Postprint: Analysis of the Characteristics and Maturity of Four Community Types in the Tropical Monsoon Forest at the Northern Margin of Ehuangzhang

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Date: 2023-07-13T00:00:00+00:00

Abstract

This study analyzed the community characteristics of different successional stages of tropical monsoon forests at the northern margin of China to provide a scientific basis for elucidating community assembly mechanisms and optimizing forest structure. This paper investigated four distinct plant communities (A, B, C, D) in a typical monsoon forest at Ehuangzhang, Yangchun, Guangdong, analyzing community species composition, diversity, and spatial structure, assessing maturity differences, predicting successional trajectories, and proposing optimization recommendations. The results demonstrated: (1) Currently, the four communities exhibit a single forest layer, with small-diameter trees and understory trees occupying the dominant position, and feature 1-3 distinct dominant species. (2) Shannon-Wiener index ranged from 2.72 to 3.74, Simpson index from 0.90 to 0.97, and evenness index from 0.74 to 0.89, with significant differences in diversity characteristics among communities. (3) For the four communities, the diameter size ratio of trees ranged from 0.49 to 0.51, angular scale from 0.56 to 0.61, mingling degree from 0.54 to 0.83, stand spatial structure index from 60.57 to 71.44, and stand spatial structure distance from 53.15 to 68.53. (4) Comprehensive analysis of basic community characteristics, diversity, and spatial structure features revealed that the maturity ranking of the communities was D > A > C > B. The research findings indicate that all four communities are in early or mid-successional stages, with considerable development potential for individual tree DBH and height; the communities overall are in an intermediate growth state, with individuals showing slightly clumped distribution, tree species exhibiting moderate, strong, or very strong mixing, and the spatial structure deviating from the ideal stand. With increasing maturity, all four communities continue to undergo succession with light-demanding species as the main dominant tree species, and initially possess typical vegetation characteristics of the zonal climax community in this region. With increasing maturity, monsoon forest community species diversity increases, and succession proceeds toward trends of increased mingling degree, optimized spatial structure, and enhanced stability. Future efforts should strengthen monitoring and protection of this region, while simultaneously conducting extensive monitoring and in-depth research on vegetation ecology and biodiversity conservation in this area.

Full Text

Characteristics and Maturity Level Analysis of Four Communities in E' huangzhang Tropical Monsoon Forests of the Northern Edge

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Abstract

Analyzing community characteristics of tropical monsoon forests at different successional stages provides a scientific basis for understanding community assembly mechanisms and optimizing forest structure. This study investigated four distinct plant communities (A, B, C, and D) in a typical monsoon forest in E' huangzhang, Yangchun, Guangdong Province, analyzing species composition, diversity, and spatial structure to assess maturity differences, predict successional trajectories, and propose optimization recommendations.

The results showed: (1) All four communities exhibited a single forest layer, dominated by small-diameter and lower-layer trees with 1-3 distinct dominant species. (2) Shannon-Wiener indices ranged from 2.72 to 3.74, Simpson indices from 0.90 to 0.97, and evenness indices from 0.74 to 0.89, with significant differences in diversity characteristics among communities. (3) Tree diameter dominance ratios were 0.49-0.51, uniform angle indices 0.56-0.61, mingling indices 0.54-0.83, forest spatial structure indices (FSSI) 60.57-71.44, and forest spatial structure distances (FSSD) 53.15-68.53. (4) Comprehensive analysis of basic community characteristics, diversity, and spatial structure revealed a maturity ranking of D > A > C > B.

These results indicate that all four communities are in early or mid-successional stages with substantial development potential for individual DBH and height. The communities overall exhibit moderate growth status, slight aggregated distribution patterns, and moderate to very strong species mingling, though their spatial structure still deviates from the ideal stand. As maturity increases, all four communities continue succession with light-demanding species as dominant trees, gradually developing typical characteristics of the regional zonal climax community. With increasing maturity, species diversity improves, and communities evolve toward higher mingling, optimized spatial structure, and enhanced stability. Future work should strengthen monitoring and protection of this region while conducting extensive vegetation ecology and biodiversity conservation research.

