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Predicting *Eremias argus* Habitat Changes Under Climate Change in Republic of Korea

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Introduction

Eremias argus, an endangered species endemic to limited regions of South Korea, is experiencing population declines and range contraction driven by rapid urbanization and habitat fragmentation. In the face of accelerating biodiversity loss, there is an urgent need for systematic, high-resolution conservation strategies for such vulnerable taxa. In this study, we built habitat-suitability models for *Eremias argus* using occurrence records and a suite of environmental predictors (climate, topography, and land cover), and we improved predictive performance through ensemble modeling. We applied Pearson correlation analysis to minimize multicollinearity among variables, and we projected habitat distribution shifts under current and future climate scenarios, revealing clear spatiotemporal patterns.

Our results pinpoint core habitats and potential conservation priority areas for *Eremias argus*, providing foundational data to guide future conservation planning and the designation of protected areas.

Methodology

1. Study Area & Occurrence Data

The Republic of Korea was divided into a 1 km × 1 km WGS84 grid. We used 23 occurrence records of *Eremias argus* (presence/absence) collected by the National Institute of Ecology from 2007~2018. Under `set.seed(123)`, pseudo-absence points were generated at 50 × nPresence per presence (PA.strategy = "random"; filter.raster = TRUE; PA.nb.rep = 3; PA.nb.absences = 50 × sum(myResp == 1)) (Figure 1).

2. Environmental Variables

We assembled 33 variables—including BIO1~BIO19 and Topographic predictors–for 2007–2018 at 1 km resolution in a common projection. After Pearson correlation filtering (│r│ > 0.7), redundant variables were removed, yielding 14 predictors for modeling.

3. Species Distribution Modeling

Using the BIOMOD2 package, we ran eight algorithms (ANN, CTA, FDA, GAM, MARS, MAXNET, RFd, SRE) with 5-fold cross-validation (80% training, 20% testing). For each model, we computed ROC-AUC and variable-importance metrics.

4. Ensemble Modeling & Projection

Individual models were combined into an AUC-weighted mean ensemble (EMwmean). Predictions were made for current conditions and for future periods (2041–2070 and 2071–2100) under SSP2-4.5 and SSP5-8.5. Scenario differences were assessed by paired t–tests and percent change.

5. Model Evaluation & Variable Contribution

We compared model performance (ROC-AUC) and variable importance across algorithms.
Boxplots of AUC distributions were used to assess model stability and performance variability.

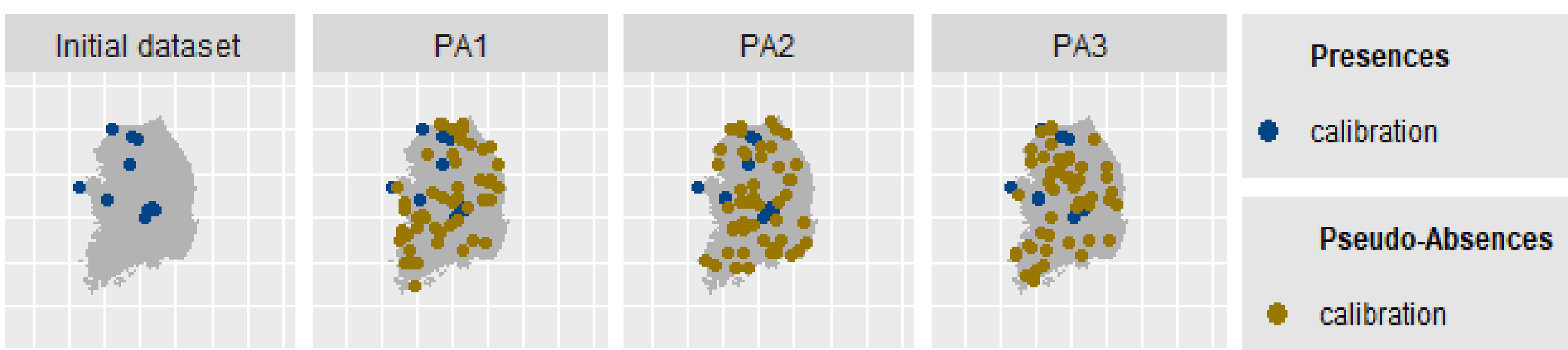

Figure 1. Generation of pseudo-absence points

Results & Discussion

Table 1. Variables

Code	Variable	Data
BIO1	Mean Annual Temperature	KMA(2007~2018)
BIO2	Mean Diurnal Temperature Range	KMA(2007~2018)
BIO12	Annual Precipitation	KMA(2007~2018)
BIO14	Precipitation of Driest Month	KMA(2007~2018)
BIO15	Precipitation Seasonality	KMA(2007~2018)
SLP	Slope (percent)	NGII
ASP	Aspect	NGII
TWI	Topographic Wetness Index	NGII
d_RES	Distance to Residential Areas	NGII
d_NAT	Distance to Natural Areas	NGII
d_ANT	Distance to Anthropogenic Areas	NGII
d_RIV	Distance to Rivers	NGII
d_OCE	Distance to Ocean	NGII
FAC	Forest Age Class	NGII

