Spatial Modeling of Critical Habitats to Guide Conservation and Research Priorities for Nubian Ibex *Capra nubiana* in Mujib Biosphere Reserve, Jordan

Nashat A. Hamidan[1*] and Natalia Boulad[2]

[1] The Royal Society for the Conservation of Nature, Amman Jordan; [2] Protected Areas, World Heritage and Biodiversity Programme, Regional Office for West Asia, IUCN (International Union for Conservation of Nature)

Received: July 19, 2025; Revised: August 29, 2025; Accepted: August 31, 2025

Abstract

The Mujib Biosphere Reserve in Jordan provides vital habitats for the endangered Nubian ibex (*Capra nubiana*), yet knowledge of its ecological distribution remains limited. This study used species distribution modeling (SDM) via the MaxEnt algorithm to predict habitat suitability based on presence-only data collected between 2005 and 2013 and a range of environmental variables collected from related literature and expert judgment. The final model performed well (mean AUC = 0.88), identifying approximately 17–18% of the reserve—mainly steep escarpments and perennial wadis—as suitable habitat. Slope and annual precipitation were the most influential predictors. Crucially, field-based ground-truth validation confirmed that over 80% of independent occurrence records fell within high-suitability zones, directly reinforcing the model's accuracy and credibility. This integration of field verification added substantial confidence to the predictions, demonstrating how on-the-ground data can correct for spatial bias and validate remote modeling outputs. The findings offer a scientifically grounded tool to guide targeted monitoring, patrolling, and habitat management programmes, and provide essential input for adaptive conservation strategies in arid and mountainous landscapes.

Keywords:
MaxEnt algorithm, suitability, ground truth verification, mountainous landscapes

Introduction

Jordan was among the first Middle Eastern countries that has established conservation initiatives in the region. As early as 1963, the government of Jordan, under the direction of the late King Hussein bin Talal, recognized the urgency of addressing the degradation of the country's natural resources. In coordination with the British Museum (Natural History), a team of experts conducted a nationwide survey, which revealed alarming declines in habitat quality and biodiversity (Evans, 1994). This work led to the initial identification of key areas for conservation, although political and social circumstances delayed formal protection. In parallel with this foundation, the Royal Society for the Conservation of Nature (RSCN) was established in 1966 as the first NGO in the Arab world mandated with the establishment and management of protected areas. The RSCN played a critical role in developing Jordan's network of reserves, with the recommendations of the 1978 Clark Expedition forming the roadmap for protected area designation (Child and Grainger, 1990).

Among the first areas protected under this framework was the Mujib Nature Reserve, established in 1985. Located at the intersection of Mediterranean, Irano-Turanian, and Sudanian biogeographical zones, declared as a Man and Biosphere Reserve in 2011 (UNESCO, 2011). Mujib represents a unique assemblage of biodiversity within the Jordan Rift Valley, Particularly the presence of the Nubian ibex (*Capra nubiana*), a flagship species

*Corresponding author: nashat@rscn.org.jo

emblematic of Jordan's rugged mountain ecosystems and historically depicted in local rock art and cultural traditions (Shackleton, 1997).

Initial conservation efforts at Mujib focused on captive breeding of *C. nubiana*. In 1989, twenty individuals were imported from the San Diego Zoo's conservation breeding program, all sourced from Middle Eastern genetic stock (Hammond *et al.,* 2001). An additional local male, named *Fareed* ("Unique"), confiscated from illegal hunting was added to the herd to enhance the genetic diversity. Over a decade, breeding success in captivity culminated in the phased release of 85 individuals into the wild between 1997 and 2000. While post-release survival was challenged by disease outbreaks such as foot-and-mouth disease, adaptive interventions including vaccination protocols maintained population viability (Reintroduction Unit, RSCN, 1999).

Despite these early successes, detailed ecological studies on the Nubian ibex in Jordan have been limited. Early faunal surveys provided baseline presence data (Harrison and Bates, 1991; Qumsiyeh, 1999; Amr, 2000), but systematic population assessments have been sporadic. A landmark survey in Mujib Reserve in 1996 indicated healthy breeding populations but underscored threats from hunting and livestock competition (Boef *et al.,* 1996). Simultaneously, advances in remote monitoring technologies, such as camera trapping (Burton *et al.,* 2015) and species distribution modeling (SDMs) (Elith and Leathwick, 2009), have transformed ecological research, enabling non-invasive, large-scale habitat assessments. Such tools offer new opportunities to bridge the persistent information gaps regarding the distribution and habitat preferences of *C. nubiana* within the reserve.

The current study aims to model the habitat suitability and predict the potential distribution of the Nubian ibex within the Mujib Biosphere Reserve using species distribution modeling (SDM) techniques, specifically the MaxEnt algorithm. By integrating occurrence records with key environmental variables, the research seeks to (i) identify critical habitat areas, (ii) determine the most influential environmental factors shaping the species' distribution, (iii) guide the optimal placement of research and monitoring efforts to enhance population assessments, and (iv) provide a scientifically grounded baseline to inform conservation strategies, habitat management, and targeted patrolling for the effective protection of *C. nubiana*.

Materials and Methods

Study Area

Mujib Biosphere Reserve (Figure 1) is situated in west-central Jordan, extending from the highlands east of the Dead Sea at an elevation of approximately 800 meters above sea level to the shoreline of the Dead Sea at around 400 meters below sea level, making it the world's lowest Biosphere reserve.

The reserve encompasses an area of about 212 km² and features an exceptionally rugged topography composed of sandstone escarpments, steep cliffs, and deeply incised wadis. Three major perennial watercourses — Wadi Mujib, Wadi Hidan, and Wadi Zarqa Ma'in provide critical water resources for the reserve's biodiversity. The climate of Mujib is arid to semi-arid, with pronounced altitudinal and spatial gradients. Annual rainfall ranges from 50 mm in the lowlands to about 300 mm in the highlands, with temperatures fluctuating from mild winters (~15°C) to extremely hot summers, where temperatures can exceed 45°C (Al-Eisawi, 2014). These variations create a diverse array of microhabitats within a relatively small geographic area.

