Ecography

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Blach-Overgaard, A., Svenning, J.-C., Dransfield, J., Greve, M. and Balslev, H. 2010. Determinants of palm species distributions across Africa: the relative roles of climate, non-climatic environmental factors, and spatial constraints. – Ecography 33: 380–391.

Supplementary material

Appendix S1. Variable selection

Climatic variables from Worldclim (AMT, TSEA, TMIN, PREC, PSEA, PDRY) were selected from the full set of 19 bioclim variables after a correlation analysis: highly correlated variables (Pearson's correlations, r > 0.8) were grouped, and only one variable (the one deemed biologically most meaningful) from each group was used as a predictor in the subsequent analyses. Subsequently, we used Pearson's correlations and One-way ANOVA to assess the collinearity patterns in the full set of the environmental variables (the retained Worldclim climatic variables, WATBAL, the habitat and human impact variables), and between the environmental variables and the 14 spatial filters. These analyses were done using values for all the variables for 10 000 random points in the study area (Table S2). The correlation tests and ANOVAs were conducted in JMP 7.0 (SAS Inst., Cary). We found that GLC in general had higher explanatory power of the continuous variables than SOIL (Table S2), and notably for PREC, GVI and VCF. The correlation test amongst the continuous variables showed five correlated pairs (Pearson's correlations, r > 0.8, Table S2) which could be expected given the nature and computations of the layers namely: PREC vs GVI, PREC vs VCF, WATBAL vs GVI, GVI vs VCF, and finally PREC vs WATBAL. Despite the higher correlations amongst some layers, all variables were kept for the analyses as we find that they individually describe different properties of the environment, and in the case of PREC vs WATBAL represent annual mean vs seasonality variation which we strongly wanted to be represented in the modelling. Correlated predictors should not affect individual model outcome in terms of the overall spatial prediction in Maxent, and the same is also true for regression modelling, where multicollinearity does not affect the joint influence of correlated variables (Harrell 2001). However, collinearity may cause incorrect estimates of the importance of single predictors, also in Maxent (Phillips et al. 2004) (as explained in the Materials and methods section).

References

Harrell, F. E. 2001. Regression modeling strategies with applications to linear models, logistic regression, and survival analysis. – Springer.

Phillips, S. J. et al. 2004. A Maximum entropy approach to species distribution modeling. – In: Proceedings of the 21st International Conference on Machine Learning. ACM Press, pp. 655–662.

Table S1. Number of geographically unique presence records used for 29 African palm species in the Maxent modelling.

Species	Records no.
Borassus aethiopum	92
Calamus deerratus	133
Chamaerops humilis	21
Elaeis guineensis	84
Eremospatha cabrae	28
Eremospatha cuspidata	23
Eremospatha haullevilleana	91
Eremospatha hookeri	41
Eremospatha laurentii	46
Eremospatha macrocarpa	122
Eremospatha wendlandiana	50
Hyphaene compressa	21
Hyphaene coriacea	35
Hyphaene petersiana	43
Hyphaene thebaica	36
Laccosperma acutiflorum	28
Laccosperma laeve	42
Laccosperma opacum	92
Laccosperma robustum	49
Laccosperma secundiflorum	95
Oncocalamus mannii	41
Oncocalamus tuleyi	23
Phoenix reclinata	171
Podococcus acaulis	30
Podococcus barteri	88
Raphia hookeri	55
Raphia palma-pinus	30
Raphia sudanica	25
Sclerosperma mannii	47

Table S2. Pearson's correlation analyses and One-way ANOVA on twenty-six continuous and two categorical predictors based on 10 000 random points extracted from the study area (continental Africa).

	AMT	TSEA	TMIN	PREC	PSEA	PDRY	WATBAL	GVI	VCF	SLOPE	POP	HMNINFL	FILTER1	FILTER2	FILTER3	FILTER4	FILTER5	FILTER6	FILTER7	FILTER8	FILTER9	FILTER10	FILTER11	FILTER12	FILTER13	FILTER14
AMT	1.000																									
TSEA	–0.135	1.000																								
TMIN	0.678	–0.745	1.000																							
PREC	–0.027	–0.773	0.548	1.000																						
PSEA	0.463	–0.021	0.141	–0.288	1.000																					
PDRY	–0.053	–0.421	0.373	0.622	–0.451	1.000																				
WATBAL	–0.336	–0.694	0.313	0.938	–0.413	0.578	1.000																			
GVI	–0.160	–0.714	0.378	0.845	–0.279	0.486	0.851	1.000																		
VCF	–0.061	–0.619	0.434	0.823	–0.343	0.674	0.785	0.802	1.000																	
SLOPE	–0.332	–0.071	–0.136	0.077	–0.096	0.022	0.179	0.094	0.046	1.000																
POP	–0.052	–0.103	0.068	0.133	–0.051	0.073	0.142	0.125	0.020	0.071	1.000															
HMNINFL	–0.046	–0.515	0.316	0.470	–0.006	0.165	0.462	0.493	0.262	0.148	0.327	1.000														
FILTER1	0.221	0.453	–0.180	–0.304	0.200	–0.269	–0.367	–0.366	–0.336	–0.113	–0.021	–0.174	1.000													
FILTER2	–0.456	–0.100	–0.238	0.166	–0.210	–0.003	0.304	0.294	0.185	0.103	0.004	0.096	–0.002	1.000												
FILTER3	–0.225	–0.005	–0.200	0.144	–0.035	0.042	0.206	0.204	0.226	–0.058	–0.054	–0.087	–0.005	–0.014	1.000											
FILTER4	–0.161	0.628	–0.596	–0.680	0.264	–0.561	–0.591	–0.584	–0.623	0.046	–0.062	–0.310	0.000	–0.007	–0.012	1.000										
FILTER5	–0.185	0.330	–0.191	–0.131	–0.341	0.097	–0.048	–0.120	–0.027	0.042	–0.001	–0.224	0.017	0.003	0.003	–0.001	1.000									
FILTER6	0.123	–0.357	0.271	0.105	0.302	–0.101	0.069	0.119	–0.021	0.056	0.100	0.246	0.004	–0.023	0.010	–0.012	–0.014	1.000								
FILTER7	–0.117	–0.101	–0.059	0.010	–0.001	–0.018	0.050	0.024	–0.084	0.037	0.049	0.075	0.017	0.003	0.031	–0.004	–0.007	0.019	1.000							
FILTER8	–0.136	0.033	–0.107	–0.087	–0.153	0.035	–0.034	–0.081	–0.088	0.001	–0.032	–0.137	0.004	0.017	0.021	–0.006	0.014	0.013	–0.012	1.000						
FILTER9	–0.078	0.114	–0.131	–0.114	0.101	–0.134	–0.084	–0.039	–0.147	0.048	0.003	0.092	0.013	–0.026	0.000	0.006	0.011	–0.004	–0.005	0.007	1.000					
FILTER10	0.028	–0.103	0.147	0.065	–0.011	–0.066	0.083	–0.009	0.006	0.129	0.043	0.147	0.015	–0.011	0.029	–0.014	–0.002	–0.011	–0.011	–0.005	0.000	1.000				
FILTER11	0.256	–0.093	0.110	–0.042	0.459	–0.313	–0.107	–0.011	–0.096	–0.018	–0.036	0.020	0.004	–0.006	0.017	0.013	–0.006	–0.002	0.006	0.005	0.010	–0.014	1.000			
FILTER12	–0.119	–0.045	–0.016	0.138	–0.128	–0.109	0.173	0.139	–0.044	0.024	0.088	0.287	0.004	0.001	–0.002	0.010	0.019	–0.006	0.005	–0.001	0.019	0.010	0.000	1.000		
FILTER13	0.032	–0.037	0.029	0.151	–0.035	0.016	0.121	0.173	0.160	0.013	–0.049	0.091	0.005	–0.007	0.004	0.015	–0.005	–0.018	0.001	0.007	–0.017	–0.012	–0.014	0.003	1.000	
FILTER14	–0.015	–0.036	0.005	–0.019	–0.058	0.027	0.001	0.046	0.009	–0.004	–0.024	–0.032	0.014	0.019	–0.002	–0.007	0.005	–0.013	–0.008	0.009	–0.005	–0.020	0.005	–0.007	0.002	1.000

