10.1071/WR23010

Wildlife Research

Supplementary Material

Ensemble forecasting of Persian leopard (*Panthera pardus saxicolor*) distribution and habitat suitability in south-western Iran

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Appendix A. Supporting information

Table S1 Definition of six classes of land cover (Zanaga *et al.* 2022).

Land Cover Class	Definition
Tree cover	This class includes any geographic area dominated by trees with a cover of 10% or more. Other land cover classes (shrubs and/or herbs in the understory, built-up, permanent water bodies, …) can be present below the canopy, even with a density higher than trees. Areas planted with trees for afforestation purposes and plantations (e.g. oil palm, olive trees) are included in this class. This class also includes tree covered areas seasonally or permanently flooded with fresh water except for mangroves.
Shrubland	This class includes any geographic area dominated by natural shrubs having a cover of 10% or more. Shrubs are defined as woody perennial plants with persistent and woody stems and without any defined main stem being less than 5 m tall. Trees can be present in scattered form if their cover is less than 10%. Herbaceous plants can also be present at any density. The shrub foliage can be either evergreen or deciduous.
Grassland	This class includes any geographic area dominated by natural herbaceous plants (Plants without persistent stem or shoots above ground and lacking definite firm structure): (grasslands, prairies, steppes, savannahs, pastures) with a cover of 10% or more, irrespective of different human and/or animal activities, such as: grazing, selective fire management etc. Woody plants (trees and/or shrubs) can be present assuming their cover is less than 10%. It may also contain uncultivated cropland areas (without harvest/ bare soil period) in the reference year.
Cropland	Land covered with annual cropland that is sowed/planted and harvestable at least once within the 12 months after the sowing/planting date. The annual cropland produces an herbaceous cover and is sometimes combined with some tree or woody vegetation. Note that perennial woody crops will be classified as the appropriate tree cover or shrub land cover type. Greenhouses are considered as built-up.
Built-up	Land covered by buildings, roads and other man-made structures such as railroads. Buildings include both residential and industrial building. Urban green (parks, sport facilities) is not included in this class. Waste dump deposits and extraction sites are considered as bare.
Bare / sparse vegetation	Lands with exposed soil, sand, or rocks and never has more than 10 % vegetated cover during any time of the year.

Table S2 Model accuracies of Persian leopard with three abiotic variables (Model Set 1; including slope, aspect, and distance from water resources) given by the mean area under the curve (AUC) values against the independent dataset in the Khaeiz and Sorkh protected area. Models with AUC ≤ 0.70 values were excluded.

