and 85% overall, for a 0.3 cut-off point) and explained the distribution of the species well. The observed restricted distribution and overall low abundance supports the maintenance of the hunting interdiction. The preference for natural vegetation during the breeding season is an important aspect. Reforestation with endemic species, control of invasive species and the maintenance of forest edges and small patches of vegetation between pastures would contribute to woodcock conservation in the island.

Key words: Azores, breeding, distribution, habitat selection, Scolopax rusticola

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Bird populations can be affected severely by human activities that cause changes in their natural habitats, and agricultural and forestry practices are amongst the most important (Newmark 1991, Edenius & Elmberg 1996, Pain & Pienkowski 1997, Aebischer et al. 2000, Newton 2004). In island ecosystems, the isolation of populations further contributes to an increased vulnerability. For instance, severe population decline was reported for the Azores Bullfinch *Pyrrhula murina*, in the archipelago of Azores (Ramos 1996a,b), primarily due to the invasion of aggressive exotic flora.

A similar phenomenon may occur with the Eurasian woodcock *Scolopax rusticola* in the Azorean archipelago. Although this migratory wader is widely distributed in the Palearctic Region, from Western Europe to Japan (Piersma et al. 1996, Ferrand & Gossmann 2001), there are sedentary populations in the Macaronesian archipelagos of Azores (Portugal), Madeira (Portugal) and Canaries (Spain) (Ferrand & Gossmann 2001). Preliminary results from genetic studies pointed out a restriction in the gene-flow between these islands and the continent, between the archipelagos and even among islands of the same archipelago (P. Cardia, unpubl. data).

The Eurasian woodcock selects habitats with particular characteristics during the breeding season. In continental Europe, it prefers mosaic habitats, e.g. extensive woodland, whether broad-leaved, mixed or coniferous (Cramp & Simmons 1983, Hirons 1987, 1988, Hirons & Johnson 1987, Ferrand 1989). In winter, habitat requirements are less specific and woodcocks mainly use woodlands and hedges during the day and fields and meadows at night (Cramp & Simmons 1983, Hirons & Bickford-Smith 1983, Wilson 1983, Gossmann et al. 1988, Duriez et al. 2005a,b). However, habitat preferences in the Macaronesian archipelagos are unknown.

The size of the woodcock populations and their trends are little known in Europe, where this species is hunted in most countries (Ferrand & Gossmann 2001). Its conservation status in Europe was established as 'vulnerable in winter' (Hoodless 1994) but it was recently revised as 'stable' (Wetlands International 2002). Although woodcock is one of the most important game species in the Azorean archipelago, no reliable data are available concerning population trends, except for Pico island where the population has seemed stable over the last five years (Machado et al., in press). Consequently, Eurasian woodcock conservation status in Azores is presently considered to be 'data deficient' (Cabral et al. 2005).

In the second half of the 20th century, a decrease in woodcock abundance in all Azorean islands was reported due to high hunting pressure during the breeding season (Bannerman & Bannerman 1966). At that time, woodcocks in S. Miguel island were already rare (Beurier 1973), which imposed legal restrictions on its hunting. Presently, local authorities and hunters in this island agree that woodcock population size has continued to decrease during the last decades. Due to this supposed decrease, hunting has been forbidden for more than two decades, but this measure seems to have failed in recovering the population size.

Being the largest and the most populated island in the Azores, S. Miguel has also suffered important landscape changes during the last century. The natural forest (Laurisilva type) has decreased due to agriculture, cattle production and the introduction of exotic flora such as sweet Pittosporum *Pittosporum undulatum*, ginger lilly *Hedychium gardneranum,* Chilean gunnera *Gunnera tinctoria* and lily of the valley tree *Clethra arborea* (Sjögren 2000, Silva & Smith 2004). These changes may have affected habitat suitability for woodcock, and could be the major factor contributing to the apparent low abundance levels in S. Miguel during the last decades.

Hence, the main objectives of our work were to assess the distribution and relative abundance of woodcock in S. Miguel island during the breeding season, identify the proximate habitat factors related to species occurrence in the island and evaluate the role of reminiscent natural Azorean forest for the management and conservation of woodcock populations.

