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Research Paper

REMNANT OF THE DRYLAND COASTAL VEGETATION OF THE SONGKHLA LAKE BASIN, SONGKHLA, THAILAND

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ARTICLE HIGLIGHTS

This article identifies and characterizes three native plant communities in the Songkhla Lake Basin, highlighting their distinct species composition, coastal zonation patterns, and ecological value. It reveals high plant diversity across remnant dryland coastal habitats and documents key native species that define each community type. The study emphasizes the negative impacts of human activity and land policies on native vegetation and offers baseline floristic data that support conservation, ecological restoration, and sustainable land-use planning.

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ABSTRACT

The remnant dryland coastal vegetation of the Songkhla Lake Basin, Songkhla, Thailand, was investigated in this study. Twenty vegetation plots were established to represent each vegetation subtype. Using Braun-Blanquet cluster analysis and the Jaccard similarity index, the vegetation was classified into three distinct communities: (1) the Coastal Woodland Community, located farthest inland and dominated by *Dipterocarpus alatus* Symington; (2) the Coastal Scrub-Shrubby Tree Community, situated inland from the coastal zone, with *Dipterocarpus chartaceus* Symington, *Neolitsea zeylanica* (Nees & T. Nees) Merr., and *Psychotria asiatica* L. identified as dominant species; and (3) the Coastal Scrub Community, occurring near the shoreline and characterized by densely clustered vegetation dominated by *Mischocarpus sundaicus* Blume, *Planchonella obovata* (R.Br.) Pierre, and *Vitex pinnata* L. Vegetation profiles for each community were delineated. Significant degradation and decline of native plant communities in the Songkhla Lake Basin have been caused by conservation activities involving the introduction of fast-growing non-native species and by governmental land tax policies.

Keywords: dryland coastal vegetation, plant community structure, Songkhla Lake Basin

INTRODUCTION

Dryland coastal vegetation is recognized as a unique but often underappreciated component of tropical coastal ecosystems (Swiderska *et al.* 2018). These communities are typically found on sandy floodplains and elevated sandbars, where harsh environmental conditions are endured, including fluctuating salinity, limited freshwater input, and intense wind exposure. Vegetation structure and species composition are influenced by these stressors, making such areas valuable for investigations of plant resilience and adaptation in marginal environments (Freeman *et al.* 2023). Additionally, drylands are shaped by aeolian processes, in which sparse vegetation and erodible surfaces are subjected to strong winds. While reductions in wind speed and sediment transport can be facilitated by vegetation through drag, the overall effects are considered complex due to turbulence, porosity, and plant flexibility. Consequently, uncertainty remains regarding the precise role of vegetation in wind-driven erosion and deposition (Mayaud & Webb 2017).

In Southeast Asia, ecological research in coastal regions has primarily been focused on mangrove forests and freshwater wetlands (Tatu & Anderson 2017; Daga & Salmo 2022; Liu *et al.* 2022; Veettil *et al.* 2024), whereas dryland coastal vegetation has been given disproportionately little attention (Marod *et al.* 2020). In Thailand, this knowledge gap is particularly evident, as much of the remaining dryland vegetation has been reduced to fragmented patches due to land-use changes, coastal development, and environmental degradation. These remnant patches are considered important since native species, ecological functions, and biogeographical signals may still be preserved, providing critical insights for understanding coastal ecosystem transitions and supporting conservation planning (Tulloch *et al.* 2015).

Previous studies have provided baseline floristic data and community classifications for portions of the southern coastline of Thailand (Laongpol 2003, 2010; Sridith 2014; Taing 2015). While these contributions are considered valuable, the focus was largely placed on species inventories and landscape profiles without explicit consideration of vegetation dynamics, environmental drivers, or conservation implications. Furthermore, the extent to which freshwater inflows, seasonal salinity, and geomorphological processes influence dryland coastal plant communities in Thailand has remained poorly documented.

This study was conducted to address these knowledge gaps by investigating the remnant dryland coastal vegetation of the Songkhla Lake Basin, southern Thailand, through a phytosociological approach. Specifically, the objectives were defined as follows: 1) the structure and composition of the remaining dryland coastal plant communities were characterized, and 2) their distribution patterns were analyzed in relation to environmental conditions.

By documenting and analyzing these vegetation remnants, critical knowledge was generated to support the conservation and management of coastal ecosystems, particularly in identifying potential areas for habitat protection, ecological restoration, and adaptive land-use planning within one of Thailand's most ecologically complex coastal regions.

MATERIALS AND METHODS

Study Area

Songkhla Lake, located in southern Thailand, is recognized as the largest lagoon system in Southeast Asia, covering approximately 1,040 km². It is situated across the provinces of Songkhla, Phatthalung, and parts of Nakhon Si Thammarat, between latitudes 6°40′ - 7°50′ N and longitudes 100°00′ - 100°40′ E. The lake is divided into four main sections: Thale Noi, a freshwater lake in the north; Upper Songkhla Lake (Thale Luang); Middle Songkhla Lake, which constitutes the brackish zone; and Lower Songkhla Lake, which directly connects to the Gulf of Thailand. The hydrology of the system is influenced by freshwater inflows from numerous small rivers and by seasonal seawater intrusion. Freshwater conditions dominate during the flood season (November - December), whereas brackish conditions prevail in the dry season due to reduced river inflows. Geomorphologically, the lagoon was formed by a series of coastal sandbars that created a semi-enclosed basin comprising diverse habitats, including peat swamps, estuarine areas, floodplains, and coastal dunes. These varied environments are considered ecologically significant due to the high biodiversity they support (Pongsaputra 1991; Tookvinas & Sirimontaporn 1988; Yokokawa 1984) (Fig. 1B).