Runs	Models								Avg.	St. dev.
	GLM	CTA	FDA	GBM	ANN	MARS	RF	MaxEnt		
1	0.89	0.85	0.86	0.96	0.88	0.84	0.94	0.90	0.89	± 0.04
2	0.97	0.91	0.95	0.92	0.88	0.95	0.86	0.98	0.93	± 0.04
3	0.91	-	0.87	0.92	0.87	0.76	0.83	0.95	0.87	± 0.06
4	0.80	0.92	0.87	0.96	0.79	0.79	0.85	0.93	0.86	± 0.07
5	0.93	0.72	0.91	0.84	0.94	-	0.85	0.92	0.87	± 0.08
6	0.91	0.84	0.90	0.86	0.88	0.92	0.84	0.78	0.86	± 0.05
7	0.93	0.85	0.92	0.94	0.96	0.88	0.97	0.93	0.92	± 0.04
8	0.87	0.73	0.86	-	0.79	0.72	0.79	0.93	0.81	± 0.08
9	0.76	0.77	0.81	0.80	-	0.73	0.74	0.76	0.77	± 0.03
10	0.95	0.86	0.96	0.91	0.90	0.90	0.93	0.97	0.92	± 0.04
11	0.95	0.85	0.92	0.95	0.90	0.86	0.96	0.97	0.92	± 0.05
12	0.92	0.79	0.90	0.94	0.92	0.81	0.86	0.93	0.88	± 0.06
13	0.91	0.77	0.88	0.92	0.97	0.85	0.94	0.90	0.89	± 0.06
14	0.88	0.94	0.91	0.95	0.80	0.95	0.90	0.94	0.91	± 0.05
15	0.92	0.72	0.89	0.79	0.91	0.84	0.84	0.93	0.85	± 0.07
16	0.90	0.91	0.90	0.95	0.83	0.94	0.86	0.94	0.90	± 0.04
17	0.88	0.86	0.87	0.94	0.91	0.81	0.88	0.89	0.88	± 0.04
18	0.80	0.81	0.85	0.81	0.73	-	0.70	-	0.78	± 0.05
19	0.80	0.77	0.86	0.90	0.95	0.85	0.90	0.92	0.87	± 0.06
20	0.94	0.89	0.93	0.95	0.82	0.86	0.94	0.90	0.90	± 0.04
21	0.81	0.92	0.90	0.96	0.93	0.86	0.92	0.95	0.91	± 0.05
22	0.92	0.91	0.94	0.94	0.86	0.87	0.89	0.95	0.91	± 0.03
23	0.78	0.78	0.81	0.81	0.80	-	-	0.76	0.79	± 0.02
24	0.82	0.76	0.92	0.94	0.80	0.89	0.91	0.95	0.87	± 0.07
25	0.81	0.85	0.90	0.94	0.91	0.79	0.95	0.93	0.88	± 0.06
Avg.	0.88	0.83	0.89	0.91	0.87	0.85	0.88	0.91		
St. dev.	± 0.06	± 0.07	± 0.04	± 0.06	± 0.06	± 0.07	± 0.07	± 0.06		

Table S3 Model accuracies of Persian leopard with three abiotic variables (Model Set 1; including slope, aspect, and distance from water resources) given by the mean true skill statistic (TSS) values against the independent dataset in the Khaeiz and Sorkh protected area. Models with TSS ≤ 0.40 values were excluded.

Runs	Models								Avg.	St. dev.
	GLM	CTA	FDA	GBM	ANN	MARS	RF	MaxEnt		
1	0.74	0.69	0.74	0.92	0.79	0.69	0.86	0.70	0.77	± 0.09
2	0.90	0.84	0.93	0.78	0.67	0.89	0.61	0.92	0.82	± 0.12
3	0.73	-	0.75	0.74	0.77	0.47	0.64	0.87	0.71	± 0.12
4	0.60	0.84	0.61	0.88	0.60	0.60	0.75	0.82	0.71	± 0.12
5	0.78	0.44	0.70	0.58	0.82	-	0.64	0.73	0.67	± 0.13
6	0.71	0.68	0.74	0.67	0.59	0.79	0.70	0.52	0.68	± 0.09
7	0.76	0.69	0.73	0.79	0.90	0.68	0.86	0.77	0.77	± 0.08
8	0.65	0.46	0.72	0.50	0.62	0.47	0.48	0.84	0.59	± 0.14
9	0.58	0.53	0.68	0.65	0.47	0.53	0.61	0.56	0.58	± 0.07
10	0.91	0.72	0.91	0.68	0.75	0.70	0.84	0.94	0.81	± 0.11
11	0.89	0.70	0.74	0.84	0.77	0.57	0.92	0.92	0.79	± 0.12
12	0.79	0.58	0.76	0.73	0.77	0.55	0.74	0.73	0.71	± 0.09
13	0.74	0.55	0.71	0.80	0.91	0.76	0.83	0.76	0.76	± 0.10
14	0.67	0.87	0.78	0.79	0.64	0.84	0.74	0.84	0.77	± 0.08
15	0.78	0.43	0.70	0.58	0.74	0.71	0.61	0.75	0.66	± 0.11
16	0.67	0.82	0.74	0.80	0.63	0.80	0.78	0.82	0.76	± 0.07
17	0.74	0.71	0.72	0.74	0.67	0.54	0.65	0.66	0.68	± 0.07
18	0.62	0.61	0.74	0.59	0.46	-	0.53	0.40	0.57	± 0.11
19	0.63	0.54	0.67	0.65	0.90	0.65	0.72	0.77	0.69	± 0.11
20	0.83	0.78	0.75	0.78	0.77	0.74	0.74	0.74	0.77	± 0.03
21	0.71	0.83	0.73	0.91	0.82	0.72	0.81	0.88	0.80	± 0.07
22	0.76	0.82	0.80	0.82	0.68	0.78	0.70	0.82	0.77	± 0.06
23	0.61	0.56	0.56	0.61	0.56	0.41	0.41	0.60	0.54	± 0.09
24	0.63	0.53	0.77	0.87	0.62	0.66	0.71	0.89	0.71	± 0.13
25	0.67	0.69	0.69	0.77	0.84	0.60	0.82	0.77	0.73	± 0.08
Avg.	0.72	0.66	0.73	0.74	0.71	0.66	0.71	0.76		
St. dev.	± 0.09	± 0.14	± 0.08	± 0.11	± 0.13	± 0.13	± 0.12	± 0.13		

