

MODELLING THE DISTRIBUTION OF THE EUROPEAN POLECAT *MUSTELA PUTORIUS* IN A MEDITERRANEAN AGRICULTURAL LANDSCAPE

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RÉSUMÉ. — *Modélisation de la distribution du Putois Mustela putorius dans un paysage agricole méditerranéen.* — L'objectif de ce travail est d'évaluer la distribution du Putois dans une région du sud du Portugal, en identifiant les descripteurs d'environnement dont il dépend et en comparant les résultats de deux méthodes différentes d'analyse de la distribution de l'espèce. La première de ces méthodes, la régression logistique (RL), utilise des données de présence/absence tandis que la seconde, l'analyse de facteurs de niche écologique (ecological niche factor analysis, ENFA), ne s'appuie que sur des données de présence. Les résultats montrent clairement qu'au Portugal, comme dans d'autres régions d'Europe, le Putois est très lié à des habitats humides et à une dense couverture végétale. Les descripteurs de l'environnement qui influencent le plus la distribution du Putois sont la longueur des cours d'eau, le nombre de touffes de broussailles, l'indice de diversité de Shannon-Wiener et le nombre de surfaces d'eau. Les méthodes utilisées montrent des différences statistiques dans leurs prévisions respectives, ainsi la RL prévoit une surface plus large que la ENFA pour la présence du putois.

SUMMARY. — The aims of the present work are 1) to evaluate the distribution of the Polecat (*Mustela putorius*) in an area of Southern Portugal, identifying the major environmental descriptors upon which it depends; and 2) to compare the results of two different approaches to model species distribution. Two methods were used; one utilizing presence/absence data in a logistic regression (LR) model, and the other using presence-only data by means of ecological niche factor analysis (ENFA). The results clearly show that, as in other parts of Europe, the Polecat's presence in Portugal is closely connected to humid habitats and dense vegetation cover. Overall, the environmental descriptors that most influence Polecat distribution are main water course length, the number of scrubland patches, the Shannon Wiener landscape diversity index and the number of water surface patches. The two methods we used generated significant differences in their predictions. LR predicts a broader area for the presence of the Polecat.

The Polecat (*Mustela putorius*) is a small mustelid species widely distributed throughout Europe, the only exception being the Balkan Peninsula (Virgós, 2002). Not much is known about this species, relative to other European carnivores, particularly in Mediterranean habitats (Virgós, 2003). Studies have focussed primarily on its diet (Roger, 1991; Jedrzejewski *et al.*, 1993; Lodé, 1993a; Prigioni & De Marinis, 1995; De Marinis & Agnelli, 1996) and habitat choices (Weber, 1988; Jedrzejewski *et al.*, 1993; Lodé, 1993a; Virgós, 2003; Zabala *et al.*, 2005).

Lodé (1993b) considered that the optimum habitat for the Polecat is one in which there are humid areas and dense forest cover. Recent studies in Spain (Zabala *et al.*, 2005) relate Polecat's presence to the occurrence of water courses and higher landscape diversity, and conclude

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that it avoids pine forests. The size of the home range for several Polecat populations has been estimated throughout its distribution area. Generally, home range size varies between 0.42 and 4.3 km² (Nilsson, 1978; Blandford, 1987; Brzezinski *et al.*, 1992; Lodé, 1993b; Baghli & Verhagen, 2004). Only in Switzerland and Russia are home ranges larger, ranging from 9 to 25 km² in Russia (Danilov & Rusakov, 1969) and being about 11 km² in Switzerland (Weber, 1989b). Some authors classify the Polecat as an opportunist carnivore (Lodé, 1990, 1993b), while others classify it as specialized on wild rabbits (Roger, 1991; Schröpfer *et al.*, 2000) or amphibians (Weber, 1989a; Jedrzejewski *et al.*, 1993). These different perceptions of the Polecat's ecology demonstrate the species' adaptability to distinct local conditions.

Over the last few decades, European populations of the Polecat have suffered a significant decline (Virgós, 2003). In Britain, road casualties, hybridization with the Ferret (Davison *et al.*, 1999) and secondary poisoning (Birks, 1998) are contributing to reduce the distribution area of the species. In Spain, the major threats to the Polecat are persecution, habitat fragmentation, reduction of the Rabbit population and fire disturbance (Virgós, 2002, 2003). The same threats might be affecting the Portuguese population, although there are no studies to confirm this hypothesis. In fact, smaller carnivores (and those with smaller home ranges) are more vulnerable to fragmentation (Sunquist & Sunquist, 2001; Gehring & Swihart, 2003). Given that generally Polecat populations are distributed in small reproductive units (Lodé *et al.*, 2003), habitat fragmentation and loss may create a threat to the species. The new IUCN category proposed for the species in Portugal is Data Deficient (Cabral, 2005), since data concerning Polecat ecology and distribution are almost non-existent. This reflects the difficulty in detecting and capturing the species in Mediterranean environments, suggesting that its abundance and ecological requirements in this region may differ from those described in central and northern European countries.