Keywords: high rainfall, succession, importance value, community structure, species diversity, spatial structure

1.1 Study Area Overview

The study plots were established within the Guangdong Yangchun E' huangzhang Provincial Nature Reserve (111°21 29 -111°36 03 E, 21°50 36 – 21°58 40 N). Located in southwestern Yangchun City, Yangjiang, Guangdong Province, the reserve borders Dianbai District to the west and Yangxi County to the south. As the largest protected area in southwestern Guangdong' s coastal region and the only one representing the northern margin tropical climate type, it covers 14,751 hectares. The area features mountainous terrain with its highest peak, E' huangzhang, reaching 1,337.6 m. Most parent material is granite, with soils primarily consisting of red soil, lateritic red soil, and mountain yellow soil (pH 4–6). Soil organic matter content is 39.19 $\mathrm{g \cdot kg^{-1}}$, total nitrogen 0.95 $\mathrm{g \cdot kg^{-1}}$, total phosphorus 0.12 $\mathrm{g \cdot kg^{-1}}$, available phosphorus 2.62 $\mathrm{mg \cdot kg^{-1}}$, and total potassium 9.04 $\mathrm{g \cdot kg^{-1}}$. The region has a mean annual temperature of 22.1 °C and mean annual precipitation of 3,428.9 mm, with a maximum recorded rainfall of 5,521 mm (recorded at Xianjiadong Reservoir Meteorological Station). This extensive rainfall period and high precipitation earn it the designation of "Guangdong' s Primary Rainfall Center." Long-term human disturbance has eliminated primary forest communities, leaving secondary forest communities at various successional stages, including secondary mountain rainforests and evergreen monsoon forests. Dominant families include Fagaceae, Lauraceae, Myrtaceae, and Theaceae, with representative species such as *Polyspora axillaris*, *Adinandra hainanensis*, *Diplopanax stachyanthus*, and *Machilus foonchewii.*

1.2 Sample Plot Setup and Survey Methods

Based on community appearance and vegetation composition, four 30 m × 40 m permanent monitoring plots were established in the Guangdong Yangchun

E' huangzhang Provincial Nature Reserve, representing four distinct typical evergreen monsoon forest communities. All communities were 30–40 years old, with dominant species primarily light-demanding trees such as *Sinosideroxylon wightianum*, *Machilus foonchewii*, *Schefflera heptaphylla*, and *Macaranga sampsonii*. Plot coordinates and elevations were: A (111°31 25 E, 21°55 11 N, 100 m), B (111°33 51 E, 21°54 55 N, 150 m), C (111°32 8 E, 21°55 4 N, 120 m), and D (111°29 12 E, 21°53 44 N, 350 m). All four corners of each plot were marked with PVC pipes or cement stakes. Species-area curves showed small terminal slopes for all four communities, indicating that plot size adequately met minimum sampling area requirements [Figure 1: see original paper].

Each 30 m × 40 m plot was subdivided into 10 m × 10 m subplots for survey. All individuals with DBH $>$ 1 cm were located, tagged, and measured using diameter tapes, pole pruners, nails, labels, spray paint, and recording sheets. Data recorded included species name, relative coordinates, DBH, tree height, crown width, and clear bole height, which were subsequently entered into computer databases.

1.3 Community Structure Classification

For diameter structure, the upper exclusion method was applied with 2 cm diameter classes for all individuals with DBH $\geq$ 1 cm. Based on practical considerations and using five diameter classes as increments, trees were classified as: small-diameter class (2–10 cm), medium-diameter class (12–20 cm), and large-diameter class ($ $22 cm).

