

Supplementary material

Appendix S1. Sensitivity and specificity for models obtained with the restricted data (sensEBCC and specEBCC) and the extensive data (sensWP and specWP), and sensitivity and specificity for the models obtained with restricted data but calculated from the extensive data range (sensEBCC_WP and specEBCC_WP) for the 152 species currently breeding at least in Iberia and in North Africa.

	sensEBCC	specEBCC	sensEBCC_WP	specEBCC_WP	sensWP	specWP
<i>Accipiter gentilis</i>	0.996	0.883	0.777	0.936	0.997	0.865
<i>Accipiter nisus</i>	0.996	0.901	0.742	0.960	0.999	0.889
<i>Acrocephalus arundinaceus</i>	0.995	0.928	0.772	0.957	0.993	0.871
<i>Acrocephalus scirpaceus</i>	0.997	0.913	0.843	0.941	0.994	0.865
<i>Alauda arvensis</i>	0.990	0.910	0.738	0.974	0.999	0.885
<i>Alcedo atthis</i>	0.992	0.934	0.772	0.968	0.994	0.894
<i>Alectoris barbara</i>	1.000	1.000	0.037	1.000	1.000	0.976
<i>Anas platyrhynchos</i>	0.993	0.911	0.712	0.984	0.995	0.888
<i>Anthus campestris</i>	0.995	0.905	0.765	0.931	0.994	0.868
<i>Apus apus</i>	0.994	0.891	0.722	0.961	0.995	0.878
<i>Apus caffer</i>	1.000	0.999	0.643	0.999	1.000	0.997
<i>Apus melba</i>	1.000	0.954	0.690	0.965	0.997	0.930
<i>Apus pallidus</i>	1.000	0.953	0.663	0.959	0.989	0.920
<i>Aquila chrysaetos</i>	0.995	0.853	0.543	0.864	0.989	0.780
<i>Aquila fasciata</i>	1.000	0.968	0.671	0.972	1.000	0.948
<i>Aquila pennata</i>	0.995	0.913	0.668	0.937	0.995	0.892
<i>Ardea purpurea</i>	1.000	0.900	0.843	0.909	0.997	0.853
<i>Ardeola ralloides</i>	0.991	0.924	0.711	0.928	0.989	0.869
<i>Asio otus</i>	0.995	0.897	0.734	0.943	0.995	0.850
<i>Athene noctua</i>	0.993	0.938	0.562	0.971	0.993	0.824
<i>Botaurus stellaris</i>	0.986	0.883	0.755	0.918	0.996	0.848
<i>Bubulcus ibis</i>	0.971	0.963	0.561	0.964	0.985	0.930
<i>Bucanetes githagineus</i>	1.000	1.000	0.015	1.000	1.000	0.927
<i>Burhinus oedicnemus</i>	0.992	0.894	0.610	0.904	0.992	0.833
<i>Buteo rufinus</i>	1.000	0.966	0.296	0.980	0.997	0.908
<i>Calandrella brachydactyla</i>	0.996	0.933	0.570	0.948	0.998	0.897
<i>Calandrella rufescens</i>	1.000	0.974	0.369	0.986	1.000	0.933
<i>Caprimulgus europaeus</i>	0.994	0.894	0.699	0.947	0.998	0.865
<i>Caprimulgus ruficollis</i>	1.000	0.992	0.547	0.993	1.000	0.983
<i>Carduelis cannabina</i>	0.986	0.912	0.737	0.962	0.998	0.889
<i>Carduelis carduelis</i>	0.992	0.915	0.700	0.972	0.991	0.886
<i>Carduelis chloris</i>	0.992	0.911	0.752	0.967	0.997	0.888
<i>Cecropis dauricus</i>	1.000	0.962	0.709	0.968	0.995	0.942
<i>Cercotrichas galactotes</i>	1.000	0.985	0.223	0.991	0.997	0.905

