Supplementary Material

Potential distribution of a climate sensitive species, the White-winged Snowfinch *Montifringilla nivalis* in Europe

MATTIA BRAMBILLA, JAIME RESANO-MAYOR, RAPHAËL ARLETTAZ, CHIARA BETTEGA, ANAÏS BINGGELI, GIUSEPPE BOGLIANI, VERONIKA BRAUNISCH, CLAUDIO CELADA, DAN CHAMBERLAIN, JULES CHIFFARD CARRICABURU, MARIA DEL MAR DELGADO, PHILIPPE FONTANILLES, PRIMOŽ KMECL, FRÄNZI KORNER, ROBERT LINDNER, PAOLO PEDRINI, JAKOB PÖHACKER, BORUT RUBINIČ, CHRISTIAN SCHANO, DAVIDE SCRIDEL, ELISEO STRINELLA, NORBERT TEUFELBAUER and MIGUEL DE GABRIEL HERNANDO

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Supplementary material for the paper

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Mattia Brambilla, Jaime Resano-Mayor, Raphaël Arlettaz, Chiara Bettega, Anaïs Binggeli, Giuseppe Bogliani, Veronika Braunisch, Claudio Celada,

Dan Chamberlain, Jules Chiffard Carricaburu, Maria Delgado, Philippe Fontanilles, Primož Kmecl, Fränzi Korner, Robert Lindner, Paolo Pedrini,

Jakob Pöhacker, Borut Rubinič, Christian Schano, Davide Scridel, Eliseo Strinella, Norbert Teufelbauer, Miguel de Gabriel Hernando

Preliminary modelling attempts

Before presenting in details the distribution model we obtained, we actually performed some other attempts with different number of background points (30 000 – 50 000 – 150 000), and different criteria for their spatial location (within a 10-km buffer from sample points, within a 50-km buffer, as in the final model). Notably, all models led to generally similar outcomes, but the ones we presented led to the most reliable estimate of occurrence of suitable habitats (at least in the well known areas).

Table S1. Summary statistics for MaxEnt model. The model highlighted in grey represents the 'final' one.
Legend of abbreviation: rm: regularization multiplier; AUC: area under the curve of the ROC plot; OR10: omission rate on test data at 10^{th} percentile; ORmin: omission rate on test data at minimum training presence.

rm	Full AUC	Mean. AUC	Var. AUC	Mean AUC DIFF	Mean OR10	AICc	ΔAICc	w.AIC	nk	AUC.1	AUC.2	AUC.3	AUC.4	OR10.1	OR10.2	OR10.3	OR10.4	ORmin.1	ORmin.2	ORmin.3	ORmin.4
0.5	0.986	0.986	0.000	0.001	0.106	48532.43	57.72	0	101	0.985	0.986	0.986	0.985	0.107	0.086	0.096	0.136	0.000	0.000	0.000	0.002
1	0.986	0.986	0.000	0.001	0.106	48506.26	31.55	0	85	0.985	0.986	0.986	0.985	0.107	0.083	0.099	0.136	0.000	0.000	0.000	0.002
1.5	0.986	0.986	0.000	0.001	0.104	48503.98	29.27	0	80	0.985	0.986	0.986	0.985	0.107	0.080	0.094	0.138	0.000	0.000	0.000	0.002
2	0.986	0.986	0.000	0.001	0.106	48511.49	36.78	0	77	0.985	0.986	0.986	0.985	0.110	0.083	0.096	0.136	0.000	0.000	0.000	0.002
2.5	0.986	0.986	0.000	0.001	0.105	48493.03	18.32	0	64	0.985	0.986	0.986	0.985	0.110	0.083	0.093	0.134	0.000	0.000	0.000	0.002
3	0.986	0.986	0.000	0.001	0.104	48474.71	0	0.62	50	0.985	0.986	0.986	0.985	0.115	0.085	0.090	0.129	0.000	0.000	0.000	0.000
3.5	0.986	0.986	0.000	0.001	0.102	48475.67	0.96	0.38	43	0.985	0.986	0.986	0.985	0.111	0.085	0.087	0.127	0.000	0.000	0.000	0.002
4	0.986	0.986	0.000	0.000	0.102	48487.93	13.22	0	40	0.985	0.986	0.986	0.985	0.111	0.085	0.090	0.124	0.000	0.000	0.000	0.002