Material and methods

Study area

The Azorean archipelago, located in the North Atlantic Ocean, comprises nine islands of volcanic origin. Our study was performed in S. Miguel, the largest (760 km^2) and the most populated island, situated between 37°42'-37°55'N and 25°8'-25° 51'W. S. Miguel includes three different geomorphologic regions (Fig. 1): the Western Region, including the volcanic massif of Sete Cidades (max-

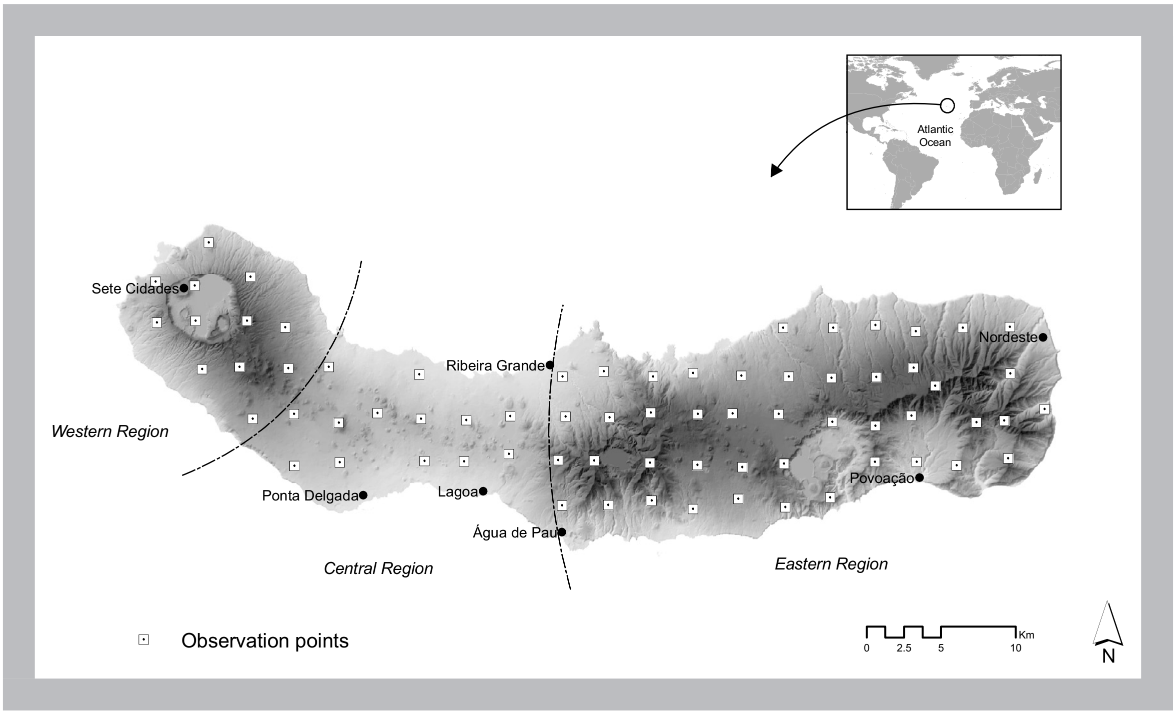

Figure 1. Observation points (N = 71) for roding Eurasian woodcock census in S. Miguel island, Azores.

imum altitude: 874 m a.s.l.); the Central Region, with several small volcanic cones; and the Eastern Region, the most mountainous area which encompasses several volcanic massifs and the highest point of the island, Pico da Vara (1,103 m a.s.l.). The climate is temperate-oceanic rainy to very rainy, with mild temperatures, moderate to high rainfall and high relative humidity. The average rainfall rate is about 1,300 mm/year, the annual mean air temperature is 15 °C and the annual mean relative humidity is 77% (Novo et al. 1999).

The majority of natural Azorean forest is Laurisilva type, dominated by laurel *Laurus* sp., juniper *Juniperus* sp., holly *Ilex* sp., blue berry *Vaccinium* sp. or yew *Taxus* sp. which are considered a Tertiary relict (Dias 1996, Sjögren 2000). However, since the arrival of the first settlers in 1439, vegetation has suffered profound and irreversible changes (Furtado 1984, Pereira et al. 1998) mostly for agricultural and forestry purposes. Currently, about half of the island surface is covered with pastures for rearing cattle and the other half is forest. Nevertheless, about 80% of the forest is composed of Japanese cedar *Cryptomeria japonica* plantations, characterised by a very high density of plants and a species-poor understorey. Additionally, the introduction of exotic and invasive plant species like Pittosporum, ginger lilly, Chilean gunnera and lily of the valley tree constitute another threat factor for the natural ecosystem of Azorean islands (Dias 1996, Sjögren 2000, Silva & Smith 2004).

