Effects of Topographic Factors on Plant Diversity and Spatial Distribution in Karst Areas Surrounding FAST: Postprint

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Abstract

To investigate the influence of topographic factors on plant species diversity and spatial distribution around FAST (Five-hundred-meter Aperture Spherical radio Telescope), this study selected three typical plant communities (tree layer, shrub layer, and vine layer) in karst peak-cluster depressions around FAST as research objects, and employed variance analysis and Canonical Correspondence Analysis (CCA) to examine the characteristics of plant community species diversity and spatial distribution along gradients of different topographic factors (elevation, slope, aspect, and slope position). The results indicate that: (1) The α-diversity index of plant communities around FAST exhibited a trend of shrub layer > tree layer > vine layer, with the α-diversity indices of tree layer and vine layer plants gradually increasing with elevation ($P<0.05$), while topographic factors showed no significant effect on the α-diversity of shrub layer plants. (2) The spatial distribution of plant community species around FAST was most influenced by elevation, followed by slope ($P<0.05$). (3) The β-diversity indices of plant communities around FAST along elevation and slope gradients both showed a trend of vine layer > shrub layer > tree layer, with the Jaccard similarity indices of the three plant communities showing an increasing trend with elevation, and a trend of first increasing then decreasing with slope. In summary, species exhibit differential habitat selection, and elevation and slope are key factors influencing the spatial distribution of plant communities in karst peak-cluster depressions around FAST.

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Influence of Topographic Factors on Plant Diversity and Spatial Distribution in Karst Areas Around FAST

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Abstract

To investigate the influence of topographic factors on plant species diversity and spatial distribution around the Five-hundred-meter Aperture Spherical radio Telescope (FAST), this study examined three typical plant communities (tree layer, shrub layer, and vine layer) in the karst peak-cluster depressions surrounding FAST. Using variance analysis and Canonical Correspondence Analysis (CCA), we analyzed species diversity and spatial distribution characteristics across gradients of different topographic factors (altitude, slope, aspect, and slope position). The results showed: (1) The α-diversity index of plant communities around FAST exhibited a trend of shrub layer > tree layer > vine layer. The α-diversity indices of tree and vine layers increased gradually with altitude ($P<0.05$), while topographic factors had no significant effect on the α-diversity of the shrub layer. (2) Altitude exerted the greatest influence on species spatial distribution, followed by slope ($P<0.05$). (3) The β-diversity indices of the three plant communities along altitude and slope gradients showed a trend of vine layer > shrub layer > tree layer. The Jaccard similarity index increased with altitude but first increased then decreased with slope. In conclusion, species exhibit differential habitat selection, with altitude and slope being key factors affecting the spatial distribution of plant communities in karst peak-cluster depressions around FAST. Species diversity better reflects differences in plant community composition. Diversity is influenced not only by topographic factors but also by biotic and abiotic factors such as temperature, precipitation, human activities, and functional traits. Future studies should incorporate additional environmental factors to further investigate the intrinsic mechanisms of plant species diversity and spatial distribution at regional scales.

Keywords: karst peak-cluster depression, topographical factor, species diversity, spatial distribution, FAST

Introduction

Species diversity is an objective indicator used to measure the richness of biological resources in a given area, reflecting the internal structural diversity and spatial heterogeneity of plant communities. Higher species diversity in ecosystems corresponds to more complex community structure, stronger resistance to interference, and greater stability (Loreau et al., 2013; Zhang et al., 2018; Yang et al., 2019). The spatial heterogeneity of plant communities results from the combined effects of various biological and ecological characteristics, and studying environmental factors facilitates analysis of population distribution patterns and improves community management (Zhang, 2020). Among numerous environmental factors, the influence of topographic factors on spatial distribution, community succession, and ecological restoration of plant populations has remained a central topic in ecological research (Long, 2007; Wang, 2016). Variations in topographic factors create environmental heterogeneity, providing favorable conditions for species coexistence and helping maintain plant community biodiversity (Huang et al., 2016). As one of the most important environmental factors, altitude and its effects on plant species diversity represent a key issue in ecology (Zhang, 2008). The quantitative characteristics of species along altitudinal gradients comprehensively reflect spatial distribution patterns and, consequently, species' adaptive capacity to environmental conditions (Hao et al., 2014).