Our study had two main goals: (i) to evaluate the distribution of the Polecat in a 640 km² area of Southern Portugal, while identifying the major environmental descriptors upon which it depends; and (ii) to compare the results generated by two different methods of modelling species distribution.

STUDY AREA, MATERIAL AND METHODS

STUDY AREA

The study site, with 64,000 hectares, is located in Alentejo, Southern Portugal (38° 13' to 38° 02' North and 7° 46' to 7° 13' West), near the Spanish border. The region is among the least-densely populated areas in Portugal (INE, 2002). The road network is short, and urban areas are small. Farm houses are a frequent feature on the landscape, this area focusing mainly on agriculture. Land uses are dominated by human-altered habitats, mainly "montado" (a traditional multiuse system that consists of a degradation of the original Mediterranean forest dominated by holm and/or cork oaks with only two strata: herbaceous and arboreal), olive orchards and cereal crops. Areas with dense vegetation cover occur mainly near rivers and streams (Figure 1). There also are some patches of pine and eucalyptus production forests. Irrigated cultures are present, particularly near the main rivers.

The climate is thermomediterranean (Rivas-Martinez, 1987). There is a dry season between May and September. Mean daily temperatures range from 9.6°C (January) to 26.1°C (August), and the mean precipitation ranges from a minimum of 1.3 mm in August to a maximum of 66.0 mm in March (INMG, 1990).

POLECAT SURVEY

The study area was divided into 640 1-km² squares, from which, 220 were sampled for Polecat's occurrence. Surveyed cells were chosen randomly after taking into account the main land uses and the conditions for sampling: landowner's agreement for entrance into their properties and existence of dirt roads and foot-paths that would facilitate the surveys. The square size was defined on the basis of the mean home range size for the Polecat, around 100-200 ha (Brzezinski *et al.* 1992; Lodé, 1993b). Each square was surveyed once by two experienced observers between November 2003 and November 2004. Surveys were based on detection and identification of presence signs along linear transects of at least 500 metres in length, avoiding periods of hard weather conditions that would destroy the signs (heavy rains) or make them less detectable (extreme dry weather complicates footprints identification). Besides data obtained through transects, data on the presence of Polecat on the study site also came from other sources: ad hoc observations, previous studies recently done in the area (Santos-Reis *et al.*, 2003) and scent stations (Figure 2). In each square sampled, absences were defined when no presence signs were found across transects of at least 800 metres. The number of absences (or pseudo-absences) was much higher than the number of presences so, for analytical purposes during logistic

