SUPPLEMENTARY INFORMATION FOR

WHERE ARE THE WILD THINGS?
WHY WE NEED BETTER DATA ON SPECIES DISTRIBUTION

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APPENDIX S1

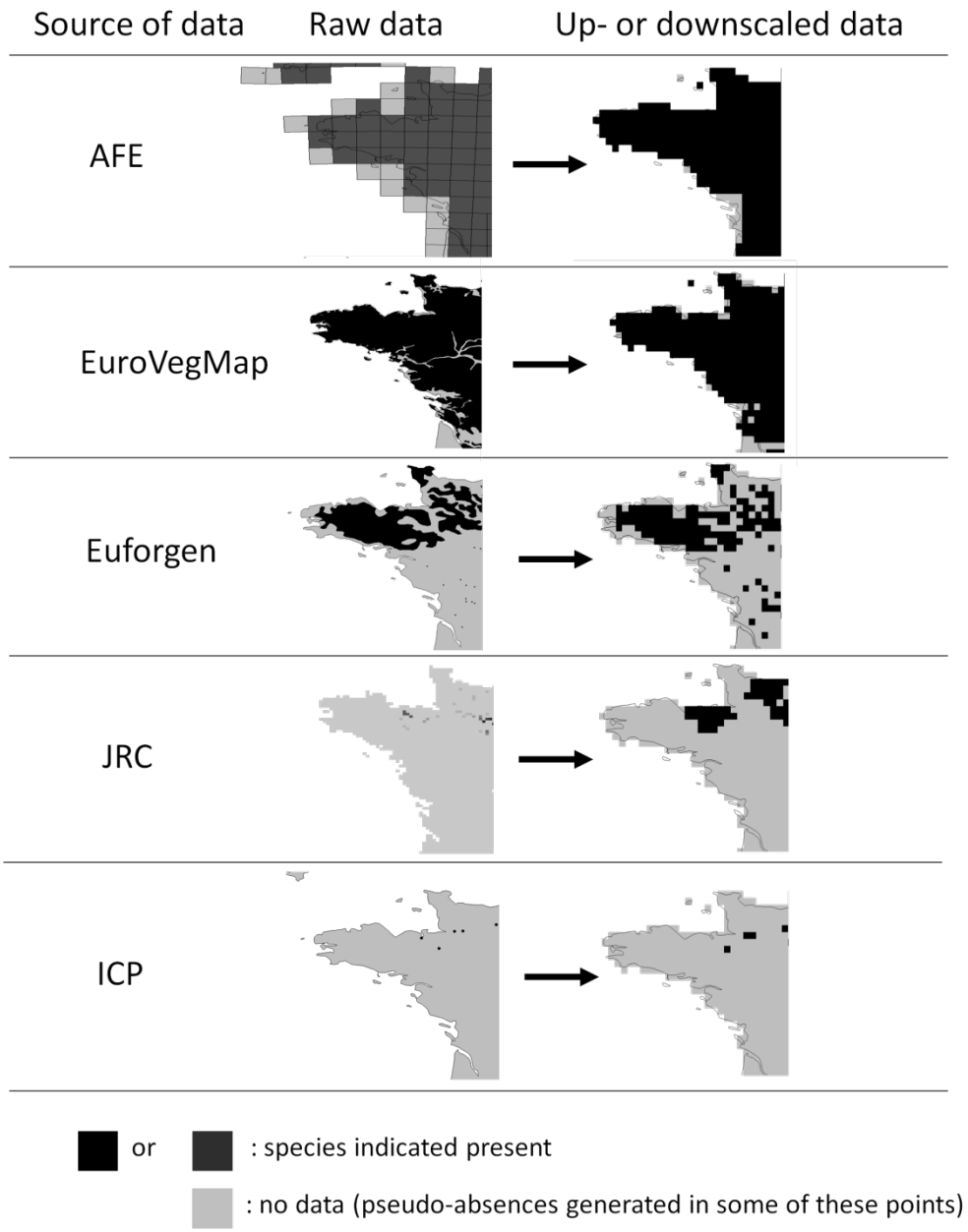
Rates of false positives and false negatives, and overall accuracy of the three atlases, when compared with forest inventory data (ICP forest dataset). These measures are thus computed only over those 5,441 pixels containing at least one ICP plot (out of 28,766 pixels). The JRC dataset is not included here: it perfectly matches the ICP dataset, because it is based on it. In this analysis, pixels are not weighted according to their area (northern pixels have a smaller area in the 10'*10' grid); weighting by area does not modify the main results: (i) all three atlases seem to overestimate distributions (the proportions of false negatives are low; but there are many false positives; yet ICP plots may not be representative of a whole 10'*10' pixel); and (ii) none of the three atlases consistently shows a better agreement with the forest inventory dataset.

	False positives (species indicated as present by the atlas, while absent)			False negatives (species indicated as absent, while present)			Accuracy (species rightly indicated as either present or absent)		
	AFE	EUFORGEN	EuroVegMap	AFE	EUFORGEN	EuroVegMap	AFE	EUFORGEN	EuroVegMap
Abies alba	21%	12%	20%	<0.5%	1%	<0.5%	79%	87%	80%
Acer campestre	NA	45%	24%	NA	<0.5%	<0.5%	NA	55%	76%
Acer pseudoplatanus	NA	32%	23%	NA	<0.5%	<0.5%	NA	68%	77%
Alnus glutinosa	80%	72%	13%	<0.5%	<0.5%	1%	20%	28%	86%
Betula pendula	71%	66%	30%	<0.5%	<0.5%	4%	29%	34%	66%
Betula pubescens	62%	NA	32%	<0.5%	NA	1%	38%	NA	67%
Carpinus betulus	43%	NA	36%	<0.5%	NA	<0.5%	57%	NA	64%
Castanea sativa	25%	10%	12%	<0.5%	<0.5%	<0.5%	75%	90%	88%
Corylus avellana	73%	NA	55%	0%	NA	0%	27%	NA	45%
Fagus sylvatica	40%	23%	31%	<0.5%	2%	1%	60%	75%	68%
Fraxinus excelsior	NA	64%	31%	NA	<0.5%	1%	NA	36%	68%
Larix decidua	8%	6%	3%	1%	1%	1%	91%	93%	96%
Picea abies	35%	25%	33%	2%	5%	3%	63%	70%	64%
Pinus halepensis	5%	3%	4%	0%	<0.5%	<0.5%	95%	97%	96%
Pinus nigra	7%	2%	7%	1%	1%	1%	92%	97%	92%
Pinus pinaster	7%	4%	4%	1%	1%	1%	92%	95%	95%
Pinus sylvestris	43%	32%	31%	1%	2%	3%	56%	66%	66%
Populus tremula	80%	80%	37%	<0.5%	<0.5%	2%	20%	20%	61%
Quercus ilex	11%	NA	12%	1%	NA	<0.5%	88%	NA	88%
Quercus pubescens	25%	NA	14%	0%	NA	<0.5%	75%	NA	86%
Quercus robur	59%	49%	46%	<0.5%	<0.5%	1%	41%	51%	53%

APPENDIX S2

Upscaling and downscaling procedure for each of the five sources of distribution data, illustrated for the region spanning 5°W to 0°E and 45°N to 50°N, for *Fagus sylvatica.* Raw data are given in the left column and up-ior downscaled data in the right column.

AFE: Atlas Florae Europaeae (Jalas & Suominen, 1964-2010; Lahti & Lampinen, 1999; http://www.luomus.fi/english/botany/afe/index.htm); EuroVegMap: map of the potential vegetation of Europe (Bohn *et al.*, 2004); EUFORGEN: Euforgen dataset (http://www.euforgen.org/distribution_maps.html); JRC: Joint Research Center dataset (http://forest.jrc.ec.europa.eu/); ICP: ICP forests dataset (http://www.icp-forests.org/).



APPENDIX S3

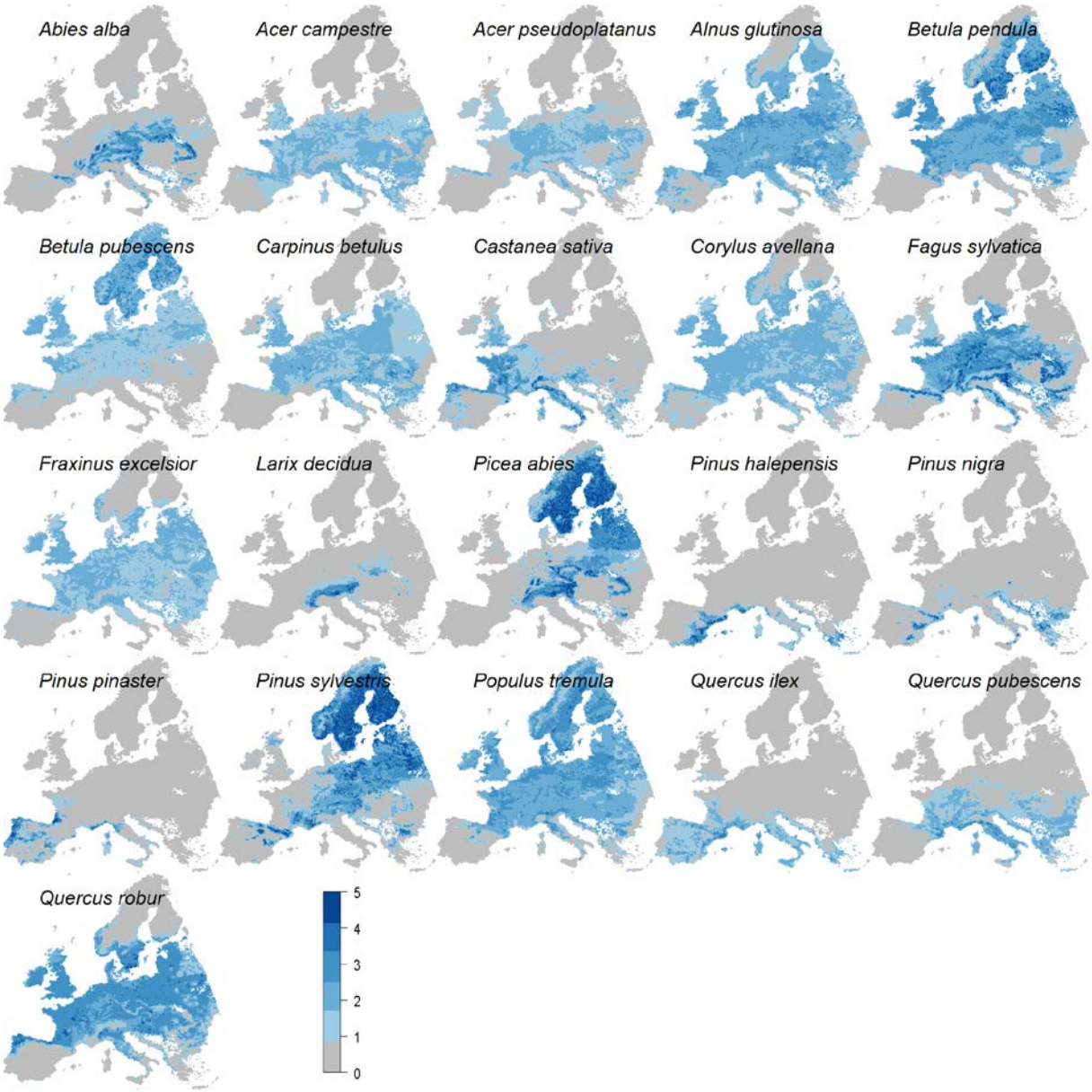
Observed and simulated (ensemble models generated using BIOMOD) distribution areas of the 21 species studied, according to the source of data. For climate scenarios (2081-2100 period), the ratios of simulated future area to simulated historical area is shown. These ratios are either raw ratios of suitable areas, or the proportion of currently suitable area projected as still suitable under the scenario ("no dispersal" columns).