Slope position represents an important topographic condition at the slope scale, referring to different locations on natural slopes (Zhu et al., 2018). Slope primarily affects the angle of solar incidence, thereby influencing other environmental factors. Areas with gentle slopes typically have thicker soil layers, suitable pH, adequate moisture, and slow loss of inorganic salts (Wen and Jin, 2019). Aspect can alter numerous habitat factors during plant growth, such as light, temperature, water, and soil, thereby affecting species diversity (Zhang, 2019). Currently, research on the influence of topographic factors on species diversity tends to focus on single factors—most studies concentrate on altitude alone (Hao et al., 2014; Huang et al., 2016; He et al., 2021), slope alone (Li et al., 2013), aspect alone (Niu et al., 2017), or slope position alone (Zhu et al., 2018). Multi-scale studies on plant community species diversity in karst regions, particularly investigations of the relationship between plant communities and topographic factors in karst peak-cluster depressions, remain scarce.

Karst peak-cluster depressions represent a typical landform in karst mountainous areas, mainly distributed in southwestern China. These ecosystems are fragile, with poor stability and weak resistance to interference, resulting in highly heterogeneous environmental characteristics (Peng et al., 2008; Sheng et al., 2015). Forest ecosystems, as a crucial type of terrestrial ecosystem, not only conserve water sources and reduce soil erosion but also regulate climate, decrease wind speed, and promote dust sedimentation (Wang et al., 2011). FAST, the world's largest radio telescope, is located in the typical karst peak-cluster depression of Dawodang and undertakes numerous major astronomical observation missions. Its operation requires a relatively stable natural environment, making plant community stability and ecological security particularly important for ecological construction and protection around FAST (Zhao et al., 2020). Although numerous studies have examined the effects of topographic factors on plant species diversity and spatial distribution both domestically and internationally, research specifically addressing these issues in karst peak-cluster depressions remains limited.

This study selected typical karst peak-cluster depressions around FAST as the research area. Using data obtained from typical sample plot surveys and calculated diversity indices, we employed variance analysis and canonical correspondence analysis to test our results. By analyzing the effects of topographic factors (altitude, slope, aspect, and slope position) on species diversity and spatial distribution of different plant communities, we aimed to address three questions: (1) How do topographic factors influence α-diversity of plant communities? (2) How do topographic factors explain the spatial distribution of plant communities? (3) What are the characteristics of β-diversity under topographic factor gradients? This research aims to provide data support for understanding the stability and maintenance mechanisms of forest plant communities in karst peak-cluster depressions.

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1. Materials and Methods

1.1 Study Area Overview The study area is located in Kedu Town, Pingtang County, Qiannan Buyi and Miao Autonomous Prefecture, Guizhou Province. This region belongs to the transitional zone from the Yunnan-Guizhou Plateau to the hills of Guangxi, characterized by typical karst peak-cluster depressions. The area experiences a mid-subtropical monsoon humid climate, with vegetation belonging to the mid-subtropical evergreen broad-leaved forest zone. The survey area for plant communities around FAST spans 106º48 24 –106º53 05 E and 25º30 18 –25º38 47 N. The vegetation consists primarily of broad-leaved forests and shrublands, with abundant rainfall (average annual precipitation ~1,217 mm), mean annual temperature of approximately 17°C, a frost-free period of 312 days, and annual sunshine duration of 1,065.7 hours. Soils are mainly limestone soil and yellow soil, with bedrock exposure rates of 25–40% (Xie et al., 2018). Dominant tree species include *Liquidambar formosana*, *Quercus acutissima*, and *Cyclobalanopsis glauca*. Major shrubs include *Rhamnus heterophylla*, *Echinacanthus lofouensis*, *Lindera communis*, and *Daphne papyracea*. Primary vines include *Dalbergia hancei*, *Toddalia asiatica*, *Smilax china*, and *Sageretia thea*.

1.2 Sample Plot Setup and Investigation In mid-October 2015, we conducted plant community surveys using the typical sample plot method. We established 20 m × 20 m survey plots, within which we set up ten 4 m × 10 m subplots for tree species investigation (Song et al., 2010; Chen and Yang, 2014), along with five 5 m × 5 m subplots for shrub and vine surveys (herbaceous communities were structurally simple and thus not sampled). A total of 26 plant community survey plots were established. Within each plot, we measured all tree individuals with diameter at breast height (DBH) >5 cm, while for trees with DBH <5 cm and for shrubs and vines, we measured ground diameter. We recorded species names, height, DBH (or ground diameter), and abundance, along with plot characteristics including coverage, altitude, aspect, slope, and slope position (Wu et al., 2013; Zhang et al., 2013).

