

Using climate change models to inform the recovery of the western ground parrot *Pezoporus flaviventris*

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SUPPLEMENTARY MATERIAL 1 GIS datasets used in climate change models to identify suitable translocation sites for the western ground parrot *Pezoporus flaviventris*. Bold font indicates databases, and italics indicate derived data.

WorldClim (<http://www.worldclim.org/>)

Historical (1960–1990 means) and future scenarios (medium and high greenhouse gas emissions for both 2050 and 2070 timeframes) as given by the Access 1.0, CNRM-CM5, HadGEM2-ES and MPI-ESM-LR global climate models were used for the following bioclimatic variables:

BIO1 = Annual mean temperature

BIO2 = Mean diurnal range (mean of monthly (max. temp–min. temp))

BIO3 = Isothermality (BIO2/BIO7) ($\times 100$)

BIO4 = Temperature seasonality (SD $\times 100$)

BIO5 = Max. temperature of warmest month

BIO6 = Min. temperature of coldest month

BIO7 = Temperature annual range (BIO5–BIO6)

BIO8 = Mean temperature of wettest quarter

BIO9 = Mean temperature of driest quarter

BIO10 = Mean temperature of warmest quarter

BIO11 = Mean temperature of coldest quarter

BIO12 = Annual precipitation

BIO13 = Precipitation of wettest month

BIO14 = Precipitation of driest month

BIO15 = Precipitation seasonality (coefficient of variation)

BIO16 = Precipitation of wettest quarter

BIO17 = Precipitation of driest quarter

BIO18 = Precipitation of warmest quarter

BIO19 = Precipitation of coldest quarter

Climate Change in Australia (CSIRO) database

(<http://www.climatechangeinaustralia.gov.au/en/>)

ESRI online databases

(<http://www.esri.com/software/arcgis/arcgisonline/arcgis-open-data>)

Background mapping; i.e. topographical imagery, boundaries and place names

Landgate (<https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>)

Western Australian fire frequency

Property (vesting)

Conservation estate

Modis (<https://earthdata.nasa.gov/>)

Fire scar

Modis burn date

Normalized digital vegetation index (NDVI)

Near infrared spectrography (NIRS)

Geoscience Australia (<http://www.ga.gov.au/search/index.html#/>)

Total magnetic intensity

Gravity anomaly

Land tenure

Digital elevation model

Slope

Ruggedness

Aspect

Water courses

Euclidean distance to water courses

Water bodies
Euclidean distance to water bodies
Geology
Land cover
Hydrology of Australia
Soil mapping of Australia
Vegetation: Pre-European settlement (1788)
Vegetation: Post-European settlement (1988)
Naturemap (<http://naturemap.dpaw.wa.gov.au/>)
Species data
Unites States Geological Survey (USGS) (<http://earthexplorer.usgs.gov/>)
Landsat mosaic
NDVI colourized
Department of Agriculture and Food WA (DAFWA)
(<https://www.agric.wa.gov.au/land-use-planning/maps-and-data>)
Veg = Beard's vegetation associations
Vegag = Department of Agriculture and Food Western Australia

SUPPLEMENTARY MATERIAL 2 Evaluation statistics for both the bioclimatic and non-bioclimatic species distribution models for the western ground parrot. Data include tests by run (or repetition), algorithm, covariance between variables, and variable contribution by algorithm for each run.

