Predicting occurrence of Iberian wolf:
the role of sample size and spatial scale

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Wildlife corridors:

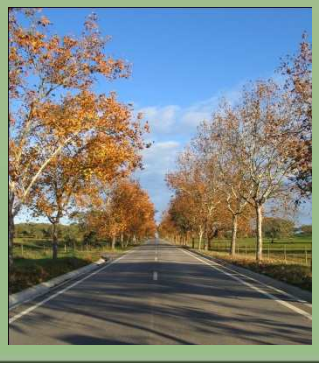
- Spatial modelling of human pressure and its usefulness for Iberian Wolf conservation

What does literature tell us about the wolf occurrence?

- ✓ **Altitude and mixed forest were positively related with Iberian wolf occurrence, whereas the high livestock density was negatively related with wolf occurrence in southern Douro river.** Analysis with 108 wolf occurrence in 2x2km squares.
  Grilo *et al.* 2002 Revista de Biologia.

- ✓ **Altitude, roughness and refuge strongly determine the Iberian wolf occurrence, followed by human pressure and food availability. Altitude was the main predictor that explain the wolf occurrence.** Analysis with 267 wolf occurrence in 5x5km squares.
  Llaneza *et al.* 2012 Diversity and Distributions

- ✓ **Iberian wolf-vehicle-collisions were more common in agricultural areas, where the population density is low**.
  Colino-Rabanal *et al*. 2011 European Wildlife Research



- ✓ **Roads are not absolute barriers to wolves but they influence wolf movements within their territories.**
  Whittington *et al*. 2004 Ecology and Society; Blanco *et al*. 2005 Canadian Journal of Zoology

What does literature tell us about

the effect of scale and sample size in modeling species response to landscape?

- ✓ **Sampling should examine a series of spatial scales, to increase the understanding of organism-environment relationships and identifying the most effective scales for predictive modeling.**
  Vaughn & Ormerod 2002, Conservation Biology

- ✓ **Arbitrarily choosing an inappropriate scale for measuring covariates, may provide biased inferences with respect to habitat selection patterns.**
  Leblond *et al*., 2011, Landscape Ecology

- ✓ **Combining two scales allowed to identify areas that should be prioritized for management actions.**
  Martin *et al*., 2012 Journal of Applied Ecology

- ✓ **Model accuracy increased with larger sample sizes for all modeling methods and is strongly influenced by species ecological characteristics independent of sample size.**
  Hernandez *et al.*, 2006, Ecography

- ✓ **Restricting the environmental range of data strongly influenced the estimation of response curves, especially towards upper and lower ends of environmental ranges.**
  Thuiller 2004, Ecography

Questions remained poorly understood…

✓**What is the effect of sample size and scale to predict wolf occurrence?**

✓**Does the relative importance of landscape, prey and human features vary with scale and sample size?**

✓**What is the best scale/sample size to predict wolf occurrence?**

Main goal

- **Predict the Iberian wolf occurrence likelihood at three scales and sample sizes:**