		Observed area (*1000 km²)	Modelled area (historical) (*1000 km²)	Modelled A1Fi / Modelled historical	Modelled A1Fi / Modelled historical, no dispersal	Modelled B2 / Modelled historical	Modelled B2 / Modelled historical, no dispersal
Abies alba	AFE	1102	1915	1.13	0.48	1.41	0.81
	EUFORGEN	536	1199	0.53	0.03	0.45	0.19
	EuroVegMap	1015	1691	0.37	0.01	0.42	0.15
	JRC	112	1041	0.82	0.22	1.02	0.52
Acer campestre	EUFORGEN	2930	2982	1.24	0.67	1.36	0.92
	EuroVegMap	1707	2250	1.44	0.58	1.65	0.89
Acer pseudoplatanus	EUFORGEN	1853	2252	0.71	0.14	1.19	0.66
	EuroVegMap	1493	2115	0.34	0.02	0.39	0.12
Alnus glutinosa	AFE	4469	4414	0.91	0.75	1.04	0.91
	EUFORGEN	3833	3522	0.71	0.43	0.96	0.74
	EuroVegMap	1092	2106	1.61	0.73	1.61	0.87
	JRC	39	1765	0.54	0.11	0.86	0.49
Betula pendula	AFE	4227	4008	0.48	0.38	0.79	0.68
	EUFORGEN	3761	3490	0.35	0.20	0.64	0.51
	EuroVegMap	1759	2440	0.23	0.09	0.37	0.17
	JRC	247	1053	0.22	0.03	0.36	0.21
Betula pubescens	AFE	3885	3678	0.20	0.20	0.33	0.33
	EuroVegMap	2044	2183	0.29	0.29	0.46	0.46
	JRC	366	897	0.12	0.02	0.42	0.18
Carpinus betulus	AFE	2679	2870	1.12	0.55	1.29	0.83
	EuroVegMap	2646	2830	1.02	0.51	1.18	0.79
	JRC	83	1310	0.63	0.04	1.31	0.46
Castanea sativa	AFE	1624	2266	2.07	0.86	2.00	0.95
	EUFORGEN	574	1454	1.29	0.18	1.83	0.55
	EuroVegMap	905	1626	1.03	0.27	1.18	0.65
	JRC	80	961	1.72	0.57	1.86	0.86
Corylus avellana	AFE	4122	4004	0.92	0.66	1.10	0.89
	EuroVegMap	3309	3203	0.67	0.27	0.93	0.66
Fagus sylvatica	AFE	2686	2845	1.11	0.52	1.36	0.87
	EUFORGEN	1410	2008	0.39	0.01	0.61	0.20
	EuroVegMap	2333	2540	0.43	0.08	0.67	0.31
	JRC	377	1446	1.06	0.34	1.52	0.78

		Observed area (*1000 km²)	Modelled area (historical) (*1000 km²)	Modelled A1Fi / Modelled historical	Modelled A1Fi / Modelled historical, no dispersal	Modelled B2 / Modelled historical	Modelled B2 / Modelled historical, no dispersal
Fraxinus excelsior	EUFORGEN	3879	3613	0.69	0.38	0.99	0.77
	EuroVegMap	2191	2804	0.77	0.31	0.99	0.66
	JRC	33	1715	1.15	0.39	1.42	0.65
Larix decidua	AFE	379	1107	0.44	0.13	0.46	0.29
	EUFORGEN	295	781	0.54	0.13	0.56	0.34
	EuroVegMap	138	408	0.28	0.11	0.43	0.32
	JRC	70	1215	0.58	0.12	0.64	0.37
Picea abies	AFE	2557	2552	0.23	0.22	0.38	0.37
	EUFORGEN	1891	2070	0.22	0.14	0.41	0.31
	EuroVegMap	2514	2518	0.22	0.16	0.38	0.31
	JRC	1003	1391	0.25	0.11	0.50	0.32
Pinus halepensis	AFE	377	983	3.39	1.00	2.09	1.00
	EUFORGEN	189	825	1.76	0.58	1.45	0.74
	EuroVegMap	419	865	2.32	0.54	1.85	0.88
	JRC	73	839	1.99	0.77	1.51	0.81
Pinus nigra	AFE	492	1596	2.33	0.77	2.09	0.91
	EUFORGEN	175	1096	0.31	0.06	0.85	0.32
	EuroVegMap	496	1460	1.84	0.43	2.23	0.82
	JRC	141	1431	1.01	0.05	1.61	0.48
Pinus pinaster	AFE	374	965	1.59	0.64	1.29	0.65
	EUFORGEN	209	773	0.63	0.12	0.78	0.23
	EuroVegMap	315	716	1.80	0.52	1.48	0.72
	JRC	125	941	1.45	0.40	1.26	0.59
Pinus sylvestris	AFE	3441	3292	0.25	0.25	0.38	0.38
	EUFORGEN	2639	2569	0.21	0.19	0.34	0.31
	EuroVegMap	2618	2534	0.21	0.15	0.38	0.30
	JRC	1208	1718	0.22	0.16	0.40	0.32
Populus tremula	AFE	4505	4179	0.43	0.43	0.67	0.65
	EUFORGEN	4534	4156	0.42	0.32	0.76	0.67
	EuroVegMap	1889	2198	0.10	0.09	0.31	0.28
	JRC	62	983	0.26	0.01	0.45	0.17
Quercus ilex	AFE	792	1445	3.10	0.95	1.94	0.99
	EuroVegMap	846	1176	2.49	0.88	1.69	0.98
	JRC	141	918	2.96	0.96	1.78	0.97
Quercus pubescens	AFE	1652	2138	2.19	0.94	2.11	0.99
	EuroVegMap	1080	1694	2.29	0.73	2.32	0.91
	JRC	95	1007	2.23	0.47	2.25	0.83
Quercus robur	AFE	3694	3544	0.77	0.45	0.94	0.72
	EUFORGEN	3016	3104	0.70	0.29	0.94	0.65
	EuroVegMap	3134	3168	0.52	0.17	0.86	0.59
	JRC	144	1834	0.62	0.04	1.08	0.34

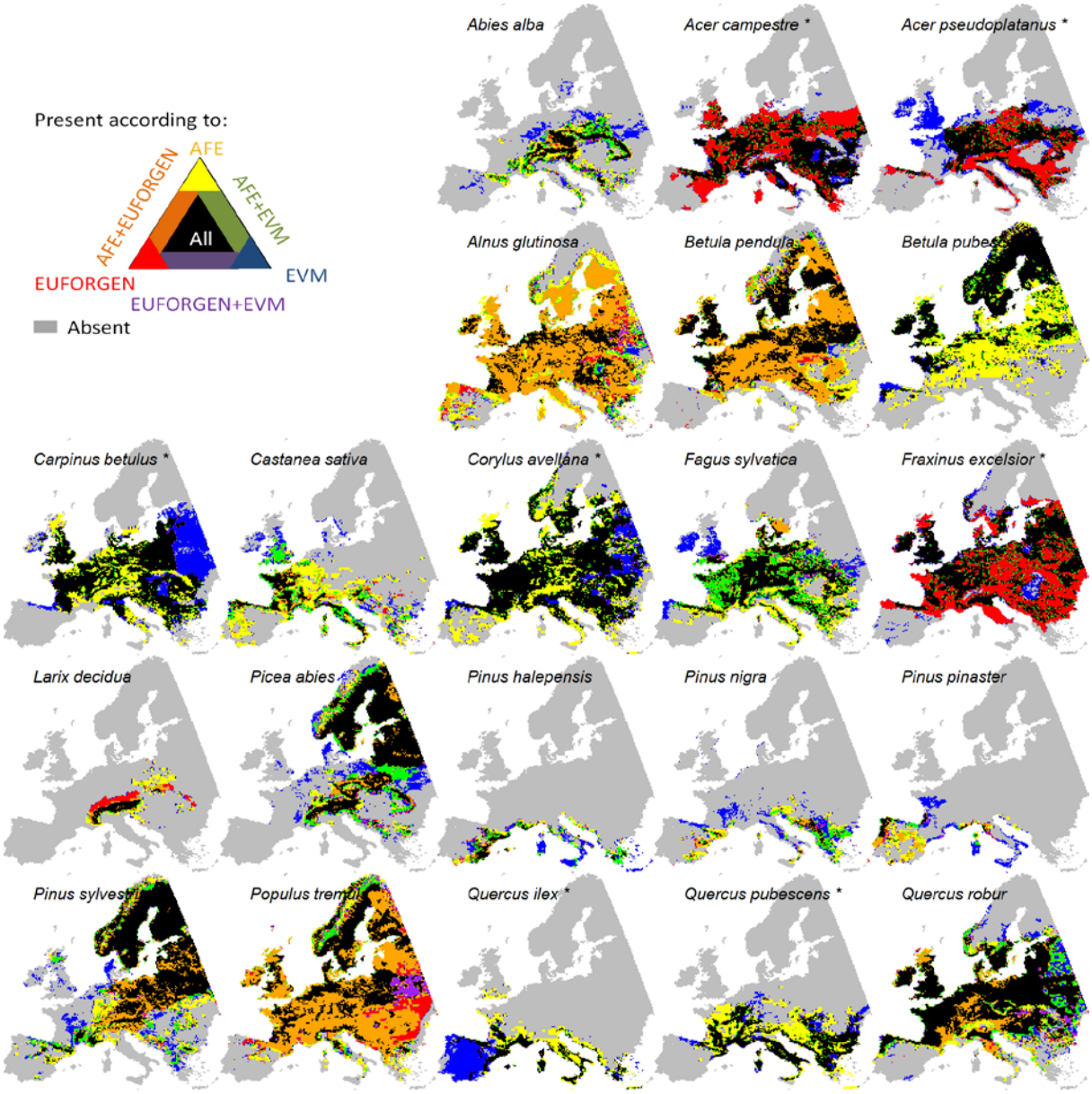
APPENDIX S4

Data source agreement for each of the 21 species. Maps showing the number of data sources (from 1 to 5) reporting the species' occurrence for each pixel. Darker colors indicate a higher number of data sources. The data sources included here are : AFE (Jalas & Suominen, 1964-2010; Lahti & Lampinen, 1999; http://www.luomus.fi/english/botany/afe/index.htm), EUFORGEN dataset (http://www.euforgen.org/distribution_maps.html), JRC database (http://forest.jrc.ec.europa.eu/), EuroVegMap (Bohn *et al.*, 2004; http://www.floraweb.de/vegetation/dnld_eurovegmap.html), and ICP forest plots (http://www.icp-forests.org/). Since JRC only covers forests, and there are only 6 146 ICP forest plots covering 5 441 pixels, total agreement between maps can be reached with a score lower than 5. Lambert Azimuthal Equal Area projection.



APPENDIX S5

Maps showing discrepancies between the three atlases covering the whole continent (AFE, EUFORGEN and EuroVegMap). Zones where all atlases agree on the species' presence (resp. absence) appear in black (resp. grey). All other colours indicate that atlases diverge. Zones where a species is indicated as present by one atlas only received primary colours (yellow for AFE, red for EUFORGEN and blue for EuroVegMap); zones where the species was given as "present" by two atlases received the corresponding secondary colours. Asterisks following species' names indicate that distribution data was missing from one atlas. Lambert Azimuthal Equal Area projection.



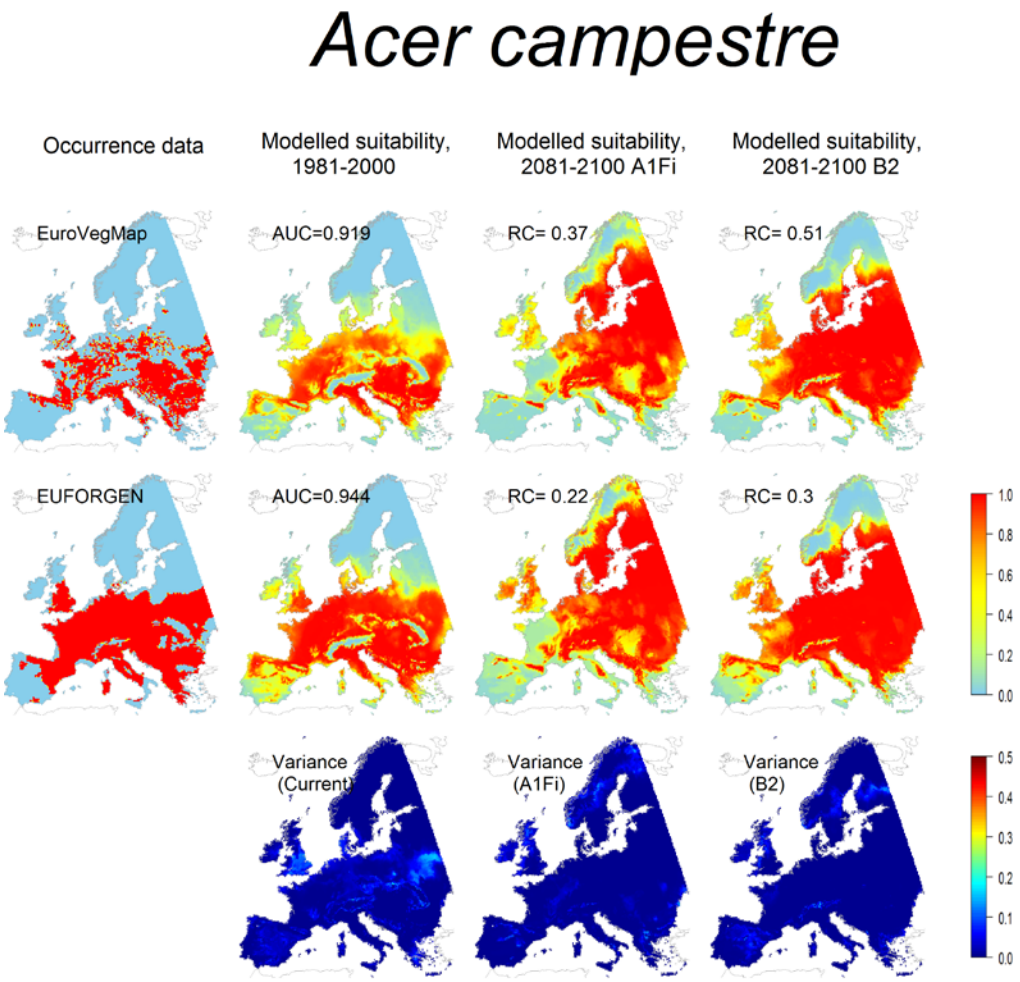
APPENDIX S6

Impact of the source of data on the projections of correlative SDMs (BIOMOD) under historical and forecast conditions. Maps showing observed occurrences (left column), simulated historical (second column) and forecast (two scenarios, third and fourth columns) habitat suitability, as inferred from the ensemble model generated from the models calibrated using presence and pseudo-absence data from each of the four data sources (rows) (one page per species). Lambert Azimuthal Equal Area projection.