1. Bioclimatic model

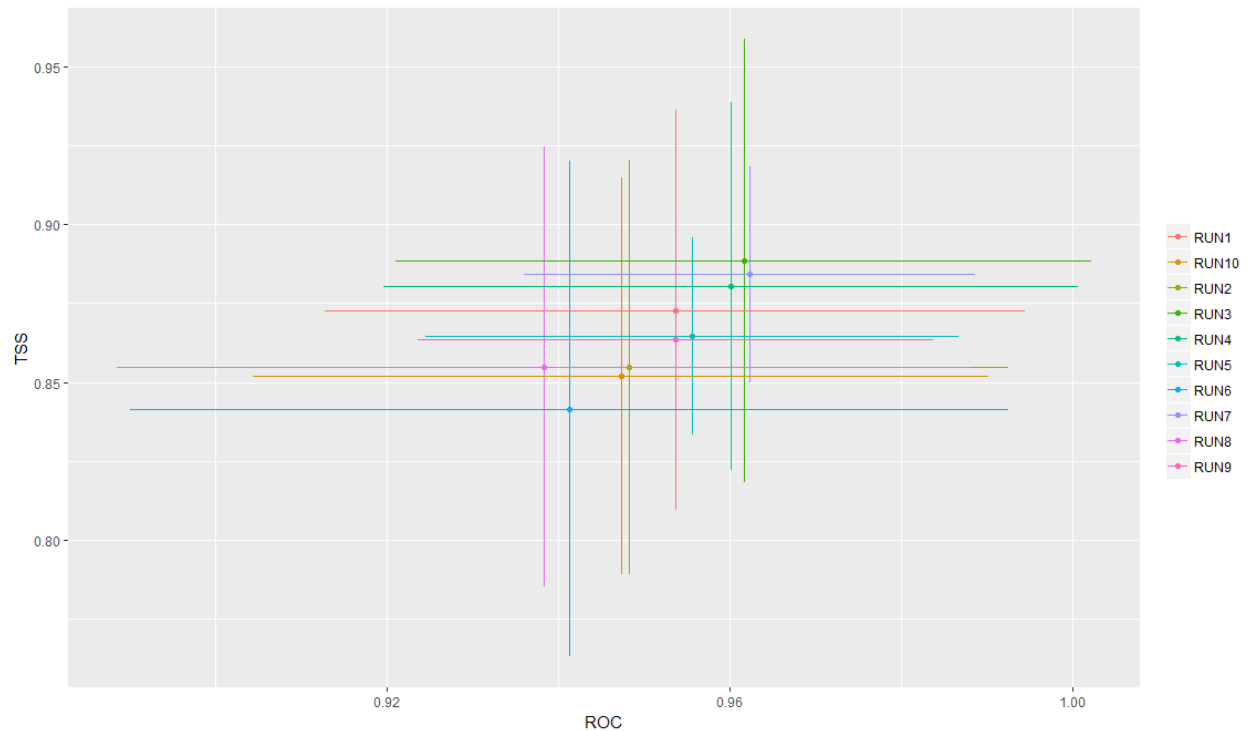


FIG. 1 Model test statistics for the bioclimatic species distribution model (receiver operating characteristic, ROC; true skill statistic, TSS) over 10 model runs (or repetitions). Horizontal and vertical lines show output range by algorithm.