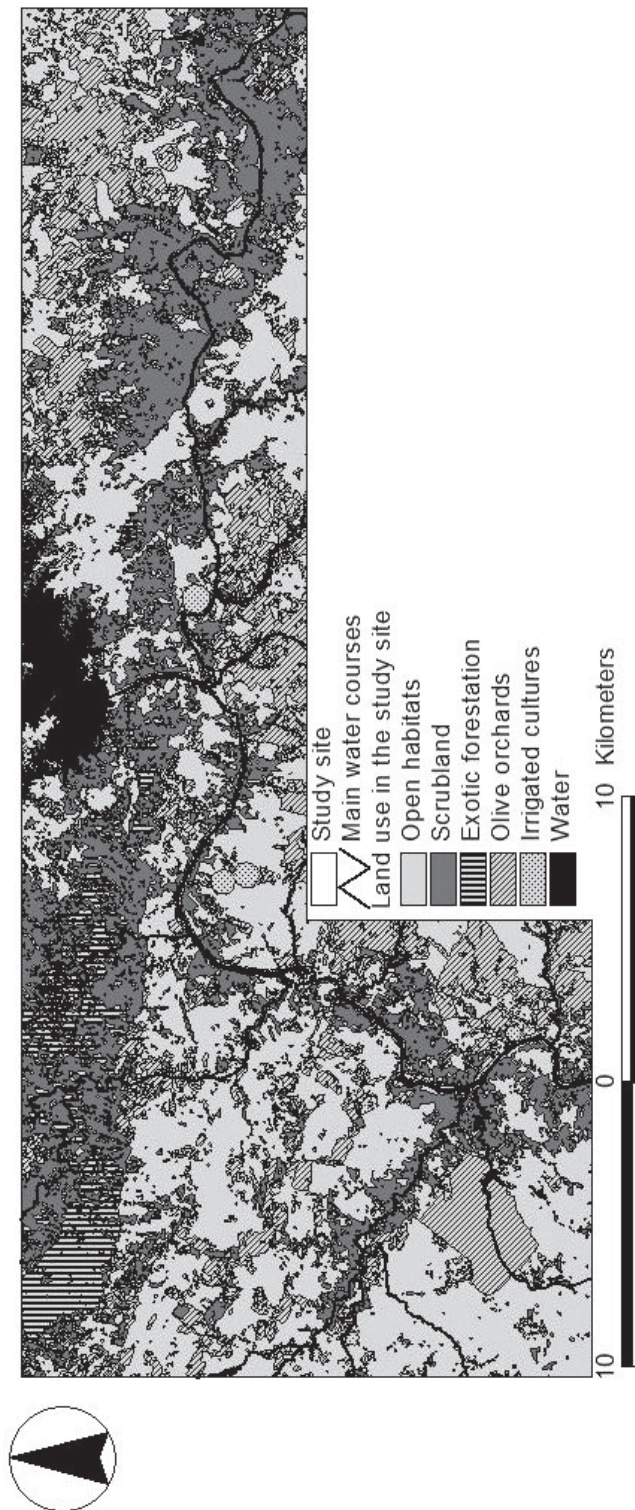


Figure 1. — Main land use classes in the study area (UMC, 2004).

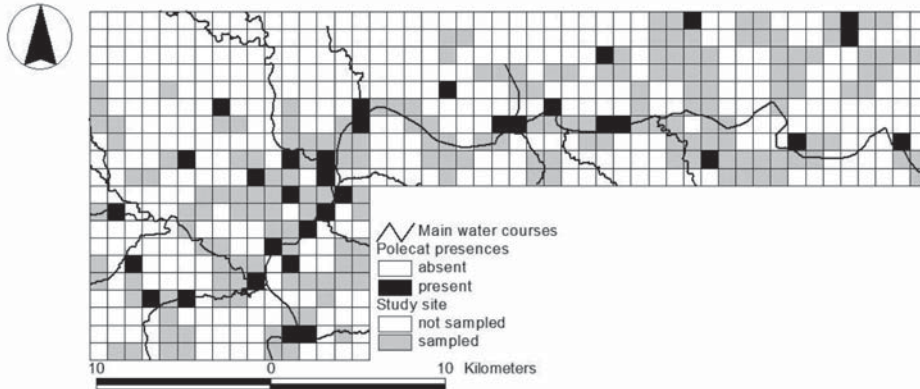


Figure 2. — Sampled squares and Polecat presences.

regression, an equal number of presences and absences was used. The absences were chosen randomly from all data with this condition.

Commonly, Polecat footprints are confused with those of the European Mink (*Mustela lutreola*) or American Mink (*Mustela vison*) (Blanco, 1998). Neither of these species occurs in the study site. In a few instances, presence signs of Polecat, mainly scats, may be similar to the ones of the Stone Marten (*Martes foina*). Such data were excluded from analyses.

ECOGEOGRAPHICAL VARIABLES (EGV)

Twenty ecologically-meaningful EGVs were selected for analysis. A short explanation of each one is presented in Table I. For each square, the area of each habitat class and of game reserves, the length of main roads and water courses, the number of patches of each habitat class, and the Shannon-Wiener landscape diversity index were computed. Land uses were determined through interpretation of satellite imagery with field-based corrections (UMC, 2004). Some uses with structural resemblance were grouped into wider classes for analysis: cereal crops, fallow lands and montado with only a few dispersed trees were defined as “open habitats”; areas with dense shrub cover, with or without tree cover (including areas of montado with a higher density of trees and some shrubs) were grouped as “scrubland”.

The digital information on game reserve limits kindly was provided by the DGRF (Forestry Services). Digital maps then were superimposed over a UTM 1-km² grid in GIS software, Arcview 3.2® (ESRI, 1999).

ANALYTICAL METHODS

Each sampled square was classified as “Polecat present”, if it showed signs of Polecat presence or as “Polecat absent” if no signs were identified. The presences or presences/absences of the Polecat were used as the dependent variable and all ecogeographical descriptors were treated as independent variables.