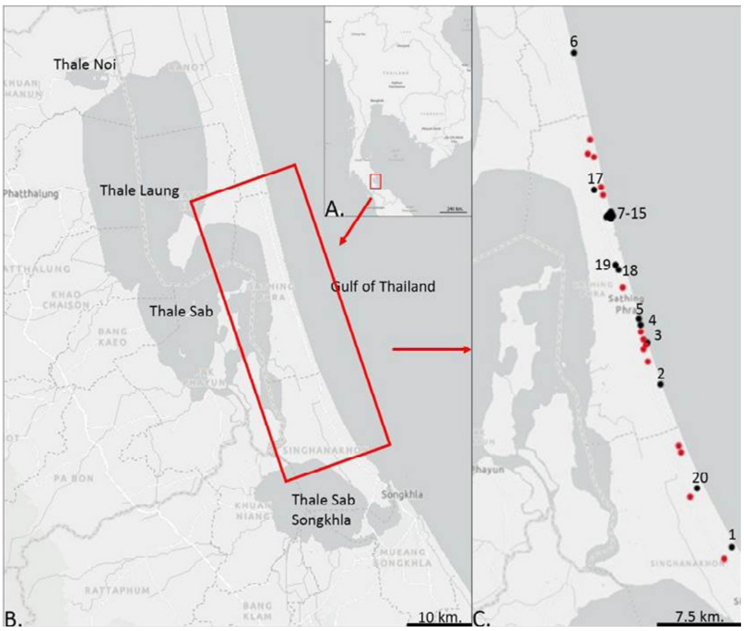

Figure 1 Study area and sampling plot

Notes: A = Map of Thailand; B = Part of Songkhla Lake; C = Sampling plots (black dots), small relic patches (red dots).

Data Collection

Field Survey

Rapid land-use changes and human activities have resulted in a significant reduction of natural forest cover in the Songkhla Lake Basin, leaving only small and scattered forest remnants. Within these patches, notable canopy structures and remnants of native plant species are still preserved, and they were selected as the primary focus of this study.

Site selection was carried out based on three main criteria: 1) the presence of natural vegetation as determined from satellite imagery and preliminary field visits; 2) accessibility to the site; and 3) the absence of invasive alien plant species. Field surveys were conducted from January to December 2023 to verify the presence of vegetation and to assess the suitability of the sites for phytosociological sampling.

Vegetation Data Collecting

A total of 20 study sites were selected across the Songkhla Lake Basin in Songkhla Province. Each selected site (indicated by black dots in Fig. 1C) encompassed an area of approximately 6,000 to 8,000 m² and was used for the collection of vegetation data. The coordinates of all study sites were recorded using GPS and subsequently mapped onto satellite imagery. During the survey, additional small forest patches (< 2,500 m²) were also identified (indicated by red dots in Fig. 1C). These patches were not selected for detailed sampling due to their limited species diversity and evidence of disturbance; however, they were noted as areas of ecological interest to reflect the extent and fragmentation of the remaining dryland vegetation in the basin.

Vegetation data were collected using standard phytosociological methods. Sampling plots were established as 20 × 20 m for the tree layer, 5 × 5 m for shrubs, and 1 × 1 m for herbaceous plants. Within each plot, species composition, abundance (using the Braun-Blanquet scale), plant height, and vegetation structure were recorded.

Vegetation Analysis

The vegetation was analyzed following the conceptual framework and methodologies of the Zürich-Montpellier School (Braun-Blanquet 1964; Bridson & Forman 1998). Study plots were systematically established at the selected sites to ensure that each stand encompassed a minimum area with homogeneous physiognomic features, thereby maintaining uniformity. For each plot, a comprehensive species inventory was compiled by stratifying the vegetation into vertical layers. Multi-structured plant communities were classified into two or three layers, i.e., tree, shrub, and herb, based on their structural characteristics.

The Braun-Blanquet method was employed to estimate species cover and sociability within each vegetation layer. Discrete plant communities were subsequently classified through the synthesis of the collected vegetation data. Profile diagrams and photographic records were constructed to illustrate stand structure at representative sites. To further analyze plant community associations, classical clustering analysis was performed using the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) based on the Bray-Curtis similarity index in PAST version 4.14. In this method, species were grouped into clusters according to similarity, beginning with the most similar pair and progressively merging less similar groups (Miyawaki & Suzuki 1980). The resulting dendrogram was used to elucidate ecological relationships among vegetation types across the study plots.

In addition, the Jaccard Similarity Index (JSI) was calculated to assess the similarity in species composition between different plots. The index is expressed as:

$$J(A, B) = \frac{A \cap B}{A \cup B}$$

The value of the Jaccard Similarity Index is expressed on a scale ranging from 0 to 1, where a value of 0 is interpreted as indicating no shared species (representing entirely dissimilar communities), whereas a value of 1 is interpreted as indicating identical species composition (representing completely similar communities) (Bisandu *et al.* 2019).

These analyses were used to provide insights into floristic relationships, habitat fragmentation, and ecological patterns among the remnant forest patches within the Songkhla Lake Basin.

