JYX
JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

This is a self-archived version of an original article. This version may differ from the original in pagination and typographic details.

Author(s): Reino, Luís; Triviño, María; Beja, Pedro; Araújo, Miguel B.; Figueira, Rui; Segurado, Pedro

Title: Modelling landscape constraints on farmland bird species range shifts under climate change

Year: 2018

Version: Accepted version (Final draft)

Copyright: © 2018 Elsevier B.V.

Rights: CC BY-NC-ND 4.0

Rights url: https://creativecommons.org/licenses/by-nc-nd/4.0/

Please cite the original version:

Reino, L., Triviño, M., Beja, P., Araújo, M. B., Figueira, R., & Segurado, P. (2018). Modelling landscape constraints on farmland bird species range shifts under climate change. Science of the Total Environment, 625(June), 1596-1605. https://doi.org/10.1016/j.scitotenv.2018.01.007

Modelling landscape constraints on farmland bird species range shifts under climate change

Luís Reino, María Triviño, Pedro Beja, Miguel B. Araújo, Rui Figueira and Pedro Segurado

Appendix A. Supplementary Data

Table S1. Summary of previous studies analyzing the relative importance of combining climate and land cover change scenarios to predict range shifts from species distribution models. In each case we indicate the reference of the study (Reference), the statistical models used (Statistical Models), the group of species (Species) and the number of species (n) analyzed, the spatial extent (Region), the climate change scenario (Climate), the land cover base map and/or the land cover change scenario (land cover), and the main conclusions (Output).

Reference	**Statistical Models[a]**	**Species**	**Region**	**Climate[a]**	**Land cover[a]**	**Output**
Pearson et al. (2004)	ANN	Plants (n=4)	Britain	From SPECIES[b]	Land Cover Map 2000 (LCM2000)	Land cover significantly improve pure climate predictions for two species.
Bomhard et al. (2005)	GAM	Proteaceae (n=227)	South Africa	Single climate change scenario (HadCM2 IS92a GGa)	Land cover change from +CC1 to +CC4	Climate change has the most severe effects, but land use change also severely affects some taxa.
Jetz et al. (2007)	Map overlaying	Birds (n=8750)	World	MEA (2050, 2100)	MEA (IMAGE 2.2 model)	Climate change will severely affect biodiversity but, in the near future, land-use change in tropical countries may lead to yet greater species loss.
Pompe et al. (2008)	GLM, GAM, RF	Plants (n=845)	Germany	Alarm project: SEDG (B1); BAMBU (A2) and GRAS (A1F1)	PELCOM	Land cover variables contribute up-to 16% of total explained variation

Reference	Statistical Models[a]	Species	Region	Climate[a]	Land cover[a]	Output
Triviño et al. (2011)	BRT, RF	Birds (n=168)	Iberian Peninsula	ALARM project: BAMBU (A2) for 2080 (10 km resolution)	LPJ-GUESS + CLC	Models using climatic variables generally fit the data better than models using vegetation or landscape configuration variables
Barbet-Massin et al. (2012)	GLM, GAM, MARS, CTA, ANN, GBM and RF	Birds (n=409)	Europe	Five GCMs (2050): BCM2, ECHAM5, HADCM3, MIROHIC3_2-HI, and MK3	3 SRES scenarios (2050), A1B, A2, and B1, of the IMAGE 2.4 mode	Climate change only and land use change only yielded contrasting predictions, and so both scenarios need to be taken in consideration.
Martin et al. (2013)	Maxent	Butterflies (n=1)	Europe	Alarm project: SEDG (B1); BAMBU (A2) and GRAS (A1F1).	CORINE landcover	Land cover added little to climate when predicting range shifts, probably due to the low spatial resolution of land cover change scenarios.
Sohl et al. (2014)	Maxent	Birds (n=50)	Conterminous United States	Six GCMs (2075): BCCR-BCM2, CCSM3, CSIRO3.0-Mk, CSIRO-Mk3.5, INM-CM3.0, and MIROC 3.2.	Land use and land cover projections for the USA (250m resolution).	Both climate and land use/land cover change are important for modelling contemporary and future species ranges
Princé et al. (2013, 2015)	GLMM	Birds (n=34)	France	Five GCMs (2050): BCM2, ECHAM5, HADCM3, MIROHIC3_2-HI, and MK3; 3 emission scenarios: SRES: A1B, B1, and A2	IMAGE model and six farmland cover scenarios based on expert opinion	Farmland cover changes has the potential to mitigate the negative effects of climate change.

[a] Acronyms. ANN: Artificial Neural Networks; BRT: Boosted Regression Trees; GAM: Generalized Additive Model, GLM: Generalized Linear Model; GLMM: Generalized Linear Mixed Models; RF: Random Forests. CLC: CORINE Land Cover. MEA: Millennium Ecosystem Assessment; GCM: General Circulation Models.

[b] Pearson et al. (2002).

Table S2. Bird species considered in this study, the respective habitat specialization (habitat), derived from the Landscape Specialization Index (LSI) and the Pan-European Conservation Status in 2004 (Status), the SPEC (Species of European Conservation Concern) category, and percentage of cells (n=5928) with presences (%).

Species		**Habitat**	**LSI**	**Status[a]**	**SPEC[b]**	**%**
Lesser kestrel	*Falco naumanni*	Specialist	0.88	U	1	17.3
Montagus' Harrier	*Circus pygargus*	Generalist	0.56	F	N	45.8
Little bustard	*Tetrax tetrax*	Specialist	0.80	U	1	24.9
Great bustard	*Otis tarda*	Specialist	0.96	U	1	8.9
Common Quail	*Coturnix coturnix*	Generalist	0.24	U	3	72.6
Pin-tailed sandgrouse	*Pterocles alchata*	Specialist	0.97	U	3	8.1
Black-bellied sandgrouse	*Pterocles orientalis*	Specialist	0.91	U	3	14.1
Eurasian stone-curlew	*Burhinus oedicnemus*	Generalist	0.64	U	3	39.9
Eurasian roller	*Coracias garrulus*	Specialist	0.89	U	2	14.9
Eurasian Skylark	*Alauda arvensis*	Generalist	0.46	U	3	51.9
Twany pipit	*Anthus campestris*	Specialist	0.61	U	3	38.5
Wood lark	*Lullula arborea*	Generalist	0.21	U	2	71.2
Calandra lark	*Melanocorypha calandra*	Specialist	0.68	U	3	36.8
Greater short-toed lark	*Calandrella brachydactyla*	Specialist	0.64	U	3	38.9
Lesser short-toed lark	*Calandrella rufescens*	Specialist	1.00	U	3	4.1
Crested lark	*Galerida cristata*	Generalist	0.25	U	3	73.2
Thekla lark	*Galerida theklae*	Generalist	0.42	U	3	55.6
Dupont's lark	*Chersophilus duponti*	Specialist	1.00	U	3	3.9
Black-eared Wheatear	*Oenanthe hispanica*	Generalist	0.43	U	2	55.3
Eurasian linnet	*Carduelis cannabina*	Generalist	0.00	U	2	92.1

Corn bunting	*Emberiza calandra*	Generalist	0.07	U	2	60.4

[a] F – Favourable; U – Unfavourable.

[b] 1 –species that are globally threatened, conservation dependent or data deficient; 2 – species with an unfavorable conservation status, concentrated in Europe; 3 – species with an unfavourable conservation status, not concentrated in Europe; N – Non-SPEC.

References:

Barbet-Massin, M., Thuiller, W., & Jiguet, F. (2012). The fate of European breeding birds under climate, land-use and dispersal scenarios. *Global Change Biology*, **18**, 881-890.

Bomhard, B., Richardson, D.M., Donaldson, J.S., Hughes, G.O., Midgley, G.F., Raimondo, D.C. & Thuiller, W. (2005). Potential impacts of future land use and climate change on the Red List status of the Proteaceae in the Cape Floristic Region, South Africa. *Global Change Biology*, **11**, 1452-1468.

Jetz, W., Wilcove, D.S. & Dobson, A.P. (2007). Projected impacts of climate and land-use change on the global diversity of birds. *PLoS Biology*, **5**, 1211-1219.

Martin, Y., Van Dyck, H., Dendoncker, N. & Titeux, N. (2013). Testing instead of assuming the importance of land use change scenarios to model species distributions under climate change. *Global Ecology and Biogeography*, **22**, 1204-1216.

Pearson, R.G., Dawson, T.P., Berry, P.M. & Harrison, P.A. (2002). Species: A spatial evaluation of climate impact on the envelope of species. *Ecological Modelling*, **154**, 289-300.

Pearson, R.G., Dawson, T.P. & Liu, C. (2004). Modelling species distribution in Britain: a hierarchical integration of climate and land cover data. *Ecography*, **27**, 285–298.

