Journal of Coastal Conservation (2020) 24: 44
https://doi.org/10.1007/s11852-020-00761-9

Woody plant community and distribution in a tropical coastal sand dune in southern Thailand

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Received: 31 January 2018 / Revised: 11 June 2020 / Accepted: 16 June 2020 / Published online: 25 June 2020

Abstract

In this study, we aimed to clarify the forest structure and species composition of a coastal sand dune and the relationship between topographical factors and woody plant distribution at the Bang Boet coastal sand dune, Southern Thailand. Three permanent transect plots (10 × 100 m) covering both windward and leeward aspects were established 300 m apart. In subplots (10 × 10 m) of each transect, all woody plants with a diameter at breast height larger than 1 cm were tagged, measured, and identified. The topographic factors were recorded for each subplot. Non-multidimensional scaling was employed to analyse the woody plant distribution, which was tested for statistical significance. We identified 36 species from 32 genera and 23 families. Species diversity was moderate based on the Shannon–Wiener index (2.81). The density and basal area of all woody plants was 3110 ± 361 stem·ha^{-1} and 7.34 ± 0.87 m^2·ha^{-1}, respectively. The dominant trees species based on the importance value index were *Pandanus odorifer*, *Syzygium antisepticum* and *Syzygium grande*. The forest structure could be classified into two canopy layers, with an open and closed crown canopy on the windward and leeward aspects, respectively. Overall, the distribution of woody plants was significantly correlated with aspect. Species diversity, tree abundance, and basal area differed significantly between the windward and leeward aspects and quantitative values were low on the windward aspect. Due to strong winds and salt spray on the windward side, the woody plant community and distribution favoured the leeward side.

Keywords Coastal sand dune · Forest structure · NMDS · Species composition · Topographic factors

Introduction

Overexploitation, habitat modification, and pollution have caused estuarine and coastal zone degradation, biodiversity loss, and a decline in ecological resilience (Lotze et al. 2006). Coastal zones are important because they support a wide range of contrasting ecosystems, such as coral reefs, lagoons, seagrass meadows, kelp forests, mangrove wetlands, sand dunes, and other types of coastal vegetation. Sand dunes consist of ridges or mounds formed by wind deposition of loose sand (Pye and Tsoar 2009) or aeolian systems that develop on sandy beaches (Martínez et al. 2004; Lancaster 2009). Sand dunes bear the full force of coastal winds, which move loose sand, burying plants and exposing their roots. Moreover, the sand surface can reach 60–70 °C under full sun exposure (Louge et al. 2013). The harsh dune environment changes from the windward (front) to the leeward (back) aspect, providing unique habitats for plants and wildlife. Native dune vegetation can reduce wind speed, thereby stabilising and trapping loose sand particles (Levin and Ben-Dor 2004; Tsoar 2005). In addition, this ecosystem protects human developments and is an important habitat for mediating the negative impacts of global climate change, including rising sea levels, large storms, and increased erosion (Cochard et al. 2008). However, it is a fragile ecosystem that is sensitive to human activities, especially tourism-driven land development.

Coastal sand dunes are useful for studying the interactions between plant species and their environment from an initial successional stage. For instance, soil is the most important factor for plant establishment. On coastal sand dunes, the soil is very fine grained (Prachantasen et al. 2008) and extremely

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porous, has low water-holding capacity (Yair et al. 2008), and may have increased salinity due to salt spray (Sevink 1991). It can cause burial, abrasion, drought, and nutrient stress in plants, especially on the foredune (Hesp and Martinez 2008). Wind is considered the main factor influencing sand movement (McLachlan 1991; Çakan et al. 2011) and is an important factor in controlling the distribution, establishment, and characteristics of plant communities (Lubke 1983; Moreno-Casasola 1986; Maun 2009). In addition, salt spray has an important role in determining plant succession on coastal sand dunes (Hesp 1991; Wilson and Sykes 1999; Griffiths and Orians 2003; Maun 2009), and most plant species are distributed based on their tolerance to salt, with those growing near the coast being more tolerant (Yura 1997). Furthermore, topography can protect plants from wind and salt spray and is related to soil nutrients; therefore, it may be an important determinant of plant distribution. These factors may act alone or in combination, and the impacts of each vary according to local environmental conditions. Thus, plant establishment on coastal sand dunes is mainly initiated by primary succession based on these crucial environmental factors (Robertson and Vitousek 1981; Lichter 2000; Walker and del Moral 2003; Álvarez-Molina et al. 2012), especially the presence of grass and some herbaceous species that function to build sand dunes due to their extensive root systems and ability to grow under constant sand burial (Botkin 1993; Maun 1998). Plant community complexes on coastal sand dunes result from the interaction between plant tolerance and the environment, with climate, rainfall, growth season, and dry periods as the main factors (Maun 2009).