RESULTS AND DISCUSSION

Species Richness, Composition, and Plant Community

A comprehensive survey of vascular plants within the study plots documented 64 species, which were distributed across 59 genera and 42 families. Among these, three species were identified as ferns: *Drynaria quercifolia* (L.) J.Sm., *Pyrrosia longifolia* (Burm.f.) C.V.Morton, and *Pyrrosia piloselloides* (L.) M.G.Price. The family Fabaceae exhibited the highest species richness, comprising four species, followed by Apocynaceae, Dipterocarpaceae, and Myrtaceae, each represented by three species. Several families, including Annonaceae, Combretaceae, Dilleniaceae, Lamiaceae, Malvaceae, Melastomataceae, Orchidaceae, Phyllanthaceae, Primulaceae, Rubiaceae, Rutaceae, and Salicaceae, were represented by two species each, while 29 families were represented by a single species (Table 1). This composition reflects the diverse floristic structure of the study plots, with Fabaceae contributing the greatest species richness among the recorded families.

Table 1 Plant species, their taxonomic families, and associated plant communities

No	Species name	Family	Com.	Ab.
1	*Uvaria ferruginea* var. cherrevensis (Pierre ex Finet & Gagnep.) Meade & J.Parn.	Annonaceae	C	+
2	*Uvaria siamensis* (Scheff.) L.L.Zhou, Y.C.F.Su & R.M.K.Saunders		C	+
3	*Amphineurion marginatum* (Roxb.) D.J.Middleton	Apocynaceae	B	+
4	*Dischidia major* (Vahl) Merr.		B	+
5	*Hoya verticillata* (Vahl) G.Don var. *verticillata*		B	+
6	*Alocasia sanderiana* W.Bull	Araceae	A	+
7	*Caryota mitis* Lour.	Arecaceae	A	+
8	*Dianella ensifolia* (L.) Redouté	Asphodelaceae	B	+
9	*Garcinia celebica* L.	Clusiaceae	C	+
10	*Combretum trifoliatum* Vent.	Combretaceae	C	+
11	*Terminalia catappa* L.		C	+
12	*Cyanotis cristata* (L.) D. Don	Commelinaceae	B	+
13	*Dillenia hookeri* Pierre	Dilleniaceae	C	+
14	*Tetracera indica* (Christm. & Panz.) Merr.		C	+
15	*Dipterocarpus alatus* Roxb. ex G.Don	Dipterocarpaceae	A	++++
16	*Dipterocarpus chartaceus* Symington		B,C	++++
17	*Anthoshorea roxburghii* (G.Don) P.S.Ashton & J.Heck.		C	+
18	*Elaeocarpus robustus* Roxb.	Elaeocarpaceae	C	+
19	*Vaccinium bracteatum* Thunb.	Ericaceae	B	+
20	*Derris trifoliata* Lour.	Fabaceae	C	+
21	*Guilandina bonduc* L.		C	+
22	*Biancaea sappan* (L.) Tod.		C	+
23	*Abrus precatorius* L.		B,C	++
24	*Vitex pinnata* L.	Labiatae	C	+++
25	*Clerodendrum indicum* (L.) Kuntze	Lamiaceae	C	+
26	*Vitex glabrata* R.Br.		C	+
27	*Neolitsea zeylanica* (Nees & T. Nees) Merr.	Lauraceae	B,C	++
28	*Sterculia villosa* Roxb. ex Sm.	Malvaceae	C	+
29	*Microcos tomentosa* Sm.			C+
30	*Memecylon edule* Roxb.	Melastomataceae	B,C	+
31	*Memecylon ovatum* Sm.		C	+
32	*Sandoricum koetjape* (Burm.f.) Merr.	Meliaceae	A	+

No	Species name	Family	Com.	Ab.
33	*Tinospora crispa* (L.) Hook.f. & Thomson	Menispermaceae	A	+
34	*Streblus asper* Lour.	Moraceae	A,B,C	++
35	*Syzygium antisepticum* (Blume) Merr. & L.M.Perry	Myrtaceae	C	+
36	*Syzygium grande* (Wight) Walp.		A,B	+
37	*Rhodomyrtus tomentosa* (Aiton) Hassk.		B,C	+
38	*Ochna integerrima* (Lour.) Merr.	Ochnaceae	C	+
39	*Olax scandens* Roxb	Olacaceae	C	+
40	*Tetrapilus brachiatus* Lour.	Oleaceae	C	+
41	*Cymbidium findlaysonianum* Lindl.	Orchidaceae	B	+
42	*Dendrobium crumenatum* Sw.		B	+
43	*Pandanus tectorius* Parkinson	Pandanaceae	C	+
44	*Phyllanthus vitis-idaea* (Burm.f.) J.Koenig ex Roxb.	Phyllanthaceae	C	+
45	*Phyllanthus subscandens* var. subscandens		C	+
46	*Bambusa bambos* (L.) Voss	Poaceae	A	+
47	*Drynaria quercifolia* (L.) J.Sm.	Polypodiaceae	B	+
48	*Pyrrosia longifolia* C.V.Morton		B	+
49	*Pyrrosia piloselloides* (L.) M.G.Price		B	+
50	*Ardisia crenata* Sims	Primulaceae	B	+
51	*Ardisia elliptica* Thunb.		B	+
52	*Ziziphus oenopolia* (L.) Mill. var. *brunoniana* (C.B.Clarke ex A.W.Hill) Tardieu	Rhamnaceae	C	+
53	*Carallia brachiata* (Lour.) Merr.	Rhizophoraceae	A,C	+
54	*Catunaregam tomentosa* (Blume ex DC.) Tirveng.	Rubiaceae	B,C	+
55	*Psychotria asiatica* L.		B	++
56	*Atalantia monophylla* (L.) DC.	Rutaceae	C	+
57	*Glycosmis pentaphylla* (Retz.) DC.		B	+
58	*Flacourtia indica* (Burm. f.) Merr.	Salicaceae	C	+
59	*Casearia grewiifolia* Vent.		A	+
60	*Dendrotrophe umbellata* (Blume) Miq.	Santalaceae	B	+
61	*Lepisanthes rubiginosa* (Roxb.) Leenh.	Sapindaceae	A,C	+
62	*Mischocarpus sundaicus* Blume		C	+++
63	*Planchonella obovata* (R.Br.) Pierre	Sapotaceae	C	+++
64	*Alpinia malaccensis* (Burm.f.) Roscoe	Zingiberaceae	A	+