Pompe, S., Hanspach, J., Badeck, F., Klotz, S., Thuiller, W., *et al*. (2008). Climate and land-use change impacts on plant distributions in Germany. *Biology Letters*, **4**, 64–567.

Princé, K., Lorrillière, R., Barbet-Massin, M. & Jiguet, F. (2013). Predicting the fate of French bird communities under agriculture and climate change scenarios. *Environmental Science & Policy*, **33**, 120-132.

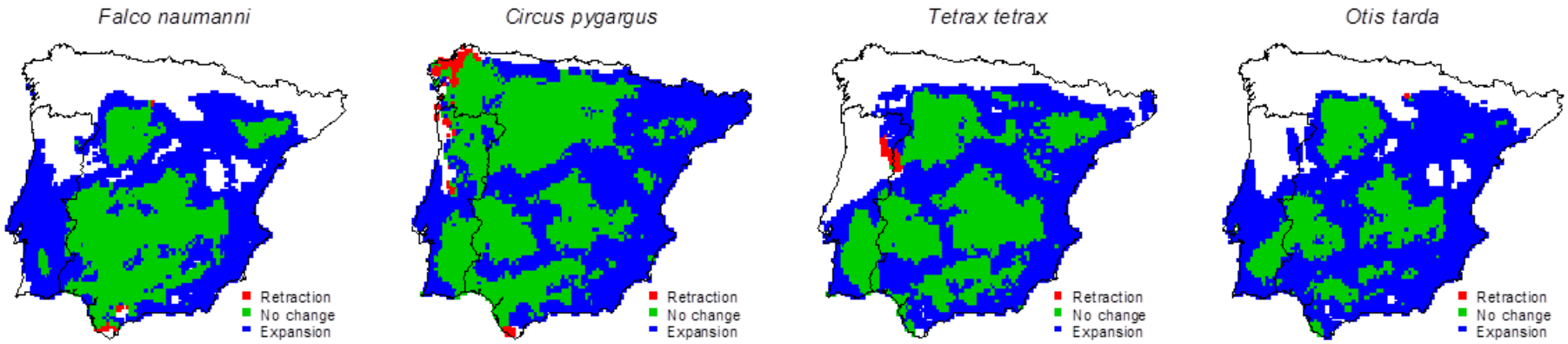
Princé, K., Lorrillière, R., Barbet-Massin, M., Léger, F. & Jiguet, F. (2015). Forecasting the Effects of Land Use Scenarios on Farmland Birds Reveal a Potential Mitigation of Climate Change Impacts. *PloS one*, ***10***(2), e0117850.

Sohl, T.R. (2014). The Relative Impacts of Climate and Land-Use Change on Conterminous United States Bird Species from 2001 to 2075. *PLoS ONE*, **9**, e112251.

Triviño, M., Thuiller, W., Cabeza, M., Hickler, T. & Araújo, M.B. (2011). The contribution of vegetation and landscape configuration for predicting environmental change impacts on Iberian birds. PLoS ONE, **6**, e29373.

Fig. S1 – Species range shift maps for the BAMBU scenario. a) climate-only models; b) climate + landscape models

a)



b)

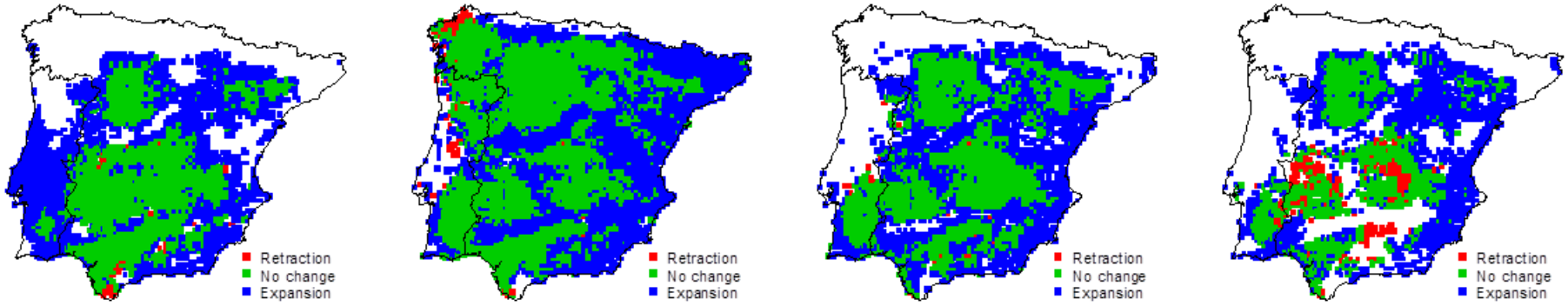
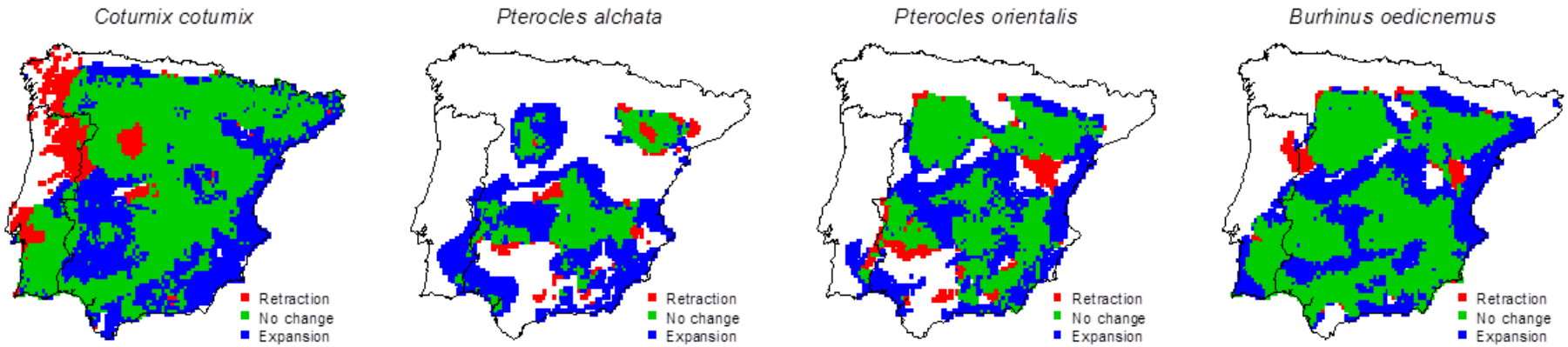


Fig. S1 (cont.)

a)



b)

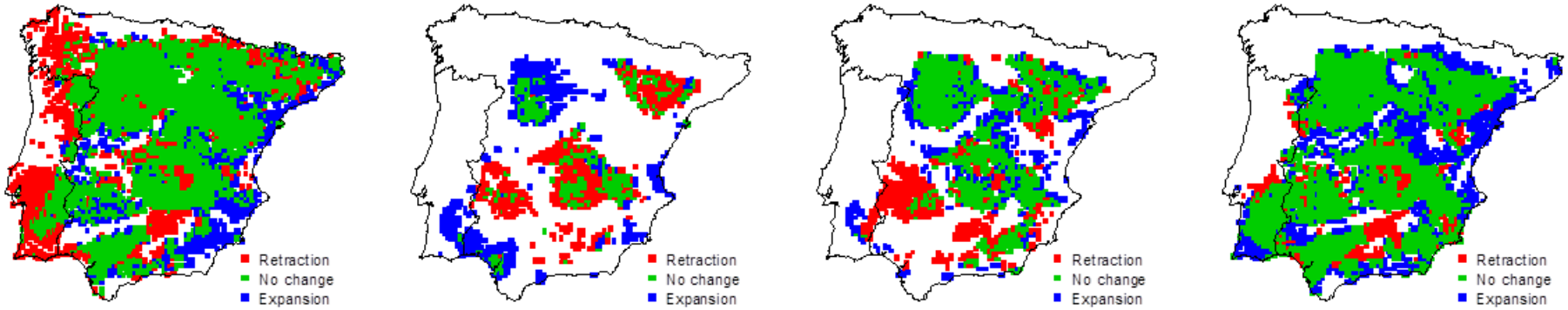


Fig. S1 (cont.)

