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Endangered *Taxus wallichiana* var. *wallichiana*—Its Forest Characteristics, Population Structure, and Regeneration Status in Yunnan, Southwestern China

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Abstract: The survival of relict *Taxus wallichiana* var. *wallichiana* (Yunnan yew) is threatened by overexploitation for its quality wood and medicinal properties, particularly for taxol extraction. Understanding the current status of its communities and populations is crucial for protecting existing natural forest resources. We established 53 vegetation plots in Yunnan, southwestern China, where *T. wallichiana* var. *wallichiana* is the primary dominant species. These plots were classified into four forest types. The forests were multi-stratified, with *T. wallichiana* var. *wallichiana* frequently dominating the subcanopy and shrub layer. Species diversity indices did not significantly differ among the four forest types. The age structure of *T. wallichiana* var. *wallichiana* exhibited a multi-modal pattern, with a maximum age of 1165 years. Growth was slow, with an average radial growth rate of 0.78 mm/year. Despite its strong sprouting ability, the species had a poor seedling/sapling bank and suffered from inadequate regeneration. Its seedlings/saplings are shade-intolerant. This study provides a scientific basis for effective conservation strategies, emphasizing the need for in situ regeneration to ensure the survival of *T. wallichiana* var. *wallichiana* and its contributions to biodiversity and ecosystem services.

Keywords: *Taxus wallichiana* var. *wallichiana*; forest type; community structure; age structure; growth trend; natural regeneration; conservation

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1. Introduction

Taxus is a genus of Taxaceae, commonly known as yews. *Taxus* species are considered relict plants, with fossils discovered in the USA, China, the Czech Republic, Romania, and Belgium, dating from the early Cretaceous to the Holocene (in the review of [1]). Approximately nine species are found in the Northern Hemisphere, with three species (*Taxus wallichiana*, *T. cuspidate*, and *T. fuana*) occurring in China [2]. *Taxus wallichiana* var. *wallichiana*, also known as Yunnan yew or Himalayan yew (formerly referred to as *Taxus yunnanensis*, *Taxus chinensis* var. *yunnanensis*, *Taxus baccata* subsp. *wallichiana*, *Taxus wallichiana* subsp. *yunnanensis*, and *Taxus baccata* var. *wallichiana*), is an evergreen coniferous tree or, rarely, a shrub. It is currently scattered in limited localities in SW China (Yunnan, SE Tibet, and SW Sichuan), Bhutan, N India, N Myanmar, Sikkim, and S Vietnam [2]. *T. wallichiana* var. *wallichiana* has its distribution center in NW Yunnan, China. It is mainly found on the slopes of the Gaoligong Mountains, along the middle and upper reaches of the Nujiang River, the upper reaches of the Lancang River, and the upper reaches of the Jinsha

River, all within the Hengduan Mountain System. This species typically grows in isolated populations in shady mountain ravines, on cliffs, and on the middle and upper slopes of shady mountains, including partial-shady slopes and valleys. It thrives in shaded and moist habitats, often as a subcanopy tree within various forest communities. *T. wallichiana* var. *wallichiana* demonstrates strong adaptability to a range of soil types, including mountain red soils, valley alluvial soils, forest brown soils, gray-brown soils, and limestone gravel soils [3–5]. It can live for over a thousand years and is regarded as a "sacred tree" by local ethnic minorities.

Taxus wallichiana var. *wallichiana* is highly valued for its taxol content, which is used in cancer treatments [6,7]. In addition to its medicinal use, the wood of the Yunnan yew is prized for its durability and aesthetic appeal. It is commonly employed in construction for beams, doors, and windows, and its beautiful red color makes it a popular choice for decorative purposes [8]. The high demand for both its medicinal and economic benefits has led to increased pressures on this species. In recent decades, the forest landscape in western and northwestern Yunnan has become increasingly fragmented due to the construction of reservoir dams, roads, and highways. Logging for construction materials and farm tools, along with the harvesting of bark and foliage for taxol extraction, has severely impacted the distribution and survival of *T. wallichiana* var. *wallichiana*. In some areas, natural resources are nearing exhaustion, further endangering the species. *Taxus wallichiana* var. *wallichiana* is listed as endangered on the IUCN Red List [9] and is classified as a first-class protected plant in China. Additionally, the species is highly vulnerable to the impacts of climate change, which may significantly reduce its current climatic range [10,11].

Previous research on *Taxus wallichiana* var. *wallichiana* has primarily focused on its genetics [12,13], chemical compositions [7,14], development and reproduction [15], seed dormancy mechanisms [16], and effect of climate change on its distribution range [10,17]. However, understanding the characteristics of its natural communities, populations, and regeneration status is crucial for its conservation, utilization, and restoration. Despite this importance, demographic and ecological studies on its forest stands and wild populations throughout its distribution range in Yunnan are very limited [5,18,19]. There is a lack of comprehensive knowledge about the communities and population dynamics of this valuable species. Studying the communities of a threatened species can help identify its interactions with other species and its role in habitat provision [20–23]. Analyzing the population structure of a threatened species, including age and size distribution, can reveal the species' resilience and adaptability to environmental changes, such as human and natural disturbances and habitat fragmentation [20]. Examining the age or size structure of populations of a threatened species can provide insights into the dynamics and regeneration of the populations [24–29]. In addition, examining the growth trends/patterns of an endangered species can help to understand its viability and provide insights into its population dynamics [30].

In this context, the objectives of this study are as follows: (1) investigate forest stands where *Taxus wallichiana* var. *wallichiana* is the primary dominant species throughout Yunnan Province; (2) analyze community characteristics; (3) clarify population structure; (4) examine growth trends and patterns of *T. wallichiana* var. *wallichiana*; and (5) assess the species' regeneration status. The goal is to address concerns about the species' long-term persistence and to provide a scientific basis and recommendations for developing effective conservation strategies.

2. Materials and Methods

2.1. Study Areas

We made extensive efforts to locate forest communities where *Taxus wallichiana* var. *wallichiana* was a primary dominant species across its entire distribution range in Yunnan, SW China. We established 53 plots in 26 locations across 7 prefectures and 14 counties in south-central, western, and northwestern Yunnan (Figure 1). Detailed plot locations and environmental characteristics are provided in Supplementary Table S1.

