Supplement S2

Environmental GIS layers used to predict Hooded Crane wintering distribution

|  |  |  |  |
| --- | --- | --- | --- |
| Environmental Layers | Description | Class | Source |
| Tmen\_(n = 1 to 12) c | Mean temperature, Jan. to Dec. (℃\*10) | Climate | Worldclim |
| Tmin\_(n = 1 to 12) c | Minimum temperature, Jan. to Dec. (℃\*10) | Climate | Worldclim |
| Tmax\_(n = 1 to 12) c | Maximum temperature, Jan. to Dec. (℃\*10) | Climate | Worldclim |
| Prec\_(n = 1 to 12) c | Precipitation, Jan. to Dec.(mm) | Climate | Worldclim |
| Bio\_(n = 1 to 7) abc | Bio-climate | Climate | Worldclim |
| Bio\_(n= 8 to 11) bc | Bio-climate | Climate | Worldclim |
| Bio\_(n= 12 to 15) abc | Bio-climate | Climate | Worldclim |
| Bio\_(n= 16 to 19) bc | Bio-climate | Climate | Worldclim |
| Altitude abc | Altitude(m) | Terrain | Worldclim |
| Aspect abc | Aspect(°) | Terrain | Derived from Altitude |
| Slope abc | Slope | Terrain | Derived from Altitude |
| Landcover abc | Landcover | Terrain | European Commission |
| Hii c | Human Interference Index | Human influence |  |
| Disroad abc | Distance to road (m) | Human influence | Road layer from Natural Earth |
| Disrard abc | Distance to rail road (m) | Human influence | Railroad layer from Natural Earth |
| Disriver abc | Distance to river (m) | Terrain | River layer from Natural Earth |
| Dislake abc | Distance to lake (m) | Terrain | Lake layer from Natural Earth |
| Discoastline abc | Distance to coastline (m) | Terrain | Coast lime layer from Natural Earth |
| Dissettle abc | Distance to settlement (m) | Human | Coast lime layer from Natural Earth |

（a）as the predictor in 21 variables model; （b）as the predictor in 29 variables model; （c）as the predictor in 78 variables model.

Supplement S3

Confusion matrix and formula for criteria

Elements of a confusion matrix\*

|  |  |
| --- | --- |
|   | Validation data set |
|  | Presence | Absence |
| Model | Presence | a | b |
| Absence | c | d |

\* An error confusion matrix used to evaluate the predictive accuracy of presence-absence

models. a, number of cells for which presence was correctly predicted by the model; b, number of cells for which the species was not found but the model predicted presence; c, number of cells for which the species was found but the model predicted absence; d, number of cells for which absence was correctly predicted by the model (Allouche et al., 2006).

Formula table\*

|  |  |
| --- | --- |
| Measure  | Formula |
| Sensitivity | $$\frac{a}{a+c}$$ |
| Specificity | $$\frac{d}{b+d}$$ |
| Kappa  | $$\frac{\left(\frac{a+d}{n}\right)-\frac{\left(a+b\right)\left(a+c\right)+(c+d)(d+b)}{n^{2}}}{1-\frac{\left(a+b\right)\left(a+c\right)+(c+d)(d+b)}{n^{2}}}$$ |
| TSS  | $$Sensitivity+Specificity-1$$ |

\*Measures of predictive accuracy calculated from a 2 x 2 error confusion matrix (Table 2). In all formula n = a + b + c + d. Overall accuracy is the rate of correctly classified cells. Sensitivity is the probability that the model will correctly classify a presence. Specificity is the probability that the model will correctly classify an absence. The kappa statistic and TSS normalize the overall accuracy by the accuracy that might have occurred by chance alone.