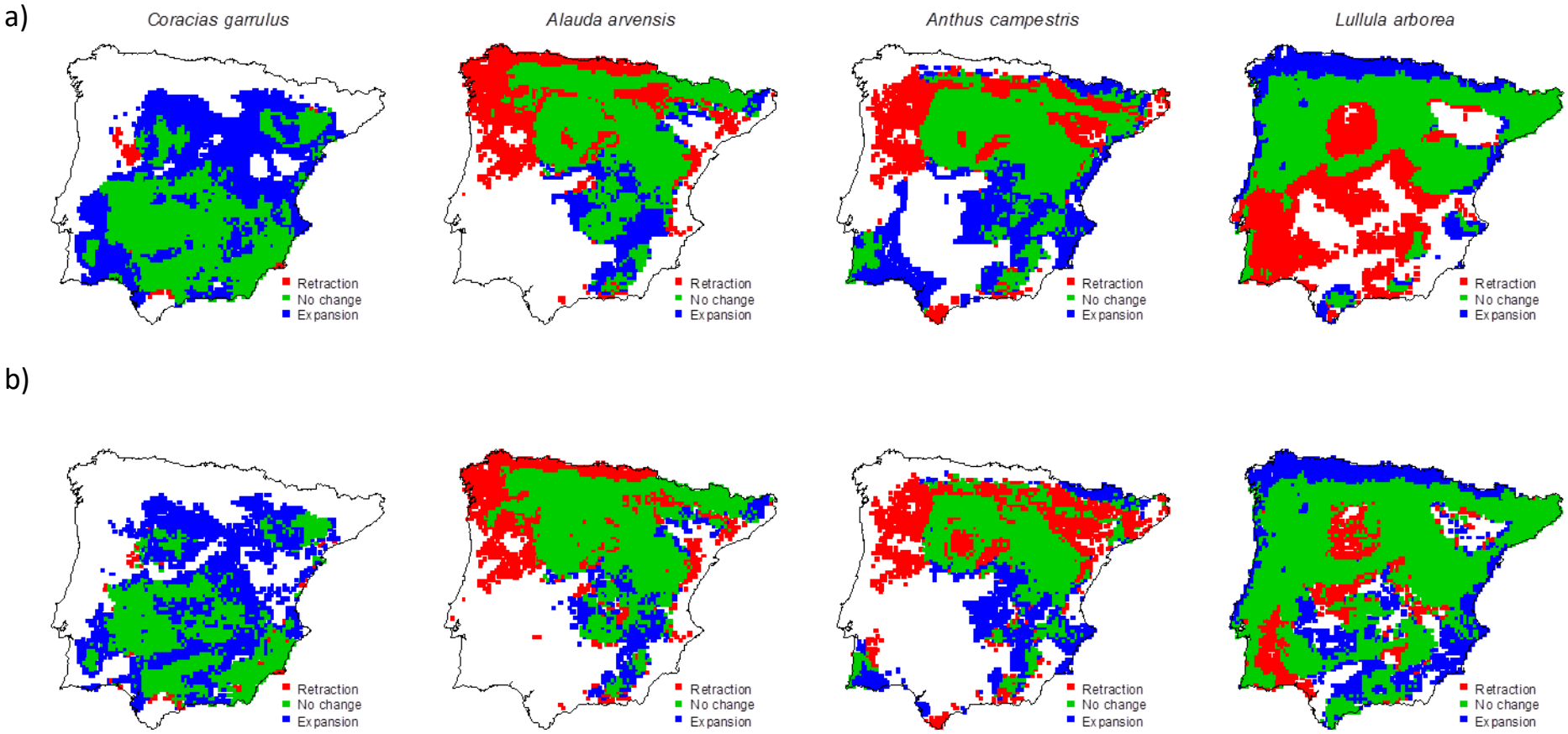

a)
Coracias garrulus
Alauda arvensis
Anthus campestris
Lullula arborea
Retraction
No change
Expansion
b)
Retraction
No change
Expansion

Fig. S1 (cont.)

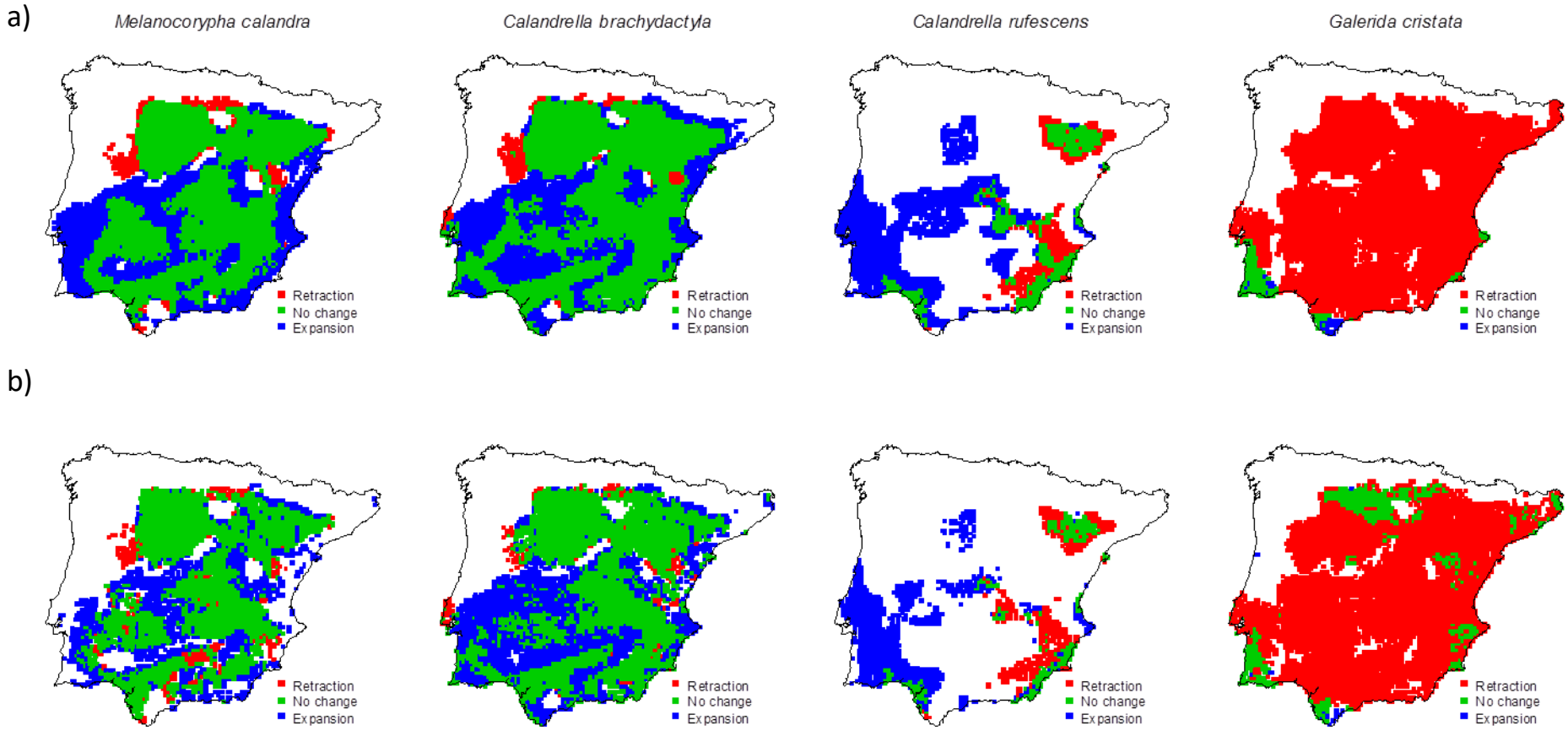

a)
Melanocorypha calandra
Calandrella brachydactyla
Calandrella rufescens
Galerida cristata
Retraction
No change
Expansion
b)
Retraction
No change
Expansion

Fig. S1 (cont.)

