18(1) 381-391, Spring 2026

Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)
Journal homepage: http://www.aejournal.ir

Original Research Paper

Vegetation Structure Complexity and Small Mammal Diversity in Grassland Restoration Projects

Subham Acharya[1*], Dr. Gargi Shekhar[2], Dr. Wasim A. Bagwan[3], Anjali Bhardwaj[4], B. Ramprasad[5], Himanshu Makhija[6], Akash Kumar Bhagat[7]

[1]Assistant Professor, Department of Agro-meteorology, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India. Email: subhamacharya@soa.ac.in, ORCID: https://orcid.org/0009-0002-8278-1359*
[2]School of Agriculture, Dev Bhoomi Uttarakhand University, Uttarakhand, India. Email: dehradunagri.gargi@dbuu.ac.in, ORCID: https://orcid.org/0000-0001-9716-9010
[3]Krishna Institute of Science and Technology, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India. Email: wasim.bagwan16@gmail.com, ORCID: https://orcid.org/0009-0000-4508-2036
[4]Assitant professor, Department of Computer Science & Engineering, Noida International University, Uttar Pradesh, India. Email: anjali.bhardwaj@niu.edu.in, ORCID: https://orcid.org/0009-0007-0254-7068
[5]Assistant professor, Department of Optometry University, School of Allied Health Sciences, VMRF - DU, Chennai, Tamil Nadu, India. Email: ramp357@gmail.com, ORCID: https://orcid.org/0009-0006-4507-8743
[6]Centre of Research Impact and Outcome, Chitkara University, Rajpura, Punjab, India. Email: himanshu.makhija.orp@chitkara.edu.in, ORCID: https://orcid.org/0009-0002-0864-9069
7Assitant Professor, Department of Computer Science & Information Technology, ARKA JAIN University, Jamshedpur, Jharkhand, India. Email: akash.b@arkajainuniversity.ac.in, ORCID: https://orcid.org/0000-0001-8717-764X

Key Words

Grassland restoration, Vegetation structure complexity, Small mammal diversity, Habitat heterogeneity, Biodiversity conservation, Species richness, Ecosystem sustainability.

Abstract

Grasslands are important ecosystems that accommodate a very rich biodiversity, but their deterioration has resulted in a massive extinction of species, especially small mammals. The restoration projects in the grasslands are trying to restore these ecosystems, although the contribution of the complexity of vegetation structure towards sustaining the small mammal communities is not well understood. This paper examines the correlation between vegetation complexity (canopy cover, plant height, and plant species richness) and small mammal diversity in restored grasslands. The aim was to determine the influence of vegetation attribute variations on the small mammals. Live trapping was done in a variety of restoration sites where vegetation complexity was measured through canopy cover, height of plants, and plant richness. The diversity of small mammals was measured using the richness and evenness of species and the Shannon-Weiner index. Statistical results showed that there was a significant positive association between greater vegetation complexity and greater diversity (specifically canopy cover and plant height) small mammals species richness (regression analysis, $p = 0.03$), while ANOVA results confirmed significant differences in diversity across sites of varying complexity ($p < 0.01$).] Places having more complicated vegetation, where the height of plants and the density of ground cover were varied, had more species and higher diversity indices. These results indicate that small mammals can have more diverse habitats by increasing vegetation complexity through restoration work, which eventually leads to the enhancement of their population. This paper highlights the need to take into consideration the complexity of the habitat in the exercise of restoration planning of grasslands. Potential ways in which small mammal diversity can be boosted are by incorporating greater plant cover in the form of canopy cover and plant diversity. This, in its turn, will add to overall biodiversity and ecosystem functioning. The study identifies vegetation complexity as an important factor in the grassland restoration plans to conserve biodiversity and ensure the sustainability of the ecosystems in the long run.

* Corresponding Author's email: subhamacharya@soa.ac.in
Received: 26 December 2025; Reviewed: 02 February 2026; Revised: 18 February 2026; Accepted: 24 April 2026
(DOI): 10.70102/AEJ.2026.18.1.33

Introduction

Grasslands are among the ecologically significant and one of the threatened ecosystems in the world. They nourish a great supply of biodiversity, are a source of critical ecosystem functions including carbon sequestration, water purification, and soil fertility, and are a home to multiple wildlife (Dusi, 2025; Costa, 2025). Small mammals are one of the various species that live in grasslands, which are critical to the workings of an ecosystem as they serve as the prey to other larger predators, dispersers of seeds, and as burrows that improve soil health. Nevertheless, there has been intense degradation of grasslands in the world through agricultural development, urbanization, invasive species, and climate change, which has caused degradation of the ecosystem and loss of biodiversity (Rajan, 2025). Consequently, grassland restoration has emerged as a key area of concern among conservationists and ecologists who seek to recover the lost and missing biodiversity, limit the impact of habitat degradation, and enhance the ecological capacity (Dondina et al., 2025).