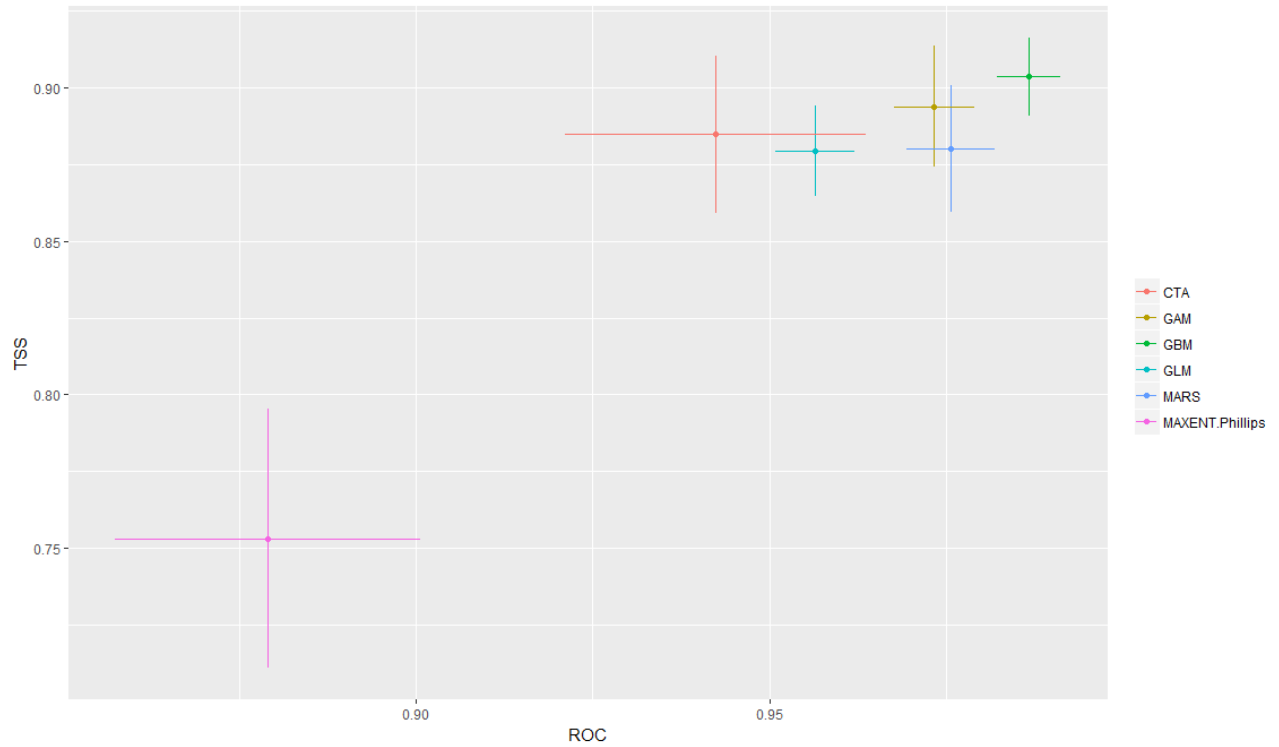


FIG. 2 Model test statistics for the bioclimatic species distribution model (receiver operating characteristic, ROC; true skill statistic, TSS) by algorithm. Horizontal and vertical lines show output range over 10 model runs (or repetitions). Algorithms are classified tree analyses (CTA), generalized additive model (GAM), generalized boosted model (GBM), generalized linear model (GLM), multiple adaptive regression splines (MARS) and MaxEnt (MAXENT.Phillips) (Thuiller et al., 2016).

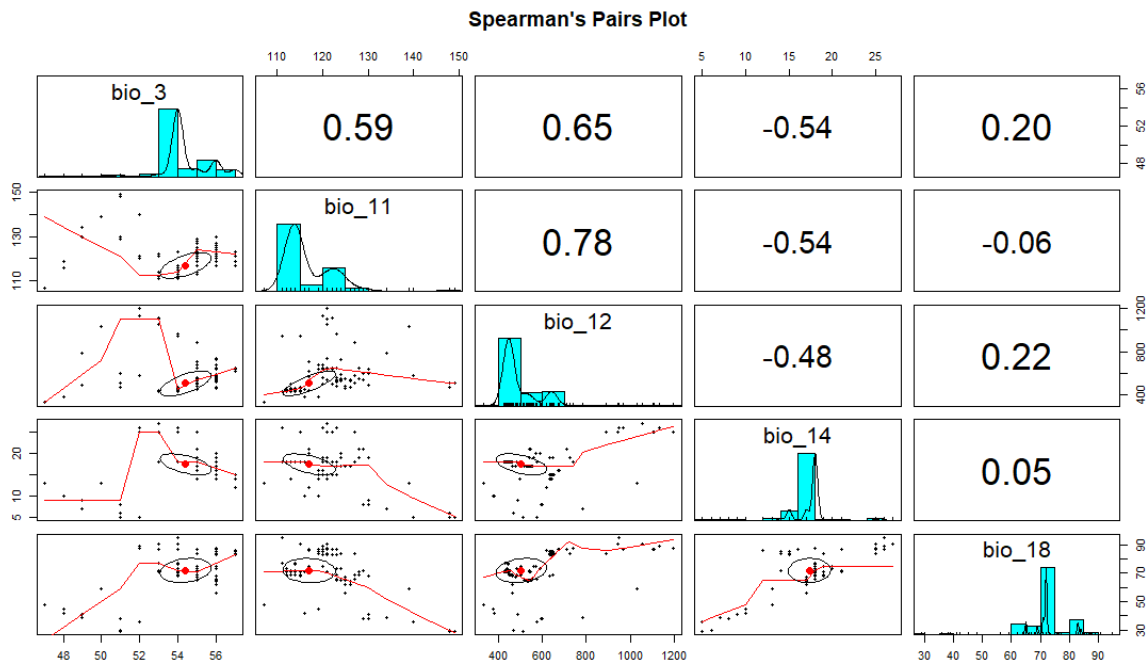


FIG. 3 Pairs panel plot for the bioclimatic species distribution model. Top right: Spearman's rank correlation coefficient. Diagonal: histogram for each variable. Bottom left: correlation scatter plot, with trend line and centroids. Variables are described in Supplementary Material 1.