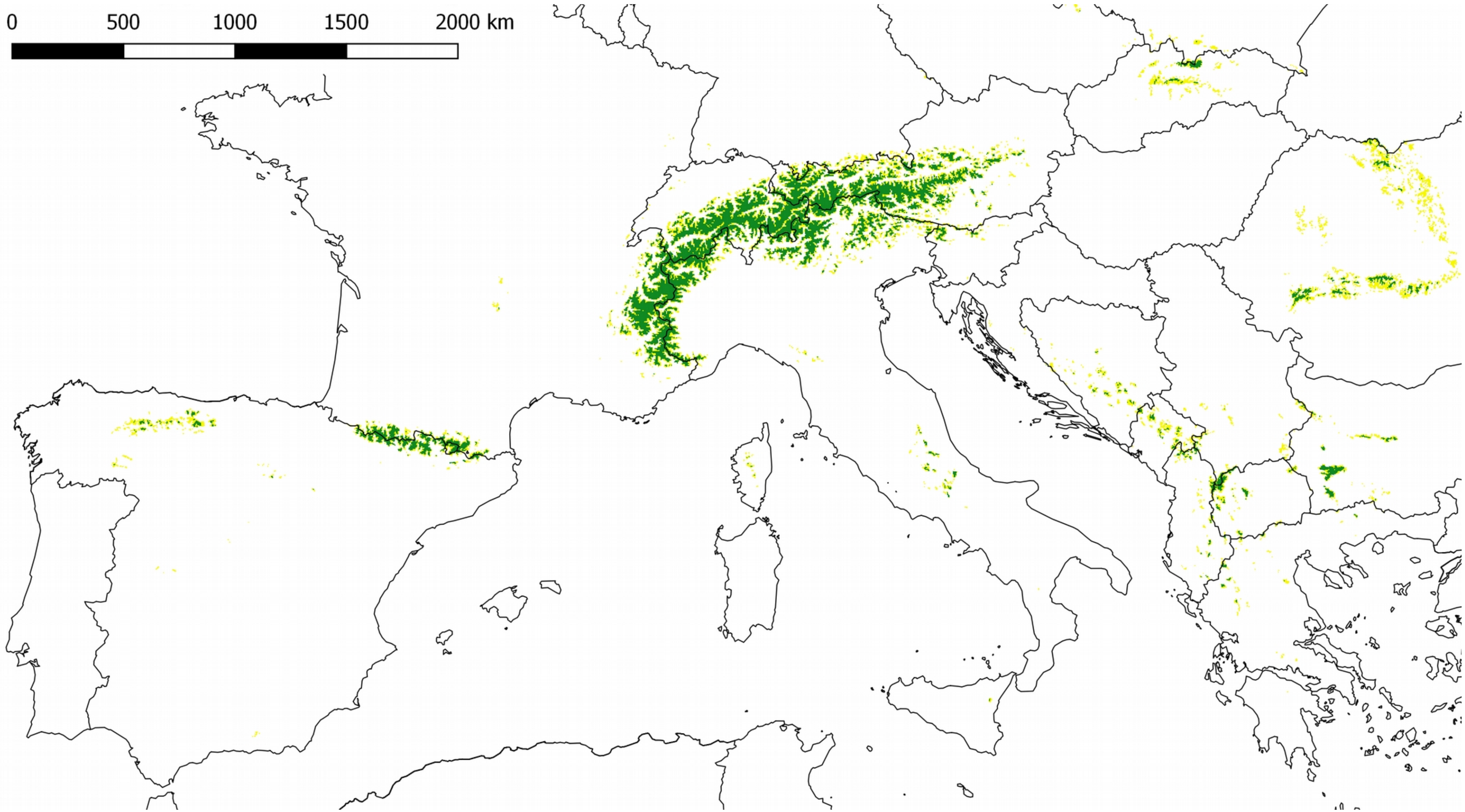
Table S2. Checklist proposed by Feng et al. (2019) compiled considering the features of our work (Feng et al. 2019. A checklist for maximizing reproducibility of ecological niche models. Nature Ecology & Evolution 3: 1382-1395).

