Moqanaki E. M., Jahed, N., Malkhasyan A., Askerov E., Farhadinia M. S., Kabir M., Adibi M. A., Ud Din J., Joolaee L., Raeesi Chahartaghi N. & Ostrowski S. 2019. Distribution and status of the Pallas's cat in the south-west part of its range. Cat News Special Issue 13, 24–30. Supporting Online Material

SOM T1. Camera trap surveys across the extent of occurrence EOO of the Pallas's cat in the study region (2008–2018). Sampling effort: The number of sampling days (24-hour) for each camera trap station summed for all the functioning stations at the site. Sampling type: Ext (Extensive): Opportunistic use of camera traps in order to identify as many target species as possible vs. Int (Intensive): Systematic use of camera traps in order to study e.g. population dynamics. # Positive captures: Independent photo-captures of the Pallas's cat during the sampling effort, i.e. if 30 minutes passed with no new captures of the species.

Site(s)	Country	Sampling dates	Sampling effort	Sampling type	Trap stations	Sampling effort/Trap stations	# Positive captures	Sampling effort/Positive captures	Target species
Bamyan Plateau[1]	Afghanistan	2015-08-09 to 2017-07-24	533	Ext	8	66.6	15	35.5	*P. pardus*
Wakhan District[1]	Afghanistan	2011-07-01 to 2018-05-01	15,000+	Int	104	144+	0	NA	*P. uncia*
Southern parts[2]	Armenia	2013-12-? to 2015-?-?	10,560	Int	24	440	0	NA	*P. pardus*
Nakhchivan[2]	Azerbaijan	2013-01-? to 2018-?-?	4,595+	Int	50+	92	0	NA	*P. pardus*
Khojir NP[*3]	Iran	2008-01-? to 2008-02-?	30+	Ext	2	25+	2	15+	*P. pardus*
Kavdeh NHA[*4]	Iran	2016-05-08 to 2016-09-26	255	Ext	15	17	2	128	*O. manul*
Jajroud PA[*4]	Iran	2016-10-27 to 2016-12-07	615	Ext	15	41	0	NA	*O. manul*
Kouh Sefid NHA[*4]	Iran	2017-04-22 to ?	675	Ext	15	45	0	NA	*O. manul*
Sarigol NP[*5]	Iran	2015-10-22 to -12-16	852	Int	19	44.8	2	426	*P. pardus*
Saluk NP-PA[*5]	Iran	2015-10-20 to -12-19	1,040	Int	22	47.3	1	1,040	*P. pardus*
Tandoureh NP[*5]	Iran	2016-05-31 to -07-25	3,597	Int	80	45.0	3	1,199	*P. pardus*
Qurumber NP[*6]	Pakistan	2012-06-18 to 2012-07-30	1,200	Ext	80	15	1	1200	*P. uncia*

? = Data is not available; NA = Not Applicable.

[*] NP: National Park, PA: Protected Area, NHA: No-hunting Area.

1. Jahed (2017) and WCS unpublished data; 2. Askerov et al. (2015) and WWF Azerbaijan/Armenia unpublished data; 3. Chalani et al. (2008); 4. Talebi Otaghvar et al. (2017) and Raeesi Chahartaghi et al. (2018); 5. M. S. Farhadinia unpublished data; 6. Hameed et al. (2014)

In the following, we describe the climate-based niche model developed in this study. We extended the modelling results of Moqanaki (2015), which used occurrence localities only from Iran, using more refined modelling methods (i.e. model tuning).

Occurrence data

Georeferenced occurrence localities were contemporary (≥ year 2000), C1 ("confirmed") and C2 ("probable") records of the Pallas's cat complied in this study (Table 1). Because of the varying spatial accuracy of this dataset, we only used records collected by either a GPS unit or those manually georeferenced to a < 5 km resolution (n = 81) based on the information provided by the contributors. To reduce the likely effects of spatial sampling biases, we filtered the occurrence data to obtain the maximum number of locations at a minimum nearest neighbour distance of 10 km using the R package spThin (Aiello-Lammens et al. 2015), which yielded 58 unique localities in total from Iran (n = 52), Afghanistan (n = 3) and Pakistan (n = 3).

Environmental data

We used 19 present-day bioclimatic data layers at 2.5 arc minutes (≈ 5 km) resolutions (Fick & Hijmans 2017, http://worldclim.org/version2). We did not account for collinearity among the variables to ensure the use of all biologically interpretable predictors. We further employed regularisation to reduce the model complexity, which reduced the number of variables selected for inclusion in the final model (see below).

Background extent

We restricted the background area to a 1° buffer around the occurrence localities. We ran all models with a single set of 10,000 background pixels from this extent.