The vegetation is categorized into five primary vegetation types: steppe, sub-tropical, saline, aquatic, and non-forested habitats (Al-Eisawi, 2014). This study focuses on the western part of the reserve, where sub-tropical and saline vegetation are dominated, and characterized by species such as *Tamarix* spp., *Ziziphus spina-christi*, and *Acacia tortilis*. These habitats are critical for the Nubian ibex, offering both foraging resources and rugged escape terrain. Key physical features of the study area include Wadi Mujib — the main river through the reserve — and Al-Marrah, a flatter expanse providing seasonal grazing grounds.

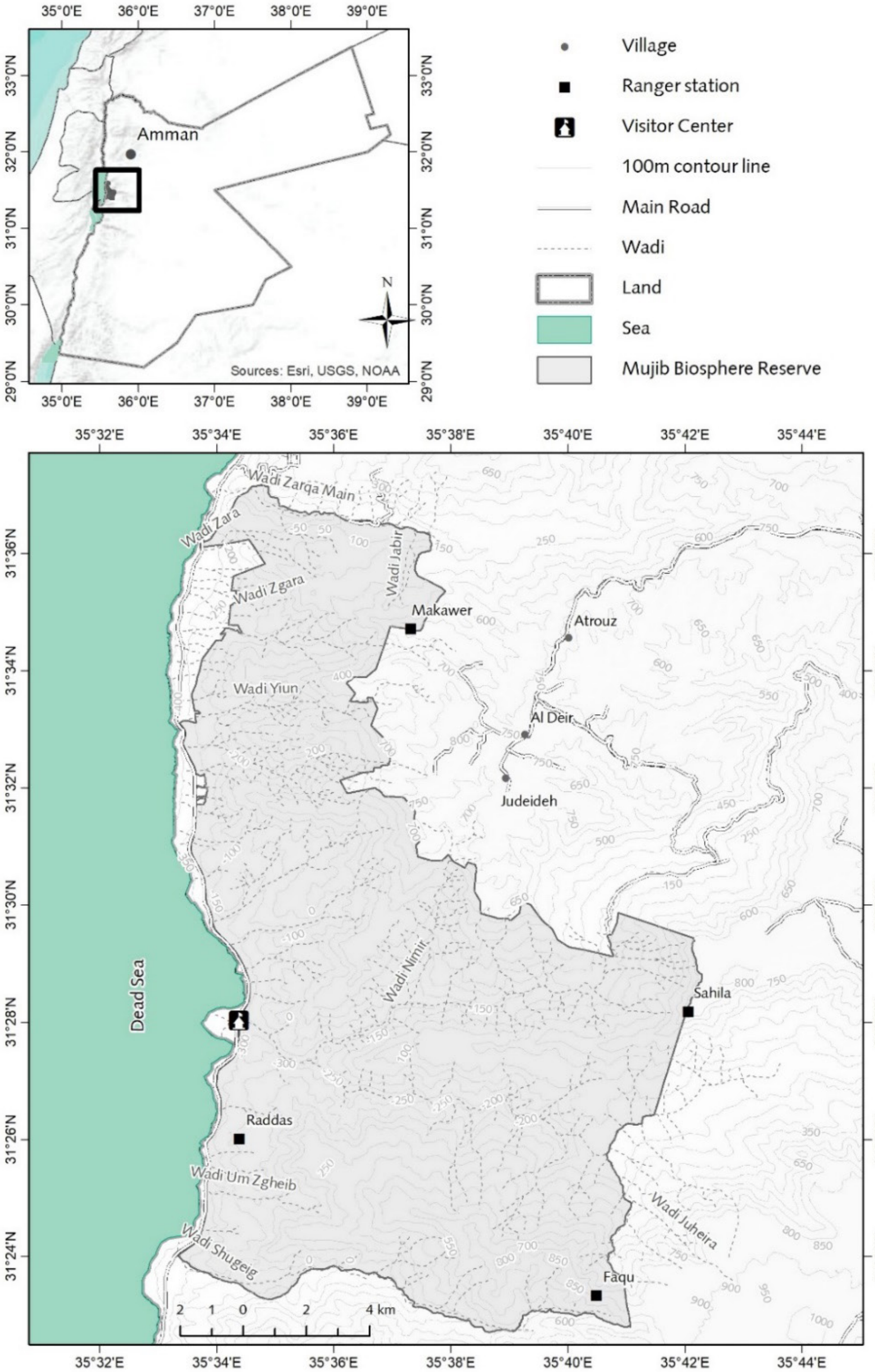

Figure 1. Location map of Mujib Biosphere Reserve within Jordan**.**

Species Occurrence Data: Occurrence records for *C. nubiana* were compiled based on historical and current observations collected between 2005 and 2013. These data were gathered systematically by reserve rangers during their daily patrolling activities, and supplemented by verified historical accounts from published literature (Habibi, 1994; IUCN SSC Caprinae Specialist Group, 2000). Each observation was georeferenced and verified to ensure spatial accuracy (Figure 2).

