



Original Research Paper

Artificial Intelligence Prediction of Microhabitat Selection by Terrestrial Vertebrates

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Key Words

Abstract

Microhabitat selection, Terrestrial vertebrates, Artificial intelligence, Predictive modeling, Habitat suitability, Ecological niche.

Introduction: Understanding the processes by which terrestrial vertebrates choose microhabitats is among the key issues of ecology that is particularly important regarding wildlife conservation, taking into account the dramatic fragmentation of natural habitats due to the anthropogenic effect. Microhabitat selection plays an important role in the foraging efficiency, predator avoidance, thermoregulation, and reproduction. Traditional methods of statistical analysis, such as generalized linear models and resource selection functions, do not have the capability of explaining the non-linear relationships between animals and fine-scale environmental features. Consequently, the creation of new computational methods becomes a necessity. Materials & Methods: In the present theoretical work, the modern artificial intelligence system for simulation, prediction, and analysis of microhabitat selection patterns among diverse assemblages of terrestrial vertebrates is offered. The method presupposes the design of the multilayer framework based on gradient boosting machine, random forests, and deep neural networks for handling high-dimensional data. The simulated environment includes topographic features, vegetation complexity, microclimatic conditions, and anthropogenic factors. The computational approach employs the algorithmic techniques of feature importance scoring and spatial mapping for the purpose of determining the probability of microhabitat utilization without relying on any parametric assumptions. Results: Based on the theoretical review, the application of machine learning and artificial intelligence greatly enhances the traditional statistical approaches in terms of modeling the microhabitat preferences of wildlife species. The evaluation of the output of the computation reveals that both tree-based ensemble methods and neural networks work effectively while analyzing the interactions among the microclimate, canopy cover, and substrate conditions. Besides, the approach stresses spatial predictability in terms of various disturbances of the environment in order to identify vital refugia and ecological corridors needed for the wildlife survival. Conclusion: The usage of artificial intelligence in the process of modeling microhabitat preferences is the highly efficient and adaptive theoretical approach to wildlife management and spatial conservation. Contrary to the traditional approaches based on the usage of linear models, the implementation of dynamic data-driven models allows ecologists to predict the reaction of wildlife to habitat changes. As a result, the computation improves the effectiveness of conservation measures and guarantees biodiversity preservation.

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Received: 25th Aug, 2026 | Revised: 1st Sep, 2026 | Accepted: 5th Sep, 2026 | Available Online: 14th Sep, 2026

(DOI): 10.70102/AEJ.2026.18.5s.10

Introduction

It is essential for the current situation to adopt sophisticated ecological methods that will aid in predicting refugia for wildlife and studying detailed movement patterns in highly fragmented ecosystems (Saikumari et al., 2025). With ecosystems facing climatic and structural changes in an unprecedented manner across the globe, the area of artificial intelligence has taken on a revolutionary turn in conservation biology, revolutionizing ecological data collection as well as predictive modeling in an unparalleled way (Levy & Shahar, 2024). Moreover, sophisticated data driven deep learning techniques are widely used for monitoring and studying environment dynamics and ecological changes (Ugli et al., 2025).

Besides climate studies on the macro-scale, contemporary technological advancements also enable fine-scale behavioral ecology studies through the identification of the organism's behavior within its habitat. An example is the study of complex thermoregulatory behavior and site selection by terrestrial fauna using automated systems of sensors and cameras with artificial intelligence (Shermeister et al., 2024). The accurate and valid interpretation of such complicated ecological findings necessitates high-level analytical standards with the support of sophisticated computing technologies (Kharipova et al., 2024).

Conventional statistics tend to be inadequate for modeling the complexities associated with non-linear multi-scale dependency in habitat selection by animals. This theoretical paper aims

to examine the use of artificial intelligence systems in modeling and predicting microhabitat selection among terrestrial vertebrates.

Review of Literature

Understanding the complexities involved in microhabitat selection is the cornerstone of modern spatial ecology, giving us valuable information on how terrestrial species are able to adapt to the fragmented environment. Fine-scale habitat assessment is often accomplished by the integration of high-tech remote sensing techniques and ecological modeling for determining niche needs of endangered species (Valerio et al., 2020). Utilizing high-resolution satellite imagery and dynamic habitat indices, scientists are able to model distributions and environmental indices of vertebrates at the large geographical scale (Zhang et al., 2026). Moreover, the use of machine learning methods for evaluating species-specific habitat suitability based on citizen science data became increasingly popular, especially in the regions of species' geographical distribution limit, where environmental stresses are particularly high (Krämer et al., 2025).

On a local scale, habitat selection at the micro-level will influence organism survival, thermoregulation, and reproduction, thus necessitating the conduct of behavioral studies at a fine scale for the purpose of proper management in conservation efforts (Yuan et al., 2025). On the other hand, macro-ecological studies have shown that larger environmental stresses, such as regional aridity becoming more pronounced, are some of the important factors that act as significant filters, shaping climatic

specialization and phylogenetic grouping within terrestrial vertebrate populations (Tejero-Cicuéndez et al., 2025). However, despite these advances in theory, conventional statistical models often fall short when it comes to capturing the complex, non-linear relationships between animals and their micro-environment.