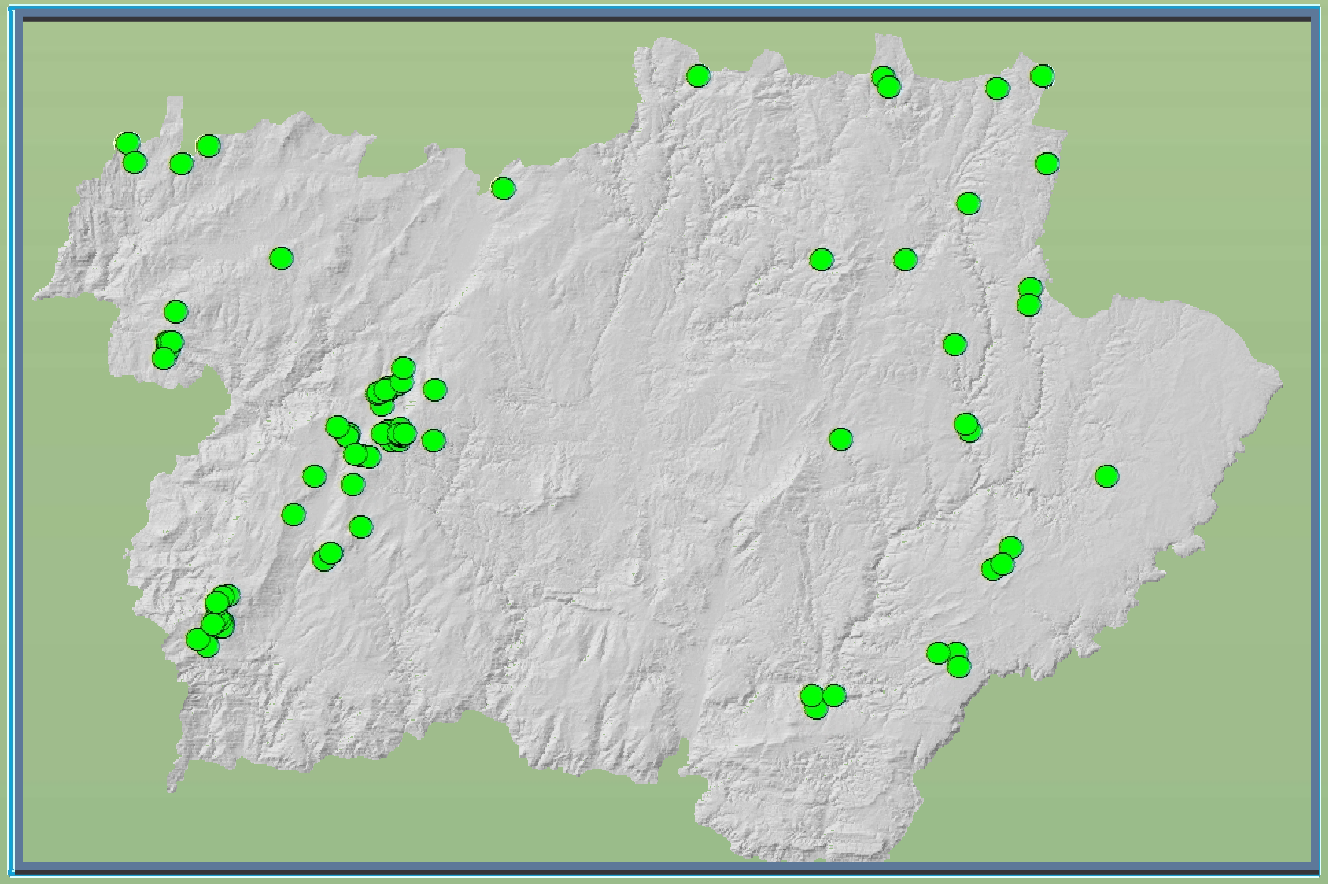
100x100m & ≈ 100 presences

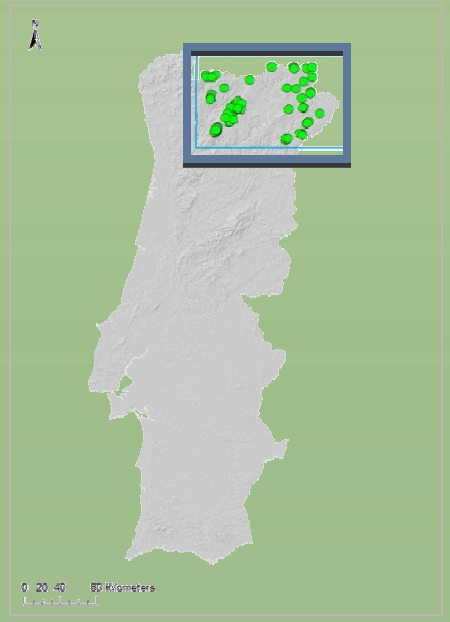
2x2km & ≈ 300 presences

10x10km & ≈1000 presences

Iberian wolf data – 100x100m

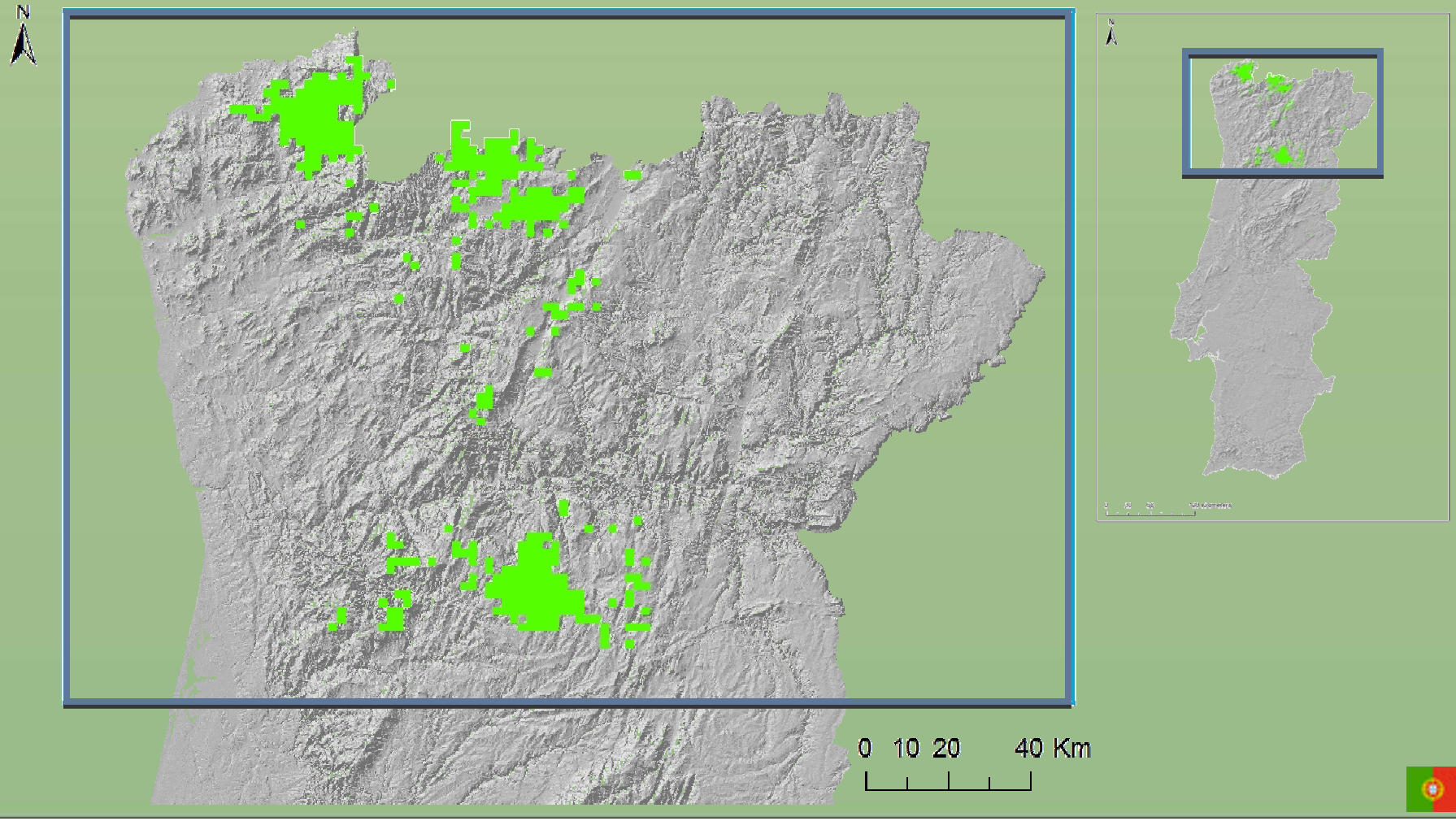
Distribution range – Northern Portugal (Vila Real and Bragança counties)
Resolution - 100x100m
Sample size – 94 squares
Type of data – Direct observations, scats confirmed with genetics, photos