One-way ANOVA results of explanatory power of categorical predictors (2) on continuous predictor variables (26): GLC, R^2_{adj} = [0.029–0.856]; SOIL, R^2_{adj} = [0.037–0.585].
AMT, annual mean temperature; TSEA, temperature seasonality; TMIN, minimum temperature of the coldest month; PREC, annual precipitation; PSEA, precipitation seasonality; PDRY, precipitation of driest quarter; WATBAL, water balance; SLOPE, slope derived from digital elevation model; SOIL, soil types; GLC, land cover types; GVI, generalised vegetation index; VCF, vegetation continuous field product; POP, human population density; HMNINFL, human influence index; Filters, spatial filters (eigenvectors) derived from a truncated distance matrix using principal coordinate analysis.

Table S3. Combinations of climatic, habitat, human impact and spatial predictor variables in nine different models implemented in Maxent.

Model		Predictors
I	Clim+hab+hum	AMT; TSEA; TMIN; PREC; PSEA; PDRY; WATBAL; SLOPE; SOIL; GLC; GVI; VCF; POP; HMNINFL
II	Clim+hab	AMT; TSEA; TMIN; PREC; PSEA; PDRY; WATBAL; SLOPE; SOIL; GLC; GVI; VCF
III	Clim+hab+hum+filters	AMT; TSEA; TMIN; PREC; PSEA; PDRY; WATBAL; SLOPE; SOIL; GLC; GVI; VCF; POP; HMNINFL; filters 1–14
IV	Clim+filters	AMT; TSEA; TMIN; PREC; PSEA; PDRY; WATBAL; filters 1–7
V	Clim	AMT; TSEA; TMIN; PREC; PSEA; PDRY; WATBAL
VI	Hab	SLOPE; SOIL; GLC; GVI; VCF
VII	Hum	POP; HMNINFL
VIII	Filters	Filters 1–7
IX	Filters	Filters 1–14

Clim+hab+hum, environmental model including all the climatic, habitat and human impact predictors; Clim+hab, combined climatic and habitat model; Clim+hab+hum+filters, environmental model including all the climatic, habitat, human impact and all fourteen spatial filter predictors; Clim+filters, model combination of all climatic (seven) and first seven spatial filter predictors; Clim, model of all climatic predictors (seven); Hab, habitat model of all habitat predictors (five); Hum, model including both human impact predictors; Filters, model of spatial filters (seven or fourteen filters, respectively); AMT, annual mean temperature; TSEA, temperature seasonality; TMIN, minimum temperature of the coldest month; PREC, annual precipitation; PSEA, precipitation seasonality; PDRY, precipitation of driest quarter; WATBAL, water balance; SLOPE, slope derived from digital elevation model; SOIL, soil types; GLC, land cover types; GVI, generalised vegetation index; VCF, vegetation continuous field product; POP, human population density; HMNINFL, human influence index; Filters, spatial filters (eigenvectors) derived from a truncated distance matrix using principal coordinate analysis.

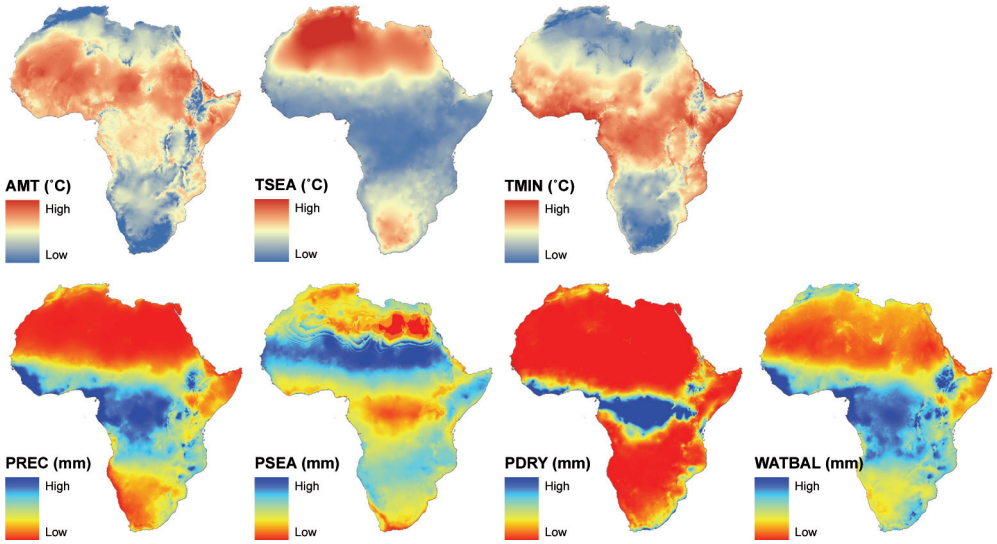


Figure S1. The distribution of the seven climatic variables: AMT, annual mean temperature; TSEA, temperature seasonality; TMIN, minimum temperature of the coldest month; PREC, annual precipitation; PSEA, precipitation seasonality; PDRY, precipitation of driest quarter; WATBAL, water balance.