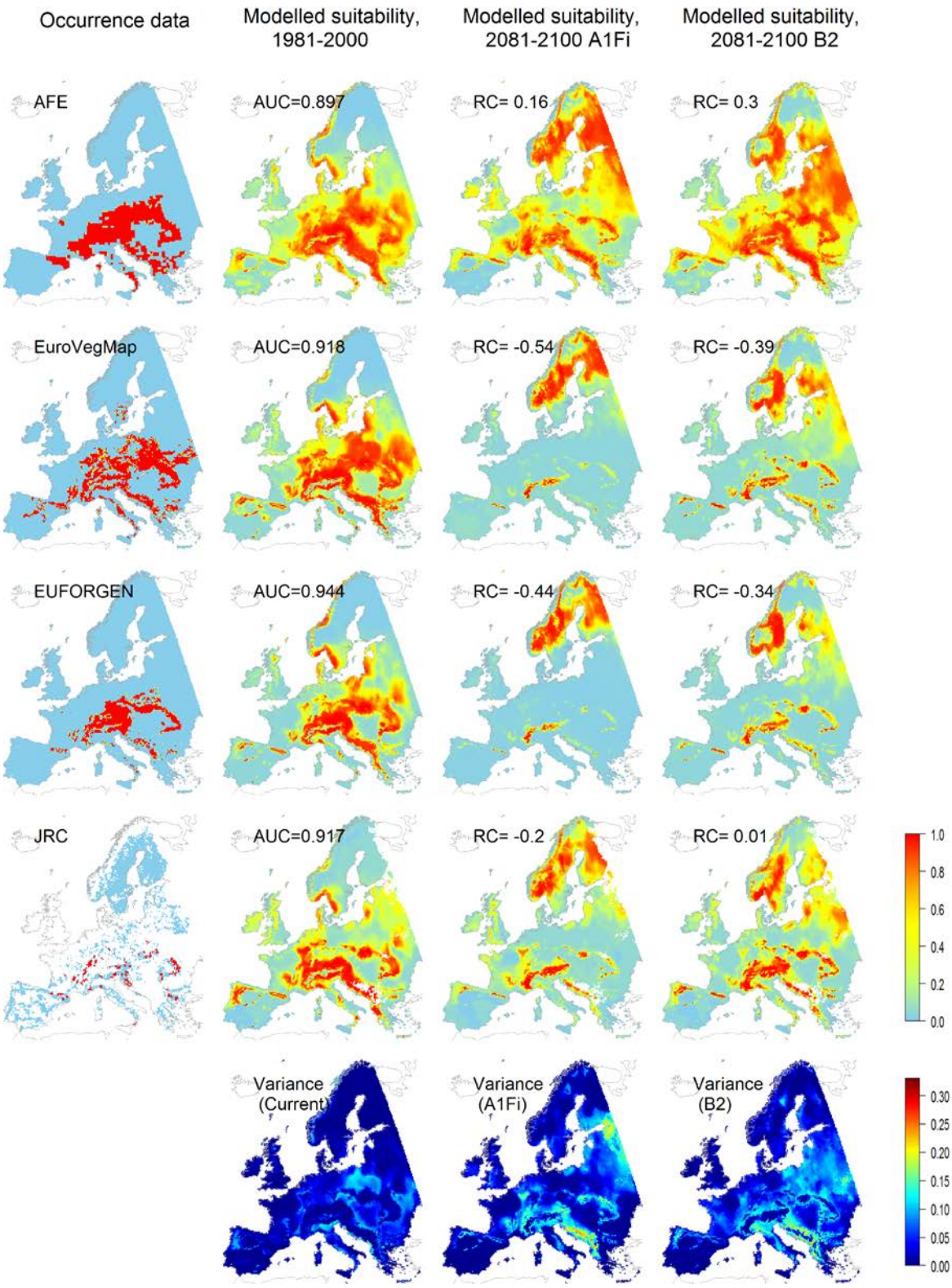
Bottom row: map of variance between projections, for each climatic dataset. The (exact) variance between projections was computed using the continuous outputs of the ensemble models generated using different data sources. Variance is plotted from its minimum (0) to its maximal possible value: 1/3 when three or four data sources were available, ½ when there were only two data sources (both *Acer* species).

RC: change in simulated suitable area under the climate scenario as compared to the simulated current suitable area. (It is thus computed assuming full dispersal.)

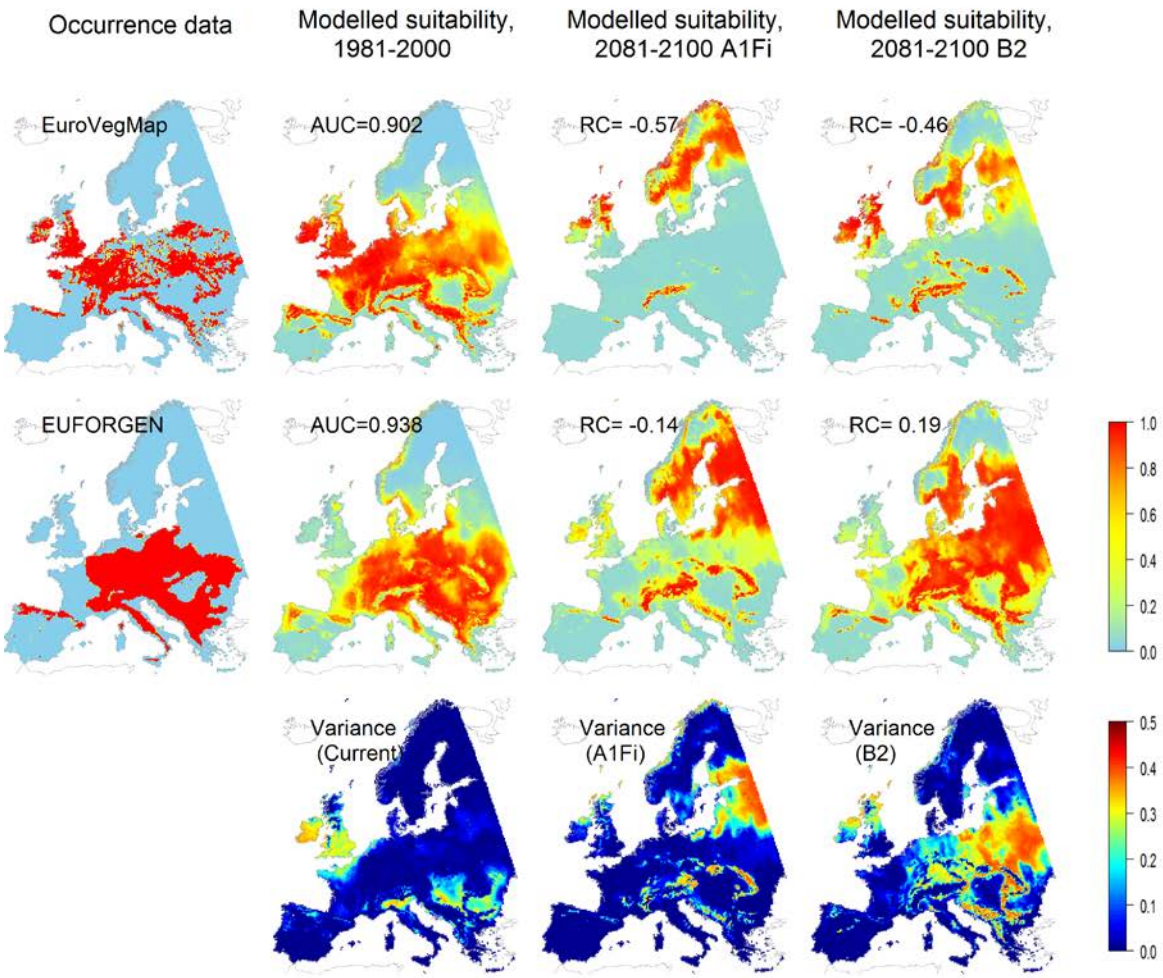
Whenever a dataset indicated the species' occurrence at fewer than 30 locations, no model was run (hence the reason why JRC data are not shown for *Acer campestre*, for example).



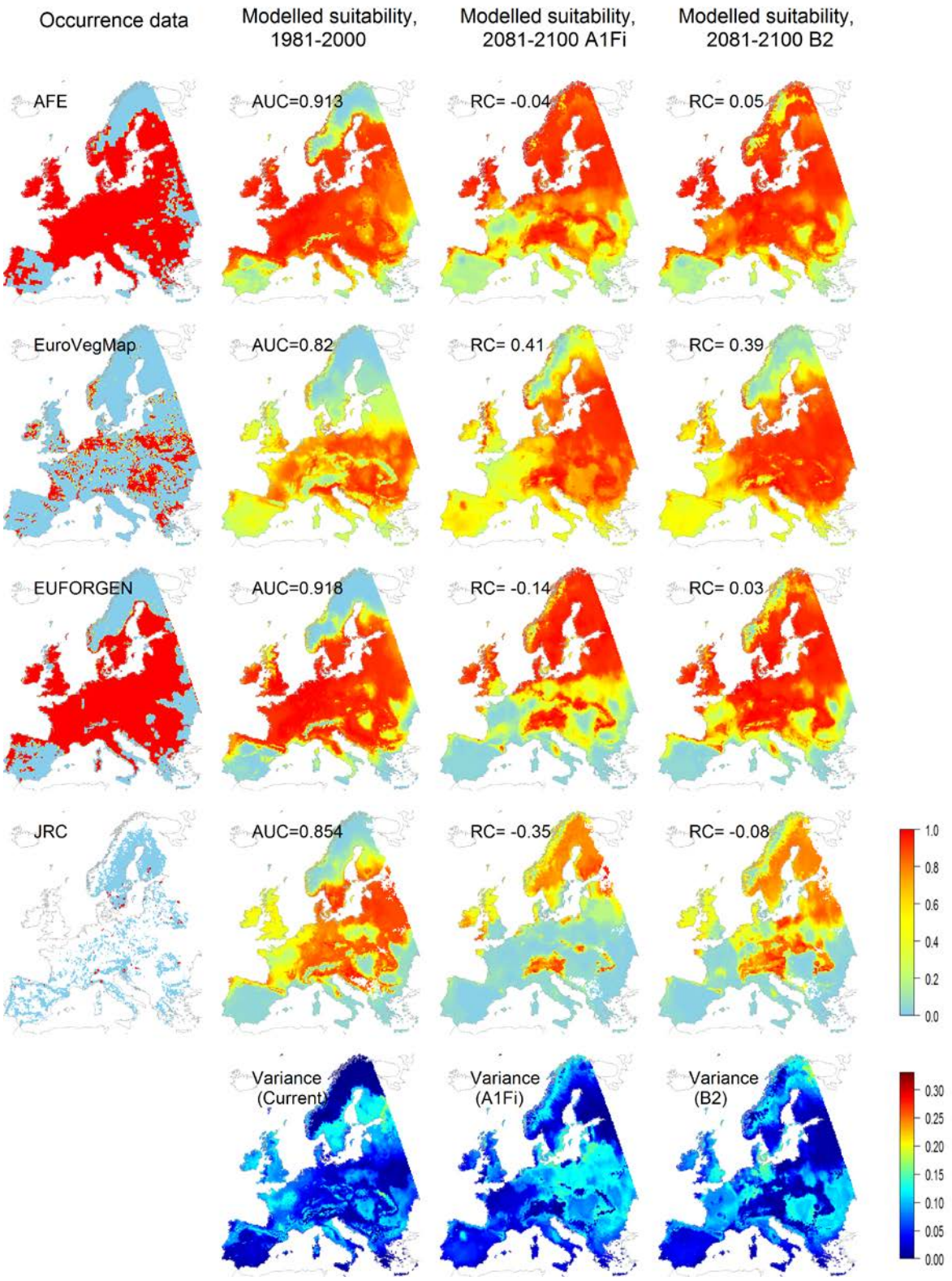
Abies alba


Occurrence data
Modelled suitability, 1981-2000
Modelled suitability, 2081-2100 A1Fi
Modelled suitability, 2081-2100 B2
AFE
AUC=0.897
RC= 0.16
RC= 0.3
EuroVegMap
AUC=0.918
RC= -0.54
RC= -0.39
EUFORGEN
AUC=0.944
RC= -0.44
RC= -0.34
JRC
AUC=0.917
RC= -0.2
RC= 0.01
Variance (Current)
Variance (A1Fi)
Variance (B2)
1.0
0.8
0.6
0.4
0.2
0.0
0.30
0.25
0.20
0.15
0.10
0.05
0.00

