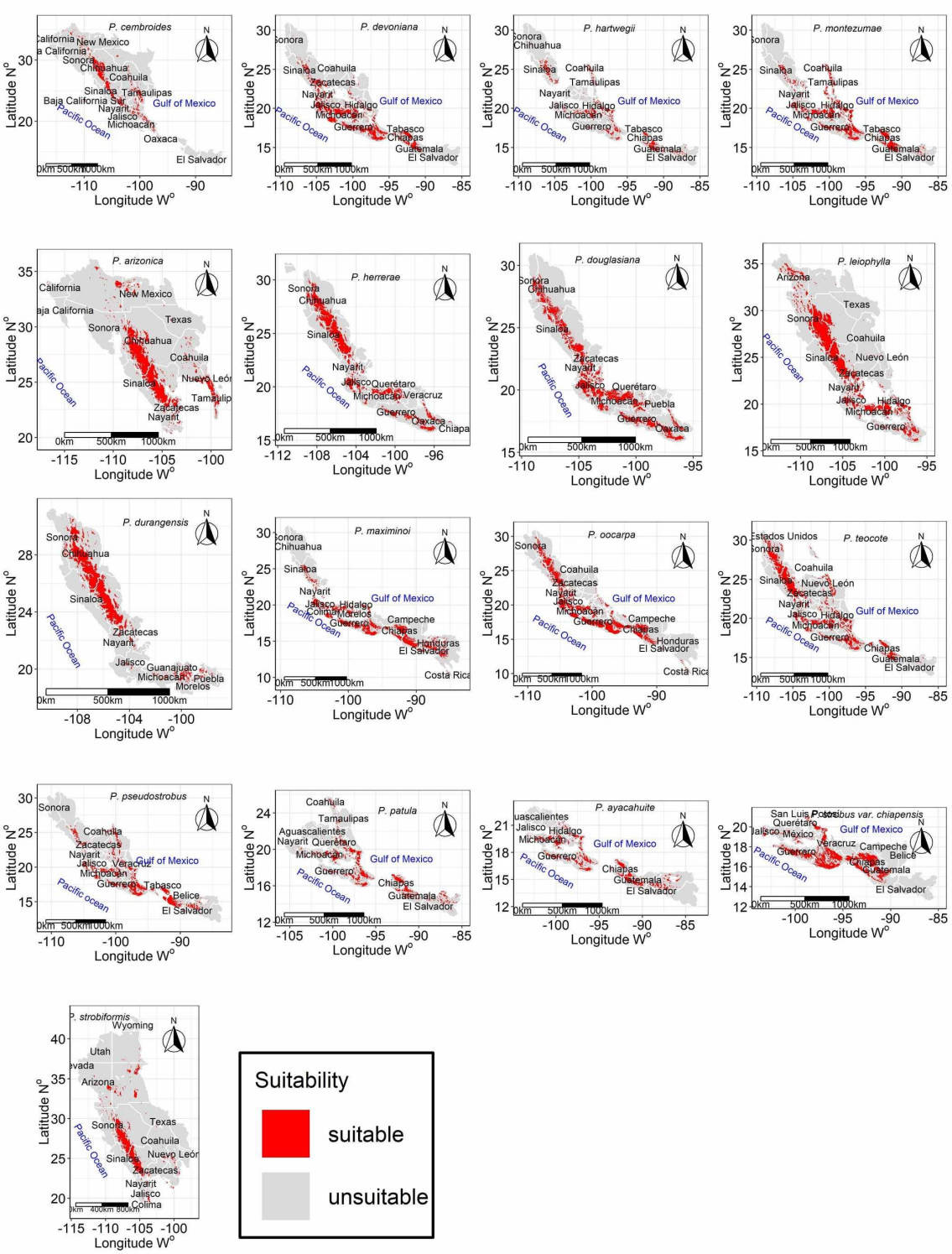
Montoya-Jiménez JC, Valdez-Lazalde JR, Angeles-Pérez G, De Los Santos-Posadas HM, Cruz-Cárdenas G (2022). **Predictive capacity of nine algorithms and an ensemble model to determine the geographic distribution of tree species**
iForest – Biogeosciences and Forestry – doi: 10.3832/ifor4084-015