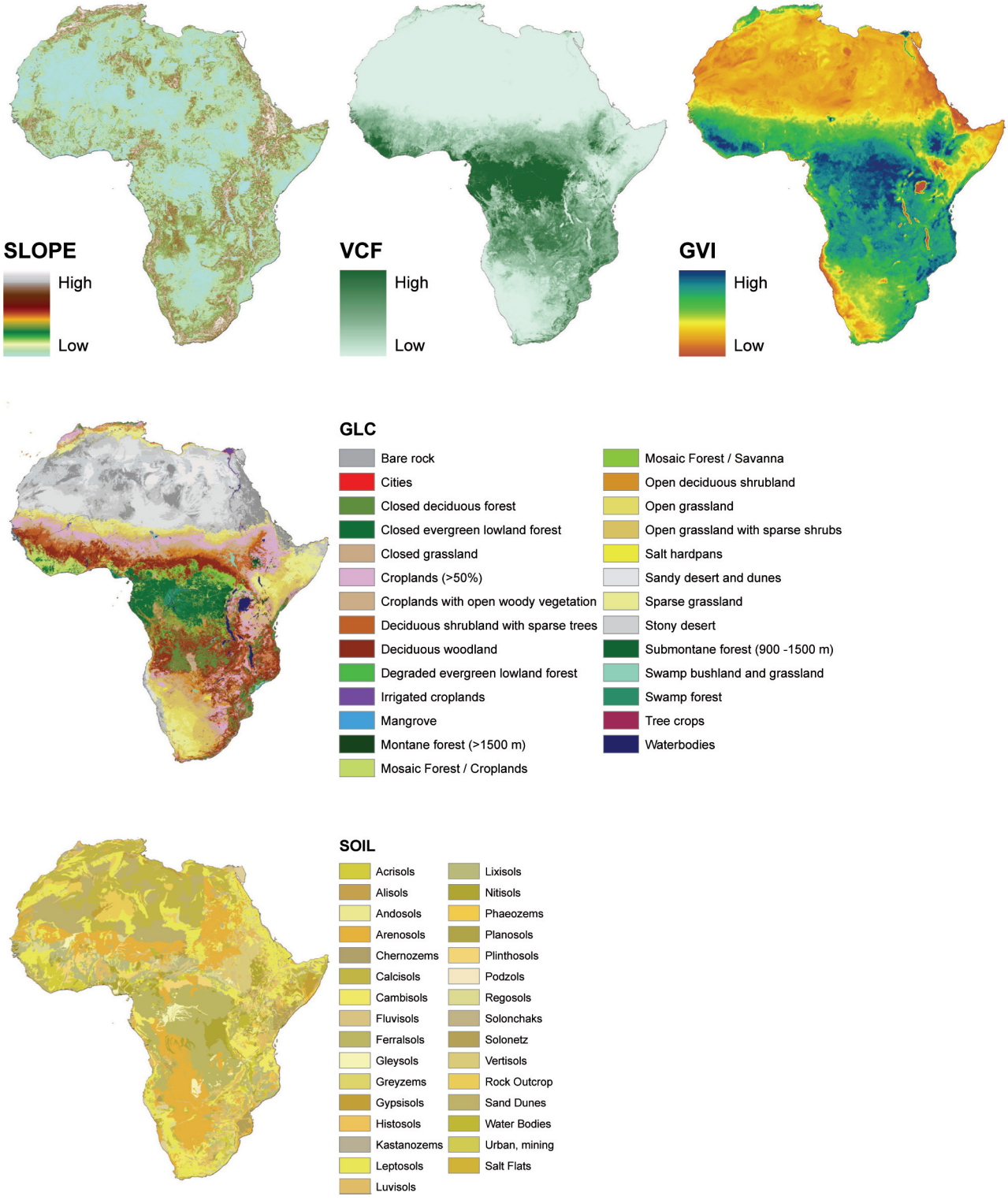


Figure S2. The distribution of the five habitat variables: SLOPE, slope derived from the digital elevation model GTOPO30; SOIL, soil types classified according to FAO90; GLC, land cover types; GVI, generalised vegetation index (total standing biomass); VCF, vegetation continuous field product (percent tree cover).

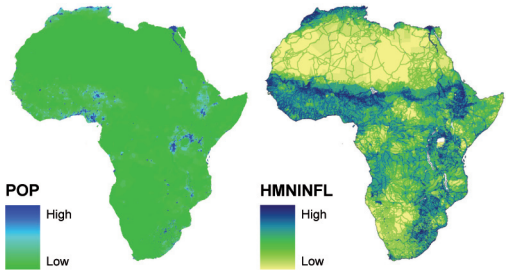


Figure S3. The distribution of the two human impact variables: POP, human population density; HMNINFL, human influence index.