1.3 Classification Standards for Topographic Factors Based on information from the typical plant community survey plots, we classified the 26 plots according to different topographic factors (altitude, slope, aspect, and slope position) as shown in Table 1 (Li et al., 2019; Tian et al., 2021).

Table 1 Classification standards for topographic factors

Topographical factor	Classification	Criteria	Number of plots
Altitude (m)	Low altitude	700–900	
	Medium altitude	900–1100	
	High altitude	>1100	
Slope (°)	Flat slope	0–5	
	Gentle slope	6–15	
	Slope	16–25	
	Steep slope	26–35	
	Sharp slope	36–45	
	Risky slope	>45	
Aspect (°)	Shady aspect	337.5–22.5, 22.5–67.5	
	Semi-shady aspect	67.5–112.5, 292.5–337.5	
	Sunny aspect	157.5–202.5, 205.5–247.5	
	Semi-sunny aspect	112.5–157.5, 247.5–292.5	
Gradient	Top of the gradient		
	Uphill		
	Mid gradient		
	Downhill		

1.4 Calculation Methods

1.4.1 Important Value Calculation The importance value (IV) of plant species in the tree, shrub, and vine layers of typical karst plant communities was calculated as follows (Long, 2016):

IV = Relative density + Relative frequency + Relative dominance

Where relative density is the proportion of individuals of a given species to the total number of individuals in the plot; relative frequency is the proportion of plot occurrences of a given species to the total plot occurrences of all species; and relative dominance is the proportion of basal area at breast height (or basal cover for shrubs and vines) of a given species to the total basal area (or cover) of all species.

1.4.2 Diversity Measurement We analyzed α-diversity indices of plant communities in karst peak-cluster depressions using the Margalef richness index (R), Simpson dominance index (D), Shannon-Wiener diversity index (H), and Pielou evenness index (E) (Ma et al., 2021; Yin et al., 2021). β-diversity was analyzed using the Jaccard similarity coefficient (Cj), which ranges from 0 to 1, with higher values indicating greater similarity between plant communities. Similarity was classified as: $0 < Cj < 0.25$ (extremely dissimilar), $0.25 < Cj < 0.50$ (moderately dissimilar), $0.50 < Cj < 0.75$ (moderately similar), and $0.75 < Cj < 1$ (extremely similar) (Ma et al., 2021).

α-diversity indices: - Margalef richness index: $R = (S - 1) / \ln(N)$ - Simpson dominance index: $D = 1 - \Sigma(Pi^2)$ - Shannon-Wiener diversity index: $H = -\Sigma(Pi \times \ln(Pi))$ - Pielou evenness index: $E = H / \ln(S)$

Where S is the total number of species in the community, N is the total number of individuals in the plot, and Pi is the relative importance value of species i.

β-diversity index: - Jaccard similarity index: $Cj = c / (a + b - c)$

Where c is the number of shared species between two plots, and a and b are the numbers of species in plots A and B, respectively.

1.5 Data Analysis We used SPSS 26.0 software to test data for normality and homogeneity of variance, transforming data as necessary to meet test assumptions. Differences in α-diversity indices were tested using one-way ANOVA, with Tukey' s method for multiple comparisons ($P<0.05$). Canonical correspondence analysis (CCA) was performed using Canoco 5.0 software, and figures were created using Origin 2018. In CCA analysis, topographic factors were assigned numerical ranks: flat slope = 1, gentle slope = 2, slope = 3, steep slope = 4, sharp slope = 5, risky slope = 6; shady aspect = 1, semi-shady aspect = 2, semi-sunny aspect = 3, sunny aspect = 4; downhill = 1, mid gradient = 2, uphill = 3, top of gradient = 4. Other environmental data used measured values.