In Thailand, the Bang Boet coastal sand dune is one of the largest sand dunes located on the inner gulf of Thailand. It was created by wind-blown sand under dry conditions, probably during and after the mid-Holocene 2220–2960 years ago (Lertnok et al. 2010), and the sediments on the sand dune were deposited by unusual storms about 100 years ago. However, this area has not been affected by typhoons in the past four decades (Prachantasen et al. 2008). Vegetation establishment on this sand dune may be affected by environmental factors similar to those affecting other coastal sand dunes, such as strong wind, salt spray, and soil. In general, coastal woody species on coastal sand dunes in Southern Thailand include *Casuarina equisetifolia*, *Terminalia catappa*, *Hibiscus tiliaceus*, and *Premna serratifolia* (Hayasaka and Fujiwara 2005). Meanwhile, the dominant species of terrestrial coastal forest along the eastern coast of peninsular Thailand are *Syzygium antisepticum* and *Syzygium grande* (Sridith and Laongpol 2003). Coastal grassland includes *Ipomoea pes-caprae*, *Ipomoea imperati*, *Fimbristylis sericea*, and *Cyperus stoloniferus*, while coastal scrub is composed of woody plants such as *Sindora siamensis*, *Planchonella obovata*, and *S. grande* (Laongpol et al. 2009). However, the interaction between plant species distribution and environmental factors is not well documented, and the destabilisation of sand dunes, especially due to damaged vegetation (e.g. during road construction, sand stabilisation, and invasion of non-native plants) requires study. Therefore, in this study, we aimed to clarify the forest structure and species composition of the Bang Boet coastal sand dune in Thailand and the relationship between topographic factors and woody plant distribution.

Materials and methods

Study site

Study site was revised as "The study was conducted on the Bang Boet natural coastal sand dune (10°55′22″–10°56′6″N, 99°29′25″–99°29′49″E), Pak Klong sub-district, Pathio district, Chumphon Province, Southern Thailand (Fig. 1), 425 km south of Bangkok. The highest elevation is approximately 20 m above mean sea level (Lertnok et al. 2010; Choowong 2011). The Bang Boet coastal sand dune experiences a tropical monsoon climate with three main seasons: rainy, winter, and dry seasons. The wet season lasts 6 months from May to October and is influenced by the southwest monsoon. Winter occurs between November and January and is influenced by the northeast monsoon. The dry season occurs between February and April and is under the influence of the humid and hot southeast monsoon. The mean annual rainfall between 1990 and 2017 was 1730.52 mm, with a minimum of 1148.10 mm in 1994 and a maximum of 2656.50 mm in 1996. The mean monthly temperature over this period was 24.83 °C, with a minimum of 19.12 °C in April and a maximum of 30.54 °C in December. The soil is Bacho seties, sandy (99.55%), and rather acidic (pH 4.20–6.30), and has a low water-holding capacity and a low nutrient content (Marod et al. 2020)".

Data collection

Three permanent transect plots that crossed the windward and leeward aspects were established in 2012 (Fig. 1). Each transect was 10 × 100 m, with 300 m between transects. Subplots of 10 × 10 m were created, yielding 30 subplots, and all woody plants with a diameter at breast height (DBH) larger than 1 cm were tagged, measured, and identified to the species level. Identification of specimens was confirmed by the Forest Herbarium, Department of National Parks, Wildlife and Plants Conservation, and species nomenclature was based on Smitinand (2014). Stratification based on Richards (1952) was used to describe the vertical and horizontal plant community structure. The topographic attribute of elevation was measured using a dumpy level in the four corners of each subplot. Mean elevation, convexity, slope, and aspect were calculated according to Legendre et al. (2009).