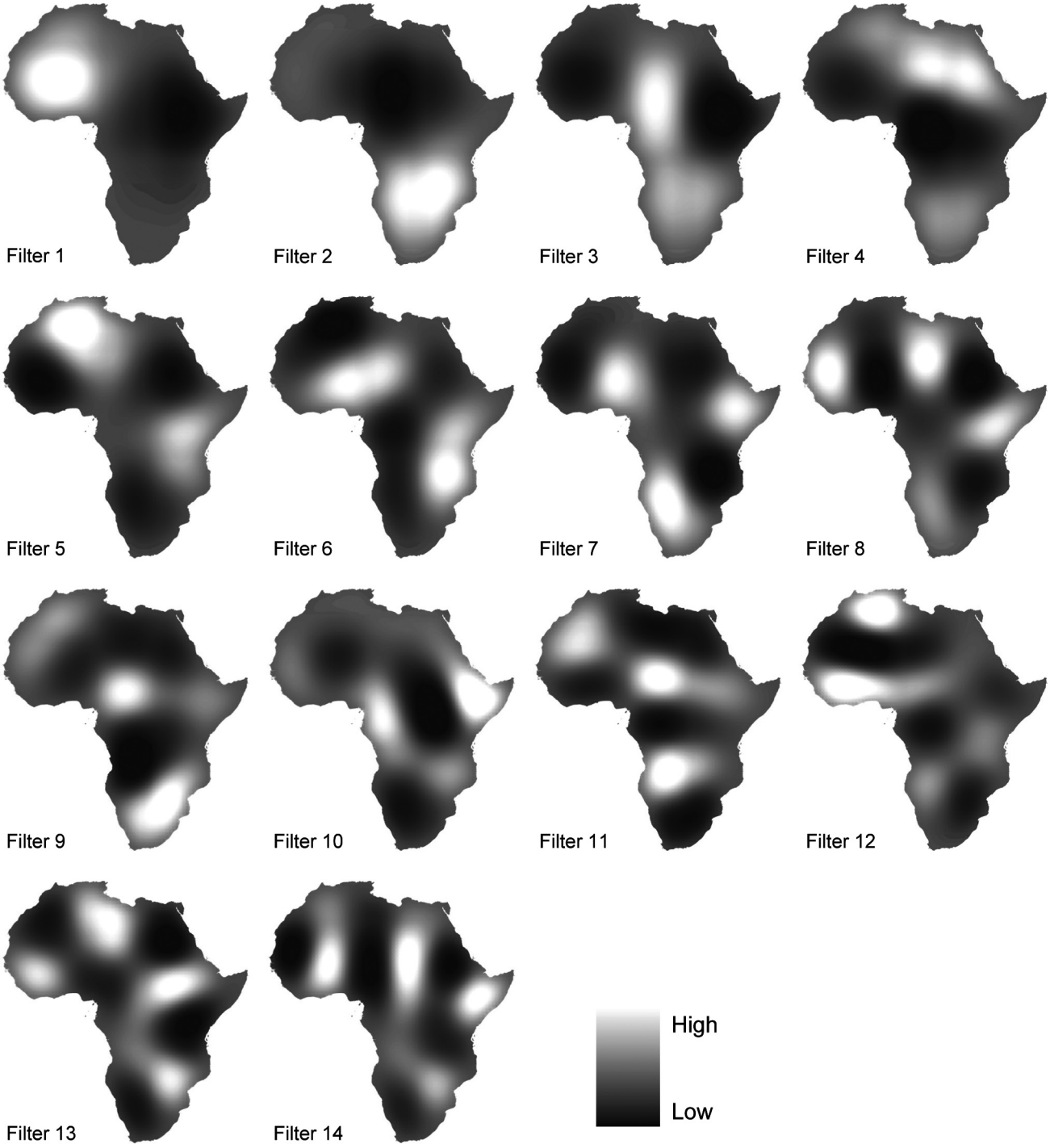


Figure S4. The geographic patterns of the 14 spatial filters showing the spatial relationship amongst cells (1 × 1 km grids). Increasingly lighter (white) colours indicate larger numerical values of the eigenvectors. The spatial pattern of Filter 1 shows two major clusters of high and low values, respectively, more or less portraying an east-west gradient in northern Africa, while Filter 2 captures a north-south gradient. Subsequent filters portray more oscillatory patterns across the continent.

