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Floristic composition and distribution pattern of coastal vegetation in Chuuk island, Federated States of Micronesia

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Abstract

The distribution pattern of the coastal vegetation that is closely related to the plant diversity of the islands was surveyed in Chuuk islands, Micronesia. In consequence of TWINSPAN, which is the classification method of plant communities, six communities were classified as 1) Mangrove, 2) *Vigna marina - Bidens pilosa var. radiata* community, 3) *Scaevola taccada - Heliotropium foertherianum* community, 4) *Thespesia populnea - Pandanus* community, 5) *Hibiscus tiliaceus - Derris trifoliate* community, 6) *Enhalus acoroides* (Sea grass) community. Mangrove forest was mainly established on a salty swamp located on the small river mouth or coastline. *V. marina - B. pilosa var. radiata* community, *S. taccada - H. foertherianum* community, and *T. populnea - Pandanus*. community established on the sandy seashore. And, the *H. tiliaceus - D. trifoliate* community was observed around the rocky coast. Vegetation patterns on an island differ among three islands. Mangrove and *H. tiliaceus - D. trifoliate* community established in Weno and Romanum island, but not in Piis. This pattern seems to be the effect of the geology of the island, i.e., base-rock type may relate to habitat formation in the coastal area. On the other hand, *V. marina - B. pilosa* var. *radiata* community that includes many invader plants was established only around the town in Weno island. This community may depend on the industrial human activity. To recognize the mechanisms of formation of vegetation on islands, we need to clarify several environment factors related to geology, sociology, and economy.

Keywords: coastal vegetation, invader species, mangrove, plant community, species richness

Introduction

The coastal vegetation that is established in the boundary between the sea and land is one of the major elements of island landscape. In general, the growth of many kinds of plants is restricted in the coastal environment i.e. high salinity, poor soil, wind damage and ground instability. Therefore, the species composition of the coastal plant community often is very simple. On the other hand, the species composition and structure of the coastal plant communities vary among the topographical or geographical conditions. Therefore, the distribution pattern of the coastal vegetation would be closely related to the plant diversity of the islands.

Muller-Dombois & Fosberg (1998) reported ten categories of vegetation in Micronesia, 1: Mangrove vegetation, 2: Strand vegetation, 3: Vegetation on the coral

atolls and low coral islands, 4: Vegetation on raised coral or elevated limestone, 5: Vegetation on coastal plains, including swamp forests, 6: Lowland rain forests, 7: Montane rain forests and cloud forest, 8: Dwarf vegetation on open crests, 9: Vegetation on open crests, 9: Vegetation of rough lava flows, 10: "Savanna," or grassland, vegetation.

The general vegetation of the Caroline Islands consists of natural broad-leaved evergreen trees and planted trees (e.g. coconuts, breadfruits, and mango). Micronesian Economic surveys in 1946 reported that the coconut (*Cocos nucifera*) and bread fruits (*Artocarpus incisus*) were planted broadly on coral islands and coastal strips of volcanic islands (Muller-Dombois & Fosberg 1998). In the Chuuk islands, the forests on the gentle slope were mostly cut, and coconuts and bread-fruits were planted broadly in the cultivated site (Kanehira 1933). Like above, there are some reports of vegetation in Micronesia. However, the vegetation pattern of small coral islands or small volcanic islands in one atoll has not been shown. I will compare the species composition of the coastal plants in the Chuuk islands, and discuss the ecological character and the diversity of the coastal vegetation.

Study site

We surveyed a series of neighboring plant communities along a coastline in Chuuk states, Federated States of Micronesia. The study site was located in the three islands in Chuuk atoll, i.e. Piis, Romanum and Weno (Fig.1).