Table S4 Model accuracies of Persian leopard with three ecological variables (Model Set 2; including livestock distribution, wild goat distribution, and caracal distribution) given by the mean area under the curve (AUC) values against the independent dataset in the Khaeiz and Sorkh protected area. Models with AUC ≤ 0.70 values were excluded.

Runs	Models								Avg.	St. dev.
	GLM	CTA	FDA	GBM	ANN	MARS	RF	MaxEnt		
1	0.87	0.78	0.77	0.96	-	0.82	0.96	0.88	0.86	± 0.08
2	0.83	0.84	0.85	0.94	0.92	0.71	0.94	0.88	0.86	± 0.08
3	0.84	0.76	0.77	0.97	0.75	0.79	0.93	0.87	0.83	± 0.08
4	0.89	0.85	0.85	0.97	0.94	0.86	0.96	0.91	0.90	± 0.05
5	0.93	0.80	0.92	0.92	0.87	0.91	0.93	0.94	0.90	± 0.05
6	0.86	0.92	0.86	0.89	0.73	0.77	0.83	0.93	0.85	± 0.07
7	0.93	0.82	0.96	0.88	0.93	0.74	0.93	0.95	0.89	± 0.08
8	0.90	0.81	0.86	0.94	0.83	0.95	0.92	0.91	0.89	± 0.05
9	0.84	0.71	0.79	0.94	0.93	0.79	0.97	0.85	0.85	± 0.09
10	0.83	0.70	0.76	0.95	0.88	0.84	0.97	0.80	0.84	± 0.09
11	0.81	0.76	0.75	0.93	0.78	0.76	0.87	0.82	0.81	± 0.06
12	0.88	0.83	0.85	0.95	0.93	0.95	0.94	0.90	0.90	± 0.05
13	0.87	0.77	0.84	0.95	0.78	0.94	0.96	0.89	0.87	± 0.07
14	0.92	0.86	0.88	0.98	0.98	0.96	0.97	0.92	0.93	± 0.05
15	0.91	0.90	0.94	0.96	0.91	0.95	0.97	0.96	0.94	± 0.03
16	0.83	0.83	0.90	0.92	0.91	0.75	0.87	0.89	0.86	± 0.06
17	0.85	0.77	0.78	0.92	0.89	0.79	0.94	0.86	0.85	± 0.06
18	0.90	0.89	0.86	0.98	0.92	0.97	0.98	0.91	0.93	± 0.04
19	0.91	-	0.86	0.95	0.95	0.89	0.96	0.77	0.90	± 0.07
20	0.88	0.84	0.84	0.99	0.89	0.95	0.99	0.90	0.91	± 0.06
21	0.84	0.78	0.75	0.94	-	0.77	0.92	0.83	0.83	± 0.07
22	0.86	0.83	0.82	0.96	0.79	0.92	0.98	0.87	0.88	± 0.07
23	0.85	0.89	0.84	0.98	0.70	0.85	0.96	0.89	0.87	± 0.09
24	0.90	0.84	0.87	0.97	0.93	0.86	0.97	0.90	0.90	± 0.05
25	0.85	-	0.75	0.90	0.92	-	0.95	0.85	0.87	± 0.07
Avg.	0.87	0.82	0.84	0.94	0.87	0.85	0.94	0.88	0.88	
St. dev.	± 0.04	± 0.06	± 0.06	± 0.03	± 0.08	± 0.08	± 0.04	± 0.05		