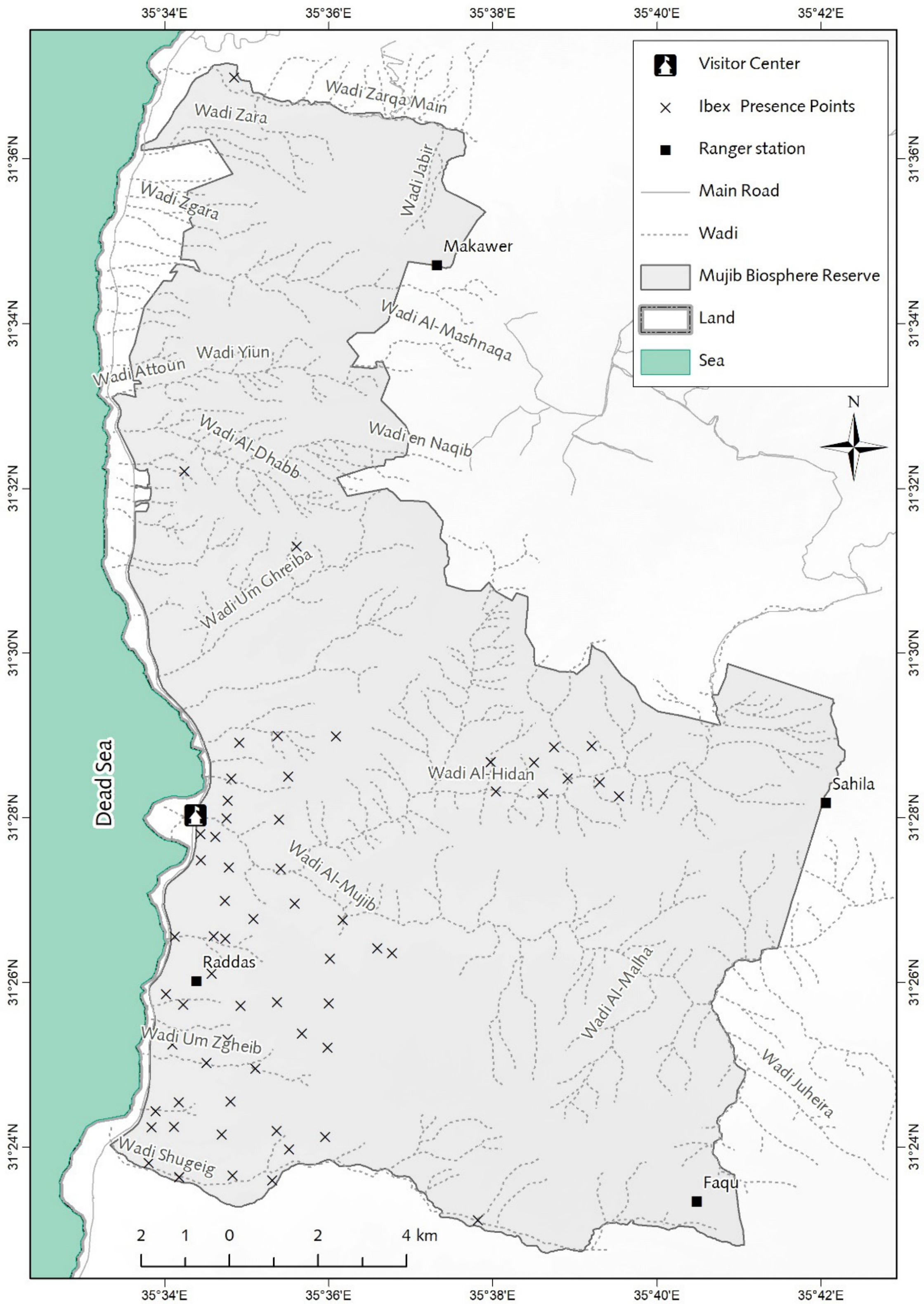

Figure 2. The distribution of the ibex occurrence records in Mujib Biosphere Reserve

Environmental Variables:

A set of environmental predictors was selected based on the species' known ecological preferences and consultations with biodiversity experts. Variables were selected to represent key ecological gradients and potential habitat constraints and were processed at a 30-meter resolution in raster format, as summarized in Table 1.

Table 1. Environmental Variables and Data Sources

Environmental Variable	Source	Year
Digital Elevation Model (DEM)	ASTER Global DEM (NASA, 2011)	
Slope	Derived from DEM (via ArcGIS Spatial Analyst)	
Geology	Natural Resources Authority of Jordan (Geological Map, 1988)	1988
Vegetation Types	Eisawi (2014)	2014
Annual Precipitation	Jordan Meteorological Department (climatological averages)	
Distance to Springs	Royal Jordanian Geographic Center (Spring Locations, 2009)	
Distance to Mujib Valley	Royal Jordanian Geographic Center (Hydrology Layers, 2009)	2009
Distance to Main Roads	Google Earth Digitized Road Network	2009
Distance to Springs	Jordan Meteorological Department (climatological averages)	2013

Environmental layers were pre-processed using ArcGIS 10.8 (ESRI, 2020) following standard protocols (Elith and Leathwick, 2009). The slope layer was derived from the DEM, and Euclidean distances to springs, valleys, and roads were computed. A composite map of the environmental variables used is shown in Figure 3.