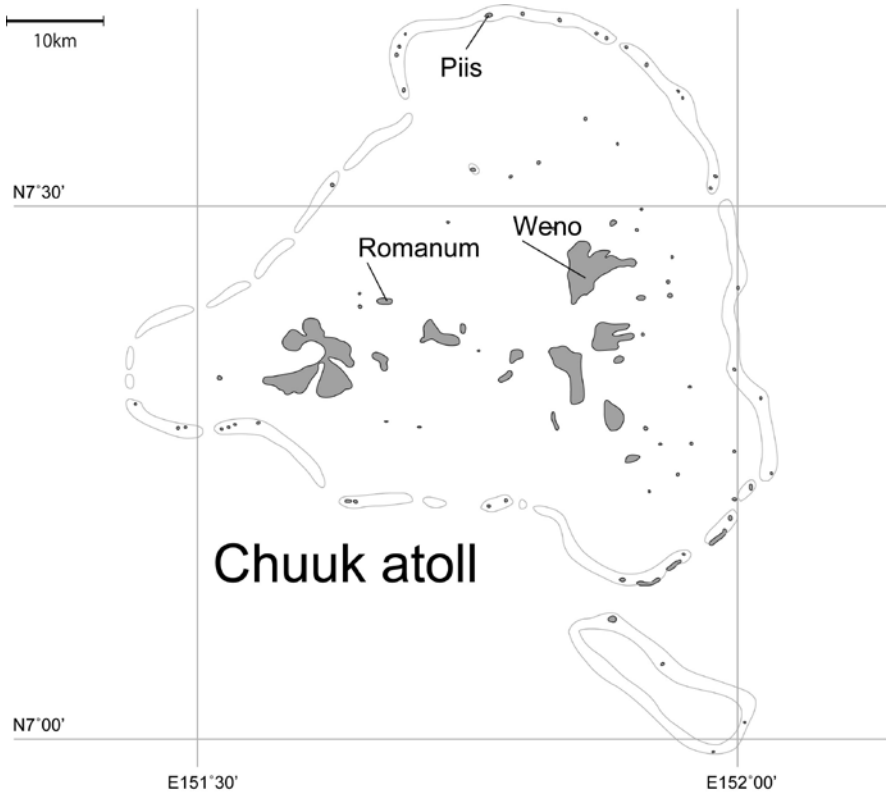

Fig. 1 Map of Chuuk atoll and studied island, Weno, Romanum, and Piis.

Weno is the capital and commercial center of Chuuk. This volcanic island has an area of over 18 km^2, and a high mountain (Mt. Tonoken, 370 m a.s.l) in the center of the island. Coastal habitats on the west side of the island are mostly changed by industrial activity, because relatively large towns are on the north-west side of the island (Galbraith et al. 2000). In contrast, Piis is a very small and flat coral island on the atoll. The length of the island is about 1km. Romanum is also a small island of about 1.5 km in length. The terrace-like ground surface with sedimentary rock was observed on the north-side of the island. On the other hand, the low-land at the south-side of island is plain of coral sand with swamp.

Methods

In this study, the vegetation on the coast line was comprehended. The habitat types on the coastline include sandy seashore, rocky coast, and salty swamp, and small sea wall.

We obtained vegetational data (43 plot) using the phytosociological method (Braun-Blanquet 1964), to recognize the species composition of the vascular plants in the coastal vegetation of the island. The surveys were conducted in August 2011. The plot area ranged from 20 m^2 (2 × 10m) to 100 m^2 (10 × 10m) because the study plot be set to correspond to the width of the habitat. The location of the individual plot was a typical point of the vegetation type. The community types were classified by TWINSPAN (two-way indicator analysis) using a computer program PC-ORD ver.5 (MjM software design).

To recognize the correspondence among the habitat types and the coastal vegetation, ground conditions were surveyed at each plot during a vegetation survey. Micro-landform, sediment (or base rock), and artificial structures were recorded by visual observation in each quadrat.

Results and discussion

1. Plant community type

TWINSPAN classification (Fig. 2) showed strong divisions forming at the first level (eigenvalues = 1.000), a group B with *Enhalus acoroides* as an indicator species containing plots characterized by sea grass species, and another large group A include the various community types.

At a second level of division (eigenvalues = 0.8069), the plots that have the indicator species *Rhizophora mucronata* and *Sonneratia alba* (A1) were separated from the others (A2) characterized by *Vigna marina* and *Thespesia populnea*. The former group was composed by the plot of Mangrove forest. On the other hand, the latter groups include the various seashore vegetation.

At a third level of division (eigenvalues = 0.5869) the plots containing the indicator species of *Derris trifoliata* (A22) were separated from the others.