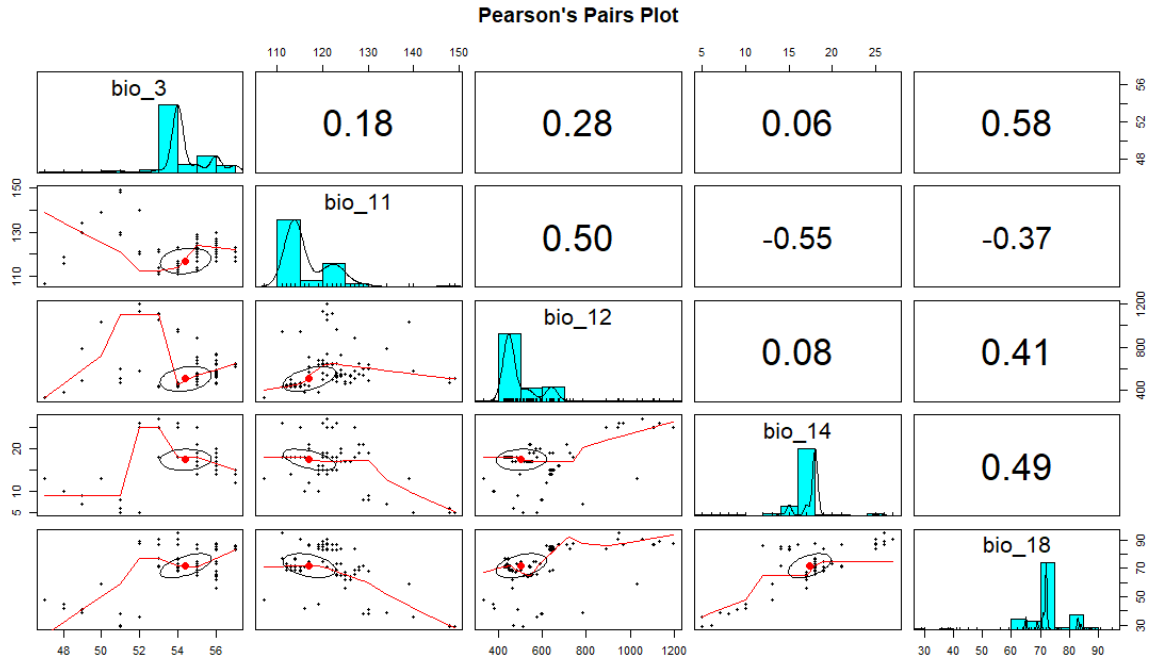


FIG. 4 Pairs panel plot for the bioclimatic species distribution model. Top right: Pearson's rank correlation coefficient. Diagonal: histogram for each variable. Bottom left: correlation scatter plot, with trend line and centroids.

TABLE 1 Contributions of all variables by algorithm and model for the first 10 training runs of the bioclimatic species distribution model.

Run 1						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.047	0.737	0.594	0.485	0.526	0.769
bio_11	0.072	0.458	0.000	0.040	0.000	0.097
bio_12	0.341	0.222	0.026	0.110	0.000	0.081
bio_14	0.240	0.277	0.247	0.159	0.467	0.198
bio_18	0.289	0.368	0.764	0.456	0.436	0.533
Run 2						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.048	0.510	0.573	0.475	0.418	0.381
bio_11	0.084	0.374	0.024	0.041	0.000	0.000
bio_12	0.451	0.284	0.006	0.124	0.000	0.065
bio_14	0.275	0.277	0.263	0.135	0.375	0.253
bio_18	0.352	0.269	0.757	0.467	0.482	0.801
Run 3						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.087	0.569	0.429	0.414	0.191	0.329
bio_11	0.098	0.306	0.016	0.049	0.175	0.183
bio_12	0.266	0.161	0.014	0.105	0.000	0.137
bio_14	0.293	0.789	0.287	0.144	0.747	0.311
bio_18	0.389	0.365	0.860	0.517	0.451	0.806
Run 4						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.253	0.514	0.574	0.299	0.250	0.412