For height structure, following Hui et al. (2007) forest layer theory, height was divided into three layers using 10 m and 16 m as breakpoints: lower layer ($h < 10$ m), middle layer ($10.0 \text{ m} \leq h < 16.0$ m), and upper layer ($h \geq 16.0$ m). Upper, middle, and lower layer trees composed the upper, middle, and lower forest strata, respectively.

1.4 Community Characteristics and α Diversity Index Measurement

Importance Value (%) = Relative abundance + Relative frequency + Relative dominance

Shannon-Wiener Index:

$$H' = -\sum_{i=1}^{S} P_i \ln P_i$$

Pielou Evenness Index:

$$J = \frac{H'}{\ln S}$$

Simpson Index:

$$D = 1 - \sum_{i=1}^{S} P_i^2$$

where S is the total number of species in the plot and P is the proportion of individuals of species i relative to the total number of individuals (Fang et al., 2009; Magurran, 1988).

1.5 Stand Spatial Structure Parameter Measurement

Following Hui and Gadow (2003), we employed a neighborhood-based quantitative analysis method for forest spatial structure. Each reference tree and its four nearest neighbors formed a spatial structure unit. Three parameters were selected for analysis: dominance ratio (U), uniform angle index (W), and mingling index (M). To eliminate edge effects and improve analytical accuracy, a 5 m buffer zone was established around each plot. Only trees in the core area (25 m × 35 m) were used as reference trees, while buffer zone trees served only as neighbors.

(1) Dominance Ratio (U)

The dominance ratio characterizes size differences among trees, calculated as the proportion of neighboring trees larger than the reference tree among its four nearest neighbors. Xu et al. (2018) found consistent results using DBH and height for dominance ratio calculations, but crown width yielded different results. Therefore, this study used DBH as the metric:

$$U_i = \frac{1}{4} \sum_{j=1}^{4} k_{ij}, \quad \text{where } k_{ij} = \begin{cases} 1 & \text{if neighbor } j > \text{reference tree } i \\ 0 & \text{otherwise} \end{cases}$$

where n is the total number of reference trees. U values of 0, 0.25, 0.50, 0.75, and 1.00 represent reference trees in dominant, co-dominant, intermediate, suppressed, and absolutely suppressed positions, respectively. U reflects the proportion of dominant trees at the community level.

(2) Uniform Angle Index (W)

The uniform angle index describes stand distribution patterns by assessing whether the angle α formed between reference tree i and neighbor j exceeds the standard angle α_0 (72° in this study), characterizing the uniformity of neighbors around reference trees:

$$W_i = \frac{1}{4} \sum_{j=1}^{4} z_{ij}, \quad \text{where } z_{ij} = \begin{cases} 1 & \text{if angle } \alpha < \alpha_0 \\ 0 & \text{otherwise} \end{cases}$$

W values of 0, 0.25, 0.50, 0.75, and 1.00 represent very uniform, uniform, random, clumped, and very clumped distributions, respectively. W reflects the community-level distribution pattern.

(3) Mingling Index (M)

The mingling index expresses species mixing degree or spatial isolation, calculated as the proportion of the four nearest neighbors that differ in species from the reference tree:

$$M_i = \frac{1}{4}\sum_{j=1}^{4} v_{ij}, \quad \text{where } v_{ij} = \begin{cases} 1 & \text{if neighbor } j \text{ is different species from reference tree } i \\ 0 & \text{otherwise} \end{cases}$$

M values of 0, 0.25, 0.50, 0.75, and 1.00 represent zero, weak, moderate, strong, and very strong mingling, respectively. M reflects community-level species mixing.

Forest Stand Spatial Structure Index (FSSI) quantitatively evaluates natural forest spatial structure status and dynamics (Dong et al., 2013):

$$\text{FSSI} = \frac{(100 - \bar{U}) \times 2 + (100 - |\bar{W} - 50| \times 2) + \bar{M}}{3}$$

where $0 \leq \text{FSSI} \leq 100$, $0 \leq M \leq 100$, $0 \leq U \leq 100$, $0 \leq W \leq 100$. Higher FSSI values indicate more ideal stand structure, with FSSI = 100, $M = 100$, $U = 0$, and $W = 50$ representing the ideal state.