Distribution and relative abundance of woodcocks

During the breeding season, male woodcocks perform display flights at dawn and dusk with the purpose of finding and attract females (Hirons 1980, 1983). Most birds display for about twice as long in the evening as in the morning (Hirons 1983, Ferrand 1993). This specific behaviour is called roding and according to Ferrand (1989, 1993) the number of contacts with roding birds in a certain place can be regarded as a relative abundance index. To determine the distribution and relative abundance of woodcocks, we recorded the number of contacts with roding birds (birds seen and/or heard) at fixed observation points, during the evening roding period (Ferrand 1989, 1993).

Fieldwork was carried out between 1 March and 15 April 2004. Previous studies conducted in Pico island (Machado et al. 2002, 2006, in press) suggested this period to be the most adequate to monitor woodcock populations in Azores by this method as the number of contacts with roding birds was high and stable during this time of year. Sampling units were based on Universal Transverse Mercator (UTM) 1 × 1 km grid cells. The first cell was randomly selected by random number generation and the others established systematically afterwards, resulting in observation points located 2-3 km apart from each other. This method of selection is expected to decrease spatial autocorrelation of observations, a phenomenon known to affect the independence of observations in ecological modelling (Cliff & Ord 1973). A total of 71 observation points, located preferentially in the centre of the cell, were established (see Fig. 1), and each point was visited once. When weather conditions were considered inadequate for bird observation (e.g. heavy rainfall or fog) the census was postponed and the point visited later.

Considering that the census in all the observation points should be carried out between March and mid-April and one observer could only perform one census per evening, six equally trained observers were conducting this part of the fieldwork.

Characterisation of habitats

To characterise the structure of the habitat surrounding each observation point, we measured nine ecogeographical variables (hereafter EGV) (Table 1), including topographical, habitat and human-related factors. Orthophotomaps and topographic maps were used as data source for the automatic measurement of EGVs, using MicroStation mapping software. Variables were quantified within a 500 m radius buffer (78.5 ha) centred in the observation point. This surface was chosen to include the potential area used by males during the evening roding period as studies with radio-tagged woodcocks showed that this area could range from 60 to 100 ha (Hirons 1980, 1983).

Natural vegetation and urban aggregations were expressed as distance and not as surface because most of the observation points did not present values for these variables within the 500 m buffer. The maximum distance considered for the quantification of these EGVs was 3 km.

Statistical analysis

A non-parametric Spearman test was used to test for possible correlations among the different EGVs, and altitude and pastures were removed due to strong correlations ($r_s > 0.6$) with other EGVs. Relations between the occurrence of woodcocks

Table 1. Ecogeographical variables (EGVs) used to characterise the habitat of Eurasian woodcock in S. Miguel island, Azores. Variables were measured within a 500 m radius buffer around the observation point, except for distance to natural vegetation and distance to urban aggregations.

EGV	Description
Altitude*	Altitude (m a.s.l.) of the observation point
Edge	Length (m) of the contact zone between forested and open areas
Water lines	Length (m) of permanent or non-permanent water lines
Cryptomeria japonica	Percentage of surface occupied by *Cryptomeria japonica* plantations
Pittosporum undulatum and/or *Acacia* sp.	Percentage of surface occupied by *Pittosporum undulatum* and/or *Acacia* sp.
Pasture*	Percentage of surface occupied by pastures
Arboreal vegetation	Percentage of surface occupied by arboreal vegetation
Distance to natural vegetation	Average distance (m) to patches of natural vegetation (endemic or autochthonous) > 1 ha
Distance to urban aggregations	Average distance (m) to urban aggregations > 1 ha

*EGVs removed from the analysis due to strong correlations with other factors (see material and methods for details).

and EGVs were estimated by logistic regression, an ecological modelling technique frequently used to predict the occurrence, distribution and habitat preferences of several species (Brito et al. 1999, Franco et al. 2000). This method relates the effects of several independent variables on a dichotomic dependent variable, presence/absence of the species (Hosmer & Lemeshow 1989). The selection of EGVs in the model was carried out by a forward stepwise method using SPSS 12.0 (SPSS Inc. 2003). From the 71 total observation points, 60 were randomly selected by random number generation to build the model and the remaining 11 points were used as a validation sample for the obtained model.