At a fourth level of division (eigenvalues = 0.4809), the plots with the indicator species *Ipomoea pes-caprae* and *Leucaena leucocephala* (A21-1) were separated from the other groups (A21-2) containing two groups derived from the final division, characterized by *Scaevola taccada* (A21-21) and *Thespesia populnea* and *Phymatosorus*

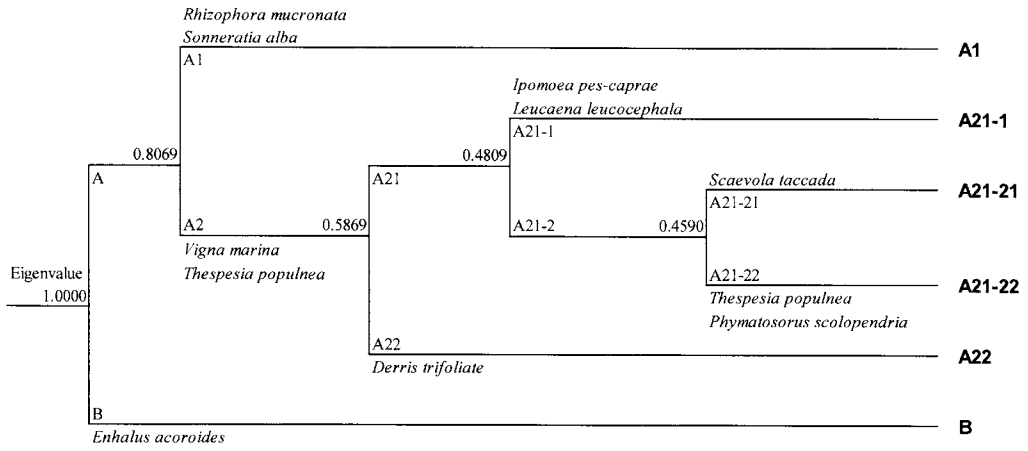

Fig. 2 TWINSPAN classification for 43 plots of coastal vegetation in Chuuk island. Species name shown in dendrogram is indicator species of each division level.

scolopendria (A21-22).

In consequence of TWINSPAN as above mentioned, six communities were classified and are named as follows:

1) Mangrove (A1)
2) *Vigna marina - Bidens pilosa var. radiata* community (A21-1)
3) *Scaevola taccada - Heliotropium foertherianum* community (A21-21)
4) *Thespesia populnea - Pandanus* community (A21-22)
5) *Hibiscus tiliaceus - Derris trifoliate* community (A22)
6) *Enhalus acoroides* (Sea grass) community (B)

Floristic composition and occurrence of these communities are shown in Table 1 and 2, respectively.

1) Mangrove

This community is mainly established on the salty swamp located on the small river mouth or coastline of the large volcanic islands such as Weno and Romanum but not in Piis island (Fig. 3, Table 2). This community mainly consists of Rhizophoraceae trees (*Rhizophora mucronata, Bruguiera gymnorhiza, Rhizophora apiculata*), and *Sonneratia alba, Excoecaria agallocha* (Species group A1, Table 1). Species diversity would be relatively low because many species such as *Avicennia marina, Xylocarpus granatum,* and *Lumnitzera littorea* that occur in well-developed Mangrove vegetation in Micronesia (Muller-Dombois & Fosberg 1998) were absent in the study site.

The canopy height of mangrove forest in the study area did not reach 10m high in every site although mature forests reach the 30-40m high like in the Pohnpei Island (Cole et al. 1999). The mangrove forests on both islands seem affected by strong human activity.

Table 1 Vegetation table of coastal vegetation in Weno, Romanum, and Piis island. Six community types are derived from TWINSPAN (see Fig. 2). The value of each species are frequency of appearance and range of dominance-scale in parentheses.

A1 : Mangrove
A21-1 : *Vigna marina - Bidens pilosa* var. *radiata* community
A21-21 : *Scaevola taccada - Heliotropium foertherianum* community
A21-22 : *Thespesia populnea - Pandanus* community
A22 : *Hibiscus tiliaceus - Derris trifoliate* community
B : *Enhalus acoroides* community