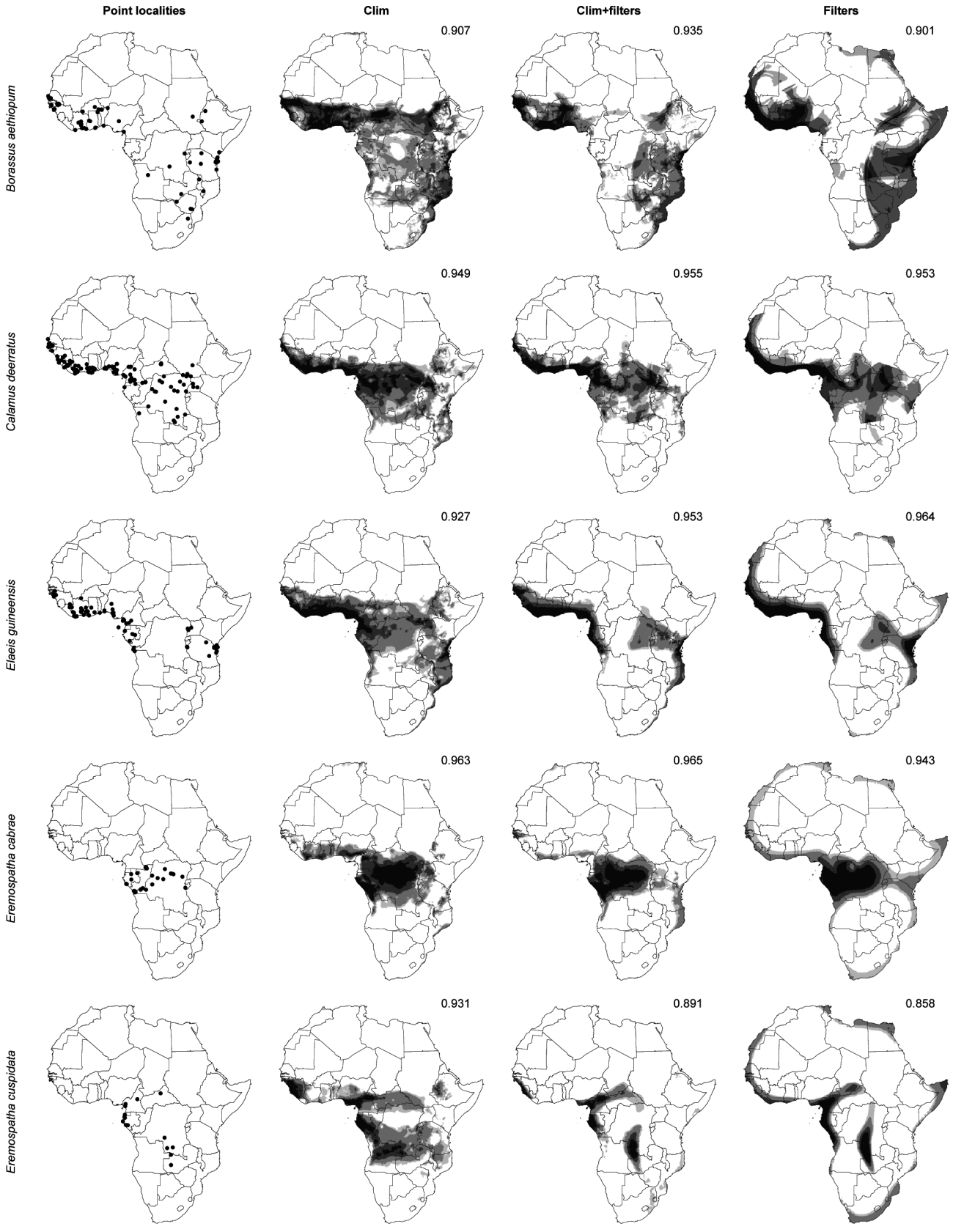


Figure S5. The presence localities and predicted distributions of 24 African palm species based on Maxent models fitted to all the presence localities per species using just climate predictors (clim), climate predictors and spatial filters (clim+filters), or just seven spatial filters (filters). AUC values are displayed in the upper right-hand corner of each predicted distribution map.

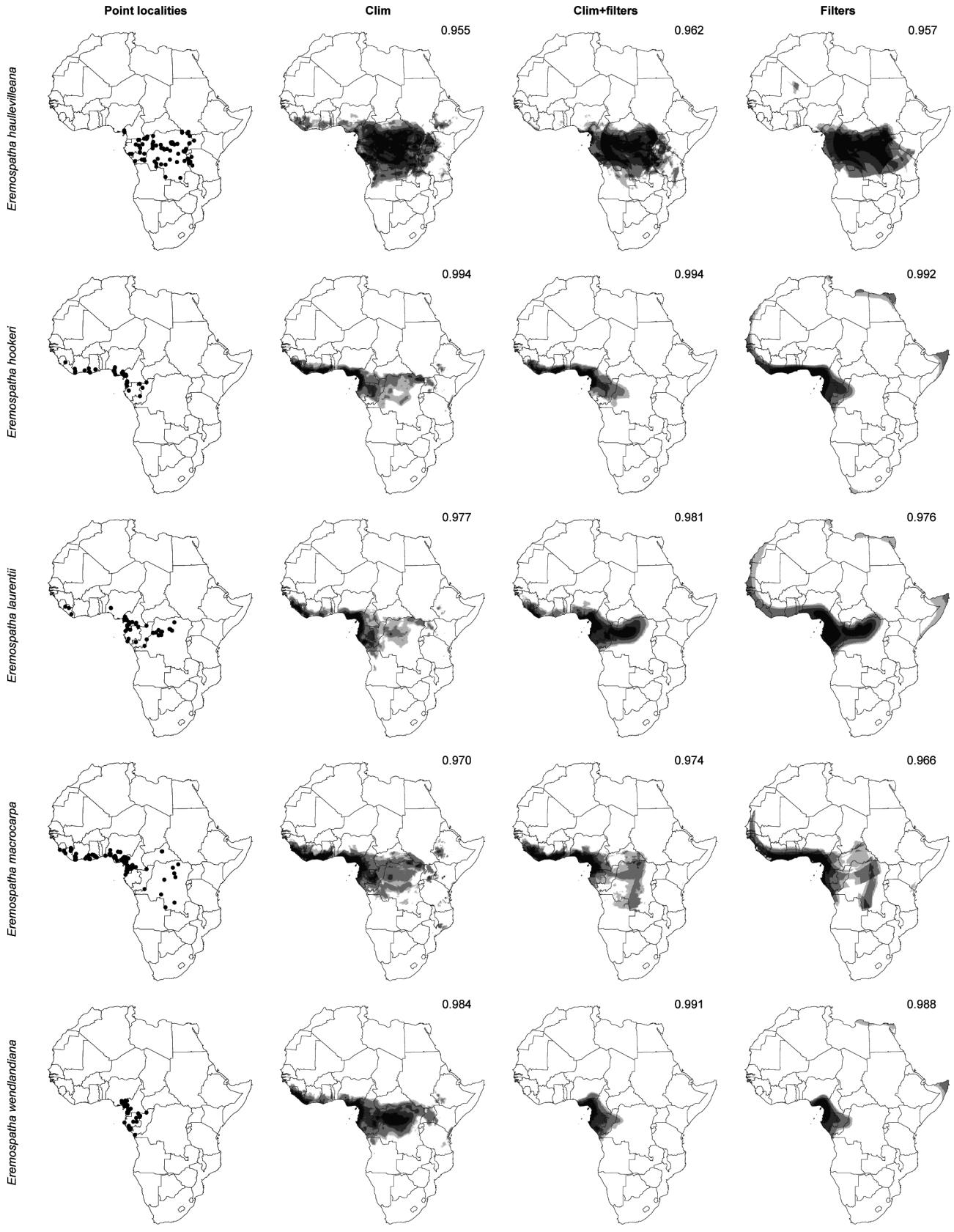


Figure S5. Continued.