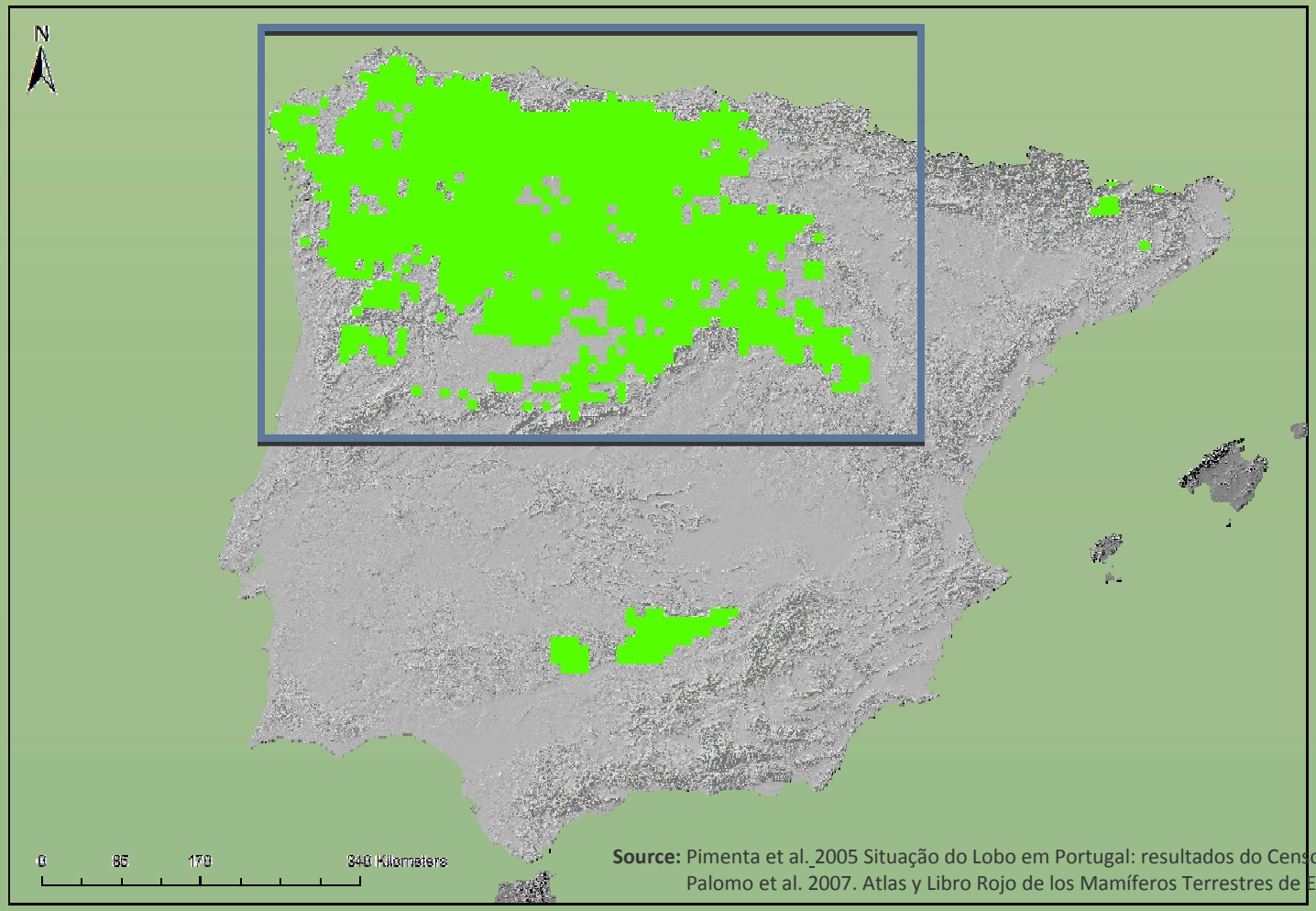
Iberian wolf data – 2x2km

Distribution range - North and southern Douro river (Peneda-Gerês, Alvão, Arada/Trancoso)
Resolution - 2x2km
Sample size - 318 squares
Type of data – Direct observations, scats confirmed with genetics, camera trapping photos, telemetry data



Iberian wolf data – 10x10

Distribution range - Iberian Peninsula
Resolution - 10x10km
Sample size - 953 squares
Type of data - Observations, scats without confirmation with genetics, camera trapping photos



Source: Pimenta et al. 2005 Situação do Lobo em Portugal: resultados do Censo Nacional 2002/2003.
Palomo et al. 2007. Atlas y Libro Rojo de los Mamíferos Terrestres de España.

Environmental variables

Variables	Source/year	Resolution	Parameters	Description
Landscape	Corine Land Cover 2006 (PT/SP)	25 ha	Open Areas	Pastures, natural grassland, bare rock, sparsely vegetated areas
			Forest	Broad leaved, coniferous, mixed forests, moors and heathland, sclerophylus vegetation, transitional woodland/shrub
		100m	Altitude	Average Altitude
Prey	INE 2011 (PT) INE/Censo agrário 2009 (SP)	county	Cattle Sheep Goat	ind./km^2
Human pressure	INE 2011 (PT/SP)	county	Population Density	ind/km^2
	IGP (PT)	1:250000	Road density; Distance to roads	km/km^2; m