Prior to any analysis, a Spearman rank correlation test was computed to evaluate eventual collinearities between the EGVs. From pairs of variables that had a correlation coefficient higher than 0.7 (Tabachnik & Fidell, 1996), only one was retained for further analysis, generally the one that was more meaningful from the biological point of view.

Spatial autocorrelation also was tested before analysis, using Moran’s I, and testing its significance with a z-test computed with the script of Lee & Wong (2001) for Arcview® (ESRI, 1999).

LOGISTIC REGRESSION

Variables were transformed (angular transformation for proportions and logarithmic transformation for other variables) in order to soften the effects of extreme values. Model building adhered to the main steps suggested by Hosmer & Lemeshow (2002).

As a first step, we created and tested a univariate logistic regression model for each EGV. Variables for which the likelihood-ratio test was significant at a 0.25 level were kept for further analysis (Hosmer & Lemeshow, 2002).

Secondly, a multivariate logistic regression model, with all the descriptors previously selected, was created and tested using the backward-stepwise selection method (p-value for variable removal = 0.10; p-value for entry = 0.05).

The Pearson’s Chi-square test, the phi coefficient of correlation and the area under the ROC curve were used to evaluate the performance of the multivariate model (Sokal & Rohlf, 1995; Hosmer & Lemeshow, 2002).

Model validation was done by means of a Jackknife procedure. This consists of the iterative computation of as many regression models as the number of cases, excluding one case at a time (Guisan & Zimmermann, 2000). The fit of these predictions (from Jackknife procedure) with the observed presences/absences was evaluated using the area under the ROC curve.

The multivariate model was applied to each of the 640 cells, resulting in a potential distribution map of the Polecat for the entire study area.

TABLE I

Ecogeographical variables, their units, code and range. The source of information upon which they were based or calculated is also presented

Variable	Unit	Code	Description	Total		Presences		Source
				min.	max.	min.	max.	
Distance to urban edge	meters	URBAN	distance of square centroid to urban edge	0	10419	1309.9	7716.2	computed with Arcview
Main road length	meters	ROAD	total length of paved road in each square	0	3743.15	0	1513	computed with Arcview
Water course length	meters	WCOURSE	length of primary and secondary water course in the square	0	2619.48	0	2420.4	computed with Arcview
Riparian vegetation area	ha	RIPARIAN	area of riparian vegetation habitat in each square	0	29.899	0	16.3	UMC (2004)
Game reserve area	ha	GAME	area of game reserves in each square	0	100	0	100	Direcção Geral dos Recursos Florestais
Shannon Wiener diversity Index	-	SHANNON	index of habitat diversity in each square	0	1.524	0	1.457	computed with Arcview extension Spatial CalcDiversity (Ebert, 1999)
Open habitats	ha	OPEN	area of open habitats	0	100	0	97.036	UMC (2004)
Scrubland area	ha	SCRUB	area of scrubland	0	97.063	0	81.29	UMC (2004)
Exotic forestation area	ha	FOREST	area of exotic forestation (<i>Pinus</i> and <i>Eucalyptus</i>)	0	98.014	0	30.564	UMC (2004)
Olive orchard area	ha	OLIVE	area of olive orchards	0	100	1.62	100	UMC (2004)
Irrigated cultures	ha	IRRG	area of irrigated cultures	0	72.29	0	17.077	UMC (2004)
Water surface area	ha	WATER	area of water surfaces	0	100	0	15.57	UMC (2004)
Number of open habitat patches	-	NOPEN	number of open habitat patches in each square	0	25	0	19	computed with Patch Analyst (Rempel 2000)
Number of scrubland patches	-	NSCRUB	number of scrubland in each square	0	29	0	18	computed with Patch Analyst (Rempel 2000)
Number of exotic forestation patches	-	NFOREST	number of exotic forestation patches in each square	0	24	0	10	computed with Patch Analyst (Rempel 2000)
Number of olive orchard patches	-	NOLIVE	number of olive orchards patches in each square	0	29	1	20	computed with Patch Analyst (Rempel 2000)
Number of irrigated culture patches	-	NIRRG	number of irrigated culture patches	0	11	0	11	computed with Patch Analyst (Rempel 2000)
Number of water surfaces	-	NWATER	number of water surfaces in each square	0	7	0	3	computed with Patch Analyst (Rempel 2000)
Medium altitude	meters	ALT	mean altitude in the square	70.7	337.128	70.737	214.91	computed with Arcview
Medium slope	degrees	SLOPE	mean aspect in the square	0.25	18.547	0.94	13.501	computed with Arcview

The software package SPSS® version 12 (SPSS Inc., 2003) was used for all analyses. Results were considered statistically significant at a $p < 0.05$ level, except where stated otherwise.