	A1	A21-1	A21-21	A21-22	A22	B
Number of stands	9	4	11	6	8	5
Mean coverage (%)	67.8	72.5	61.8	63.3	76.3	72.0
Mean community height (m)	9.3	4.8	7.1	11.5	9.2	6.0
Species group A1						
Cassytha filiformis	11 (1)	-	9 (1)	-	22 (1-2)	-
Clerodendrum inerme	44 (1-2)	-	-	-	44 (1-4)	-
Bruguiera gymnorhiza	22 (2-3)	-	-	-	-	-
Rhizophora apiculata	33 (2-3)	-	-	-	-	-
Vitaceae sp.	11 (1)	25 (1)	-	-	11 (1)	-
Davallia solida	11 (1)	-	-	17 (+)	-	-
Excoecaria agallocha	11 (2)	-	-	17 (2)	-	-
Rhizophora mucronata	78 (1-5)	25 (+)	-	17 (+)	-	-
Sonneratia alba	67 (1-4)	-	-	-	-	-
Species group A2						
Cocos nucifera	11 (+)	25 (1)	64 (+-4)	83 (1-2)	33 (2-3)	-
Nephrolepis sp.	-	-	-	33 (1-2)	11 (+)	-
Thespesia populnea	11 (1)	75 (2)	18 (+-1)	100 (+-3)	67 (1-3)	-
Guettarda speciosa	-	-	18 (1)	33 (1)	11 (2)	-
Phymatosorus scolopendria	-	25 (+)	9 (+)	83 (+-1)	33 (+-1)	-
Sida rhombifolia	-	75 (+-1)	-	-	11 (1)	-
Wedelia trilobata	-	50 (1-2)	-	-	11 (1)	-
Digitaria sp.	-	25 (2)	-	-	11 (+)	-
Desmodium umbellatum	-	25 (1)	-	33 (1-2)	11 (1)	-
Ipomoea pes-caprae	-	75 (1-3)	-	-	11 (1)	-
Premna serratifolia	-	50 (1)	18 (+-1)	50 (1)	11 (1)	-
Hernandia nymphaeifolia	-	-	18 (1)	50 (2-3)	11 (2)	-
Species group A21						
Cenchrus echinatus	-	25 (1)	18 (+)	-	-	-
Cordia subcordata	-	50 (2)	27 (2)	-	-	-
Fimbristylis cymosa	-	25 (+)	27 (+-1)	17 (+)	-	-
Lepturus repens	-	50 (1)	64 (+-3)	17 (2)	11 (1)	-
Pemphis acidula	-	25 (1)	9 (2)	33 (1)	-	-
Vigna marina	-	100 (1-4)	82 (+-3)	50 (+-2)	-	-
Species group A21-1						
Bidens pilosa var. *radiata*	-	50 (1)	-	-	-	-
Ipomoea littoralis	-	25 (+)	-	-	-	-
Panicum maximum	-	50 (1)	-	-	-	-
Polygala paniculata	-	25 (+)	-	17 (+)	-	-
Senna occidentalis	-	25 (1)	-	-	-	-
Stachytarpheta jamaicensis	-	75 (+-1)	-	-	-	-
Vernonia cinerea	-	25 (+)	-	-	-	-
Solanum sp.	-	25 (1)	-	-	-	-
Cyperus sp.	-	25 (+)	-	-	-	-
Species group A21-21						
Canavalia cathartica	-	-	27 (1-3)	-	-	-
Chamaesyce atoto	-	-	36 (+-1)	-	-	-
Heliotropium foertherianum	-	-	64 (1-3)	17 (1)	-	-
Psidium guajava	-	-	9 (+)	-	-	-
Scaevola taccada	-	25 (1)	82 (+-4)	33 (+-2)	-	-
Terminalia samoensis	-	-	36 (+-1)	-	-	-
Thuarea involuta	-	-	27 (1-2)	-	-	-
Triumfetta procumbens	-	-	36 (+-2)	-	-	-
Garcinia sp.	-	-	9 (1)	-	-	-
Crinum sp.	-	-	36 (+-2)	17 (+)	-	-