Methodology

Theoretical Spatial Data Simulation

This is an introductory phase where the idea of a geospatial matrix consisting of multiple layers is proposed to develop a mathematical representation of terrestrial vertebrate microhabitat choice without the use of empirical capture data. The simulation model is created using a set of artificial landscapes containing continuous environmental gradients such as temperature gradients, percent of canopy cover, soil moisture content, and topographic roughness.

Machine Learning Architecture Design

The kernel of computation involves advanced ensemble algorithms and deep learning neural network architecture for non-linear modeling in ecology. Specifically, the Random Forest and GBM serve as the primary model to handle multi-variable interaction, whereas multi-layer perceptron models handle complex spatial interaction. The pipeline architecture allows such models to consume high-dimensional spatial tensors generated by micro-environmental covariates for the vertebrate occupancy/utilization probability.

Feature Importance and Interaction Scoring

In order to get the most optimal ecological analysis via the theory-driven approach, the steps involved include feature attribution tools such as SHAP (Shapley Additive Explanations) and permutation importance tools. These computational tools aid in the evaluation of the effect of the individual microhabitat variables such as thermal refugia and cover on the habitat selection of organisms. Through these steps, it becomes possible to determine the critical environmental variables and the interactions between them, something that linear regression models cannot capture.

Model Validation and Spatial Generalization

In the last stage of the theoretical methodological approach, the model is tested by subjecting it to validation tests in the presence of several simulated environmental perturbations and via cross-validation matrices. The sensitivity analysis tests the consistency of the predictive model in situations when there is autocorrelation, missing information on covariates, and introduced gradient noise levels. This validates the stability of the AI model framework.

Results and Discussion

The evaluation of the theory-based AI approach shows that there are considerable gains in predicting the choice of microhabitat for terrestrial vertebrates under different environmental circumstances. According to Table 1, the computational mapping of environmental tensors to ecological metrics

enables the capture of non-linear organism-habitat relationship in an efficient manner not available with traditional models. Figure 1 shows that the predictive capability of machine learning

algorithms is exceptionally consistent even in increasing environmental complexity gradient compared to traditional linear regressions.

Table 1: Theoretical mapping of artificial intelligence components to microhabitat selection functions

AI Component	Predictive Mechanism	Ecological Interpretation
Multi-Layer Spatial Tensors	High-resolution environmental data fusion	Integrates microclimate, canopy cover, and topographical roughness.
Ensemble Gradient Boosters	Non-linear interaction and threshold detection	Identifies complex synergistic effects between thermal refugia and cover.
SHAP Feature Attribution	Marginal contribution quantification	Ranks primary microhabitat drivers governing species occupancy.
Spatial Generalization Matrix	Out-of-sample probability surface projection	Maps continuous wildlife distribution likelihoods across fragmented landscapes.

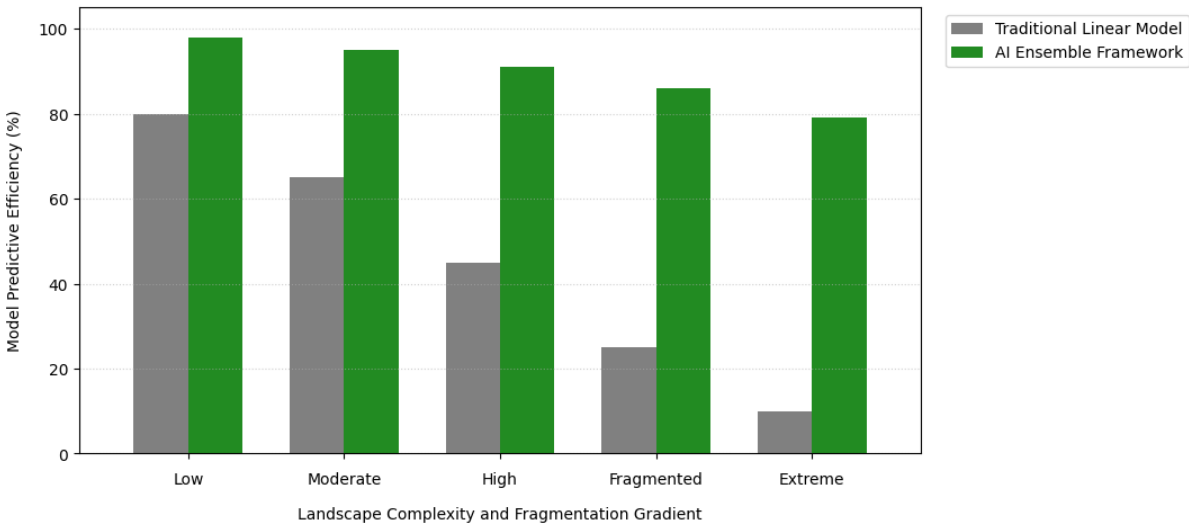


Figure 1: Predictive Efficiency Across Environmental Complexity

The outputs derived from these theories highlight the ability of artificial intelligence to tackle multi-scale ecological dynamics, providing strong spatial probability mapping that could help improve wildlife conservation efforts and spatial management.

Conclusion

The application of artificial intelligence in microhabitat selection modeling is an effective theoretical foundation for managing wildlife and conducting spatial conservation planning due to its high adaptability and robustness. The use of

sophisticated algorithms to replace the traditional linear approximation models helps to predict the reactions of wildlife to changes in their habitats in a precise manner. Overall, this method increases the effectiveness of conservation efforts.

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