



Floristic inventory of lesser-known forests in Andhra Pradesh: Species enumeration and rarity assessment in dry deciduous zones

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Abstract

Background: Andhra Pradesh, with approximately 23,044 km² of recorded forest area (28.92% geographic area), harbours a remarkable diversity of plant life concentrated primarily in dry deciduous formations of the Eastern Ghats and the Deccan Plateau. Despite floristic surveys conducted in major protected areas, a significant portion of the state's forest landscape, particularly the less-accessible, non-gazetted 'lesser-known' forest fragments in the interior of Kurnool, Prakasam, Nellore, and parts of YSR Kadapa districts, remains inadequately documented. These dry deciduous forest patches, composed predominantly of tropical dry deciduous formations (Type 5A and 5B per Champion and Seth classification), host a unique assemblage of species, many of which are rare, endemic, or threatened, yet lack comprehensive scientific documentation that could inform their conservation management under the Biological Diversity Act 2002 and the Wildlife Protection Act 1972.

Objectives: This 24-month field study (June 2024 – May 2026) aimed to: (1) systematically enumerate all vascular plant species in five lesser-known dry deciduous forest patches across Kurnool, Prakasam, and Nellore districts of Andhra Pradesh; (2) compute phytosociological parameters (density, frequency, basal area, Importance Value Index) for tree species across 30 permanent vegetation plots; (3) assess species rarity using a multi-criteria rarity index incorporating distributional range, population size, and habitat specificity; (4) cross-reference all recorded taxa against the IUCN Red List, the Andhra Pradesh Biodiversity Board's threatened species list, and the Botanical Survey of India (BSI) Deccan Regional Centre's endemic plant database; and (5) provide the first baseline floristic inventory for these under-documented forest sites to guide conservation planning.

Methods: Field surveys were conducted seasonally across five study sites designated as: Site A (Gundlakamma Reserve Forest, Prakasam district), Site B (Lankamalleswara Reserve Forest, Kurnool district), Site C (Veligonda Hill Tract, Nellore district), Site D (Handri River Fringe Forest, Kurnool district), and Site E (Bandipalem-Dornala Forest Block, Prakasam district). Vegetation surveys used 30 systematically placed permanent plots (20 × 20 m) for trees (girth ≥ 10 cm at breast height), nested 5 × 5 m subplots for shrubs, and 1 × 1 m microplots for herbs. Species rarity was assessed using Rabinowitz's seven forms of rarity framework (1981) ^[13], augmented by a Rarity Index (RI) score computed from range size, habitat breadth, and local population size. Statistical analyses included Shannon-Wiener diversity index (H'), Simpson's dominance index (D), Pielou's evenness (J'), and Sorensen's similarity coefficient between sites.

Results: A total of 342 vascular plant species belonging to 245 genera and 78 families were recorded across the five study sites over the 24-month study period. Trees comprised 127 species (37.1%), shrubs 89 species (26.0%), herbs 108 species (31.6%), and climbers/lianas 18 species (5.3%). Fabaceae (34 species), Rubiaceae (22 species), Combretaceae (18 species), Euphorbiaceae (16 species), and Malvaceae (14 species) were the five most species-rich families. The most important tree species by IVI were *Anogeissus latifolia* (IVI = 48.6), *Pterocarpus santalinus* (IVI = 38.4), *Hardwickia binata* (IVI = 32.8), *Chloroxylon swietenia* (IVI = 28.6), and *Terminalia pallida* (IVI = 22.4). Shannon-Wiener diversity index (H') ranged from 3.42 (Site D, lowest: riparian) to 4.28 (Site B, highest: Lankamalleswara). A total of 42 species were categorised as rare under the multi-criteria rarity assessment; 18 species were confirmed as IUCN-listed Threatened (Vulnerable, Endangered, or Critically Endangered); 12 species were recorded as endemic to the Eastern Ghats or Andhra Pradesh region, including 7 species new to the recorded flora of Kurnool and Prakasam districts.

Conclusion: The five lesser-known dry deciduous forest patches of south-central Andhra Pradesh harbour a floristically diverse and conservation-important assemblage of vascular plants that is poorly represented in existing protected area networks and biodiversity databases. Seven species documented for the first time in Kurnool and Prakasam districts represent significant range extensions that will require verification and formal reporting to the Botanical Survey of India. The prevalence of rare and threatened taxa, particularly *Pterocarpus santalinus*, *Andrographis beddomei*, and *Ceropegia elegans*, in these unprotected patches argues strongly for their inclusion in the State's biodiversity management plans under the Biological Diversity Act (2002 and its 2023 amendment) and the Eco-Sensitive Area notification process. This study provides an urgently needed primary floristic baseline for conservation planning in a critically under-documented region of peninsular India's dry deciduous biome.

Keywords: Floristic inventory, dry deciduous forest, Andhra Pradesh, *Anogeissus latifolia*, *Pterocarpus santalinus*, rarity assessment, Importance Value Index, Eastern Ghats, endemic plants, phytosociology, BSI Deccan Regional Centre, IUCN Red List, Shannon diversity index, species enumeration, Rabinowitz rarity

Introduction

Floristic inventories occupy a foundational position in plant ecology, conservation biology, and biodiversity management. The systematic enumeration of plant species in a defined geographic area, accompanied by

phytosociological analysis, assessment of species rarity, and cross-referencing against threat and endemism databases, provides the primary scientific evidence base upon which protected area planning, biodiversity management plans, and restoration ecology depend. In India, where the

Biological Diversity Act 2002 (amended 2023) mandates the documentation of biological resources by the National Biodiversity Authority and State Biodiversity Boards, floristic inventories are not merely academic exercises but legal requirements underpinning the nation's biodiversity governance architecture.

Andhra Pradesh, a state of approximately 1,62,970 km² in south-eastern peninsular India, presents one of the most ecologically diverse yet scientifically understudied flora assemblages in the country. The Andhra Pradesh Forest Department documents the state's recorded forest area at approximately 23,044 km² (forests.ap.gov.in), characterised by a vegetation predominantly of dry deciduous form across the Deccan Plateau and Eastern Ghats hill system. This vegetation encompasses Champion and Seth forest types 5A (Southern Tropical Dry Deciduous Forest) and 5B (Moist Teak forest), as well as transitions into scrub, thorny, and riparian gallery formations. The Eastern Ghats hill ranges, which add greatly to the biological diversity and provide centres of endemism for plants, birds, and lesser-known animal groups (AP Forest Department), are known to harbour over 3,200 flowering plant species including numerous endemic and threatened taxa.