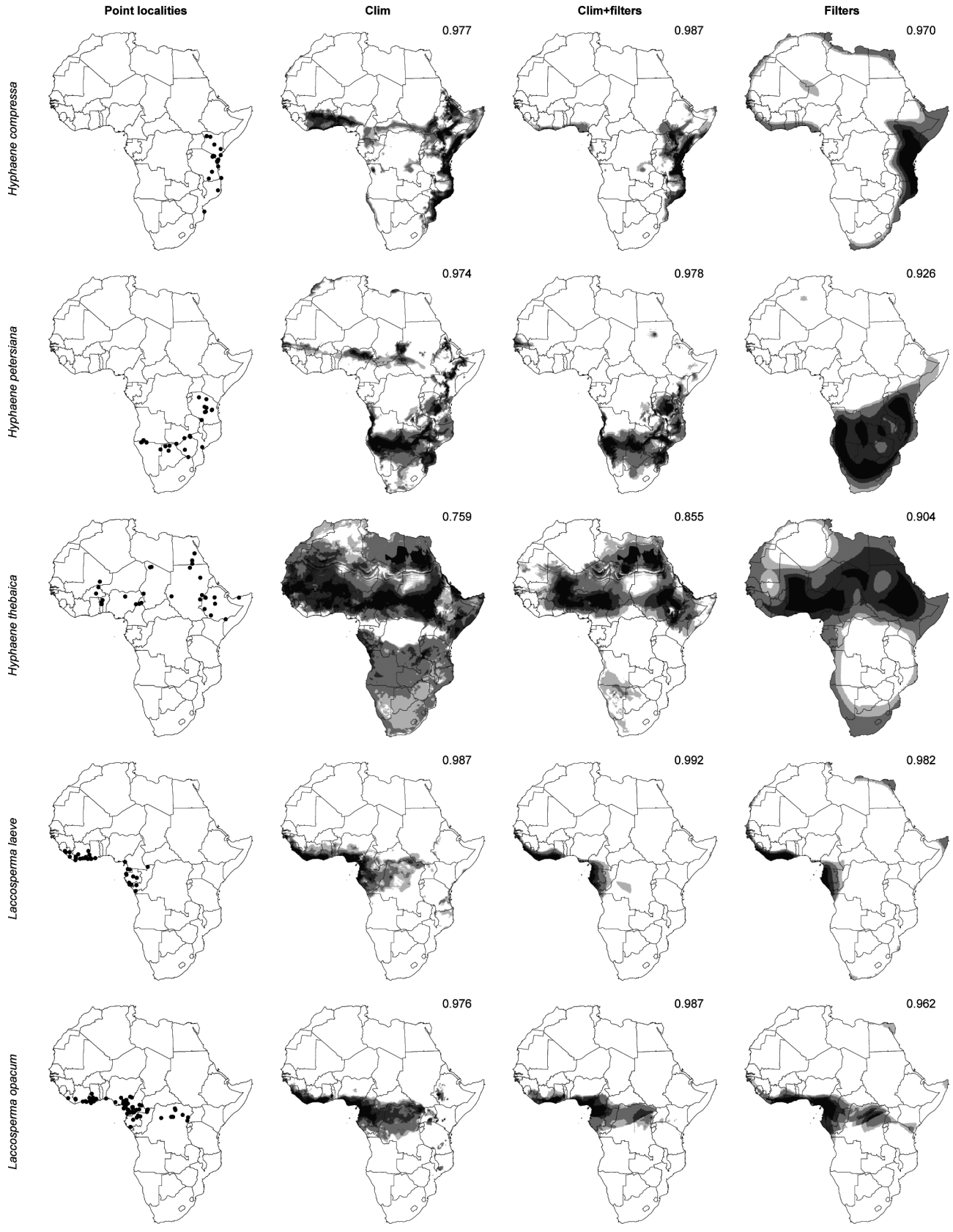
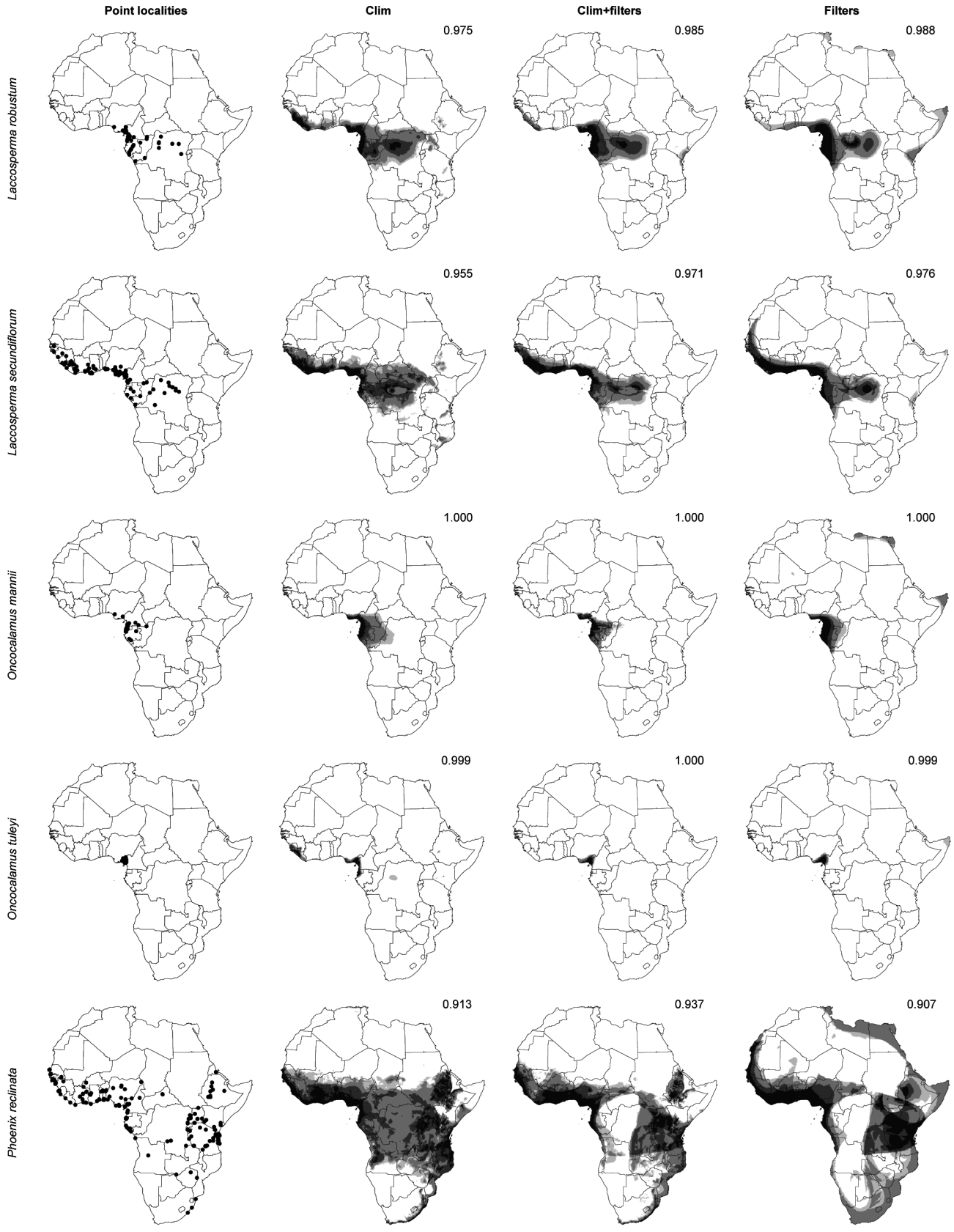


Figure S5. Continued.



