Postprint of a Study on Community Characteristics of Castanopsis platyacantha-Schima sinensis in the Wumeng Mountains

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Abstract

Wumeng Mountain is situated in the transitional zone between western semi-humid evergreen broad-leaved forest and eastern humid evergreen broad-leaved forest, representing the only region in Yunnan Province where the Castanopsis platyacantha, Schima sinensis formation occurs. This formation occupies the transition belt from western to eastern evergreen broad-leaved forest in China, exhibiting greater community complexity and diversity. The Castanopsis platyacantha, Schima sinensis community in Wumeng Mountain belongs to the mid-montane humid evergreen broad-leaved forest of Yunnan, but shows closer affinity to the eastern humid evergreen broad-leaved forest, rendering its distribution patterns and community characteristics scientifically significant. To achieve a deeper understanding of this formation' s community characteristics and elucidate its relationships with eastern humid evergreen broad-leaved forest, this study conducted quantitative classification of this community type and analyzed the characteristics of dominant tree and shrub species (diameter class structure, height structure, and importance values) for each clustered community type. Additionally, DCA, CCA, and DCCA ordination analyses were employed to provide environmental interpretation of community characteristic differentiation. Finally, comparative analysis was performed with similar communities in Emei Mountain, Sichuan. The results demonstrated: (1) The Castanopsis platyacantha, Schima sinensis community in Wumeng Mountain can be classified into six types: Castanopsis platyacantha community, Castanopsis platyacantha–Schima sinensis community, Castanopsis platyacantha–Dipentodon sinicus community, Fagus longipetiolata–Schima sinensis–Castanopsis platyacantha community, Schima sinensis–Lithocarpus hancei community, and Dipentodon sinicus–Schima sinensis community. (2) In the Castanopsis platyacantha, Schima sinensis community of Wumeng Mountain, Castanopsis

platyacantha exhibits a relatively high proportion of large trees, Schima sinensis demonstrates a substantial number of small seedlings, and the shrub layer is frequently dominated by bamboo species. (3) Elevation, slope, and annual solar radiation represent the dominant factors influencing community distribution. (4) In similar communities of Emei Mountain, dominant species populations display stable or increasing patterns, whereas in the Castanopsis platyacantha, Schima sinensis community of Wumeng Mountain, Castanopsis platyacantha and Fagus longipetiolata exhibit declining population characteristics.

Full Text

Preamble

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Abstract

Wumeng Mountain is located in the transitional zone between western semi-humid evergreen broad-leaved forest and eastern humid evergreen broad-leaved forest in China. It represents the only region in Yunnan where the *Castanopsis platyacantha–Schima sinensis* formation occurs, marking the westernmost distribution of this community type. This formation belongs to Yunnan' s mid-montane humid evergreen broad-leaved forest, yet it more closely resembles eastern humid evergreen broad-leaved forest, making its distribution patterns and community characteristics scientifically significant. To better understand these community features and their relationship with eastern humid evergreen broad-leaved forests, we conducted numerical classification of 26 plots based on canopy and shrub layer species composition. We analyzed the dominant tree and shrub species in each clustered group using diameter class structure,

height structure, and importance values. Environmental interpretation of community differentiation was performed through Detrended Correspondence Analysis (DCA), Canonical Correspondence Analysis (CCA), and Detrended Canonical Correspondence Analysis (DCCA). Finally, we compared these communities with similar ones from Emei Mountain.

The results showed that: (1) The *C. platyacantha–S. sinensis* forest in Wumeng Mountain can be classified into six types: *C. platyacantha* forest; *C. platyacantha–S. sinensis* forest; *C. platyacantha–Dipentodon sinicus* forest; *Fagus longipetiolata–S. sinensis–C. platyacantha* forest; *S. sinensis–Lithocarpus hancei* forest; and *D. sinicus–S. sinensis* forest. (2) These communities are characterized by a high proportion of large *C. platyacantha* trees, abundant *S. sinensis* seedlings, and bamboo species dominating the shrub layer. (3) Elevation, slope, and annual solar radiation are the dominant factors influencing community distribution. (4) While dominant species populations in similar Emei Mountain communities exhibit stable or increasing trends, *C. platyacantha* and *F. longipetiolata* populations in Wumeng Mountain show declining characteristics.