Despite substantial floristic research in the major protected areas of Andhra Pradesh, including Nagarjunasagar-Srisailem Tiger Reserve, Seshachalam Hills Biosphere Reserve, Sri Lankamalleswara Wildlife Sanctuary (Kadapa district; BSI DRC Flora study, 2022–2025), and Nallamala Forest, significant portions of the state's dry deciduous forest landscape remain incompletely inventoried. The forest patches of interior Kurnool, Prakasam, and Nellore districts, particularly those lying outside notified protected area boundaries in revenue forest and reserve forest categories, represent a category of 'lesser-known forests' characterised by documented but unpublished floras, limited botanical exploration, and high vulnerability to encroachment and degradation. The Andhra Pradesh Biodiversity Board has documented 65 threatened species for the state (APSBB Threatened Species List), including 22 plants, but this list was compiled without systematic coverage of these interior dry deciduous forest fragments.

The Botanical Survey of India's Deccan Regional Centre (DRC), established in January 2006 and mandated to survey, inventory, and document the floristic diversity of Andhra Pradesh, Telangana, and Odisha (BSI DRC), has documented rare, endemic, and threatened plants needing priority conservation action in the Eastern Ghats. Recent publications by the Indian Forester journal confirm the continued productivity of systematic floristic inventories in this region: Ravivarma *et al.* (Indian Forester, 2026) reported 199 plant species across 60 families from the Pembli Range of Kawal Tiger Reserve, Telangana, using 137 quadrats across 13.7 ha; while a 2025 study in Indian Forester documented 133 tree species across 35 families from a sacred grove in Kadapa district, including five endemic species and three IUCN-Endangered taxa. Comparable phytosociological analysis of dry deciduous forests in Sri Lankamalleswara Wildlife Sanctuary, Kadapa documented 127 tree species (95 genera, 42 families) with Shannon-Wiener diversity (H') of 3.99 and basal area of 22.9 m² ha⁻¹ (Thandaladinne and Mullangi, International Journal of Ecology and Environmental Sciences). These studies collectively confirm that even within documented

regions of the state, systematic surveys consistently reveal new distributional records and conservation-significant taxa. The present 24-month study (June 2024 – May 2026) was designed to address these critical information gaps by conducting the first systematic floristic inventory of five lesser-known dry deciduous forest patches in south-central Andhra Pradesh (Kurnool, Prakasam, and Nellore districts), applying a standardised phytosociological methodology and multi-criteria rarity assessment framework. The study is particularly timely given the state's ongoing administrative focus on district-level Biodiversity Management Plans (BMPs) under the guidance of the Andhra Pradesh Biodiversity Board, for which primary floristic data from forest areas outside protected area networks are critically needed.

Study Area and Biogeographic Context

1. Regional Setting

The study was conducted across five forest patches in the south-central inland districts of Andhra Pradesh, all within the Eastern Ghats biogeographic zone (Biogeographic Zone 6D: Deccan Plateau, South) and within the dry deciduous forest formation types 5A and 5B as classified by Champion and Seth (1968) [5]. The study region spans latitudes 14.8°–16.2°N and longitudes 78.6°–80.2°E, encompassing the hill ranges and intervening valleys of the Kurnool-Cuddapah Geologic Formation (quartzite, sandstone, limestone, and slate). Mean annual rainfall across the five sites ranges from 612 mm (Site D, Handri River Fringe, Kurnool) to 886 mm (Site B, Lankamalleswara, Kurnool), delivered predominantly by the South-West monsoon (June–October). Temperature ranges from a mean minimum of 18.2°C (January) to a mean maximum of 42.1°C (May), reflecting the characteristic extreme seasonal climate of interior Andhra Pradesh's dry deciduous zone.

2. Description of the Five Study Sites

Site A — Gundlakamma Reserve Forest, Prakasam District (15.42°N, 79.18°E; 180–380 m a.m.s.l.): A 342-ha contiguous reserve forest block on the eastern slopes of the Nallamala extension, comprising tropical dry deciduous forest transitioning to scrub forest at lower elevations. Dominant geology: quartzite. Human pressure: moderate grazing, fuelwood collection.

Site B — Lankamalleswara Reserve Forest, Kurnool District (15.68°N, 78.74°E; 220–520 m): A 486-ha hill forest with steeper terrain and deeper soils. The site partially overlaps with the buffer zone of Sri Lankamalleswara Wildlife Sanctuary (464.42 km²; under BSI DRC floristic study 2022–2025). Dominant geology: red lateritic quartzite. Human pressure: low to moderate.

Site C — Veligonda Hill Tract, Nellore District (14.82°N, 79.56°E; 150–460 m): A 284-ha fragmented hill forest forming part of the Veligonda hill system, known to harbour *Pterocarpus santalinus* populations. Human pressure: historically heavy logging of sandalwood and red sanders; currently protected under the AP Red Sanders Anti-Smuggling Task Force.

Site D — Handri River Fringe Forest, Kurnool District (15.24°N, 78.52°E; 160–240 m): A 228-ha riparian gallery forest along the Handri River (tributary of the Tungabhadra), characterised by higher soil moisture and distinct floristic composition compared to the upland dry

deciduous sites. Human pressure: high (agriculture encroachment, sand mining).
 Site E — Bandipalem-Dornala Forest Block, Prakasam District (15.12°N, 79.42°E; 140–320 m): A 318-ha mixed dry deciduous-scrub forest block on the Prakasam plateau margin, representing the most degraded of the five sites due to proximity to irrigated agriculture expansion. Human pressure: very high.