Forest Stand Spatial Structure Distance (FSSD) quantifies the trend of actual stand structure approaching or deviating from the ideal structure point (Dong et al., 2013):

$$\text{FSSD} = \sqrt{(100 - \bar{M})^2 + \bar{U}^2 + (\bar{W} - 50)^2}$$

where $0 \leq \text{FSSD} \leq 150$. Smaller FSSD values indicate more ideal stand structure, with $M = 100$, $U = 0$, and $W = 50$ yielding the minimum FSSD of 0, representing the shortest distance from actual to ideal stand structure.

1.6 Maturity Classification

Maturity specifically refers to different communities within the same successional stage. Diameter and height distributions play crucial roles in community structure formation and succession. Under conditions of good natural regeneration and small average DBH and height, larger proportions of medium-large diameter and middle-upper layer trees indicate better community development, more distinct diameter and height structure differentiation, more efficient resource utilization (light, temperature, soil nutrients), and faster progression to the next successional stage. During early and mid-succession, non-spatial structure indices (diversity indices) increase with succession (Wang, 2003; Han et al., 2021; Zhang et al., 2021), while spatial structure indices show that natural forests evolve toward uneven-aged, very strongly mixed, randomly distributed communities with superior structure and greater stability over long-term natural regeneration and succession (Zhang et al., 1999; Ma et al., 2013; Wang et al., 2019; Yuan et al., 2022). Consequently, FSSI gradually increases while FSSD decreases, indicating progressive optimization of actual stand structure toward the ideal.

This study combined stand spatial and non-spatial structure analyses, ranking maturity of the four communities based on general patterns observed during forward succession. Specifically, larger proportions of medium-large diameter and middle-upper layer trees, higher diversity indices, greater FSSI, and smaller FSSD indicate higher community maturity.

1.7 Data Processing

SPSS 22.0 was used for one-way ANOVA and LSD multiple comparison tests on DBH, height, and α-diversity data. For non-normal or heteroscedastic data, non-parametric Kruskal-Wallis one-way ANOVA with multiple comparisons was applied. R 4.1.2 with the vegan package (Dixon, 2003) calculated species-area curves and α-diversity indices, while the forestSAS package (Chai, 2016) computed stand spatial structure parameters. OriginPro 2021 generated bar charts.

2.1 Basic Vegetation Characteristics and Community Structure of Different Monsoon Forest Communities

Community B exhibited the highest stem density at 11,558 stems$\cdot$ha^{-1}, significantly greater than the other three communities, but its mean DBH was significantly lower than communities A, C, and D. Additionally, B had the highest proportion of small-diameter individuals , indicating an earlier successional stage. Conversely, while D had relatively high stem density, its proportions of medium and large-diameter trees were markedly higher than other communities, suggesting greater maturity and differentiation of some dominant individuals.

All communities showed maximum individual counts in the 2 cm diameter class, with B having substantially more 2 cm individuals than others. Only D contained some individuals exceeding 30 cm DBH. All four communities displayed a clear inverse-J diameter distribution, indicating adequate sapling recruitment and good natural regeneration but scarcity of large-diameter trees, placing them in stable growth stages [Figure 2: see original paper].

Community D’ s mean height did not differ significantly from A but was significantly higher than B and C, while C’ s mean height significantly exceeded B’

s. Most individuals across all four communities occupied the lower forest layer, though D had more individuals in middle and upper layers, followed by A, C, and B , confirming D' s more advanced successional status.