Notes: Com. = community; Ab. = abundance; A = Coastal woodland community; B = Coastal scrub-shrubby tree shrub community; C = Coastal scrub community.

The Songkhla Lake Basin is situated on the Sathing Phra Peninsula, a narrow and elongated landform extending along the longitudinal axis of Songkhla Lake from its northern to southern reaches. The plant communities within this region have been subjected to prolonged anthropogenic disturbances over time (Prapruit *et al.* 2023). Nevertheless, certain areas still retain remnants of the original vegetation, which can be used as important indicators for reconstructing the potential native plant composition that once characterized the Songkhla Lake Basin ecosystem.

The cluster analysis and Jaccard similarity matrix based on species composition distinguished three types of plant communities (Fig. 5; Table 2). The Woodland community is represented by the plant community situated farthest inland. The Scrub community is represented by the plant community occurring closest to the coastline. The Scrub-Woodland mixed community is represented by the transitional zone between these two communities, reflecting a gradient of environmental conditions and species composition. The proposed plant communities and their species richness are presented in Figure 2.

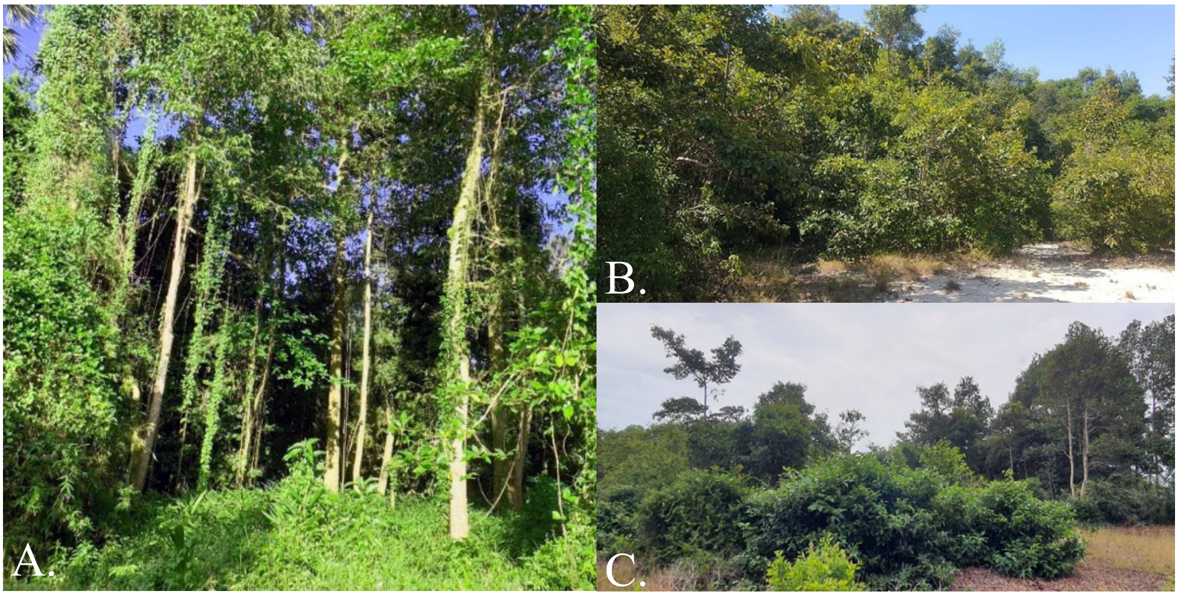

Figure 2 Coastal vegetation

Notes: A. Coastal Woodland Community (Plot No.20); B. Coastal Scrub-Shrubby Tree Community (Plot No.10); and C. Coastal Scrub Community (Plot No.3).

(A) Coastal Woodland Community

The plant community located farthest inland was represented by four sampling plots (Plots 17 - 20), in which 12 vascular plant species were recorded. *Dipterocarpus alatus* Symington, a characteristic emergent tree species, dominated the canopy layer. The understory layer was composed of *Bambusa bambos* (L.) Voss, *Carallia brachiata* (Lour.) Merr., *Casearia grewiifolia* Vent., *Lepisanthes rubiginosa* (Roxb.) Leenh., *Sandoricum koetjape* (Burm.f.) Merr., and *Syzygium grande* (Wight) Walp., which were characteristic components of the coastal sand ridge plant community. Their presence had also been documented in previous studies (Congdon 1982; Sridith 2002; Laongpol 2010), contributing to the structural complexity of the community.