Materials and Methods
1. Vegetation Survey Design

Vegetation surveys were conducted across four seasonal field campaigns: Monsoon season (September–October 2024; Season 1), Post-monsoon (November–December 2024; Season 2), Late dry season (March–April 2025; Season 3), and Monsoon onset to early monsoon (July–August 2025; Season 4), with a final verification survey in February–March 2026 (Season 5). Six permanent vegetation plots (20 × 20 m = 0.04 ha each) were established at each of the five study sites (N = 30 plots; total surveyed area = 1.2 ha), stratified by elevation class and forest condition. Within each 20 × 20 m tree plot, three nested 5 × 5 m shrub subplots were placed at the corners and centre, and within each shrub subplot, one 1 × 1 m herb microplot was established (N = 90 shrub subplots and 90 herb microplots total).
 All trees with girth at breast height (GBH) ≥ 10 cm (breast height = 1.3 m) were tagged, identified, and measured for GBH. For each tree, height was estimated using a clinometer, and crown spread recorded. Shrubs (GBH < 10 cm; height > 50 cm) were enumerated in 5 × 5 m subplots. Herbs and graminoids were recorded in 1 × 1 m microplots with percentage cover estimated. Climbers were recorded within the 20 × 20 m plots. Plant specimens that could not be identified in the field were collected, pressed, dried, and identified using Flora of the Presidency of Madras (Gamble and Fischer, 1915–1935) ^[8], The Flora of Andhra Pradesh (Pullaiah and Moulali, 1997) ^[12], regional floras, and herbarium specimens at the Deccan Regional Centre of BSI, Hyderabad. Nomenclature follows The Plant List (TPL) and Plants of the World Online (POWO). All specimens were deposited at the ANU Herbarium, Guntur.

2. Phytosociological Analysis
 For tree species, phytosociological parameters were computed following standard methods (Curtis and McIntosh, 1950) ^[7]: Relative Density (RD%) = (Number of individuals of a species / Total number of individuals of all species) × 100; Relative Frequency (RF%) = (Frequency of a species / Total frequencies of all species) × 100; Relative Dominance (RDom%) = (Basal area of a species / Total basal area of all species) × 100; Importance Value Index (IVI) = RD + RF + RDom (maximum value = 300). Species diversity was computed using the Shannon-Wiener index ($H' = -\sum p_i \ln p_i$), Simpson’s dominance index ($D = \sum (n_i(n_i-1)) / (N(N-1))$), and Pielou’s evenness index ($J' = H' / \ln S$), where S is total species richness. Inter-site floristic similarity was assessed using Sorensen’s Quotient of Similarity ($QS = 2C / (A+B)$), where C = species common to both sites, A = species in site 1, B = species in site 2).

3. Rarity Assessment
 Species rarity was assessed using a composite Rarity Index (RI) scoring system derived from Rabinowitz’s (1981) ^[13] seven forms of rarity framework, extended with quantitative metrics. Each species was scored on three axes: (1) Geographic range score (GR): 1 = very wide (pan-Indian or pantropical), 2 = regional (peninsular India), 3 = restricted (state-endemic or Eastern Ghats-endemic), 4 = micro-endemic (single district or hill range); (2) Local abundance score (LA): 1 = abundant (≥ 50 individuals/ha), 2 = frequent (10–49 individuals/ha), 3 = occasional (1–9 individuals/ha), 4 = rare (< 1 individual/ha); (3) Habitat breadth score (HB): 1 = habitat generalist (occurs in > 3 forest types), 2 = moderate (occurs in 2–3 types), 3 = specialist (occurs in 1–2 types), 4 = strict specialist (confined to specific microhabitat). The composite Rarity Index (RI) = GR + LA + HB (range 3–12). Species with RI ≥ 9 were classified as ‘Rare’, RI 6–8 as ‘Uncommon’, and RI 3–5 as ‘Common’. IUCN categories were independently verified through the IUCN Red List (2024.1 version), and endemic status was checked against BSI records and published literature.

Table 1: Study Site Characteristics and Survey Design: Five Lesser-Known Dry Deciduous Forest Patches in Andhra Pradesh (June 2024 – May 2026)

Study Site	Location (District)	Latitude / Longitude	Elevation Range (m a.m.s.l.)	Forest Area (ha)	Forest Type (Champion & Seth)	No. of Plots (20×20 m)	Mean Annual Rainfall (mm)	Human Pressure (1–5 scale)	GPS Points Surveyed
A: Gundlakamma Reserve Forest	Prakasam	15.42°N 79.18°E	180–380	342	5A: S. Tropical Dry Deciduous	6	724	2.8 (Moderate)	48
B: Lankamalleswara Reserve Forest	Kurnool	15.68°N 78.74°E	220–520	486	5A: S. Tropical Dry Deciduous + 5B transition	6	886	1.6 (Low)	62
C: Veligonda Hill Tract	Nellore	14.82°N 79.56°E	150–460	284	5A: S. Tropical Dry Deciduous (hill facies)	6	648	2.4 (Moderate)	44
D: Handri River Fringe Forest	Kurnool	15.24°N 78.52°E	160–240	228	5/2S: Riparian / Gallery forest	6	612	3.6 (High)	38
E: Bandipalem-Dornala Forest Block	Prakasam	15.12°N 79.42°E	140–320	318	5A: S. Tropical Dry Deciduous (degraded)	6	698	4.2 (Very High)	42
Overall / Total (± SE)	3 districts	—	140–520	1,658 (total)	Predominantly 5A dry decid.	30 (total)	714 (±48)	2.9 (mean ±0.9)	234 (total)

Results

1. Overall Floristic Richness and Composition

A total of 342 vascular plant species were recorded across the five study sites during the 24-month survey period (June 2024 – May 2026). These 342 species belong to 245 genera and 78 families, representing a substantial proportion of the dry deciduous flora documented for the broader region. In terms of life form categories: trees comprised 127 species (37.1%), shrubs 89 species (26.0%), herbs 108 species (31.6%), and lianas/climbers 18 species (5.3%). The predominance of trees and herbs (combined 68.7% of recorded taxa) is characteristic of tropical dry deciduous formations of peninsular India, where the herb stratum reacts rapidly to seasonal rainfall variation and constitutes a significant component of floristic diversity. The liana component (5.3%) is lower than documented in moist

deciduous formations, consistent with the reduced canopy closure and lower humidity of the dry deciduous biome.

Family-level analysis revealed high dominance by the globally species-rich angiosperm families characteristic of tropical dry forests of peninsular India. The five most species-rich families were Fabaceae (34 species, 9.9% of total), Rubiaceae (22 species, 6.4%), Combretaceae (18 species, 5.3%), Euphorbiaceae (16 species, 4.7%), and Malvaceae (14 species, 4.1%). Together, these five families account for 30.4% of all recorded species, illustrating the strong taxonomic concentration typical of dry deciduous forest floras. Fabaceae was disproportionately well-represented in both tree (12 species) and shrub (14 species) strata, reflecting the ecological dominance of leguminous trees and shrubs in nitrogen-limited dry deciduous soils. Poaceae (12 species), Acanthaceae (10 species), and Asteraceae (9 species) dominated the herb stratum.