bio_11	0.054	0.317	0.000	0.044	0.000	0.372
bio_12	0.294	0.144	0.030	0.090	0.000	0.378
bio_14	0.220	0.822	0.272	0.162	0.611	0.292
bio_18	0.297	0.538	0.806	0.485	0.425	0.796
Run 5						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.250	0.710	0.589	0.531	0.474	0.271
bio_11	0.107	0.288	0.000	0.064	0.000	0.224
bio_12	0.246	0.124	0.040	0.090	0.000	0.082
bio_14	0.162	0.702	0.240	0.128	0.506	0.300
bio_18	0.306	0.477	0.764	0.437	0.485	0.938
Run 6						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.296	0.662	0.712	0.377	0.429	0.241
bio_11	0.071	0.344	0.000	0.042	0.000	0.243
bio_12	0.327	0.409	0.011	0.105	0.000	0.159
bio_14	0.189	0.363	0.258	0.150	0.482	0.361
bio_18	0.257	0.476	0.678	0.552	0.525	0.823
Run 7						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.218	0.742	0.551	0.524	0.411	0.759
bio_11	0.113	0.281	0.000	0.048	0.000	0.096
bio_12	0.296	0.132	0.023	0.040	0.000	0.073
bio_14	0.274	0.682	0.270	0.142	0.431	0.160
bio_18	0.312	0.523	0.804	0.485	0.465	0.560
Run 8						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.032	0.753	0.719	0.613	0.360	0.375
bio_11	0.104	0.448	0.004	0.052	0.000	0.166
bio_12	0.255	0.305	0.008	0.097	0.000	0.067
bio_14	0.247	0.436	0.296	0.145	0.306	0.284
bio_18	0.305	0.369	0.668	0.427	0.555	0.792
Run 9						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.050	0.646	0.561	0.419	0.409	0.371
bio_11	0.073	0.229	0.000	0.061	0.000	0.175
bio_12	0.226	0.182	0.038	0.112	0.000	0.073
bio_14	0.244	0.780	0.267	0.161	0.643	0.277
bio_18	0.437	0.509	0.768	0.457	0.513	0.794
Run 10						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
bio_3	0.109	0.725	0.489	0.546	0.391	0.637
bio_11	0.081	0.171	0.012	0.040	0.000	0.370
bio_12	0.298	0.163	0.021	0.048	0.000	0.477
bio_14	0.233	0.600	0.304	0.165	0.313	0.583
bio_18	0.279	0.383	0.843	0.528	0.493	0.770

2. Non-bioclimatic model

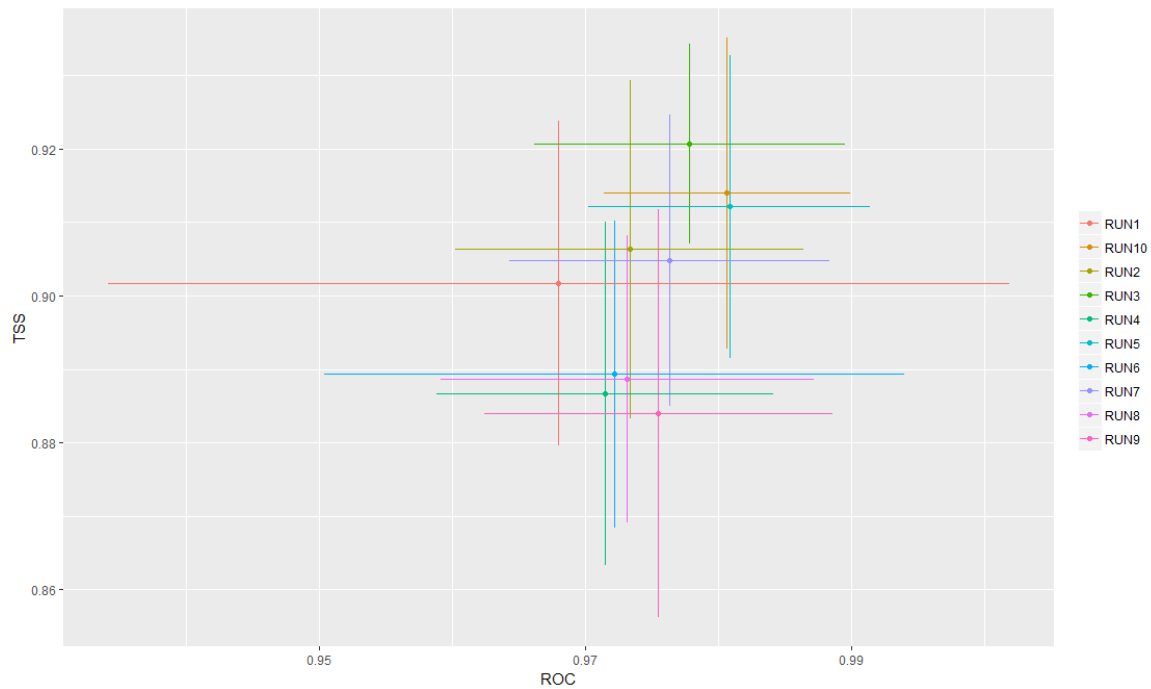


FIG. 5 Model test statistics for the non-bioclimatic species distribution model (receiver operating characteristic, ROC; true skill statistic, TSS) over 10 model runs (or repetitions). Horizontal and vertical lengths show output range by algorithm.