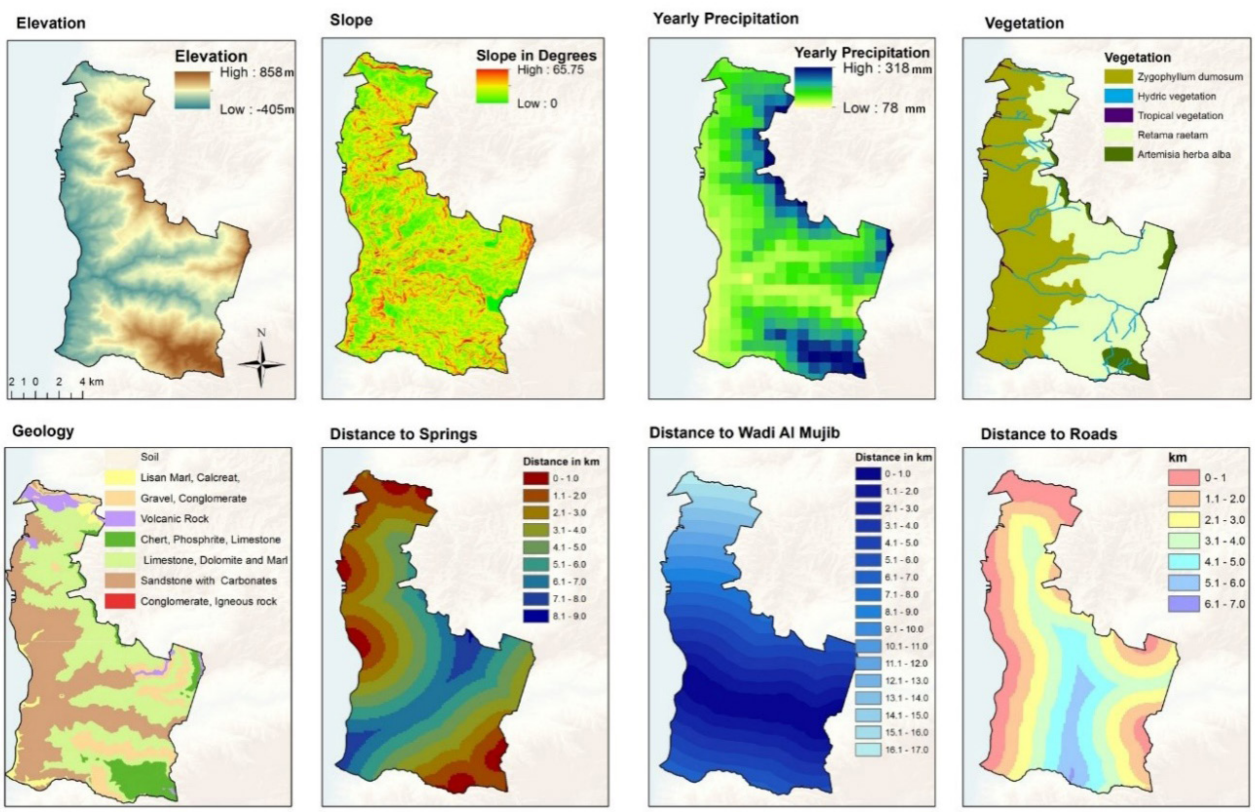

Figure 3. Environmental layers prepared for the species distribution modeling analysis.

Species Distribution Modeling Approach:
Species distribution modeling (SDM) was conducted using the Maximum Entropy algorithm implemented in MaxEnt version 3.4.1 (Phillips *et al.,* 2006). MaxEnt is particularly suitable for presence-only data and has been demonstrated to outperform other modeling approaches (Elith *et al.,* 2011). Model settings included 10 replicates with a cross-validation scheme, randomly splitting occurrence data into 70% training and 30% testing sets. Default regularization parameters were used to minimize overfitting. Predictive performance was evaluated across the ensemble of 10 replicate models.

Model Calibration and Threshold Selection:
Continuous habitat suitability maps generated by MaxEnt were thresholded to create binary habitat maps. The threshold used was the Equal Training Sensitivity and Specificity (ETSS), recognized for balancing omission and commission errors and widely used in conservation applications (Liu *et al*., 2013). The ETSS threshold was calculated for each replicate, and the mean threshold was applied to the averaged prediction map (Figure 4).

Model Evaluation:
Model predictive performance was assessed using the Area Under the Receiver Operating Characteristic Curve (AUC). Mean AUC values were computed over the 10 replicates. AUC values were interpreted following standard thresholds (Swets, 1988): values >0.9 indicate excellent, 0.8–0.9 good, and 0.7–0.8 fair discrimination. Mean AUC for the final model ensemble was 0.88, indicating good predictive performance.

Variable Importance Analysis:
A Jackknife test was conducted in MaxEnt to assess the importance of individual environmental predictors. This method measures the model's training gain with each variable individually and when each variable is excluded (Phillips *et al*., 2006).

Results Post-Processing:
Habitat suitability predictions were averaged across all replicates, and a final binary map of predicted suitable habitat was generated. The extent of suitable habitat was quantified and compared to the total area of the reserve to assess habitat availability for *C. nubiana*.

Results

The MaxEnt model produced habitat suitability maps highlighting the spatial distribution patterns of *C. nubiana* within Mujib Biosphere Reserve (Figure 5). The continuous logistic output values ranged from 0 (unsuitable) to 1 (highly suitable), with the highest predicted suitability concentrated in areas characterized by steep slopes and moderate proximity to water sources. Approximately 18% of the reserve was identified as suitable habitat based on the model outputs. The predicted high suitability zones were located along the western escarpments of the reserve. The spatial predictions showed that areas near perennial watercourses exhibited consistently higher habitat suitability compared to the surrounding plateau and desert zones. The areas classified as having high suitability were primarily composed of rugged cliffs and narrow valleys — typical habitats for *C. nubiana*.

Binary Habitat Classification

Applying the Equal Training Sensitivity and Specificity (ETSS) threshold yielded a binary classification map (Figure 4). Areas exceeding the ETSS threshold were classified as suitable habitat, whereas areas below the threshold were considered unsuitable. Using this approach, approximately 17% of the total area of Mujib Reserve was categorized as suitable habitat for the Nubian ibex. The binary map indicated habitat fragmentation, with suitable areas often isolated and aligned with major wadis.