To evaluate the fit of the model, two procedures were used: calculation of the prediction success and the Area Under the Curve (AUC) of a plot Receiver Operating Characteristic (ROC, *sensu* Liu et al. 2005). The presences, absences and overall prediction success were calculated for ten cut-off points, defined from 0.1 to 1.0, with intervals of 0.1. As the model classified the observation points with a continuous probability of occurrence, it was necessary to define a threshold, above which we considered the species to be present. The chosen cut-off point was the one that produced the most equilibrated correct classification rates. In this case, it was preferable to optimise the correct classification of presences because some absences might have resulted from the fact that the observer could not detect the species (Franco et al. 2000).

The ROC curve relates the sensitivity (probability of classifying presences correctly) and specificity (probability of classifying absences correctly) of the model and it is independent of event frequencies and of the decision criterion (Swets 1988, Pearce & Ferrier 2000). In this analysis the AUC can be interpreted as the probability of the model to distinguish correctly between an occupied and a non-occupied place, and it ranges from 0.0 (randomness) to 1.0 (perfect fit) (Liu et al. 2005).

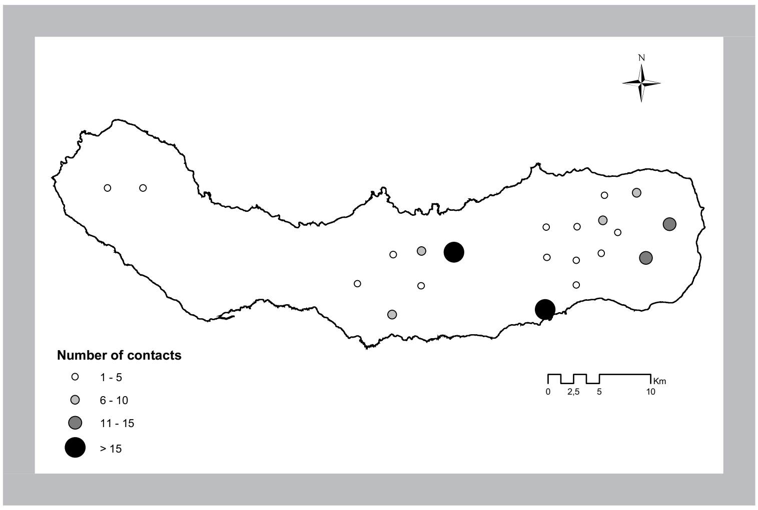

Figure 2. Distribution and variation of relative abundance of Eurasian woodcocks (classes of number of contacts with roding birds) in S. Miguel Island, Azores (≥ 1 contact; 21 observation points).

Results

Distribution and relative abundance of woodcocks

Woodcocks were found in 29.6% of the observation points (21 out of 71), most of them located in the Eastern region of S. Miguel, the most mountainous and forested area of the island (Fig. 2). In the

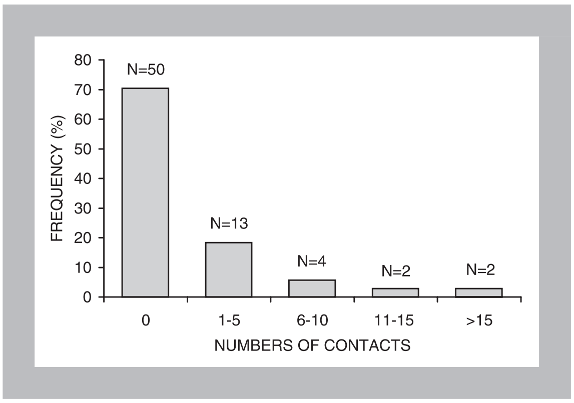

Figure 3. Frequency of Eurasian woodcock relative abundance classes (classes of number of contacts with roding birds) in S. Miguel Island, Azores (71 observation points).