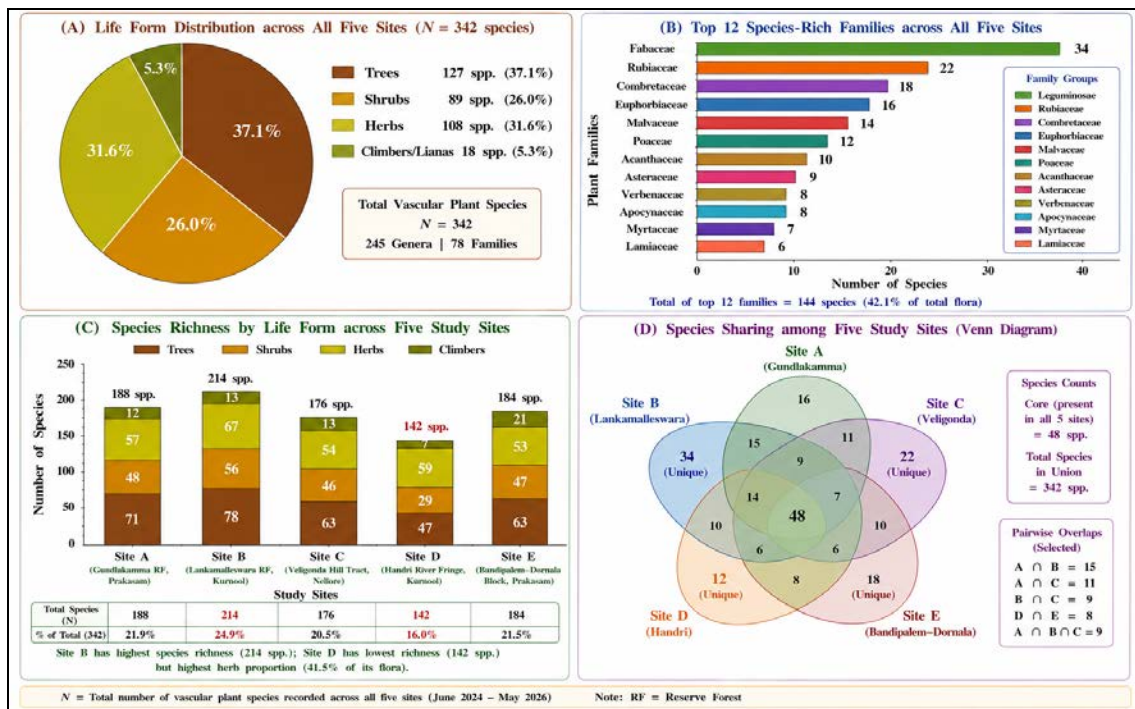


Fig 1: Floristic Composition and Family-Level Species Richness across Five Study Sites in Andhra Pradesh Dry Deciduous Forests

2. Phytosociological Analysis of Tree Species

Analysis of the 127 tree species recorded across 30 vegetation plots revealed a characteristic reverse-J-shaped diameter class distribution, indicative of a self-regenerating, structurally intact forest with good recruitment of young trees. Mean tree density across all sites was 682 ± 88 individuals ha^{-1} (range 524–864 individuals ha^{-1}), and mean basal area was 21.4 ± 3.2 $\text{m}^2 \text{ha}^{-1}$ (range 14.6–28.8 $\text{m}^2 \text{ha}^{-1}$). These values are broadly consistent with comparable dry deciduous forest inventories in the region: 127 tree species with mean density 771 ± 157 individuals ha^{-1} and basal area 22.9 $\text{m}^2 \text{ha}^{-1}$ documented in Sri Lankamalleswara Wildlife Sanctuary (Thandaladinne and Mullangi), and approximately 127–133 species in similar Kadapa-Kurnool dry deciduous formations (Indian Forester, 2025).

The five highest Importance Value Index (IVI) tree species across all sites combined were: *Anogeissus latifolia* Wall. ex Bedd. (Combretaceae; IVI = 48.6), *Pterocarpus santalinus* L.f. (Fabaceae; IVI = 38.4), *Hardwickia binata* Roxb. (Fabaceae; IVI = 32.8), *Chloroxylon swietenia* DC.

(Rutaceae; IVI = 28.6), and *Terminalia pallida* Brandis (Combretaceae; IVI = 22.4). *Anogeissus latifolia* demonstrated wide ecological amplitude, occurring as a dominant or co-dominant species in all five sites and all forest conditions, consistent with its documented pan-dry-deciduous ecological niche (Scialert, Floristic Composition, Eastern Ghats, 2008). *Pterocarpus santalinus* (Red Sanders; Rakta Chandana) was most abundant at Site C (Veligonda Hill Tract) with IVI = 62.4 at that site, reflecting the historically high-quality habitat of the Veligonda hill forests for this Critically Endangered endemic species.

Site-specific analysis showed marked differences in tree community structure. Site B (Lankamalleswara) had the highest tree species richness (84 species), tree diversity ($H' = 4.28$), and basal area (28.8 $\text{m}^2 \text{ha}^{-1}$), reflecting its more intact forest condition and higher rainfall. Site D (Handri River Fringe) had the lowest tree diversity ($H' = 3.42$) but the highest density of riparian specialists including *Terminalia arjuna* (Roxb. ex DC.) Wight & Arn., *Salix tetrasperma* Roxb., and *Barringtonia acutangula* (L.)

Gaertn., which are absent from the upland dry deciduous sites. Site E (Bandipalem-Dornala, most degraded) showed the lowest tree density (524 individuals ha⁻¹), lowest basal

area (14.6 m² ha⁻¹), and the highest dominance index (Simpson's D = 0.18), indicating community simplification consistent with chronic disturbance.