Restoration activities in grasslands are aimed at recovering ecological processes and encouraging the reappearance of native plant life, which forms the basis of biodiversity. The quality of the habitat is an important factor in these ecosystems through vegetation complexity, a measure of the structural variation of plant species, canopy height, ground cover, and plant density (Minor & Eichholz, 2024; Rowland-Schaefer et al., 2024; Ayodele, 2025). Specifically, the vegetation structure can contribute to the appropriateness of the habitat to different species, including small mammals, which are highly sensitive to environmental changes (Shilereyo et al., 2023; Casula et al., 2017). These creatures rely on the physical makeup of the environment to protect themselves, nourish themselves, and breed. Greater heterogeneity of vegetation has been observed to offer more niche, creating more species richness and diversity (Al-Edhari & Alsamee, 2025).

Nonetheless, even though the role of vegetation structure in sustaining biodiversity is appreciated, there is a knowledge gap on the impact of certain elements of vegetation complexity on small mammal diversity in restored grasslands (Lazăr et al., 2025; Santoro et al., 2017; Liu et al., 2025). Although more general ecological investigations indicate that complexity in the habitat may lead to better diversity of species, little research has specifically addressed how structural elements of vegetation influence the population of small mammals in grassland restoration situations (Massawe et al., 2025; Jung, 2026). These relations are very important to understand in order to develop more successful restoration strategies that may increase the diversity of plants and animals, which will lead to more resilient ecosystems (Graham et al., 2019).

The proposed paper seeks to fill this gap through examining the role of varied components of vegetation structure, which include plant height, canopy cover, and species diversity, in influencing small mammal diversity in restored grasslands. With this study, the research aims to give a better insight into how vegetation

complexity can be relevant in sustaining the small mammal populations, as this can be a good measure of overall ecological wellbeing in the restored ecosystems. Moreover, the proposed study will be useful to develop more specific restoration practices that would take into account the needs of both vegetation and animal communities, increase the effectiveness of grassland restoration projects, and ensure biodiversity conservation.

The paper is organized in such a way that Section 2 provides the methodology, where data were collected based on vegetation complexity (canopy cover, plant height, and species richness), and small mammal surveys were performed by live trapping, and statistical analysis (correlation analysis, regression models). Section 3 discusses the findings, emphasizing the relationship between the complexity of vegetation and small mammal diversity, which is supported by statistical data and graphs. Section 4 talks about findings, the interpretation of the ecological role vegetation structure plays in the sustenance of small mammals' communities, and compares findings and literature available, as well as solving the challenges in restoration practices. Section 5 wraps up with a summary of the main findings that were made, as well as the implications of the findings on restoration strategies and a proposal for future research on long-term monitoring and the incorporation of plant and animal diversity in restoration models.

Materials and Methods

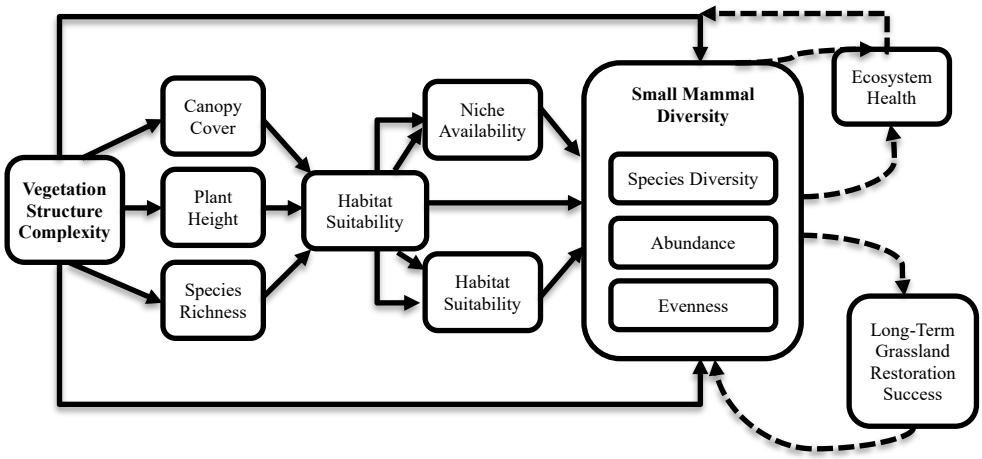

Figure 1: Conceptual Framework of Vegetation Complexity and Small Mammal Diversity in Grassland Restoration