ECOLOGICAL NICHE FACTOR ANALYSIS (ENFA)

Modelling through ENFA was done using Biomapper software, version 3.1 (Hirzel *et al.*, 2002b). This method compares 1) the ecological space of the cells with species presence versus 2) the ecological space of all the cells, and then computes a number of uncorrelated factors that reflect the main environmental gradients within the study area (Hirzel *et al.*, 2002a). The first factor, marginality, quantifies how different the species means and global means are for each variable. The coefficient attributed to each EGV in this first factor is higher for those where species presence is farther from the mean values of the area. Negative coefficients show that the species prefers values that are lower than the mean value of the variable. All the other factors are specialization factors. Specialization demonstrates how specialized the species is with respect to each EGV. Higher coefficients (absolute values, since the signs are arbitrary) are associated with a more restricted range of the species for that EGV (Hirzel *et al.*, 2002a). Other outputs of the ENFA are global marginality and tolerance. These values summarize the relationship between the species and its environment. Global marginality values range from 0 (the species tends to live in average conditions) to 1 (the species tends to live in extreme habitats). Global tolerance values range from 0 (specialist species) to 1 (generalist species) (Hirzel *et al.*, 2002a).

In order to obtain comparable models, in this analysis we used only EGVs that remained in the final multivariate logistic regression model.

Prior to analysis, all variables were transformed (Box-Cox transformation) and verified for inconsistencies (the maps must be capable of being overlaid, and constant or nearly-boolean maps should not be considered).

The number of factors that express the environmental gradients of species distribution was selected by means of MacArthur's broken stick method (Hirzel *et al.*, 2002b). Model fit was evaluated via the phi coefficient of correlation (to test for the association between the observed and predicted values in the classification tables) and the area under the ROC curve (Sokal & Rohlf, 1995; Hosmer & Lemeshow, 2002).

To obtain the Polecat potential distribution within the study area, the model was applied to each of the 640 cells.

METHOD COMPARISON

Probabilities of the Polecat's presence in each 1-km² square obtained through both models were compared, using Wilcoxon's signed-rank test (Sokal & Rohlf, 1995). The comparison was done using the probability classes used for the map's production (<0.3; 0.3-0.5; 0.5-0.7; 0.7-0.9 and >0.9).

A comparison of model performance was done by means of calculating the phi coefficient, area under the ROC curve, and sensitivity (Fielding & Bell, 1997). A 0.5 cut-off level was used to distinguish between absences and presences.

RESULTS

The Moran I value was 0.014 ($Z=0.98$, $p>0.05$), which demonstrates that there was no significant spatial autocorrelation in our data. From the original twenty environmental descriptors, eleven were removed, because they were not significant during univariate logistic regression, and four were removed due to high correlations with other descriptors. After univariate logistic regressions and Spearman rank correlation analysis (Table II) only five EGVs (length of water courses, Shannon-Wiener Diversity Index, number of scrubland or dense evergreen forest stand patches, number of water surfaces, and number of irrigated culture patches) were retained for multivariate analysis (in Table II, excluded environmental descriptors are tagged with an asterisk, *).

LOGISTIC REGRESSION

Only three EGV were retained in the multivariate logistic regression model. Consequently, the main effects model included the constant term plus the "Shannon-Wiener Landscape Diversity Index", the "Number of Scrubland or Dense Evergreen Forest Stands" and the "Length of Main Water Courses" (Table III). This model was significant (chi-square = 104.72; $p<0.01$) and 72.1 % of the cases were correctly classified (76.5% of presences and 67.6% of absences). The association between observed and predicted values also was significant ($\phi=0.443$, $p<0.001$; AUC = 0.804, $p<0.001$). Model validation via a Jackknife procedure suggests that the model performs well and can be used to predict the probability of Polecat presences over the entire study area (AUC = 0.755; $p<0.001$).