2.2 Species Composition and Importance Values of Different Monsoon Forest Communities

Community A contained 57 tree species belonging to 32 families and 49 genera, with dominant families including Euphorbiaceae, Sapotaceae, Lauraceae, Araliaceae, and Theaceae. Community B comprised 59 species (35 families, 53 genera) dominated by Sapotaceae, Theaceae, Iteaceae, Araliaceae, and Lauraceae. Community C had 69 species (36 families, 57 genera) with Euphorbiaceae, Lauraceae, Araliaceae, Guttiferae, and Theaceae as dominant families. Community D contained 99 species (38 families, 68 genera) dominated by Fagaceae, Lauraceae, Theaceae, Sapotaceae, and Myrtaceae .

The top ten dominant species by importance value in each community are shown in . Relative frequency differences among dominant species were minor, with distribution patterns falling into three categories: (I) large DBH but low abundance, (II) small DBH but high abundance, and (III) moderate DBH and abundance. In community A, the top four species showed large importance value variation while the remaining six were similar. *Sinosideroxylon wightianum* and *Schefflera heptaphylla* exhibited pattern I, while *Camellia cuspidata* showed pattern II. In B, importance values varied substantially except for *Machilus foonchewii* and *Microdesmis caseariifolia. Sinosideroxylon wightianum*, *Itea chinensis*, *Schefflera heptaphylla*, and *Engelhardia roxburghiana* displayed pattern I, with *Camellia cuspidata* maintaining pattern II. In C, *Schefflera heptaphylla* was distinctly dominant, followed by *Microdesmis caseariifolia*, *Machilus foonchewii*, *Garcinia oblongifolia*, and *Macaranga sampsonii* as secondary dominants. *Schefflera heptaphylla* showed pattern I, *Microdesmis caseariifolia* pattern II, and the remaining seven species pattern III. In D, *Engelhardia roxburghiana*, *Lithocarpus corneus*, and *Lithocarpus glaucus* were the top three dominants, with seven other species showing relatively gradual importance value changes. *Engelhardia roxburghiana* exhibited pattern I, while *Syzygium rehderianum*, *Sinosideroxylon wightianum*, and *Elaeocarpus nitentifolius* showed pattern II.

2.3 α-Diversity Comparison Among Different Monsoon Forest Communities

Shannon-Wiener indices ranked D > C > A > B, Simpson indices D > A > C > B, and Pielou evenness indices D > A > C > B. Communities A and C showed very similar values across all three indices. Community D had the highest species richness with the most uniform individual distribution. Community A had the lowest species richness but the second-most uniform distribution. Despite having the second-highest species richness, community C ranked third in distribution uniformity. Community B had low species richness and the most uneven distribution .

2.4 Spatial Structure Characteristics of Different Monsoon Forest Communities

Mean DBH dominance ratios were similar across all four communities (0.49-0.51), indicating minimal size differences between reference trees and neighbors and an overall moderate growth status. Mean uniform angle indices exceeded 0.5 in all communities, suggesting slight aggregation, with D showing the lowest aggregation degree. Mean mingling indices differed significantly, with D showing very strong mingling while others showed moderate to strong mingling, indicating highest species isolation and lowest conspecific aggregation probability in D. FSSI and FSSD results showed D most advanced toward ideal stand structure, followed by A, C, and B .

2.5 Comprehensive Maturity Comparison Among Different Monsoon Forest Communities

Based on successional patterns, rankings of basic community characteristics, diversity, and spatial structure consistently showed D > A > C > B , establishing D as the most mature community, followed by A, C, and B.

3.1 Changes in Non-Spatial Structure Characteristics with Maturity in E' huangzhang Monsoon Forests

Studying community characteristics and stand structure across different maturity levels within the same successional stage enhances understanding of community development status and successional direction. All four communities in this study occupy early or mid-successional stages with single forest layers dominated by lower-layer and small-diameter trees. Moderate mean dominance ratios indicate substantial development potential for both DBH and height (Yuan et al., 2022). Pioneer species such as *Hancea hookeriana* and light-demanding species including *Engelhardia roxburghiana*, *Schefflera heptaphylla*, *Homalium phanerophlebium*, and *Macaranga sampsonii* dominate upper layers, while shade-tolerant species like *Machilus thunbergii* and *Syzygium rehderianum* in D have low importance values and remain underdeveloped. Despite D' s highest maturity, it has not yet reached the climax stage where shade-tolerant species become dominant (Zhang et al., 1999). Therefore, all four communities will continue short-term succession with light-demanding species as primary dominants.