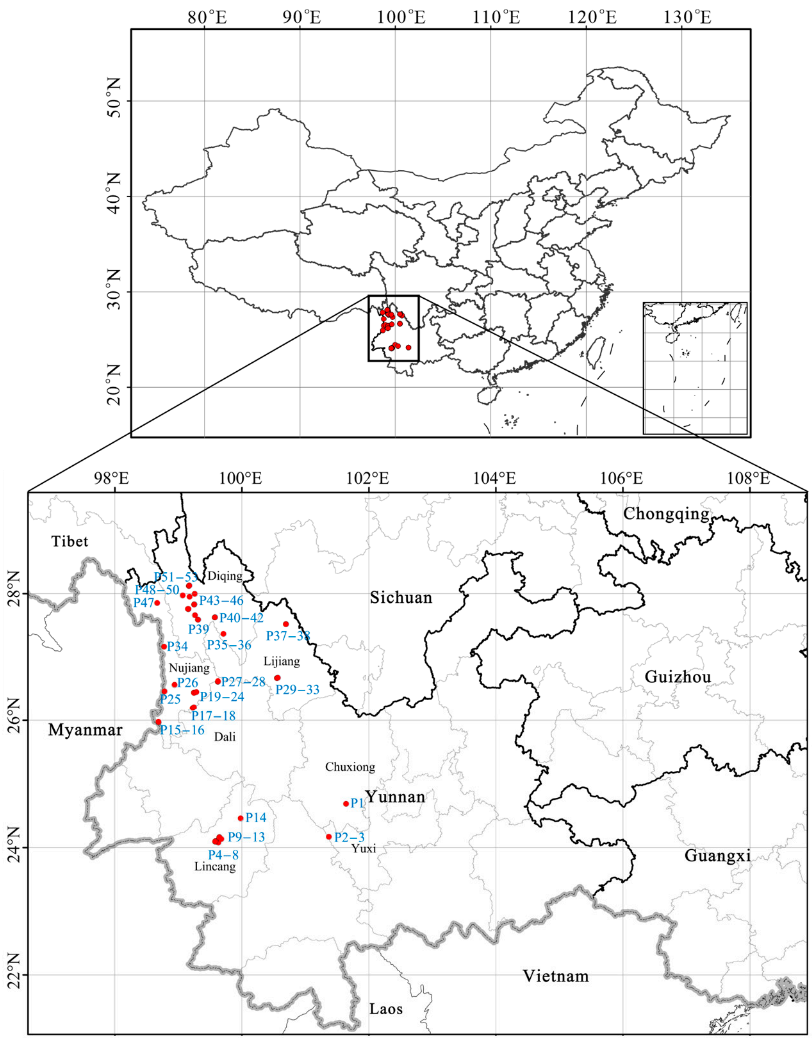

Figure 1. Study areas and plot locations in Yunnan, SW China.

The climate of the study areas is predominantly influenced by the Indian Ocean monsoon during the summer. For the plot sites, the annual mean temperature ranges from 0.1 °C to 19.6 °C. The mean temperature of the warmest month, July, varies from 6.1 °C to 24.1 °C, while the mean temperature of the coldest month, January, ranges from −6.2 °C to 12.7 °C. Annual mean precipitation ranges from 770 mm to 1363 mm, and evapotranspiration ranges from 356 mm to 883 mm. The moisture index ranges from 0.8 to 1. These data for the plot sites were extrapolated from observed data collected over 50 years (1950–2000) from local climatological stations.

2.2. Species

Taxus wallichiana var. *wallichiana* typically grows to a height of 10–20 m and can reach up to 1 m in diameter at breast height. The leaves are linear, dark green on the upper surface, and paler underneath. The bark is reddish-brown and flakes off in thin strips. This species is dioecious; male cones are small and spherical, while female cones are modified into berry-like structures known as arils, which turn red when mature [2]. Trees in their native habitat usually start producing seeds after about 15 years, and even trees over 200 years old can still flower and produce seeds. However, the natural seed-setting rate is very low, with significant annual and individual variation in seed production. In natural populations, male trees are much more common than female trees, with females being about one-third as frequent as males, leading to fewer seed-bearing plants (Fu and Fang, 1994). Generally, flowering occurs from March to April, while fruiting takes place from

August to October of the following year. Seed dispersal is by gravity, as well as by birds and rodents [31].

Taxus wallichiana var. *wallichiana* contains physiologically active compounds with anticancer properties, such as taxol, which is used in the treatment of leukemia and tumors. Its fruit aril is rich in over 20 aromatic compounds, making it a valuable source for extracting premium aromatic oils and extracts [32].

2.3. Data Collection and Analyses

We established 53 plots, covering a total area of 21,300 m^2, across 26 locations in Yunnan Province to study various *Taxus wallichiana* var. *wallichiana*-primarily dominated plant communities. Plot sizes ranged from 10 m $\times$ 10 m to 30 m $\times$ 20 m, chosen based on the smallest area needed to capture the maximum number of species and the accessibility of the terrain. Each plot was divided into 10 m $\times$ 10 m subplots. Within each plot, all woody individuals at least 1.3 m tall were identified to species level, numbered, tagged, and measured for diameter at breast height (DBH) and height. We also recorded general plot information, including slope position, altitude, slope exposure, slope inclination, and human disturbance history. Woody stems ($\geq$1.3 m tall) in the overstory were categorized into two layers based on their vertical position and height: the arboreal layer (height $\geq$ 5 m) and the shrub layer (1.3 m $\leq$ height < 5 m). The arboreal layer was further divided into canopy (height $\geq$ 15 m) and subcanopy (5 m $\leq$ height < 15 m) sublayers. All woody species in the understory less than 1.3 m tall were identified, counted, and measured for height and percent cover. Special attention was given to the microhabitats of *Taxus wallichiana* var. *wallichiana* seedlings. Forest stratification was analyzed by examining the frequency distribution of height classes for woody species (height $\geq$ 1.3 m).

In each plot, we established five 1 m $\times$ 1 m squares for investigating herbaceous taxa in the understory. These squares were positioned at the four corners and the center of each subplot. Herbaceous taxa were identified, and the coverage and number of individuals of each species were recorded.

For floristic features, the distribution types of seed plant families and genera were classified using Wu's system [33,34].

Increment core samples were collected from 31 *Taxus wallichiana* var. *wallichiana* trees with varying diameters at breast height (DBHs) in the study plots. From each tree, a single increment core was taken 1.3 m above ground level. Based on tree ring analysis of saplings with a height of 1.3 m, it was estimated that the time from the 1.3 m position to ground level was approximately twelve years. This twelve-year period was added to the ages obtained from the increment cores. Tree ages were determined using the WinDENDRO tree ring analysis software (Regent Instruments Inc., Canada). We derived a linear equation to correlate age and DBH: $y = 6.3923x + 10.895$ ($R^2 = 0.7899$, $n = 31$) (Supplementary Figure S1). Using this equation, we estimated the ages of *Taxus wallichiana* var. *wallichiana* trees in the study plots based on their DBH values. To provide a detailed and informative view of the age structure, we determined that 5-year intervals are appropriate for age classes, even though *Taxus wallichiana* var. *wallichiana* typically takes 15 years to produce fruit and has a long lifespan. Tree ring analysis also allowed us to determine ring widths, and we calculated the average ring width for each year to represent growth rates.