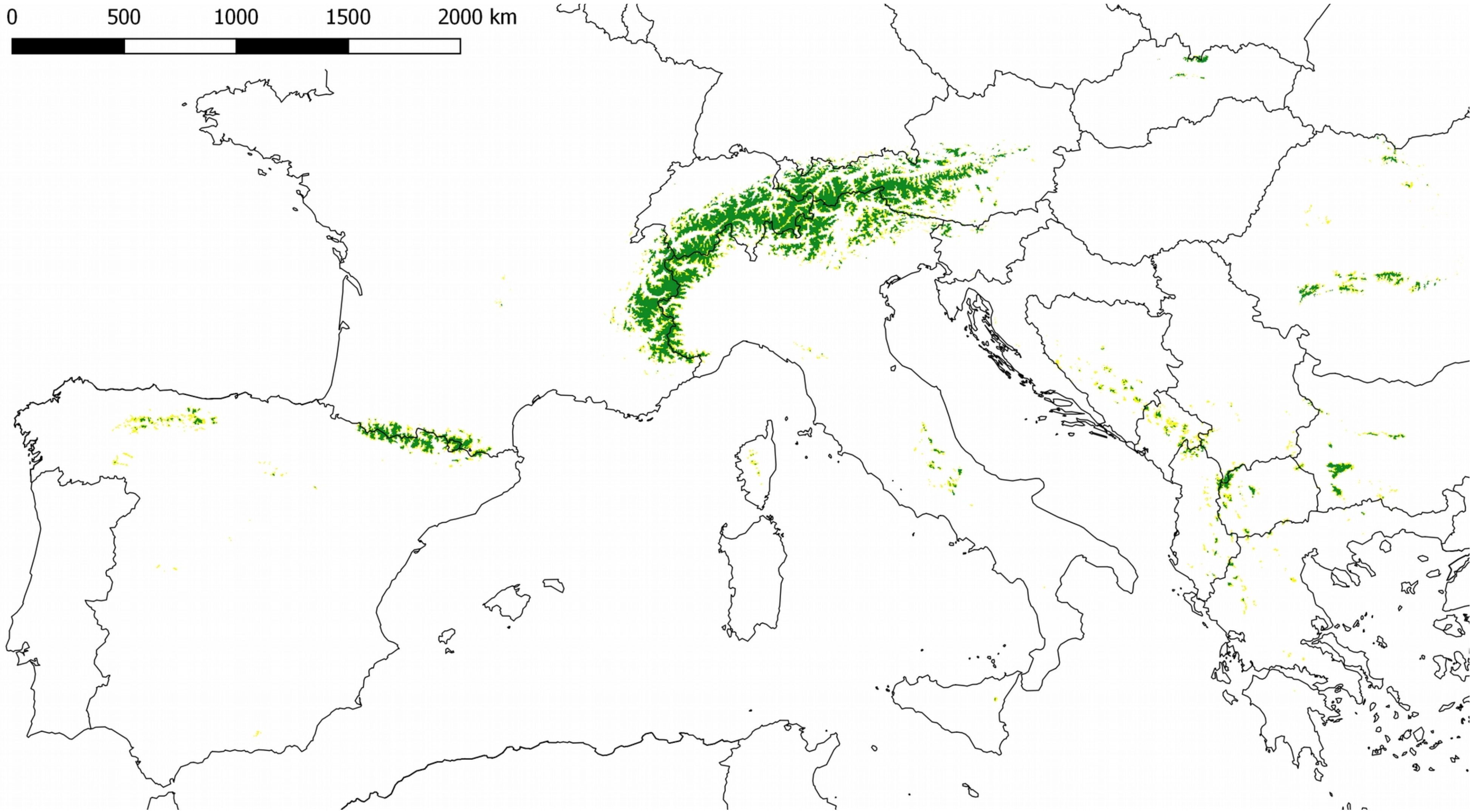
Workflow	Category	What to report	Our paper
(A) Obtaining and processing occurrence data	metadata	(A1) source of occurrence data	multiple sources, reported
		(A2) download date; version of data source	reported (approx.) / NA
		(A3) basis of records	reported
		(A4) spatial extent	reported and visually displayed in maps
		(A5) temporal range	reported
	processing	(A6-1) duplicate coordinates	records from the same 2 km x 2 km cells were removed
		(A6-2) spatial/environmental outlier; error	data were carefully checked before analyses
		(A6-3) spatial/coordinate uncertainty	data at ‘coarse’ resolution (over 1 km) were discarded
		(A7-1) sampling bias	described in text and maps
		(A7-2) spatial autocorrelation	partition of records into four spatially independent bins
(B) Obtaining and processing environmental data	metadata & processing	(B1) source	reported
		(B2) download date; version of data source	reported
		(B3) spatial resolution	reported