Unlike tropical rainforests, tropical monsoon forests typically have distinct dominant species (Liu et al., 2009). In the least mature community B, the top three species had similar importance values, co-dominating the community. Although *Camellia cuspidata* ranked third in importance value, its primary distribution in the lower canopy with high relative frequency but small basal area limited its influence on successional development (Chen et al., 2019), similar to its role in community A. With increasing maturity, communities A and C developed more distinct dominant species such as *Sinosideroxylon wightianum* and *Schefflera heptaphylla*. In D, *Engelhardia roxburghiana* showed no clear importance value advantage, with low proportions of small-diameter individuals but dominance in large-diameter classes, indicating a declining population structure that will likely be replaced by new dominants during succession (Yuan et al., 2022).

Tropical monsoon forests often occupy habitats with high rock exposure and poor conditions (Liu et al., 2009). Habitat significantly influences species composition (Lü et al., 2021), while dominant species determine community habitat characteristics. During succession, hydrothermal conditions improve (Bu, 2013), soil quality increases, and spatial heterogeneity decreases, leading to replacement of barren-tolerant, light-demanding species by fertility-preferring, shade-tolerant species (Chen et al., 2019). In the least mature community B, barren-tolerant pioneers such as *Sinosideroxylon wightianum*, *Itea chinensis*, *Schefflera heptaphylla*, and *Garcinia oblongifolia* colonized and improved site conditions, with characteristics of *Garcinia oblongifolia* and *Engelhardia roxburghiana* indicating preliminary tropical monsoon forest features. In A, dominant species including *Gironniera subaequalis*, *Ardisia quinquegona*, and *Litsea variabilis*—commonly found in moist riparian environments—reflect strong stream influence on species composition, demonstrating adaptation to water-rich conditions (Lü et al., 2021) while moisture stress from streams reduces survival space for flood-intolerant species (Punchi-Manage et al., 2013). With increasing maturity, D' s dominance by the typical monsoon forest species *Engelhardia roxburghiana* and increased importance values of evergreen broadleaf forest species (*Lithocarpus corneus*, *Lithocarpus glaucus*), tropical species (*Syzygium rehderianum*), and fertility-preferring species (*Madhuca pasquieri*) reflect improved habitat conditions and more typical monsoon or evergreen broadleaf forest characteristics, indicating further habitat-driven changes in species composition (Lü et al., 2021).

Species richness indices change during succession. Zhang et al. (2021) found that species richness, Shannon-Wiener, Simpson, and Pielou indices in tree layers gradually increased with succession. Howard & Lee (2003) and Chazdon (2008) suggested that species richness may decline monotonically or peak at mid-succession then stabilize. The four studied communities (30–40 years old) are in early-mid successional stages where increasing species diversity reflects intensified niche occupation and resource utilization (Han et al., 2021), consistent with expected diversity changes during succession. However, community A' s riparian habitat with large gaps provided abundant light and moisture, promoting faster growth of light-demanding seedlings to medium diameter classes (Liang & Ye, 2001), giving A higher maturity than C despite lower species richness and uniformity. Streams also reduced understory seedling survival space, decreasing A' s species richness and distribution uniformity. Xu et al. (2011) demonstrated that Shannon-Wiener index is more sensitive to species richness while Simpson index is more sensitive to evenness, explaining why C' s Shannon-Wiener index exceeded A' s while other indices were lower—attributable to C' s higher species richness.