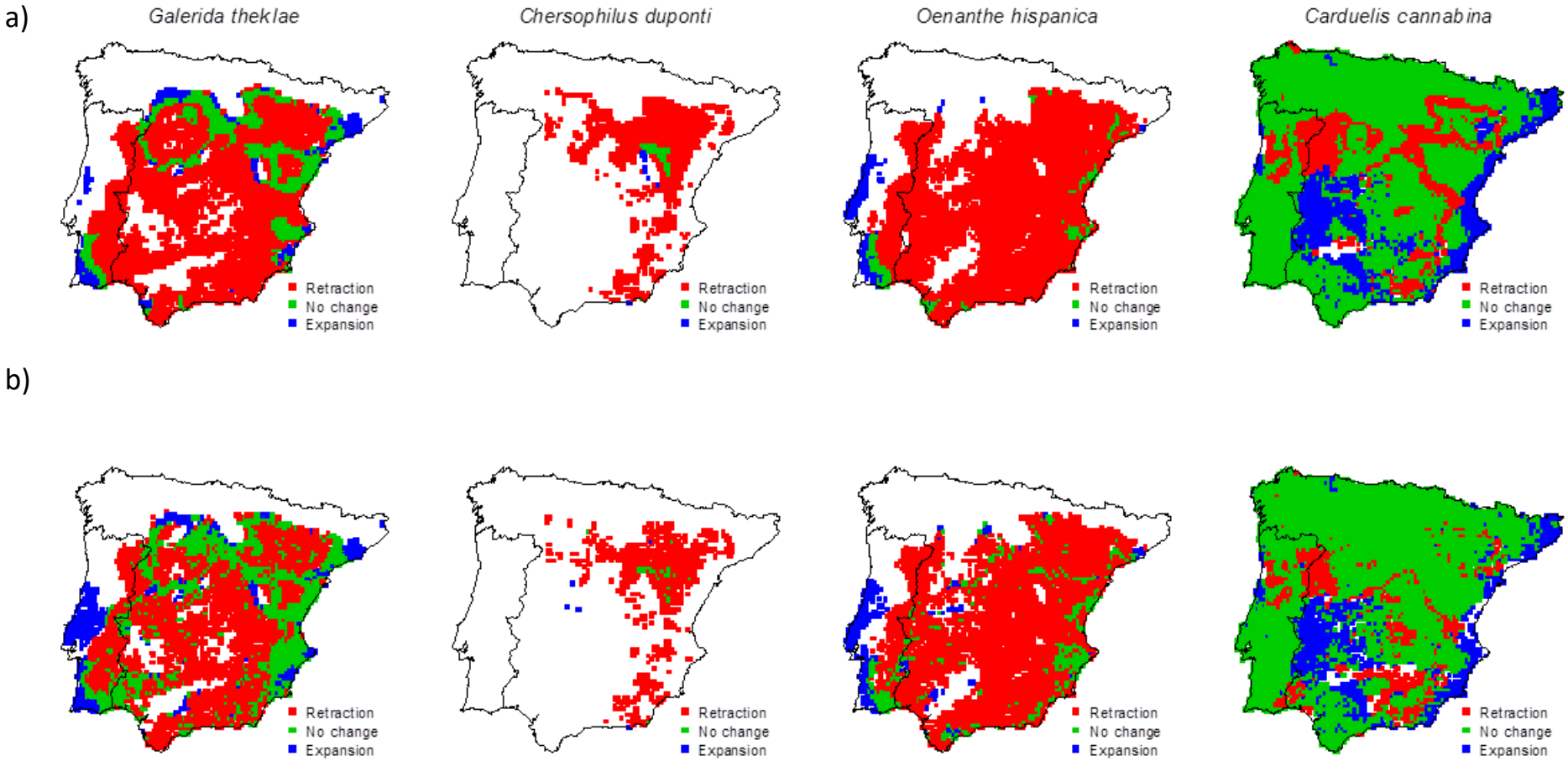
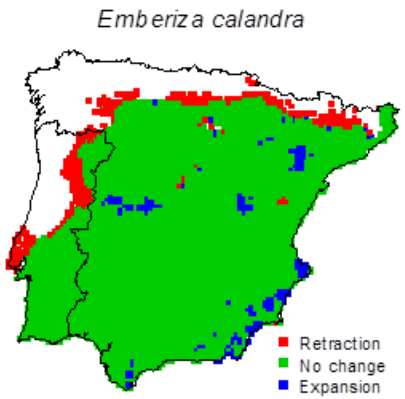

a)
Galerida theklae
Chersophilus duponti
Oenanthe hispanica
Carduelis cannabina
Retraction
No change
Expansion
b)
Retraction
No change
Expansion

Fig. S1 (cont.)

a)



b)

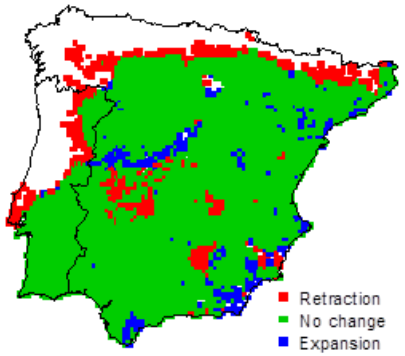
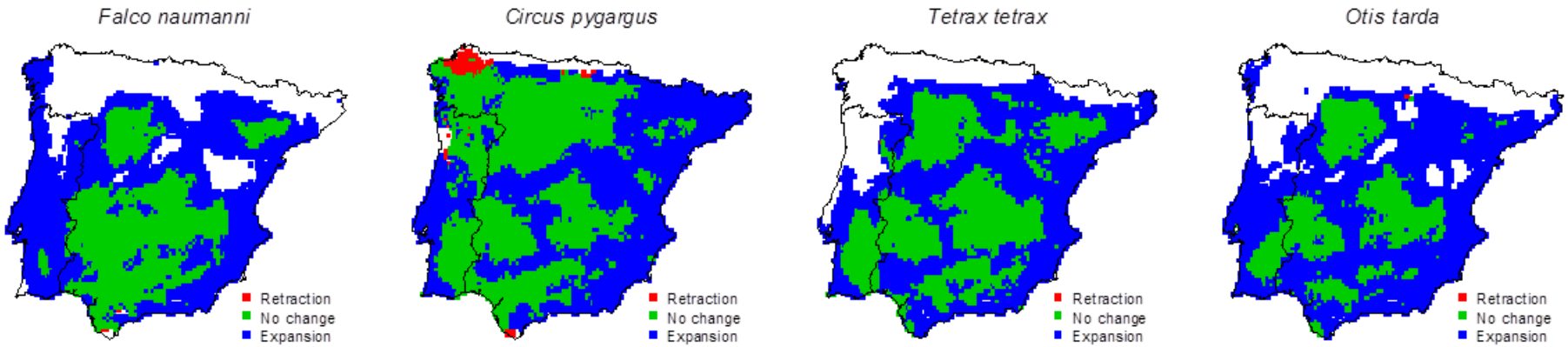


Fig. S2 – Species range shift maps for the GRAS scenario. a) climate-only models; b) climate + landscape models

a)



b)

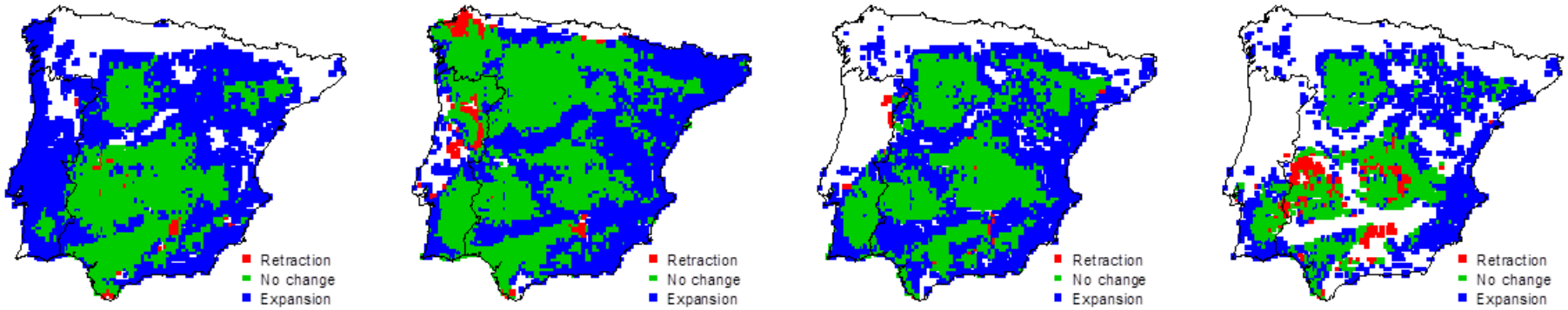


Fig. S2 (cont.)

a)