# Supplementary Material

**Fig. S1 -** Binary prediction of the ensemble model for 17 species of pines.



Montoya-Jiménez JC, Valdez-Lazalde JR, Angeles-Pérez G, De Los Santos-Posadas HM, Cruz-Cárdenas G (2022). **Predictive capacity of nine algorithms and an ensemble model to determine the geographic distribution of tree species**
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**Fig. S2 -** True statistical skill and AUC of nine algorithms and ensemble model for modeling *P. arizonica* (a), *P. ayacahuite* (b), *P. cembroides* (c), *P. devoniana* (d), *P. douglasiana* (e), *P. durangensis* (f), *P. hartwegii* (g), *P. herrerae* (h) *P. leiophylla* (i), *P. maximinoi* (j), *P. montezumae* (k), *P. oocarpa* (l), *P. patula* (m), *P. pseudostrobus* (n), *P. strobiformis* (o), *P. strobus var. chiapensis* (p), *P. teocote* (q).

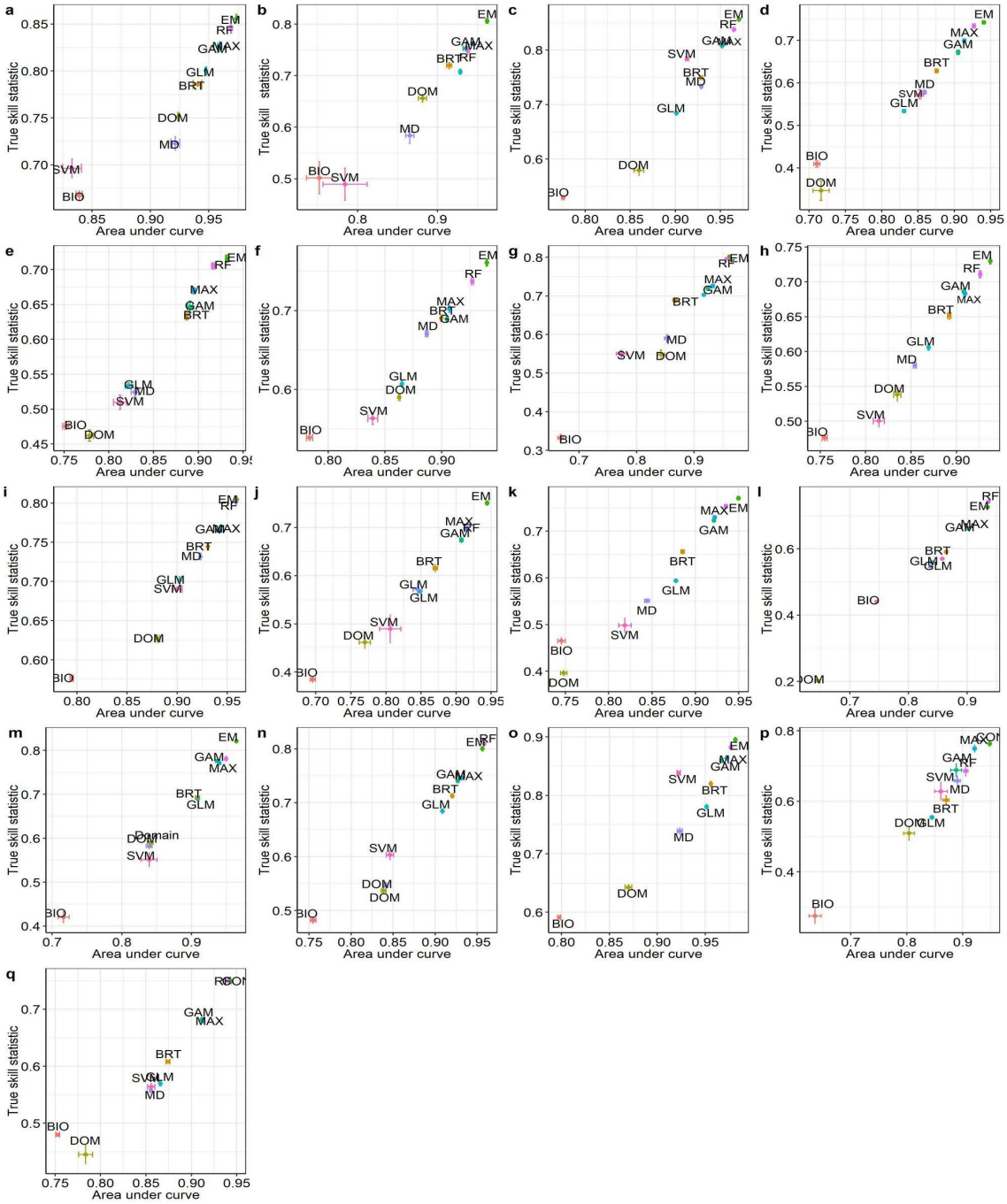
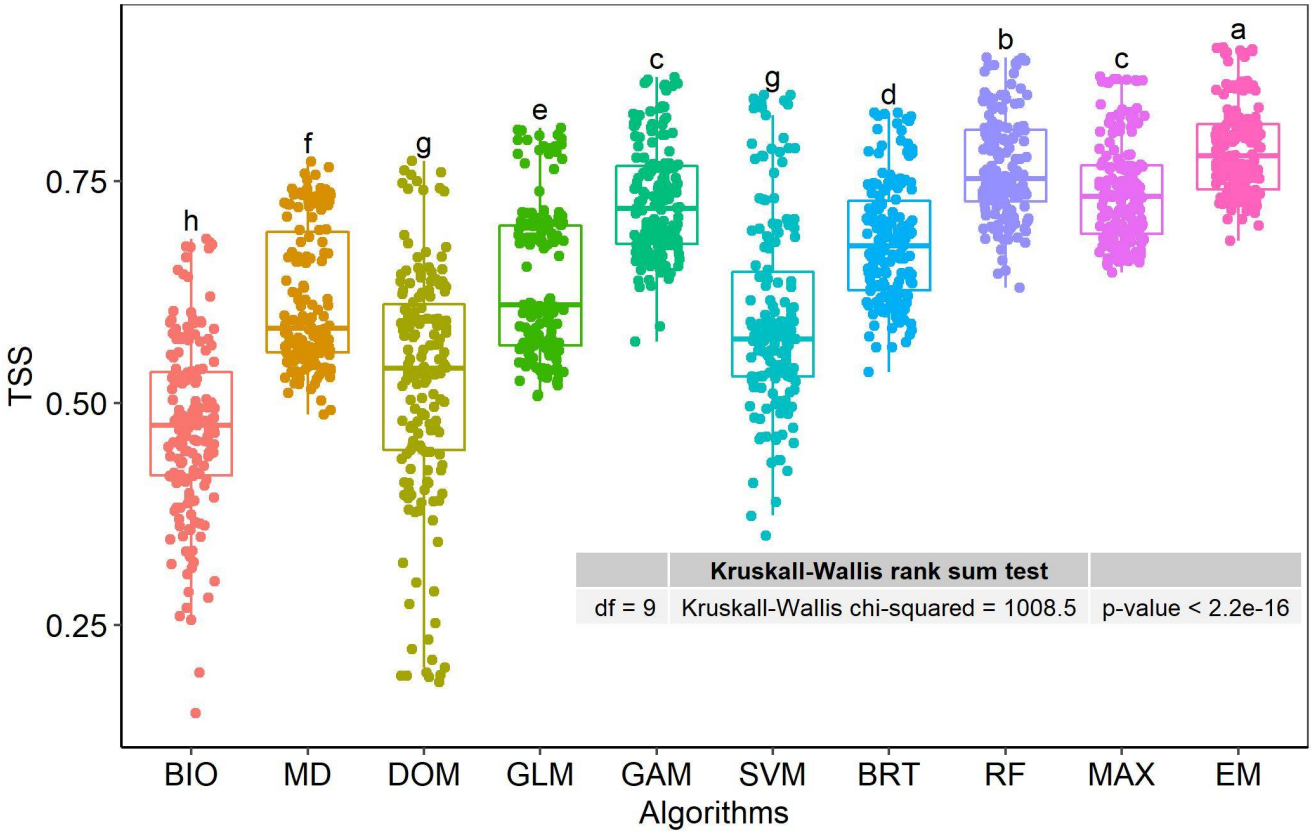