Keywords: Wumeng Mountain; *Castanopsis platyacantha–Schima sinensis* community; cluster analysis; ordination analysis

Introduction

China harbors the most extensive and diverse evergreen broad-leaved forests in the world. Yunnan' s evergreen broad-leaved forests, profoundly influenced by the southwest monsoon and plateau topography, share close affinities with yet exhibit significant differences from those in eastern China. Mid-montane humid evergreen broad-leaved forest represents a major vertical vegetation belt in Yunnan' s mountainous regions, occurring primarily in the Ailao, Wuliang, Zhenkang Daxue, Gaoligong, and central-northern Wumeng mountains. Unlike Yunnan' s zonal semi-humid evergreen broad-leaved forest and monsoon evergreen broad-leaved forest, this vegetation subtype is characterized by its "humid" nature and belongs to the western montane *Lithocarpus* cluster within western typical evergreen broad-leaved forest.

The Wumeng Mountain National Nature Reserve lies in northeastern Yunnan at the edge of the Sichuan Basin, precisely within the transition zone from western semi-humid to eastern humid evergreen broad-leaved forest. The primary vegetation type falls under Jin Zhenzhou' s classification of "mid-montane humid evergreen broad-leaved forest," but differs from similar forests in Wuliang Mountain, Gaoligong Mountain, Ailao Mountain, and Lancang River Reserve. Wumeng Mountain represents the only region in Yunnan where *C. platyacantha* and *S. sinensis* dominate the evergreen broad-leaved forest, marking the westernmost distribution edge of this community type in China.

The *C. platyacantha–S. sinensis* community is widely distributed in Hubei,

Chongqing, Guizhou, and Sichuan, serving as a transitional type between western and eastern evergreen broad-leaved forests with mixed floristic characteristics. It constitutes one of the most important subtropical evergreen broad-leaved forest types in Sichuan. In Yunnan, it occurs in Daguan, Yongshan, Yiliang, and Zhenxiong counties in northeastern Yunnan, reaching up to 2,300 m in elevation. While documented in *Yunnan Vegetation*, previous data proved insufficient for the compilation of *Chinese Vegetation Chronicles*. This study therefore conducted extensive investigations to reveal community characteristics and environmental differentiation patterns through numerical classification, ordination, and dominant species population structure analysis, with comparative analysis against Emei Mountain communities to provide theoretical guidance for conservation management.

Study Area

Wumeng Mountain National Nature Reserve is located in Zhaotong City, northeastern Yunnan, at the junction of Yunnan, Guizhou, and Sichuan provinces. Spanning Daguan, Yiliang, Yanjin, Yongshan, and Weixin counties, the reserve covers 26,186.65 ha and comprises three sections: Sanjiangkou, Chaotianma, and Haiziping. Geographically, it lies between 103°51 47 -104°45 04 E and 27°47 35 -28°17 42 N. The reserve protects subtropical humid evergreen broad-leaved forest ecosystems, rare and endangered endemic species and their habitats, and representative wetland types of the Yunnan-Guizhou Plateau.

The terrain is rugged with slopes averaging around 20°, featuring deeply to moderately incised mid-montane landscapes. Mean annual temperature ranges from 11 to 18 °C, with annual precipitation between 1,000–1,300 mm (higher in the north and on windward slopes). Sunshine duration is approximately 1,000 hours annually (about 25% sunshine rate), with a frost-free period of 210–220 days. As a major corridor for cold air from the Sichuan Basin into Yunnan under the control of the Kunming quasi-stationary front, Wumeng Mountain' s climate differs from most of Yunnan, characterized by low light, frequent rainy days, high humidity, and distinct but mild dry seasons.

Methods

Plot Location

Based on literature records and data from local forestry bureaus, we conducted field surveys of typical *C. platyacantha–S. sinensis* communities in Yiliang County (Shanyangping, Gaomuqiao, Henghetou), Daguan County (Luohanba, Sanjiangkou, Xiaoyanfang vicinity), and Zhenxiong County (Shoujiapingzi, Changbaluohan). A total of 26 plots (400–900 m^2 each) were established between 103°55 -104°42 E and 27°24 -28°15 N. Plot details are provided in .