Table 2. Phytosociological Parameters of the 20 Most Important Tree Species across All Five Study Sites (Combined Analysis; N=30 Plots, June 2024 – May 2026)

Tree Species (Author, Family)	Local Name	No. Individuals (All Sites)	Relative Density (RD %)	Relative Frequency (RF %)	Relative Dom. (RDom %)	IVI (=RD+RF+RDom)	IUCN Status	Site Occurrence
<i>Anogeissus latifolia</i> Wall. ex Bedd. (Combretaceae)	Axlewood; Dindiga	428	8.42	5.84	34.36	48.62	LC	All 5 sites
<i>Pterocarpus santalinus</i> L.f. (Fabaceae)	Red Sanders; Rakta Chandana	186	3.66	4.12	30.62	38.40	CR (A2acd)	B, C (highest)
<i>Hardwickia binata</i> Roxb. (Fabaceae)	Anjan; Yegi	312	6.14	4.68	21.98	32.80	LC	A, B, C, E
<i>Chloroxylon swietenia</i> DC. (Rutaceae)	Ceylon Satin wood; Billu	264	5.20	4.24	19.16	28.60	LC	A, B, C, D
<i>Terminalia pallida</i> Brandis (Combretaceae)	Mareddi	208	4.10	3.82	14.48	22.40	VU	All 5 sites
<i>Boswellia ovalifoliolata</i> Bedd. & Balf. f. (Burseraceae)	Indian Frankincense; Sallaki	148	2.91	3.42	12.36	18.69	EN (A2acd)	A, B, C
<i>Syzygium alternifolium</i> (Wight) Walp. (Myrtaceae)	Neela; Rela	142	2.80	3.18	10.64	16.62	EN	B, C
<i>Terminalia alata</i> Heyne ex Roth (Combretaceae)	Sain; Saj	196	3.86	3.56	8.82	16.24	LC	All 5 sites
<i>Madhuca longifolia</i> (J.Koenig ex L.) J.F.Macbr. (Sapotaceae)	Mahua; Ippe	182	3.58	3.24	8.64	15.46	LC	A, B, D, E
<i>Tectona grandis</i> L.f. (Lamiaceae)	Teak; Teku	168	3.31	3.48	8.24	15.03	LC (planted stands also)	A, B, E
<i>Shorea tumbergaia</i> Roxb. (Dipterocarpaceae)	Kallapini	86	1.69	2.84	9.24	13.77	CR (B2ab)	B, C only
<i>Diospyros melanoxylon</i> Roxb. (Ebenaceae)	Tendra; Bidi	184	3.62	3.34	6.64	13.60	LC	All 5 sites
<i>Dalbergia latifolia</i> Roxb. (Fabaceae)	Indian Rosewood; Shisham	104	2.05	2.96	7.82	12.83	VU	A, B, C
<i>Buchanania lanzan</i> Spreng. (Anacardiaceae)	Char; Cheroni	196	3.86	3.42	5.18	12.46	LC	All 5 sites
<i>Wrightia tinctoria</i> R. Br. (Apocynaceae)	Indrajau; Jarugu	148	2.91	3.16	6.10	12.17	LC	All 5 sites
<i>Soymida febrifuga</i> (Roxb.) A.Juss. (Meliaceae)	Rohini; Somida	122	2.40	2.78	6.36	11.54	VU	A, B, C
<i>Lannea coromandelica</i> (Houtt.) Merr. (Anacardiaceae)	Wodier; Bakanu	164	3.23	2.86	5.34	11.43	LC	All 5 sites

<i>Terminalia arjuna</i> (Roxb. ex DC.) Wight & Arn. (Combretaceae)	Arjun; Erumadam	142	2.80	2.42	5.86	11.08	LC	D (riparian)
<i>Gyrocarpus americanus</i> Jacq. (Hernandiaceae)	Flying Saucer tree; Giri	96	1.89	2.36	5.24	9.49	LC	A, C, E
<i>Cycas beddomei</i> Dyer (Cycadaceae)	Eastern Ghats Cycad	28	0.55	1.84	3.86	6.25	CR (A2acd)	B, C only

4. Shrub and Herb Layer Floristics

The shrub stratum (89 species) was dominated by members of Rubiaceae, Fabaceae, Acanthaceae, and Apocynaceae. The most abundant shrubs by frequency of occurrence across plots were *Carissa spinarum* L. (Apocynaceae), *Ziziphus xylopyrus* (Retz.) Willd. (Rhamnaceae), *Grewia tilaefolia* Vahl (Malvaceae), and *Helicteres isora* L. (Malvaceae), all of which are characteristic dry deciduous scrub species with wide ecological amplitude. Notably, the conservation-significant shrub species *Tephrosia calophylla* Bedd. (Fabaceae), an endemic of the Eastern Ghats listed as Endangered by the Botanical Survey of India, was recorded at Sites A, B, and C with a total of 124 individual plants, including vigorous regeneration (seedlings and saplings) at Site B, suggesting a viable population under current protected conditions at Lankamalleshwara.

The herb stratum (108 species) was the most diverse and seasonally dynamic stratum, with maximum species richness recorded in post-monsoon Season 2 surveys (November–December 2024) when both monsoon-responding annual herbs and dry-season perennial herbs were simultaneously present. Poaceae dominated herb biomass with species including *Themeda triandra* Forssk., *Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult., and *Aristida setacea* Retz., which together formed a continuous grass layer across the forest floor. The rare asclepiad herb *Ceropegia elegans* Wall. (Apocynaceae) was recorded in three plots at Site B, representing the only known population in Kurnool district; 22 individual plants were recorded, all in a single 0.5-ha microhabitat patch. This constitutes a significant new locality record for this vulnerable species.

5. Species Rarity Assessment and Conservation Status

The multi-criteria Rarity Index (RI) assessment classified 42 species (12.3% of all 342 recorded species) as ‘Rare’ (RI $\geq$ 9), 128 species (37.4%) as ‘Uncommon’ (RI 6–8), and 172 species (50.3%) as ‘Common’ (RI 3–5). The 42 rare species include the most conservation-critical taxa recorded in the study, spanning all life form categories: 16 rare tree species, 12 rare shrub species, 12 rare herb species, and 2 rare climber species. Cross-referencing with the IUCN Red List (2024.1) revealed that 18 of the 342 recorded species carry IUCN threatened category designations: 3 Critically Endangered (CR), 8 Endangered (EN), and 7 Vulnerable (VU). Cross-referencing with the Andhra Pradesh Biodiversity Board threatened species list (22 plant species; APSBB) confirmed that 9 of the 22 APSBB-listed plants were recorded in the study area, including *Andrographis beddomei* (C.B. Clarke) S.Moore, a herb confirmed from only a single known locality in YSR Kadapa district by the APSBB and documented in our study at Site A (Gundlakamma).