<i>Certhia brachydactyla</i>	0.997	0.966	0.919	0.970	0.998	0.949
<i>Cettia cetti</i>	0.996	0.963	0.630	0.973	0.998	0.916
<i>Charadrius alexandrinus</i>	0.987	0.913	0.614	0.922	0.994	0.849
<i>Chersophilus duponti</i>	1.000	0.993	0.434	0.993	1.000	0.969
<i>Ciconia ciconia</i>	0.996	0.909	0.780	0.930	0.996	0.879
<i>Cinclus cinclus</i>	1.000	0.892	0.813	0.902	0.997	0.816
<i>Circaetus gallicus</i>	0.993	0.913	0.592	0.946	0.996	0.900
<i>Circus aeruginosus</i>	0.987	0.900	0.641	0.924	0.997	0.837
<i>Circus pygargus</i>	0.993	0.882	0.714	0.910	0.995	0.845
<i>Cisticola juncidis</i>	1.000	0.965	0.744	0.970	0.996	0.945
<i>Clamator glandarius</i>	1.000	0.975	0.744	0.979	1.000	0.960
<i>Coccothraustes coccothraustes</i>	0.978	0.906	0.734	0.945	0.994	0.879
<i>Columba oenas</i>	0.995	0.896	0.704	0.938	0.997	0.885
<i>Columba palumbus</i>	0.992	0.875	0.752	0.946	0.995	0.850
<i>Coracias garrulus</i>	0.997	0.914	0.618	0.945	0.996	0.885
<i>Corvus corax</i>	0.990	0.877	0.650	0.937	0.994	0.858
<i>Corvus monedula</i>	0.985	0.901	0.690	0.947	0.994	0.871
<i>Coturnix coturnix</i>	0.991	0.895	0.683	0.943	0.995	0.859
<i>Cuculus canorus</i>	0.990	0.909	0.722	0.990	0.998	0.910
<i>Delichon urbicum</i>	0.983	0.914	0.718	0.991	0.993	0.898
<i>Dendrocopos major</i>	0.993	0.892	0.743	0.945	0.996	0.842
<i>Dendrocopos minor</i>	0.996	0.897	0.694	0.945	0.999	0.853
<i>Egretta garzetta</i>	0.994	0.915	0.843	0.921	0.996	0.879
<i>Elanus caeruleus</i>	1.000	0.993	0.509	0.993	1.000	0.974
<i>Emberiza calandra</i>	0.996	0.943	0.795	0.971	0.997	0.938
<i>Emberiza cia</i>	1.000	0.952	0.728	0.957	1.000	0.912
<i>Emberiza cirrus</i>	1.000	0.973	0.896	0.979	1.000	0.962
<i>Emberiza hortulana</i>	0.987	0.872	0.662	0.909	0.997	0.849
<i>Emberiza schoeniclus</i>	0.996	0.896	0.704	0.948	0.998	0.872
<i>Eremophila alpestris</i>	0.987	0.953	0.459	0.958	0.995	0.918
<i>Erithacus rubecula</i>	0.995	0.911	0.776	0.967	1.000	0.900
<i>Falco biarmicus</i>	1.000	0.990	0.202	0.990	1.000	0.851
<i>Falco naumanni</i>	1.000	0.931	0.584	0.948	0.997	0.892
<i>Falco peregrinus</i>	0.992	0.847	0.522	0.854	0.998	0.737
<i>Falco subbuteo</i>	0.993	0.889	0.704	0.941	0.996	0.875
<i>Falco tinnunculus</i>	0.993	0.898	0.656	0.983	0.986	0.853
<i>Fringilla coelebs</i>	0.994	0.911	0.731	0.979	0.997	0.873
<i>Fulica atra</i>	0.992	0.907	0.992	0.907	0.993	0.902
<i>Galerida cristata</i>	0.996	0.940	0.590	0.960	0.997	0.859
<i>Galerida theklae</i>	1.000	0.992	0.332	0.993	1.000	0.974
<i>Gallinula chloropus</i>	0.993	0.920	0.721	0.955	0.983	0.847
<i>Garrulus glandarius</i>	0.994	0.908	0.712	0.963	0.996	0.875
<i>Glareola pratincola</i>	1.000	0.940	0.718	0.943	1.000	0.896
<i>Gyps fulvus</i>	0.989	0.944	0.616	0.951	0.989	0.925
<i>Himantopus himantopus</i>	0.995	0.900	0.832	0.906	0.993	0.862
<i>Hippolais opaca</i>	1.000	0.991	0.373	0.992	1.000	0.976
<i>Hippolais polyglotta</i>	1.000	0.981	0.822	0.983	1.000	0.978
<i>Hirundo rustica</i>	0.993	0.909	0.720	0.979	0.995	0.864
<i>Ixobrychus minutus</i>	0.998	0.922	0.677	0.940	0.988	0.853
<i>Jynx torquilla</i>	0.993	0.904	0.740	0.946	0.999	0.898