Species group A21-22						
Carica papaya	-	-	-	17 (1)	-	-
Ficus sp.	-	-	-	17 (1)	-	-
Ficus tinctoria	-	-	-	17 (1)	-	-
Pandanus sp.	-	-	45 (+-3)	100 (+-2)	11 (1)	-
Terminalia catappa	-	-	-	33 (+-2)	-	-
Zoysia sp.	-	-	-	17 (3)	-	-
Euphorbiaceae sp.	-	-	-	17 (1)	-	-
Sapindaceae sp.1	-	-	9 (+)	50 (+-2)	-	-
Psilotum nudum	-	-	-	17 (+)	-	-
Paspalum sp.	-	-	18 (+-2)	17 (3)	-	-
Sapindaceae sp.2	-	-	18 (1)	17 (1)	-	-
Species group A22						
Acrostichum aureum	-	-	-	-	11 (+)	-
Allophylus ternatus	-	-	-	-	11 (+)	-
Barringtonia asiatica	-	-	9 (1)	17 (1)	33 (1-2)	-
Derris trifoliata	-	-	-	-	89 (+-2)	-
Dioscorea bulbifera	-	-	-	-	11 (1)	-
Heritiera littoralis	-	-	-	-	11 (3)	-
Hibiscus tiliaceus	-	-	-	-	56 (1-4)	-
Macaranga carolinensis	-	-	-	-	11 (3)	-
Melanthera biflora	-	-	9 (1)	-	11 (3)	-
Nephrolepis sp.2	-	-	-	-	11 (1)	-
Procris pedunculata	-	-	-	-	22 (1)	-
Gramineae sp.	-	-	9 (+)	-	11 (1)	-
Asplenium sp.	-	-	-	17 (+)	22 (1)	-
unknown	-	-	-	-	11 (1)	-
Paliurus sp.	-	-	-	-	33 (1-2)	-
Convolvulaceae sp.	-	-	-	-	11 (1)	-
Leucaena leucocephala	-	75 (2-4)	-	-	33 (1-3)	-
Musa sp.	-	-	-	-	22 (1-2)	-
Leguminosae sp.	-	50 (+)	-	-	11 (3)	-
Species group B						
Enhalus acoroides	-	-	-	-	-	100 (3-5)
Zostera sp.	-	-	-	-	-	20 (1)

Table 2 Existence pattern of costal vegetation in Weno, Romanum, and Piis island. Community types are derived from TWINSPAN (see Fig. 2). Existence of the community type are shown as *.

	Piis	Romanum	Weno
Mangrove		*	*
Vigna marina - Bidens pilosa var. *radiata* com.			*
Scaevola taccada - Heliotropium foertherianum com.	*	*	
Thespesia populnea - Pandanus com.	*	*	*
Hibiscus tiliaceus - Derris trifoliate com.		*	*
Enhalus acoroides com.	*	*	*

A2 type communities (A21-1, A21-21, A21-22, and A22) distributed on the terrestrial habitat along the coastline and characterized by *Cocos nucifera, Hernandia nymphaeifolia, Phymatosorus scolopendria* and so on. The community type of A21 (A21-1, A21-21, A21-22) and A22 were characterized by species group A21 (e.g. *Vigna marina, Lepturus repens, Pemphis acidula*), and the species group A22 (e.g. *Barringtonia asiatica,*

Fig. 3 Mangrove forest (Romanum island).

Derris trifoliate, Hibiscus tiliaceus) respectively. The former communities established on the sandy seashore of three islands. The latter was observed on the rocky coast of Romanum and Weno Island.

***2) Vigna marina - Bidens pilosa var. radiata* community**

This is occupied by a shrub (e.g. *Leucaena leucocephala, Thespesia populnea*) and vine (*Vigna marina, Ipomoea pes-caprae*) and many herbaceous plants. This community is mainly established on the artificial coast on Weno island (Fig. 4), and includes many invader species, such as *Bidens pilosa var. radiate, Ipomoea littoralis, Panicum maximum, Polygala paniculata, Senna occidentalis, Stachytarpheta jamaicensis, Vernonia cinerea, Cenchrus echinatus* (Space et al. 2000).

Fig. 4 *Vigna marina - Bidens pilosa* var. *radiata* community (Weno island). Left: *Leucaena leucocephala* and *Ipomoea pes-caprae* dominated type. Right: *Vigna marina* and *Panicum maximum* dominated type.

3) *Scaevola taccada - Heliotropium foertherianum* community

This would be one of the natural vegetations on the sandy seashore in Chuuk (Fig. 5). Some shrub species such as *Heliotropium foertherianum, Scaevola taccada, Terminalia samoensis* with vines; *Canavalia cathartica, Vigna marina, Triumfetta procumbens* distribute to the front side of the *Cocos* plantation. In addition, coastal herbs *Chamaesyce atoto, Thuarea involute,* and *Crinum* sp. were observed in this community characteristically.

Fig. 5 *Scaevola taccada - Heliotropium foertherianum* community (Piis island).

4) *Thespesia populnea - Pandanus* community (A21-22)

This community was established on the similar habitat of *Scaevola taccada - Heliotropium foertherianum* community (Fig. 6). Large trees such as *Thespesia populnea, Hernandia nymphaeifolia, Terminalia catappa,* and *Pandanus* sp. dominated and form a relatively higher canopy than the *S. taccada - H. foertherianum* community (Table 2).