**Fig. S3 -** Kruskall-Wallis non-parametric test and classification of algorithms. The letters indicate the predictive performance of the algorithms in descending order (a = highest; h = lowest; middle letters = medium performance, equal letters means similar performance).



Montoya-Jiménez JC, Valdez-Lazalde JR, Angeles-Pérez G, De Los Santos-Posadas HM, Cruz-Cárdenas G (2022). **Predictive capacity of nine algorithms and an ensemble model to determine the geographic distribution of tree species**
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**Tab. S1** - Relative importance of the variables (AUC_test) obtained in the pre-modelling process of 17 pine species. (alt): altitude (m); (bd): bulk density (cg/cm3); (bio1): annual mean temperature (°C); (bio10): mean temperature of warmest quarter (°C); (bio11): mean temperature of coldest quarter (°C); (bio12): annual precipitation (mm); (bio13): precipitation of wettest month (mm); (bio14): precipitation of driest month (mm); (bio16): precipitation of wettest quarter (mm); (bio17): precipitation of driest quarter (mm); (bio2): mean diurnal range (°c); (bio5): maximun temperature of warmest month (°c); (bio6): minimun temperature of coldest month (°c); (cec): cation exchange capacity (mmol(c)/kg); (ci): convergence index; (clc): clay content (g/kg); (dah): diurnal anisotropic heat; (nit): nitrogen (cg/kg); (ocd): organic carbon density (g/dm3); (ph): ph water (ph*100); (sa): sand (g/kg); (slo): slope (°); (sil): silt (g/kg); (ocs): organic carbon soil (dg/kg); (socs): soil organic carbón stock (t/ha); (tri): terrain ruggedness index (m); (twi): topographic wetness index.