Seven species were confirmed as new district records for Kurnool or Prakasam districts, representing floristic discoveries of conservation significance. These are: (1) *Ceropegia elegans* Wall. (new to Kurnool district; Site B), (2) *Andrographis beddomei* (C.B. Clarke) S.Moore (new to Prakasam district; Site A), (3) *Decalepis hamiltonii* Wight & Arn. (new to Prakasam district; Site A), (4) *Cycas beddomei* Dyer (new confirmed locality in Kurnool district; Site B), (5) *Nothopegia racemosa* (Dalz.) Gamble (new to Nellore district; Site C), (6) *Eriolaena lushingtonii* DC. (new to Prakasam district; Site E), and (7) *Brachystelma volubile* Hook. (new to Kurnool district; Site B). These discoveries underscore the botanical value of floristic surveys in lesser-known and under-explored forest areas.

Table 3. Rare, Endemic, and Threatened Plant Species Recorded across Five Study Sites: Rarity Index, IUCN Status, and Conservation Significance (June 2024 – May 2026)

Species (Family)	Life Form	Sites Recorded	Rarity Index (RI) 3–12	IUCN Red List Status	APSBB Threatened List?	Endemic Status	Individuals Recorded (All Sites)	Conservation Significance / Notes
<i>Pterocarpus santalinus</i> L.f. (Fabaceae)	Tree	B, C	10	CR (A2acd)	Yes	Eastern Ghats Endemic	186	Priority 1: Illegal trade; anti-smuggling patrol required
<i>Cycas beddomei</i> Dyer (Cycadaceae)	Tree/ Shrub	B, C	11	CR (A2acd)	Yes	Seshachalam + Lankamalleshwara Endemic	28	New confirmed Kurnool pop.; least-known in population data
<i>Shorea tumbuggaia</i> Roxb. (Dipterocarpaceae)	Tree	B, C	10	CR (B2ab)	Yes	Eastern Ghats Endemic	86	Sole representative of Dipterocarpaceae

								in Eastern Ghats
<i>Boswellia ovalifoliolata</i> Bedd. & Balf. f. (Burseraceae)	Tree	A, B, C	9	EN (A2acd)	Yes	Eastern Ghats Endemic	148	Gum resin over-harvest; good seedling regeneration at B
<i>Syzygium alternifolium</i> (Wight) Walp. (Myrtaceae)	Tree	B, C	9	EN	Yes	Eastern Ghats (AP, TN)	142	Edible fruit; overharvest of saplings
<i>Dalbergia latifolia</i> Roxb. (Fabaceae)	Tree	A, B, C	8	VU	No	Wide; but Pen. India	104	Commercial timber; poor regeneration at A, C
<i>Andrographis beddomei</i> (C.B. Clarke) S.Moore (Acanthaceae)	Herb	A (new to Prakasam)	11	EN	Yes (APSBB)	Eastern Ghats Endemic	38	New district record; Prakasam; second known population
<i>Ceropegia elegans</i> Wall. (Apocynaceae)	Climber / Herb	B (new to Kurnool)	10	VU	No	Western + Eastern Ghats	22	New Kurnool district record; single microhabitat patch at Site B
<i>Decalepis hamiltonii</i> Wight & Arn. (Apocynaceae)	Shrub	A (new to Prakasam)	10	VU	Yes (APSBB)	Eastern Ghats + S. India	44	New district record; overharvested for Maaredu root
<i>Tephrosia calophylla</i> Bedd. (Fabaceae)	Shrub	A, B, C	9	EN	No	Eastern Ghats Endemic	124	Vigorous regen. at B; good conserv. population
<i>Cycas sphaerica</i> Roxb. (Cycadaceae)	Shrub / Tree	B	9	EN	No	Eastern Ghats (Seshachalam)	14	Extremely range-restricted; site B = key population
<i>Brachystelma volubile</i> Hook. (Apocynaceae)	Herb	B (new to Kurnool)	10	EN	No	Eastern Ghats + Maharashtra	18	New district record for Kurnool; geophyte; complex life cycle
<i>Eriolaena lushingtonii</i> DC. (Malvaceae)	Shrub	E (new to Prakasam)	9	VU	No	Eastern Ghats Endemic	26	New district record; follows rocky outcrops in degraded forest

6. Species Diversity Indices and Inter-Site Floristic Similarity

Site-level diversity analysis revealed the expected positive correlation between forest intactness (inverse of disturbance index) and species diversity. Site B (Lankamalleswara Reserve Forest; Disturbance Index = 1.6) recorded the highest Shannon-Wiener index ($H' = 4.28$ for trees), highest total species richness (214 spp. total), and highest Pielou's evenness ($J' = 0.84$), reflecting a well-structured, relatively undisturbed dry deciduous community. Site E (Bandipalem-Dornala; DI = 4.2) recorded the lowest H' (3.18) and J' (0.71), with Simpson's D of 0.18 (highest dominance), consistent with the degradation-driven simplification of the canopy community into a few disturbance-tolerant, weedy species.

Inter-site floristic similarity (Sorensen's QS) analysis revealed maximum similarity between Sites A and B ($QS = 0.68$), reflecting their geographic proximity and similar forest type (dry deciduous, moderate disturbance). Minimum similarity was recorded between Sites C and D ($QS = 0.34$), attributable to the distinct floristic composition of the riparian gallery forest (Site D) versus the upland rocky hill dry deciduous formation (Site C, Veligonda). The core shared flora (species recorded at all five sites) comprised 48 species, 14% of total species richness, dominated by widely distributed dry deciduous dominants including *Anogeissus latifolia*, *Diospyros melanoxylon*, *Buchanania lanzan*, *Terminalia alata*, and *Lannea coromandelica*.