Fig. 6 *Thespesia populnea - Pandanus* community (Romanum island).

5) *Hibiscus tiliaceus - Derris trifoliate* community (A22)

Hibiscus tiliaceus, Barringtonia asiatica, Macaranga carolinensis, and many tree species comprise this forest community. The richness of forest floor herbs (e.g. *Nephrolepis, Procris pedunculata*) and epiphytic plants (e.g. *Asplenium*) are relatively high. This type was observed on the rocky coast of Romanum and Weno island.

6) *Enhalus acoroides* (Sea grass) community (B)

This consists of one or some kinds of sea-grass such as *Enhalus acoroides*. This grass community was established in the shallow sea bottom (Fig. 7).

Fig. 7 *Enhalus acoroides* community: seagrass vegetation (Piis island).

2. Distribution pattern of coastal plant community

Although some endemic species of Chuuk, such as *Maniltoa yokotai* (Kaneh.) Hosok., *Garcinia ponapensis* var. *trukensis* (Kaneh.) Fosberg, *Mischocarpus guillauminii* Kaneh., and *Semecarpus kraemeri* Lauterb., have been known (Kanehira 1933), especially species in phytogeography, species like these did not occur in coastal vegetation. Many coastal species observed in the study sites have a broad distribution area around the Pacific. For example, *Sonneratia alba* and *Rhizophora mucronata* in Mangrove, and *Scaevola taccada, Hernandia sonora, Cassytha filiformis, Thespesia populnea, Hibiscus tiliaceus* in terrestrial coast vegetation reach to the Ryukyu Islands, Japan.

Vegetation pattern on the islands differs among these three islands. The mangrove and *Hibiscus tiliaceus - Derris trifoliate* community is established on Weno and Romanum islands, but not in Piis (Table 2). This pattern seems to be affected by the geology of the island, i.e., the base-rock type may relate to soil the condition or habitat formation in coastal areas. On the other hand, the *Vigna marina - Bidens pilosa* var. *radiata* community was established only on Weno island. The floristic character of this community is high dominant and rich with invader plants (except for crop plants). The establishment of this community may depend on human activity, because invader plants invade the open site that has been created artificially. However, this community

is absent in the coastal habitat on the village side of Piis and Romanum even though land-use seems strong and frequent. Therefore, the establishment of this community may be affected by the activity style of the people (traditionally or industrially?). To recognize the mechanisms of the formation of vegetation on an island, we need to clarify several environment factors related to geology, sociology, and economy.

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＜要約＞

ミクロネシア，チューク諸島において，島の植生の分布パターンと多様性を明らかにすることを目的とし，ウエノ（Weno）島，ロマヌム島（Romanum），ピース島（Piis）において海岸植生の調査を行った。海岸植生は，１）マングローブ，２）ハマアズキ（*Vigna marina*）－オオバナノセンダングサ（*Bidens pilosa* var. *radiata*）群落，３）クサトベラ（*Scaevola taccada*）－モンパノキ（*Heliotropium foertherianum*）群落，４）サキシマハマボウ（*Thespesia populnea*）－パンダヌス（*Pandanus*）群落，５）オオハマボウ（*Hibiscus tiliaceus*）－シイノキカズラ（*Derris trifoliate*）群落，６）ウミショウブ（*Enhalus acoroides*）群落の６群落に区分された。マングローブは主に小河川の河口や海岸の塩生湿地に成立していた。一方，ハマアズキ－オオバナノセンダングサ群落，クサトベラ－モンパノキ群落，サキシマハマボウ－パンダヌス群落は砂浜に，オオハマボウ－シイノキカズラ群落は主に岩石海岸に成立していた。ウミショウブ群落は浅い海底に成立していた。このような分布パターンは各島の地質，地形的要因と関連していると考えられた。また，砂浜に成立している群落のうち，外来種を多く含むハマアズキ－オオバナノセンダングサ群落は，都市の発達したウエノ島のみで確認されたことから，人間活動も海岸植生の種組成に大きく影響を及ぼしていることが予想された。島の植生の形成メカニズムを理解するためには，地質・地形的要因および人間活動に関する要因が植生に及ぼす影響を明らかにする必要がある。

Chuukの海岸植生。ココヤシとともに様々な樹木，草本が海岸植生を形成している。写真はRomanum島のサキシマハマボウ－パンダヌス群落