TABLE II

*Logistic regression coefficients and significance of each EGV in the univariate logistic regression model (variables are ordered by significance level); * = excluded EGVs*

EGV	B	Significance
Water course length	0.241	0.002
Medium altitude*	- 2.703	0.007
Riparian vegetation area*	7.609	0.015
Number of scrubland patches	0.974	0.015
Number of irrigated culture patches	0.938	0.018
Water surface area*	4.251	0.079
Irrigated cultures area*	4.553	0.107
Number of water surfaces	0.647	0.242
Shannon Wiener diversity Index	1.371	0.248
Number of olive orchards patches*	0.472	0.260
Game reservation area*	0.321	0.424
Number of open habitat patches*	- 0.263	0.466
Exotic forestation area*	1.581	0.531
Medium slope*	0.269	0.545
Olive orchards area*	0.365	0.623
Scrubland area*	- 0.309	0.657
Distance to urban edge*	0.222	0.664
Number of exotic forestation patches*	- 0.071	0.808
Main road length*	- 0.006	0.942
Open habitats area*	0.026	0.972

TABLE III

Results of the multivariate logistic regression model; β = regression coefficient, SE = standard error of the regression coefficients, Wald = Wald statistics, P = significance level

	β	SE	Wald	P
Shannon	- 3.316	1.862	3.172	0.075
Nscrub	1.532	0.558	7.545	0.006
Wcourse	0.295	0.093	10.14	0.001
Constant	- 1.578	0.873	3.272	0.070

The number of scrubland patches and the water course length promoted species presence. However, according to LR results, an increase in the heterogeneity of the landscape seems to contribute to a decrease in species occurrence in the multivariate model, which contradicts the results of univariate analysis. This suggests that the effect of this descriptor may be influenced by the values of other EGVs.

A map of probabilities of Polecat occurrence in the studied area, obtained using the LR model, is presented in Figure 3. Higher probabilities occur in areas near main rivers, but also include some scrubland and dense evergreen forest stand spots.

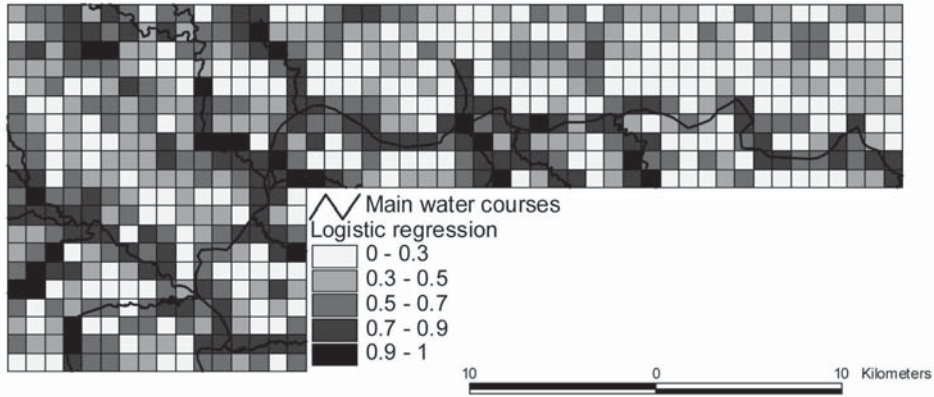


Figure 3. — Distribution map (probability of presence) of the Polecat, according to the results of the logistic regression model.

ECOLOGICAL NICHE FACTOR ANALYSIS

One EGV (number of irrigated culture patches) was eliminated from the Ecological Niche Factor Analysis, by Biomapper, since the map was not continuous enough.

The ENFA model explained 94.8% of the information. Global marginality was 0.665, indicating that the Polecat is a moderately specialist mustelid. Tolerance was 0.833, which suggests that the Polecat is tolerant to changes in the variables that explain its distribution. The first factor, marginality, explained only 12% of the specialization, which means that the species is not very restrictive in its choices for variables for which the Polecat's optimum is furthest from mean area conditions (Hirzel *et al.*, 2004). Model fit was moderate (Φ coefficient=0.308, $p=0.011$ and area under the ROC curve=0.682, $p=0.010$). Table IV shows the coefficients of each EGV among the first three factors.

According to the marginality factor, water course length is the variable for which the sampled squares with Polecat are most different from the global mean. The number of scrubland patches and number of water surfaces are the EGVs that have higher coefficients among the specialisation factors. These EGVs are those for which the Polecat has a higher degree of specialization and, consequently, is less tolerant to changes.

Figure 4 represents the potential distribution map of the Polecat within the study area, according to the ENFA approach. One can verify that the areas of highest probability of occurrence are confined to the periphery of main rivers, similar to the results obtained using LR. However, the potential occupied area is narrower than the one obtained with the previous model.