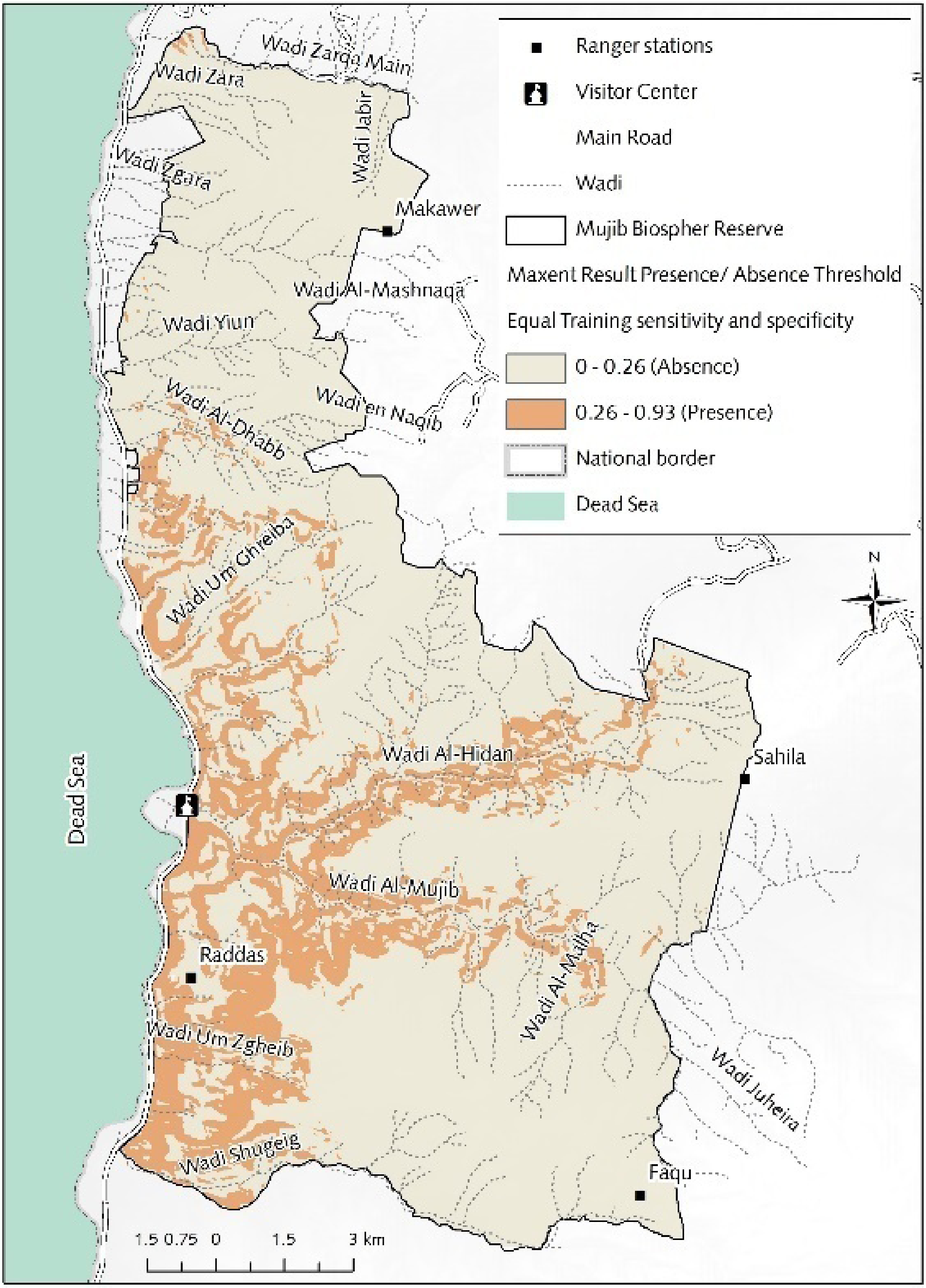

Figure 4. Threshold-dependent binary classification based on ETSS.

Model Performance Evaluation

The mean Area Under the Curve (AUC) across the 10 model replicates was 0.88 (±0.02), the omission rates were consistent across the training and testing datasets, further supporting the stability of the model and suggesting minimal overfitting and indicating good model performance and reliable discriminatory capacity between suitable and unsuitable habitats. According to standard AUC interpretation thresholds, values between 0.8 and 0.9 reflect robust predictive capability, supporting the credibility of the generated distribution model.