Western region, the woodcock was observed only in two observation points, both with a number of contacts lower than five.

Considering the points where birds were detected, the number of contacts was equal or inferior to five in 62% of cases (N = 13) and only in two points (9.5%) were > 15 contacts recorded (Fig. 3). The median of the number of contacts was 4.0 (range: 1-29).

Factors affecting occurrence of woodcock

The occurrence of woodcocks was negatively correlated with the distance to natural vegetation and positively correlated to the total surface occupied by arboreal vegetation (Table 2).

Table 2. Coefficients (βx), standard error (SE), values of Wald test and significance of the variables included in the logistic regression model explaining the occurrence of Eurasian woodcock in S. Miguel island, Azores.

Variables	Coefficient (βx)	SE	Wald*	P
Distance to natural vegetation	-0.002	0.001	13.067	< 0.001
Arboreal vegetation	0.029	0.015	3.828	0.049
Constant (β_0)	0.836	0.886	0.889	0.346

*Wald = $(\beta x/\ SE)^2$.

The 0.5 cut-off point optimised the overall prediction success (86.7%), correctly classifying 72.2% of the presences and 92.9% of the absences. Nevertheless 0.3 was considered to be the best cut-off point, since it produced more equilibrated classification rates. For this cut-off point, the prediction success was 88.9% for presences, 83.3% for absences and 85% overall. In the validation sample (N = 11), the prediction success reached 100% in the correct classification rate of presences, absences and overall, for both 0.3 and 0.5 cut-off points. From the ROC curve obtained with the 71 observation points, the AUC parameter was estimated at 0.934 ± 0.29 (P < 0.001), i.e. in 93% of the cases, the model could make the distinction between a presence and an absence.

Both observed and predicted distributions were similar, assuming 0.3 as the cut-off point (Fig. 4). The model correctly predicted the regions where the species was present and also the absence of the species in the Central Region.

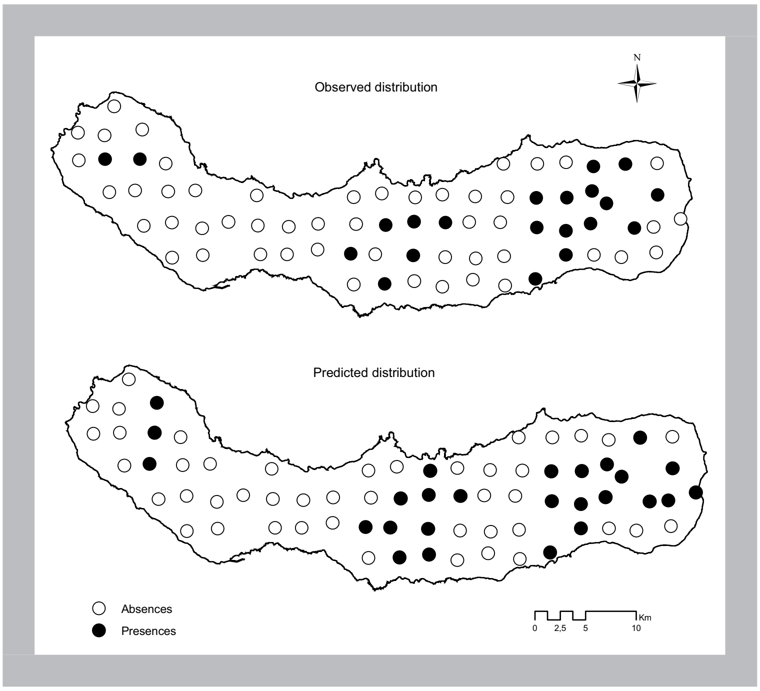

Figure 4. Observed and predicted by logistic regression distribution of Eurasian woodcock in S. Miguel island, Azores.

Discussion

Woodcocks were apparently absent from a considerable area of S. Miguel island. Roding birds were detected only in about 30% of the observation points, whose distribution was almost restricted to the Eastern region of the island, with more mountainous and forested areas. Since male display activity is concentrated in areas where receptive females are most likely to be found and most nests to be located (Hirons 1987, Ferrand 1989), the areas with more contacts in S. Miguel should be considered priority for conservation management plans.

