Journal of Plant Development Sciences
Meerut, India

RESEARCH ARTICLE

LIFE-FORM CLASSIFICATION OF PLANTS GROWING ALONG TRANSITION ZONES BETWEEN GRASSLAND-WOODLAND IN PATNITOP LANDSCAPE OF NORTH-WESTERN HIMALAYA

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Received-18.04.2025, Revised-08.05.2025, Accepted-20.05.2025

Abstract: The present study investigates the life-form classification across grassland–woodland transition zones in Patnitop Landscape in north-western Himalaya. These transition zones, where grassland merge with forested habitats, represent ecotonal regions of high ecological significance, characterized by sharp gradients in microclimate, soil properties, and disturbance regimes. A total of 75 plant species were recorded from diverse microhabitats along the transition zones between Grasslands and Woodlands. These plant species were classified into different life-form categories as per the Raunkiaer's system. The transition zones in Patnitop Land scape are dynamic for biodiversity conservation, as they support species from both the adjacent communities, acting as refugia for many herbaceous and shrubby species. The dominance of low-lying perennials and disturbance-tolerant species reflects the impact of trampling, clearing, and edge effects. Life-form analysis in such zones provides valuable ecological indicators to assess vegetation structure, resilience, and ongoing shifts due to environmental and anthropogenic stressors. This study not only contributes to baseline data for the floristic and ecological understanding of transition zone but also underscores the need for sustainable management practices to protect these transitional habitats from degradation.

Keywords: Patnitop, Landscape, Grasslands, Woodlands

INTRODUCTION

Ecotones are the transition zones between two distinct ecological communities and generally known for biologically rich habitats. These zones are characterized by a blending of species from adjacent ecosystems and the presence of unique assemblages adapted to edge environments (Walker et al., 2003). The grassland–woodland transition zones in mountainous regions such as Patnitop, located in the north-western Himalayas are characterized by open alpine or subalpine meadows gradually merged into dense coniferous or mixed forests, creating complex ecological gradients (Körner, 2003). Patnitop and its adjoining areas, situated at approximately 600–2900 meters above sea level in the Udhampur district of Jammu and Kashmir, serve as a typical representation of such ecotonal habitats. The transition zones in this region are influenced both by natural factors such as altitude and slope, and anthropogenic pressures including tourism, grazing, and infrastructure development.

Although this lifeform concept was given first by Humboldt (1806) and popularized by several ecologists (Raunkiaer, 1934, Ellenberg and Muller 1974, Box, 1981) who devised different systems for the description and classification of plant lifeforms. But classification based on the position and degree of protection of the renewing buds to unfavorable conditions is most accepted and widely used system of classification of life form given by Raunkiaer (1934). It has been known that a plant's life-form reflects its functional processes and is always evolved in direct response to environmental conditions (Cain, 1950). Changes in the structure and composition of plant communities are often indicative of broader environmental shifts. Therefore, analyzing the life-form spectrum of a region is essential for understanding and identifying its ecological dynamics and various phytoclimatic zones.

Understanding distribution of plant life-forms in the particular zones is crucial, as they are sensitive indicators of ecological health, successional status, and disturbance (Cain, 1950; Shimwell, 1971). According to Raunkiaer's system Life-form are categorizes based on position of their perennating buds and reflects their adaptive strategies to environmental stress. The biological spectrum is the proportional representation of each life-form and is used to assess the stability and resilience of vegetation (Ellenberg & Mueller-Dombois, 1974; Whittaker, 1975).

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Despite their ecological importance, grassland–woodland ecotones in the Himalayan region remain under-researched. Most ecological studies in the Himalaya tend to focus either on forest ecosystems or alpine meadows, often neglecting the interface where significant ecological interactions, biodiversity exchange, and edge dynamics occur (Rawat, 2005). These ecotones serve as vital corridors for species migration and ecological processes, especially in the context of climate change and habitat fragmentation. This study addresses that gap by documenting the floristic diversity and life-form composition in Patnitop's transition zones. Although Life forms in this region were previously studied in Patnitop forests by Kumar (1997). But they have not concentrated their study on transition zones. By examining how plant communities shift across these boundaries, we aim to provide insights into vegetation dynamics and inform sustainable conservation practices suited for ecotonal environments under increasing anthropogenic pressure.