Niche modelling

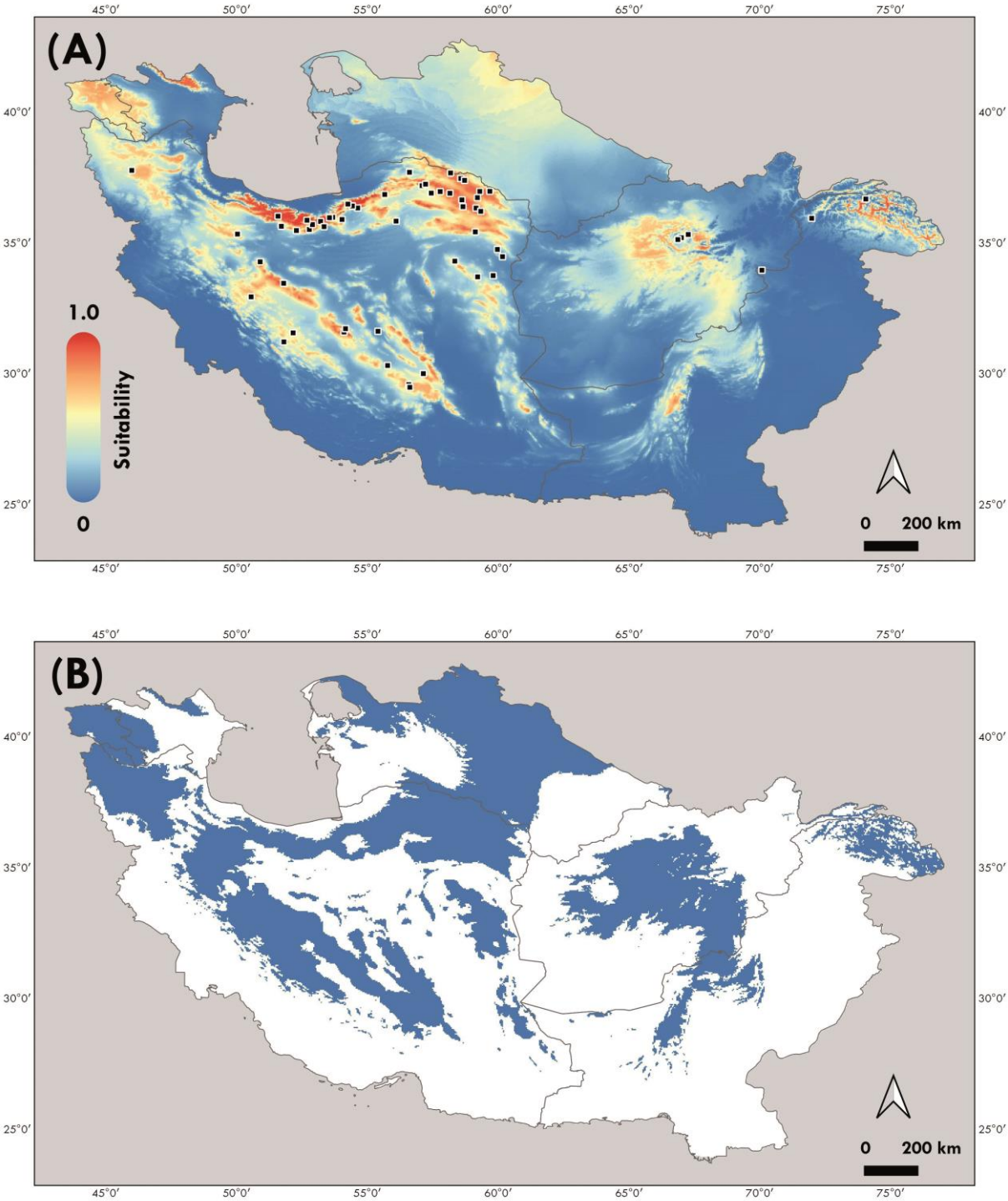
We modelled the potential distribution of the Pallas's cat using Maxent, a machine learning, presence-background ecological niche modelling technique (see Phillips & Dudík 2008). To investigate the possibility of making better models, we performed species-specific tuning of model parameters (Radosavljevic & Anderson 2014, Boria et al. 2017). We spatially partitioned the filtered localities into testing and training bins for cross-validation (Shcheglovitova & Anderson 2013) using the block method (aggregation factor= 2) in R package ENMeval (Muscarella et al. 2014). We then built models across a set of feature classes (Linear; Linear and Quadratic; Hinge; and Linear, Quadratic and Hinge) and regularisation multiplier values (1-5, increasing by increments of 0.5) implemented with the R package ENMeval (Muscarella et al. 2014). This resulted in 36 candidate models in total. We chose the raw output format (except for visualization purposes) with clamp predictions deactivated for all analyses. We followed a sequential procedure and Akaike information criterion corrected for small sample sizes (AICc) scores to select the final model (Boria et al. 2017). Specifically, we determined the optimal setting as the model with the lowest average Minimum Training Presence (MTP)' omission rate, as a measure of overfitting, and the highest average area under the curve (test AUC) values, as a measure of overall discriminatory ability, using the R package ENMeval (Muscarella et al. 2014). We used QGIS 3.0.2 (QGIS Development Team 2018) and R 3.5.0 (R Development Core Team 2018) to visualize and interpret all maps.