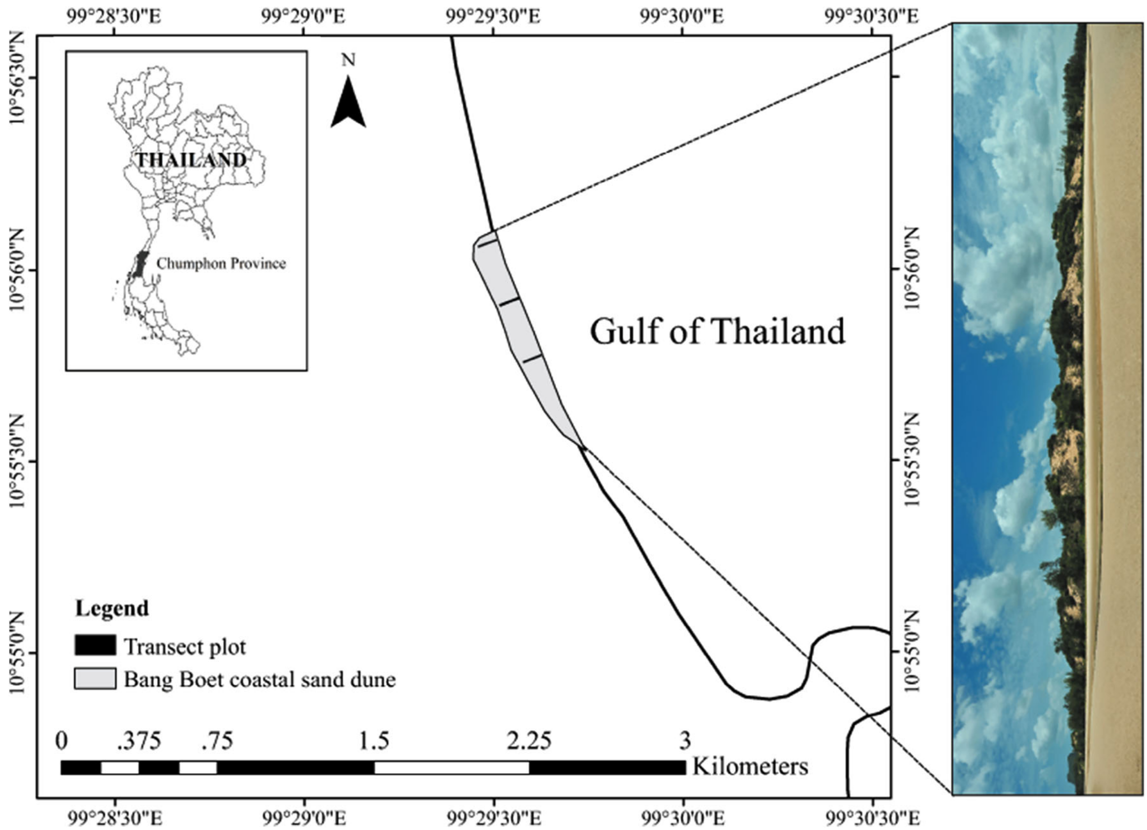

Fig. 1 Study site at Bang Boet coastal sand dune on the inner gulf of Thailand

Data analysis

Data analysis was revised as "Species richness (at the species, genus, and family levels) was assessed for all transects. Species diversity based on the Shannon–Wiener (H') index and Fisher's alpha diversity index (Shannon and Weaver 1949; Fisher et al. 1943) was analysed using the *diversity* and *fisher.alpha* function, respectively, in the vegan package (Oksanen et al. 2015). The forest horizontal structure was described in terms of woody plant density (stem·ha^{-1}), basal area (m^{2}·ha^{-1}), and DBH class distribution. To detect the dominant species, saplings ($1 \leq$ DBH < 5 cm) and trees (DBH ≥ 5 cm) were used to analyse the importance value index (IVI). The IVI was calculated as the sum of three indices: the relative dominance in basal area, relative density, and relative frequency (Curtis and McIntosh 1950). To detect the relationship between topographic factors and woody plant distribution, ordination analysis based on non-metric multidimensional scaling (NMDS) was used. The ordination dimension selected was that which provided lower stress. The data were organised into subplot × species matrices with the cells filled with the abundance values of each species and into subplot × topographic matrices with the cells filled with the values of each factor. NMDS was used with the *metaMDS* function as implemented in the vegan package and Bray–Curtis dissimilarity as the metric distance (Oksanen et al. 2015). Subsequently, the *envfit* function over the NMDS ordination was used to fit vectors representing the sand dune communities. Finally, the significance of the factors was tested using the permutation test (9999 permutations). Then, one-way analysis of similarity (ANOSIM) was used to test for significant differences in the composition patterns of woody plant species revealed in the NMDS ordination (Clarke 1993). The data were organised into subplot × species matrices with the cells filled with the abundance values of each species and into subplot × side matrices with the cells filled with the code side of each subplot. ANOSIM was performed using the *anosim* function as implemented in the vegan package (Oksanen et al. 2015). The Wilcoxon statistical test was used to identify significant differences among the community types on the coastal sand dune. All analyses were performed using the R data analysis package ver. 3.2.5 (R Development Core Team 2016)."