Statistical analysis

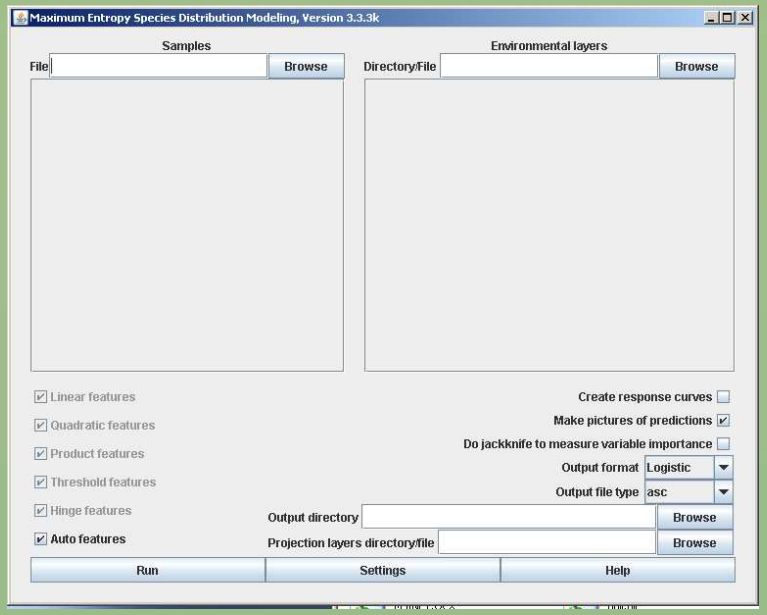
100x100m

Maximum entropy modeling of species geographic distribution

- Maxent software
- presence-only data

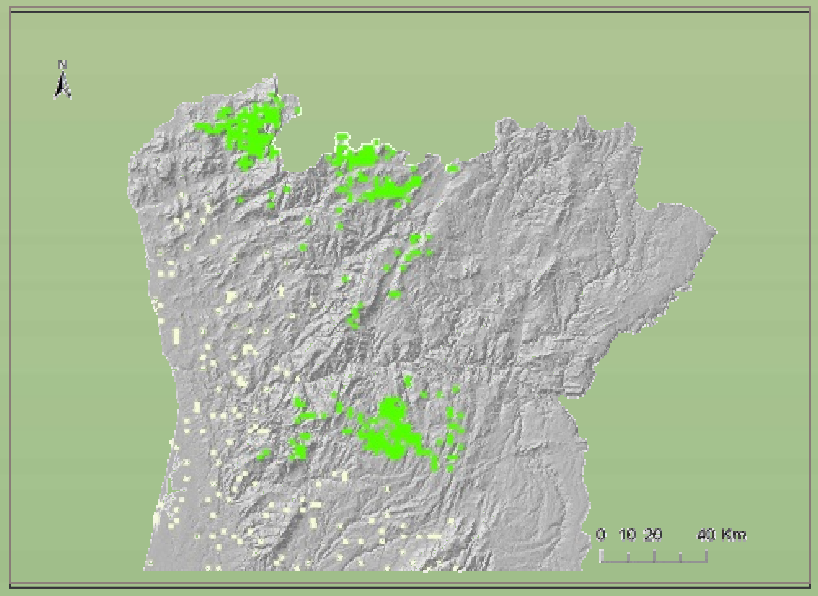
•presences are described in terms of environmental variables

•model all that is known and assume nothing about that which is unknown



Statistical analysis

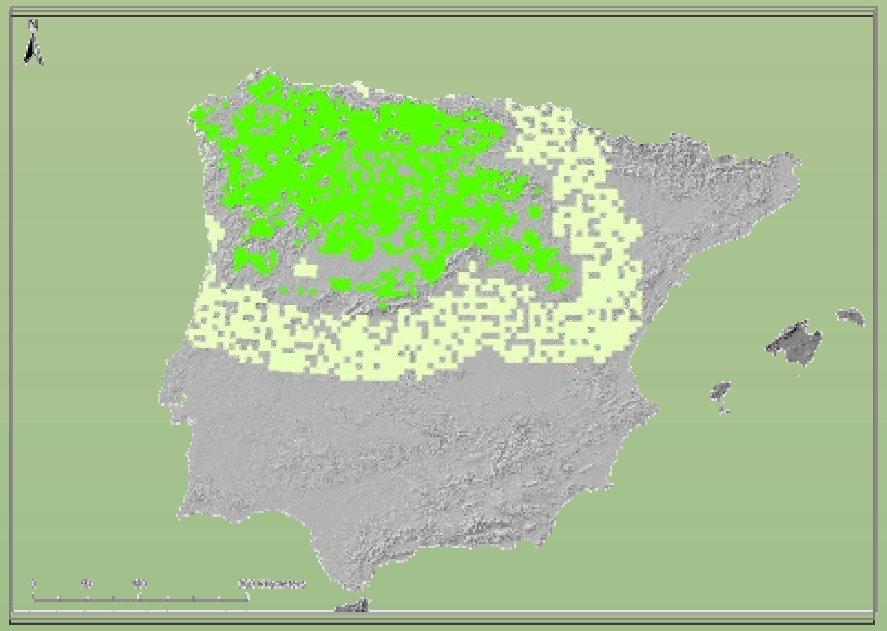
- **2x2km**



- **Generalized Linear Models**
- R software
- binary data (presence/absence),
- binomial distribution and logistic link
- presence/absence is described in terms of environmental variables
- Training data - 80% of wolf presence (318 sq. 2x2km;)
- Validation data - 20% of the wolf presence (80 sq. 2x2km; 10x10km)
- Ranking models accordingly to Akaike's Information Criterion (AIC)

Statistical analysis

- **10x10km**



- **Generalized Linear Models**
- R software
- binary data (presence/absence),
- binomial distribution and logistic link
- presence/absence is described in terms of environmental variables
- Training data - 80% of wolf presence (953sq. 10x10km)
- Validation data - 20% of the wolf presence (239 sq. 10x10km)
- Ranking models accordingly to Akaike's Information Criterion (AIC)

Iberian wolf occurrence models – general results

Scale/sample size	AUC	Classification	Validation
100x100m/94 sq.	**0.93**	--	--
2x2km/318 sq.	**0.97**	**92%**	**93%**
10x10km/953 sq.	**0.88**	**81%**	**76%**

100x100m/94 sq.