		(B4) temporal range	reported
(C) Model calibration	data input	(C1) modelling domain	reported
		(C2) number of background data	150 000
		(C3) sampling method for background data	randomly scattered over fully sampled countries
		(C4) variable selection	based on knowledge on species' ecology; process described; variables leading to multicollinearity issues removed (VIF > 5)
	algorithm	(C5) name	reported
		(C6) version of algorithm and software	reported
		(C7) parameterization	reported
(D) Model transfer and evaluation	evaluation	(D1) evaluation index	AUC and omission rates over independent bins
		(D2) threshold for evaluation index	MTP and 10th percentile for omission rates
		(D3) dataset used to evaluate models	different bins
	output	(D4) format/transformation	logistic; reported
		(D5) threshold	MTSS and 10th percentile
	extrapolation	(D6) novelty of projected environments compared with training environments	within the values sampled in training data (occurrence + background)
		(D7) collinearity shift between training and projected	very limited for variables selected in the model; VIF for

	environments	removal of multicollinear variables was calculated over all the area, including that of "extrapolation"
	(D8) extrapolation strategy	simple prediction
metadata	(D9) source	Same of training data
	(D10) download date; version of data source	
	(D11) spatial resolution	
	(D12) temporal range	

Figure S1. Comparison between the full model prediction (upper) and that with sites below 1500 m asl filtered as unsuitable (lower).





The main differences are found for the Carpathians, which are outside the range of the species. Also a few sites along the northern edge of the Alps are regarded as potentially suitable by the model but are discarded as they are below 1500 m asl. These are mostly sites located in colder valleys, and with some grassland, but in fact do not host the species (C. Schano & R. Arlettaz, pers. obs.).

Figure S2. Modelled distribution and current species range according to BirdLife distribution (light blue; BLD hereafter) in southern Italy and the Balkans.
1: Central Apennines: full concordance between the two; our modelled suitable areas are more accurate, BLD includes large unsuitable portions.
2: Croatia: the species currently does not breed (K. Mikulic com. pers.) in the country (as suggested by our model, contrary to BLD).
3: Relatively good concordance in Bosnia-Herzegovina and almost so in Montenegro.
4: Albania: suitable sites occurring within the country, but largely outside the BLD. To be investigated.
5: Macedonia: suitable areas located also just outside the BLD; one isolated area occupied according to BLD apparently does not include any suitable patch. To be investigated.
6: Nothern-central Greece: BLD, which includes several areas <1500 m asl, likely overestimates the real species distribution. Some suitable patches occur outside the BLD. To be investigated.
7: Southern Greece: occurring according to BLD, but almost no suitable area found there according to our model. To be investigated.
8: Southern Bulgaria: not occurring according to BLD; recently reported as non breeding in the country, but historical records of breeding pairs in 1960s (though regarded as not reliable) for Mt. Rila (Ivanov, B. 2011. The Fauna of Bulgaria. Vol. 30. Aves. Part III. Sofia, Prof. Marin Drinov Publ. House), the site with highest suitability according to our model. To be investigated.