The ground layer was represented by two herbaceous species, *Alocasia sanderiana* W. Bull and *Alpinia malaccensis* (Burm.f.) Roscoe, and one climbing species, *Tinospora crispa* (L.) Hook.f. & Thomson, was also recorded. Additionally, seedlings of *Ardisia elliptica* Thunb., *Caryota mitis* Lour., and *Streblus asper* Lour. were observed (Figs. 3 & 2A). According to Laongpol (2010), plant communities containing *Dipterocarpus alatus* Symington were classified as dune woodland communities. This classification is consistent with the findings of the present study; however, the observed species diversity was lower than that reported in previous research, likely due to human habitation and various land-use activities in the surrounding area, which may have impacted the vegetation at the study site.

Results from cluster and similarity analyses indicated that this plant community, comprising Plots 17, 18, 19, and 20 (Fig. 6), exhibited the highest level of similarity within the group. The short branch lengths in the dendrogram, coupled with moderate similarity indices in the Jaccard matrix (e.g., Plot 17 vs. Plot 18: 0.25; Plot 19 vs. Plot 20: 0.13; Table 2), suggest that these plots share a common set of species. This high degree of resemblance is attributed to their proximity to similar environmental conditions.

(B) Coastal Scrub-Shrubby Tree Community

The area inland from the coastal zone was surveyed using 12 sampling plots (Plots 7 - 14), in which 24 plant species were documented. The canopy layer was predominantly characterized by *Dipterocarpus chartaceus* Symington, which emerged as the dominant species and was consistently recorded across all surveyed plots. *Neolitsea zeylanica* (Nees & T. Nees) Merr. was present within the sub-canopy layer, while *Psychotria asiatica* L. was ubiquitously recorded, highlighting its ecological significance in this stratum.

The understory layer was primarily composed of *Dianella ensifolia* (L.) Redouté, representing the most abundant species at this level. A notable presence of the climbing species *Hoya verticillata* (Vahl) G.Don var. *verticillata* was observed throughout the plots. Furthermore, two orchid species, *Cymbidium findlaysonianum* Lindl. and *Dendrobium crumenatum* Sw., were recorded, indicating a diversity of epiphytic flora. Fern species, including *Drynaria quercifolia* (L.) J.Sm., *Pyrrosia longifolia* (Burm.f.) C.V.Morton, and *Pyrrosia piloselloides* (L.) M.G.Price, were also documented, contributing to the compositional and structural complexity of the community (Figs. 4 & 2B).

Compared to previous studies by Laongpol (2010), several plant species recorded in the present study are classified within the dune scrub community, including *Dianella ensifolia* (L.) Redouté, *Hoya verticillata* (Vahl) G.Don var. *verticillata*, and *Dischidia major* (Vahl) Merr.

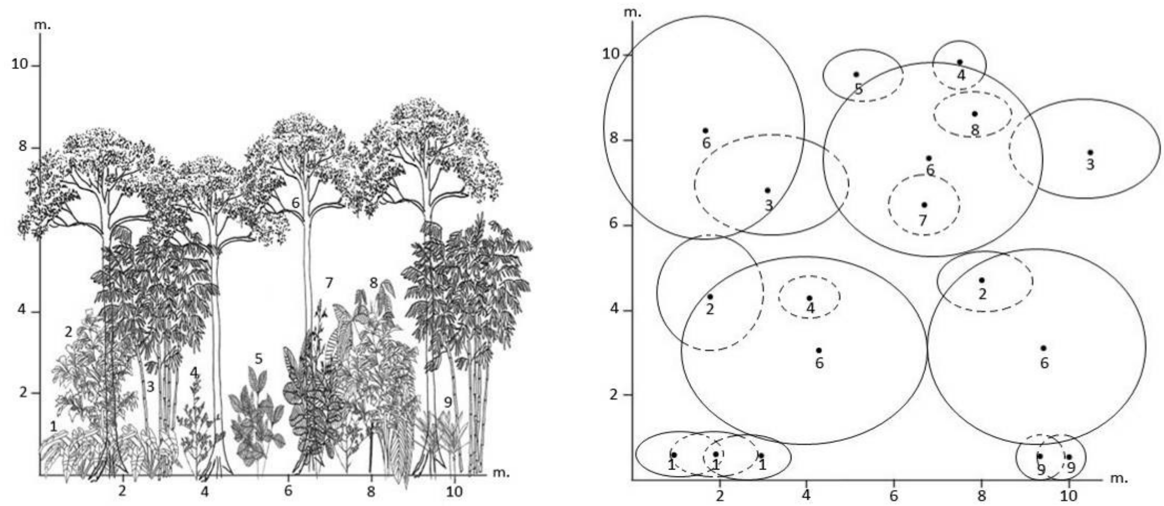

Figure 3 Community A (Plot No. 17)

Notes: 1 = *Alocasia sanderiana* W.Bull; 2 = *Caryota mitis* Lour.; 3 = *Bambusa bambos* (L.) Voss; 4 =*Streblus asper* Lour.=; 5 =*Carallia brachiata* (Lour.) Merr.; 6 = *Dipterocarpus alatus* Roxb. ex G.Don; 7 =*Lepisanthes rubiginosa* (Roxb.) Leenh.; 8 =*Sandoricum koetjape* (Burm.f.) Merr.; 9. *Alpinia malaccensis* (Burm.f.) Roscoe.