Figure 1 shows the relationships proposed between the complexity of vegetation structures and the diversity of the small mammals in the restored grasslands. The diagram identifies the most important parts of vegetation structure, such as the canopy cover, the height of the plants, and the richness of the species, which are theorized to affect the heterogeneity in the habitat. All of these elements define the presence of niches and the suitability of the habitat of the small mammals. The framework proposes that with the increased vegetation complexity, there was an increase in

species in terms of diversity, abundance, and evenness in the population of the small mammals. The arrows in the diagram show the positive correlation between these variables, and the feedback loops show that an increase in small mammal diversity, in its turn, could improve the ecosystem health, as well as become a contributor to the long-term success of grassland restoration projects. The framework is a graphic illustration of the hypothesis of the study, and it would be used to analyze the data collected further.

Study Area

The experiment was carried out in the Tallgrass Prairie Preserve, which is a massive restoration site in Osage County, Oklahoma, in the USA. The area, in the center of the great plains, is characterized by a temperate climate, hot during the summer (average weather reaches up to 30 °C), cold during the winter (average weather gets down to about -5 °C). The region gets a yearly precipitation of 900 mm, which is experienced in the spring and summer seasons. The grasslands there are categorized into tallgrass prairies, which are a very productive and biodiverse ecosystem characterized by the presence of tall grasses that are very dense and diverse herbaceous plants. These prairies used to occupy large areas of the United States central regions, but they have been cut down drastically by agricultural activities and city systems. The locations of the study are at an elevation of about 300 feet above sea level, which is found in the diverse habitats within the preserve that have actively restored sites, as well as the remains of the native prairie. The chosen locations were selected due to their role in the current activities of restoring the grassland habitat to improve the biodiversity of the plants and animals that have been disturbed by human activities. Such restoration activities involve the planting of native species, controlling the invasive species, and enhancing soil health to help restore the native flora and fauna of the prairie.

Vegetation Assessment

The complexity of vegetation was measured by a variety of structural indices to estimate the heterogeneity of a habitat. Canopy cover was determined by the point intercept method, in which a corpus of 10 transects, each measuring 50 meters in length, was laid across the research areas. In these transects, the vegetation cover was observed every 1 meter, and each position was noted when vegetation crossed the sampling line. This is the best way to measure the %age of ground covered by vegetation at a particular location. The height of the plants was determined by the height of the tallest vegetation species in every plot. To maintain consistency, measurements were keyed on the prevalent plant species, which are known to add to the habitat structure, including tall grasses and forbs. The richness of species was established by observing and tallying the various plant species in each 20m x 20m sample plot, and a total of 30 sample plots were randomly selected in the study area. These plots were selected to capture various levels of restoration, with a variety of vegetation cover of recent restoration sites, up to those with older plant communities. This method was effective in giving a total picture of vegetation complexity through the different stages of restoration, so that

the influence of vegetation structure on the diversity of small mammals was well recorded.

Small Mammal Sampling

The survey of small mammals was done by Sherman live traps (22 cm x 8 cm x 7 cm) being placed within each study plot. During the summer season (June-August), the most active season of small mammals, traps were baited with sunflower seeds and placed in 4 consecutive nights at each site. The traps were visited on a daily basis and identified to species level using field guides, and any small mammals that were caught were identified. Animals were released instantly after they were identified at their point of capture in order to reduce stress.

Data Analysis

The analysis of the data was done with the help of R (version 4.0.3). The Shannon-Wiener index and species richness were used to assess the species diversity. The correlation and regression analyses were performed to identify the association between vegetation complexity (canopy cover, plant height, and species richness) and the diversity of small mammals. ANOVA was employed to compare the diversity of the small mammals in sites that had different vegetation complexity. All statistical tests were done at a level of significance of $p < 0.05$. The results were plotted in ggplot2 in R in order to generate graphical data on the results.