MATERIALS AND METHODS

***Study Area*:** The study was conducted in Patnitop Landscape in Jammu and Kashmir, India. The study area is located at an altitude of *ca*. 2,024 meters above sea level and forms part of a complex ecotonal system where grasslands transition into temperate coniferous forests. The region experiences a temperate climate with cold winters, mild summers, and moderate to heavy snowfall during winter months, conditions typical of mid-altitude Himalayan zones. Its varied topography, comprising rolling meadows, forested slopes, and rocky outcrops that creates a diverse range of microhabitats conducive to species richness and floristic diversity.Vegetation in the study area includes coniferous forests dominated by *Cedrus deodara*, *Pinus wallichiana*, and *Abies pindrow*, accompanied by an understory of shrubs and herbaceous layers that are characteristic of temperate Himalayan forest mosaics.

Sampling: To document floristic composition and plant life-form diversity, field surveys were conducted during the two main growing periods: spring (April to June) and late summer (August to October). This timing was chosen to capture both early- and late-season flora and to account for phenological variability (Tomar, 2024). Sampling was carried out using both random and stratified approaches across major habitat types like open meadows, forest edges, shrub-lands, and disturbed ecotones, to ensure comprehensive representation of the region's habitat heterogeneity (Kershaw, 1973). Transects and quadrats were laid out at selected sites, and all vascular plant species encountered were recorded. Specimens were collected, pressed, and identified using regional floras, and life-form categorization was performed following Raunkiaer's system (Raunkiaer, 1934), which classifies species based on the position of their perennating buds relative to the ground surface. Plant specimens were collected, pressed, dried, and preserved using standard herbarium techniques. Taxonomic identification was carried out with the help of regional Flora (Sharma & Kachroo, 1981), and nomenclature was verified using The Plant List and POWO database.

Life-Form Classification: Each identified plant species was classified into life-form categories based on Raunkiaer's system (1934), which considers the position of perennating buds during unfavorable conditions (Table 1).

Table 1: Life forms and Normal Spectrum after Raunkiaer, 1934.

Life Form	Characters	Abbreviation	Normal Spectrum
Macrophanerophytes	Over 8 m large trees	M	28
Nanophanerophytes	Over 2m tall small shrubs	N	15
Chamaephytes	Plants with perennating buds near the soil surface	CH	9
Hemi-cryprophtes	Plants with perennatingbuds partially hidden under the soil.	HC	26
Geophytes	Plants have underground storage organs (bulbs, corms, or rhizomes) containing perennating buds	G	4
Therophytes	Annual plants that survive the unfavorable cold or dry season as seeds	TH	13
Halophytes and Hydrophyes	Hydrophytes and Halophytes	HH	2
Climbers and Lianas	Woody plants having stems that climb up other plants, trees, or structures.	C/L	0
Epiphytes/ Parasites	Plants that grow on other plants.	E	3

The biological spectrum was calculated as the percentage representation of each life-form type relative to the total number of species recorded.

RESULTS AND DISCUSSION

Extensive survey in the study area documented 75 plant species encompassing variety of life-forms. The recorded species were found across a variety of ecological microhabitats, including sunlit open meadows and shaded woodland edges that exhibited differences in moisture levels and soil depth. The transition zones/ecotones, exhibited considerable floristic richness and structural heterogeneity, supporting species from both the adjoining ecosystems (grassland and woodland communities), along with specialists adapted to edge environments.

Table 2: Comparison of biological spectrum of study area with Normal Biological Spectrum after Raunkiaer, 1934.

Life forms	Normal Spectrum	Study Sites	Deviation from Normal Biological Spectrum
M	1.33	28	-26.67
N	10.66	15	-4.34
CH	49.33	9	40.33
HC	14.66	26	-11.34
G	8	4	4
TH	5.33	13	-7.67
HH	4	2	2
C/L	6.66	0	6.66
E	0	3	-3

Chamaephytes representing the predominant life-form in the transition zones between grassland and woodland account *ca*. 40.33%and is notably higher than the 9% suggested by Raunkiaer's normal spectrum (Table 2; Figure 1). This prominence is likely due to the transitional zone's edge environment, characterized by both climatic stresses, such as winter frost, snow and human-induced disturbances like grazing, trampling, and trail formation. Chamaephytes, being low-growing perennials with buds positioned close to the ground, are particularly adapted to such conditions and function effectively as ecological stabilizers in degraded or semi-natural settings (Raunkiaer, 1934; Cain, 1950). These results align with findings from other Himalayan ecotones, where intermediate habitats often endure greater land-use pressures than core forests or open grasslands.