Altitude	(70%)
Forest	(7%)
Open areas	(1%)
Cattle	(11%)
Goat	(1%)
Sheep	(2%)
Population density	(2%)
Road distance	(6%)

2x2km/318 sq.

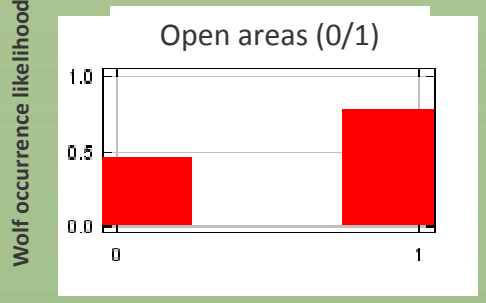
- Altitude+ altitude^2
- Forest
- Open areas + Open Areas^2
- Cattle + Cattle^2
- Sheep + Sheep^2
- Population density

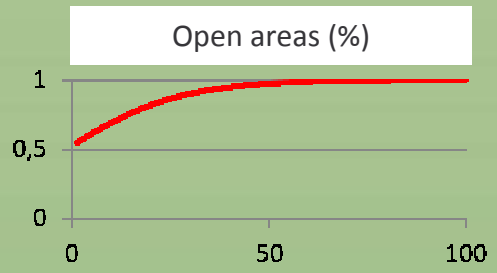
10x10km/953 sq.

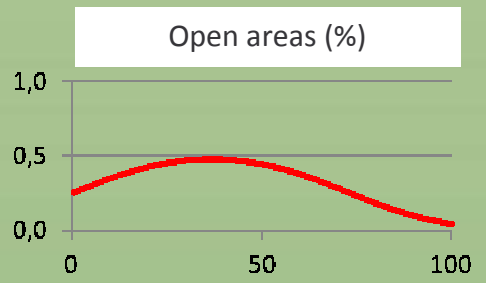
- Altitude+ altitude^2
- Forest
- Open areas + Open Areas^2
- Cattle + Cattle^2
- Goat + Goat^2
- Sheep + Sheep^2
- Population density
- Road density

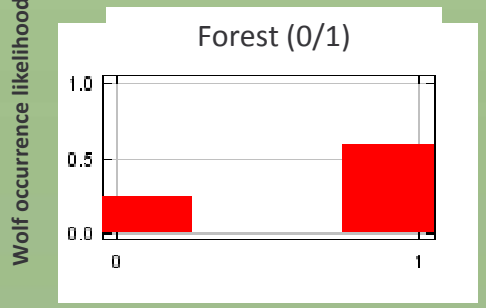
Iberian wolf occurrence models – landscape