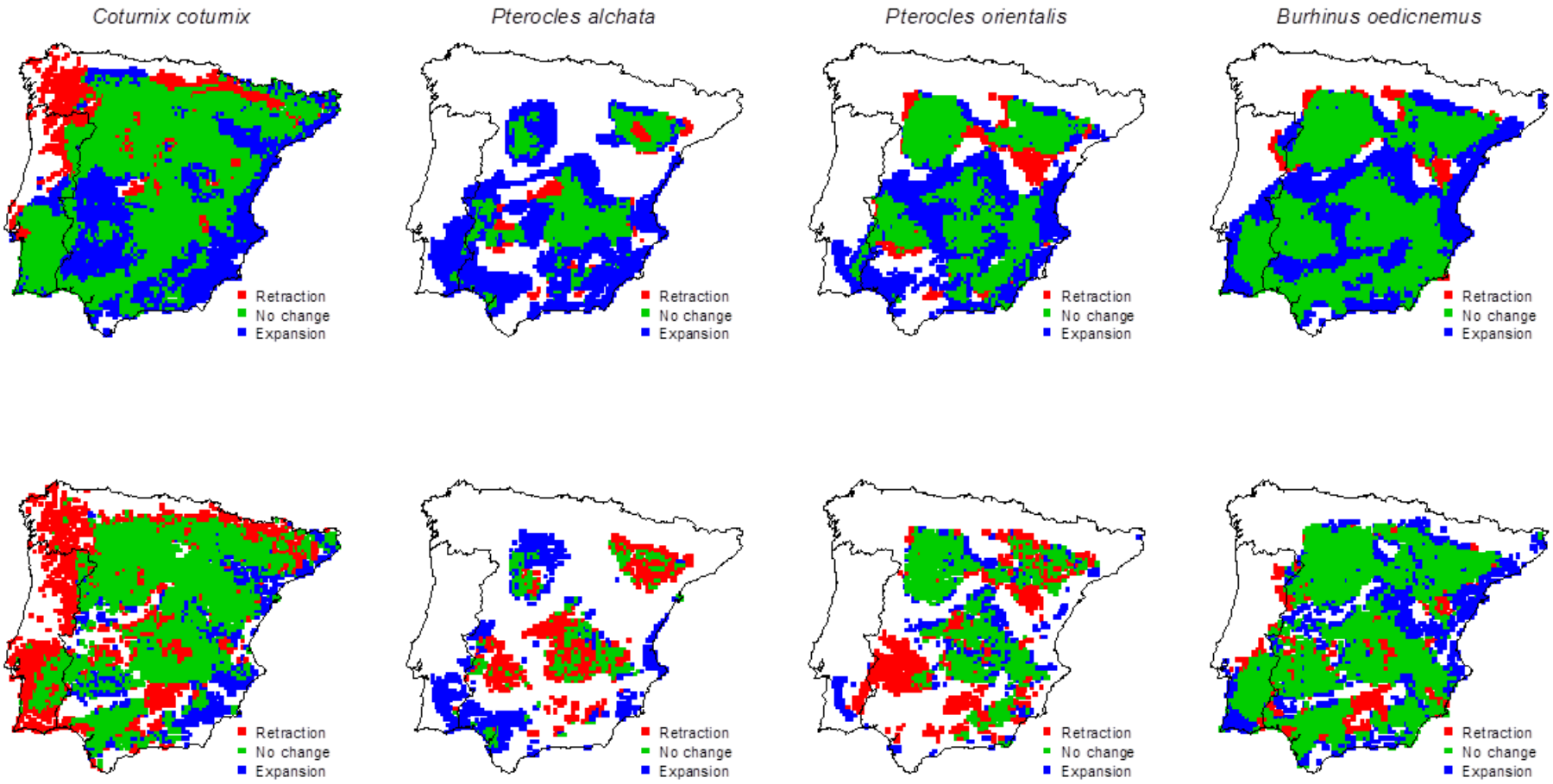

Coturnix coturnix
Pterocles alchata
Pterocles orientalis
Burhinus oedicnemus
Retraction
No change
Expansion
b)

Fig. S2 (cont.)

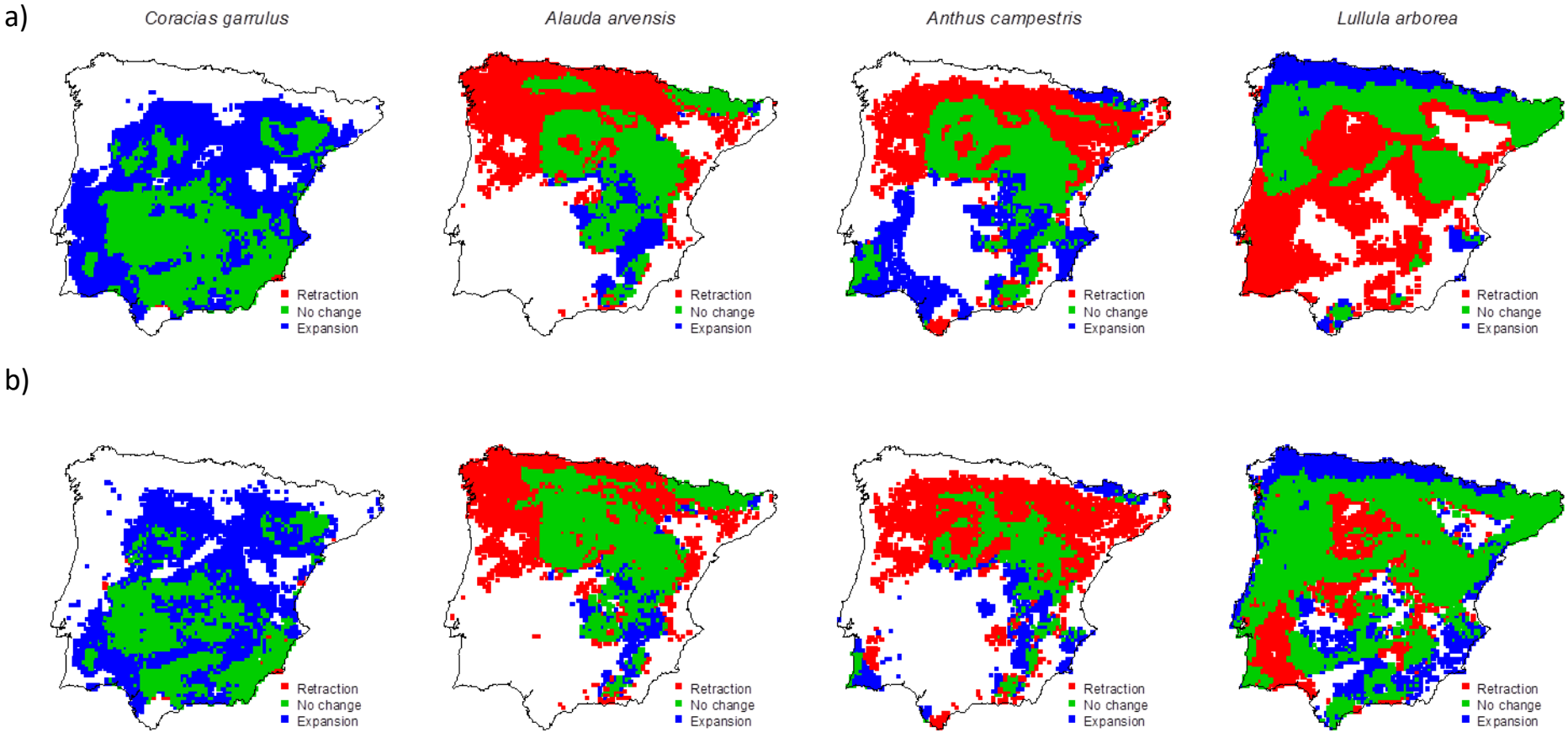
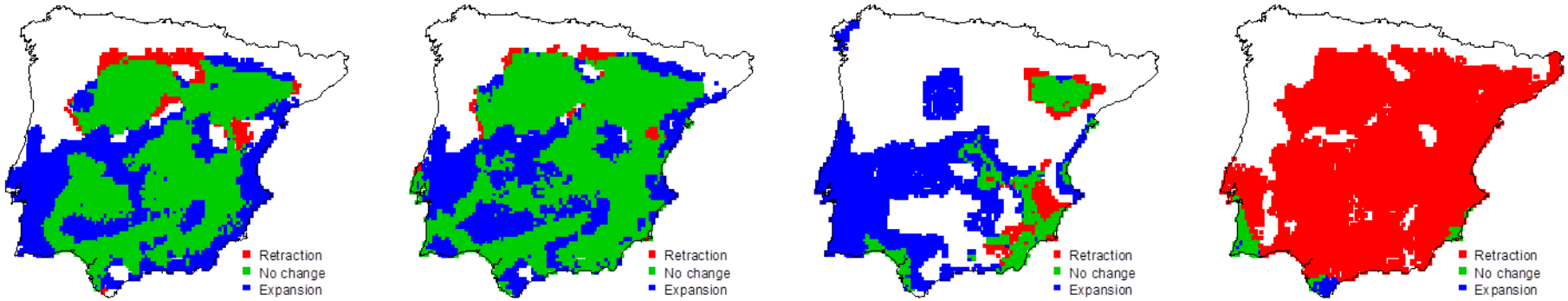

a)
Coracias garrulus
Alauda arvensis
Anthus campestris
Lullula arborea
Retraction
No change
Expansion
b)
Retraction
No change
Expansion

Fig. S2 (cont.)

a)

Melanocorypha calandra *Calandrella brachydactyla* *Calandrella rufescens* *Galerida cristata*



b)