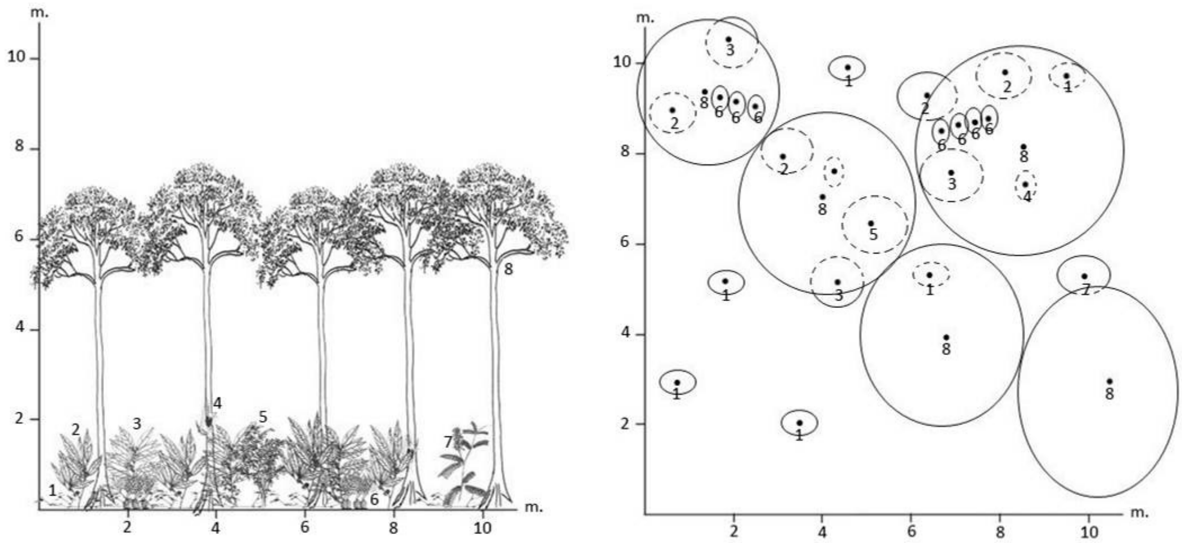

Figure 4 Figure 4 Community B (Plot No. 8)

Notes: 1 =*Cyanotis cristata* (L.) D.Don; 2 = *Neolitsea zeylanica* (Nees & T.Nees) Merr.; 3 = *Psychotria asiatica* L.; 4 = *Hoya verticillata* (Vahl) G.Don var. *verticillata*; 5 = *Caryota mitis* Lour.; 6 = *Drynaria quercifolia* (L.) J.Sm.; 7 = *Abrus precatorius* L.; 8 = *Dipterocarpus chartaceus* Symington.

(C) Coastal Scrub Community

This plant community, located near the shoreline, is characterized by densely clustered vegetation and comprises eight plots (Plots 1 - 5, 15, and 16). It exhibits the highest species diversity among all communities, with 39 species recorded. The dominant species within this community include *Mischocarpus sundaicus* Blume, *Planchonella obovata* (R.Br.) Pierre, and *Vitex pinnata* L. *Dipterocarpus chartaceus* Symington was the most frequently encountered tree species.

Several tree species in this community exhibited a shrubby crown structure, despite typically developing regular, well-formed crowns when growing further inland. Notably, 29 species recorded in this community were absent from the previously described plant communities, highlighting its unique floristic composition (Figs. 5 & 2C).

The natural forest patches studied exhibited clear zonation. Salt-tolerant plant species were observed in the frontal zone closest to the saltwater. Behind this zone, species such as *Pandanus tectorius* (Merlin 1999) and *Planchonella obovata* (R.Br.) functioned as a buffer against salinity intrusion. Further inland, dipterocarp species (*Dipterocarpus alatus* Roxb. ex G.Don, *Dipterocarpus chartaceus* Symington) were present; these species are less salt-tolerant but were protected by the vegetation in the frontal zones. When the frontal zone vegetation was removed, the inner zones were also negatively affected due to increased salinity. In certain cases, human-made structures or cultivated plants were employed as barriers to limit salt intrusion (Su *et al.* 2025). The gradual disappearance of dipterocarp species was primarily attributed to human harvesting rather than natural mortality, as natural plant death was rarely observed; anthropogenic activities were the predominant cause of vegetation loss.

The analysis results included plots 4, 7, 8, 9, 10, 11, 12, and 13 (Fig. 6). Notably, several plots within this community, particularly plots 9, 10, 11, and 12, exhibited high similarity values (up to 0.67, Table 2), as reflected by the shorter branches in the dendrogram. This finding indicates a strong floristic cohesion, which may be attributed to shared habitat characteristics, such as moderate exposure to environmental stress or similar successional stages. The relatively higher species turnover observed between plots in this community, compared to Community A, suggests the presence of microhabitat heterogeneity or slight variations in disturbance regimes.

The findings of the present study are largely consistent with those reported by Laongpol (2010) regarding the composition of this plant community. Analysis of Community C revealed the greatest heterogeneity, with plots 1, 2, 3, 5, 6, 14, 15, and 16 exhibiting longer branch lengths and lower similarity values across the matrix. The isolation of plots such as 1, 2, and 5 reflects their distinct species assemblages. These patterns suggest that Community C may encompass a broader range of environmental conditions or historical land-use impacts, resulting in increased species variability. Additionally, the presence of unique species not shared with other communities indicates reduced influence from coastal stressors and potentially more stable or mature vegetation.