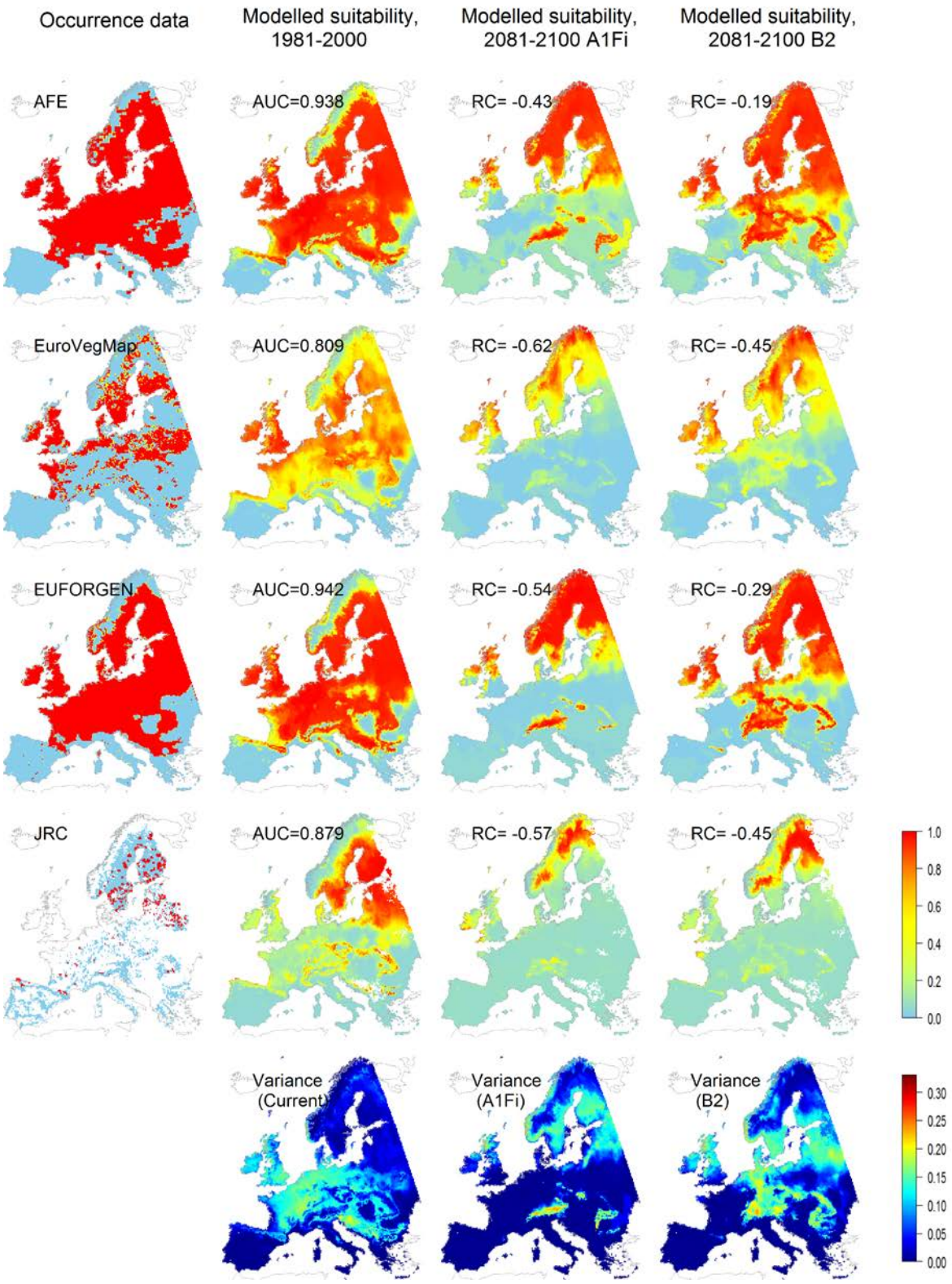
Acer pseudoplatanus



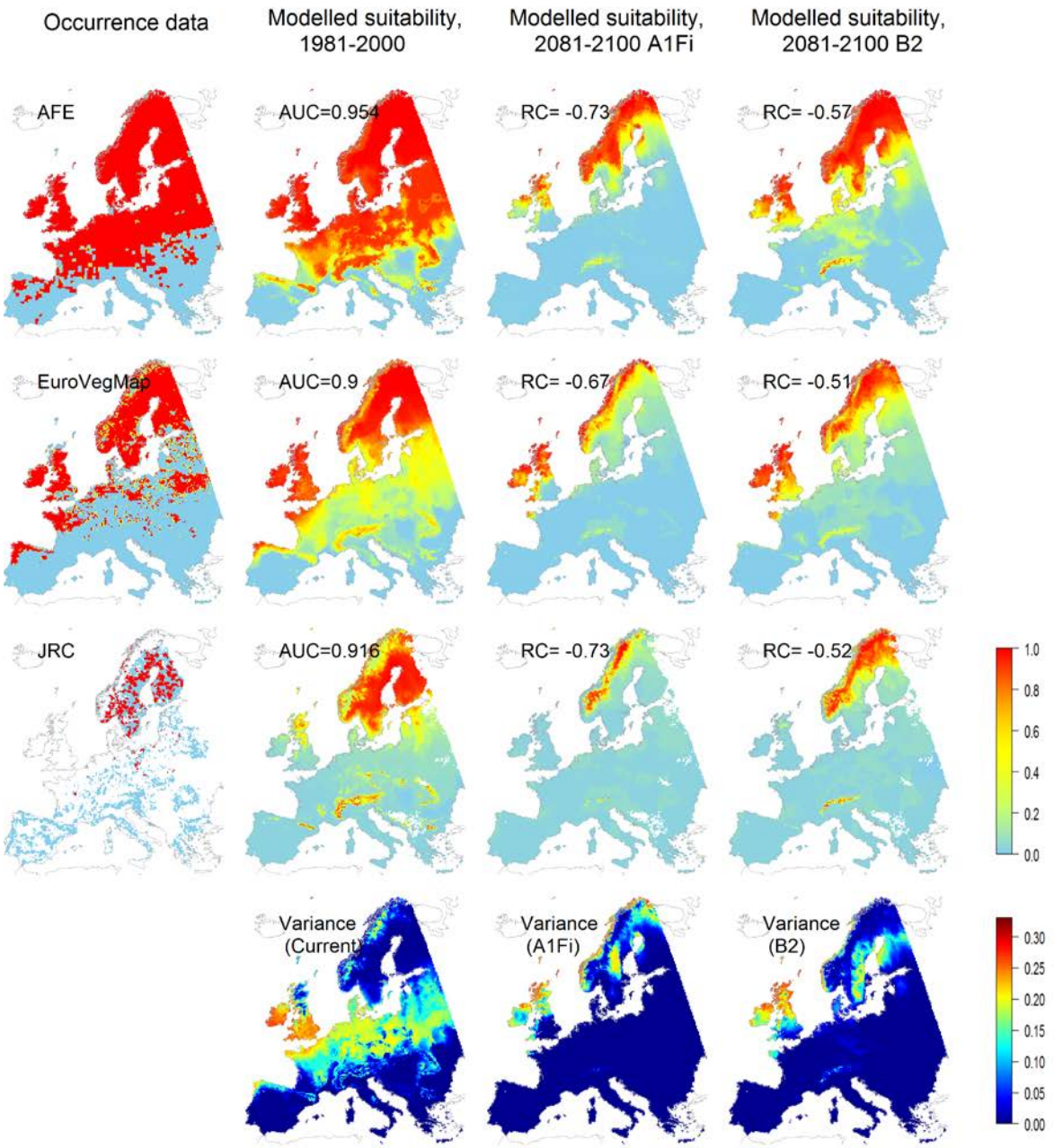
Alnus glutinosa



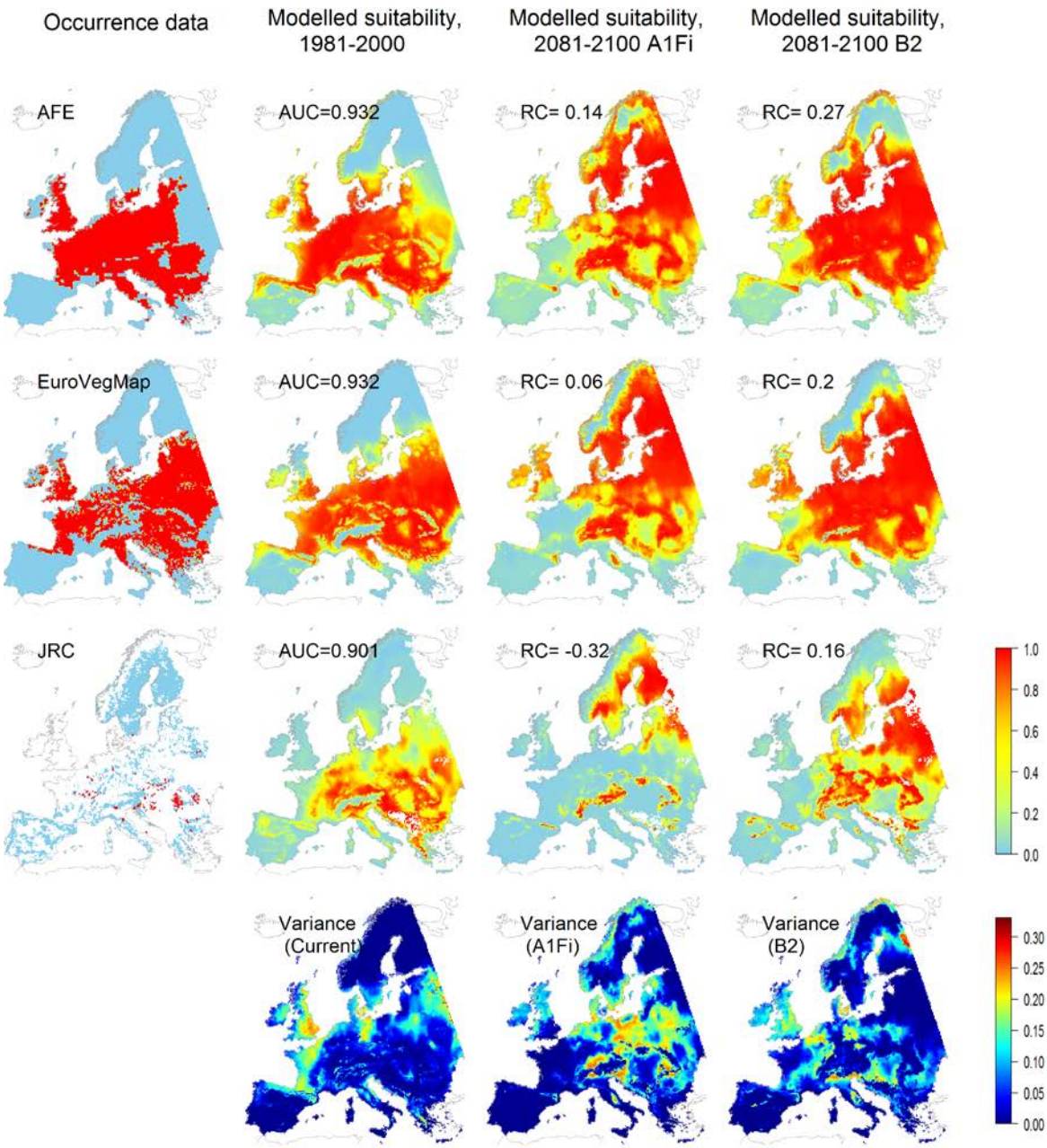
Betula pendula



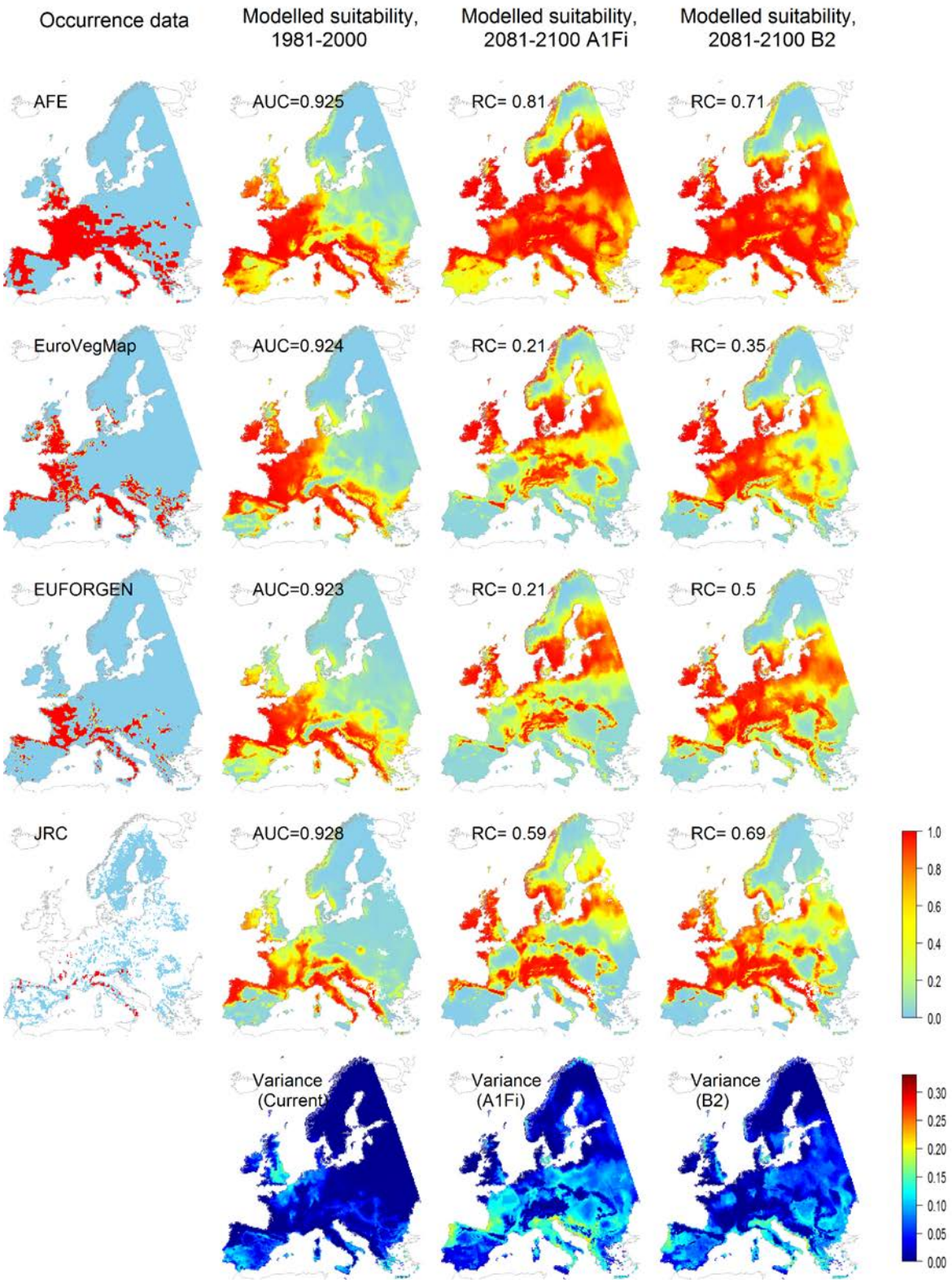
Betula pubescens



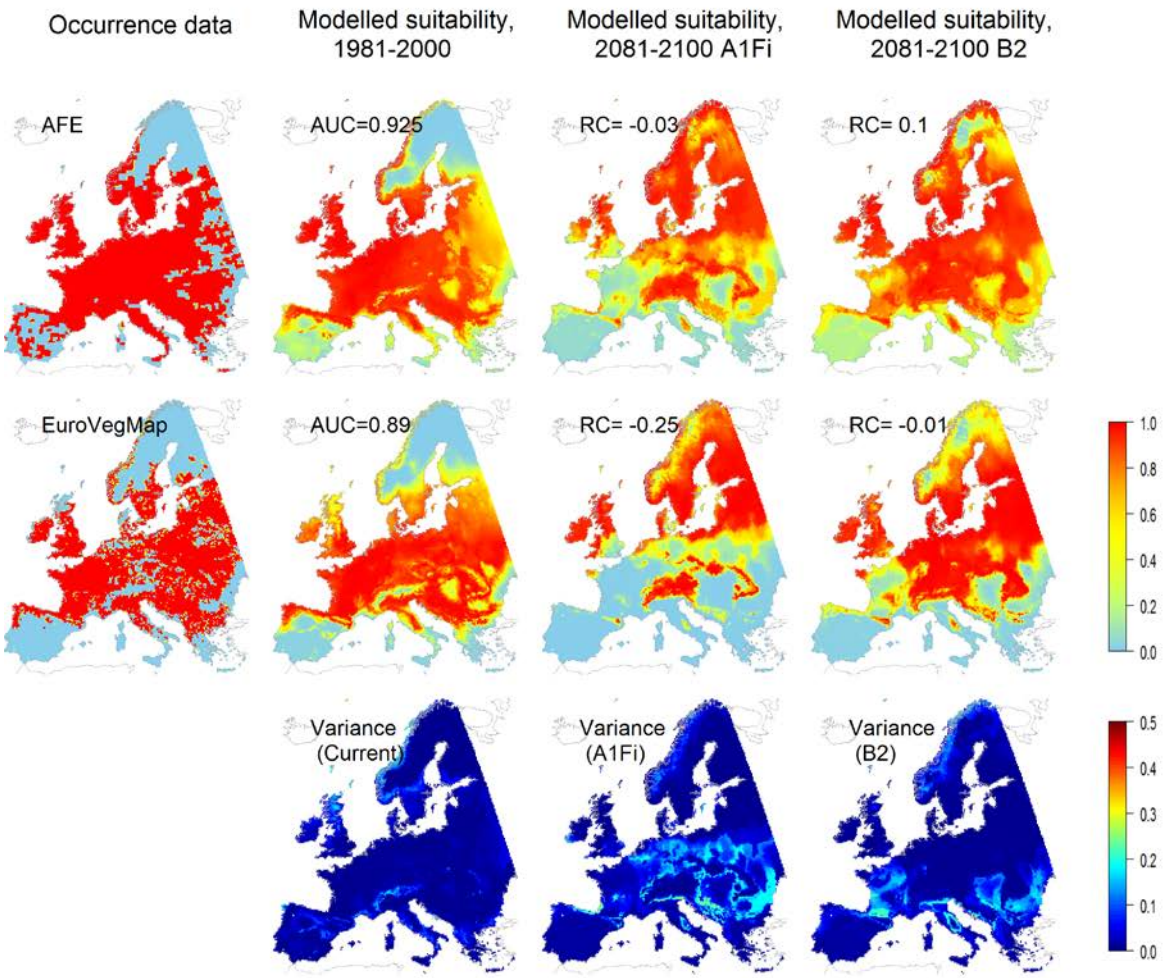
Carpinus betulus



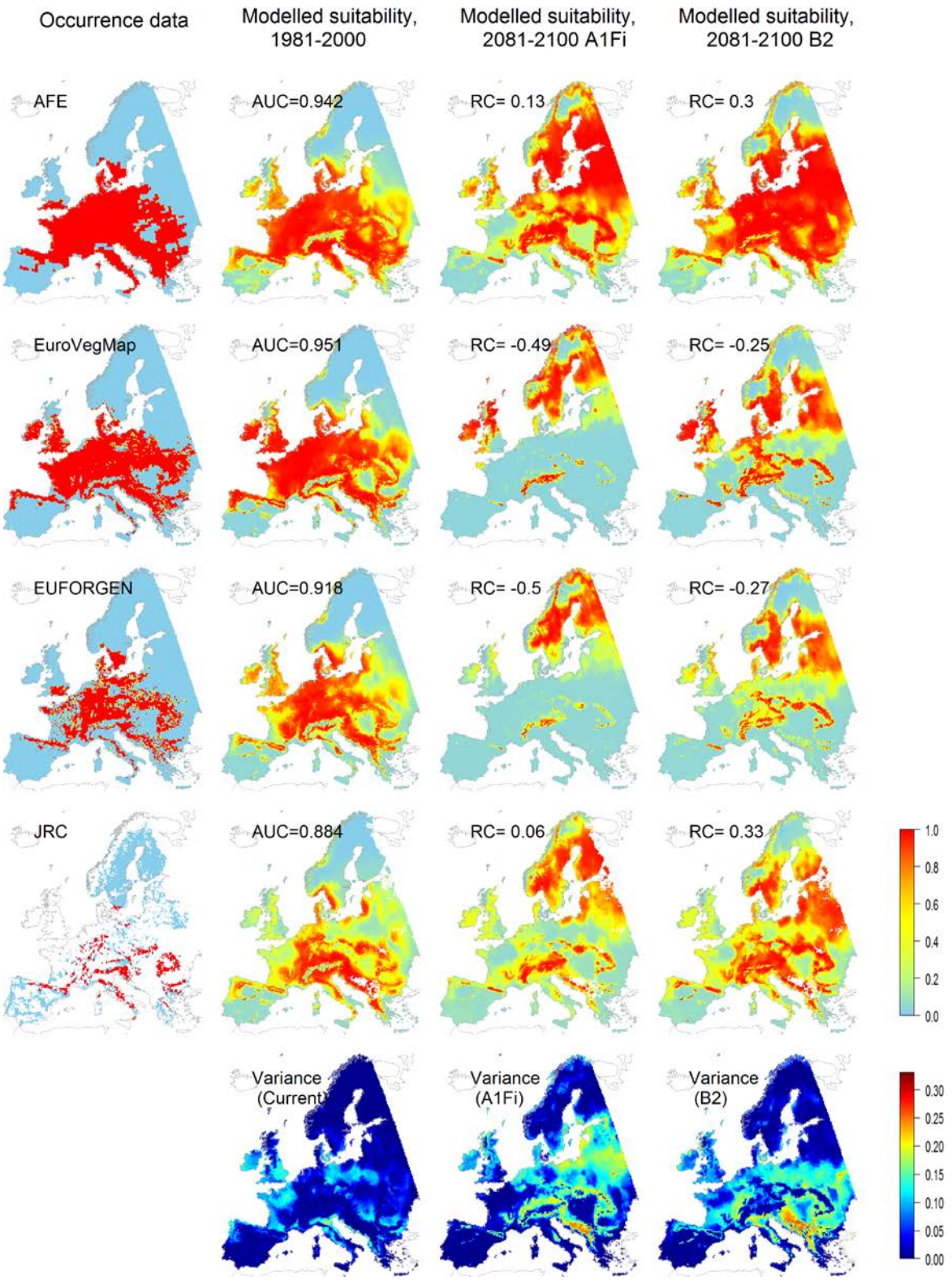