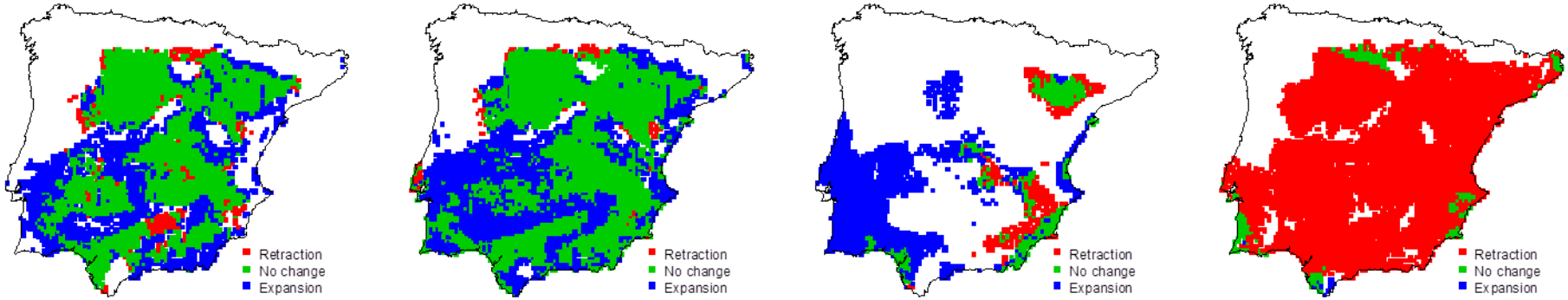
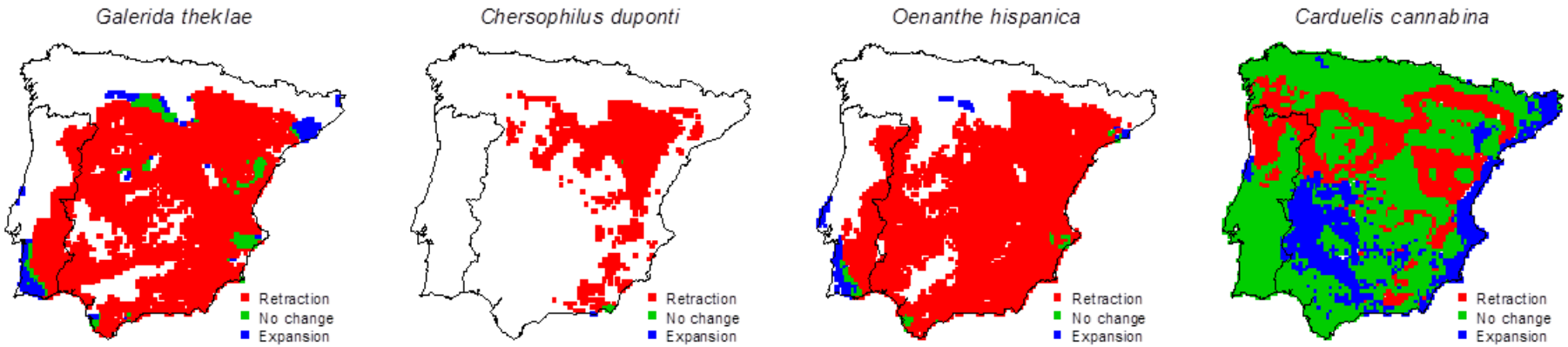


Fig. S2 (cont.)

a)



b)

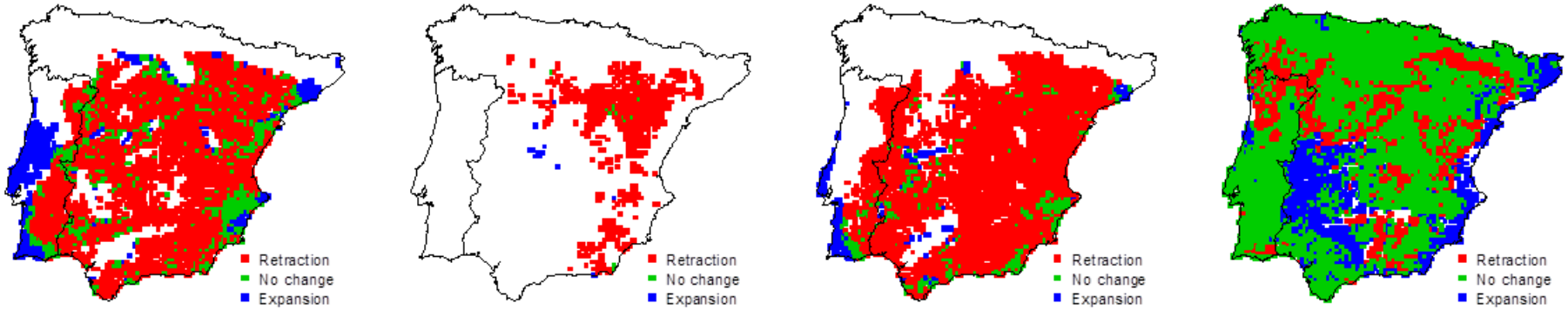
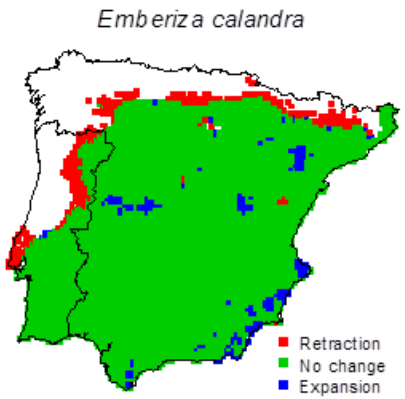


Fig. S2 (cont.)

a)



b)

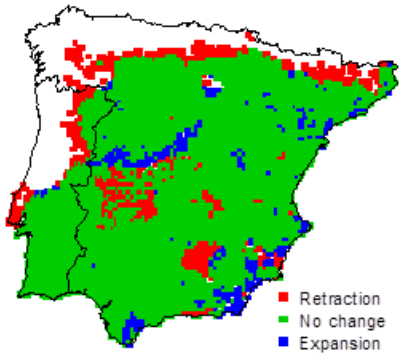
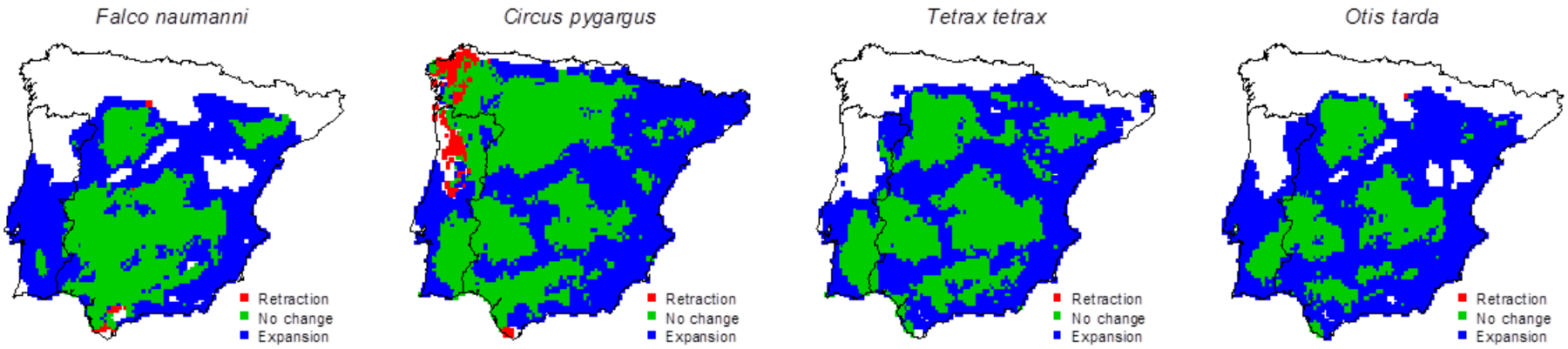


Fig. S3 – Species range shift maps for the SEDGE scenario. a) climate-only models; b) climate + landscape models

a)



b)

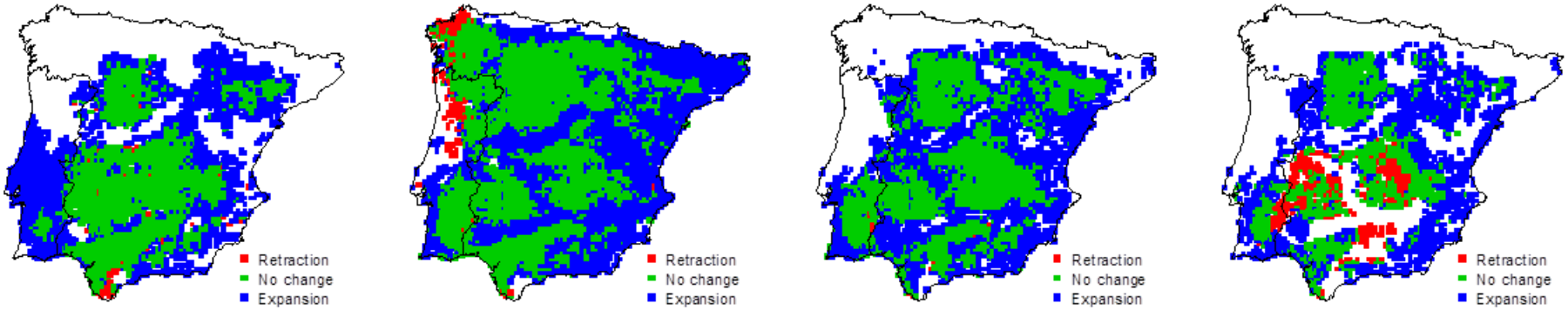


Fig. S3 (cont.)