An interesting ecological observation is that tree species within certain plots exhibit a shrubby crown form near the coastline but develop a normal canopy structure further inland. This morphological adaptation is likely a response to abiotic stressors such as strong winds, high salinity, or nutrient-poor soils in the coastal zone, reinforcing the clustering patterns observed in Community A (Jiang *et al.* 2025). Overall, the strong correspondence between the dendrogram and the similarity matrix supports the robustness of the clustering results. The differentiation among the three communities appears to reflect gradients of environmental stress, disturbance history, and microhabitat variation. Future analyses incorporating specific environmental parameters, such as soil salinity, elevation, and wind exposure, are recommended to further elucidate the ecological drivers shaping these plant communities.

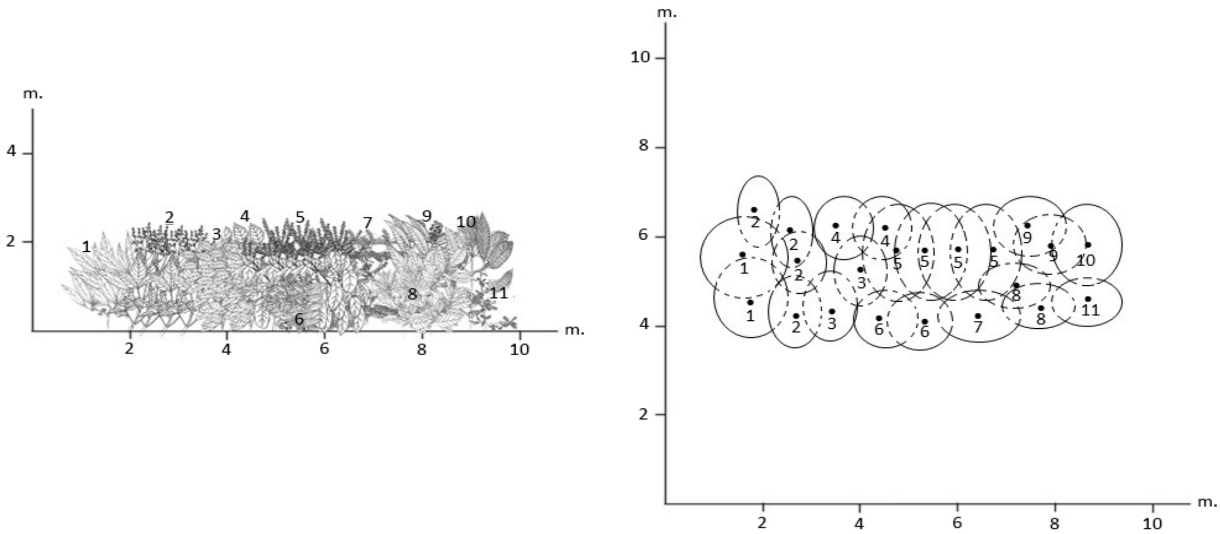

Figure 5 Community C (Plot No. 4)

Notes: 1 = *Neolitsea zeylanica* (Nees & T. Nees) Merr.; 2 = *Vitex pinnata* L.; 3 = *Olax scandens* Roxb; 4 =*Derris trifoliata* Lour.; 5 = *Mischocarpus sundaicus* Blume; 6 = *Ziziphus oenoplia* (L.) Mill.; 7 = *Abrus precatorius* L.; 8 = *Planchonella obovata* (R.Br.) Pierre; 9 = *Syzygium antisepticum* (Blume) Merr. & L.M.Perry; 10 = *Garcinia celebica* L; 11 = *Flacourtia indica* (Burm. f.) Merr.

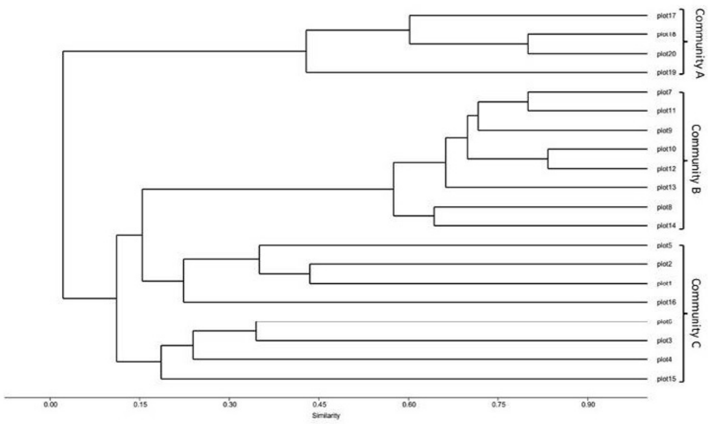

Figure 6 The cluster analysis dendrogram presents the results of a hierarchical cluster analysis (HCA) based on the similarity of 20 vegetation plots

Notes: The plots are grouped into three distinct plant communities, labeled as:

Community A comprises plots 17, 18, 19, and 20. These plots are highly similar, as indicated by the short branch lengths within this cluster, suggesting strong compositional resemblance among these plots.

Community B consists of plots 4, 7, 8, 9, 10, 11, 12, and 13. Although this community exhibits more internal variation than Community A, the plots still share significant floristic similarities.