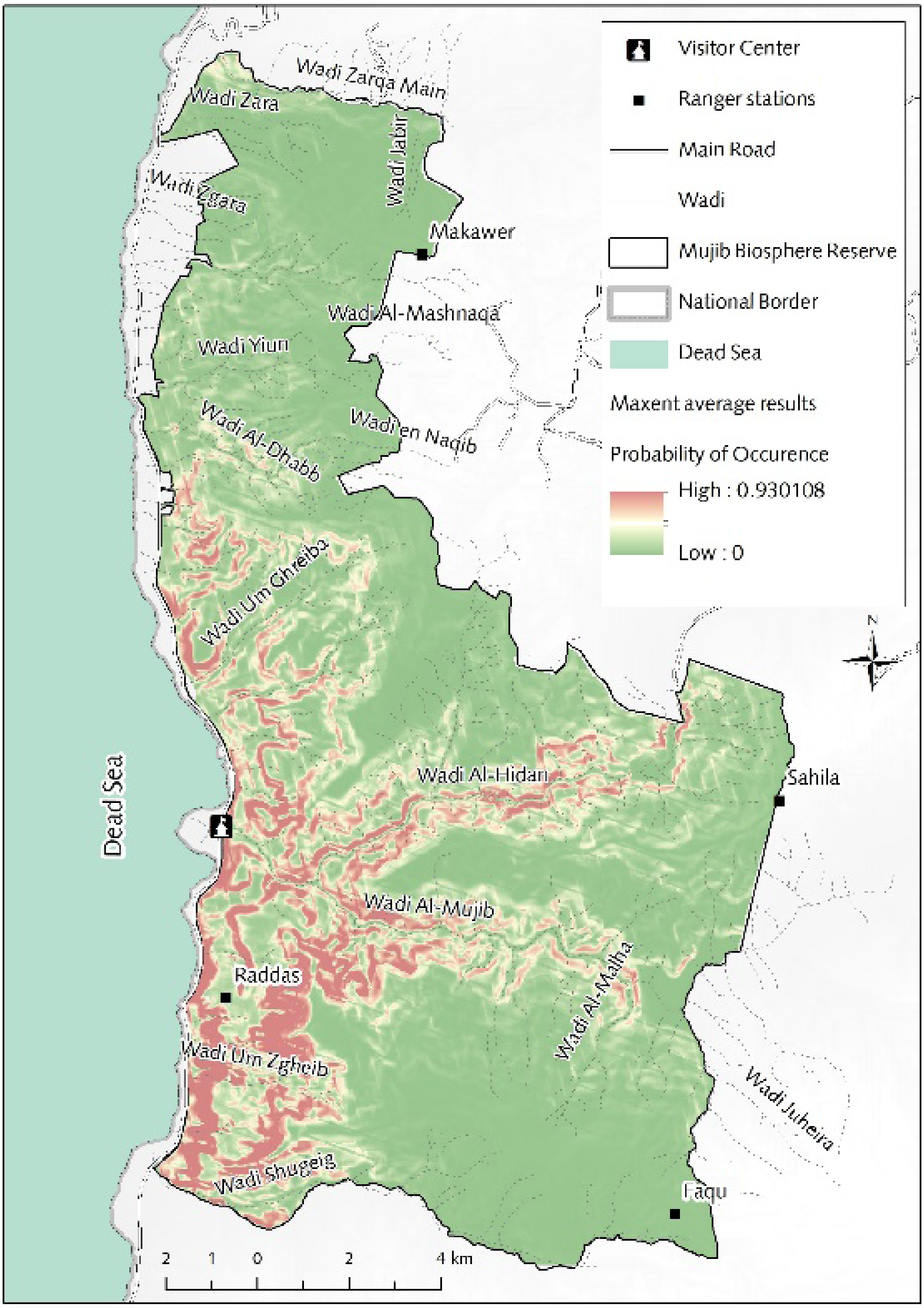

Figure 5. Average Probability of occurrence for Nubian Ibex western Mujib Biosphere Reserve

Variable Importance and Response

The Jackknife analysis of regularized training gain (Figure 6) demonstrated that slope was the most influential environmental variable, achieving a training gain of 0.75 when used in isolation. This was notably higher than all other variables evaluated. Yearly precipitation was the second most important predictor, with a training gain of 0.55. Elevation and geology followed, with training gains of 0.35 and 0.32, respectively. Vegetation type had a moderate influence with a gain of 0.28. In contrast, other environmental variables, including distance to roads, distance to springs, and distance to Wadi Mujib, exhibited very low individual contributions, each with training gains below 0.1.

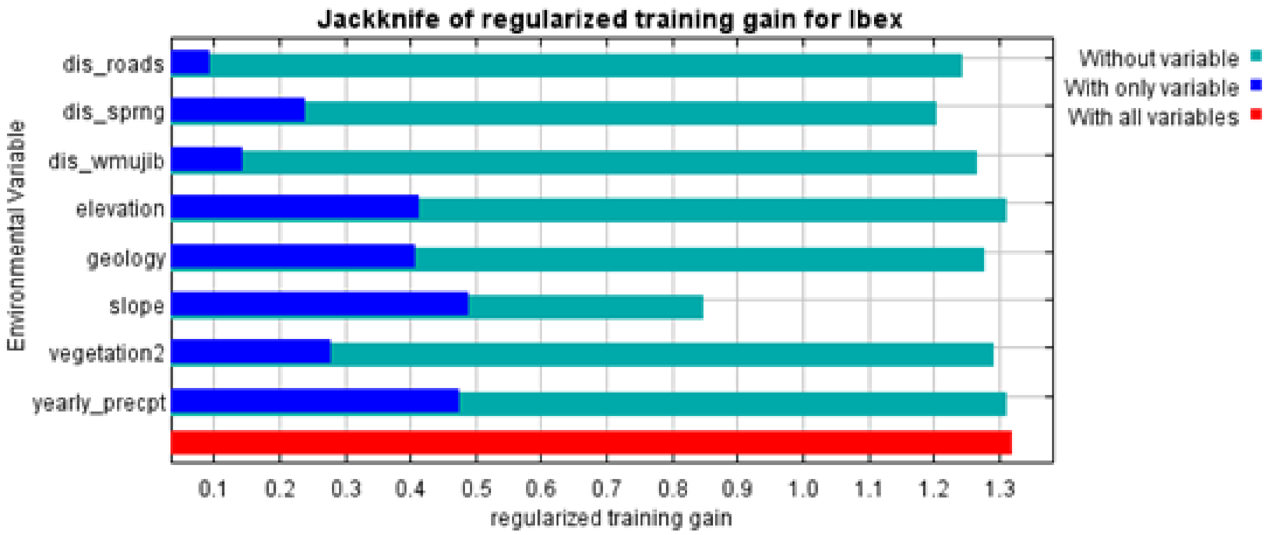

Figure 6. Results of the Jackknife test of variable importance.

The pattern of variable importance was further confirmed by the drop in training gain observed when slope was omitted from the model, indicating that slope provided unique information not compensated for by other variables. Similar, although less pronounced, reductions in training gain were observed with the removal of yearly precipitation, elevation, and geology. These results collectively highlight the primary role of topographic and climatic factors in determining the habitat suitability for *C. nubiana* within the study area, as opposed to proximity to anthropogenic features or specific vegetation types.

Ground-Truth Validation

A total of 82% independent records were located within the areas predicted by the MaxEnt model as high-suitability zones, based on the applied ETSS threshold. The spatial distribution of the validation records showed a clear overlap with the predicted high-suitability areas, primarily concentrated along the western cliffs of the Mujib Biosphere Reserve and the Mujib and Hidan wadis. Validation presence points consistently aligned with regions where the logistic output values exceeded the threshold, indicating consistency between the model's predicted suitable habitats and the independent occurrence data. A validation map was generated, illustrating the correspondence between the independent sightings and the modeled high-suitability areas (Figures 5 and 6). The overlay analysis indicated that the majority of validation points fell within zones classified as suitable, reinforcing the spatial agreement between predicted habitat suitability and field observations.