Results

Forest structure and species composition

Woody plants consisted of 933 stems representing 36 species from 32 genera and 23 families (Appendix Table 3). The dominant families based on species numbers were Myrtaceae (six species) and Rubiaceae (five species), whereas other families were represented by only one or two species. The genus *Syzygium* had the highest number of species (four species), whereas other genera were represented by only one or two species. The woody plant density for all woody plant species, trees, and sapling stages varied among the transects (Table 1). The mean (± standard deviation) density and mean basal area for all woody plants were 3110 ± 361 stem·ha^{-1} and 7.34 ± 0.87 m^2·ha^{-1}, respectively. The diameter class distribution was significantly represented by a negative power growth form (Fig. 2). Moderate plant species diversity was found based on the H′ index (2.81) and Fisher's alpha index (7.45).

The dominant species were mostly saplings and trees. Of the trees, *Pandanus odorifer* had the highest IVI (53.20%), followed by *Syzygium antisepticum* (46.97%), *Syzygium grande* (39.39%), *Planchonella obovata* (32.34%), *Mischocarpus sundaicus* (20.92%), *Sindora siamensis* (16.92%), *Syzygium claviflorum* (13.67%), *Chaetocarpus castanocarpus* (12.19%), *Suregada multiflora* (11.74%), and *Atalantia monophylla* (10.27%). Of the saplings (including shrubs and small trees), *M. sundaicus* had the highest IVI (55.39%), followed by *Eurycoma longifolia* (33.45%), *Ochna integerrima* (26.02%), *S. antisepticum* (24.27%), *Scaevola taccada* (18.19%), *S. siamensis* (17.79%), *P. obovata* (16.16%), *Aporosa planchoniana* (14.95%), *Champereia manillana* (11.02%), and *S. grande* (9.06%).

Two canopy layers, a top and a middle layer, were apparent, and there was a large amount of overlap between the layers. Correspondingly, trees higher than 7 m tended to be grouped separately from shorter trees. The top layer (height range: 7–12 m) consisted of predominantly adults of species such as *P. obovata*, *S. grande*, *S. antisepticum*, *S. multiflora*, *P. odorifer*, and *Casuarina equisetifolia*. The middle layer (< 7 m) was dominated by shrubby trees and shrubs such as *M. sundaicus*, *Aporosa planchoniana*, *O. integerrima*, *A. monophylla*, *E. longifolia*, and *S. taccada*. The windward and leeward sides were characterised by an open and a closed canopy, respectively (Fig. 3).

Relationship between topographic factors and woody plant distribution

The NMDS analysis revealed lower stress (0.075) for the two-dimensional ordination, which was chosen as the most appropriate NMDS ordination. The first and second axes revealed two distinct groups of subplots in the Bang Boet community (Fig. 4). The windward group included 14 subplots (P1, P2, P3, P8, P11, P12, P13, P14, P15, P16, P21, P23, P24, and P25), the leeward group included 12 subplots, and the remaining four plots contained no woody plants. This pattern was confirmed by the results of the one-way ANOSIM, which indicated that woody plant species composition differed significantly between the windward and leeward sides ($r = 0.335$, $P = 0.001$). However, the Wilcoxon tests of species diversity, tree abundance and basal area differed significantly between the windward and leeward aspects ($W = 10$, $W = 12$, and $W = 21$, $P < 0.001$, respectively), with lower quantitative values on the windward side.

Two topographic factors significantly affected woody plant distribution (Table 2), but the correlations between the axes of the topographic factors differed. The distribution of all woody plant species was significantly and positively correlated with aspect ($R^2 = 0.488$, $P < 0.001$), but not with elevation, slope, and convexity. Therefore, aspect could be used to identify the woody plant distribution at the study site. These results revealed that the species composition and community structure pattern were differentiated along the direction of sand dune advancement, where the leeward aspect had greater plant establishment than the windward aspect.