<i>Lanius meridionalis</i>	1.000	0.995	0.203	0.996	0.995	0.934
<i>Lanius senator</i>	0.992	0.939	0.712	0.944	0.997	0.893
<i>Larus michahellis</i>	0.986	0.939	0.929	0.940	0.987	0.927
<i>Locustella lusciniooides</i>	0.995	0.892	0.867	0.916	0.991	0.863
<i>Loxia curvirostra</i>	0.997	0.869	0.730	0.904	1.000	0.825
<i>Lullula arborea</i>	0.989	0.930	0.780	0.965	0.992	0.911
<i>Luscinia megarhynchos</i>	0.995	0.967	0.832	0.978	0.998	0.930
<i>Marmaronetta angustirostris</i>	1.000	1.000	0.136	1.000	1.000	0.972
<i>Melanocorypha calandra</i>	0.995	0.942	0.619	0.958	0.995	0.920
<i>Merops apiaster</i>	0.987	0.897	0.637	0.918	0.993	0.869
<i>Milvus migrans</i>	0.994	0.895	0.618	0.935	0.991	0.860
<i>Milvus milvus</i>	0.992	0.907	0.978	0.910	0.996	0.906
<i>Monticola saxatilis</i>	1.000	0.950	0.757	0.952	0.996	0.917
<i>Monticola solitarius</i>	0.988	0.960	0.679	0.971	1.000	0.938
<i>Motacilla alba</i>	0.995	0.902	0.727	0.985	0.995	0.922
<i>Motacilla cinerea</i>	0.996	0.919	0.858	0.924	0.997	0.867
<i>Motacilla flava</i>	0.994	0.902	0.692	0.952	0.985	0.849
<i>Muscicapa striata</i>	0.994	0.910	0.738	0.974	0.997	0.885
<i>Neophron percnopterus</i>	1.000	0.950	0.449	0.954	0.993	0.906
<i>Netta rufina</i>	0.993	0.891	0.809	0.895	1.000	0.861
<i>Nycticorax nycticorax</i>	0.996	0.899	0.842	0.902	0.997	0.859
<i>Oenanthe hispanica</i>	0.993	0.963	0.541	0.973	0.997	0.929
<i>Oenanthe leucura</i>	1.000	0.988	0.441	0.991	1.000	0.982
<i>Oenanthe oenanthe</i>	0.993	0.893	0.704	0.966	0.997	0.887
<i>Oriolus oriolus</i>	0.991	0.917	0.753	0.966	0.995	0.878
<i>Otis tarda</i>	1.000	0.955	0.669	0.958	0.994	0.922
<i>Otus scops</i>	0.991	0.928	0.617	0.959	0.996	0.885
<i>Parus major</i>	0.997	0.885	0.754	0.965	0.994	0.867
<i>Passer domesticus</i>	0.996	0.870	0.662	0.949	0.993	0.808
<i>Passer hispaniolensis</i>	1.000	0.957	0.551	0.970	1.000	0.923
<i>Passer montanus</i>	0.992	0.866	0.734	0.927	0.997	0.863
<i>Periparus ater</i>	0.993	0.898	0.993	0.898	0.997	0.728
<i>Petronia petronia</i>	0.985	0.958	0.551	0.965	1.000	0.910
<i>Phasianus colchicus</i>	0.994	0.924	0.888	0.948	0.996	0.906
<i>Phoenicurus ochruros</i>	0.993	0.910	0.928	0.928	0.993	0.890
<i>Phoenicurus phoenicurus</i>	0.996	0.872	0.744	0.935	0.996	0.843
<i>Phylloscopus bonelli</i>	1.000	0.975	0.864	0.977	1.000	0.968
<i>Pica pica</i>	0.995	0.890	0.721	0.968	0.995	0.883
<i>Podiceps cristatus</i>	0.993	0.893	0.769	0.929	0.995	0.854
<i>Porphyrio porphyrio</i>	1.000	0.986	0.371	0.987	1.000	0.968
<i>Pterocles alchata</i>	1.000	0.988	0.238	0.988	1.000	0.956
<i>Pterocles orientalis</i>	1.000	0.992	0.280	0.992	1.000	0.952
<i>Ptyonoprogne rupestris</i>	1.000	0.959	0.698	0.965	1.000	0.943
<i>Pyrrhocorax graculus</i>	1.000	0.962	0.646	0.964	0.993	0.923
<i>Pyrrhocorax pyrrhocorax</i>	1.000	0.962	0.655	0.963	1.000	0.923
<i>Rallus aquaticus</i>	0.995	0.912	0.773	0.947	0.991	0.868
<i>Regulus ignicapillus</i>	1.000	0.962	0.930	0.963	1.000	0.928
<i>Saxicola torquatus</i>	0.989	0.898	0.821	0.928	0.994	0.883
<i>Serinus serinus</i>	0.996	0.958	0.839	0.964	0.998	0.947
<i>Sitta europaea</i>	0.994	0.916	0.718	0.947	0.996	0.874

<i>Streptopelia turtur</i>	0.994	0.904	0.650	0.942	0.990	0.860
<i>Strix aluco</i>	0.992	0.920	0.761	0.959	0.998	0.879
<i>Sturnus unicolor</i>	1.000	0.989	0.810	0.991	1.000	0.985
<i>Sylvia atricapilla</i>	0.995	0.910	0.803	0.945	0.999	0.881
<i>Sylvia cantillans</i>	0.994	0.972	0.887	0.975	0.995	0.961
<i>Sylvia communis</i>	0.995	0.900	0.751	0.954	0.995	0.870
<i>Sylvia conspicillata</i>	1.000	0.977	0.675	0.980	1.000	0.971
<i>Sylvia hortensis</i>	1.000	0.980	0.745	0.982	1.000	0.969
<i>Sylvia melanocephala</i>	0.994	0.971	0.760	0.980	0.988	0.963
<i>Sylvia undata</i>	1.000	0.982	0.974	0.986	1.000	0.985
<i>Tachybaptus ruficollis</i>	0.992	0.927	0.864	0.946	0.997	0.887
<i>Tetrao tetrix</i>	0.991	0.965	0.713	0.967	1.000	0.955
<i>Troglodytes troglodytes</i>	0.995	0.903	0.824	0.951	0.996	0.859
<i>Turdus merula</i>	0.991	0.911	0.792	0.965	0.997	0.888
<i>Turdus viscivorus</i>	0.996	0.876	0.748	0.920	0.999	0.829
<i>Tyto alba</i>	0.998	0.972	0.797	0.974	0.990	0.942
<i>Upupa epops</i>	0.993	0.940	0.665	0.972	0.989	0.899
<i>Vanellus vanellus</i>	0.990	0.893	0.728	0.952	0.998	0.883

Appendix S2. Sensitivity and specificity for models obtained with the extensive data (sens and spec) for the 27 species currently breeding in North Africa but not in Europe.

	sens	spec
<i>Ammomanes cincturus</i>	1.000	0.932
<i>Ammomanes deserti</i>	0.997	0.890
<i>Apus affinis</i>	1.000	0.979
<i>Bubo ascalaphus</i>	0.998	0.958
<i>Corvus ruficollis</i>	1.000	0.927
<i>Cursorius cursor</i>	1.000	0.950
<i>Cyanistes teneriffae</i>	1.000	0.991
<i>Emberiza sahari</i>	1.000	0.966
<i>Eremophila bilopha</i>	1.000	0.964
<i>Falco pelegrinoides</i>	1.000	0.970
<i>Ficedula speculigera</i>	1.000	0.988
<i>Merops persicus</i>	1.000	0.962
<i>Oenanthe deserti</i>	0.992	0.960
<i>Oenanthe leucopyga</i>	1.000	0.904
<i>Oenanthe moesta</i>	1.000	0.977
<i>Phoenicurus moussieri</i>	1.000	0.989
<i>Picus vaillanti</i>	1.000	0.994
<i>Pterocles coronatus</i>	1.000	0.939
<i>Pterocles senegallus</i>	1.000	0.924
<i>Pycnonotus barbatus</i>	1.000	0.981
<i>Rhamphocoris clotbey</i>	1.000	0.985
<i>Riparia paludicola</i>	1.000	0.999
<i>Scotocerca inquieta</i>	1.000	0.988
<i>Streptopelia senegalensis</i>	0.993	0.900
<i>Sylvia deserticola</i>	1.000	0.986
<i>Tadorna ferruginea</i>	1.000	0.949
<i>Tchagra senegala</i>	1.000	0.988