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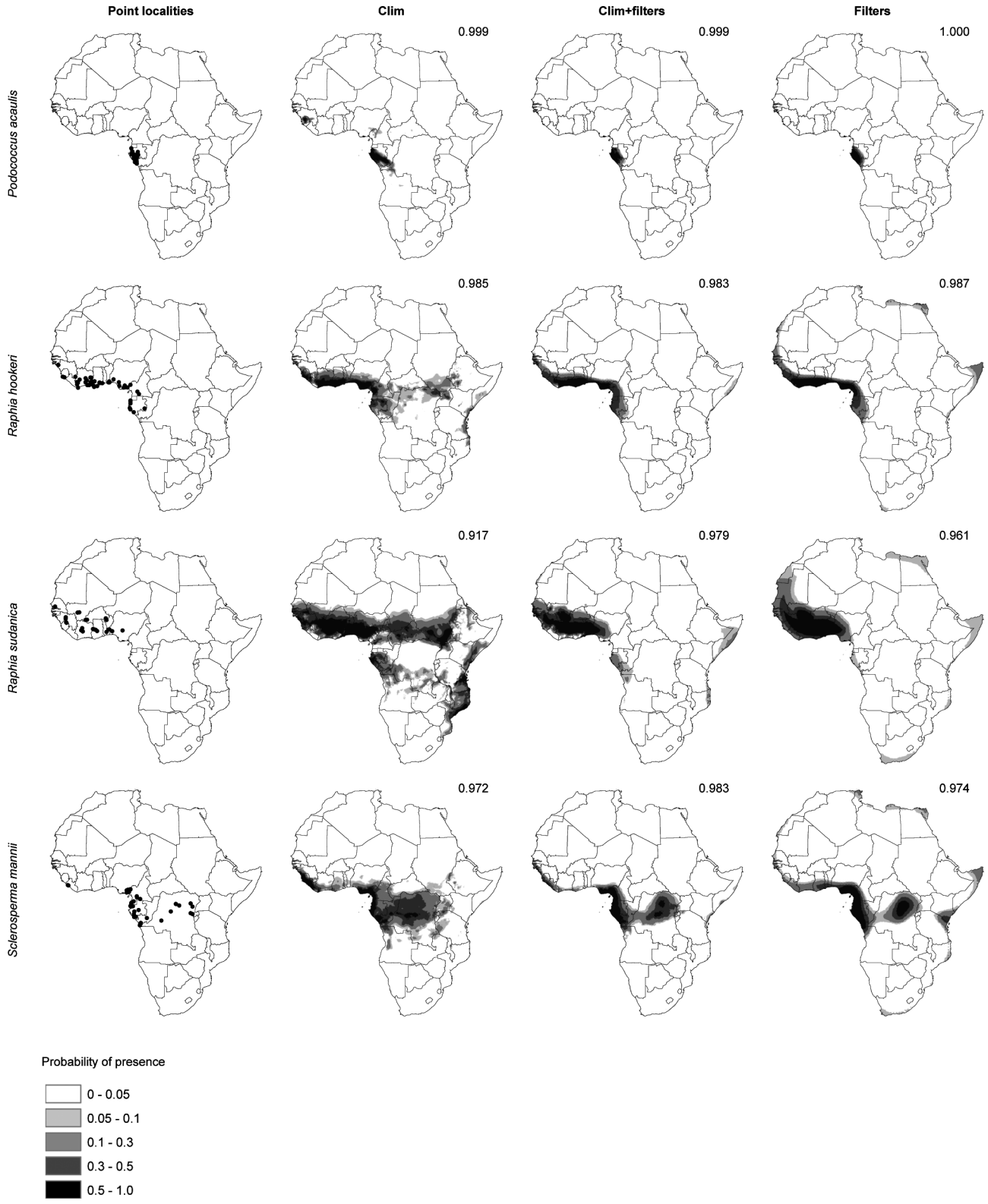