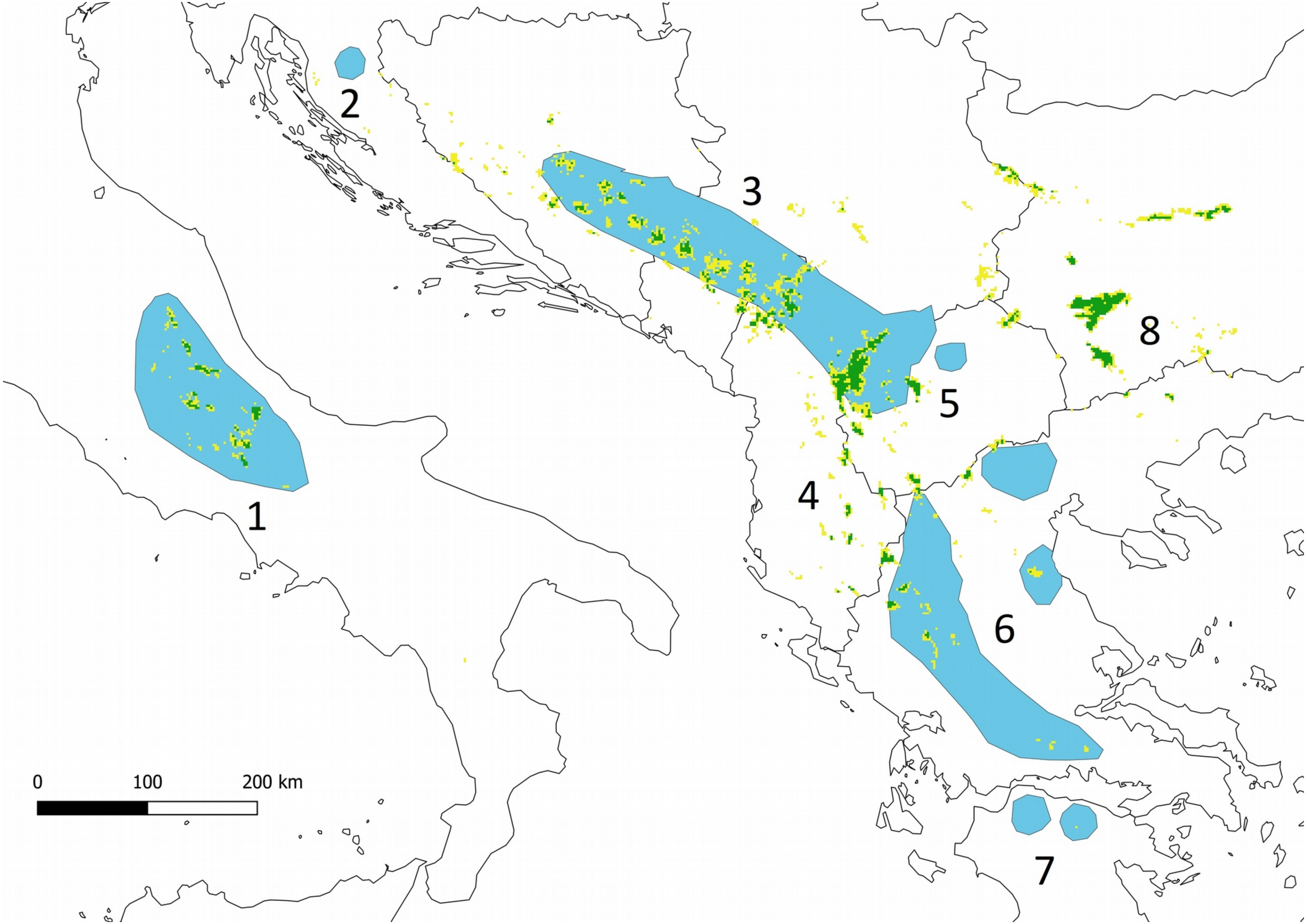

1
2
3
4
5
6
7
8
0
100
200 km

Figure S3. Modelled distribution and current species range according to BirdLife distribution (light blue; BLD hereafter) in western Europe.
1: Cantabrian Mountains: general concordance between BLD and model prediction, but the latter matches the occurrence data much better (plotted), especially in the west.
2: Pyrenees: the model provides a more accurate description of the local distribution of the species, which breeds in Andorra, whereas it is unlikely to occur in the NW part of the BLD, which covers a low-elevation area (largely between 30 and 500 m asl).
3: Western Alps: BLD tends to overestimate the actual species distribution, by including pre-alpine hills on both sides of the Alps, where the model depicts a total lack of suitable sites.