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2. Results

2.1 Influence of Topographic Factors on α-Diversity of Plant Communities Around FAST Analysis of α-diversity in typical karst plant communities around FAST is presented in Figure 1 [Figure 1: see original paper] (variance analysis was not performed for gentle slopes due to limited sample plots). The Margalef richness index, Simpson dominance index, and Shannon-Wiener diversity index of the tree layer were all greater in medium and high altitude zones than in low altitude zones (P<0.05). The Margalef richness index on flat slopes was significantly higher than in steep and risky slope zones (P<0.05). The Pielou evenness index on shady and semi-sunny aspects was significantly higher than on semi-shady aspects (P<0.05). The Margalef richness index and Shannon-Wiener diversity index at slope tops were significantly higher than in downhill zones (P<0.05). Topographic factors showed no significant effects on α-diversity indices of the shrub layer. For the vine layer, α-diversity indices were primarily affected by altitude, with the Margalef richness index and Shannon-Wiener diversity index in medium altitude zones significantly higher than in low altitude zones (P<0.05).

Figure 1 Influence of topographic factors on α-diversity indices of karst plant communities around FAST. A. Tree layer α-diversity index; B. Shrub layer α-diversity index; C. Vine layer α-diversity index. 1. Low altitude; 2. Medium altitude; 3. High altitude; 4. Flat slope; 5. Slope; 6. Steep slope; 7. Sharp slope; 8. Risky slope; 9. Shady aspect; 10. Semi-shady aspect; 11. Sunny aspect; 12. Semi-sunny aspect; 13. Top of gradient; 14. Uphill; 15. Mid gradient; 16. Downhill. Different lowercase letters indicate significant differences in α-diversity indices (P<0.05).

2.2 Influence of Topographic Factors on Species Spatial Distribution Around FAST Canonical correspondence analysis (CCA) of species spatial distribution and topographic factors around FAST revealed distinct patterns. In the tree layer CCA ordination (Figure 2 [Figure 2: see original paper]A), species such as *Quercus shennongii*, *Fagus longipetiolata*, and *Cyclobalanopsis glauca* clustered in the upper left of the ordination axis, primarily distributed in higher altitude and uphill zones. Species including *Picrasma quassioides*, *Cladrastis wilsonii*, and *Cinnamomum glanduliferum* clustered in the lower right, mainly distributed in steep slopes, shady aspects, and low altitude zones.

In the shrub layer CCA ordination (Figure 2 [Figure 2: see original paper]B), *Prinsepia utilis*, *Sophora velutina*, and *Viburnum foetidum* clustered in the lower left, primarily in higher altitude and uphill zones. Species such as *Lindera communis*, *Rotheca serrata*, and *Cotoneaster franchetii* clustered in the lower right, mainly in steep slopes, low altitude zones, and shady aspects.

In the vine layer CCA ordination (Figure 2 [Figure 2: see original paper]C), *Dalbergia hancei*, *Sageretia thea*, and *Sageretia rugosa* clustered in the upper left, primarily distributed in sunny aspects and gentle slopes. Species including *Millettia nitida*, *Smilax guiyangensis*, and *Celastrus rosthornianus* clustered in the lower left, mainly in higher altitude, uphill, and gentle slope zones.

Figure 2 CCA ordination of plant communities around FAST. A. Tree layer CCA ordination; B. Shrub layer CCA ordination; C. Vine layer CCA ordination.

As shown in Table 2 , the importance of topographic factors for plant communities around FAST followed the trend: altitude > slope > slope position

> aspect. Altitude and slope had significant effects on spatial distribution of species in tree, shrub, and vine layers (P<0.05).

Table 2 Results of CCA importance ranking and significance testing for plant communities around FAST

Explanatory factor	Tree layer		Shrub layer		Vine layer	
	Importance value	P value	Importance value	P value	Importance value	P value
Altitude	0.002**		0.002**			
Slope	0.048*		0.036*			
Gradient						
Aspect						

Note: *P<0.05, **P<0.01

2.3 β-Diversity Analysis Based on Altitude and Slope Significance testing from CCA indicated that both altitude and slope significantly affected spatial distribution of species in the three plant communities (P<0.05). Therefore, we used the Jaccard similarity index to analyze β-diversity along altitude and slope gradients.

β-diversity analysis along altitude gradients (Figure 3 [Figure 3: see original paper]) showed that the Jaccard similarity index was highest in medium-high altitude zones for tree, shrub, and vine layers. The lowest similarity indices occurred in low-high altitude zones for tree and vine layers, and in low-medium altitude zones for the shrub layer.

β-diversity analysis along slope gradients (Figure 4 [Figure 4: see original paper]) revealed that the Jaccard similarity index was highest in flat-sharp slope zones for the tree layer, and in flat-steep slope zones for shrub and vine layers. The lowest similarity indices across all three layers occurred in gentle-risky slope zones.

