

SPATIAL ECOLOGY OF EARTHWORM COMMUNITIES ALONG LAND-USE GRADIENTS IN NORTHEAST INDIA

Chingtham Naobema Devi¹, Dr. Amit Kumar Sharma²

Research Scholar, Department of Applied Sciences (Zoology), Dr. K.N.Modi University

Newai, Rajasthan 304021, India¹

Associate Professor, Department of Applied Sciences (Zoology), Dr. K.N.Modi University

Newai, Rajasthan 304021, India²

Email address - chingthamnaobema@gmail.com

Email address - aks00977@gmail.com

ABSTRACT

Earthworms are key soil ecosystem engineers that influence decomposition, nutrient cycling, soil aggregation, aeration and organic matter transformation. Their distribution is strongly affected by land use, soil properties and vegetation structure. Northeast India, part of the Indo-Burma biodiversity hotspot, contains highly diverse landscapes including natural forests, plantations, grasslands, agricultural fields and disturbed habitats. This paper synthesizes available evidence on the spatial ecology of earthworm communities across these land-use gradients. Regional studies report around 125 earthworm species belonging to 28 genera and 10 families, with approximately 68.8% native and 31.2% exotic species. In Assam, earthworm density ranged from 56 to 238 individuals m⁻² and biomass from 1.0 to 5.4 g m⁻² across different habitats. In Manipur, natural mixed forest supported 12 species compared with only four in an oak plantation. Mixed forests have also shown higher Shannon diversity values than highly disturbed habitats. Soil moisture, pH, organic carbon, litter quality, vegetation heterogeneity and land-use intensity emerge as major determinants of community structure. The findings indicate that earthworm abundance alone cannot represent soil biodiversity; species richness, functional composition and native–exotic turnover must also be considered.

Keywords: *Earthworms*¹; *Land-use gradient*²; *Spatial ecology*³; *Northeast India*⁴; *Soil biodiversity*⁵; *Forest conversion*⁶; *Habitat preference*⁷

1. INTRODUCTION

Earthworms constitute one of the most important groups of soil macrofauna. Their feeding, casting and burrowing activities influence soil fertility, organic matter decomposition, nutrient cycling, water infiltration and aggregation. Because earthworms respond rapidly to changes in soil moisture, organic matter, pH, vegetation and disturbance, their communities can serve as useful indicators of land-use change. Northeast India forms an important part of the Indo-Burma biodiversity hotspot and contains tropical and subtropical forests, bamboo systems, plantations, grasslands, agricultural fields and expanding urban landscapes. This environmental heterogeneity supports considerable earthworm diversity. Recent regional synthesis has recorded approximately 125 species belonging to 28 genera and 10 families, of which about 86 species are native and 39 exotic. Land-use change can substantially alter this community structure by modifying vegetation, litter input, soil temperature, moisture and organic carbon. The present study reviews the spatial patterns of earthworm communities along different land-use gradients in Northeast India.

2. OBJECTIVES

The study aims to:

1. compare earthworm diversity and abundance across major land-use systems;
2. examine native and exotic species distribution;
3. identify major environmental factors influencing spatial patterns; and
4. assess the ecological implications of land-use change.

3. METHODOLOGY

The study is based on a review and synthesis of published ecological and taxonomic studies from Northeast India.

The main variables considered were:

- species richness;
- density;
- biomass;
- Shannon diversity;

- habitat type;
- native/exotic status;
- soil moisture;
- pH;
- organic carbon; and
- vegetation structure.

Numerical data presented in this paper are derived from previously published studies and are used for comparative interpretation.

4. REGIONAL DIVERSITY

The earthworm fauna of Northeast India includes both native and exotic taxa.

Table 1. Broad Composition of Earthworm Fauna in Northeast India

Category	Number of species	Percentage
Native	86	68.8
Exotic	39	31.2
Total	125	100

The predominance of native species indicates the conservation significance of natural and semi-natural habitats in the region.

However, exotic and peregrine species are increasingly associated with modified habitats such as plantations, agricultural fields and settlements.

5. EARTHWORM COMMUNITIES ALONG LAND-USE GRADIENTS

A generalized land-use gradient in Northeast India can be represented as:

Natural Forest → Secondary Forest/Bamboo → Plantation → Grassland → Agriculture → Highly Disturbed Habitat

Community structure changes along this gradient because of changes in litter availability, soil moisture, vegetation complexity, pH and disturbance intensity.

5.1 Natural Forests

Natural mixed forests generally support greater species richness because they provide continuous litter input, stable soil moisture and heterogeneous microhabitats.

A study in Manipur recorded **12 earthworm species in natural mixed forest compared with only four species in an oak plantation.**

Table 2. Species Richness in Two Forest Habitats of Manipur

Habitat	Species richness
Natural mixed forest	12
Oak plantation	4

The result suggests that simplification of vegetation may reduce earthworm species richness and favour more adaptable taxa.

6. AGRICULTURAL AND GRASSLAND HABITATS

Agricultural systems can support high earthworm abundance when soil moisture and organic inputs remain favourable.