TABLE IV

Results of Ecological Niche Factor Analysis
Environmental variables sorted by decreasing absolute values of the coefficients for marginality

Marginality		Specialization			
Factor 1 (12%)		Factor 2 (38%)		Factor 3 (23%)	
WCOURSE	(0.82)	NSCRUB	(0.64)	NWATER	(- 0.58)
SHANNON	(0.39)	NWATER	(- 0.60)	NSCRUB	(- 0.57)
NWATER	(0.38)	SHANNON	(- 0.35)	SHANNON	(- 0.56)
NSCRUB	(0.17)	WCOURSE	(0.31)	WCOURSE	(0.12)

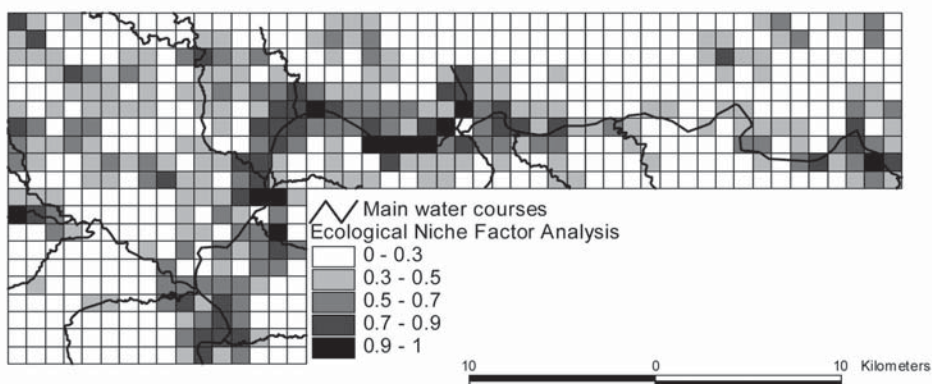


Figure 4. — Distribution map (probability of presence) of the Polecat, according to the results of the Ecological Niche Factor Analysis model.

METHOD COMPARISON

The Wilcoxon test shows that both models generated statistically-different predictions ($Z=-10.547$; $p<0.001$). The phi coefficient, the sensitivity and the area under the ROC curve suggest a better statistical fit for the LR (Table V). The higher sensitivity of the LR indicates that this method more accurately predicts true presences than the ENFA.

TABLE V

Summary of the model fit measures for LR and ENFA

Φ coefficient	Sensitivity	Model	ROC curve
0.308 ($p=0.011$)	0.471	ENFA	0.682 ($p=0.010$)
0.443 ($p<0.001$)	0,676	LR	0.804 ($p<0.001$)

DISCUSSION

Our study presents the first published data concerning the ecological needs of the Polecat in Portugal. The relationship between Polecat distribution and landscape descriptors is a difficult issue to evaluate. Is the Polecat dependent upon water courses, irrespective of the surrounding landscape matrix, or is it using the water course because it is the only favourable habitat remaining? Features like riparian vegetation composition and dimension of streams seem to have a great influence on Polecat distribution. In fact, using both analytical methods, the length of water courses appears to be the most important variable explaining Polecat distribution. However, the global marginality (0.665) and global tolerance (0.833) values (generated by ENFA), suggest that the Polecat is a moderately-specialist species. These results point out that, although its distribution reflects preferences for certain environmental conditions, the Polecat has some plasticity and can accommodate moderate changes in these conditions. According to the ENFA model, water course length is the EGV for which the Polecat is furthest from mean area conditions (greatest marginality), but it also is a variable that has lower specialization coefficients. This leads us to suggest that, despite the Polecat's preference for water courses, it may explore surrounding habitats as well. Therefore, within the study area, the Polecat might be using water courses as a last resource shelter, given the absence of significant vegetative cover in other habitats. This preference for rivers and streams is in accordance with

results from other investigators studying other regions (Weber, 1988; Jędrzejewski *et al.*, 1993; Lodé, 1993b, 1994; Sidorovich *et al.*, 1996; Zabala *et al.*, 2005), and stresses the importance of shelter for carnivorous species (when riparian vegetation is present), particularly in regions where the main landscape matrix is composed of agricultural fields (Virgós, 2001).

Besides persecution and occasional road kills, agriculture, which is becoming more intensive in the region, may be a factor of disturbance for the Polecat population. In fact, construction of the Pedrógão reservoir will cause the loss of the most suitable habitats, whether by eliminating riparian vegetation or by flooding important areas. Furthermore, higher water availability will promote more intensive agriculture, with vast irrigated cultures thereby replacing more traditional forms of agriculture and changing the original landscape matrix.