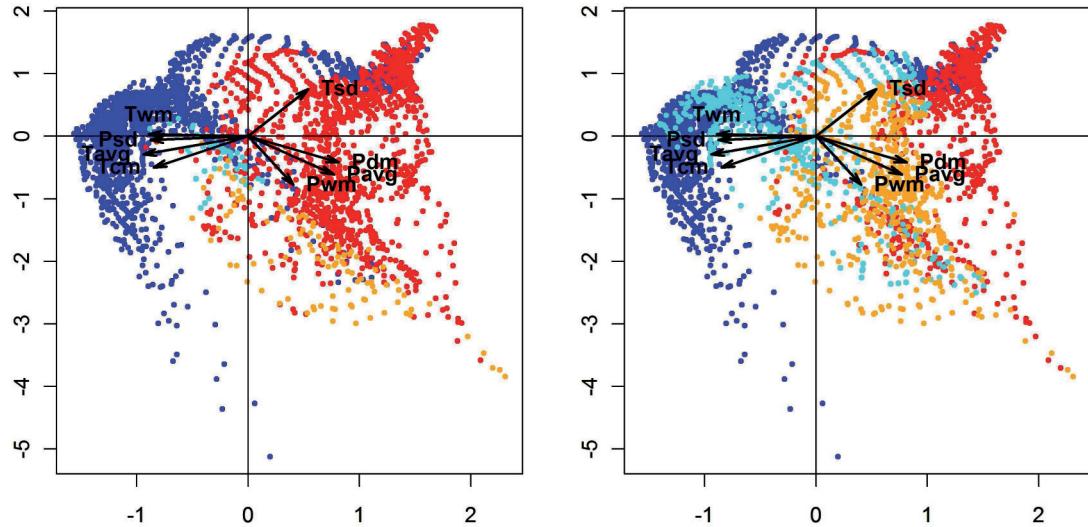


Figure S3. Occurrence data in the climatic space (the first two significant axis of the PCA) compared to all available pixels of the study for *Sylvia hortensis* (left) and *Galerida critata* (right). Red points and blue points stand for the space available for European-restricted data and for the points added to get the extensive ranges. Orange and cyan points represent the presence points used for the model from restricted data and added to get the full extensive range of the considered species. The projection of the climatic variables in the climatic space defined by the two significant axes of the PCA is added to each graphic. Climatic variables are: Tavg = annual mean temperature, Twm = mean temperature of the warmest month, Tcm = mean temperature of the coldest month, Tsd = temperature seasonality, Pavg = annual precipitation, Pwm = precipitation of the wettest month, Pdm = precipitation of the driest month and Psd = precipitation seasonality.