A habitat-based study in Assam recorded substantial spatial variation in earthworm density and biomass.

Table 3. Earthworm Density and Biomass in Selected Assam Habitats

Habitat	Density (individuals m ⁻²)	Biomass (g m ⁻²)
Agricultural system	238	5.4
Mixed forest	212	5.1
Open grassland	131	4.3
Nursery stock	89	3.3

Habitat	Density (individuals m ⁻²)	Biomass (g m ⁻²)
Cow-dung deposited soil	78	2.4
Upland soil	66	1.6
Alluvial soil	62	1.2
Waste heap	56	1.0

The highest density occurred in agricultural soil, followed by mixed forest.

This demonstrates that **high earthworm abundance does not always indicate high biodiversity**. Agricultural fields may contain large populations dominated by only a few tolerant species.

7. DIVERSITY ALONG DISTURBANCE GRADIENTS

Mixed forests in Northeast India have reported Shannon diversity values of approximately **1.76–2.72**, while highly disturbed municipal waste habitats have recorded values as low as **0.42**.

This indicates that habitat complexity generally favours greater community diversity.

Natural habitats tend to support:

- higher species richness;
- greater representation of native taxa;
- more habitat specialists; and
- greater ecological heterogeneity.

Disturbed environments often favour widespread and adaptable species.

8. ENVIRONMENTAL FACTORS INFLUENCING SPATIAL DISTRIBUTION

Soil Moisture

Earthworms require moist soil for respiration and activity. Forest cover and litter help maintain favourable moisture, while irrigation can make agricultural land similarly suitable.

Soil pH

Earthworm species differ in their tolerance of acidic conditions. In the Assam study, agricultural soil with pH around 6.5 supported high density, whereas more acidic waste habitat showed much lower abundance.

Soil Organic Carbon

Organic carbon provides food directly or indirectly through microbial activity. Forest litter, manure, crop residues and compost can enhance earthworm populations.

Vegetation and Litter

Mixed vegetation produces heterogeneous litter and root resources, creating more ecological niches than monoculture plantations.

Soil Disturbance

Repeated tillage and compaction can damage burrows and reduce habitat quality, particularly for deep-burrowing species.

9. NATIVE AND EXOTIC SPECIES TURNOVER

Land-use modification can alter the balance between native and exotic earthworms.

Natural forests tend to retain more native and habitat-specific taxa, while disturbed habitats may facilitate widespread peregrine species.

For example, *Pontoscolex corethrurus* has been reported more extensively in plantation habitats than in natural mixed forest in Manipur.

Such changes may lead to **biotic homogenization**, in which distinct local communities become increasingly similar because of the spread of widespread species.

10. DISCUSSION

The available evidence shows that land use strongly influences earthworm spatial ecology in Northeast India.

Natural mixed forests generally support greater species richness and ecological complexity. The comparison of 12 species in natural forest and four in oak plantation in Manipur clearly demonstrates this pattern.

However, agricultural land may support high numerical abundance. In Assam, agricultural soils contained 238 individuals m^{-2} compared with 212 individuals m^{-2} in mixed forest.

This illustrates the difference between **abundance and diversity**.

A habitat can support large earthworm populations while having comparatively low species richness or being dominated by exotic species.

Therefore, land-use effects should be assessed using multiple indicators including:

- species richness;
- density;
- biomass;
- Shannon diversity;
- native/exotic composition; and
- ecological functional groups.

11. CONSERVATION IMPLICATIONS

Conservation of earthworm diversity in Northeast India requires:

1. protection of natural mixed forests;
2. maintenance of litter and organic matter;
3. promotion of agroforestry and reduced-tillage practices;
4. prevention of excessive soil compaction;
5. maintenance of vegetated corridors between forest fragments;
6. monitoring of exotic earthworm species; and
7. incorporation of soil biodiversity into land-management planning.

12. RESEARCH GAPS AND FUTURE DIRECTIONS

Future studies should focus on standardized, spatially explicit sampling across multiple land-use systems. Particular priorities include:

- GIS-based mapping of species distributions;
- DNA barcoding for accurate identification;
- analysis of beta diversity and community turnover;

- long-term seasonal monitoring;
- investigation of native–exotic interactions; and
- integration of earthworm data with soil physicochemical properties.

13. CONCLUSION

Earthworm communities in Northeast India show clear spatial variation along land-use gradients. Natural forests generally maintain greater species richness and native diversity, whereas agricultural and disturbed habitats frequently support more adaptable species.

Published data demonstrate that natural mixed forest in Manipur supported 12 species compared with four in an oak plantation, while agricultural soil in Assam supported the highest recorded density of 238 individuals m⁻².

These findings show that land-use change does not simply reduce earthworm abundance. Instead, it restructures communities by changing species composition, functional diversity and native–exotic relationships.

Assessment of earthworm communities should therefore integrate abundance, biomass, species richness and community composition. Such an approach can provide a valuable indicator of soil health and landscape ecological change in Northeast India.

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