Castanea sativa



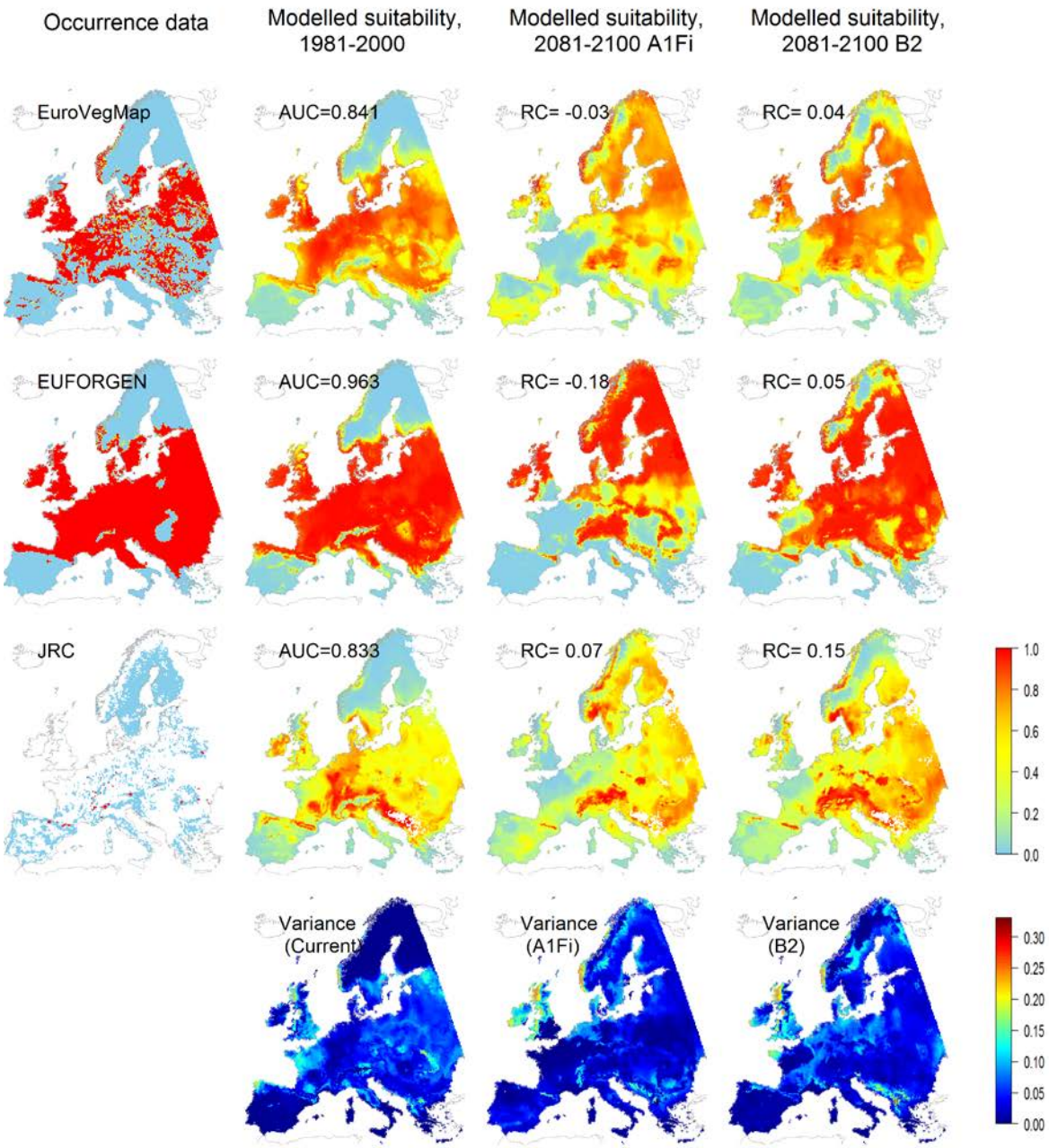
Corylus avellana



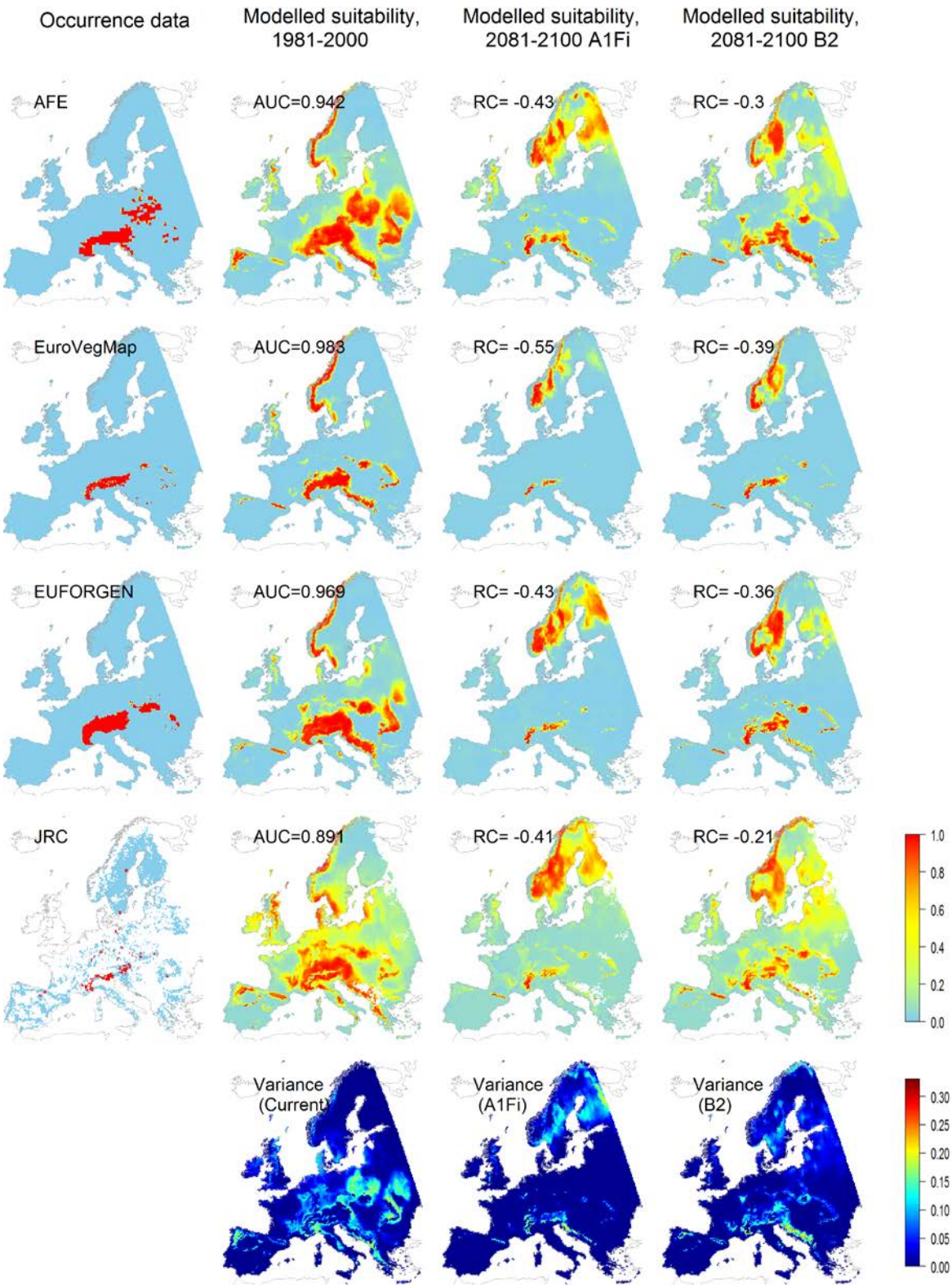
Fagus sylvatica



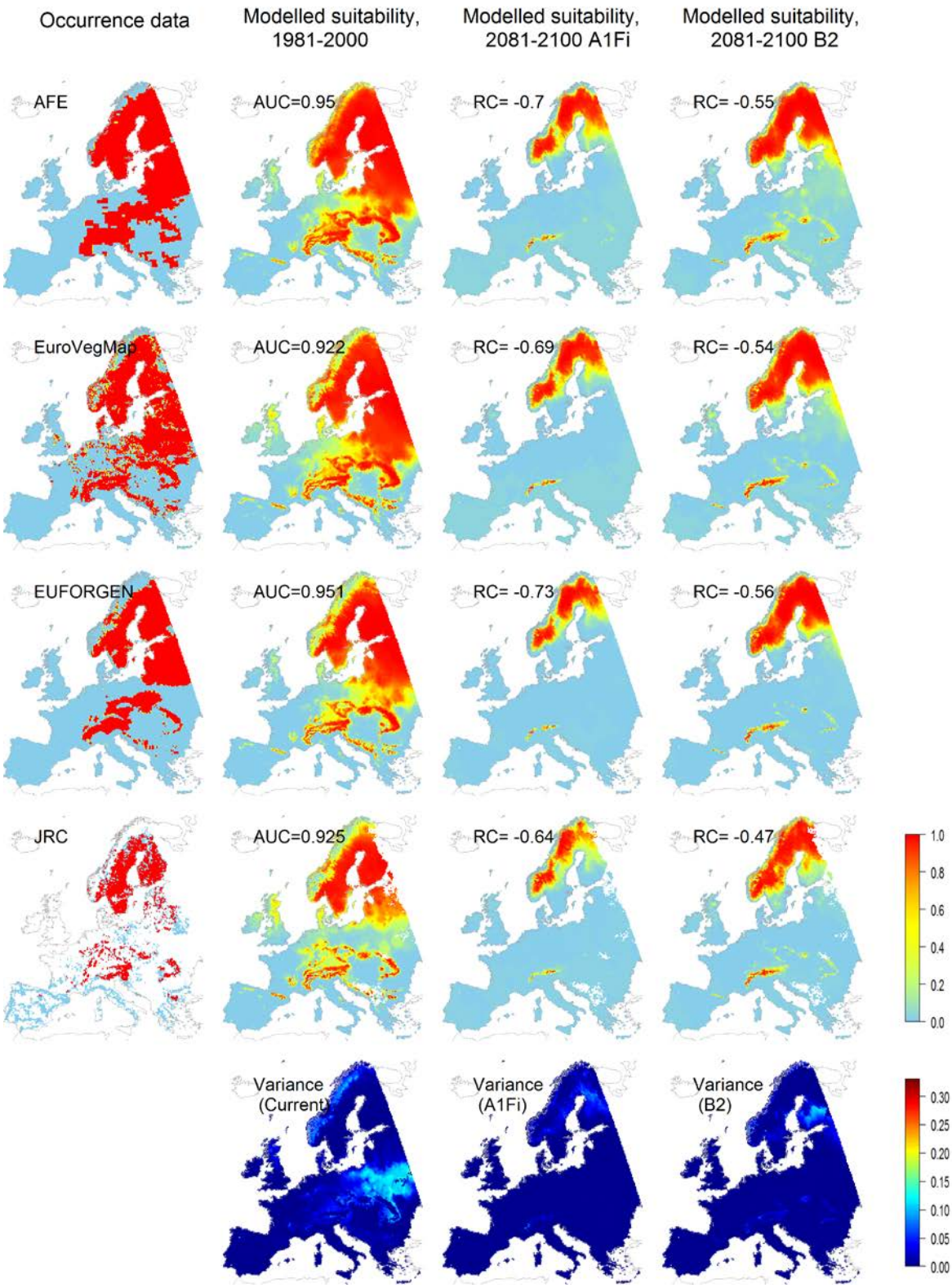
Fraxinus excelsior



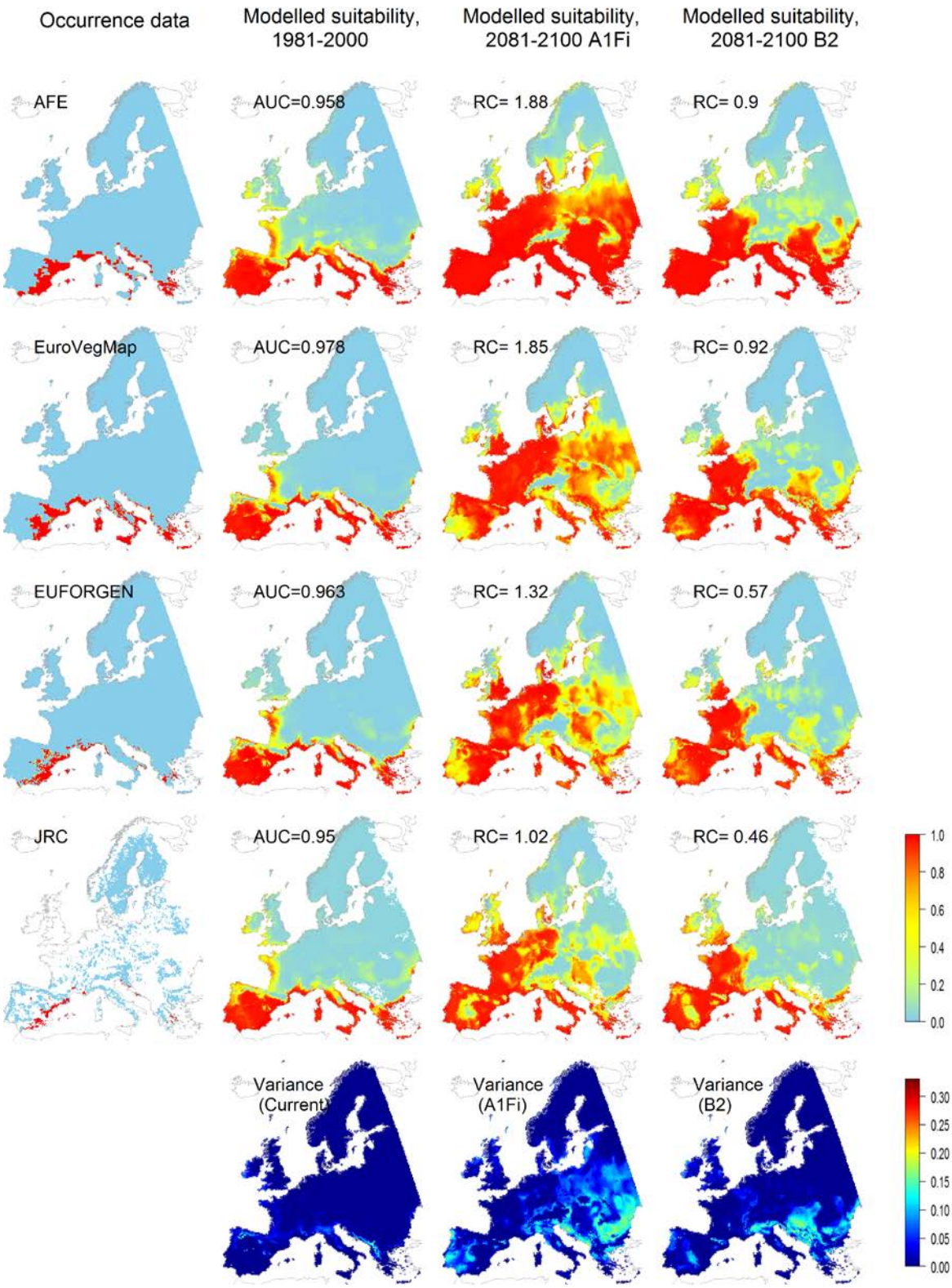
Larix decidua



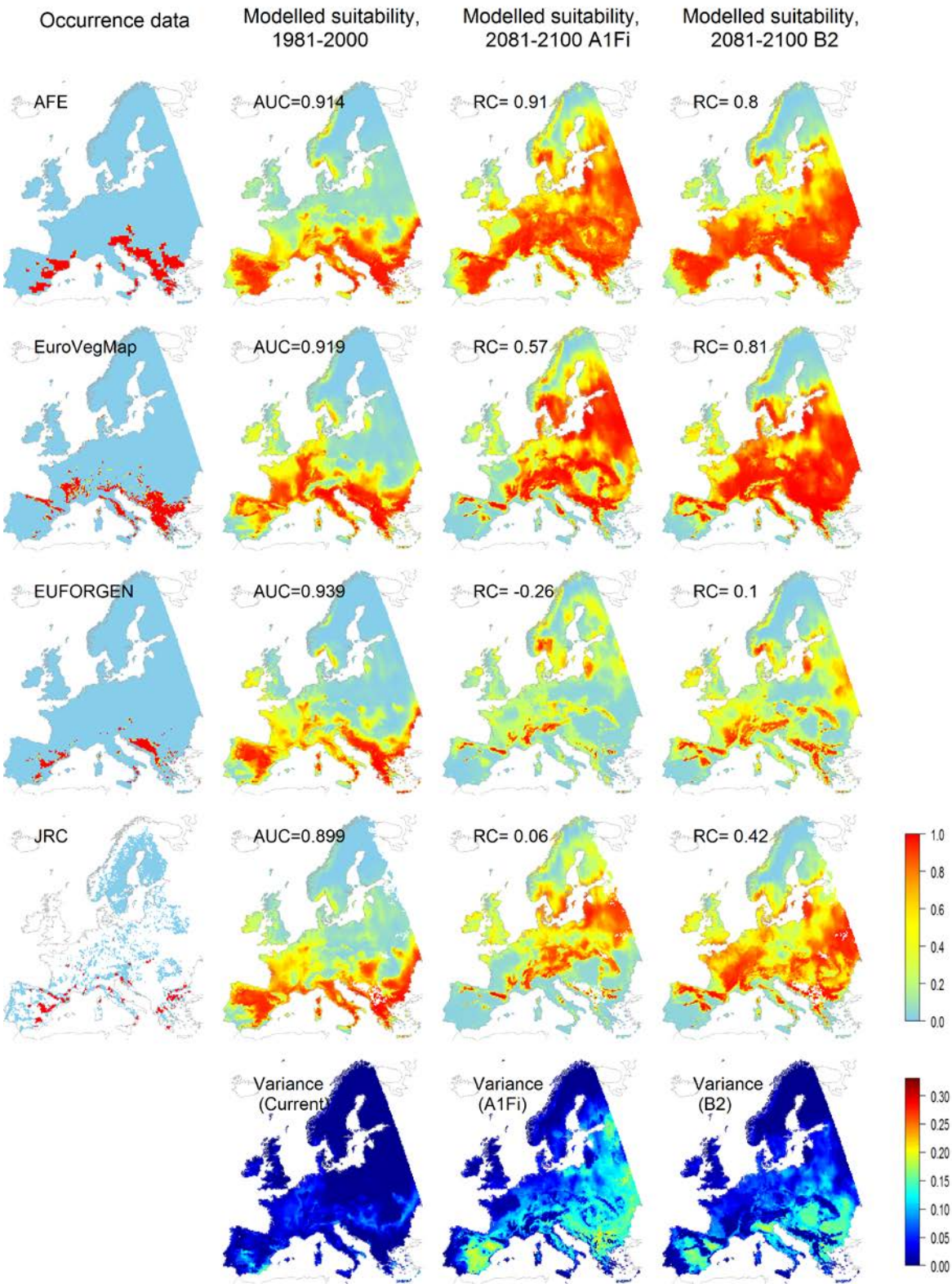
Picea abies


Occurrence data
Modelled suitability, 1981-2000
Modelled suitability, 2081-2100 A1Fi
Modelled suitability, 2081-2100 B2
AFE
AUC=0.95
RC= -0.7
RC= -0.55
EuroVegMap
AUC=0.922
RC= -0.69
RC= -0.54
EUFORGEN
AUC=0.951
RC= -0.73
RC= -0.56
JRC
AUC=0.925
RC= -0.64
RC= -0.47
Variance (Current)
Variance (A1Fi)
Variance (B2)
1.0
0.8
0.6
0.4
0.2
0.0
0.30
0.25
0.20
0.15
0.10
0.05
0.00