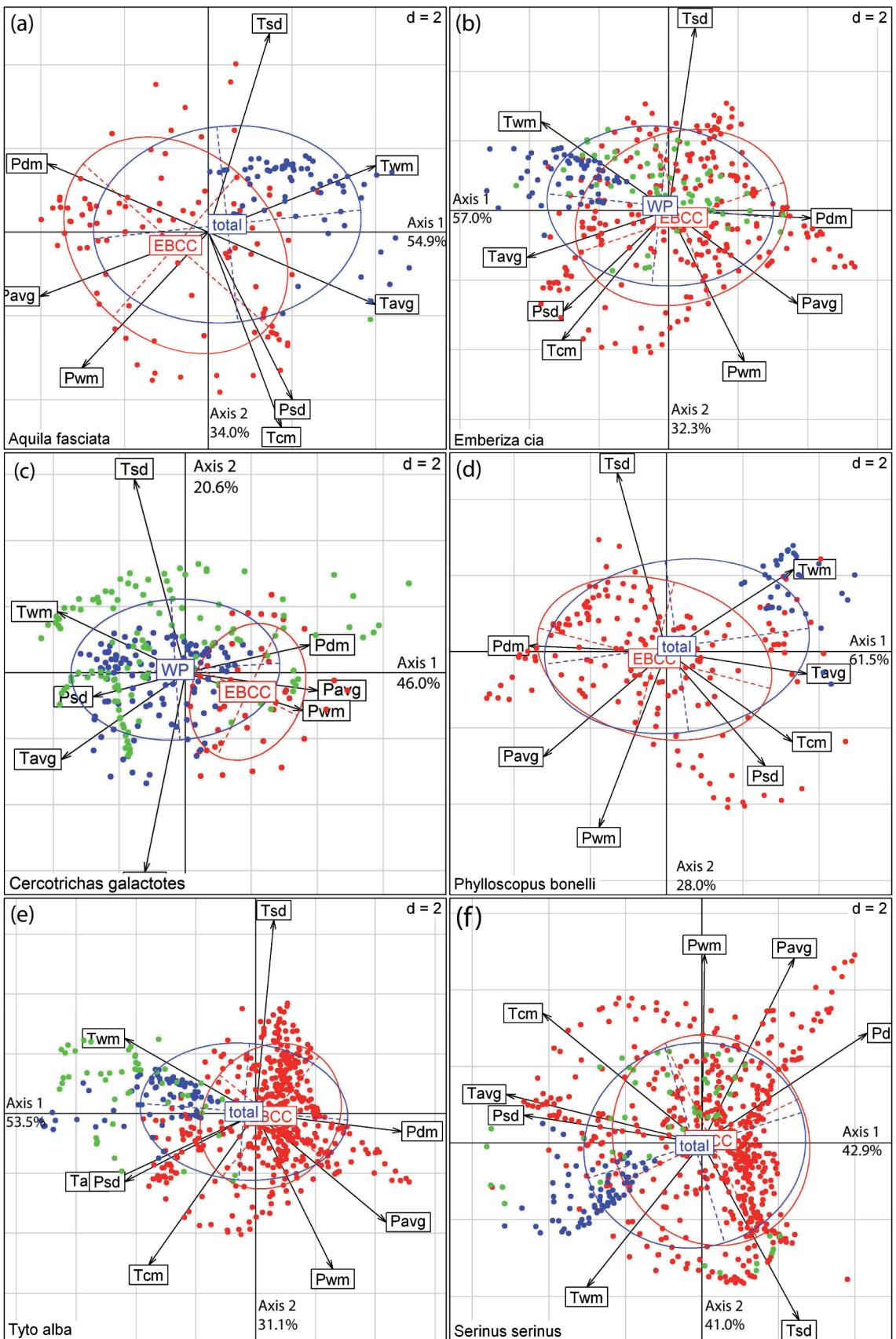


Figure S4. Occurrence data in the climatic space (the first two significant axis of the PCA) for (a) *Aquila fasciata*, (b) *Emberiza cia*, (c) *Cercotrichas galactotes*, (d) *Phylloscopus bonelli*, (e) *Tyto alba* and (f) *Serinus serinus*. The part of the variance explained by each axis is specified. Red points stand for European-restricted data, whereas blue and green points represent the data points added to get the full WP range (blue points standing for North African pixels and green points standing for pixels from Middle East to Siberia). The 1.5 inertia ellipses for European-restricted data (EBCC, red) and extensive data (WP, blue) illustrate the climatic niche extension (the red ellipse stands for only the red points (European atlas data) and the blue ellipse stands for all the points (full WP data)). The projection of the climatic variables in the climatic space defined by the two significant axes of the PCA is added to each graphic. Climatic variables are: Tavg = annual mean temperature, Twm = mean temperature of the warmest month, Tcm = mean temperature of the coldest month, Tsd = temperature seasonality, Pavg = annual precipitation, Pwm = precipitation of the wettest month, Pdm = precipitation of the driest month and Psd = precipitation seasonality.

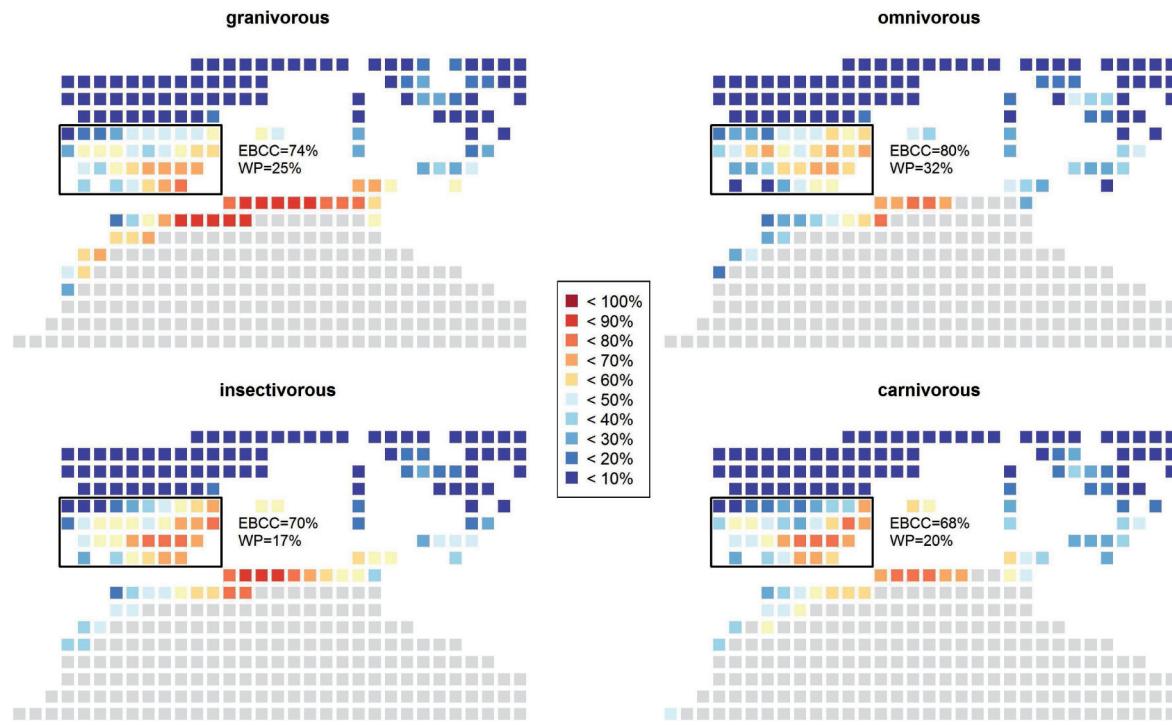
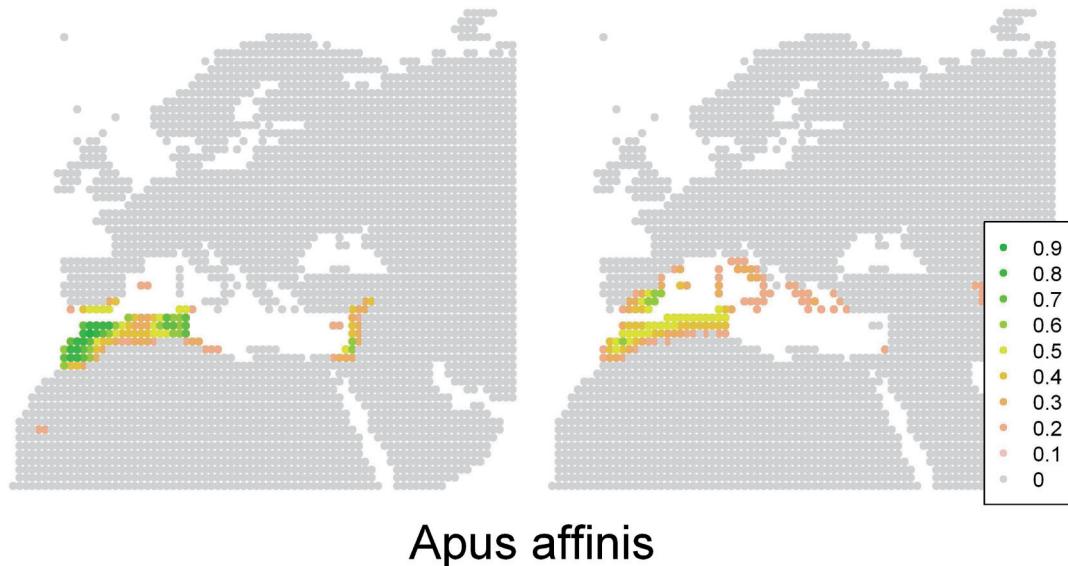