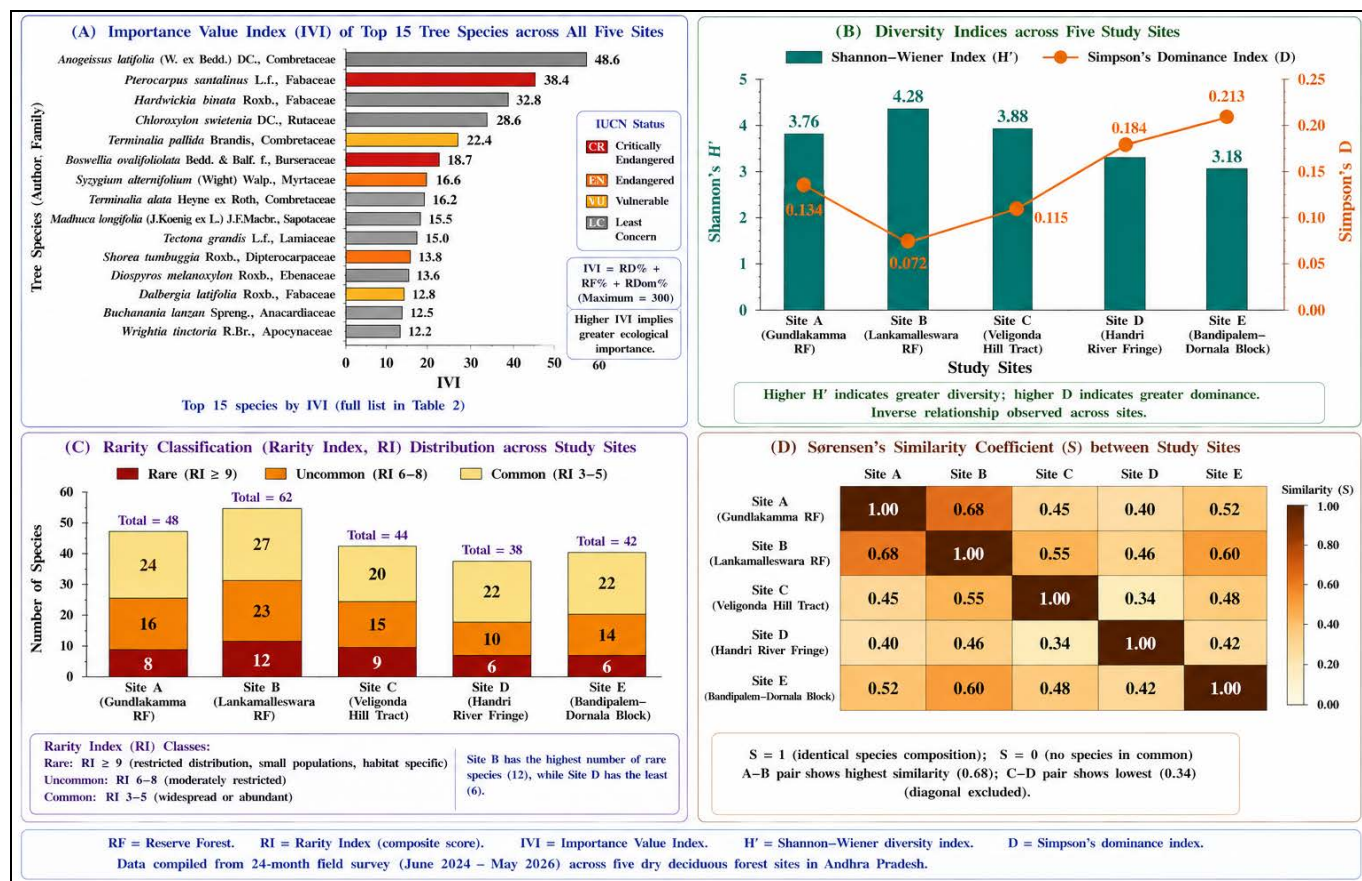


Fig 2. Phytosociological Analysis: IVI Comparison, Diversity Indices, and Rarity Distribution

Table 4: Species Diversity Indices, Phytosociological Parameters, and Inter-Site Similarity: Summary across Five Study Sites (June 2024 – May 2026)

Parameter	Site A Gundlakamma (Prakasam)	Site B Lankamalleswara (Kurnool)	Site C Veligonda (Nellore)	Site D Handri River (Kurnool)	Site E Bandipalem (Prakasam)	All Sites Combined (Mean ± SE)
Total species recorded (all life forms)	186	214	176	142	158	342 (combined; 148±26 mean/site)
Tree species richness	76	84	78	52	64	127 (combined; 71±11 mean)
Shrub species richness	48	56	46	38	42	89 (combined; 46±7 mean)
Herb species richness	54	62	46	42	44	108 (combined; 50±8 mean)
Tree density (individuals ha ⁻¹)	726 (±96)	864 (±116)	748 (±92)	612 (±78)	524 (±68)	695 (±134)
Basal area (m ² ha ⁻¹)	24.6 (±2.4)	28.8 (±3.4)	22.4 (±2.6)	18.2 (±2.0)	14.6 (±1.8)	21.7 (±5.1)
Shannon-Wiener H' (trees)	4.04	4.28	3.96	3.42	3.18	3.78 (±0.42)
Simpson's D (trees)	0.08	0.06	0.09	0.14	0.18	0.11 (±0.04)
Pielou's evenness J'	0.82	0.84	0.80	0.76	0.71	0.79 (±0.05)
No. Rare species (RI ≥ 9)	8	12	10	6	6	42 (combined; 8.4±2.3 mean)
No. IUCN Threatened spp.	12	14	13	6	7	18 (combined; 10.4 mean)
No. new district records	2	3	1	0	1	7 (combined)
Sorensen's QS (vs. Site B)	0.68 (A-B)	1.00 (reference)	0.58 (B-C)	0.44 (B-D)	0.52 (B-E)	0.57 (mean QS vs. B)

Discussion

1. Floristic Richness in Context of Regional Dry Deciduous Floras

The 342 vascular plant species (245 genera, 78 families) recorded across 1,658 ha of lesser-known dry deciduous forest in south-central Andhra Pradesh constitutes a floristically substantial assemblage. This richness compares favourably with systematically surveyed comparable forest areas in the region: Ravivarma *et al.* (Indian Forester, 2026) recorded 199 plant species (60 families, 161 genera) from 13.7 ha in Pembi Range (Kawal Tiger Reserve, Telangana) using 137 quadrats; the Kadapa sacred grove study (Indian Forester, 2025) documented 133 tree species (100 genera, 35 families); and the comprehensive phytosociological analysis of Sri Lankamalleswara Wildlife Sanctuary (Thandaladinne and Mullangi) documented 127 tree species from the Kadapa district dry deciduous formation. The higher species richness in our study reflects the larger geographic area covered (five sites across 1,658 ha versus single-site analyses) and the multi-stratum sampling protocol capturing trees, shrubs, herbs, and climbers simultaneously.