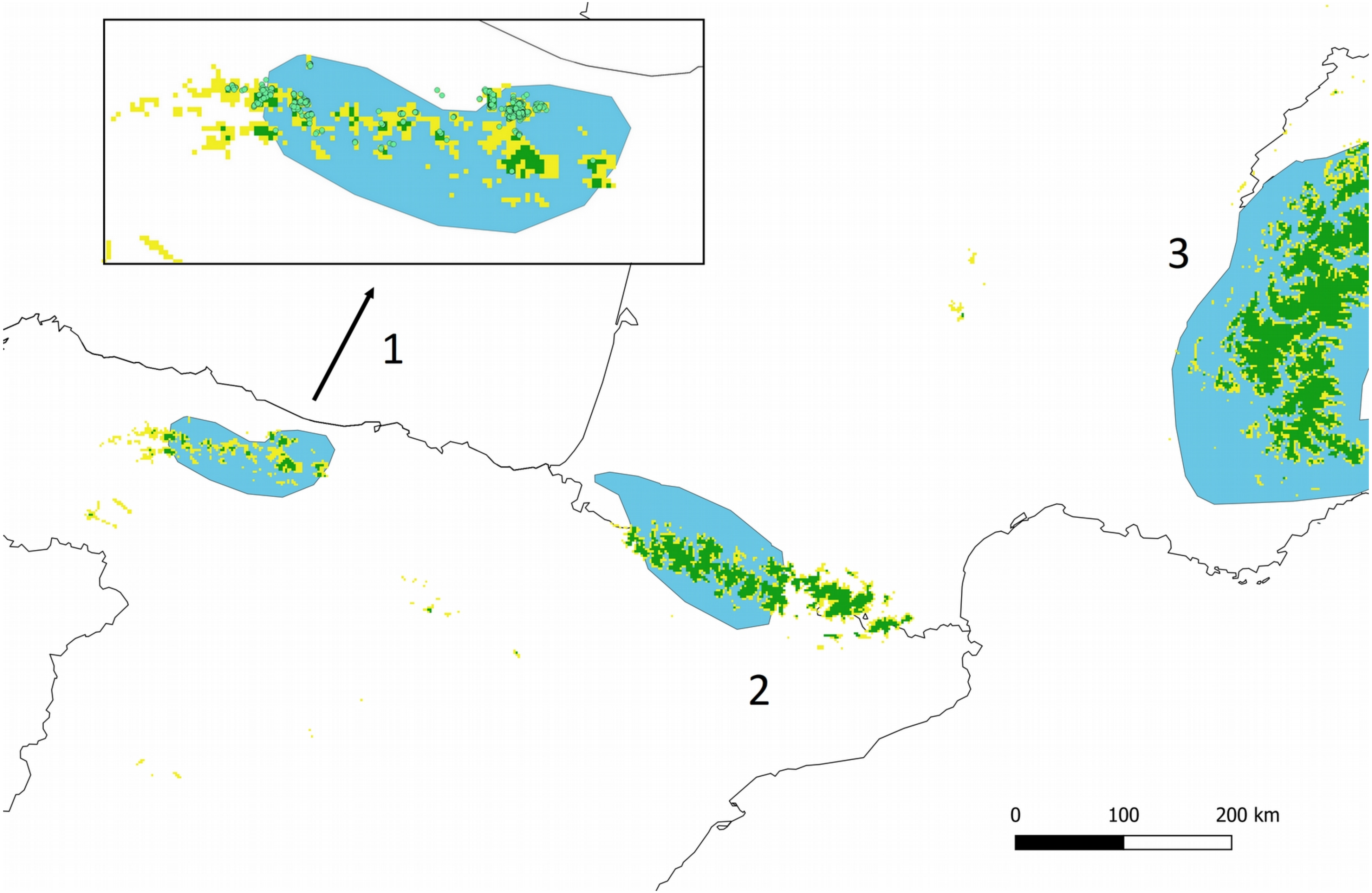

1
2
3
0
100
200 km

Figure S4. Response curves for variables included in the model (according to the full model and calculated keeping the other variables at their mean values). Note that values on the axes vary across variables.