Discussion

Woody plant community

The woody plant species on the Bang Boet coastal sand dune were mostly similar to the species found in beach forests in Thailand. Except for *Casuarina equisetifolia*, *Pandanus odorifer*, and *Scaevola taccada* found at the study site, the remaining species are common to other tropical to subtropical regions (Appendix Table 3). *C. equisetifolia* inhabits Australia and other Pacific subtropical areas (Lin et al. 2017). *P. odorifer* inhabits India, Sri Lanka, and the Maldives in the east to southern China and south through Indochina and the Philippines to Indonesia. The species has also been introduced elsewhere, including eastern Africa (Allen 2011). Finally, *S. taccada* inhabits tropical and subtropical Indo-Pacific coastal land, from East Africa to Oceania and Japan (Tanaka et al. 2015).

Table 1 Horizontal structure (mean ± standard deviation) of all woody plants, trees, and saplings on the Bang Boet coastal sand dune according to transect, with diameters and basal areas

Transect	All woody plants (stem·ha^{-1})	Trees (stem·ha^{-1})	Saplings (stem·ha^{-1})	Diameter (cm)	Basal area (m^2·ha^{-1})
1	2540 ± 315	960 ± 128	1580 ± 218	4.60 ± 3.04	6.06 ± 0.73
2	2930 ± 328	900 ± 116	2030 ± 235	4.47 ± 3.31	7.11 ± 0.90
3	3860 ± 440	730 ± 73	3130 ± 399	4.08 ± 3.55	8.85 ± 0.98
Mean	3110 ± 361	863 ± 106	2247 ± 284	4.34 ± 3.35	7.34 ± 0.87

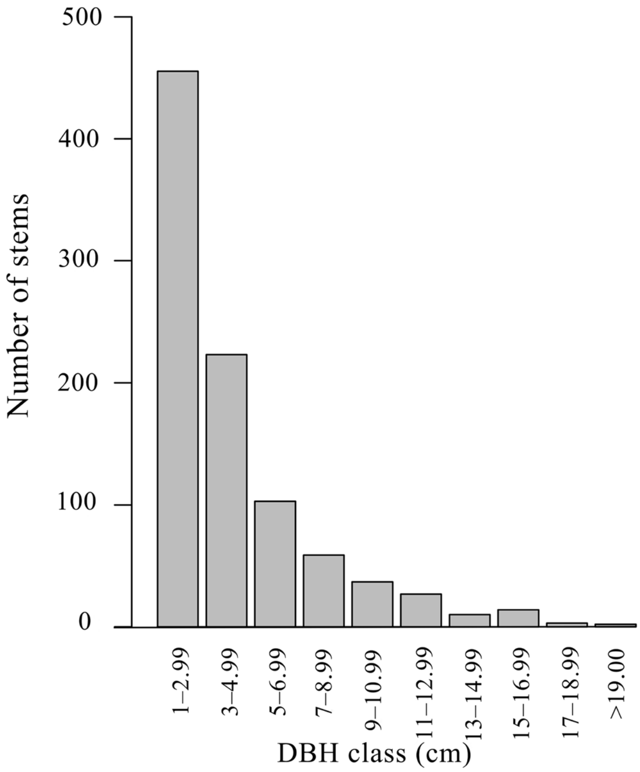

Fig. 2 Diameter class distribution of all woody plants on the Bang Boet coastal sand dune

Tree size distribution is related to concurrently measured demographic rates across species (Lima et al. 2016) when describing successional pathways and structural development (Zenner 2005) and predicting future forest stand structure (Feeley et al. 2007). In the present study, as the diameter increased, the number of stems decreased (Fig. 2), indicating that the regeneration process of the plant community was associated with a seral succession stage.

High IVI values indicate that the dominant species are distributed across a wide area (Curtis and McIntosh 1950). In the present study, *P. odorifer*, *Syzygium antisepticum*, *Syzygium grande*, *Planchonella obovata*, and *Mischocarpus sundaicus* were indicative of the Bang Boet coastal sand dune. In addition, *C. equisetifolia* and *Hibiscus tiliaceus* are generally found on coastal sand dunes in Southern Thailand (Hayasaka and Fujiwara 2005).

Tropical tree species adapted to high-wind environments might be expected to differ systematically in terms of stem allometry and life-history patterns compared to species found in less windy forests (Thomas et al. 2015). Some researchers have reported that strong winds substantially modify tree size and shape along the coast, as evidenced by the development of scrub and branches on only the leeward side (Telewski 1995). In this study, *S. grande*, *S. antisepticum*, and *Sindora siamensis* had characteristics of scrub trees. In contrast, *C. equisetifolia* and *P. odorifer* were highly resistant and could easily establish near the sea (Fig. 3). *C. equisetifolia* is a distinctive species that adapts to coastal stress by altering its tree shape and dry mass density (Lin et al. 2017). Meanwhile, *P. odorifer*, which had the highest IVI, is adapted to coastal stress. Forests with multiple vertical structures on beaches interspersed with old-growth and regrowth *Casuarina* stands, dense *P. odorifer*, and other trees and shrub species may be more resilient to tsunamis (Tanaka et al. 2007).