Discussion

Strengths of Using MaxEnt for *Capra nubiana* Modeling

The choice of MaxEnt was critical for achieving reliable predictions given the presence-only nature of *C. nubiana* occurrence data in Mujib Biosphere Reserve. MaxEnt has consistently demonstrated clear performance in similar arid and mountainous contexts globally, offering strong resistance to overfitting even with small sample sizes (Elith *et al*., 2011; Merow *et al.,* 2013). In the Middle East, recent applications for Scimitar-horned Oryx in Tunisia *Oryx dammah* (Louhichi *et al.,* 2024) revealed MaxEnt's robustness under rugged terrain conditions, confirming its appropriateness for species with niche specialization in harsh environments. The model's AUC of 0.88 is consistent with these studies and exceeds thresholds set in broader biodiversity modeling benchmarks (Franklin, 2010), demonstrating discrimination capacity. Notably, MaxEnt's capacity to integrate complex environmental relationships was instrumental in identifying the non-linear effects of slope and precipitation — two factors that emerged as primary habitat determinants.

Comparative Insights with National and Regional Studies

In Jordan, species distribution modeling remains limited for mountain ungulates. Previous expert-based suitability mapping for *C. nubiana* (RSCN, 2012) highlighted general habitat zones but lacked the resolution and statistical background presented in this study. The findings of this study also come in agreement with regional studies on mountain goats (*Oreamnos americanus*) in North America, where terrain ruggedness and water proximity are similarly critical (Gross *et al.,* 2002). This reinforces the ecological principle that mountainous ungulates, regardless of geographic location, exhibit convergent habitat preferences shaped by predator avoidance strategies and hydration requirements. Locally, the current work acknowledged the spatial resolution and ecological depth of earlier habitat classifications within Mujib Biosphere Reserve (Al-Eisawi, 1996 and 2014), which were based primarily on vegetation and geomorphological mapping without species-specific validation. The integration of ground-truthing in this study further strengthens the credibility of the model outcomes.

While alternatives such as Random Forest and Boosted Regression Trees (BRT) have gained traction for distribution modeling, studies in comparable environments suggest MaxEnt maintains better performance with limited and biased occurrence datasets (Wisz *et al.,* 2008). Random Forest models require large, balanced datasets, often unavailable for elusive and endangered species like *C. nubiana* (Breiner *et al.,* 2015). The use of MaxEnt, validated by strong AUC performance and low omission rates, supports its continued recommendation for species with sparse datasets. Furthermore, MaxEnt's internal Jackknife test allows for variable contribution analysis, a feature not inherently available in other machine learning approaches. Identifying slope and precipitation as critical variables supports the species' known eco-physiological constraints (Habibi, 1994).

Advancements Over Traditional Suitability Mapping

Habitat suitability assessments in Jordan have traditionally relied on expert-based evaluations and land-cover associations (Child and Grainger, 1990). Although these approaches have contributed foundational knowledge, they are inherently subjective and sometimes fail to capture the full complexity of multi-scalar environmental determinants influencing species distributions. In contrast, species distribution models (SDMs), particularly MaxEnt, provide a statistically robust, quantitative, and replicable framework for habitat prediction. These models account for non-linear relationships among environmental variables and are capable of projecting future scenarios under changing climatic and land-use regimes, thereby offering enhanced utility for conservation planning (Araújo and Peterson, 2012).

The present model, operating at a spatial resolution of approximately 30 meters, facilitates the translation of results into actionable field-level management interventions. High-suitability areas delineated by the model can inform the spatial allocation of critical resources such as artificial water supplementation sites and optimized patrolling efforts. These applications have the potential to increase operational efficiency and conservation efficacy. For instance, camera trap deployment guided by SDM outputs has been shown to improve detection probabilities and reduce monitoring costs, particularly in the context of ungulate population studies (Burton *et al*., 2015). Similarly, the strategic concentration of patrolling efforts in high-probability areas has demonstrated significant gains in conservation outcomes, as evidenced by the improved protection of *Diceros bicornis* in Etosha National Park, Namibia (Leader-Williams *et al*., 2011).

Furthermore, the spatial outputs generated by the SDM offer valuable insights for habitat management and restoration planning. Fragmented habitat patches identified through the model underscore the necessity of maintaining or enhancing landscape connectivity to mitigate the adverse effects of habitat isolation. The development of wildlife corridors between suitable yet disjointed habitats may reduce the risk of genetic bottlenecks and promote metapopulation dynamics.

Limitations and Future Directions

Despite the strengths, limitations exist. The presence-only data may be biased towards areas accessible to patrols. Future models should incorporate systematic survey designs and, where possible, presence-absence data to improve model robustness. Additionally, while slope and precipitation were key predictors, microhabitat variables like forage quality and predation risk could refine model precision if integrated into future analyses. Expanding environmental layers to include dynamic variables such as Normalized Difference Vegetation Index (NDVI) could also enhance temporal modeling capabilities and can be incorporated to anticipate range shifts, a practice increasingly recommended in SDM applications for arid-land ungulates (Reside *et al.,* 2012).

In conclusion, the application of species distribution modelling in this study provides a clear spatial framework to inform conservation strategies for *C. nubiana* in Mujib Biosphere Reserve. Beyond identifying suitable habitat, the integration of field validation and expert judgment enhances the ecological credibility of the results and demonstrates the practical utility of SDMs in challenging arid landscapes. These findings underline the importance of aligning predictive tools with on-the-ground knowledge to improve reserve-level decision-making. As environmental pressures intensify, such evidence-based spatial analyses will be increasingly vital for adaptive management, long-term monitoring, and the development of targeted interventions that support the persistence of vulnerable mountain ungulate populations.