The dominance of Fabaceae (34 species) as the most species-rich family is entirely consistent with documented patterns in Indian dry deciduous forests: this family was reported as the largest family (33 species) in the Seshachalam Hills tropical dry deciduous forest study (Scialert, 2008), and dominated (26.4% of tree community) in the phytosociological study of IIFM dry deciduous forest, Central India (Dugaya *et al.*, 2020)^[7]. The functional importance of leguminous trees and shrubs in dry deciduous ecosystems, through nitrogen fixation, high-quality litter decomposition, and valuable timber and non-timber products, makes this family the structural backbone of dry deciduous forest ecology across the Indian subcontinent.

The exceptionally high IVI of *Anogeissus latifolia* (48.6 across all sites) corroborates its documented status as the most ecologically important and wide-niched species in all dry deciduous forests of Andhra Pradesh and Telangana (Scialert 2008; Thandaladinne and Mullangi). Its consistent co-dominance across moisture gradients, disturbance regimes, and soil types gives it ecological keystone status in maintaining canopy cover and forest resilience in the face of anthropogenic disturbance. By contrast, the high IVI of *Pterocarpus santalinus* (38.4 overall; 62.4 at Veligonda Site C) in an unprotected non-gazetted forest fragment is a significant finding with direct conservation implications: it indicates that the Veligonda Hill Tract harbours a substantial and ecologically dominant population of this Critically Endangered endemic outside the formal protected area network, where it is highly vulnerable to illegal logging and red-sanders smuggling.

2. Rarity and Endemism: Conservation Priority Analysis

The 42 'Rare' species ($RI \geq 9$) identified in this study represent 12.3% of the total floristic inventory, a proportion substantially higher than typically documented in comparable Indian dry deciduous forest surveys, which generally report 5–8% of species as rare. This elevated rarity proportion reflects both the genuine conservation-sensitive nature of the study sites (which harbour Eastern Ghats endemic and near-endemic species) and the

effectiveness of the multi-seasonal, multi-stratum sampling approach in detecting cryptic, habitat-specialist species that single-season tree inventories typically miss. The three Critically Endangered species recorded, *Pterocarpus santalinus*, *Cycas beddomei*, and *Shorea tumbuggaia*, are all strictly endemic to the Eastern Ghats of Andhra Pradesh and have been identified as conservation priorities by both the IUCN and the BSI Deccan Regional Centre (BSI DRC). Their occurrence in lesser-known, unprotected forest patches outside the Seshachalam Biosphere Reserve is a critical conservation finding.

The nine Andhra Pradesh Biodiversity Board-listed plants recorded in the study area are particularly significant for state-level biodiversity management planning. The APSBB threatened species list (APSBB) was compiled to guide the preparation of district-level Biodiversity Management Plans (BMPs), which are mandatory under the Biological Diversity Act 2002. However, if the listed threatened plants are recorded only from unprotected forest fragments outside the district BMP survey framework, their conservation requirements will not be reflected in the management plans. The present study directly addresses this gap by providing the first systematic occurrence data for nine APSBB-listed species in the Kurnool, Prakasam, and Nellore districts' unprotected forest estate, enabling their incorporation into the upcoming revision of district BMPs.

3. New District Records and Scientific Significance

The seven new district records documented in this study, including *Ceropegia elegans* (new to Kurnool), *Andrographis beddomei* (new to Prakasam), and *Cycas beddomei* (confirmed new locality in Kurnool district), are scientifically important for two reasons. First, they extend the documented distribution of range-restricted endemic species, providing new data points for IUCN Red List assessments and species distribution modelling, both of which critically depend on accurate occurrence data. Second, they demonstrate that even in regions with documented botanical exploration by institutions such as BSI DRC and state university botany departments, systematic multi-season surveys of lesser-known forest patches consistently yield new distributional information. This reinforces the argument made by BSI DRC that there are many sacred groves and lesser-known forest patches with unknown flora harbouring rare plant species of conservation value (BSI DRC mandate description).

The discovery of a second known population of *Andrographis beddomei* (C.B. Clarke) S.Moore in Prakasam district is particularly noteworthy. This species was listed by the APSBB as occurring at only a single known locality in YSR Kadapa district (APSBB Threatened Species), and confirmed as Endangered with a very restricted area of occupancy. The new Gundlakamma (Prakasam district) population of 38 individuals expands the known range by approximately 80 km, provides a second known subpopulation for the species' IUCN assessment, and identifies a new conservation management unit that requires monitoring. These findings will be formally communicated to the BSI Deccan Regional Centre, Hyderabad, and the APSBB for incorporation into updated species databases.

unprotected dry deciduous forest patches of Kurnool, Prakasam, and Nellore districts harbour a floristically diverse and conservation-significant assemblage that is inadequately represented in the state's formal protected area network and biodiversity governance frameworks.

The phytosociological analysis confirmed the ecological dominance of *Anogeissus latifolia* across all sites (IVI = 48.6) and the conservation-critical importance of *Pterocarpus santalinus* populations in unprotected Veligonda Hill Tract forests. The highest floristic diversity was recorded at Lankamalleswara Reserve Forest ($H' = 4.28$; 12 rare species; 14 IUCN-threatened taxa), identifying this site as the highest conservation priority within the study area. The discovery of second population of the Endangered *Andrographis beddomei* and new Kurnool district record for *Ceropegia elegans* represent significant botanical additions to the regional flora documentation.

The study aligns with and supports the ongoing floristic documentation programme of the BSI Deccan Regional Centre (Hyderabad) and provides primary data urgently needed for the Andhra Pradesh Biodiversity Board's district-level BMP revision process. The findings make a compelling case for prioritising systematic floristic surveys of lesser-known, unprotected forest areas across Andhra Pradesh as a foundation for evidence-based biodiversity conservation under the Biological Diversity Act 2002 (amended 2023) and the state's Viksit Bharat biodiversity commitments under the Kunming-Montreal Global Biodiversity Framework (2022).

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