To measure species abundance, we used the relative importance value (RIV) for overstory species, calculated as (Relative density + Relative basal area)/2, and for understory species, calculated as (Relative density + Relative coverage)/2 [35]. Plant communities were classified using a floristic similarity dendrogram with Relative Euclidean distance and Ward's Method [36]. The communities were named according to the dominant species in the overstory, with shared dominant species connected by "-". The diversity of woody species (height $\geq$ 1.3 m) for each forest plot was assessed using species richness (i.e., number of species), the Shannon–Wiener diversity index (H′), Pielou's evenness index, and Simpson's diversity index (D) [37,38].

3. Results

3.1. Floristic Feature, Forest Types, Stratification and Species Diversity

In 53 sample plots, we identified a total of 88 families, 192 genera, and 358 species of vascular plants. This includes 72 families, 168 genera, and 317 species of angiosperms; 3 families, 7 genera, and 12 species of gymnosperms; and 13 families, 17 genera, and 29 species of ferns. Among the seed plants, there were 29 families and 56 genera with tropical components, representing 55.8% of the families and 36.4% of the g enera. Conversely, 23 families and 98 genera had temperate components, making up 44.2% of the families and 63.6% of the genera (Supplementary Table S2). Genera, being lower taxonomic units compared to families, exhibit more distinct taxonomic features and better reflect the ecological characteristics of the study area and its evolutionary geographic elements. Therefore, the flora in *Taxus wallichiana* var. *wallichiana* forests shows a predominance of temperate elements.

A cluster analysis of the 53 sample plots revealed that, at a floristic similarity level of approximately 48%, the communities could be classified into four distinct forest types (see Figure 2A). The stratification of woody species (height $\geq$ 1.3 m) in each community, including the canopy, subcanopy, and shrub layers, is illustrated in Figure 2B.

Type 1: *Taxus wallichiana* var. *wallichiana—Tsuga dumosa* evergreen coniferous forest, found along riversides, steep slopes, outcrop-rich sites, gullies, and limestone habitats, at elevations ranging from 2522 to 3313 m. Numerous individuals of *Taxus wallichiana* var. *wallichiana* are concentrated in the subcanopy and shrub layers, co-dominating with *Tsuga dumosa* in the subcanopy. The maximum height of *T. dumosa* reached 33 m. A few *Betula albosinensis* individuals were present, along with some *Rhododendron annae* in the subcanopy and shrub layers.

Type 2: *Taxus wallichiana* var. *wallichiana* evergreen coniferous forest, occurring along riversides, steep slopes, cliffs, gullies, and outcrop-rich limestone habitats, at elevations of 2478 to 3256 m. *T. wallichiana* var. *wallichiana* was abundant and dominant in the subcanopy and shrub layers. *Myrsine semiserrata* and *Quercus spinosa* were also present in the shrub layer. Few trees reached heights $\geq$ 20 m, with rare individuals of *Schima wallichiana*, *Picea brachytyla* var. *complanata*, etc., reaching 20–35 m. Sprouting of *T. wallichiana* var. *wallichiana* was evident, particularly in areas of past human disturbance. In the understory, which was dominated by the bamboo *Fargesia pleniculmis* in several locations, not a single seedling or sapling of *T. wallichiana* var. *wallichiana* was found.

Type 3: *Taxus wallichiana* var. *wallichiana—Abies ernestii* var. *salouenensis* evergreen coniferous forest, found on mountain slopes, in outcrop-rich sites, and along riversides at elevations of 2613 to 3080 m. *T. wallichiana* var. *wallichiana* dominated the subcanopy and shrub layers, while co-dominant *Abies ernestii* var. *salouenensis* reached heights of 10–25 m. Accompanying species include *Acer oliverianum* and *Rhododendron annae*.

Type 4: *Taxus wallichiana* var. *wallichiana—Quercus spinosa* evergreen coniferous and broad-leaved mixed forest, occurring in gullies, steep slopes, cliffs, and limestone habitats, at elevations of 3067 to 3338 m. *T. wallichiana* var. *wallichiana* dominated the subcanopy and shrub layers, while *Quercus spinosa* mainly occupied the canopy, accompanied by *Tsuga dumosa* and *Lithocarpus craibianus*. Overall, *Quercus spinosa* co-dominated with *T. wallichiana* var. *wallichiana* in the community.

The representative forest profiles of each type are shown in Figure 3A–D, and the representative forests and their habitats in Figure 4A–F.

It is evident that the four forest types are heterogeneous, exhibiting different species compositions, dynamics, and complex structures. Populations of *Taxus wallichiana* var. *wallichiana* grow in these heterogeneous forest stands and habitats (Figures 2A,B, 3A–D and 4A–F).