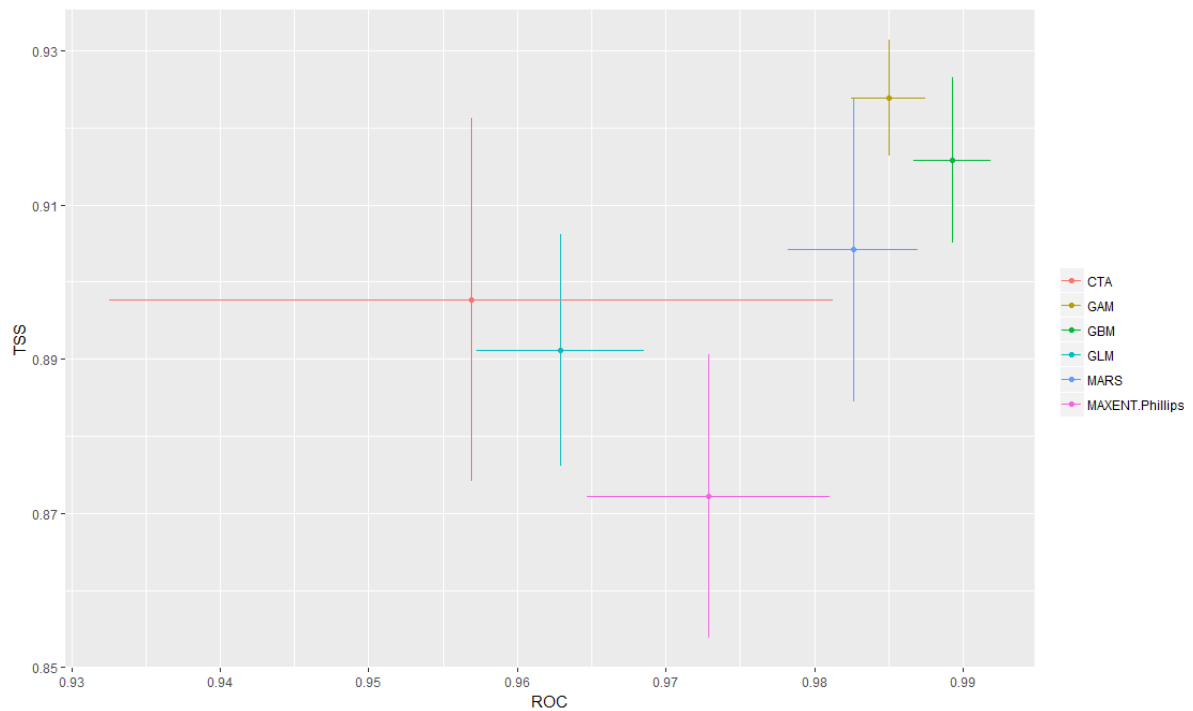


FIG. 6 Model test statistics for the non-bioclimatic species distribution model (receiver operating characteristic, ROC; true skill statistic, TSS) by algorithm. Horizontal and vertical lengths show output range by run for each algorithm over 10 runs (or repetitions). Algorithms are classified tree analyses (CTA), generalized additive model (GAM), generalized boosted model (GBM), generalized linear model (GLM), multiple adaptive regression splines (MARS) and MaxEnt (MAXENT.Phillips) (Thuiller et al. 2016).