Supplement S4

Model accuracy evaluation of AUC, Kappa and TSS

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | Number of predictor | Evaluation metric | AUC | Kappa | TSS |
| RF | 1 | aspatial | 0.896 | 0.213 | 0.748 |
| RF | 1 | spatial | 0.852 | 0.256 | 0.707 |
| RF | 3 | aspatial | 0.9182 | 0.737 | 0.789 |
| RF | 3 | spatial | 0.947 | 0.506 | 0.890 |
| RF | 5 | aspatial | 0.970 | 0.731 | 0.871 |
| RF | 5 | spatial | 0.957 | 0.638 | 0.908 |
| RF | 8 | aspatial | 0.978 | 0.660 | 0.868 |
| RF | 8 | spatial | 0.963 | 0.697 | 0.924 |
| RF | 11 | aspatial | 0.970 | 0.632 | 0.873 |
| RF | 11 | spatial | 0.980 | 0.759 | 0.960 |
| RF | 21 | aspatial | 0.985 | 0.663 | 0.913 |
| RF | 21 | spatial | 0.970 | 0.734 | 0.939 |
| RF | 29 | aspatial | 0.983 | 0.616 | 0.888 |
| RF | 29 | spatial | 0.972 | 0.767 | 0.945 |
| RF | 78 | aspatial | 0.982 | 0.586 | 0.884 |
| RF | 78 | spatial | 0.961 | 0.824 | 0.921 |
| TN | 1 | aspatial | 0.963 | 0.240 | 0.855 |
| TN | 1 | spatial | 0.859 | 0.209 | 0.719 |
| TN | 3 | aspatial | 0.991 | 0.570 | 0.940 |
| TN | 3 | spatial | 0.925 | 0.451 | 0.849 |
| TN | 5 | aspatial | 0.993 | 0.627 | 0.956 |
| TN | 5 | spatial | 0.934 | 0.520 | 0.867 |
| TN | 8 | aspatial | 0.998 | 0.646 | 0.962 |
| TN | 8 | spatial | 0.927 | 0.539 | 0.855 |
| TN | 11 | aspatial | 0.996 | 0.688 | 0.980 |
| TN | 11 | spatial | 0.940 | 0.544 | 0.881 |
| TN | 21 | aspatial | 0.997 | 0.713 | 0.978 |
| TN | 21 | spatial | 0.943 | 0.559 | 0.887 |
| TN | 29 | aspatial | 0.997 | 0.693 | 0.983 |
| TN | 29 | spatial | 0.945 | 0.558 | 0.890 |
| TN | 78 | aspatial | 0.997 | 0.698 | 0.985 |
| TN | 78 | spatial | 0.940 | 0.547 | 0.879 |

Supplement S5

The model and quantity of predictors used in some reference

|  |  |  |
| --- | --- | --- |
| Reference | Model | predictors |
| Leathwick et al., 1996 | GAM | 7 |
| Manel et al., 1999 | MDA; LR; ANN | 32 |
| Peterson, 2001 | GARP | 8 |
| Anderson et al., 2002 | GARP | 4 |
| Zaniewski et al., 2002 | GAM; ENFA | 10 |
| Anderson et al., 2003 | GARP | 21 |
| Thuiller, 2003 | GLM; GAM; CART; ANN | 7 |
| Engler et al., 2004 | ENFA; GLM | 11 |
| Seoane et al., 2004 | GAM | 24 |
| Liu et al., 2005 | ANN | 5 |
| Elith et al., 2006 | MAXENT; BRT | 11-13 |
| Garzon et al., 2006 | CART; RF; ANN | 14 |
| Hijmans and Graham, 2006 | BIOCLIM; DOMAIN; GAM; MAXENT | 6,18 |
| Guisan et al., 2007 | DIVA-GIS; DOMAIN; GLM; GAM; BRUTO; BRT; OM-GARP; GDMSS; MAXENT  | 11,13 |
| Zhu et al., 2007 | GARP | 23 |
| Pearson et al., 2007 | GARP; MAXENT | 20 |
| Chefaoui and Lobo, 2008 | GLM; ENFA; MDE | 15 |
| Leng et al., 2008 | Random Forest | 18 |
| Kumar and Stohlgren, 2009 | MAXENT | 10 |
| Marmion et al., 2009 | GLM; GAM; MARS; ANN; GBM; RF; CTA; MDA | 16 |
| Booms et al., 2010 | TreeNet | 12 |
| Menon et al., 2010 | GARP; MAXENT | 11 |
| Wei et al., 2010 | RF | 39 |
| Hardy et al., 2011 | Random Forest; TreeNet; MARS | 20 |
| Thorne et al., 2012 | MAXENT | 11 |
| Baltensperger et al., 2013 | Random Forest | 12 |
| Herrick et al., 2013 | Random Forest | 5 |
| Liu et al., 2013 | MD; ENFA; GAM; RF | 18 |
| Keith et al., 2014 | BRT | 13 |
| Pradervand et al., 2014 | GLM; GAM; GBM | 8 |