Figure S5. Difference in local extinction rates obtained from restricted data and extensive data, for 4 guilds of birds. The percentages represent the average extinction rate of the southern part of Iberia (within the box) for the species richness modelled from restricted data (EBCC) and for the species richness modelled from extensive data (WP).

(a)

1990

2100



(b)

1990

2100

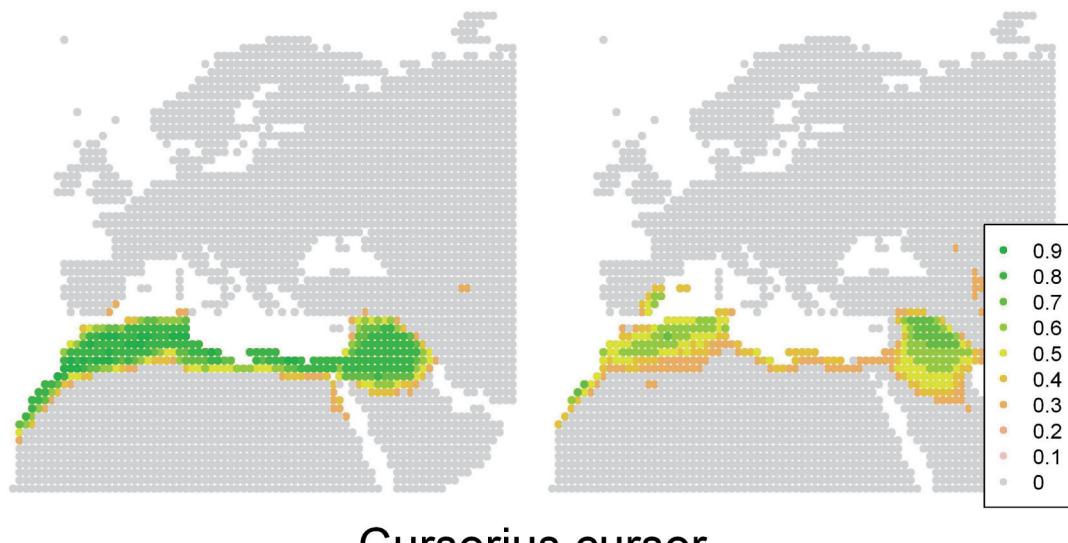


Figure S6a, b. Current and future modelled distribution for 6 species currently breeding in North Africa but not in Europe which are potential climatic colonizers: (a) *Apus affinis*, (b) *Cursorius cursor*.