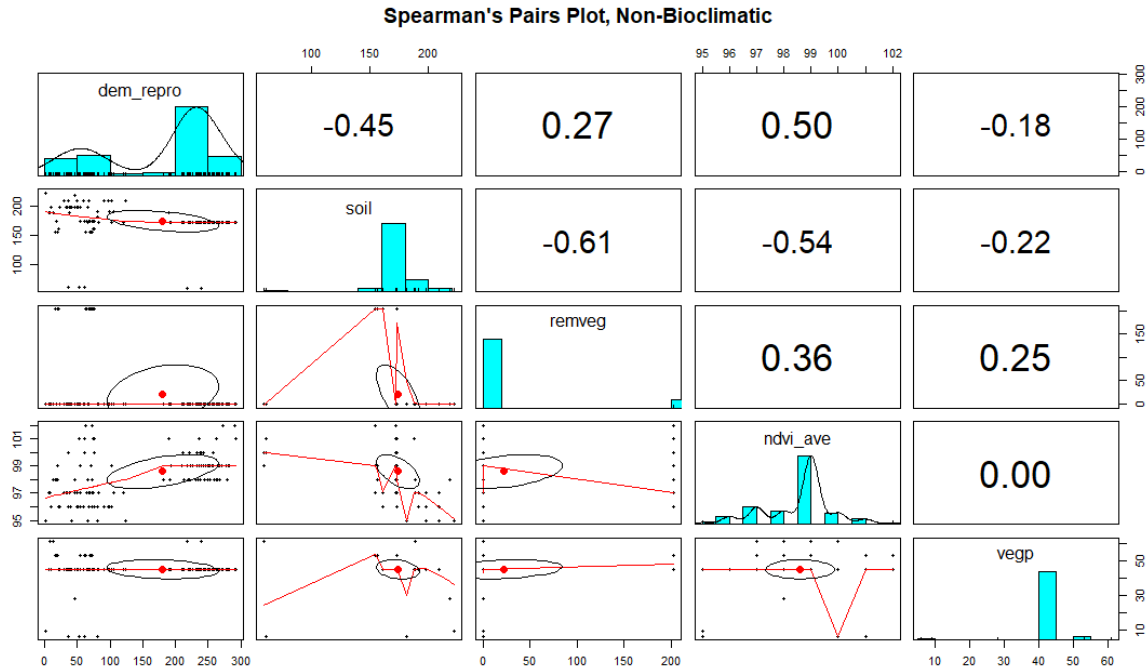


FIG. 7 Pairs panel plot for the non- bioclimatic species distribution model. Top right: Spearman's rank correlation coefficient. Diagonal: histogram for each variable. Bottom left: correlation scatter plot, with trend line and centroids. Variables are described in Supplementary Material 1.

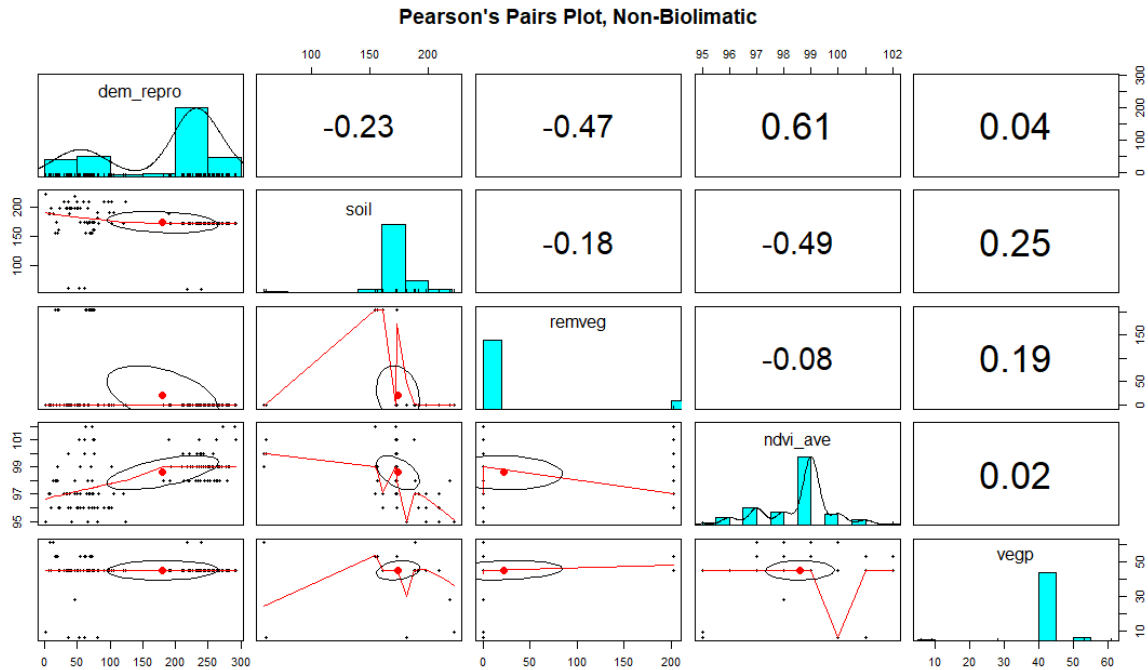


FIG. 8 Pairs panel plot for the non-bioclimate species distribution model. Top right: Pearson's rank correlation coefficient. Diagonal: histogram for each variable. Bottom left: correlation scatter plot, with trend line and centroids. Variables are described in Supplementary Material 1.