Agricultural intensification often implies the loss of hedgerows, stone walls, banks and riparian corridors. MacDonald & Birks (2003) point out that the loss of linear features reduces food supply to mustelids; and Lodé (1995, 1999) showed that the activity pattern of the Polecat is highly related to prey availability and activity. Some of the main preys of the Polecat, small mammals and amphibians, are more abundant near rivers and streams, since these habitats are recognized as important abundance reservoirs for small mammals and amphibians (Maison-neuve & Rioux, 2001; Chapman & Ribic, 2002). Most of the amphibians develop their sexual activity in Autumn and Spring, concentrating in the pools near the streams, making predation easier for the Polecat.

Irrigated cultures had a positive coefficient in the univariate logistic regression model (both the number of patches and the area), which might lead us to admit that these cultures promote the presence of the Polecat. We believe that this result reflects the fact that, at our study site, the patches are relatively small and located close to the main rivers. However, with higher water availability due the recent implementation of two large water reservoirs nearby, irrigated cultures soon will occupy a broader area with much larger patches. This expected intensification of the agriculture in the region, replacing the existing heterogeneous landscape matrix with homogeneous irrigated cultures, should be examined carefully, because it may have a different impact on the Polecat population than that suggested by our results.

The importance of the landscape matrix in explaining Polecat distribution also is revealed by the presence of the “Shannon-Wiener Landscape Diversity Index” (SHANNON) and “Number of Scrubland Patches” (NSCRUB) in the models. It is interesting to note that “Area of Scrubland” (SCRUB), contrary to what happened with “Number of Scrubland Patches”, was not significant during univariate logistic regression. This suggests that the Polecat prefers areas where a high number of relatively small patches are available, rather than those with a large monotonous patch of scrubland. According to Zabala (2005), greater landscape diversity is positive for the Polecat for two main reasons: 1) it allows the Polecat to shift prey in times of shortage; and 2) landscape diversity increases connectivity in the landscape matrix. In Spain, Zabala (2005) concluded that areas with greater structural diversity, near streams, are particularly good for the Polecat. Our results, concerning the effect of the heterogeneity of the landscape on Polecat presence, as stated before, are contradictory and don't allow us to be conclusive concerning this issue.

The model resulting from the LR has a better statistical fit with the data, as shown by the phi coefficient, area under ROC curve and sensitivity. However, the model produced by ENFA is easily understood from the ecological point of view, and allowed for important conclusions about the niche breadth of the species that otherwise would not have been possible. Concerning data, the main difference between the two approaches is the use of absences in the LR. If absences are reliable, then LR generally should produce more accurate results. Considering the LR results (72.1% of cases correctly classified), Polecat absences seem to be reliable. However, Hirzel *et al.* (2001) stated that, when the objective of the study is to make an ecological interpretation, then ENFA might be a better choice, even when LR has a higher adjustment of model to field data. The better results for LR suggest that the Polecat might be using optimal and secondary habitats (Hirzel *et al.*, 2001). In fact, when the species occurs in all suitable habitats and these are scarce, presence-only approaches may be biased, because the relative importance of such habitats might be outweighed by a large number of observations in secondary habitats

(Brotons *et al.*, 2004). According to Segurado & Araújo (2004) truly widespread species have greater overall errors (Kappa index). However the amount of unexplained variation (sensitivity) is not greater for these species.

The current landscape changes within the study site are in accordance with the tendency observed at a wider level for the entire country. Agriculture presently is undergoing an intensification process, replacing more traditional ways of exploring the land with large patches of intensive cultures. These include the implementation of large irrigated culture areas, with the destruction of riparian vegetation and substitution of extensive pastures and scrubland.

The importance of the riparian areas and small scrubland patches for the presence of the Polecat in the Mediterranean region was supported by the present work, thereby strengthening the conclusions of other authors (Lodé, 1994; Virgós, 2001; Zabala *et al.*, 2005). Concerning the environmental pressures that are acting on the study site, conservation measures aiming to maintain or restore suitable habitats for the Polecat and its prey should be undertaken. The recovery of riparian vegetation around some streams, particularly those where the surrounding habitats are dominated by open areas, such as pastures and agricultural crops, should be a priority. Another important action would be to establish a net of hedgerows and/or small scrubland patches in the agricultural matrix, that may act as corridors or step-stone shelters that favour the Polecat and other carnivorous species.

Current knowledge about the ecology and distribution of the Polecat in Portugal is very limited, and the work presented here should be viewed as a first contribution. However, in order to clarify the Polecat's conservation status and develop conservation and mitigation measures, basic ecological data concerning its distribution, space use, diet, population dynamics, and other attributes must be gathered in the near future.

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