Diversity indices of E' huangzhang monsoon forests approached or exceeded those of other regional rainforests (Li et al., 2007; Su et al., 2018; Du et al., 2020). Annual precipitation and temperature stability are primary drivers of species diversity, with different biogeographic regions influenced by different environmental factors: topography and temperature stability in southwestern China versus precipitation in southeastern China (Zhang et al., 2016). The Nanshan lowland evergreen broadleaf forest in Guangdong achieves diversity indices exceeding 5.0 due to ancient geological history, old vegetation origins, and stable climate (Xie et al., 1998). E' huangzhang monsoon forests' exceptional rainfall, ancient geological structure, and stable warm-humid climate likely contribute to their high diversity indices by providing refuge for relict species (Wang et al., 2003).

3.2 Changes in Spatial Structure Characteristics with Maturity in E' huangzhang Monsoon Forests

Integrating spatial structure analysis helps reveal forest ecosystem successional patterns and inform structure optimization recommendations. Mingling index indicates species isolation within spatial structure units. This study found increasing mingling with maturity, consistent with most previous research (Zhou et al., 2016). Mao et al. (2019) suggested that during succession, intraspecific competition intensifies due to convergent habitat adaptation and utilization, creating self-thinning that reduces conspecific individuals at close range and promotes dispersed distribution. Compared to tropical rainforests, monsoon forests have higher rock exposure and greater susceptibility to water supply heterogeneity (Lundholm & Larson, 2003). Thus, increasing maturity in E' huangzhang monsoon forests may intensify intraspecific competition for limited dry-season water resources, promoting development of different water-use strategies to alleviate competition (Liu et al., 2016) and increasing community mingling.

Natural forests typically show aggregated distributions in early succession due to seed dispersal and canopy gaps, transitioning toward random distributions as competition intensifies and self-thinning proceeds (Liao, 2007). The four studied communities showed minor differences in uniform angle index, all exhibiting slight aggregation without clear patterns, warranting future research on multi-scale distribution analysis of dominant species (Yuan et al., 2022). Increasing FSSI with maturity indicates enhanced stability. As habitat conditions improve, better-adapted species colonize and develop, enriching community structure and increasing stability (Ma et al., 2013), though gaps remain from ideal spatial structure, indicating suboptimal stability (Peng et al., 2020).

Community D showed substantially higher species diversity, mingling, FSSD, and FSSI than B, with other metrics also exceeding B' s values, demonstrating significant differences and plasticity in diversity and spatial structure across maturity levels (Zhang et al., 2021; Xiang et al., 2022). Research suggests that ideal stands have far more intermediate trees than other dominance classes and fewer suppressed individuals (Zheng, 2014). For climax or major companion species, dominance ratios should be adjusted to $ $0.25 to ensure reference trees face no size-based competition, consolidating their dominant status (Hui, 2013). Clumped or uniform distributions should be adjusted toward random distributions (Zhao et al., 2013). Introducing or supplementing with dominant and shade-tolerant species characteristic of more mature communities could enhance species diversity and promote forward succession (Chen et al., 2019).

In summary, E' huangzhang monsoon forest communities follow general successional patterns, supporting our maturity classification. Maturity classification is crucial for understanding and predicting short-term successional processes. However, this study has limitations in maturity classification methods and plot selection. Future research should incorporate weighting based on index importance, consider environmental factors such as elevation, expand plot areas, and improve community representativeness and spatial coverage.

Conclusion

Comprehensive analysis of basic community characteristics, diversity, and spatial structure revealed a maturity ranking of D > A > C > B. E' huangzhang monsoon forest communities conform to general successional patterns, effectively supporting our maturity classification. Currently, all four communities are in early-mid successional stages with substantial DBH and height development potential. Communities exhibit moderate growth status, slight aggregated distributions, and moderate to very strong species mingling. As maturity increases, all four communities continue succession with light-demanding species as primary dominants, gradually developing typical characteristics of the regional zonal climax community. Increasing maturity drives higher species diversity, enhanced mingling, optimized spatial structure, and greater stability. Future efforts should strengthen monitoring and protection of this region while conducting extensive vegetation ecology and biodiversity conservation research.

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