| Var/sp | *P. arizonica* | *P. ayacahuite* | *P. cembroides* | *P. devoniana* | *P. douglasiana* | *P. durangensis* | *P. hartwegii* | *P. herrerae* | *P. leiophylla* | *P. maximinio* | *P. montezumae* | *P. oocarpa* | *P. patula* | *P. pseudostrobus* | *P. strobiformis* | *P. strobus* var. *chiapensis* | *P. teocate* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| alt | 0.21* | 0.31 | 0.32 | 0.29 | 0.08* | 0.16 | 0.07 | 0.20 | 0.12* | 0.21 | 0.19 | 0.19 | 0.31 | 0.16 | 0.18* | 0.20 | 0.20 |
| deap | 0.07* | 0.11* | 0.00x | 0.09* | 0.00x | 0.00x | 0.06* | 0.00x | 0.00x | 0.05* | 0.06* | 0.00x | 0.11* | 0.06* | 0.03* | 0.08* | 0.00x |
| bio_1 | 0.43 | 0.54 | 0.29 | 0.69 | 0.47 | 0.27 | 0.79 | 0.68 | 0.30 | 0.72 | 0.42 | 0.64 | 0.79 | 0.47 | 0.39 | 0.79 | 0.30 |
| bio_10 | 0.66 | 0.39 | 0.31 | 0.68 | 0.86 | 0.46 | 0.27 | 0.40 | 0.36 | 0.51 | 0.59 | 0.38 | 0.32 | 0.48 | 0.52 | 0.56 | 0.45 |
| bio_11 | 0.56 | 0.57 | 0.38 | 0.73 | 0.36 | 0.36 | 0.35 | 0.54 | 0.42* | 0.78 | 0.54 | 0.65 | 0.97 | 0.42 | 0.51 | 0.74 | 0.30* |
| bio_12 | 0.62 | 0.18 | 0.16* | 0.06 | 0.24 | 0.00x | 0.45 | 0.09 | 0.26 | 0.09 | 0.49 | 0.20 | 0.07 | 0.17 | 0.46 | 0.00x | 0.18 |
| bio_13 | 0.22* | 0.02* | 0.00x | 0.06* | 0.09* | 0.26* | 0.00x | 0.26* | 0.09 | 0.07* | 0.00x | 0.04* | 0.21* | 0.00x | 0.26* | 0.00x | 0.24* |
| bio_14 | 0.01* | 0.10* | 0.05* | 0.00x | 0.00x | 0.02* | 0.01* | 0.00x | 0.00x | 0.08* | 0.00x | 0.06* | 0.25* | 0.03* | 0.00x | 0.00x | 0.00x |
| bio_16 | 0.78 | 0.00x | 0.00x | 0.07 | 0.00x | 0.00x | 0.00x | 0.07 | 0.00x | 0.00x | 0.52* | 0.02 | 0.00x | 0.00x | 0.24 | 0.63* | 0.00x |
| bio_17 | 0.01 | 0.37 | 0.05 | 0.06* | 0.06* | 0.05 | 0.00x | 0.09* | 0.00x | 0.13 | 0.00x | 0.05 | 0.00x | 0.27 | 0.01* | 0.00x | 0.00x |
| bio_2 | 0.00x | 0.27* | 0.01* | 0.14* | 0.02* | 0.24* | 0.35* | 0.04* | 0.00x | 0.29* | 0.06* | 0.02 | 0.20* | 0.06* | 0.01* | 0.31* | 0.69* |
| bio_5 | 0.35 | 0.50* | 0.43* | 0.37* | 0.60 | 0.90* | 0.43* | 0.63* | 0.25 | 0.59* | 0.39* | 0.68* | 0.50* | 0.30* | 0.60 | 0.86* | 0.28* |
| bio_6 | 0.54 | 0.71 | 0.35* | 0.71 | 0.40 | 0.43 | 0.58 | 0.87 | 0.47 | 0.44 | 0.35 | 0.78 | 0.45 | 0.51 | 0.59 | 0.22 | 0.56 |
| cic | 0.00x | 0.00x | 0.07* | 0.04* | 0.00x | 0.00x | 0.01* | 0.00x | 0.02* | 0.00x | 0.01* | 0.02* | 0.00x | 0.01* | 0.00x | 0.06* | 0.03* |
| ic | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.01* | 0.00x | 0.00x | 0.00x | 0.00x |
| coar | 0.00x | 0.03* | 0.01* | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.01* | 0.00x | 0.00x | 0.00x | 0.06* | 0.00x |
| cad | 0.00x | 0.00x | 0.00x | 0.06* | 0.02* | 0.00x | 0.00x | 0.00x | 0.00x | 0.05* | 0.01* | 0.05* | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x |
| nit | 0.01 | 0.00x | 0.00x | 0.02* | 0.04* | 0.00x | 0.00x | 0.04* | 0.01 | 0.05* | 0.00x | 0.00x | 0.00 | 0.00x | 0.00x | 0.05* | 0.03* |
| deco | 0.08 | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.12* | 0.00x | 0.00x | 0.00x | 0.00x | 0.04 | 0.01 | 0.00x | 0.02 |
| pH | 0.15 | 0.00x | 0.06* | 0.14* | 0.11* | 0.08* | 0.14* | 0.12* | 0.13* | 0.00x | 0.00x | 0.10 | 0.00x | 0.00x | 0.07 | 0.00x | 0.09* |
| are | 0.00x | 0.53* | 0.00x | 0.06* | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.04* | 0.00x | 0.00x | 0.00x | 0.05* | 0.00x |
| limo | 0.00x | 0.00x | 0.00x | 0.02* | 0.00x | 0.00x | 0.01* | 0.00x | 0.00x | 0.02* | 0.01* | 0.05* | 0.02* | 0.00x | 0.00x | 0.05* | 0.00x |
| pen | 0.01* | 0.02* | 0.00x | 0.05* | 0.00x | 0.00x | 0.03* | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.01* | 0.00x | 0.00x |
| cos | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.05* | 0.05 | 0.02* | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.02* | 0.05 | 0.00x | 0.01* |