According to the abundance categories delimited by Ferrand (1989) and Mulhauser (2002), the majority of the observation points (57.1%; 12 out of 21) with roding birds in S. Miguel presented very low to low relative abundance ($\leq$ 4 contacts), 33.3% (7 out of 21) presented mean abundance (12 < contacts $\leq$ 20) and only 9.5% (2 out of 21) presented very high abundance ($\geq$ 21 contacts). For Pico island, Machado et al. (2002) obtained values comparatively higher: about 74% of the 19 observation points systematically distributed along the island presented > 10 contacts (43% presented > 21 contacts).

The occurrence of woodcocks was negatively correlated with the distance to natural vegetation and positively with the surface occupied by arboreal vegetation. Since woodcock is essentially a silvicolous species, these results were partially expectable. However, the species seems to prefer the Azorean natural forest to other types of woodland like plantations of Japanese cedar or formations of sweet Pittosporum and/or wattle *Acacia* sp. The highest relative abundances ($\geq$ 21 contacts) were obtained in observation points with natural vegetation within the 500 m buffer. The preference for natural vegetation may be due to its structure, which presents a more developed lower stratum, providing an adequate refuge for nests and broods and probably offering more food, especially earthworms (Granval 1987, 1988, Hirons & Bickford-Smith 1983). Breeding in young and dense woodlands could be an anti-predatory strategy (Hirons 1987, 1988, Hirons & Johnson 1987, Ferrand 1989), however, the role of buzzard *Buteo buteo rothshildi*, long-eared owl *Asio otus* or ferret *Mustela furo* as possible predators in the Azores should be evaluated.

The plantations of Japanese cedar in Azores expanded largely during the second half of the last century, mainly in S. Miguel island (with a surface of 760 km^2): 2400 ha in 1948, 5000 ha in 1963 (Oliveira 1965) and 8500 ha (i.e. 80% of the forestall area) in the 1990s (Goes 1991). For comparison, the area occupied by this exotic tree in Pico island (the second largest island of the archipelago, 433 km^2) was only 260 ha in the 1990s (Goes 1991). The plantations of Japanese cedar are characterised by a high density of trees with compasses of 2 $\times$ 2 m or 2 $\times$ 3 m being used, but shorter compasses of 1 $\times$ 1 m were common in the past (Goes 1991). After thicket stage, the closed canopy prevents sun light to enter and reach the soil, leading to a drastic impoverishment of the understorey (Hoodless 1994).

The sampling scheme was strongly conditioned by the area of the island. The increase in the number of observation points, at the cost of decreasing the distance between them, could lead to the registration of the same birds at different observation points. Despite the sample size, the built model presented a high prediction success, both in analysed samples and validation samples, suggesting that the model is capable of predicting woodcock distribution in S. Miguel reasonably well (Liu et al. 2005). According to Swets (1988), models with estimated AUC values of ROC curves > 0.9 exhibited a good discrimination capacity. Taking this into account, the model obtained in this work can be used to extrapolate the distribution of woodcock to the entire island and, with the necessary validations, to other Azorean islands. At present, the lack of complete soil occupation or vegetation cover maps is a serious limitation.

Given that woodcock hunting in S. Miguel has been forbidden for at least two decades, the results of the present work suggest that the restricted distribution and overall low abundance presently observed is probably due to habitat changes over time. The area of natural vegetation has been decreasing, not only in S. Miguel but in all the Azorean islands (Tutin 1964, Sjögren 1973, Furtado 1984, Pereira et al. 1998). The preferences for natural vegetation by woodcock during the breeding season are an important aspect to take into account in future management practices. The maintenance of forest edges and small patches of vegetation between pastures could create alternative wintering refuges and breeding areas, simultaneously working as natural corridors along the island.

The observed overall low values of relative abundance and the restricted distribution pattern of the woodcock in S. Miguel island, supports the maintenance of hunting interdiction. However, monitoring of the species would be important to improve present estimations and detect long-term trends in the population. In order to decrease the human pressure in some breeding sites, it would also be important to create local protected areas, where several human activities should be restricted (such as the training of hunting dogs), at least during the breeding season.

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