a)

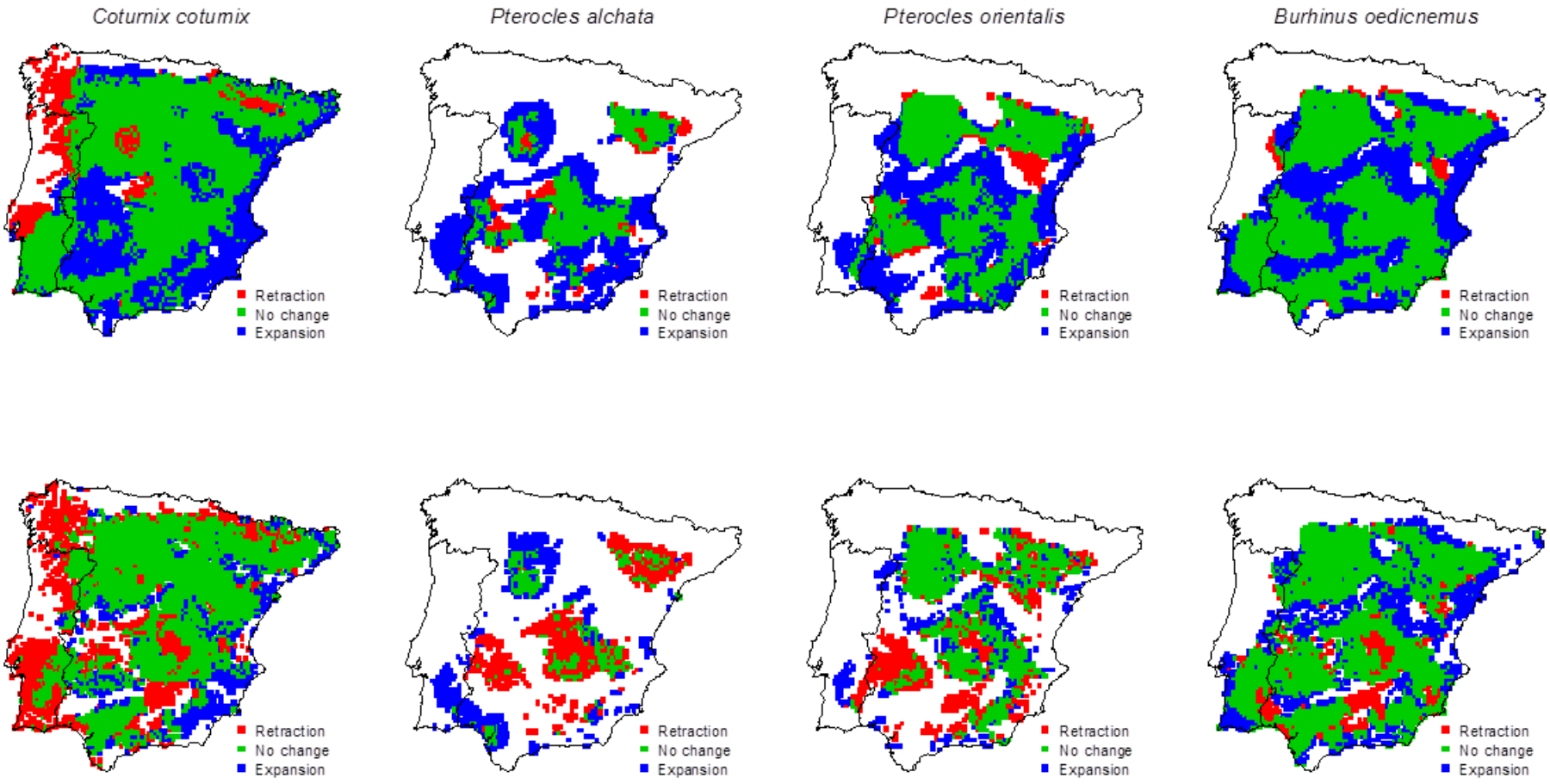

Coturnix coturnix
Pterocles alchata
Pterocles orientalis
Burhinus oedicnemus
Retraction
No change
Expansion
b)

Fig. S3 (cont.)

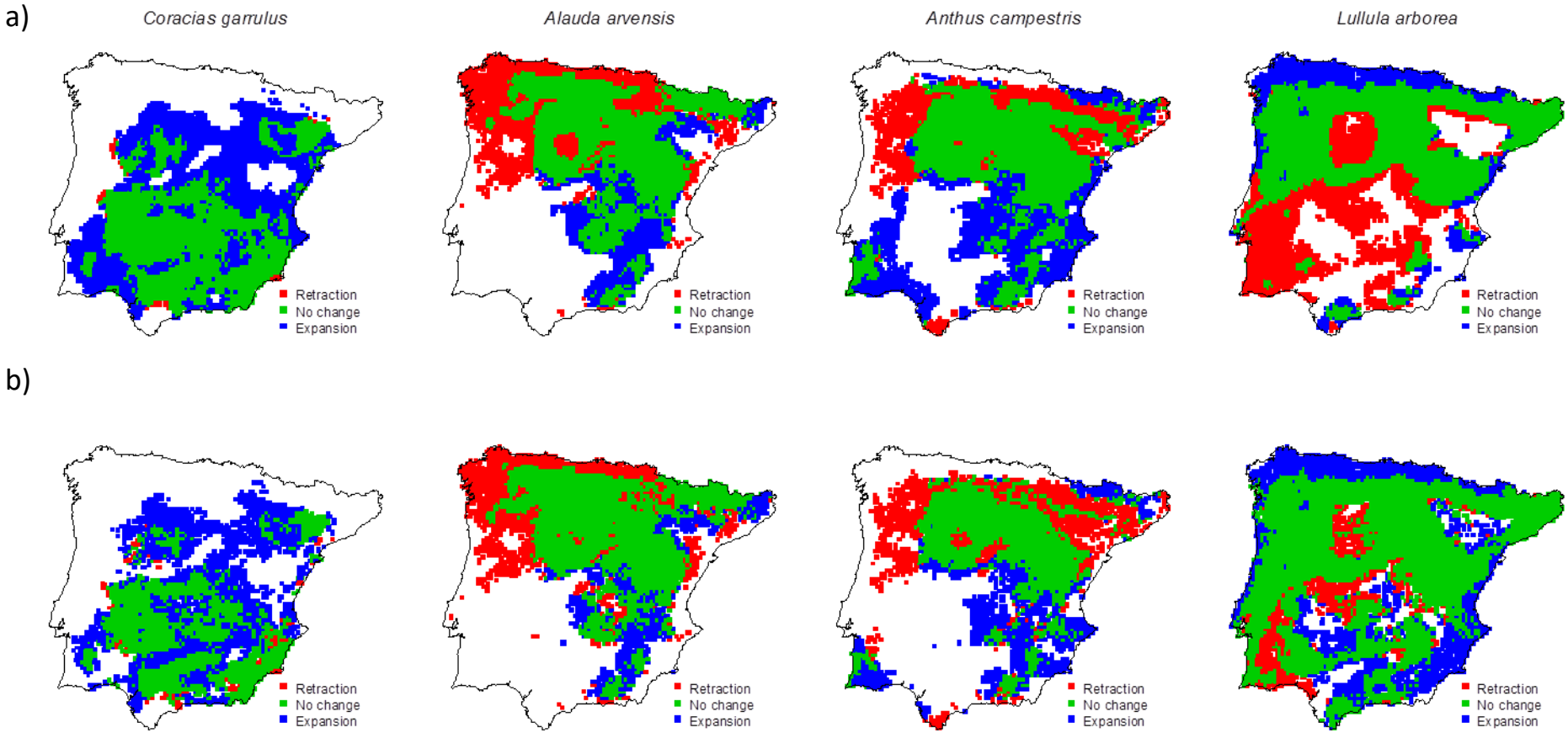

a)
Coracias garrulus
Alauda arvensis
Anthus campestris
Lullula arborea
Retraction
No change
Expansion
b)
Retraction
No change
Expansion

Fig. S3 (cont.)