Optimal model and projection

The optimal model setting was Linear, Quadratic and Hinge with a regularisation multiplier value of 3.0 (LQH_3): MTP Omission rate = 0.035; test AUC = 0.802; ΔAICc= 4.933. The highest contributing bioclimatic variables (non-zero lambda weights) were: annual mean temperature, precipitation of coldest quarter, mean temperature of coldest quarter, isothermality and precipitation seasonality (Fick & Hijmans 2017). We projected this model to all of study region (SOM F1). We transformed the outcome of the final model into a binary output, as an index of suitability, representing Pallas's cat's abiotically suitable (occupied and unoccupied) versus unsuitable areas according to the 10% training omission-rate threshold of the LQH_3 model (SOM F1).

Geographic distribution

To calculate alternative estimates of the geographic distribution for the Pallas's cat in the study region, we used the binary output and extracted the suitable area inside the extent of occurrence and area of occupancy per range country (see main text for details; Table 2).



SOM F1. (A) Maxent's prediction of climatically suitable areas for the Pallas's cat in the study region (logistic output). Spatially filtered occurrence localities (contemporary, C1 and C2 records; n= 58) are shown as black squares. Warmer colours indicate areas with higher predicted suitable conditions. (B) Binary prediction after applying threshold (10% training omission-rate= 0.194), showing suitable areas used to modify the estimates of Extent of Occurrence EOO and Area of Occupancy AOO for the Pallas's cat (see main text).

SOM T2. Minimum and maximum values of each bioclimatic variable for the occurrence localities of the Pallas's cat (i.e. contemporary, C1 and C2 occurrence records with reliable spatial accuracy). The highest contributing variables (shown in bold) are those that were incorporated in the final Maxent model (LQH_3).

Bioclimatic variables*	Occurrence records
Annual mean temperature	-2.4–20.2
Mean diurnal range	9.3–16.9
Isothermality	24–43
Temperature seasonality	78.1–96.7
Maximum temperature of warmest month	16.6–40.3
Minimum temperature of coldest month	-23.2–1.1
Temperature annual range	33.7–43.6
Mean temperature of wettest quarter	-6.8–13.6
Mean temperature of driest quarter	0.4–31.2
Mean temperature of warmest quarter	9.3–31.2
Mean temperature of coldest quarter	-15.2–9.0
Annual precipitation	68–756
Precipitation of wettest month	15–140
Precipitation of driest month	0–22
Precipitation seasonality	45–97
Precipitation of wettest quarter	40–373
Precipitation of driest quarter	0–73
Precipitation of warmest quarter	0–121
Precipitation of coldest quarter	35–223

** Temperature and precipitation-related variables are measured in Degrees Celsius (°C) and Millimetres (mm), respectively. Exceptions are isothermality (a unitless ratio multiplied by 100), temperature seasonality (standard deviation of values in °C multiplied by 100) and precipitation seasonality (the unitless coefficient of variation multiplied by 100). See Fick & Hijmans (2017) for details.*

References

Aiello-Lammens M. E., Boria R. A., Radosavljevic A., Vilela B. & Anderson R. P. 2015. spThin: an R package for spatial thinning of species occurrence records for use in ecological niche models. Ecography 38, 541–545.

Boria R. A., Olson L. E., Goodman S. M. & Anderson R. P. 2017. A single-algorithm ensemble approach to estimating suitability and uncertainty: cross-time projections for four Malagasy tenrecs. Diversity and Distributions 23, 196–208.

Fick S. E. & Hijmans R. J. 2017. Worldclim 2: New 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37, 1–14.

Moqanaki E. M. 2015. Defining research and conservation priority landscape for the Near-Threatened Pallas's cat (*Otocolobus manul*) at its southwestern range limit. Final report to Wildlife Conservation Research Unit, Department of Zoology, University of Oxford, Tubney, UK. 16 pp.

Muscarella R., Galante P. J., Soley-Guardia M., Boria R. A., Kass J. M., Uriarte M. & Anderson R. P. 2014. ENMeval: An R package for conducting spatially independent evaluations and estimating optimal model complexity for Maxent ecological niche models. Methods in Ecology and Evolution 5, 1198–1205.

Phillips S. J. & Dudík M. 2008. Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. Ecography 31, 161–175.

QGIS Development Team. 2018. QGIS Geographic Information System. Open Source Geospatial Foundation. http://qgis.osgeo.org.

R Development Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Radosavljevic A. & Anderson R. P. 2014. Making better Maxent models of species distributions: complexity, overfitting and evaluation. Journal of Biogeography 41, 629–643.

Shcheglovitova M. & Anderson R. P. 2013. Estimating optimal complexity for ecological niche models: a jackknife approach for species with small sample sizes. Ecological Modelling 269, 9–17.