Woody plant distribution

Topographical habitat is instrumental in determining species composition and community structure (Addo-Fordjour and Rahmad 2015). The present study showed that species diversity, tree abundance, and basal area were differentiated based on aspect. Aspect is usually related to different environmental factors in topographical habitats, especially wind speed and direction (le Roux and McGeoch 2008). According to Qian et al. (2009), wind speed is a strong influence on the windward, rather than the leeward, side. Moreover, the windward aspect of coastal sand dunes is exposed to salt spray, and wind speed is greater than on the leeward aspect (Maun 2009), making wind and salt spray important factors in controlling the distribution, establishment, and characteristics of plants communities (Lubke 1983; Moreno-Casasola 1986; Wilson and Sykes 1999; Maun 2009). In the present study, the leeward side had a higher woody plant distribution and greater establishment by *Planchonella obovata* (PLANOB), *Mischocarpus sundaicus*

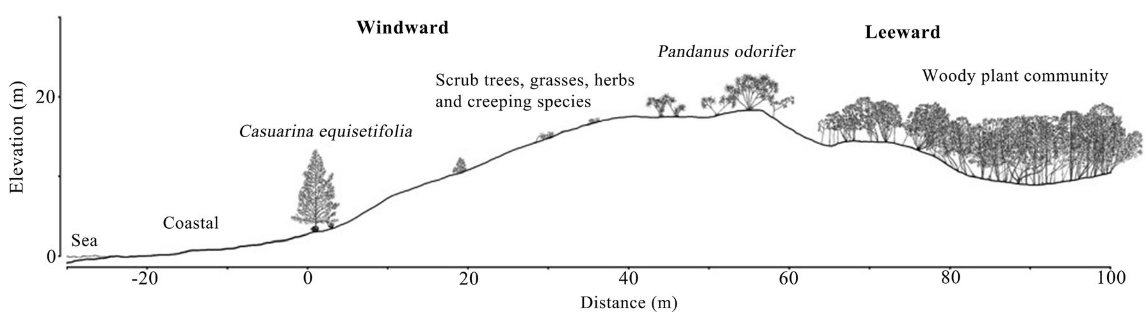

Fig. 3 Profile diagram across the altitudinal gradient of the Bang Boet coastal sand dune