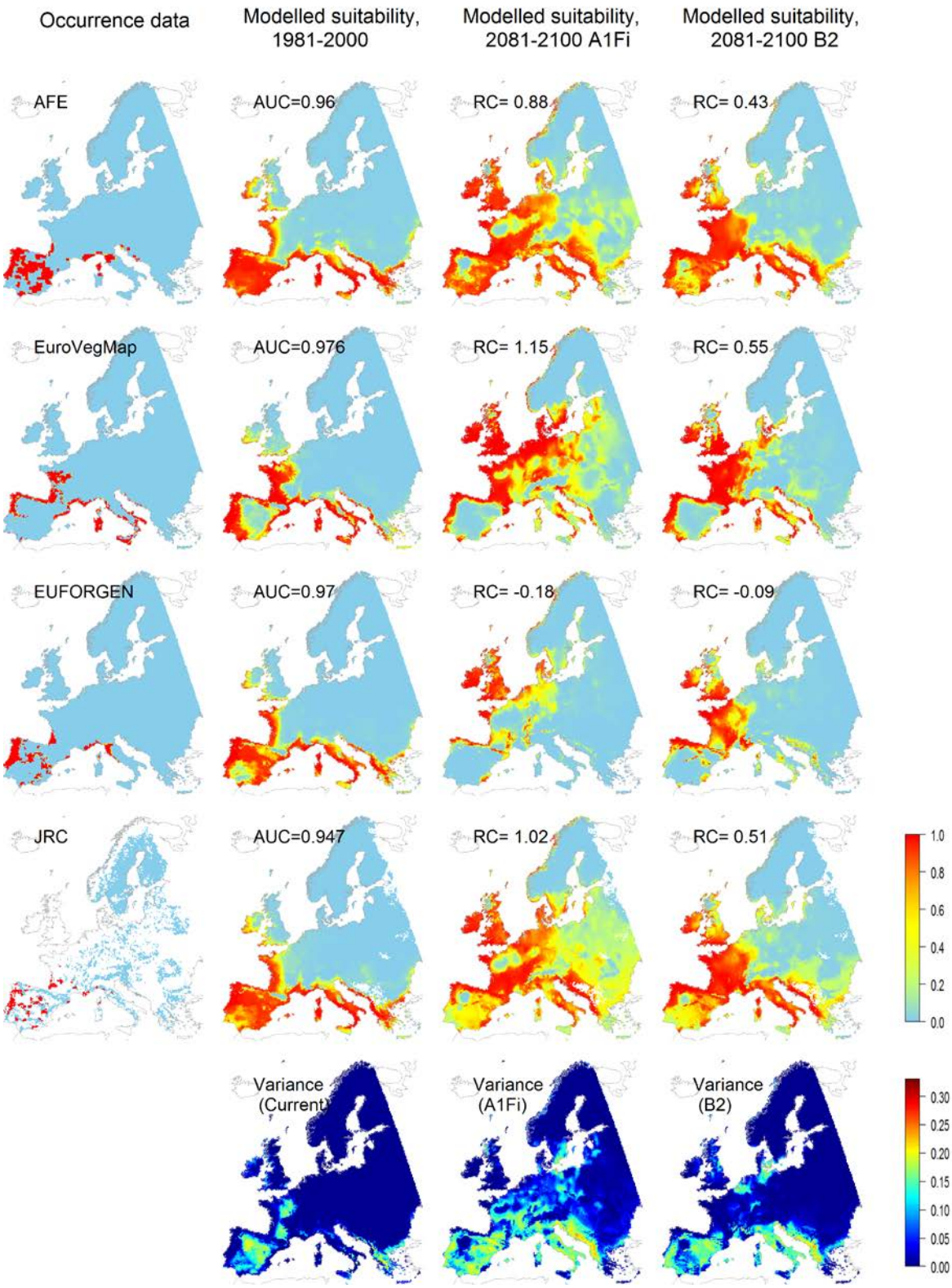
Pinus halepensis



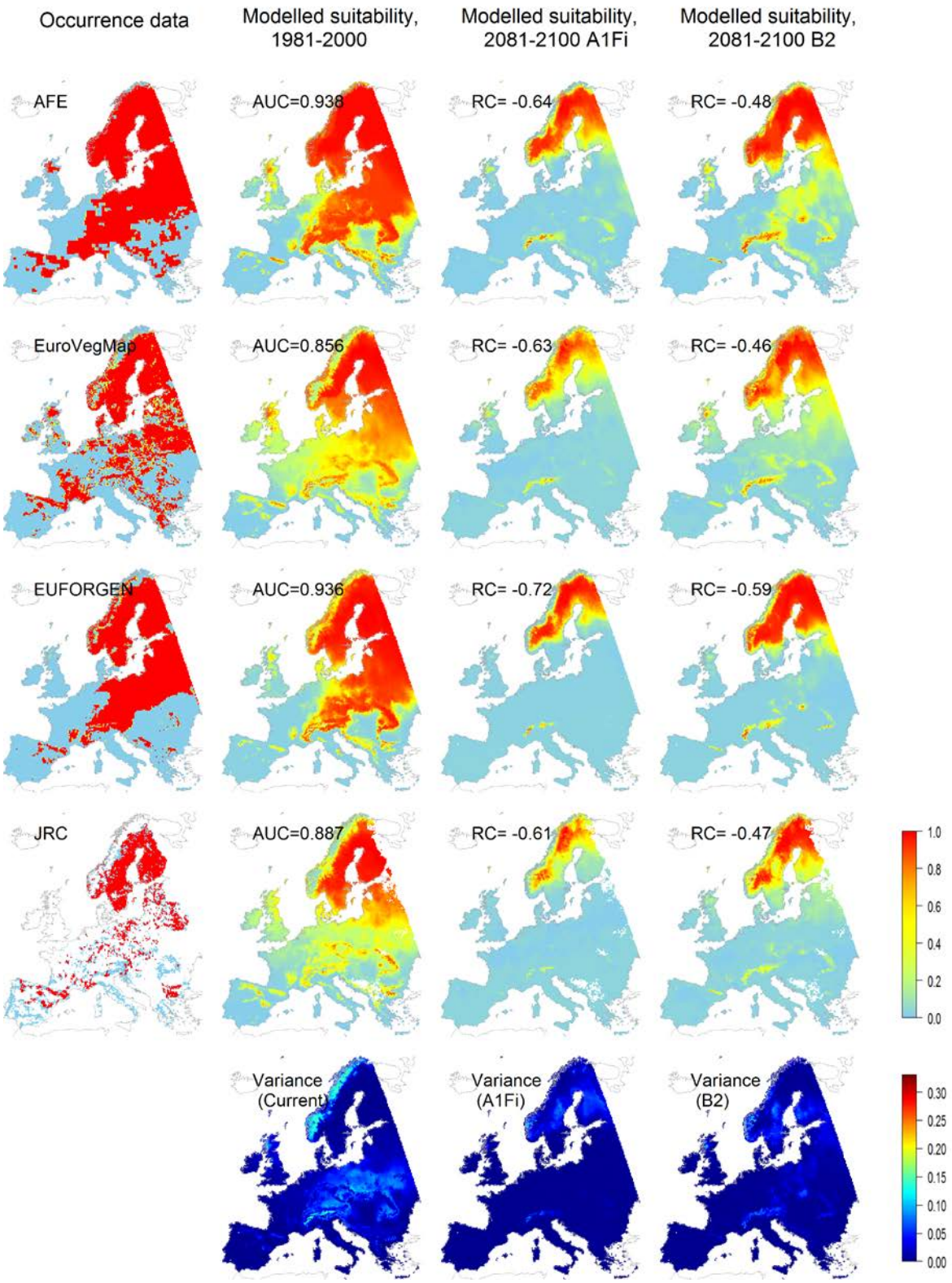
Pinus nigra


Occurrence data
Modelled suitability, 1981-2000
Modelled suitability, 2081-2100 A1Fi
Modelled suitability, 2081-2100 B2
AFE
AUC=0.914
RC= 0.91
RC= 0.8
EuroVegMap
AUC=0.919
RC= 0.57
RC= 0.81
EUFORGEN
AUC=0.939
RC= -0.26
RC= 0.1
JRC
AUC=0.899
RC= 0.06
RC= 0.42
Variance (Current)
Variance (A1Fi)
Variance (B2)
1.0
0.8
0.6
0.4
0.2
0.0
0.30
0.25
0.20
0.15
0.10
0.05
0.00