Table S5 Model accuracies of Persian leopard with three ecological variables (Model Set 2; including livestock distribution, wild goat distribution, and caracal distribution) given by the mean true skill statistic (TSS) values against the independent dataset in the Khaeiz and Sorkh protected area. Models with TSS ≤ 0.40 values were excluded.

Runs	Models								Avg.	St. dev.
	GLM	CTA	FDA	GBM	ANN	MARS	RF	MaxEnt		
1	0.74	0.56	0.56	0.92	-	0.79	0.87	0.73	0.74	± 0.14
2	0.71	0.68	0.68	0.78	0.77	0.52	0.86	0.69	0.71	± 0.10
3	0.62	0.53	0.53	0.92	0.58	0.66	0.81	0.65	0.66	± 0.14
4	0.71	0.70	0.70	0.91	0.90	0.80	0.85	0.73	0.79	± 0.09
5	0.76	0.64	0.88	0.77	0.59	0.81	0.87	0.88	0.77	± 0.11
6	0.72	0.83	0.67	0.70	0.47	0.59	0.60	0.81	0.67	± 0.12
7	0.82	0.66	0.88	0.61	0.85	0.65	0.81	0.87	0.77	± 0.11
8	0.67	0.63	0.66	0.83	0.55	0.88	0.81	0.70	0.72	± 0.11
9	0.60	0.43	0.57	0.79	0.69	0.67	0.94	0.64	0.67	± 0.15
10	0.61	0.41	0.55	0.82	0.74	0.71	0.90	0.56	0.66	± 0.16
11	0.58	0.52	0.52	0.79	0.61	0.55	0.78	0.60	0.62	± 0.11
12	0.70	0.67	0.68	0.88	0.86	0.91	0.80	0.73	0.78	± 0.10
13	0.74	0.54	0.68	0.81	0.50	0.90	0.87	0.79	0.73	± 0.15
14	0.72	0.71	0.78	0.89	0.93	0.91	0.84	0.73	0.81	± 0.09
15	0.76	0.78	0.81	0.85	0.68	0.84	0.95	0.89	0.82	± 0.08
16	0.72	0.66	0.73	0.82	0.71	0.64	0.74	0.70	0.72	± 0.05
17	0.59	0.54	0.54	0.78	0.60	0.64	0.75	0.60	0.63	± 0.09
18	0.77	0.80	0.69	0.96	0.82	0.94	0.97	0.81	0.85	± 0.10
19	0.70	-	0.71	0.85	0.86	0.67	0.90	0.59	0.75	± 0.12
20	0.69	0.68	0.68	0.97	0.68	0.83	0.97	0.73	0.78	± 0.13
21	0.60	0.55	0.50	0.80	-	0.66	0.77	0.59	0.64	± 0.11
22	0.77	0.66	0.66	0.84	0.60	0.77	0.92	0.73	0.74	± 0.10
23	0.79	0.78	0.70	0.95	0.47	0.82	0.85	0.75	0.76	± 0.14
24	0.75	0.66	0.69	0.94	0.83	0.77	0.90	0.79	0.79	± 0.10
25	0.72	-	0.42	0.76	0.84	-	0.82	0.70	0.71	± 0.15
Avg.	0.70	0.64	0.66	0.84	0.70	0.75	0.85	0.72	0.73	
St. dev.	± 0.07	± 0.11	± 0.11	± 0.09	± 0.14	± 0.12	± 0.08	± 0.09		