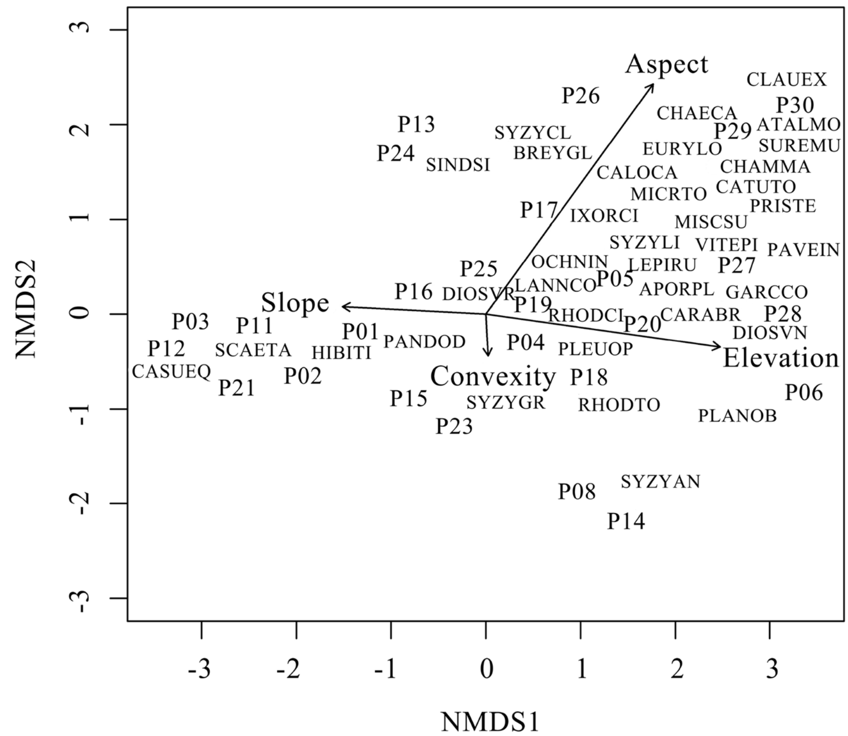

Fig. 4 Non-metric multidimensional scaling (NMDS) of woody plant distribution with topographic variables (aspect, elevation, slope, and convexity). P and the corresponding ranking number indicate the subplot number from subplot 1 (P1) to 30 (P30). Appendix Table 3 lists the species codes

(MISCSU), *Syzygium claviflorum* (SYZYCL), *Chaetocarpus castanocarpus* (CHAECA), and *Suregada multiflora* (SUREMU) compared with the windward side, as shown in Fig. 4. This pattern indicated that strong wind prevents tree establishment on coastal sand dunes, and only a few highly adapted species can succeed, such as *Pandanus odorifer* (PANDOD), *Casuarina equisetifolia* (CASUEQ), *Hibiscus tiliaceus* (HIBITI), and *Scaevola taccada* (SCAETA).

On coastal sand dunes, shrubs and grasses mainly occupy the windward, rather than the leeward, side (Isermann 2011; Peyrat and Fichtner 2011), particularly *S. taccada*, which is a coastal shrub with thick fleshy leaves that dominates beach crests and is highly salt and wind tolerant. The presence of a salt-tolerant *S. taccada* hedge along the coast can result in increased growth of other tree species (Komdeur and Pels 2005). *H. tiliaceus* is a fast-growing and wind- and salt-resistant coastal shrub or shrubby tree that has adapted to a wide range of environments, and it has been used to stabilise sand dunes and form coastal windbreaks (Tang et al. 2003). In addition, some large tree species (e.g. *C. equisetifolia*) are dominant tree species due to their pioneering characteristics, including fast growth, adaptability to barren soils, and wind resistance (Liu et al. 2014). *C. equisetifolia* is important in terms of sand dune stabilisation (Karthikeyan et al. 2013), and many researchers have recommended that it be planted as a shelter belt (Harvey et al. 2004; De Zoysa 2008; Atangana et al. 2014). However, the specimens in the present study were small, and only a few individuals were identified, even though it is recognised as an important species, is widespread along beaches in Southeast Asia (Wong 2005), and it is a common coastal species on coastal sand dunes in Southern Thailand (Hayasaka and Fujiwara 2005). Such facilitator or builder species can stabilise shifting sand and lead to the development of a foredune or windward break, giving way to other herbaceous vegetation, which in turn is taken over by shrubs that may be replaced by trees (Martínez et al. 2001). The results of the present study support the high succession of the woody plant community and distribution on the leeward rather than the windward side on the Bang Boet coastal sand dune.

Table 2 Permutation test of the abundance of all woody plants with topographic variables in the subplots

Topographic factor	NMDS1	NMDS2	R^2	*Pr* (>*r*)	Significance
Aspect	0.588	0.809	0.488	0.001	***
Elevation	0.990	−0.139	0.338	0.010	**
Slope	−0.999	0.051	0.124	0.237	ns
Convexity	0.052	−0.999	0.010	0.878	ns

***$P < 0.001$, **$P < 0.01$, *$P < 0.05$, ns = nonsignificant. *P* is the result of a 1000-iteration permutation test; R^2 is the determination coefficient of the topographic factor; *Pr* represents the correlation significance test

Conclusions

Low species diversity (36 species from 32 genera and 23 families) was found on the Bang Boet coastal sand dune, Thailand. The DBH class distribution of all woody plant species was negative and approximated a power growth form. The relationship between topographic factors and woody plant distribution was significantly associated with aspect, and most species were distributed on the leeward, rather than the windward, side of the dune. The tree species *Pandanus odorifer*, which was the dominant species, inhabited both aspects due to its high wind resistance. The other dominant species were mainly shrubby trees and trees such as *Syzygium antisepticum* and *Syzygium grande*, which were also well established, especially on the leeward side. These results indicate that strong winds influenced the effects of aspect at the study site, which is an important factor in determining the woody plant community and its distribution on this coastal sand dune.