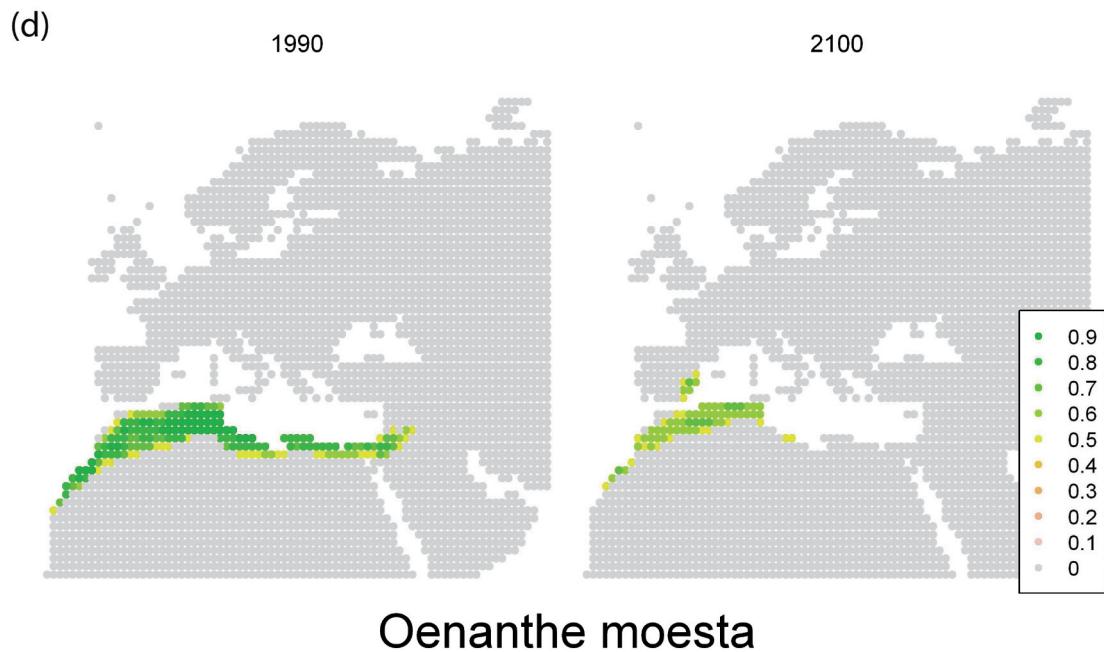
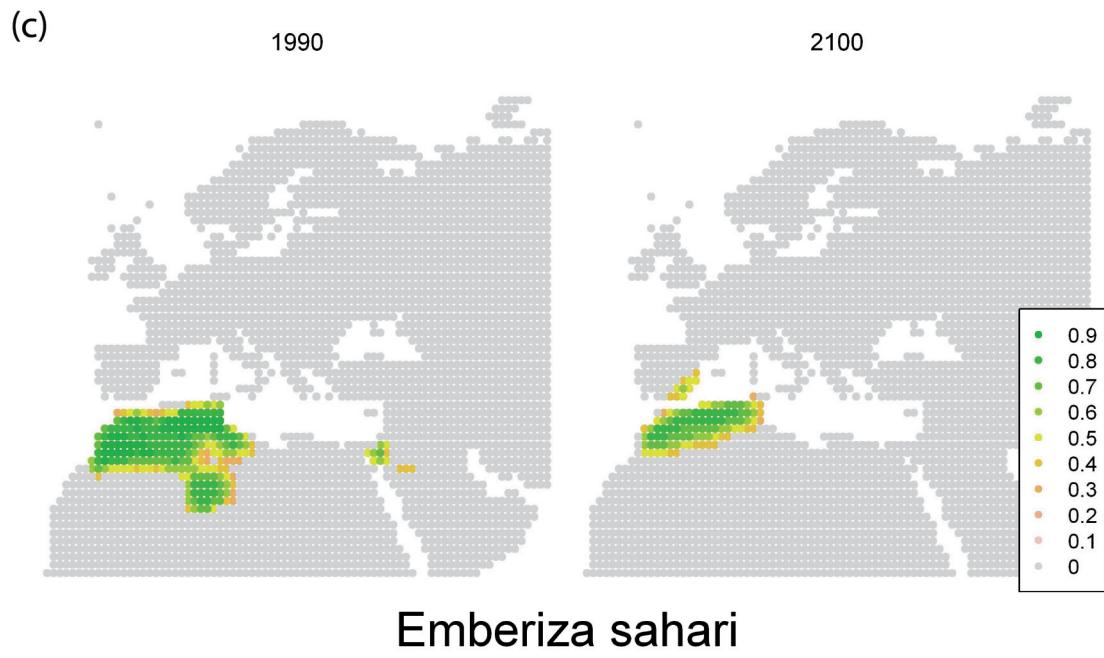
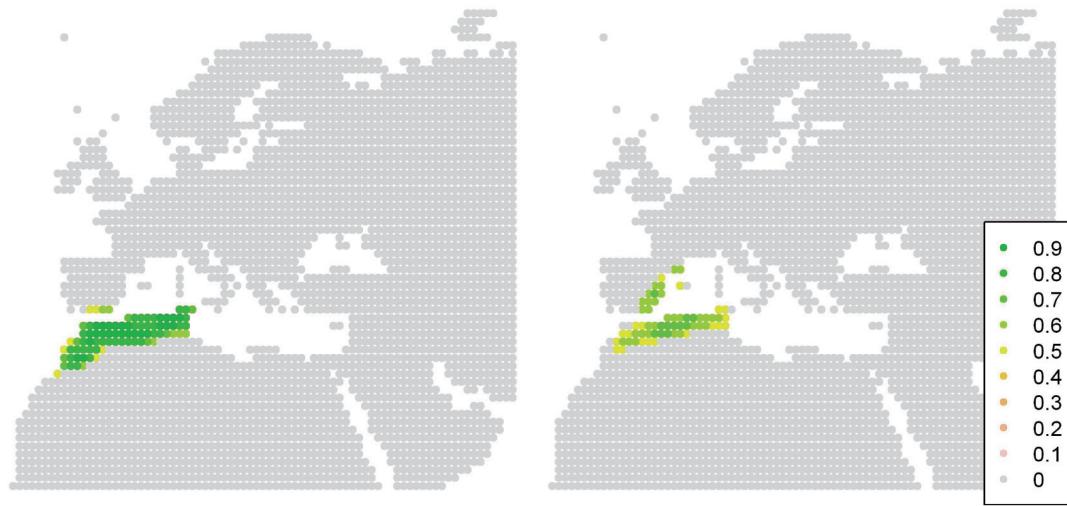


Figure S6c, d. Current and future modelled distribution for 6 species currently breeding in North Africa but not in Europe which are potential climatic colonizers: (c) *Emberiza sahari*, (d) *Oenanthe moesta*.