Such life-forms act as buffer species in transition zones between grassland and woodland, maintaining ground cover, reducing erosion, and facilitating nutrient cycling. Prevalence of CH also suggests that the transition zones in the studied region may be undergoing early or arrested successional stages, where herbaceous perennials dominate due to ongoing human and climatic stress. C/L were the second most representing group, which typically inhabit forest edges. The moderate representation of C/L indicates that certain areas of the ecotone still retain features of stable temperate grassland ecosystems, though these are increasingly subjected to environmental and anthropogenic stress. The forest edge in the study area appears fragmented, likely due to logging, collection of firewood, and tourism-related activities (Tomar, 2015). However, in natural woodland transition zones, phanerophytes would be expected to have an increase in number as succession progresses. Their low representation here indicates arrested successional development, where shrubs (Nanophanerophytes) dominate over large trees (Megaphanerophytes), reflecting long-term anthropogenic disturbance. The low proportions of Therophytes and Hydrophytes/Helophytes indicate a relatively stable vegetation cover within the transition zones. This stability may be due to persistent snow cover and low winter temperatures, which limit the survival benefits of short-lived species in alpine ecotones. Hydrophytes were similarly scarce, typically confined to small moist depressions or areas near seasonal rivulets along the woodland margins. Their limited number reflects the topography and hydrological constraints of the study area rather than broader ecological patterns. Climbers and Lianas were only restricted to areas with moderate vertical structure, typically shrub lands and low woodland patches. The occurrence of climbers and lianas reflects a transitional canopy structure, characterized by partial vertical stratification that still provides adequate support for climbing growth forms. This group of life-forms is highly responsive to architecture of woodland and forest (Ellenberg& Mueller-Dombois,1974).

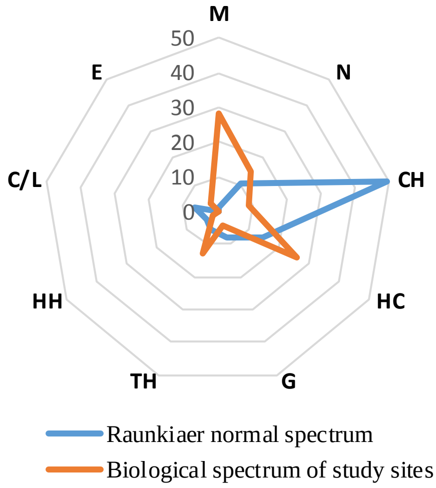

Figure 1 : Comparison of biological spectrum of grassland-woodland transtion zones of Patnitop Landscape with Raunkiaer's normal spectrum

CONCLUSIONS

This investigation presents a comprehensive analysis of the life-form classification within the grassland woodland transition zones of the study area. The results emphasize that these ecotonal habitats function as vital reservoirs of biodiversity, hosting plant communities influenced by environmental pressures like frost, seasonal drought, and anthropogenic disturbances. The limited enumeration of Phanerophytes, especially Megaphanerophytes, indicates a reduction in mature woody vegetation, likely resulting from human-induced factors such as forest degradation, uncontrolled tourism, and overgrazing by livestock. Similarly, the sparse presence of other life forms like Therophytes and Hydrophytes indicates a dominance of perennial, stress-resilient flora, rather than opportunistic or hydrophilic species

Transition zoneslike the one studied here are ecologically significant due to their high edge effects, transitional species composition, and role as ecological corridors. They also act as early indicators of habitat disturbance and climate change because of their sensitivity to even minor environmental changes/fluctuations. The dominance of low-stature, perennial life-forms in the study area ecotone suggests both natural adaptation to harsh climatic conditions and the impact of human-induced degradation, potentially leading to arrested succession and loss of ecosystem complexity.

The findings also highlight the importance of recognizing grassland–woodland transition zones not as peripheral or buffer areas but as critical components of the Himalayan landscape that require active conservation. Extensive efforts involving local population should be directed toward limiting anthropogenic pressure, restoring native vegetation, and maintaining the structural and functional integrity of these zones. There is also a need of sustainable tourism management, regulated grazing, and community-based conservation programs that could significantly enhance the ecological stability of these sensitive landscape in the face of ongoing environmental change.

ACKNOWLEDGMENTS

Authors are thankful to Head, Department of Botany, University of Jammu for all the necessary facilities to conduct the field surveys. Authors also acknowledge DST-FIST for providing funding to strengthen the instrumentation facilities in the department to conduct research activities.

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