Community C includes plots 1, 2, 3, 5, 6, 14, 15, and 16. Plots within this group demonstrate distinct characteristics, especially plots 1, 2, and 5, which show longer branch lengths, indicating lower similarity to other plots.

Table 2 Jaccard similarity matrix between the plots

	pl.1	**pl.2**	**pl.3**	**pl.4**	**pl.5**	**pl.6**	**pl.7**	**pl.8**	**pl.9**	**pl.10**	**pl.11**	**pl.12**	**pl.13**	**pl.14**	**pl.15**	**pl.16**	**pl.17**	**pl.18**	**pl.19**	**pl.20**
pl.1	1																			
pl.2	0.29	1																		
pl.3	0.09	0.13	1																	
pl.4	0.05	0.06	0.18	1																
pl.5	0.25	0.17	0.00	0.06	1															
pl.6	0.11	0.13	0.33	0.22	0.06	1														
pl.7	0.08	0.10	0.00	0.05	0.09	0.10	1													
pl.8	0.06	0.08	0.00	0.04	0.07	0.14	**0.58**	1												
pl.9	0.08	0.10	0.00	0.10	0.09	0.10	0.45	0.46	1											
pl.10	0.10	0.14	0.00	0.06	0.13	0.12	0.44	0.45	**0.63**	1										
pl.11	0.09	0.13	0.00	0.05	0.11	0.11	**0.56**	0.42	0.40	**0.57**	1									
pl.12	0.10	0.14	0.00	0.06	0.13	0.12	0.44	0.33	0.44	**0.67**	**0.57**	1								
pl.13	0.07	0.08	0.00	0.09	0.08	0.09	0.38	0.31	0.38	0.36	0.33	0.50	1							
pl.14	0.07	0.08	0.00	0.09	0.08	0.14	0.38	0.40	0.29	0.36	0.45	0.36	0.43	1						
pl.15	0.00	0.00	0.06	0.23	0.00	0.17	0.00	0.04	0.00	0.00	0.06	0.00	0.00	0.05	1					
pl.16	0.20	0.13	0.20	0.18	0.11	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	1				
pl.17	0.00	0.00	0.07	0.00	0.08	0.00	0.00	0.00	0.06	0.00	0.07	0.00	0.00	0.00	0.05	0.00	1			
pl.18	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	1		
pl.19	0.00	0.00	0.09	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.25	0.22	1	
pl.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.60	0.13	1

Conservation Measures

The dryland coastal vegetation of the Songkhla Lake Basin, Songkhla, Thailand, is considered significant for regulating water dynamics in the coastal dunes. It contributes to the maintenance of water levels accumulated in the sandbars, originating both from mountain runoff along the descending slopes of the basin, driven by gravity, and from rainfall that is collected within the sandbars themselves (Finkl & Makowski 2017).

The composition, structure, and diversity of the plant community have been significantly influenced by reforestation efforts and government policies. In past reforestation programs, certain tree species may have been introduced, natural regeneration processes altered, and land-use patterns modified, all of which affected native vegetation dynamics (Willium *et al.* 2024). Furthermore, government policies concerning land management, conservation, and development have shaped the establishment and persistence of these plant communities over time (Talerngsri 2020). Conservation activities have included reforestation projects that introduced fast-growing invasive species, such as *Casuarina equisetifolia* L. and *Acacia mangium* Willd., which inhibit the growth of native plants and destroy existing seed banks and seedling reserves of indigenous species.

Coastal zones are characterized by high biodiversity and complex interconnections among terrestrial and marine ecosystems, as well as social and governance systems. Despite ongoing conservation efforts, unsustainable resource use continues to persist, presenting significant governance challenges due to the complexity and cross-sectoral nature of these issues. Effective management requires an interactive governance approach that accounts for the relationships among ecological, social, and governing systems at multiple levels: understanding the complexity of coastal zones (first order), improving legal and institutional frameworks (second order), and establishing principles and values to guide challenging decisions (meta order) (Satumantpan & Chuenpagdee 2022). In the Songkhla Lake Basin, the destruction of dryland coastal vegetation has been notably influenced by government policies (Wear & Wibbenmeyer 2023). For instance, new land tax laws have compelled landowners to remove remaining natural plant communities classified as forest patches to avoid high taxes. To comply, crops specified under the law have been cultivated in place of native vegetation, leading to the near-elimination of indigenous plant communities on the dry coastal dunes of the basin. However, the environmental impacts of these government policies have been insufficiently studied. This lack of comprehensive research has allowed the continued destruction of valuable coastal vegetation, resulting in the rapid loss of ecologically important areas.

CONCLUSION

The remnant dryland coastal vegetation of the Songkhla Lake Basin represents a highly diverse yet fragile ecosystem shaped by both natural gradients and intense anthropogenic pressures. Three distinct plant communities, i.e., coastal woodland, coastal scrub-scrubby tree, and coastal scrub communities, reflect ecological adaptations to inland-to-shoreline conditions but remain increasingly threatened by land-use change, harvesting, invasive species, and misguided policies. The primary drivers of degradation are not natural processes but human interventions, particularly land tax laws and inappropriate reforestation practices. Effective conservation requires an integrated governance approach that recognizes ecological functions, reforms counterproductive policies, and prioritizes the intrinsic value of native ecosystems. Without timely and coordinated action, these unique and irreplaceable plant communities face imminent and irreversible loss.

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