Table 2. Percentages Relative to the 2020s for Each Scenario

Scenario	Area	2020s Baseline
2020s (Baseline)	9417 km²	100 %
SSP2-4.5 (2041–2070)	4282 km²	45.5 %
SSP2-4.5 (2071–2100)	4608 km²	48.9 %
SSP5-8.5 (2041–2070)	3181 km²	33.8 %
SSP5-8.5 (2071–2100)	4440 km²	47.2 %

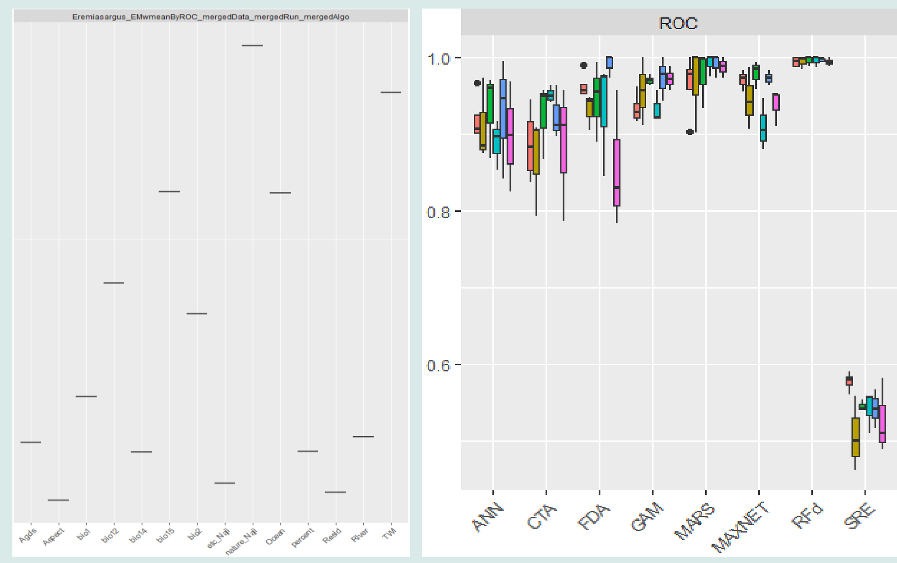

Figure 3. Model Performance & Variable Contribution

1. Current Habitat Suitability Distribution

Under present-day (2020s) climate conditions, the habitat suitability map (Figure 2) shows that areas of high suitability (suitability index ≥ 7) were concentrated in the Yeongdong region of Gangwon Province and the northern mountainous zones of Gyeongbuk Province. Medium-suitability areas (6–7) occurred in northern Gyeonggi and inland Chungcheong, while low-suitability zones (< 6) were primarily distributed across the western plains of the Seoul Capital Area and along the southern coast.

2. Future Scenario Changes

SSP2-4.5 (2041-2070): Habitat suitability area declined from 9417 km² to 4282 km² (45.5 %) (Figure 4).

SSP2-4.5 (2071–2100): Further contraction to 4608 km² (48.9 %) (Figure 5).

SSP5-8.5 (2041–2070): More severe reduction to 3181 km² (33.8 %) (Figure 6).

SSP5-8.5 (2071–2100): Partial mid- to long-term recovery to 4440 km² (47.2 %) (Figure 7).

3. Model Performance & Variable Contribution

The ROC distributions summarized in the box plots of model performance and variable contribution (Figure 3) indicate that most algorithms (ANN, CTA, FDA, GAM, MARS, MAXNET, RFd) achieved AUC values ≥ 0.90, with SRE remaining lower. The AUC-weighted mean ensemble (EMwmean) leveraged these strengths to reach an average AUC ≥ 0.978. In variable importance analysis, four predictors emerged as the most influential: distance to natural vegetation (d_NAT), topographic wetness index (TWI), distance to ocean (d_OCE), and precipitation seasonality (BIO15). Together, they accounted for over 70% of the total importance, underscoring the dominant role of climatic and topographic factors in determining habitat suitability. Under the high-emissions SSP5-8.5 scenario, *Eremias argus* faces severe habitat loss—particularly in the mid–to long–term—suggesting that conservation efforts should focus first on regions most sensitive to d_NAT, d_OCE, TWI, and BIO15.