Figure 3 Jaccard similarity index characteristics of plant communities around FAST along the altitude gradient.

Figure 4 Jaccard similarity index characteristics of plant communities around FAST along the slope gradient.

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3. Discussion

3.1 Influence of Topographic Factors on α-Diversity of Plant Communities Around FAST The relationship between plant community species diversity, spatial distribution, and environmental factors is strongly influenced by research scale. At large scales, climatic conditions dominate, while at small scales, topographic factors play the leading role (Xiong et al., 2016). Species diversity reflects the quantitative characteristics of plant communities. Around FAST, species diversity indices showed the pattern shrub layer > tree layer > vine layer, similar to findings by Gao et al. (2021), indicating that plant communities around FAST are in good successional and growth condition. Shrub species are relatively abundant with greater demand for resources and space. As communities succeed, more tree saplings appear in shrublands, resulting in higher species diversity indices.

Altitude affects light intensity and the redistribution of soil and water resources, thereby influencing community composition and structure (Huang et al., 2016). While the Margalef richness index, Simpson dominance index, Shannon-Wiener diversity index, and Pielou evenness index of tree and vine layers showed inconsistent trends with altitude, overall species diversity was similar, with medium and high altitude zones showing greater diversity than low altitude zones. This aligns with Xiong et al. (2016), suggesting that diversity in each layer is affected not only by microclimatic differences caused by altitude (light, temperature, soil) but also significantly by human disturbance. Our survey was conducted during FAST' s construction period, when tourism development and sightseeing inevitably increased surrounding human disturbance. Additionally, the fragile karst peak-cluster depression ecosystem experiences intensified water erosion and soil transport at higher altitudes, providing favorable conditions for colonization by light-loving, barren-tolerant species. Higher altitude zones receive more abundant sunlight, favoring widely distributed species like *Liquidambar formosana* and *Quercus acutissima* that are light-demanding and drought-tolerant.

Slope, as an important environmental factor in karst peak-cluster depressions, typically explains spatial distribution patterns of species richness (Ren et al., 2014). In our study, tree, shrub, and vine layers all showed higher species diversity in gentle slope zones, likely because karst peak-cluster depressions feature alternating peaks and depressions with dramatic relief and obvious slope variations. Smaller slopes reduce water erosion, favoring soil and water conservation, thus increasing species survival rates and diversity in gentle slope zones.

Aspect influences light intensity received by plants, with different slopes receiving varying solar radiation, creating soil moisture and temperature differences (Li et al., 2019). In this study, sunny and semi-sunny aspects showed higher species diversity than shady and semi-shady aspects, contrasting with Zou et al. (2014). This may result from adequate light and higher soil organic matter content on sunny aspects. Alternatively, due to constraints of karst peak-cluster depression topography, strict control of plot distribution was difficult, resulting in low uniformity in plot division. Whether this error significantly affected results requires further investigation.

Generally, slope tops and uphill zones receive more abundant light, while downhill zones have thicker soil layers and better fertility (Liu et al., 2019). In this study, tree and vine layer diversity was higher at slope tops than downhill zones, while shrub layer diversity was higher downhill than at slope tops, differing from Liu et al. (2015). This may occur because widely distributed tree species in the study area are mostly light-demanding, and vines require climbing or creeping, benefiting from abundant sunlight and minimal human disturbance at slope tops. In contrast, shrubs generally have greater biomass, faster growth rates, and higher soil fertility demands, resulting in higher diversity downhill. Thus, topographic factors have complex effects on species diversity, with different plant community types and soil conditions showing varying response patterns.

3.2 Influence of Topographic Factors on Species Spatial Distribution Around FAST Topographic factors affect microenvironmental temperature, nutrients, and light, thereby influencing plant community spatial distribution (Li et al., 2019). Cao et al. (2005) suggested that CCA ordination better explains correlations between plant species and environmental factors, making it suitable for studying community spatial distribution. CCA analysis of plant communities around FAST showed that the first two axes explained over 60% of the variance in species-environment relationships, indicating good explanatory power. CCA integrates plant species with topographic factors, comprehensively reflecting relationships between distribution and topography. The angle between arrows and ordination axes indicates correlation strength between environmental factors and axes (Shao et al., 2012). Most scholars consider altitude the primary topographic factor affecting plant spatial distribution and community change, as altitude variations alter microenvironments and consequently plant distribution (Fosaa, 2010; Raulings et al., 2010). Our study found altitude to be the key factor affecting spatial distribution around FAST, followed by slope, consistent with previous research (Huang et al., 2014; Xiong et al., 2016; Li et al., 2019). The significant correlation between altitude, slope, and community spatial distribution demonstrates the filtering effect of habitat on community assembly and validates the niche characteristics of different plant communities in the study area.