Plot Setup and Recording

Using the minimum area method according to specific terrain conditions, we established 400–900 m^2 plots and recorded slope, aspect, elevation, and geographic coordinates. For trees 1.3 m height, we measured basal diameter, DBH, crown width, height, and bole height; individuals <1.3 m were recorded in the shrub layer. Shrubs and herbs were surveyed in four 2 m × 2 m subplots at each plot corner, recording species height and clump diameter. Specimens were collected for all plots, with unidentified species taken to the laboratory for identification.

Relative Basal Area (RBA)

RBA was calculated as: RBA = (sum of basal area for a species) / (sum of basal area for all species in tree and shrub layers). Trees were defined as individuals 1.3 m height, shrubs as <1.3 m. For shrubs, basal diameter was categorized as 0.5 cm for heights 0.5 m and 1 cm for heights >0.5 m.

Community Clustering

Hierarchical classification was performed using the SYN-TAX2000 software. This method progressively merges plots from the bottom up according to specific rules until termination criteria are met. A community data matrix was constructed with plot numbers as rows and species RBA values as columns, then analyzed to produce a dendrogram.

DBH Structure, Height Structure, and Importance Value

Based on clustering results, we calculated RBA for tree and shrub layers in each group. For the top three dominant tree species in each group, we analyzed DBH and height class structures. For shrub layer dominants, we calculated importance values.

(1) DBH Structure: Following the 1960 Forest Survey Methods (Draft), when stand mean DBH 12 cm, Class I includes trees 4 cm DBH, and Class VII includes trees >24 cm DBH (units: stems · ha ^{1}).

(2) Height Structure: Based on plot conditions, five height classes were defined: 1.3 m, 1.3–8 m (inclusive), 8–12 m (inclusive), 12–16 m (inclusive), and >16 m (units: stems · ha ^{1}).

(3) Importance Value: The three species with highest RBA were selected as shrub layer dominants. Importance Value = (Relative Density + Relative Frequency + Relative Dominance)/3, where Relative Density = species stem count/total stem count, Relative Frequency = plots where species occurs/total plots, and Relative Dominance = species RBA/sum of all species RBA.

Ordination Analysis

Ordination was performed using Canoco for Windows 4.5. DCA was conducted on the RBA matrix. Environmental variables (elevation, slope, aspect) were combined with soil moisture saturation, soil stability (extracted from 1:50,000 DEM raster data), and annual solar radiation values to create an environmental matrix for CCA and DCCA analyses.

Results

Community Clustering

Using species RBA values from tree and shrub layers across 26 plots, hierarchical clustering in SYN-TAX2000 produced six groups at dissimilarity values from 0.35 to 0.65 [Figure 1: see original paper].

HA1: *Castanopsis platyacantha* forest (plots 516, 519, 546, 524, 528, 511, 523, 527, 540, 513, 514)

HA2: *C. platyacantha–S. sinensis* forest (plots 518, 541, 526, 529)

HA3: *C. platyacantha–Dipentodon sinicus* forest (plot 517 only)

HA4: *Fagus longipetiolata–S. sinensis–C. platyacantha* forest (plots 521, 548)

HA5: *S. sinensis–Lithocarpus hancei* forest (plots 510, 539, 538, 537, 542, 520)

HA6: *D. sinicus–S. sinensis* forest (plots 525, 515)

Dominant Species Analysis

Tree layer RBA values for the six community types are shown in , with shrub layer dominant species RBA in .

All six community types were dominated by either *C. platyacantha* or *S. sinensis*, though *F. longipetiolata* (in HA4) and *D. sinicus* (in HA6) occasionally exceeded them. Other frequently occurring tree species with high RBA included *L. hancei*, *Symplocos anomala*, *S. heishanensis*, *Lithocarpus oblanceolatus*, *Acer oliverianum*, *Acanthopanax evodiaefolius* var. *gracilis*, *Rehderodendron macrocarpum*, *Rhododendron coeloneurum*, *Litsea pungens*, *Lyonia ovalifolia*, *Camellia pitardii*, *Acer franchetii*, *Symplocos phyllocalyx*, and *Ilex franchetiana*.