Acknowledgments This research was supported by the Center for Advanced Studies in Tropical Natural Resources (CASTNaR), Kasetsart University, Bangkok, Thailand, and the Kasetsart University Research and Development Institute (KURDI). We would like to thank the Royal Development Projects of His Majesty King Bhumibol Adulyadej for supplying essential facilities during the fieldwork. In addition, the team at the Thai Forest Ecological Research Network (T–FERN) supported field data collection and analysis.

Appendix

Table 3 Woody plant species found on the Bang Boet coastal sand dune, southern Thailand

Family	Scientific name	Species codes	Habits
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	LANNCO	Tree
Calophyllaceae	*Calophyllum calaba* L. var. *calaba*	CALOMC	Tree
Casuarinaceae	*Casuarina equisetifolia* L.	CASUEQ	Tree
Celastraceae	*Pleurostylia opposita* (Wall.) Alston	PLEUOP	Shrub
Clusiaceae	*Garcinia cowa* Roxb. ex Choisy	GARCCO	Shrubby Tree
Ebenaceae	*Diospyros venosa* Wall. ex A. DC.	DIOSVN	Tree
Ebenaceae	*Diospyros vera* (Lour.) A. Chev.	DIOSVR	Tree
Euphorbiaceae	*Suregada multiflora* (A. Juss.) Baill.	SUREMU	Shrub/Tree
Fabaceae	*Sindora siamensis* Teijsm. ex Miq. var. *siamensis*	SINDSI	Tree
Goodeniaceae	*Scaevola taccada* (Gaertn.) Roxb.	SCAETA	Shrub
Labiatae	*Vitex pinnata* L.	VITEPI	Tree
Malvaceae	*Hibiscus tiliaceus* L.	HIBITI	Shrub/Shrubby Tree
Malvaceae	*Microcos tomentosa* Sm.	MICRTO	Tree
Myrtaceae	*Rhodamnia cinerea* Jack	RHODCI	Shrub
Myrtaceae	*Rhodomyrtus tomentosa* (Aiton) Hassk.	RHODTO	Shrub
Myrtaceae	*Syzygium antisepticum* (Blume) Merr. & L. M. Perry	SYZYAN	Shrubby Tree/Tree
Myrtaceae	*Syzygium lineatum* (DC.) Merr. & L.M. Perry	SYZYLI	Shrubby Tree/Tree
Myrtaceae	*Syzygium grande* (Wight) Walp.	SYZYGR	Tree
Myrtaceae	*Syzygium claviflorum* (Roxb.) Wall. ex A. M. Cowan & Cowan	SYZYCL	Tree
Ochnaceae	*Ochna integerrima* (Lour.) Merr.	OCHNIN	Shrub/Shrubby Tree
Opiliaceae	*Champereia manillana* (Blume) Merr.	CHAMMA	Shrubby Tree
Pandanaceae	*Pandanus odorifer* (Forssk.) Kuntze	PANDOD	Tree
Peraceae	*Chaetocarpus castanocarpus* (Roxb.) Thwaites	CHAECA	Shrub/Tree
Phyllanthaceae	*Breynia glauca* Craib	BREYGL	Shrub
Phyllanthaceae	*Aporosa planchoniana* Baill. ex Müll. Arg.	APORPL	Shrub/Shrubby Tree
Rhizophoraceae	*Carallia brachiata* (Lour.) Merr.	CARABR	Tree
Rubiaceae	*Pavetta indica* L. var. *tomentosa* (Roxb. Ex Sm.) Hook. f.	PAVEIN	Shrub
Rubiaceae	*Prismatomeris tetrandra* (Roxb.) K. Schum. subsp. *malayana* (Ridl.) J. T. Johanss.	PRISTE	Shrub
Rubiaceae	*Catunaregam tomentosa* (Blume ex DC.) Tirveng.	CATUTO	Shrub/Shrubby Tree
Rubiaceae	*Ixora cibdela* Craib	IXORCI	Shrubby Tree
Rutaceae	*Clausena excavata* Burm. f.	CLAUEX	Shrub/Shrubby Tree
Rutaceae	*Atalantia monophylla* (L.) DC.	ATALMO	Shrubby Tree
Sapindaceae	*Lepisanthes rubiginosa* (Roxb.) Leenh.	LEPIRU	Shrub/Shrubby Tree
Sapindaceae	*Mischocarpus sundaicus* Blume	MISCSU	Shrubby Tree/Tree
Sapotaceae	*Planchonella obovata* (R. Br.) Pierre	PLANL	Tree
Simaroubaceae	*Eurycoma longifolia* Jack	EURYLO	Shrub

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