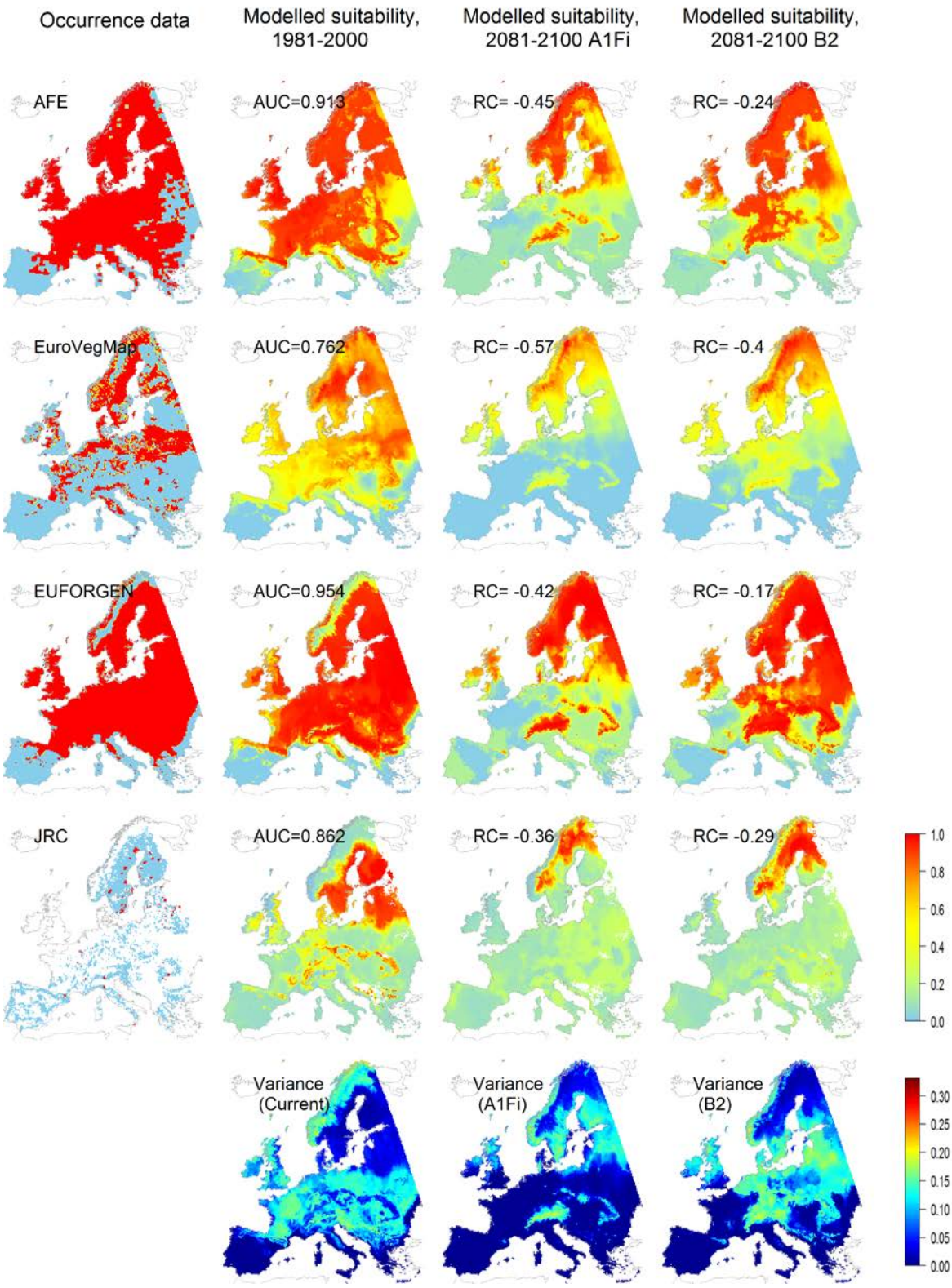
Pinus pinaster



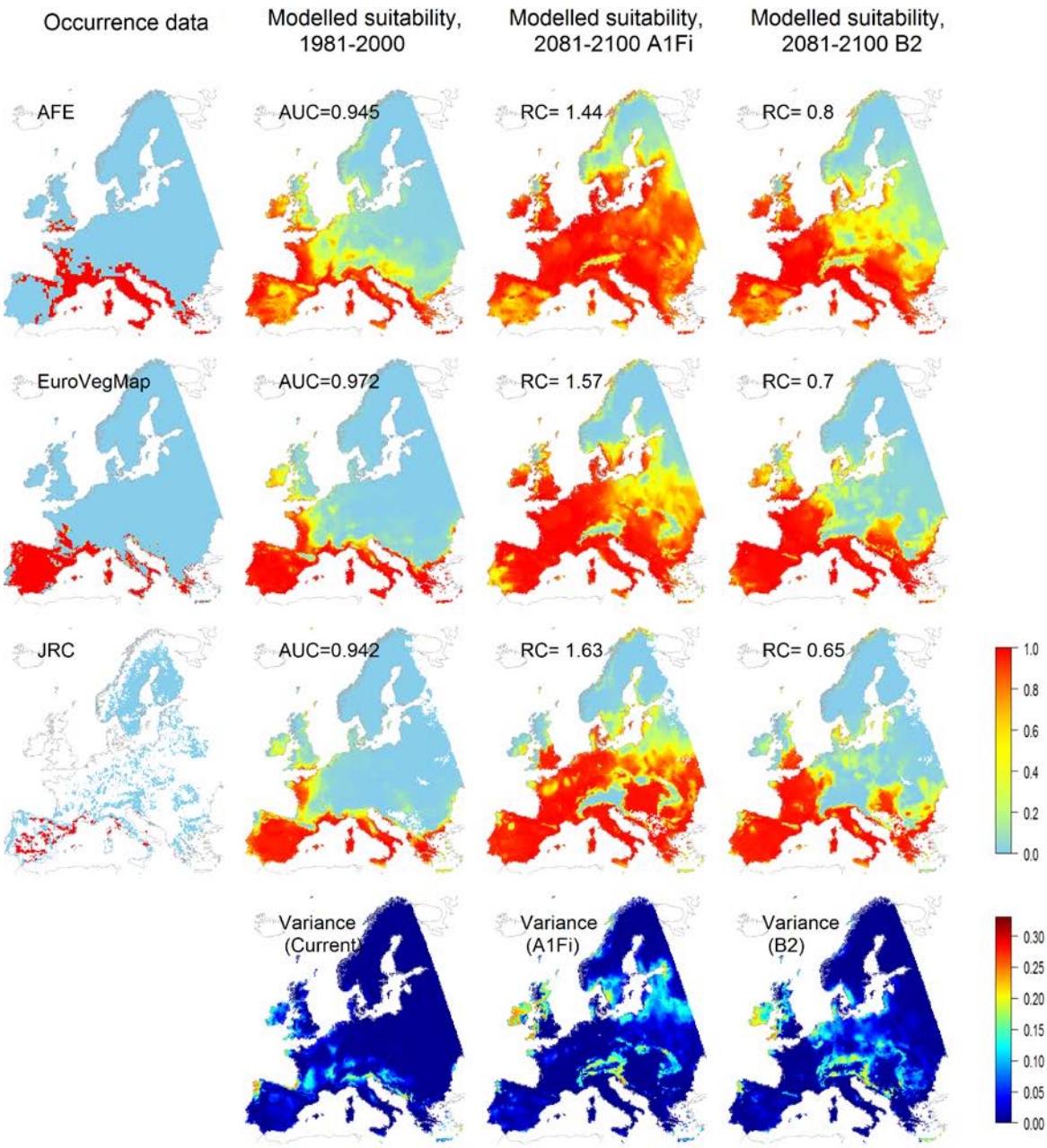
Pinus sylvestris



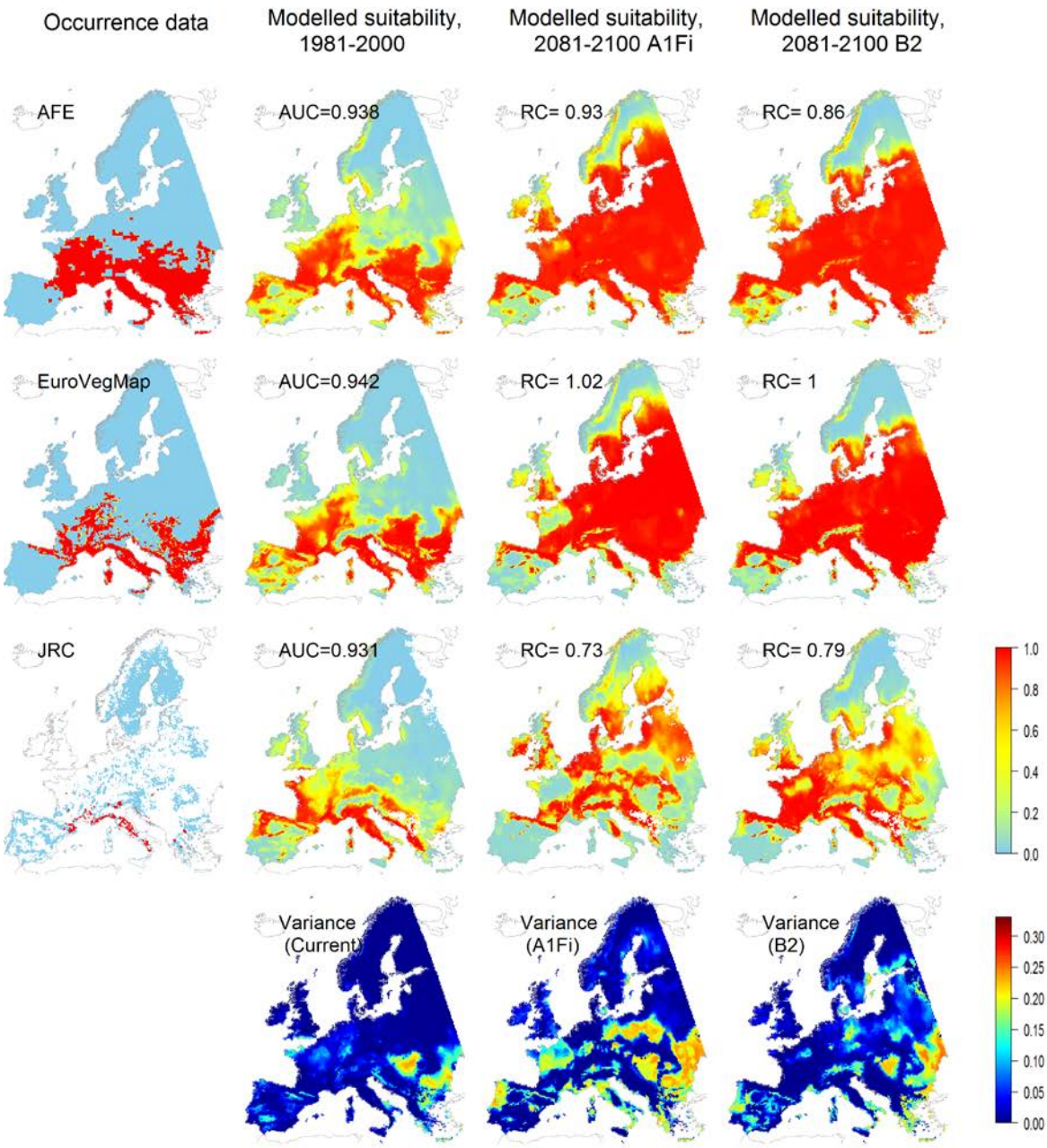
Populus tremula



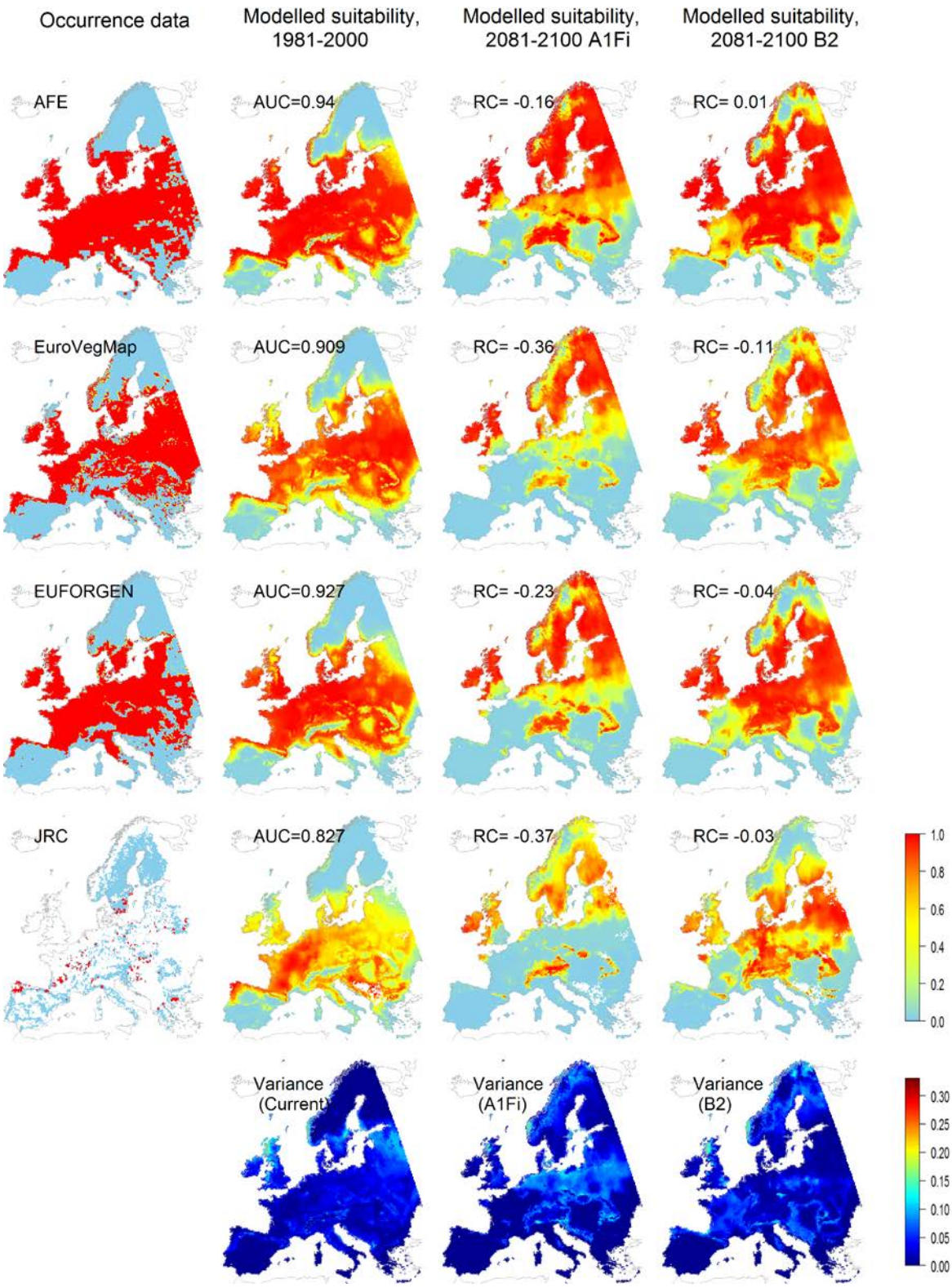
Quercus ilex



Quercus pubescens



Quercus robur



APPENDIX S7

Proportion of model discrepancies within the area predicted as suitable by at least one ensemble model built using BIOMOD using data from one source of occurrence data, under historical (1980-2000) and forecast conditions (2080-2100; A1Fi and B2 scenarios).

	Historical (1980-2000)	A1Fi (2080-2100)	B2 (2080-2100)
Abies alba	53%	76%	85%
Acer campestre	25%	13%	10%
Acer pseudoplatanus	48%	75%	82%
Alnus glutinosa	67%	71%	58%
Betula pendula	49%	83%	82%
Betula pubescens	49%	56%	47%
Carpinus betulus	40%	42%	31%
Castanea sativa	50%	72%	64%
Corylus avellana	24%	43%	33%
Fagus sylvatica	44%	82%	75%
Fraxinus excelsior	35%	42%	34%
Larix decidua	75%	88%	83%
Picea abies	30%	40%	28%
Pinus halepensis	22%	63%	47%
Pinus nigra	62%	92%	79%
Pinus pinaster	67%	80%	72%
Pinus sylvestris	34%	50%	43%
Populus tremula	73%	92%	87%
Quercus ilex	35%	41%	35%
Quercus pubescens	33%	26%	23%
Quercus robur	35%	51%	35%
Median	44%	63%	47%
Minimum	22%	13%	10%
Maximum	75%	92%	87%

APPENDIX S8

Post-hoc assessment of two process-based models (PHENOFIT, Chuine & Beaubien, 2001; LPJ, Sitch *et al.*, 2003) for three European trees varies according to the source of occurrence data. The values in the table are the AUC of each model, using different occurrence data as inputs. All available pixels were used (*i.e.* 28,776 pixels for the AFE, EUFORGEN and EuroVegMap atlases; and the 10,296 pixels located in forests for the JRC dataset). Model performance is assessed as "good" for 0.8<AUC<0.9, "fair" for 0.7<AUC<0.8, "poor" for 0.6<AUC<0.7, "fail" for AUC<0.6 (Araújo *et al.*, 2005).

Source of occurrence data	*Fagus sylvatica* (European beech)		*Quercus robur* (pedunculate oak)		*Pinus sylvestris* (Scots pine)	
	PHENOFIT	LPJ	PHENOFIT	LPJ	PHENOFIT	LPJ
AFE	0.818	0.886	0.851	0.846	0.706	0.692
EuroVegMap	0.818	0.858	0.755	0.758	0.666	0.611
EUFORGEN	0.766	0.834	0.804	0.835	0.690	0.652
JRC	0.801	0.842	0.763	0.798	0.615	0.547

APPENDIX S9

The area of "suitable" regions of three European species, as projected by two process-based models (LPJ and PHENOFIT), varies with the map used as a reference to define a presence/absence threshold. Each process-based model was run once for each climatic scenario, but a threshold was defined, above which the species was deemed as "present". This threshold is chosen so as to maximize the sum of sensitivity and specificity (Nenzén & Araújo, 2011), thus it varies with the map used as a reference. The ratios of maximal to minimal projected areas are generally low, but can be substantial.

		PHENOFIT				LPJ			
			Projected area (*1000 km²)				Projected area (*1000 km²)		
Species	Source of occurrence data	threshold	Historical (1980-2000)	A1Fi (2080-2100)	B2 (2080-2100)	threshold	Historical (1980-2000)	A1Fi (2080-2100)	B2 (2080-2100)
Fagus sylvatica (European beech)	AFE	0.14	2658	2152	2495	0.75	2171	3056	2874
	EuroVegMap	0.15	2562	2082	2390	0.72	2399	3056	2874
	EUFORGEN	0.14	2658	2152	2495	0.77	1977	2985	2809
	JRC	0.13	2762	2170	2525	0.65	2681	3056	2874
	Ratio max/min		**1.08**	**1.04**	**1.06**		**1.36**	**1.02**	**1.02**
Quercus robur (pedunculate oak)	AFE	0.58	3792	3198	3770	0.01	4248	3948	4071
	EuroVegMap	0.41	4313	3538	4291	0.66	3495	3948	4071
	EUFORGEN	0.57	3798	3200	3772	0.67	3444	3946	4071
	JRC	0.57	3798	3200	3772	0.73	2931	3598	3626
	Ratio max/min		**1.14**	**1.11**	**1.14**		**1.45**	**1.10**	**1.12**
Pinus sylvestris (Scots pine)	AFE	0.75	3079	983	2202	0.58	4750	4303	4591
	EuroVegMap	0.66	3529	1087	2398	0.62	4619	4174	4521
	EUFORGEN	0.71	3300	1075	2375	0.63	4588	4132	4488
	JRC	0.21	4530	1087	2398	0.65	4516	4022	4396
	Ratio max/min		**1.47**	**1.11**	**1.09**		**1.05**	**1.07**	**1.04**

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