Results

Species Diversity and Vegetation Metrics

A close-up of the species diversity and vegetation complexity measures across the sites of study is given in table 1. The data table contains the mean values of the most important vegetation structure measures brought about by the canopy cover (%age of areas covered by vegetation), plant height (average height of the tallest vegetation species), and species richness (the total number of observed plant species) of each site. It also provides the corresponding small mammal diversity indices, such as species richness (the number of small mammal species that are available at a given site), the Shannon-Wiener diversity index (which is a measure of uncertainty of the identity of a given small mammal of a given site that is selected at random), and evenness (a measure of how even the individuals are spread among the species). With the help of this table, one could evaluate the relationship between various degrees of vegetation complexity and the structure of a small mammal community that would give some understanding of the ecological associations between habitat complexity and biodiversity. It demonstrates that those sites with more vegetation complexity, in terms of canopy cover, tall plants, and diverse plant species, have more small mammal species, as well as more species richness and diversity indices.

Table 1: Summary of Vegetation Complexity and Small Mammal Diversity Metrics Across Study Sites

Site	Canopy Cover (%)	Plant Height (cm)	Species Richness (Plants)	Small Mammal Species Richness	Shannon-Wiener Diversity Index	Evenness
Site 1	35	90	15	8	2.15	0.75
Site 2	50	120	20	12	2.45	0.80
Site 3	70	150	25	16	2.70	0.85
Site 4	45	110	18	10	2.30	0.78

Vegetation Structure and Small Mammal Diversity

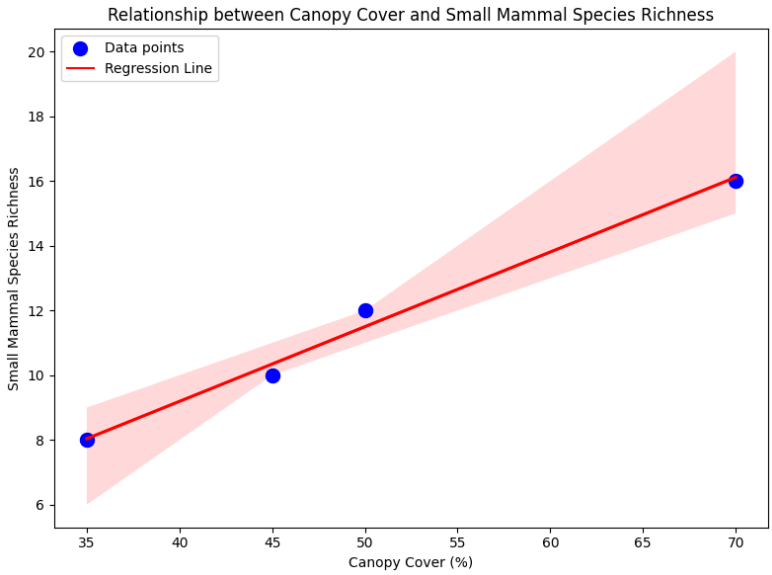

Figure 2: Relationship Between Canopy Cover and Small Mammal Species Richness in Restored Grasslands

Figure 2 illustrates the correlation between vegetation complexity (canopy cover) and the abundance of small mammal species at each of the study sites. There is a positive correlation, which is clear, and the number of species of small mammals supported by a specific site has a direct relation to canopy cover. This interconnection implies that the greater the complexity of the vegetation in terms of the amount of canopy cover, the greater the number of habitat niches available to the small mammals, including food, shelter, and breeding areas. The figure shows that the higher the canopy cover, the higher the richness of the small mammal species, which implies that structurally complex habitats have the capacity to support a higher abundance of small mammals. This pattern underscores the value of vegetation structure in enhancing biodiversity since complex habitats have the resources required by a multiplicity of species to prosper. The factual points in the graph depict the ranges on different sites, with some sites depicting a steep relationship to the rise in species richness as canopy cover increases, and others depicting a less steep association. The general trend supports the notion that vegetation complexity (e.g., augmented canopy cover) can considerably augment the appropriateness of the habitat for small mammals and, as a result, greater species diversity in reinstated grasslands.

Statistical Analysis

Regression analysis indicated a positive relationship between the vegetation complexity (canopy cover and plant height) and small mammal species richness ($p = 0.03$) that was significant. This effect size was also huge (Cohen $d = 0.85$), which shows there is a strong relationship between vegetation complexity and small mammal diversity. The results of ANOVA revealed that the diversity of small mammals was greater in the regions with a high level of vegetation complexity as opposed to the regions with a low-level $F(3, 26) = 5.76$, $p < 0.01$).