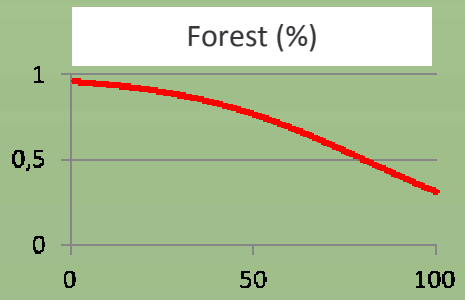
100x100m	2x2km	10x10km

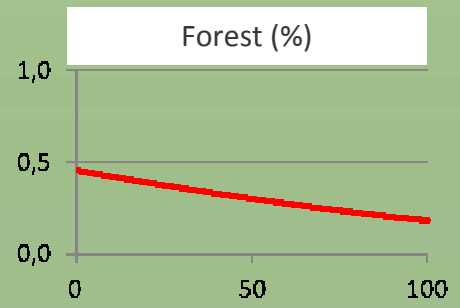


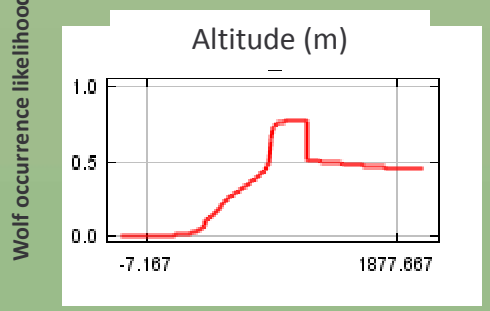


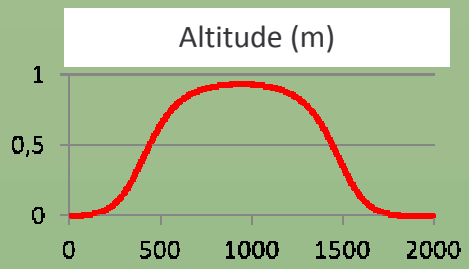


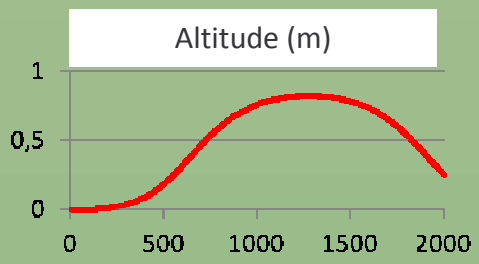






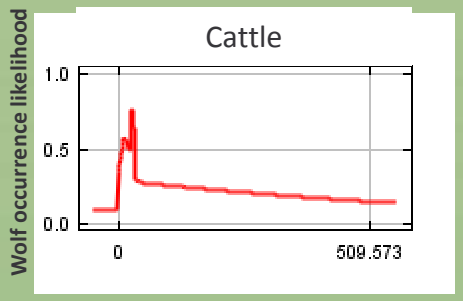


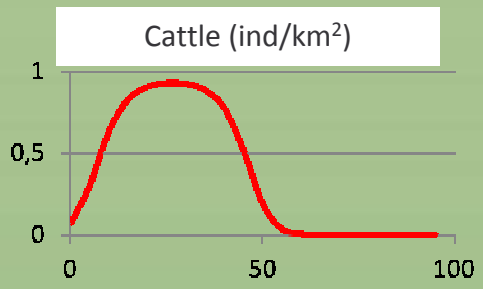


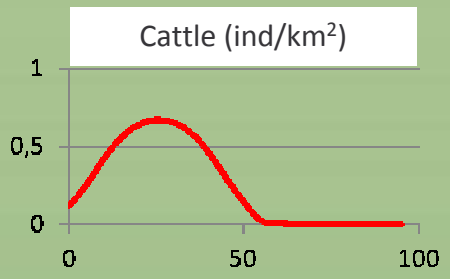


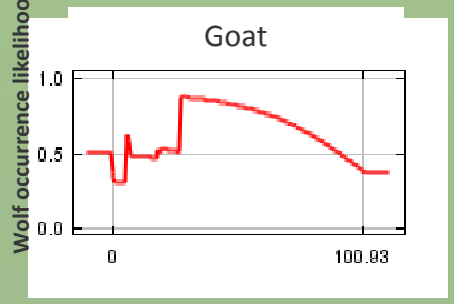
Iberian wolf occurrence models – prey

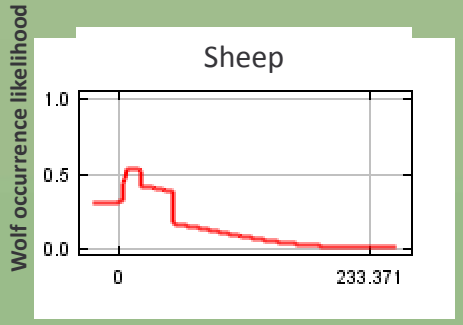
100x100m	2x2km	10x10km

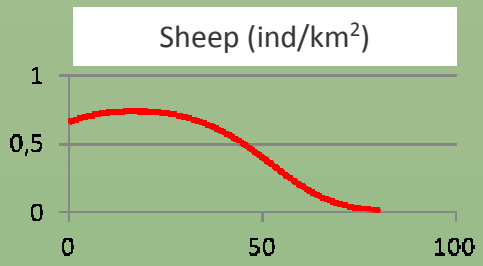


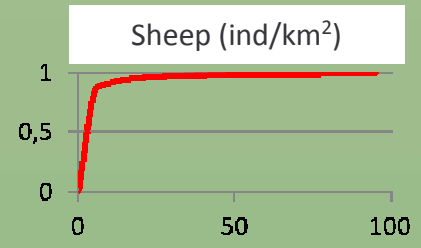






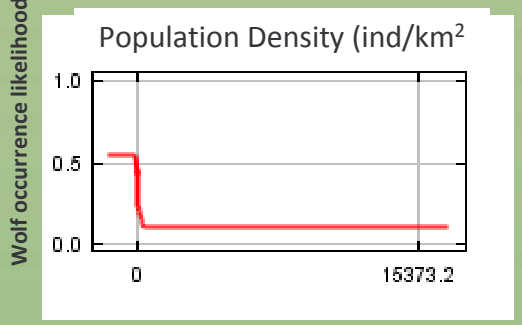


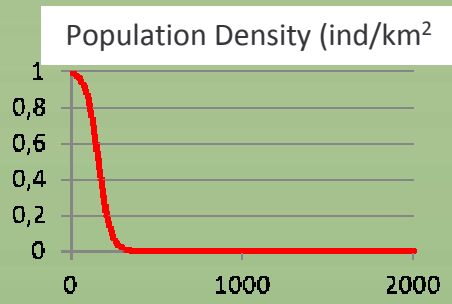


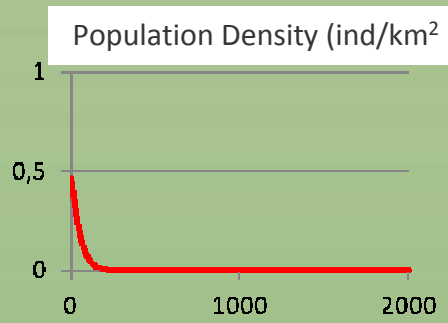


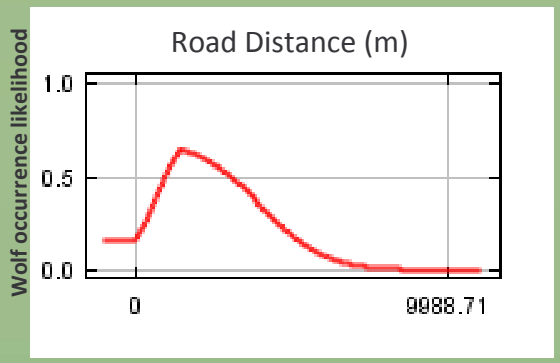
Iberian wolf occurrence models – human pressure