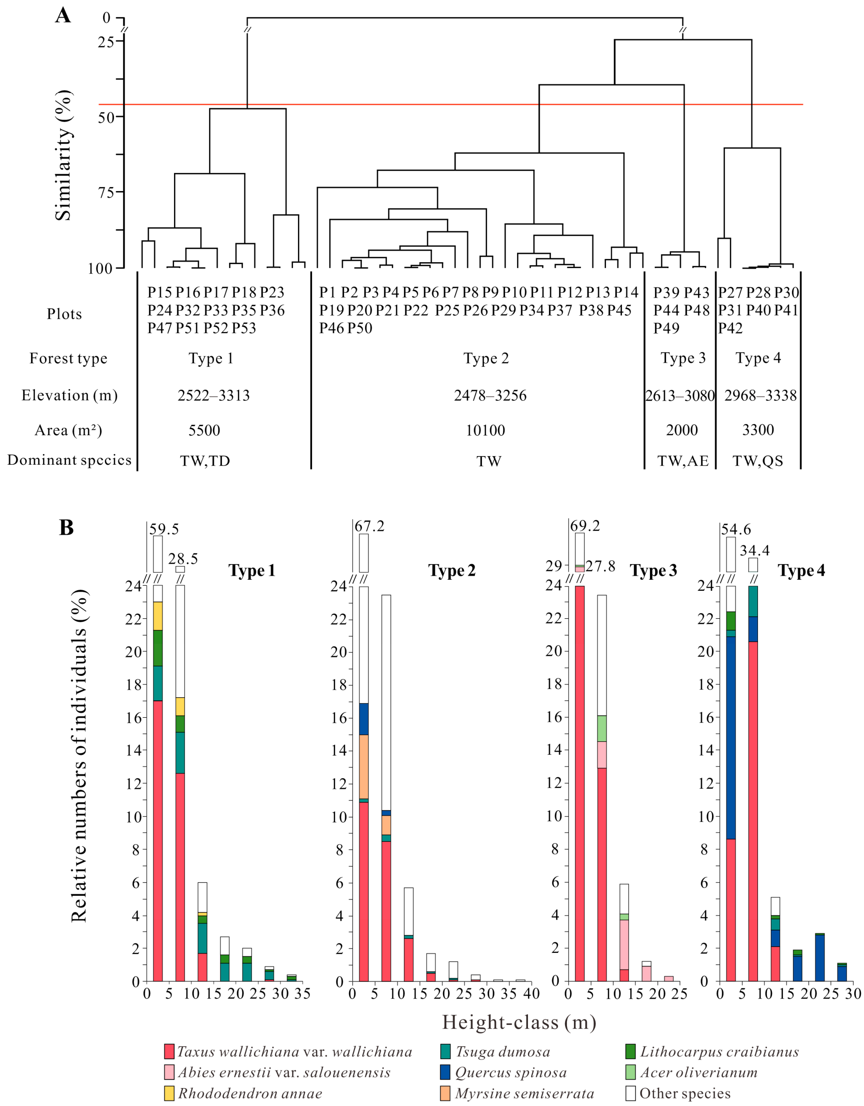

Figure 2. Cluster analysis and height-class frequency distribution of woody species (height ≥ 1.3 m). (**A**) Cluster analysis of the 53 plots. (**B**) Height-class frequency distribution for each forest type. TW: *Taxus wallichiana* var. *wallichiana*; TD: *Tsuga dumosa*; Ae: *Abies ernestii* var. *salouenensis*; QS: *Quercus spinosa*. Type 1: *Taxus wallichiana* var. *wallichiana*—*Tsuga dumosa* evergreen coniferous forest. Type 2: *Taxus wallichiana* var. *wallichiana* evergreen coniferous forest. Type 3: *Taxus wallichiana* var. *wallichiana*—*Abies ernestii* var. *salouenensis* evergreen coniferous forest. Type 4: *Taxus wallichiana* var. *wallichiana*—*Quercus spinosa* evergreen coniferous and broad-leaved mixed forest.

Among the four forest types, the average number of woody species (ranging from 11 to 14), as well as the Shannon–Wiener diversity (1.765–1.981), Pielou's evenness (0.739–0.803), and Simpson's diversity (0.757–0.797) indices, showed no statistically significant differences ($p < 0.05$) (Figure 5).

The species composition for each forest type is presented in Supplementary Tables S3–S5.

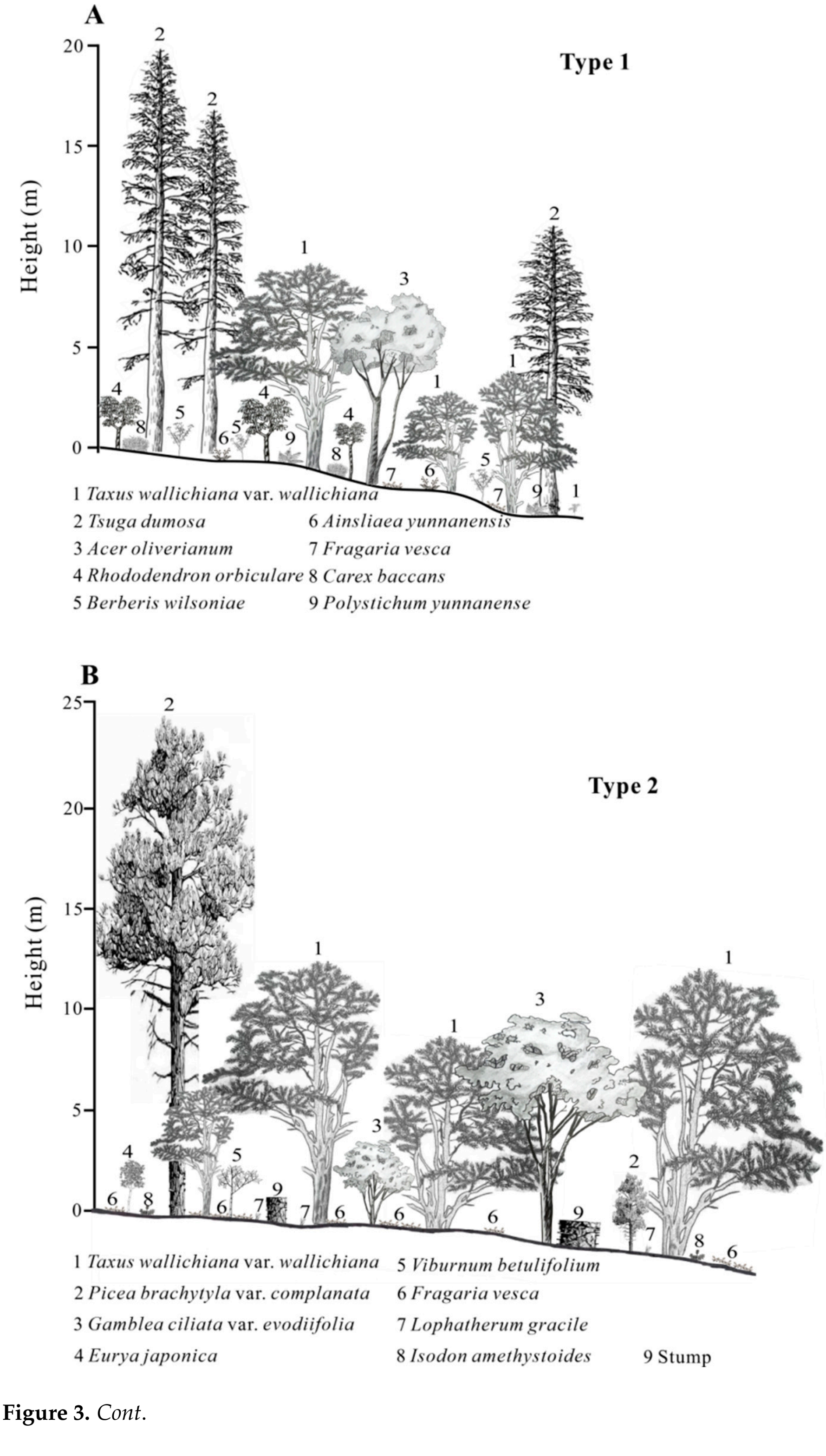

Figure 3. *Cont*.