(e)

1990

2100

***Phoenicurus moussieri***

(f)

1990

2100

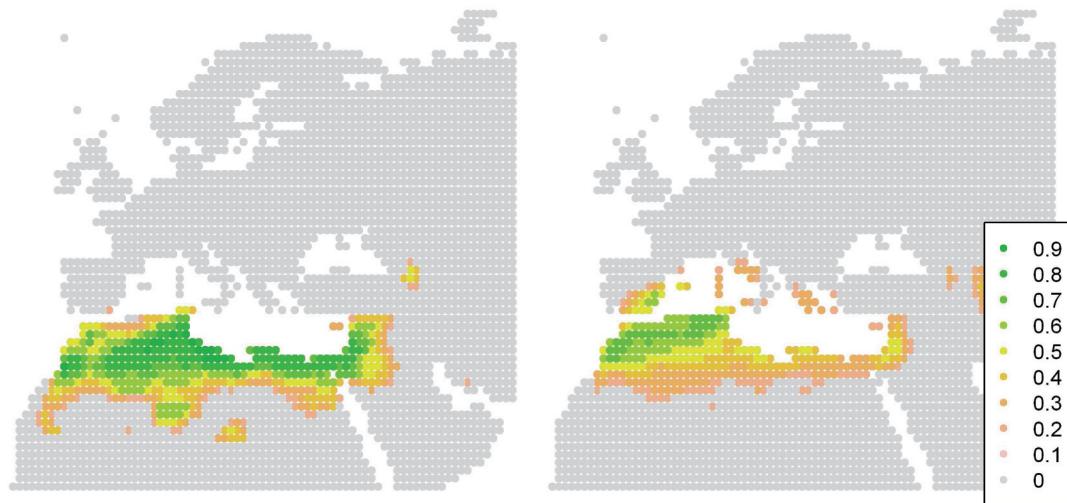
***Streptopelia senegalensis***

Figure S6e, f. Current and future modelled distribution for 6 species currently breeding in North Africa but not in Europe which are potential climatic colonizers: (e) *Phoenicurus moussieri* and (f) *Streptopelia senegalensis*.

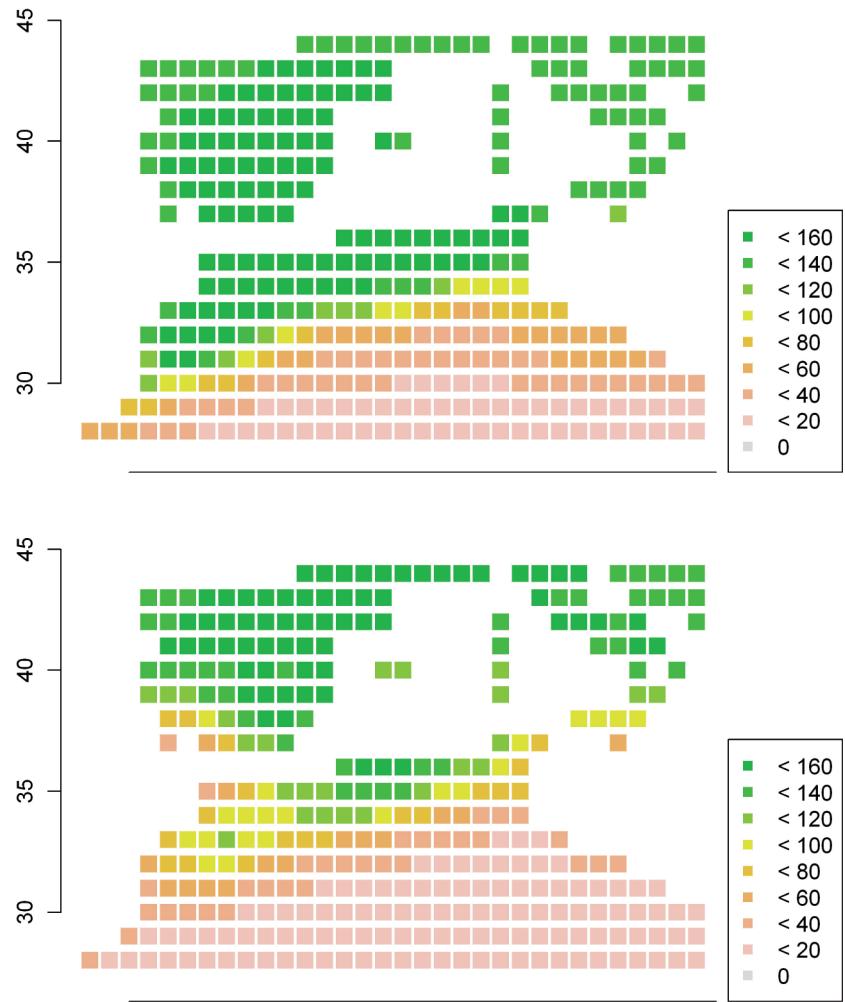


Figure S7. Current (top) and future by 2100 (bottom) predicted bird species richness for the 179 species.