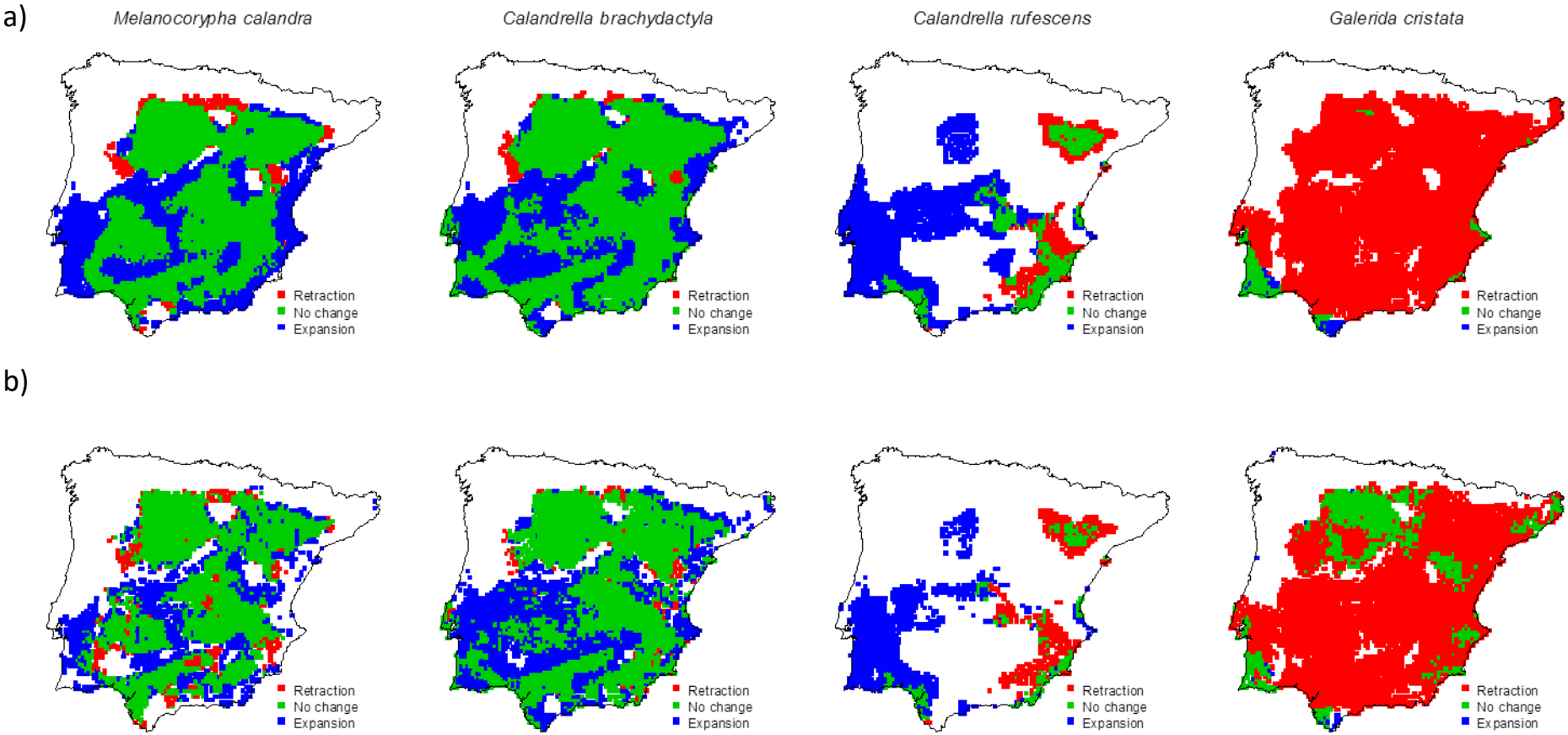
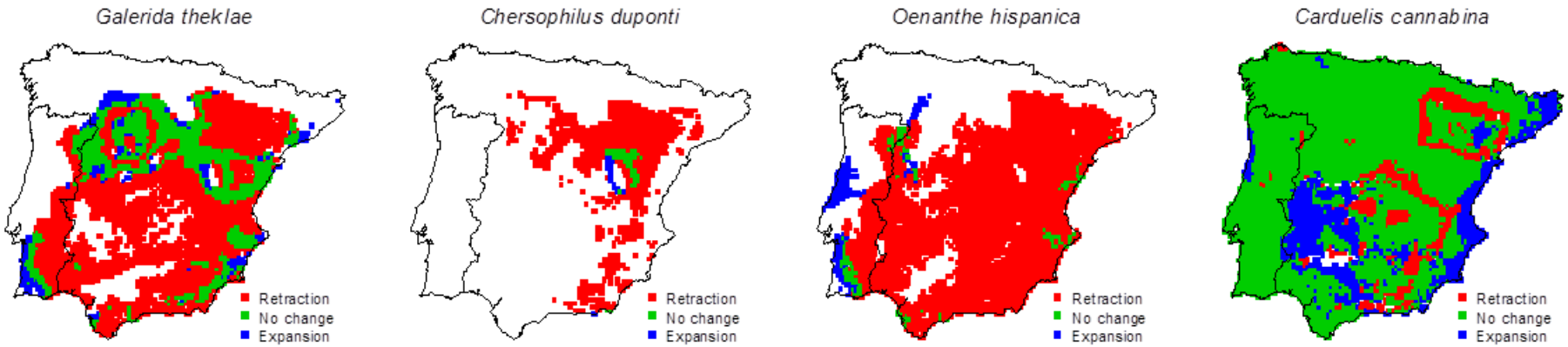

a)
Melanocorypha calandra
Calandrella brachydactyla
Calandrella rufescens
Galerida cristata
Retraction
No change
Expansion
b)
Retraction
No change
Expansion

Fig. S3 (cont.)

a)



b)

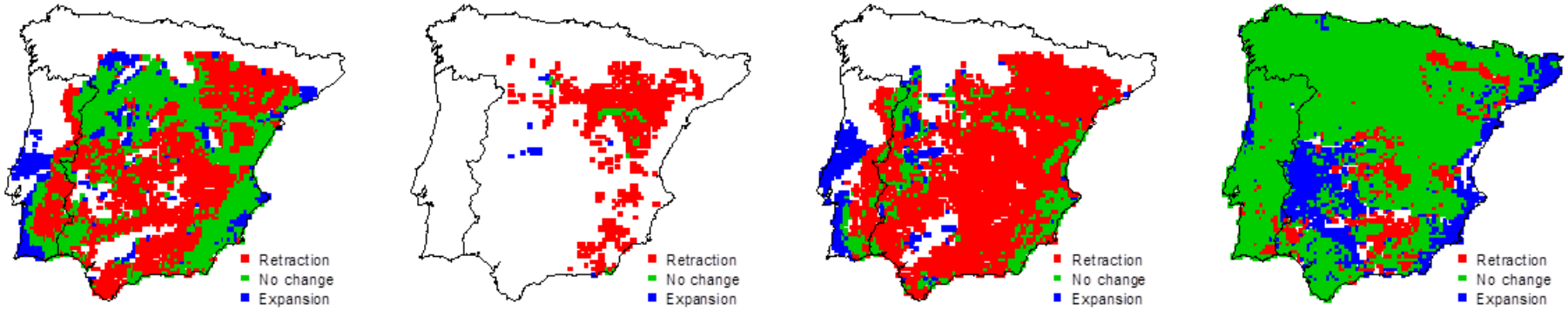
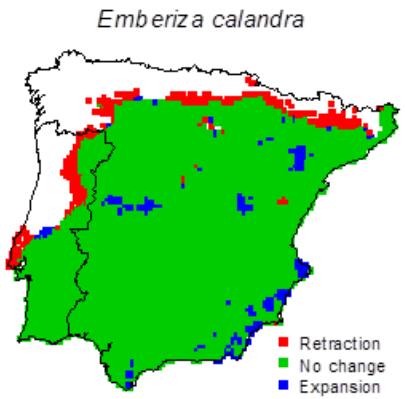
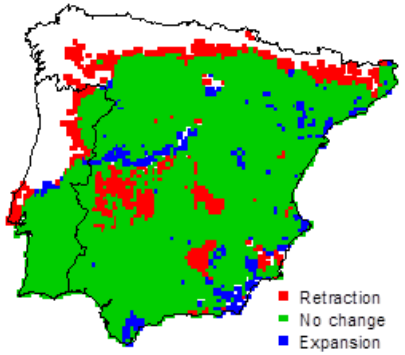


Fig. S3 (cont.)

a)


Emberiza calandra
Retraction
No change
Expansion

b)


Retraction
No change
Expansion