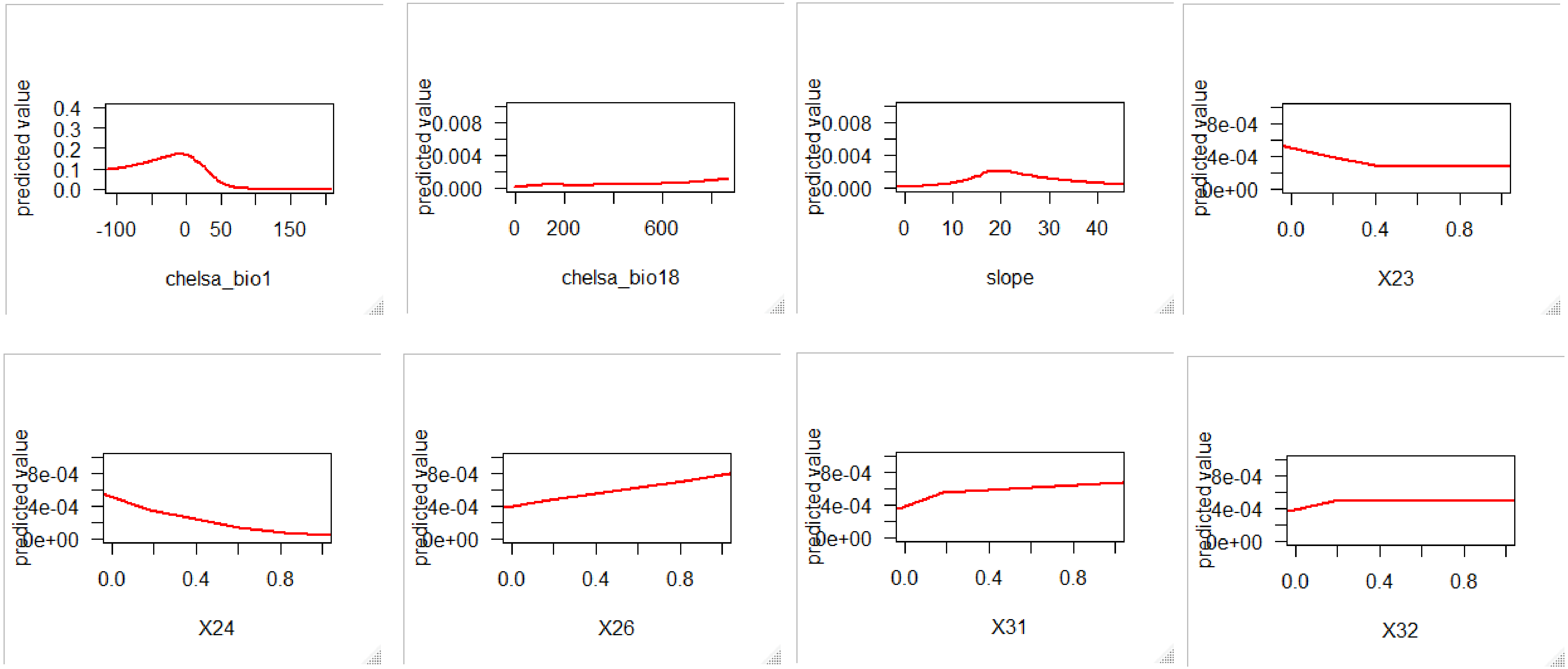


Figure S5. Number of independent records (occupied cells of 2 km x 2 km) for each cell of a 50 km x 50 km grid covering the entire area.