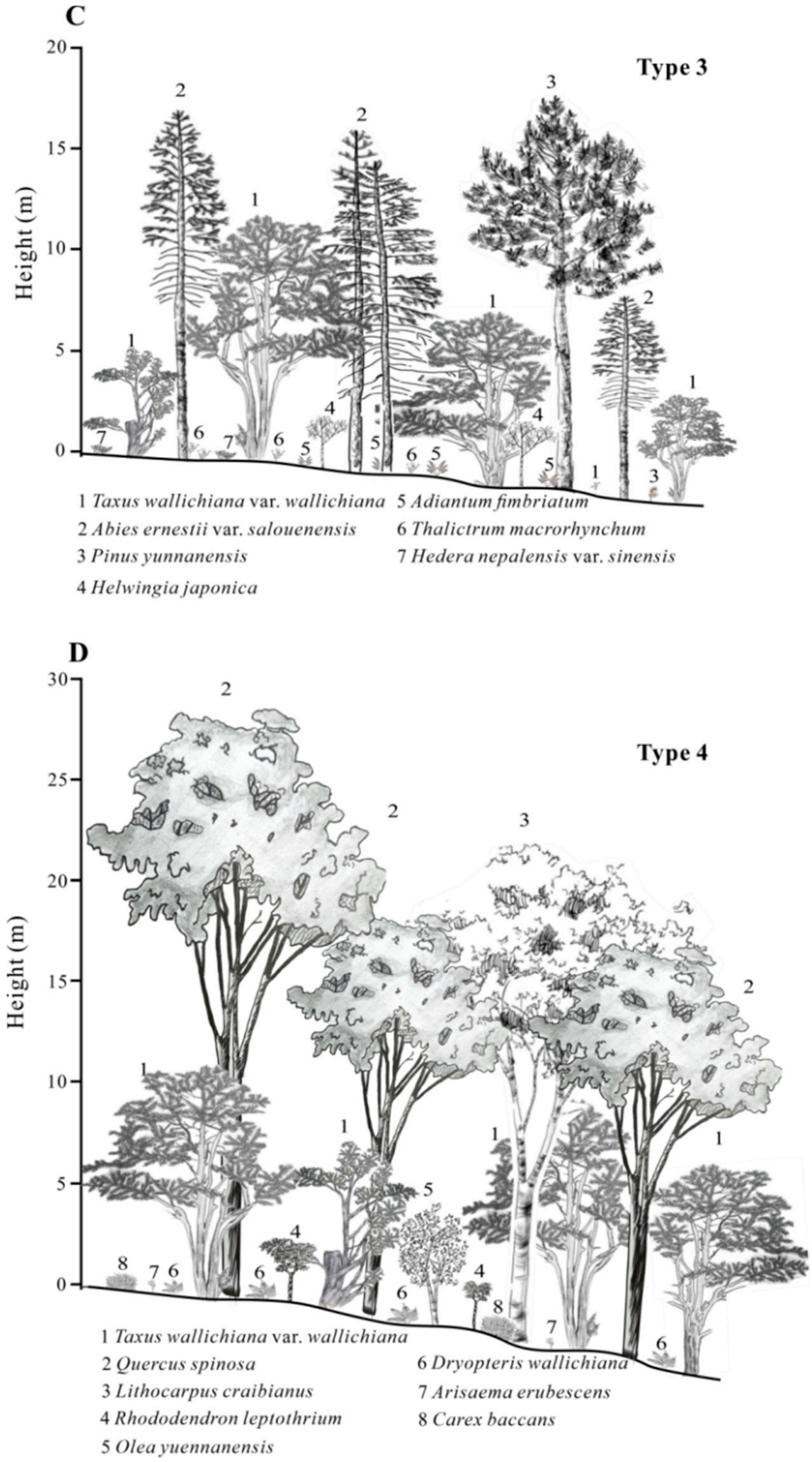

Figure 3. Representative forest profile of each forest type. (**A**) *Taxus wallichiana* var. *wallichiana—Tsuga dumosa* evergreen coniferous forest (Type 1) at 2964 m a.s.l. in Kenacun, Tachengxiang, Deqing County, Yunnan Province; (**B**) *Taxus wallichiana* var. *wallichiana* evergreen coniferous forest (Type 2) at 3213 m in Fuhecun, Lajing Zhen, Lanping County, Yunnan Province. (**C**) *Taxus wallichiana* var. *wallichiana—Abies ernestii* var. *salouenensis* evergreen coniferous forest (Type 3) at 2613 m a.s.l. in Shirongcun, Xiruoxiang, Deqing County, Yunnan Province; (**D**) *Taxus wallichiana* var. *wallichiana—Quercus spinosa* evergreen coniferous and broad-leaved mixed forest (Type 4) at 3192 m in Haohuiwencun, ShunzhouZhen, Yongsheng County, Yunnan Province.

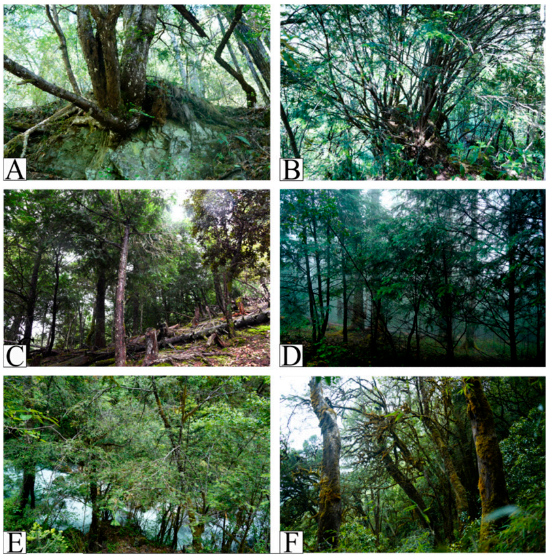

Figure 4. *Taxus wallichiana* var. *wallichiana* and its representative forest stands and habitats. (**A**) A *T. wallichiana* var. *wallichiana* tree with a lot of sprouts growing in limestone habitat; (**B**) Sprouts of a *T. wallichiana* var. *wallichiana* stump; (**C**) A *T. wallichiana* var. *wallichiana* forest with some logged *T. wallichiana* var. *wallichiana* trees; (**D**) A *T. wallichiana* var. *wallichiana* forest on an upper slope; (**E**) A *T. wallichiana* var. *wallichiana* forest by a streamside; (**F**) A *T. wallichiana* var. *wallichiana* forest on a steep slope.