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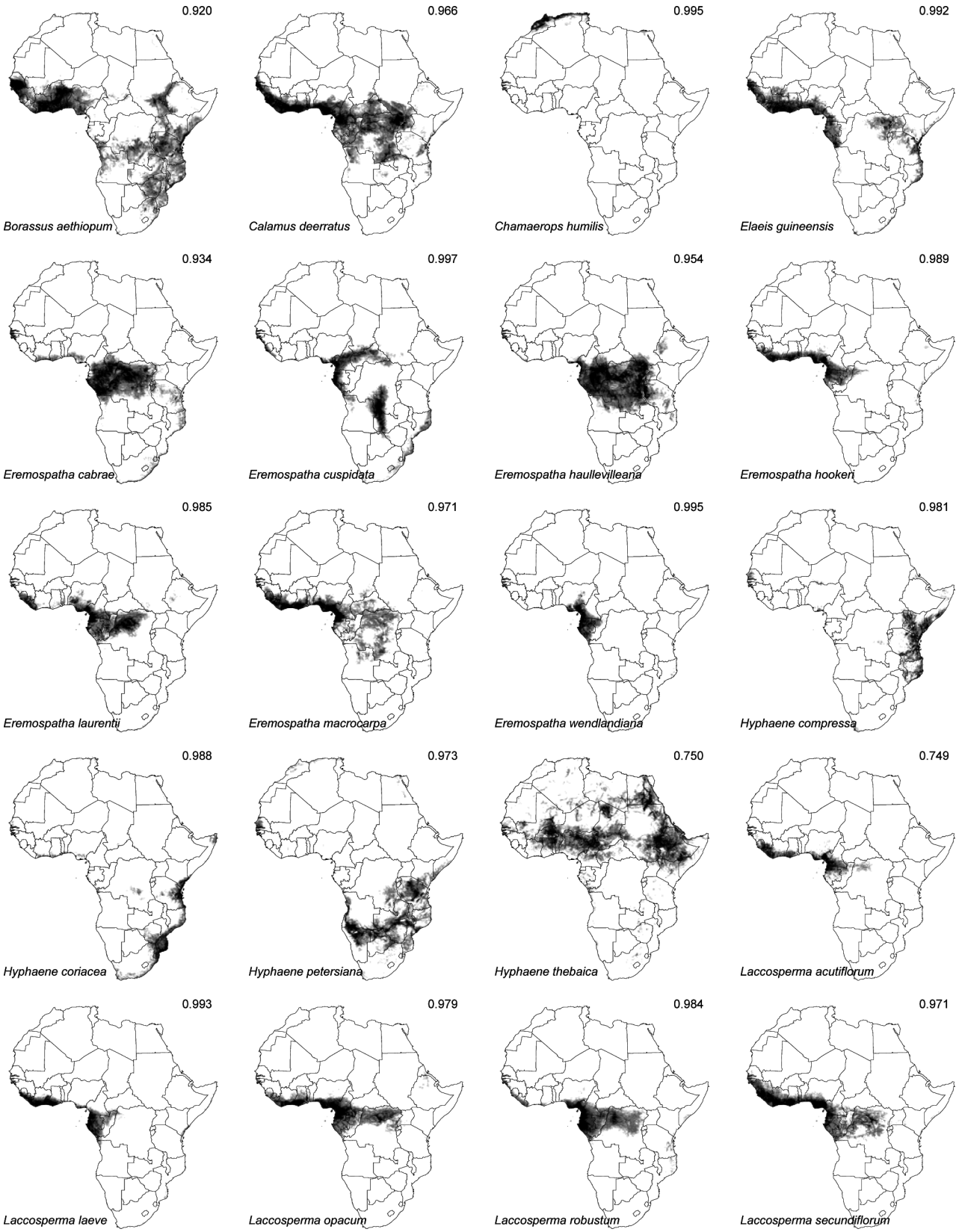

Figure S6. Predicted distributions of 29 African palm species according to Maxent models fitted to all the presence localities per species using all 14 environmental predictors and all 14 filters (clim+hab+hum+filters model). AUC values are displayed in the upper right-hand corner of each map.

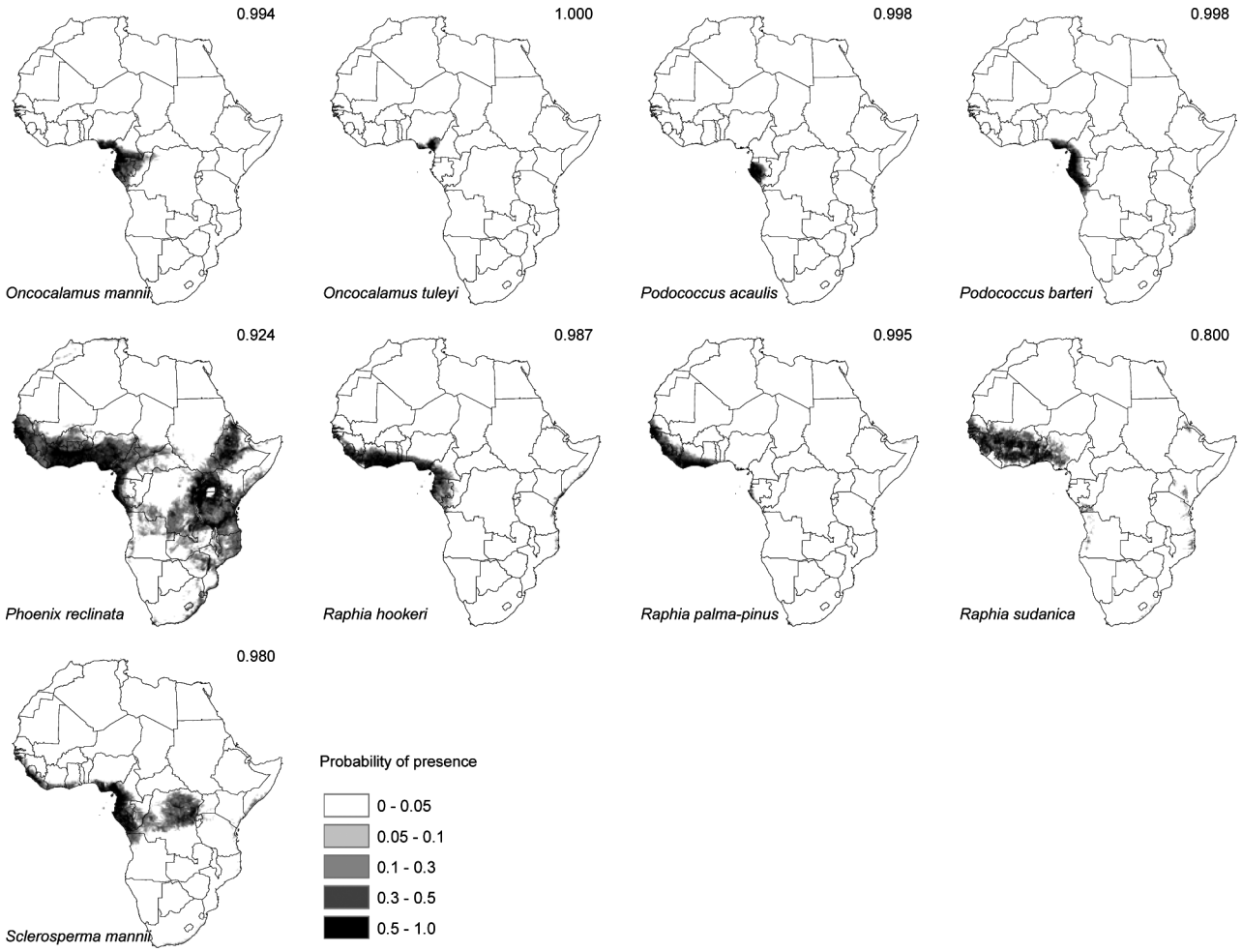

Figure S6. Continued.