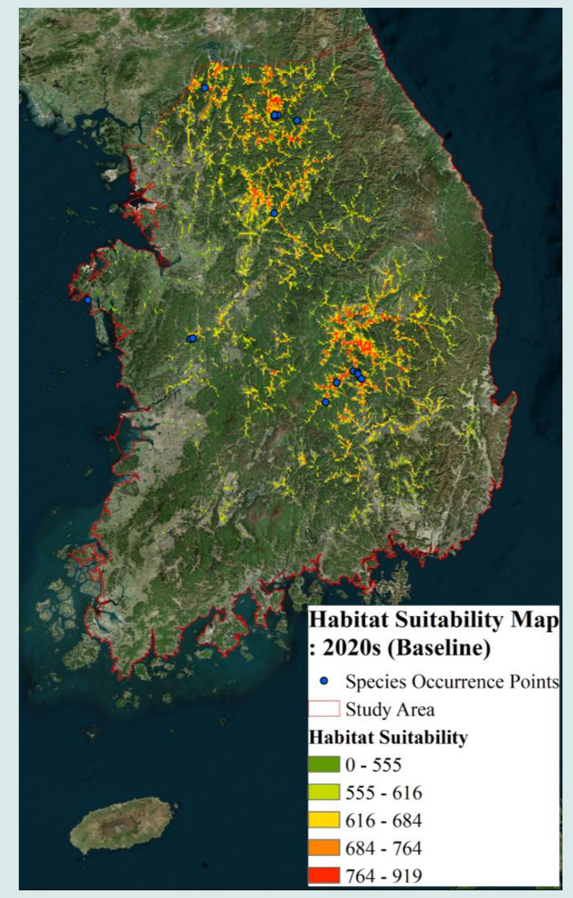

Figure 2. *Eremias argus* current habitat suitability map

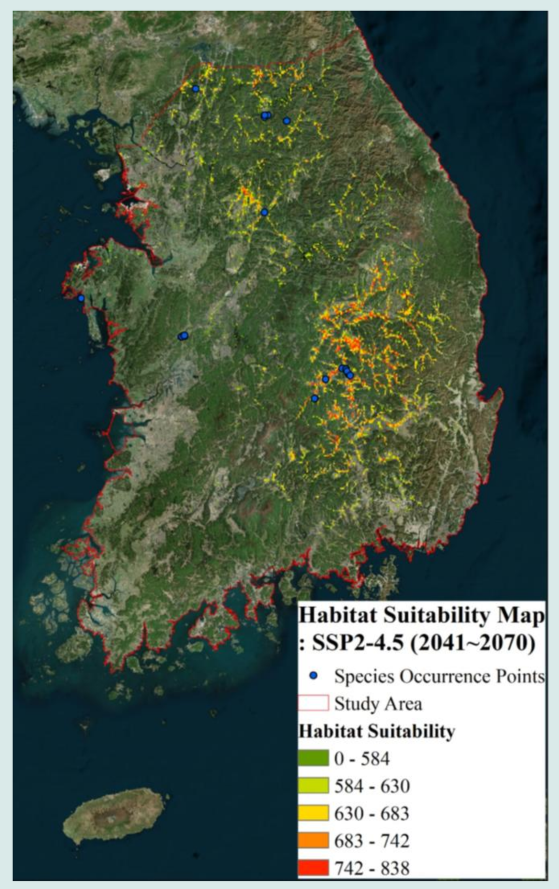

Figure 4. *Eremias argus* habitat suitability map under SSP2-4.5 (2041–2070)

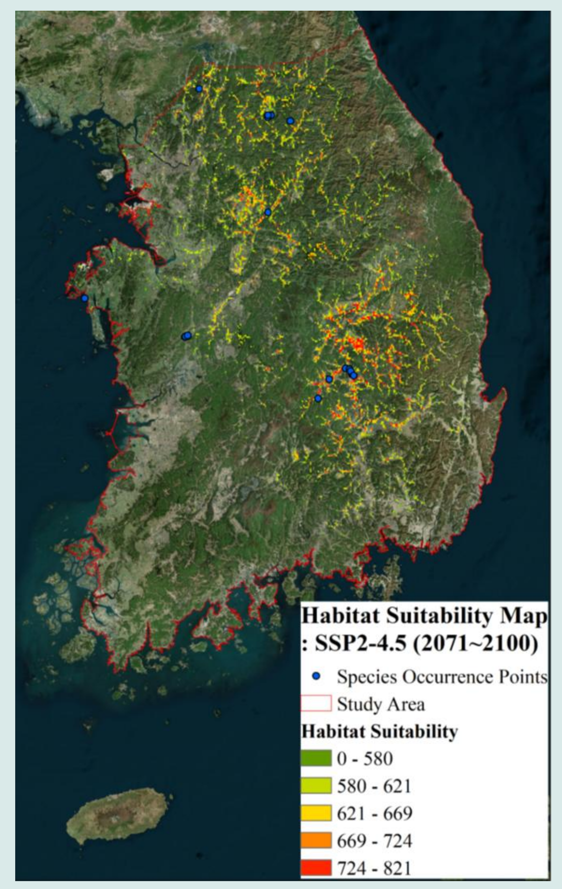

Figure 5. *Eremias argus* habitat suitability map under SSP2-4.5 (2071–2100)