| Var/sp | *P. arizonica* | *P. ayacahuite* | *P. cembroides* | *P. devoniana* | *P. douglasiana* | *P. durangensis* | *P. hartwegii* | *P. herrerae* | *P. leiophylla* | *P. maximinio* | *P. montezumae* | *P. oocarpa* | *P. patula* | *P. pseudostrobus* | *P. strobiformis* | *P. strobus* var. *chiapensis* | *P. teocate* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| rcos | 0.11* | 0.03* | 0.00x | 0.00x | 0.00x | 0.00x | 0.01* | 0.00x | 0.00x | 0.00x | 0.02* | 0.00x | 0.03* | 0.05 | 0.01* | 0.13* | 0.00x |
| irt | 0.00x | 0.02 | 0.04* | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.00x | 0.01* | 0.02* | 0.05* | 0.00x | 0.00x | 0.01* |
| ith | 0.00x | 0.00x | 0.00x | 0.00x | 0.03* | 0.00x | 0.07* | 0.06* | 0.07* | 0.00x | 0.00x | 0.00x | 0.00x | 0.07* | 0.00x | 0.00x | 0.00x |

* variables included in final model
x Variables eliminated due to null contribution in pre-modeling

**Tab. S2** - Variance inflation factor of the variables included in final models of spatial distribution of 17 species of pines. (alt): altitude (m); (bd): bulk density (cg/cm3); (bio1): annual mean temperature (°C); (bio10): mean temperature of warmest quarter (°C); (bio11): mean temperature of coldest quarter (°C); (bio12): annual precipitation (mm); (bio13): precipitation of wettest month (mm); (bio14): precipitation of driest month (mm); (bio14): precipitation of driest month (mm); (bio16): precipitation of wettest quarter (mm); (bio17): precipitation of driest quarter (mm); (bio2): mean diurnal range (°c); (bio5): maximun temperature of warmest month (°c); (bio6): minimun temperature of coldest month (°c); (cec): cation exchange capacity (mmol(c)/kg); (ci): convergence index; (clc): clay content (g/kg); (dah): diurnal anisotropic heat; (nit): nitrogen (cg/kg); (ocd): organic carbon density (g/dm$^3$); (ph): ph water (ph*100); (sa): sand (g/kg); (slo): slope (°); (sil): silt (g/kg); (ocs): organic carbon soil (dg/kg); (socs): soil organic carbón stock (t/ha); (tri): terrain ruggedness index (m); (twi): topographic wetness index.