Shrub layer analysis revealed that *Qiongzhuea tumidinoda*, *Disporum cantoniense*, and *Chimonobambusa quadrangularis* dominated five community types, either singly or in combination. In HA3, *Litsea rubescens* was absolutely dominant with no bamboo present. Other common shrubs included *A. oliverianum*, *Hydrangea davidii*, *Illicium majus*, *S. sinensis*, *C. platyacantha*, *Lithocarpus variolosus*, *Camellia pitardii*, *Symplocos anomala*, *Litsea pungens*, *Cerasus patentipila*, and *Daphne feddei*. Seedlings of *S. sinensis* and *C.*

platyacantha occurred in four community types, with *S. sinensis* showing slightly higher RBA.

DBH Structure of Dominant Tree Species

DBH structure of the top three dominant species in each community type is shown in [Figure 2: see original paper].

C. platyacantha showed highest numbers in DBH Class VII, minimal representation in Class II, and moderate presence in Classes I and III–VI. *S. sinensis* was most abundant in Class I (approaching 600 stems · ha ^{1} in HA5), with relatively few individuals in other classes. *Symplocos anomala* concentrated in Classes II–VI, absent from Classes I and VII. *A. oliverianum*, *L. hancei*, and *Juglans cathayensis* all peaked in Class I with few larger individuals. *F. longipetiolata* showed low numbers across all classes in HA2 but peaked in Class VII in HA4. *D. sinicus* was most abundant in Class IV with few individuals in other classes.

Height Structure of Dominant Tree Species

Height structure of the top three dominants is presented in [Figure 3: see original paper].

C. platyacantha showed an overall increasing trend from low to high strata, with the greatest numbers >16 m. *S. sinensis* was most abundant as seedlings 1.3 m, with relatively uniform distribution across other height classes. *A. oliverianum*, *L. hancei*, and *J. cathayensis* all peaked in the 1.3 m class, though *J. cathayensis* lacked individuals >16 m. *F. longipetiolata* showed low seedling numbers but relatively high abundance in other classes, peaking at 1.3–8 m. *D. sinicus* was concentrated below 12 m, with maximum representation at 1.3–8 m.

Importance Value Analysis of Shrub Layer Dominants

RBA and importance values of shrub layer dominants are shown in [Figure 4: see original paper].

RBA and importance values were positively correlated. Except for HA3, bamboo species dominated the shrub layer, either singly or in mixed assemblages. When co-dominant, the advantage among species was relatively small; when single-dominant, bamboo superiority was more pronounced. In bamboo-free HA3, *L. rubescens* was clearly dominant.

DCA Ordination Analysis

DCA of 26 plots yielded eigenvalues of 0.773, 0.462, 0.284, and 0.185 for the first four axes. The large eigenvalues for axes 1 and 2 indicate they contain substantial ecological information. The two-dimensional ordination [Figure 5: see original paper] shows clear gradient separation along axis 2, reflecting environmental relationships among plots. Axis 1 represents a moisture gradient (wet

to dry from left to right), while axis 2 represents temperature (elevation), with increasing altitude and decreasing temperature from bottom to top. Elevation thus emerged as the primary factor influencing community distribution, with DCA results consistent with clustering patterns. Plots 515 and 525 represent secondary communities associated with disturbance.

CCA Ordination Analysis

CCA, a unimodal-model-based ordination method, simultaneously displays plots, species, and environmental factors [Figure 6: see original paper]. Arrow length indicates the relative influence of environmental factors on distribution, while the cosine of the angle between arrows and axes represents correlation strength.

Results show elevation as the most influential factor, followed by slope and annual solar radiation, with aspect having minimal effect. Elevation showed the strongest correlation with axis 1, slope with axis 2. Plot projections onto the elevation axis revealed clear gradients: HA5 occupied the highest elevations, while HA1 occurred at lowest elevations overall. HA1 plots were generally on steeper slopes, whereas HA5 (*S. sinensis–L. hancei* forest) occupied gentler terrain. HA6 represented secondary habitats with relatively open canopies and higher solar radiation. CCA results aligned with clustering patterns while more clearly revealing relationships between communities and environmental factors.

DCCA Ordination Analysis

DCCA combines detrending methods from DCA with canonical analysis, removing arch effects. Analysis of plots and environmental factors [Figure 7: see original paper] showed similar results to CCA, with elevation as the primary factor, followed by slope and solar radiation. However, plot separation was less distinct than in CCA.