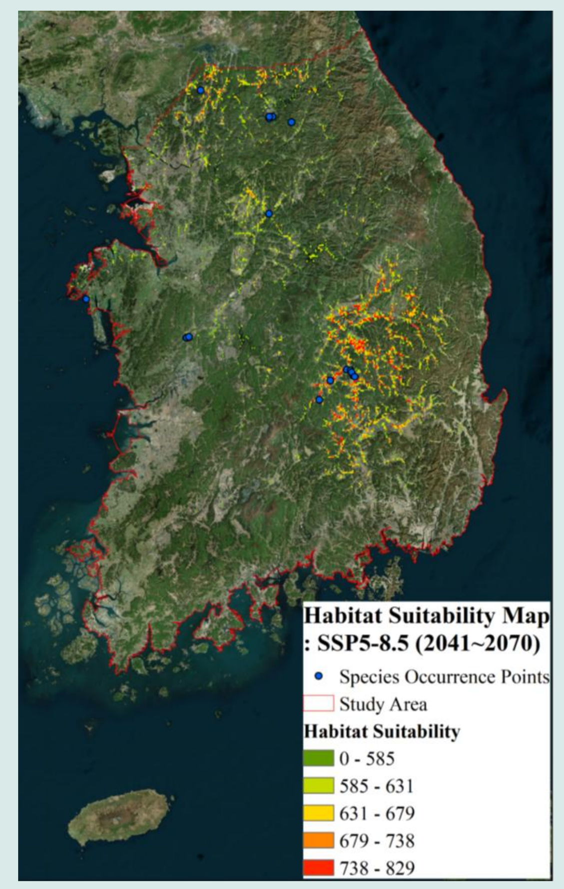

Figure 6. *Eremias argus* habitat suitability map under SSP5-8.5 (2041–2070)

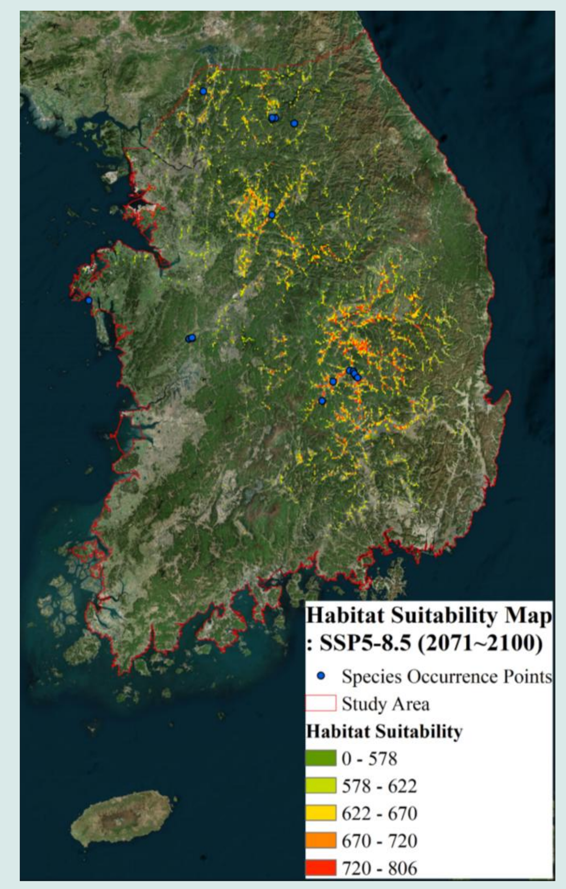

Figure 7. *Eremias argus* habitat suitability map under SSP5-8.5 (2071–2100)

Conclusion

Under future climate scenarios, suitable habitat area for *Eremias argus* contracted sharply to 34–47% of present–day levels—reaching its nadir under SSP5-8.5 in the mid–century period (2041–2070). Predictive performance was excellent: all individual algorithms except SRE achieved AUC ≥ 0.90, and the EMwmean ensemble reached AUC ≥ 0.978. The top three contributing variables were d_NAT, TWI, and BIO15. Based on these findings, it is necessary to prioritize protection of climate-sensitive regions, establish ecological corridors between remaining habitat patches, and implement long-term monitoring with adaptive strategy adjustments.

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