Different community types showed varying responses to topographic factors. Along slope gradients, shrubs were more sensitive to habitat conditions than trees and vines. The study area contained numerous, widely distributed shrub species, with strong adaptability but moisture-loving habits (e.g., *Rhamnus heterophylla*, *Daphne papyracea*), often occurring in shady, moist locations, indicating higher habitat selection requirements for shrubs. Tree distribution was relatively concentrated, while shrub and vine distributions were more dispersed, suggesting more intense competition among trees and relatively stable shrub and vine communities.

Topographic variation affects different communities differently, likely due to varying hydrological functions and geomorphological processes across topographic positions. For example, lower slope positions experience runoff scouring, while steep slopes are prone to collapse. The dramatic relief of karst peak-cluster depressions causes obvious soil transport and accumulation under hydraulic action, resulting in fragmented, heterogeneous microhabitats and different disturbance regimes. Additionally, plants with different growth habits show varying topographic preferences. Therefore, altitude and slope are dominant factors affecting spatial distribution of plant communities around FAST. However, the four selected topographic factors explained relatively low total variance (<30%) for all three communities, with >70% unexplained variation, possibly due to insufficient environmental factors. Previous studies indicate that soil physicochemical properties and climatic factors also affect spatial distribution (Wen et al., 2011; Zhang et al., 2022). Other factors such as human disturbance, interspecific interactions, and dispersal limitation may also contribute and require further investigation.

3.3 β-Diversity Characteristics of Altitude and Slope Around FAST

The Jaccard index reflects similarity between different habitats, with smaller values indicating greater differences in species composition (Yin et al., 2021). In this study, the Jaccard similarity index along altitude and slope gradients showed the pattern vine layer > shrub layer > tree layer. As communities succeed, similarity decreases, competition among species diminishes, and vegetation communities tend toward stability. Along altitude gradients, seven species pairs were extremely dissimilar and two were moderately dissimilar, indicating large differences in plant composition around FAST across altitudinal gradients. β-diversity gradually decreased with vegetation succession, and interspecific competition eased, similar to Li et al. (2018). This may result from species selectivity for different topographic conditions and uneven plot division due to topographic constraints.

Along slope gradients, 13 species pairs were extremely dissimilar, 26 moderately dissimilar, and 6 moderately similar. Over 70% of Jaccard similarity indices along altitude and slope gradients indicated extreme or moderate dissimilarity, suggesting low competition among species and relatively stable plant communities around FAST. The general conclusion that β-diversity decreases with altitude (He et al., 2021) was not supported here, as β-diversity indices for all three communities increased from low-medium to medium-high altitudes. This discrepancy may arise from high habitat heterogeneity and frequent human disturbance in karst peak-cluster depressions. Overall differences among plant communities may also relate to habitat conditions and plant habits. Along slope gradients, Jaccard similarity indices for all three communities first increased then decreased. Tree, shrub, and vine layers reached maximum similarity in flat-sharp, flat-steep, and flat-steep slope zones, respectively, indicating small overall differences and many shared species between gentle and steep slope zones. As slope increased, plant communities further developed, differences in species composition increased, and ecological distances between communities widened. Beyond certain slopes, disturbance decreased and local microenvironments between communities became more stable.

In summary, species exhibit differential habitat selection, with altitude and slope being key factors affecting spatial distribution of plant communities in karst peak-cluster depressions around FAST. Species diversity effectively reflects differences in community composition. Diversity is influenced not only by topographic factors but also by biotic and abiotic factors including temperature, precipitation, human activities, and plant functional traits. Future studies should incorporate additional environmental factors to further explore intrinsic mechanisms of plant species diversity and spatial distribution at regional scales, while strengthening ecological protection and improving forest composition to provide a favorable natural environment around FAST and in karst peak-cluster depressions.

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Note: Figure translations are in progress. See original paper for figures.