| Var/sp | *P. arizonica* | *P. ayacahuite* | *P. cembroides* | *P. devoniana* | *P. douglasiana* | *P. durangensis* | *P. hartwegii* | *P. herrerae* | *P. leiophylla* | *P. maximinio* | *P. montezumae* | *P. oocarpa* | *P. patula* | *P. pseudostrobus* | *P. strobiformis* | *P. strobus var. chiapensis* | *P. teocate* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| alt | 1.46 | * | * | * | 2.16 | * | * | * | 2.18 | * | * | * | * | * | 2.24 | * | * |
| bd | 1.16 | 1.47 | * | 2.20 | * | * | 1.65 | * | * | 1.36 | 1.45 | * | 1.30 | 1.34 | 1.28 | 1.66 | * |
| bio_1 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| bio_10 | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| bio_11 | * | * | * | * | * | * | * | * | 2.15 | * | * | * | * | * | * | * | 4.56 |
| bio_12 | * | * | 4.56 | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| bio_13 | 1.93 | 2.28 | * | 3.15 | 3.03 | 2.16 | * | 2.81 | * | 2.67 | * | 1.95 | 1.67 | * | 1.93 | * | 3.20 |
| bio_14 | 1.47 | 1.99 | 2.46 | * | * | 1.36 | 1.39 | * | * | 1.96 | * | 2.21 | 1.46 | 1.95 | * | * | * |
| bio_16 | * | * | * | * | * | * | * | * | * | * | 1.61 | * | * | * | * | 1.93 | * |
| bio_17 | * | * | * | 1.50 | 1.42 | * | * | 1.53 | * | * | * | * | * | * | 1.85 | * | * |
| bio_2 | * | 3.18 | 3.03 | 2.07 | 1.68 | 1.53 | 2.31 | 1.72 | * | 2.34 | 2.18 | * | 2.10 | 2.29 | 1.89 | 1.96 | 3.66 |
| bio_5 | * | 1.55 | 2.34 | 1.66 | * | 2.31 | 1.41 | 2.22 | * | 1.38 | 1.63 | 1.24 | 1.46 | 1.27 | * | 1.94 | 3.50 |
| bio_6 | * | * | 3.61 | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| cec | * | * | 1.83 | 1.36 | * | * | 1.43 | * | 1.34 | * | 1.34 | 1.72 | * | 1.19 | * | 1.81 | 1.16 |
| ci | * | * | * | * | * | * | * | * | * | * | * | * | 1.03 | * | * | * | * |
| clc | * | 2.13 | 2.09 | * | * | * | * | * | * | * | * | 2.18 | * | * | * | 2.74 | * |
| dah | * | * | * | 1.03 | 1.02 | * | * | * | * | 1.03 | 1.03 | 1.03 | * | * | * | * | * |
| nit | * | * | * | 2.38 | 1.92 | * | * | 2.50 | * | 1.58 | * | * | * | * | * | 1.49 | 2.63 |
| ocd | * | * | * | * | * | * | * | * | 2.01 | * | * | * | * | * | * | * | * |
| pH | * | * | 1.85 | 3.06 | 1.42 | 1.48 | 1.65 | 1.59 | 1.45 | * | * | * | * | * | * | * | 1.91 |
| sa | * | 2.13 | * | 1.97 | * | * | * | * | * | * | * | 1.68 | * | * | * | 2.09 | * |
| sil | * | * | * | 1.81 | * | * | 1.70 | * | * | 1.47 | 1.75 | 1.35 | 1.55 | * | * | 1.72 | * |
| slo | 1.38 | 1.27 | * | 1.34 | * | * | 1.51 | * | * | * | * | * | * | * | 1.41 | * | * |
| ocs | * | * | * | * | * | 2.62 | * | 3.27 | * | * | * | * | * | 2.31 | * | * | 3.40 |

| Var/sp | *P. arizonica* | *P. ayacahuite* | *P. cembroides* | *P. devoniana* | *P. douglasiana* | *P. durangensis* | *P. hartwegii* | *P. herrerae* | *P. leiophylla* | *P. maximinio* | *P. montezumae* | *P. oocarpa* | *P. patula* | *P. pseudostrobus* | *P. strobifformis* | *P. strobus var. chiapensis* | *P. teocate* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| socs | 2.70 | 2.72 | * | * | * | * | 2.99 | * | * | * | 2.74 | * | 2.48 | * | 2.31 | 2.81 | * |
| tri | * | * | 1.41 | * | * | * | * | * | * | * | * | 1.15 | 1.29 | 1.44 | * | * | 1.58 |
| twi | * | * | * | * | 1.16 | * | 1.38 | 1.13 | 1.21 | * | * | * | * | 1.34 | * | * | * |

* Variance inflation factor > 5 (highly correlated)