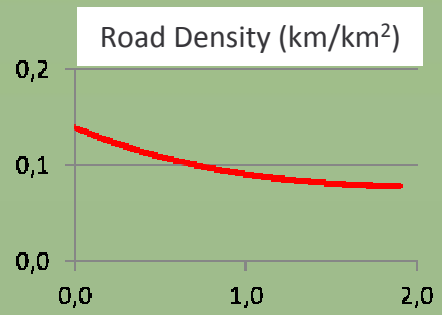
100x100m	2x2km	10x10km





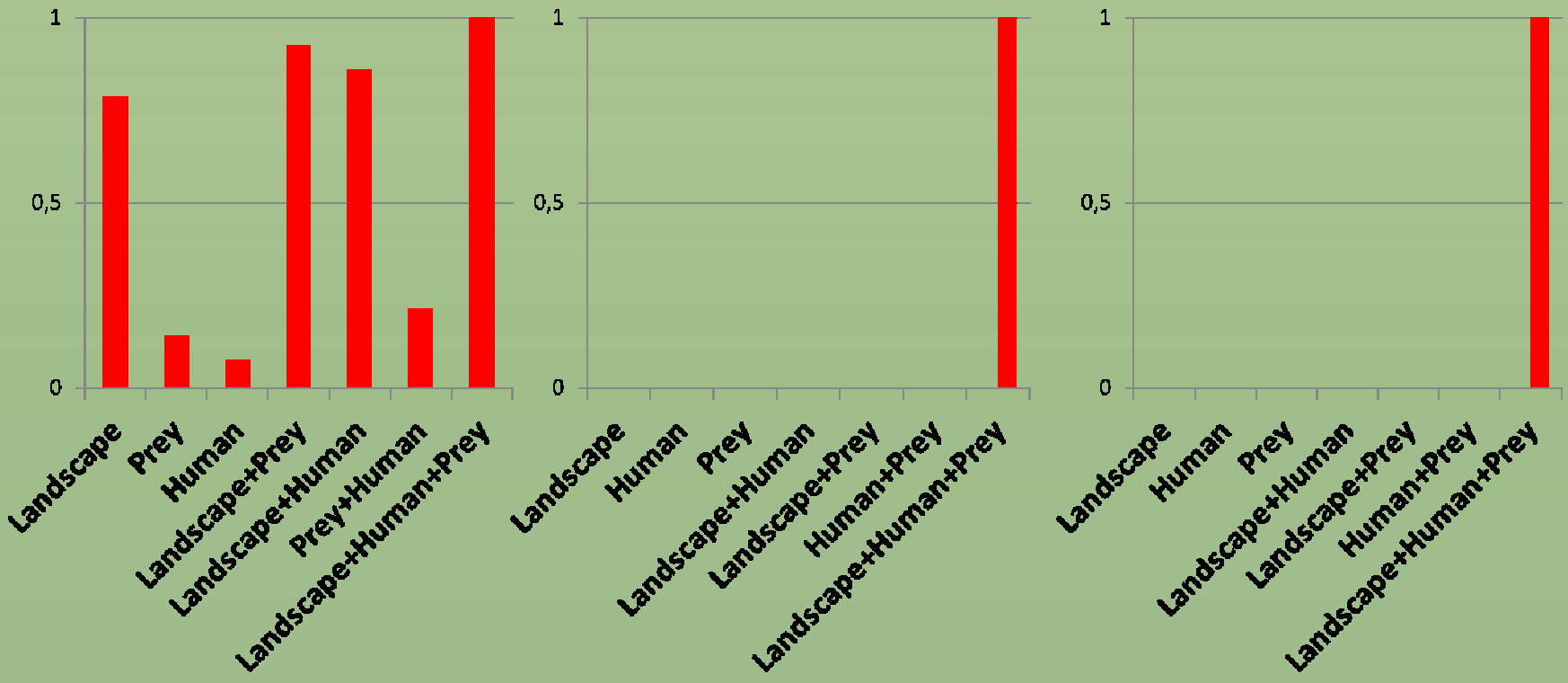






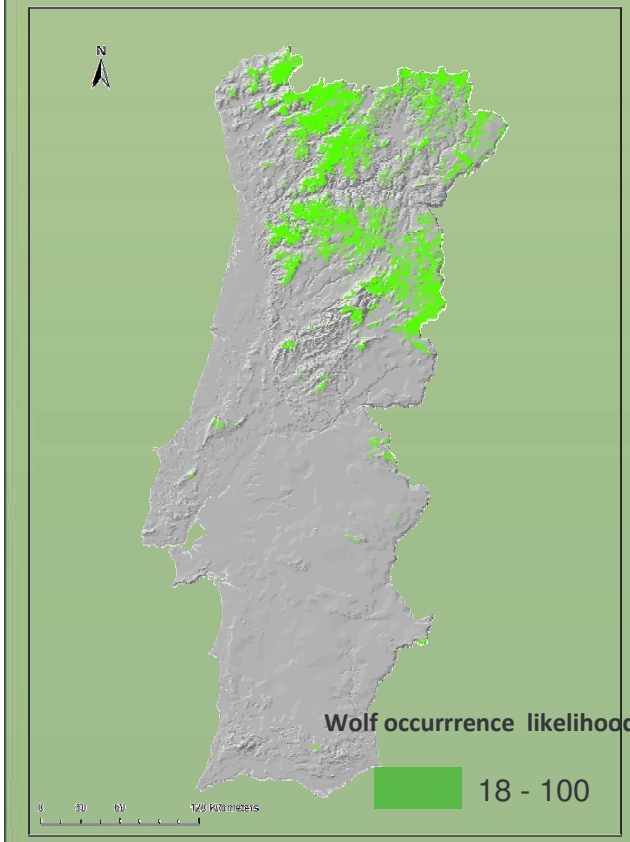
Relative weight of each group of variables