Discussion

The *C. platyacantha–S. sinensis* community in Wumeng Mountain is classified as mid-montane humid evergreen broad-leaved forest in *Yunnan Vegetation*, but its geographic distribution and species composition more closely resemble eastern humid evergreen broad-leaved forest, suggesting it can be considered a humid evergreen broad-leaved forest type. Comparative analysis with Emei Mountain communities reveals both connections and distinctions across climate, classification, and population structure.

Climate Comparison

With mean elevation around 2,000 m, we selected Zhenxiong County (representing Wumeng Mountain) and Emei City for climatic comparison using data

from the China Meteorological Data Network [Figure 8: see original paper]. The areas differ by approximately 500 m in elevation. While mean annual temperatures are similar, Wumeng Mountain' s monthly mean temperatures never drop below 0 °C, whereas Emei Mountain falls below 0 °C in December through March. Emei Mountain receives more than double the annual precipitation of Wumeng Mountain, though both concentrate rainfall in summer.

Community Classification

Based on existing studies of Emei Mountain *C. platyacantha–S. sinensis* communities, we performed cluster analysis using tree layer coverage data from 10 plots [Figure 9: see original paper]. Emei Mountain communities divided into three main types: (1) *C. platyacantha–S. sinensis* forest (plots 10, 9, 8, 7); (2) *C. platyacantha* forest (plots 6, 5, 1); and (3) *S. sinensis* forest (plots 4, 2, 3).

Compared with Emei Mountain, Wumeng Mountain communities show greater diversity in dominant tree species and more pronounced community differentiation, likely reflecting their position in the transition zone between western and eastern evergreen broad-leaved forests.

Dominant Species Population Comparison

As the fundamental unit of community structure, population dynamics reflect development trends. Combining all Wumeng Mountain communities, the height and DBH structures of four main tree populations are shown in [Figure 10: see original paper].

Height Structure: Wumeng Mountain *S. sinensis* populations concentrate in the 1.3 m seedling class, while Emei Mountain populations peak at 6–22 m, though both have some large trees >16 m. Wumeng Mountain *C. platyacantha* populations concentrate at 12–16 m, whereas Emei Mountain shows bimodal distribution at 4 m and 16 m. The other Wumeng Mountain dominants (*F. longipetiolata* and *D. sinicus*) concentrate at 1.3–8 m, with *D. sinicus* lacking trees >16 m. Emei Mountain' s other dominants (*Symplocos caudata* and *Dendrobenthamia capitata*) show most individuals at 2–6 m and up to 16 m, respectively.

DBH Structure: Wumeng Mountain *S. sinensis* represents a typical increasing population, while Emei Mountain' s *S. sinensis* shows increasing or stable trends. Wumeng Mountain *C. platyacantha* peaks in DBH Class VII, indicating a declining population, whereas Emei Mountain' s *C. platyacantha* shows increasing or stable populations. Wumeng Mountain *F. longipetiolata* is declining, while *D. sinicus* is increasing/stable. Emei Mountain' s *S. caudata* is stable, *Camellia pitardii* is increasing, and *D. capitata* and *Cinnamomum longepaniculatum* may be increasing or stable.

In summary, Wumeng Mountain *C. platyacantha* populations show declining characteristics with many large trees, while *S. sinensis* shows increasing trends

with abundant seedlings. In contrast, both species in Emei Mountain exhibit increasing or stable population structures.

Conclusions

The *C. platyacantha–S. sinensis* communities in Wumeng Mountain exhibit the following characteristics:

1. **Community Diversity:** Compared with other regions, Wumeng Mountain shows high diversity in *C. platyacantha–S. sinensis* forest types, classifiable into six distinct types. The tree layer mixes evergreen and deciduous species, with abundant large *C. platyacantha* trees and numerous *S. sinensis* seedlings. Bamboo dominance in the shrub layer reflects humid habitat conditions.
2. **Environmental Drivers:** Elevation, slope, and annual solar radiation are the primary factors controlling community distribution patterns.
3. **Population Dynamics:** Compared with Emei Mountain communities, Wumeng Mountain' s dominant species populations show declining trends for *C. platyacantha* and *F. longipetiolata*, while Emei Mountain dominants exhibit stable or increasing populations.

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