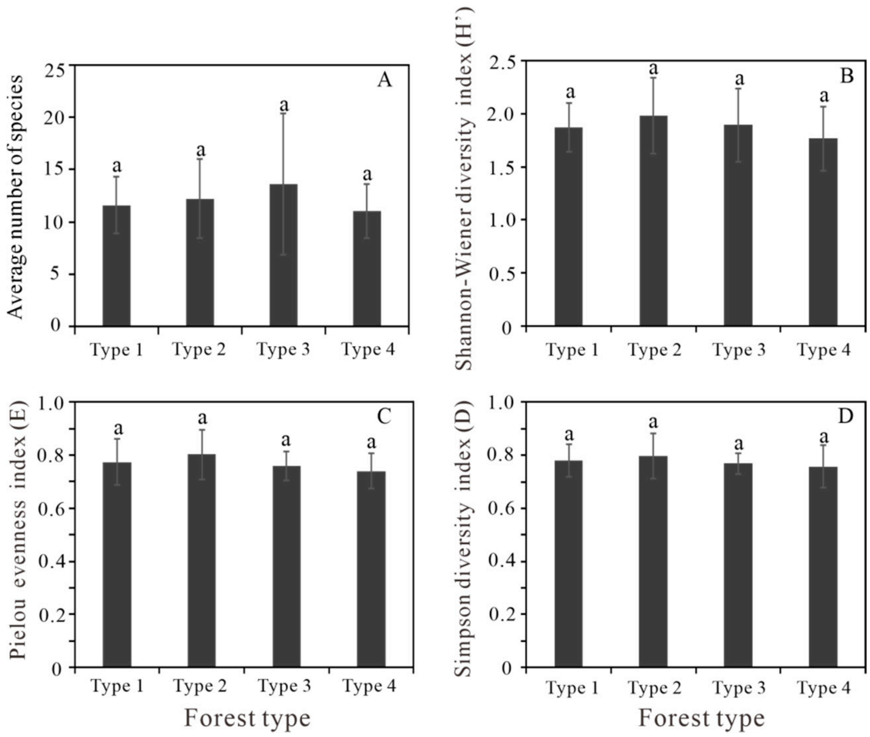

Figure 5. Diversity of woody species (height $\geq$ 1.3 m) in each forest type. (**A**) Average number of species in each forest type; (**B**) Shannon–Wiener diversity index in each forest type; (**C**) Pielou evenness index in each forest type; (**D**) Simpson diversity index in each forest type. Forests sharing the same letters do not differ significantly according to the non-parametric Kruskal–Wallis all-pairwise comparisons test ($p < 0.05$). Bars represent standard deviation.

3.2. Population Structure

The age–class frequency distribution of *Taxus wallichiana* var. *wallichiana* in each forest type shows a multi-modal pattern, with very few individuals younger than 20 years (Figure 6). Across all four forest types, the population of *T. wallichiana* var. *wallichiana* had the highest number of individuals in the 35–40-year age range, followed by the 105–110 and 90–100 year ranges. The maximum age recorded was 1165 years.

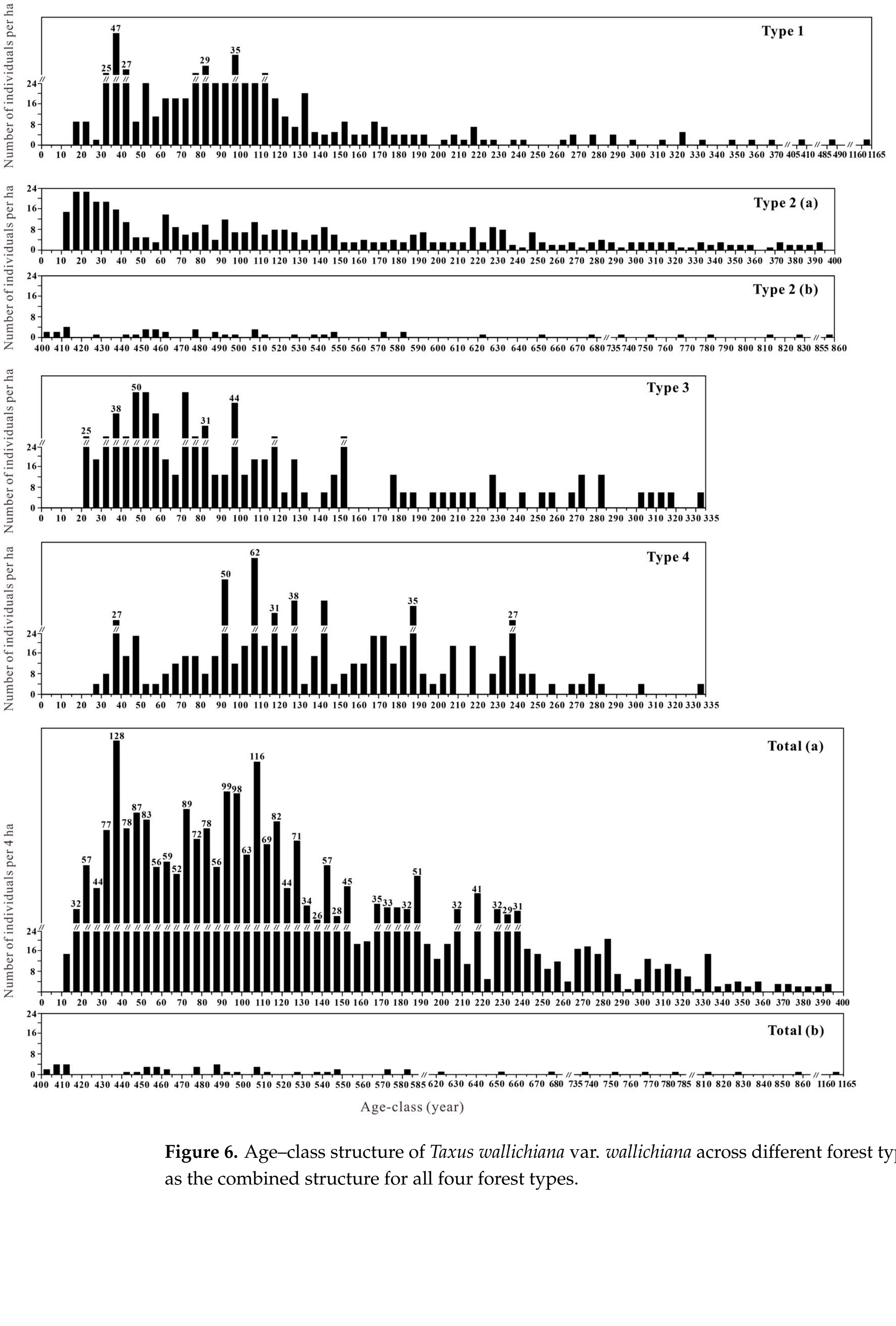

Figure 6. Age–class structure of *Taxus wallichiana* var. *wallichiana* across different forest types, as well as the combined structure for all four forest types.

3.3. Growth Trends

The average annual ring width growth of *Taxus wallichiana* var. *wallichiana* was 0.78 mm/year. Overall, there was a decreasing trend in growth, though it fluctuated with age (Figure 7A). To better understand how growth rates changed with age and analyze differences in growth trends over time, ring width growth was plotted for three age groups: 12–130 years, 130–240 years, and 240–312 years (Figure 7B). The annual ring width growth fluctuated significantly in the 12–130 and 130–240-year age groups. In the 240–312-year age group, the growth rate was relatively more stable, with smaller fluctuations compared to the younger age groups. Generally, trees in the younger age groups (12–130 and 130–240 years) exhibited faster growth than those in the 240–312-year age group; that is, the closer to the present, the faster the ring growth (Figure 7B).