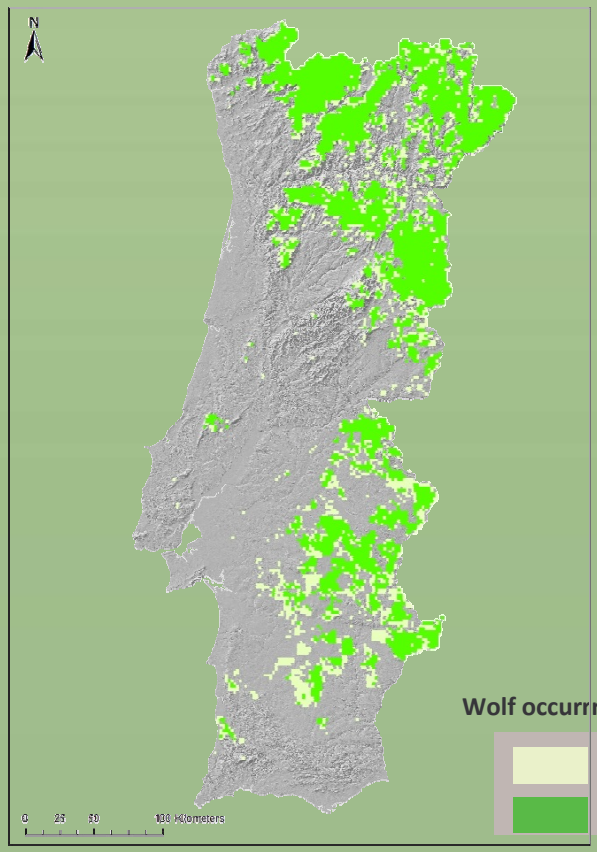
100x100m	2x2km	10x10km

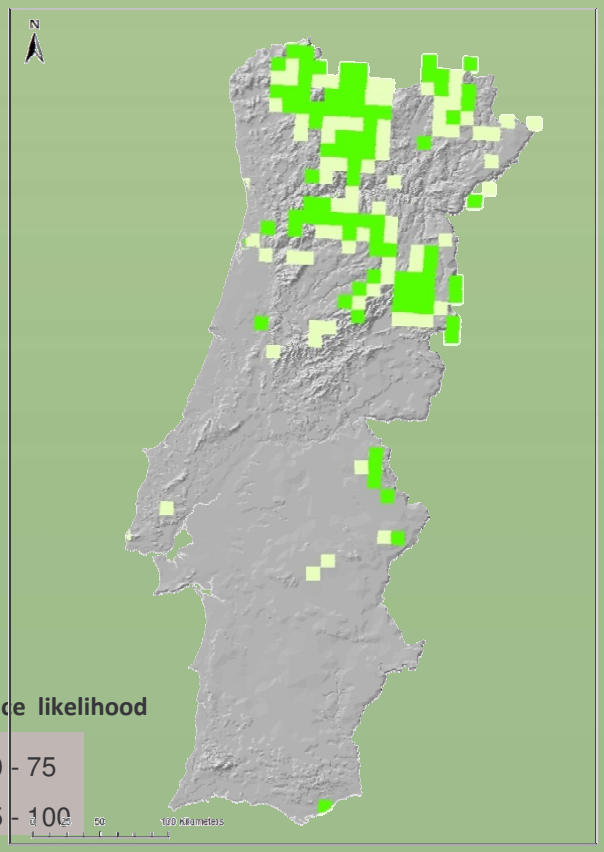


Iberian wolf occurrence likelihood

100x100m	2x2km	10x10km





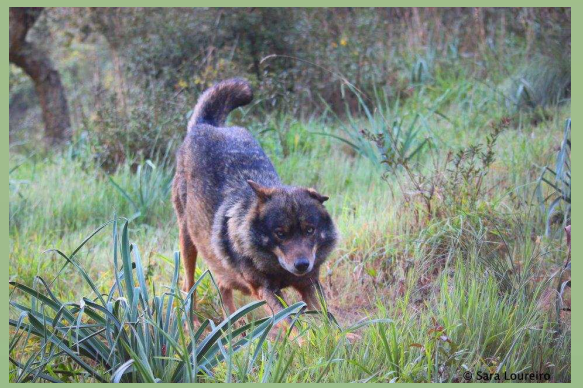


Area with 75% of wolf occurrrence likelihood = 17 444km²

Area with 75% of wolf occurrrence likelihood = 9 100 km²

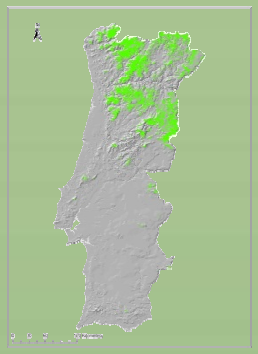
Correct classification: wolf squares *vs.* scales

Model	Vila Real and Bragança counties, NE Portugal	North and southern Douro river	Iberian peninsula
100x100m	--	**95%**	**62%**
2x2km	**91%**	--	**93%**
10x10km	**66%**	**71%**	--

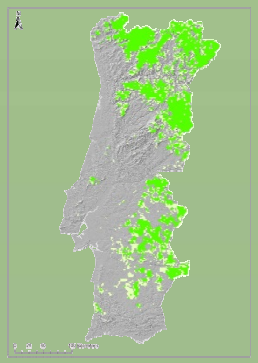


Conclusions

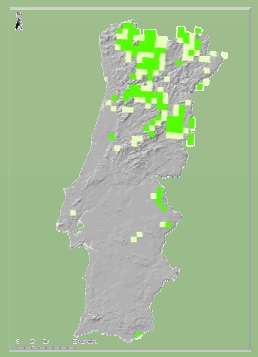
What is the effect of sample size and spatial scale to predict suitable habitat for wolf?



- ✓ **Local scale** (high resolution with low sample size) provided a **good model with a low extrapolation accuracy**.



- ✓ **Regional scale** (medium resolution and high sample size) provided the **best model with the highest extrapolation accuracy**.



- ✓ **Iberian Peninsula scale** (low resolution and the highest sample size) can lead to **less accurate results and extrapolation accuracy**.

Conclusions

Does the relative importance of landscape, human and prey-related features vary with sample size/scale?

- The combination **of landscape+prey+human** provided the best model for the **3 samples/scales levels**.
- **Landscape** (mainly, altitude) was the most influential group of variables at **local scale**.
- **The relationship between wolf occurrence likelihood and variables varied among scales**.
- **Prey (e.g. sheep and goat) and, human pressure (e.g. road density)** had different effects on **2x2km** and **10x10km models.**

What is the best trade-off between scale and sample to predict suitable habitat?

- **Sampling in locations that comprise all habitats used by Iberian wolf with high resolution may provide accurate habitat suitability models**

Take-home message

- **Co-operation among wolf research groups in Portugal and Spain is crucial** to evaluate the real preferences in order to perform conservation planning.

Next steps…

- **Disentangling the effects of sample and scale** on the wolf models accuracy.

- Incorporate data **on breeding sites and mortality** to improve the wolf occurrence models.

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PTDC/AAC-AMB/111457/2009

ACHLI
Associação de Conservação do Habitat do Lobo Ibérico

Institutions involved

GRUPO LOBO

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Centro de Biologia Ambiental

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Centro de Investigação em Biodiversidade e Recursos Genéticos

Estación Biológica Doñana CSIC

CESAM
Centre for Environmental and Marine Studies
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