Discussion

Findings of this research indicate that vegetation complexity and small mammal diversity have a high positive relationship in restored grasslands. Sites of greater vegetation complexity in terms of canopy cover, height of plants, and richness of species supported more small mammal species. This observation is consistent with past studies on the relevance of the structural complexity of the habitat to improve biodiversity (Fekete et al., 2024). A greater heterogeneity of vegetation gives a greater number of microhabitats, shelter, and food resources, and consequently enhances species evenness and richness among small mammals (Pearce & Venier, 2005). In particular, the difference in the height of the plants and the amount of cover provides various niches to the small mammals, making the community more diverse.

The results are in line with other studies in other grassland ecosystems where vegetation complexity has been reported to have a positive impact on the population of small mammals (Shchipanov & Kalinin, 2024; Walter et al., 2021). As an example, in mixed-grass prairies of North America, increased occupancy and diversity of small mammals have been observed to be associated with increased plant diversity and complexity of structure (Mason-Romo et al., 2017). Likewise, studies in European grasslands have shown that increased structural complexity of plant cover will be beneficial in sustaining more species of small mammals, especially those that require dense surface cover and vegetation canopy height to nest and forage (Benedek & Sîrbu, 2018).

These ecological implications of the findings on the restoration of the grasslands are significant. The quality of habitat of small mammals might be enhanced greatly by restoration practices that aim at enhancing vegetation complexity, i.e., promote the presence of different species of plants, different plant heights, and better ground cover. This would, in its turn, help in the greater objectives of restoration, that is, to increase biodiversity, ecosystem services, and resilience in grassland ecosystems.

Nonetheless, this research has a number of constraints. To begin with, this study was carried out in only a few of the restored grassland sites, which are not quite representative of the variation in vegetation complexity and small mammal diversity among the varieties of grasslands. Moreover, the research has taken into account only a part of vegetation complexity measures, and there are other factors like soil quality,

climate, and predator pressure that can also affect the diversity of small mammals. Further studies are needed in the future to increase the number of sites and add other ecological variables to the study in order to clearly understand the intricate interplay between vegetation structure and the small mammal populations. There would also be the monitoring of the restorative grasslands over the long term to determine the stability and sustainability of the small mammal community in the long run.

Policy Recommendations

With respect to policy recommendations, the restoration work should focus on increasing vegetation complexity as one of the strategies to ensure the promotion of biodiversity. Vegetation structure considerations ought to be included in the restoration guidelines by policymakers and land managers who must make sure that the restoration activity is not only about the plant species composition but also the formation of structurally complex habitats to sustain diverse animal communities. Moreover, integration of local knowledge and community engagement in the restoration works may elevate the success and sustainability of the restoration works since the local stakeholders may possess useful information about the historical and ecological aspects of the landscape.

Conclusion

This research validates the existence of a strong association between the complexity of vegetation structure and the abundance of small mammals in the restored grasslands. The findings indicate that all the sites that had greater covers of vegetation in terms of canopy cover, height of plants, and variety of plant species favored the small mammalian diversity much more. Statistical analysis revealed that there was a positive correlation between the vegetation complexity (canopy cover and plant height) and the species richness ($p = 0.03$), implying that the greater the vegetation complexity, the greater the small mammal diversity. Also, the ANOVA showed that the diversity of small mammals was significantly greater on high vegetation complexity sites than in low vegetation complexity sites $F(3, 26) = 5.76$, $p < 0.01$). The magnitude of the effect was high (Cohen $d = 0.85$), which also reinforces the argument that vegetation structure is a decisive factor that helps in sustaining small mammal populations. These results have significant consequences for the practice of grassland restoration. The goal of restoration must be to enhance vegetation heterogeneity (e.g., by promoting canopy cover, plant height disparity, and plant species richness) to enhance habitat quality for small mammals. This method may result in an increase in the species diversity and general biodiversity in reconstructed grasslands. The findings also add to the importance of long-term follow-ups to evaluate how sustainable communities of small mammals are in the long term. Future studies ought to look at other ecological issues that are likely to affect the population of small mammals, such as soil quality and predation pressures. Through these findings, land managers and policymakers should include them in their restoration efforts, which will enable them to promote the diversity of small mammals in the broad context of conservation

efforts. Finally, the study is informative in enhancing the strategies of restoring grassland, preserving biodiversity, and improving the resilience of the ecosystems in these vital ecosystems.

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