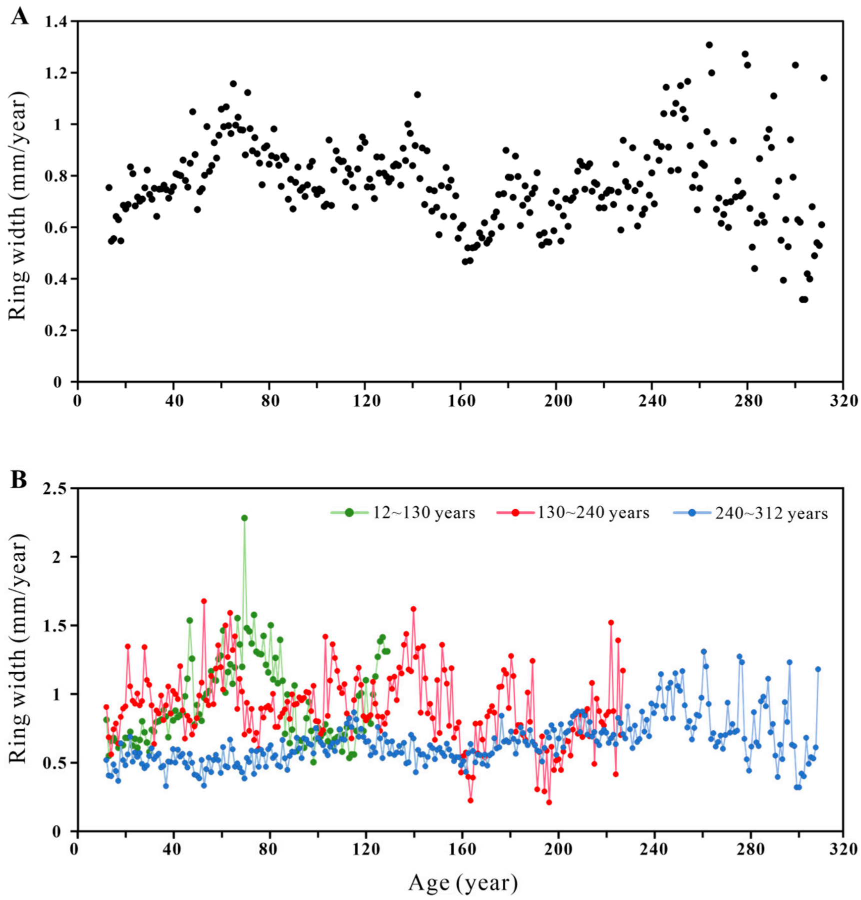

Figure 7. Growth trends of *Taxus wallichiana* var. *wallichiana* trees (height ≥ 1.3 m). (**A**) Changes in ring width with age. (**B**) Ring width for trees in three age groups (12–130, 130–240, and 240–312 years).

3.4. Regeneration Status

Only a small number of *Taxus wallichiana* var. *wallichiana* seedlings were found under forest canopies, in forest gaps, along roadsides, and in rock crevices. The seedlings were mostly concentrated in the 0–30 cm height class. As seedling height increased to 90 cm, the number of seedlings in the 30–60 cm and 60–90 cm height classes decreased in all micro-habitats. Relatively more seedlings (height ≥ 90 cm) were established in forest gaps (Figure 8). However, due to the small number of seedlings, statistical analysis was not possible. Notably, no seedlings or saplings were found in areas of the understory with high bamboo coverage.

Sprouting was also a mode of regeneration for *Taxus wallichiana* var. *wallichiana*. The proportion of sprouts to main stems was 28.7%, indicating a strong sprouting ability.

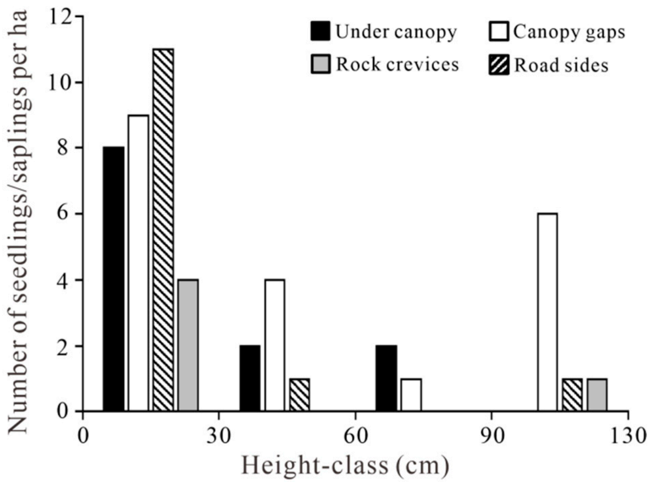

Figure 8. Variation in the density of seedlings and saplings of *Taxus wallichiana* var. *wallichiana* across different height classes in various micro-habitats.

4. Discussion

4.1. Habitats, Growth and Regeneration

Table 1 compares the habitats and forest characteristics of *Taxus wallichiana* var. *wallichiana* with other *Taxus* species worldwide. Based on our results, *T. wallichiana* var. *wallichiana* grows along ravines, on steep slopes and cliffs, in gullies, and in limestone areas at elevations ranging from 2450 to 3350 m. It is commonly found with associated species such as *Tsuga dumosa*, *Abies ernestii* var. *salouenensis*, *Picea brachytyla* var. *complanata*, *Acer oliverianum*, *Betula albosinensis*, *Quercus spinosa*, and *Rhododendron annae* in temperate coniferous or mixed coniferous and broad-leaved forests. These forests are typically located on shady and semi-shady slopes, with some occurrences on sunny sites and low-lying areas. In moist areas at elevations of 2800 to 3100 m, *T. wallichiana* var. *wallichiana* can grow into trees with a median height of 10–15 m, developing a prominent main trunk and becoming a dominant species in the subcanopy layer. In drier conditions, it is often found mixed with *Pinus yunnanensis*, various species of *Quercus*, *Rhododendron*, and *Vaccinium*, typically as shrubs 2–5 m tall.

Compared to *T. cuspidata* in northern China, *T. baccata* in Europe, *T. brevifolia* in North America, and *T. globosa* in Mexico, *T. wallichiana* var. *wallichiana* has a higher altitudinal distribution. However, all five *Taxus* species generally thrive better in humid habitats than in dry ones. They typically appear as trees or small trees in humid conditions and as shrubs in drier habitats.

T. wallichiana var. *wallichiana* and *T. baccata* are often found on steep slopes, cliffs, and in limestone areas, whereas the other three species are rare in these habitats. *T. wallichiana* var. *wallichiana* seedlings and saplings are shade intolerant, though young and mature trees are shade tolerant. In contrast, the other four species are generally shade tolerant throughout their life stages, although *T. baccata* can also withstand full sun. In the canopy and subcanopy layers, *T. wallichiana* var. *wallichiana*, *T. baccata*, and *T. globosa* are commonly associated with conifers, and both evergreen and deciduous broad-leaved trees, while *T. cuspidata* associates with conifers and deciduous broad-leaved trees, and *T. brevifolia* mainly associates with conifers [22,39–44].

Table 1. General characteristics of *Taxus wallichiana* var. *wallichiana* compared with other species of *Taxus* worldwide.