TABLE 2 Contributions of all variables by algorithm and model run for the first 10 training runs of the non-bioclimatic species distribution model.

Run 1						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.213	0.319	0.331	0.098	0.243	0.528
soil	0.222	0.471	0.056	0.565	0.052	0.778
remveg	0.074	0.031	0.438	0.264	0.047	0.352
ndvi_ave	0.020	0.227	0.209	0.074	0.112	0.228
vegp	0.154	0.672	0.102	0.159	0.582	0.509
Run 2						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.185	0.359	0.306	0.095	0.181	0.494
soil	0.340	0.467	0.084	0.592	0.036	0.763
remveg	0.109	0.040	0.394	0.267	0.082	0.323
ndvi_ave	0.003	0.218	0.159	0.035	0.062	0.144
vegp	0.138	0.647	0.151	0.198	0.636	0.550
Run 3						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.244	0.377	0.314	0.132	0.116	0.628
soil	0.305	0.525	0.054	0.564	0.067	0.618
remveg	0.095	0.027	0.416	0.283	0.183	0.332
ndvi_ave	0.010	0.230	0.204	0.026	0.098	0.000
vegp	0.106	0.653	0.122	0.172	0.588	0.448
Run 4						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.267	0.325	0.278	0.103	0.170	0.251
soil	0.228	0.511	0.059	0.558	0.020	0.623
remveg	0.100	0.028	0.394	0.264	0.215	0.286
ndvi_ave	0.027	0.232	0.247	0.081	0.176	0.208
vegp	0.126	0.715	0.166	0.210	0.619	0.464
Run 5						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.234	0.313	0.330	0.109	0.195	0.255
soil	0.171	0.559	0.048	0.534	0.010	0.570
remveg	0.064	0.174	0.413	0.263	0.039	0.311
ndvi_ave	0.004	0.284	0.208	0.021	0.126	0.000
vegp	0.219	0.636	0.142	0.294	0.642	0.502
Run 6						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.196	0.354	0.299	0.076	0.187	0.504
soil	0.243	0.551	0.088	0.596	0.008	0.753
remveg	0.087	0.031	0.426	0.260	0.043	0.259
ndvi_ave	0.013	0.269	0.186	0.057	0.135	0.042
vegp	0.149	0.631	0.122	0.171	0.626	0.540
Run 7						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.271	0.364	0.307	0.103	0.190	0.289
soil	0.262	0.454	0.086	0.598	0.058	0.609
remveg	0.092	0.036	0.423	0.263	0.023	0.284
ndvi_ave	0.014	0.213	0.174	0.042	0.082	0.000
vegp	0.116	0.689	0.114	0.155	0.683	0.538

Run 8						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.257	0.337	0.267	0.102	0.164	0.177
soil	0.285	0.506	0.076	0.588	0.034	0.718
remveg	0.078	0.046	0.416	0.266	0.111	0.194
ndvi_ave	0.004	0.206	0.225	0.033	0.141	0.000
vegp	0.111	0.753	0.187	0.186	0.670	0.354
Run 9						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.195	0.354	0.273	0.086	0.171	0.294
soil	0.251	0.511	0.119	0.604	0.053	0.741
remveg	0.090	0.017	0.384	0.266	0.004	0.360
ndvi_ave	0.008	0.207	0.147	0.029	0.067	0.000
vegp	0.158	0.687	0.242	0.237	0.816	0.480
Run 10						
	MAXENT.Phillips	GAM	GLM	GBM	MARS	CTA
dem_repro	0.181	0.374	0.319	0.095	0.225	0.598
soil	0.235	0.541	0.071	0.618	0.054	0.743
remveg	0.071	0.058	0.431	0.272	0.053	0.378
ndvi_ave	0.004	0.226	0.162	0.032	0.070	0.056
vegp	0.165	0.619	0.118	0.141	0.584	0.497