Acknowledgement

The authors would like to thank the rangers of the Mujib Biosphere Reserve and its management for providing access to the daily Nubian ibex log used in this study. Appreciation is also extended to the GIS and research teams for their support in analyzing the log data. The continuous support of the Royal Society for the Conservation of Nature (RSCN) in facilitating research and monitoring programmes is gratefully acknowledged.

References

Al-Eisawi, D., 2014. Vegetation Community Analysis in Mujib Biosphere Reserve, Jordan. *Jordan Journal of Natural History*, **1**: 35-58

Al-Eisawi, D., 1996. **Vegetation of Jordan**. Cairo: UNESCO–RSCN Project.

Amr, Z. S., 2000. **Mammals of Jordan,** 2nd Ed, Al-Rai' press. Amman, Jordan.

Araújo, M.B. and Peterson, A.T., 2012. Uses and misuses of bioclimatic envelope modeling. *Ecology*, **93(7),** 1527–1539.

Boef, K., Kiwan, K, and K. Nassar. 1996. Ibex Survey and re-introduction master planning. The Royal Society for the Conservation of Nature, Amman, Jordan [unpublished report].

Breiner, F.T., Guisan, A., Bergamini, A. and Nobis, M.P., 2015. Overcoming limitations of modelling rare species by using ensembles of small models. *Methods in Ecology and Evolution*, **6(10):**1210–1218.

Burton, A.C., Neilson, E., Moreira, D., Ladle, A., Steenweg, R., Fisher, J.T., Bayne, E. and Boutin, S., 2015. Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. *Journal of Applied Ecology*, **52(3**): 675–685.

Child, G. and Grainger, J., 1990. *A System Plan for Protected Areas for Wildlife Conservation and Sustainable Rural Development in Saudi Arabia*. Riyadh: National Commission for Wildlife Conservation and Development (NCWCD) and IUCN.

Elith, J. and Leathwick, J.R., 2009. Species distribution models: ecological explanation and prediction across space and time. *Annual Review of Ecology, Evolution, and Systematics*, **40**:677–697. DOI: 10.1146/annurev.ecolsys.110308.120159

Elith, J., Phillips, S.J., Hastie, T., Dudík, M., Chee, Y.E. and Yates, C.J., 2011. A statistical explanation of MaxEnt for ecologists. *Diversity and Distributions*, **17(1)**: 43–57. doi: 10.1111/j.1472-4642.2010.00725.x

Evans, M.I., 1994. **Important Bird Areas in the Middle East**. Cambridge: BirdLife International.

Franklin, J. and Miller, J.A., 2010. **Mapping Species Distributions: Spatial Inference and Prediction.** Cambridge: Cambridge University Press.

Gross, J.E., Kneeland, M.C., Reed, D.F. and Reich, R.M., 2002. GIS-based habitat models for mountain goats. *Journal of Mammalogy*, **83(1):**218–228.

Habibi, K. 1994. **The Desert Ibex, National Commission for Wildlife Conservation and Development (NCWCD),** Immel, Publishing LTD, London. pp 192.

Harrison, D. L., and P.J.J.Bates, 1991. **The Mammals of Arabia**. 2nd Ed., Harrison Zoological Museum Pub. pp.354.

IUCN SSC Caprinae Specialist Group, 2000. *Capra nubiana*. The IUCN Red List of Threatened Species 2000: e.T3786A10087833.

Leader-Williams, N., Albon, S.D. and Berry, P.S.M., 2011. Integrating wildlife conservation with anti-poaching. *In*: G. Cowlishaw and R. Dunbar, Eds. **Primate Conservation Biology.** Chicago: University of Chicago Press.

Liu, C., White, M. and Newell, G., 2013. Selecting thresholds for the prediction of species occurrence with presence-only data. *Journal of Biogeography*, **40(4):**778–789.

Louhichi, M., Khorchani, T., Eifler, D., Eifler, M., Orton, M., Dadi, K., Zaydi, A., Jarray, M. and Chammem, M. 2024. Modelling habitat suitability of reintroduced Scimitar-horned oryx (*Oryx dammah*) in Sidi Toui National Park, Tunisia. *Journal of oasis agriculture and sustainable development.* **6 (2):**1–13. doi: 10.56027/JOASD.162024.

Merow, C., Smith, M.J. and Silander, J.A., 2013. A practical guide to MaxEnt for modeling species' distributions: what it does, and why inputs and settings matter. *Ecography*, **36(10):**1058–1069.

Phillips, S.J., Anderson, R.P. and Schapire, R.E., 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, **190(3-4):**231–259.

Qumsiyeh, M.B., 1999. **Mammals of the Holy Land**. Lubbock: Texas Tech University Press.

Reside, A.E., VanDerWal, J. and Kutt, A.S., 2012. Projecting the impact of climate change on the distribution of species: a case study of Australian tropical savanna birds. *Diversity and Distributions*, **18(5):**440–451.

Shackleton, D.M. (Ed.), 1997. **Wild Sheep and Goats and Their Relatives: Status Survey and Conservation Action Plan for Caprinae**. Gland, Switzerland and Cambridge, UK: IUCN Species Survival Commission. 390 pp.

Swets, J.A., 1988. Measuring the accuracy of diagnostic systems. *Science*, **240(4857)**: 1285–1293.

The Royal Society for the Conservation of Nature. 1999. Reintroduction unit report. 1999. [Unpublished Report].

UNESCO, 2011. **Mujib Biosphere Reserve, Jordan**. [online] Available at: https://en.unesco.org.

Wisz, M.S., Hijmans, R.J., Li, J., Peterson, A.T., Graham, C.H. and Guisan, A., 2008. Effects of sample size on the performance of species distribution models. *Diversity and Distributions*, **14(5)**:763–773