Species	Distribution Region	Height (m)	DBH (cm)	Age (Year)	Major Habitats and Elevations	Shade Tolerance	Major Associated Species as Examples	Source
T. wallichiana var. *wallichiana*	a	2–15 (38)	5–50 (190)	42–299 (1125)	Steep slopes, ravines, gullies, and limestone habitat at ca. 2450–3350 m a.s.l	Shade-intolerance for seedlings/saplings, shade tolerance for young and mature trees	*Tsuga dumosa*, *Abies ernestii* var. *salouenensis*, *Acer oliverianum*, *Quercus spinosa*, *Betula albosinensis*, *Picea brachytyla var. complanata*, *Lithocarpus craibianus*, *Rhododendron annae*, *Myrsine semiserrata*, etc.	This study
Taxus cuspidata	b	9–20 (28)	20–60 (280)	(961)	Hills and mountain slopes with high humidity at 100–1600 m a.s.l.	Tolerance, but can withstand full sun	*Pinus koraiensis*, *Tilia amurensis*, *Picea jezoensis*, *Abies nephrolepis*, *Acer ukurunduense*, etc.	[44–47]
Taxus baccata	c	6–20 (40)	5–135 (400)	800–1000 (4000)	Ravines, cliffs, and limestone habitat at 320–2000 m a.s.l.	Tolerance	*Fagus sylvatica*, *Corylus avellana*, *Ilex aquifolium*, *Vaccinum myrtillus*, *Fraxinus excelsior*, *Betula alba*, *Quercus petraea*, *Juniperus communis*, *Pinus nigra* ssp. *salzmanii*, *Quercus pubescens*, *Sorbus aria*, etc.	[20,22,28,29,42, 43,47–49]
Taxus brevifolia	d	15 (26)	50 (148)	350–650	Moist flats, slopes, deep ravines, and coves, 0–2200 m a.s.l.	Tolerance	*Abies grandis*, *Thuja pli-cata*, *Tsuga heterophylla*, *Pseudotsuga menziesii*, etc.	[39,47,50]
Taxus globosa	e	ca. 15	ca. 60–80	NA	Shady sites, roadsides, 1300–3000 m	Tolerance	*Pinus pseudostrobus*, *Pinus ayacahuite*, *AbiesGuatemalensis*, *Arbutus xalapensis*, *Quercus crassifolia*, *Q. germana*, *Tilia Mexicana*, *Meliosma dentata*, *Abies religiosa*, *Abies guatemalensis*, *Ostrya virginiana* *Liquidambar styraciflua*, *Cornus discifloral*, etc.	[40,41,47]

Common ranges of variables are presented with maximum values in parentheses. a. Yunnan, SE Tibet, W Sichuan, the Himalayan region, and S Vietnam; b. N Korea, NE China, Japan, SE Russia; c. Türkiye, Europe, Caucasia regions, and Morocco; d. USA and Canada; e. Mexico and northern Central America.

T. wallichiana var. *wallichiana* exhibits slow growth, with an average radial growth rate of 0.78 mm/year, and has a long lifespan, reaching approximately 1165 years at an elevation of 2523 m in Gongshan, northwestern Yunnan. In comparison, the oldest living *Taxus cuspidata* tree in China is 961 years old (as reported in 2012, previously 949 years old) and grows at an elevation of 950 m in Laoyeling, Jilin, NE China [45]. *Taxus baccata* is assumed to have reached 4000 years old in England [48]. Generally, younger *T. wallichiana* var. *wallichiana* trees grow faster than older trees of the same age, indicating that ring growth has increased over recent decades, possibly due to global warming (Figure 7B).

Although young and mature *T. wallichiana* var. *wallichiana* trees are shade-tolerant, their seedlings and saplings are shade-intolerant. No seedlings or saplings were found in areas with high bamboo coverage in the understory of forests. Seedlings and saplings were primarily located in specific micro-habitats such as steep slopes, cliffs, crevices, stream edges, outcrop sites, and limestone habitats where canopy gaps exist.

The age–class structure reveals a significant lack of young *T. wallichiana* var. *wallichiana* trees, suggesting a continuing population decline (Figure 6). The seedling bank is very poor, and current regeneration relies mainly on sprouting.

4.2. Recommendations of Conservation and Management

Conservation and management actions are crucial for preserving the valuable Yunnan yew and its forests. First, to address factors hindering Yunnan yew regeneration, it is essential to reduce the bamboo coverage of *Fargesia pleniculmis* in Zhongshan Cun, Yongkang Zhen, Youngde County, to promote the establishment and growth of *T. wallichiana* var. *wallichiana* seedlings and saplings, as they are shade-intolerant at these stages. Second, although illegal logging has significantly decreased under current protection measures, some issues persist. Local villagers have established beekeeping farms around the forests, particularly at around 3014 m a.s.l. in Muhuashan, Xiaruo Xiang, and continue to practice understory grazing at approximately 3038 m a.s.l. in Kenacun, Dachengxiang, Deqin County, NW Yunnan. This indicates a lack of protection awareness. To address this, it is crucial to enhance awareness through education, protect native habitats, implement grazing controls, delineate grazing areas scientifically, and focus on the supervision and protection of *T. wallichiana* var. *wallichiana* forest plots. Third, given the species' strong sprouting ability, developing vegetative propagation methods is recommended for ex situ conservation in botanical gardens and nurseries. Fourth, as there are no existing studies on the population genetics of this species, it is suggested to conduct research on genetic variation within and between populations in Yunnan to enhance gene flow. Finally, for sustainable silvicultural management of *T. wallichiana* var. *wallichiana*, a study should be conducted to predict the species' potential distribution areas.

5. Conclusions

Taxus wallichiana var. *wallichiana* is primarily associated with coniferous species of *Tsuga*, *Abies*, and *Pinus*, as well as broad-leaved species of *Quercus*, *Rhododendron*, *Acer*, and *Betula* in the canopy and subcanopy. It is commonly found in the subcanopy and shrub layer. Its forest communities are typically found in moist ravine sites, but it also demonstrates strong adaptability to somewhat drier environments, such as limestone habitats and areas with many outcrops. While *T. wallichiana* var. *wallichiana* is shade-intolerant during the seedling/sapling stage, it becomes shade-tolerant as it matures into the young and adult stages. Despite its slow growth and long lifespan, *T. wallichiana* var. *wallichiana* has extremely poor regeneration. We recommend implementing management strategies to reduce bamboo coverage in the understory and regulate beekeeping and grazing in its native habitats to support in situ regeneration.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d16100642/s1, Figure S1: The relationship of age and DBH of *T. wallichiana* var. *wallichiana*. Table S1: Environmental characteristics of plots in each forest type. LS: Low slope; MS: Middle slope; US: Upper slope. Table S2: Floristic areal types of families and genera of seed plants in the forests. Table S3: Species composition of the arborous layer (height ≥ 5 m) in each forest type. Species with a relative importance value (RIV) ≥ 0.01% are shown. Table S4: Species composition of the shrub layer (5 m > height ≥ 1.3 m) in each forest type. Species with a relative importance value (RIV) ≥ 0.01% are shown. Table S5: Species composition of the herb layer (height < 1.3 m) in each forest type. Species with a relative importance value (RIV) ≥ 0.01% are shown.

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