

Floristic Description of Native Upland Forests on Kosrae, Eastern Caroline Islands

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Abstract -- Native upland forest vegetation was organized into ecological units called habitat types on the island of Kosrae, Eastern Caroline Islands. Habitat types were described by naming the common plants which make each type unique. This habitat type system was developed specifically for the island of Kosrae.

Introduction

Kosrae is a small island, 42 square miles (109 km²), located 5 degrees north of the equator in Micronesia. It is on the edge of the tradewind belt and rarely experiences typhoons. Its waif biota contains extensive stands of untouched upland rain forest, and it has had relatively few introduced plant species. Historic occupation of Kosrae by man has had a relatively slight effect on the native vegetation as compared to that of some of the war-torn islands of western Micronesia. Disturbance by man in the upland forests has been limited by the steep slopes that dominate the interior of the island. Cultivation has been restricted to lower slopes and stream bottoms which are easily accessible from the coastal plain. Cultivation now determines the lower limit of the native upland forest, although there is evidence that the rain forest in the past extended down to the coastal zones.

The undisturbed, native upland forest flora of Kosrae can most easily be described in terms of vegetation types used on other islands as the primary unit of organization. There are definite differences, however, between the islands of the Carolines in the environmental conditions that govern vegetation types. Kosrae is geologically young relative to the other islands and therefore has significantly different geography. It is characterized by steep slopes, narrow ridges, and a narrow coastal plain zone between the mountains and the coast (Fig. 1). This geography, coupled with the small

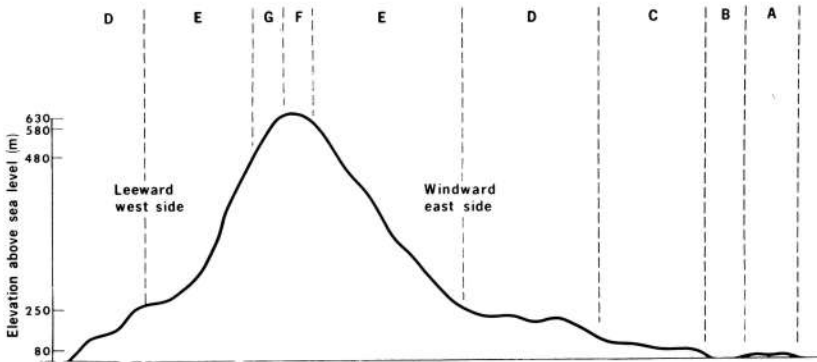


Fig. 1. Vegetation habitat and community types on Kosrae according to geography and elevation (not an exact profile of Kosrae). A, Beach Strand; B, Mangrove Swamp; C, Coastal Plain (includes *Terminalia carolinensis* -- *Barringtonia racemosa* Habitat Type); D, *Camptosperma brevipetiolata* -- *Ixora casei* Habitat Type; E, *Horsfieldia nunu* -- *Syzygium stelechanthum* Habitat Type; F, *Dicranopteris linearis* Community Type; G, *Elaeocarpus carolinensis* -- *Cyathea ponapeana* Habitat Type.

size of the island, has definite effects on the local climate. Studies of plant ecology on other high islands of Micronesia (Ponape, Truk, Yap, and Palau) have been applied in relative vegetational organization to Kosrae. However, I believe there are specific differences in the vegetation of Kosrae which should not be lost in generalization of floral description systems.

Species composition of the native rain forest in Kosrae has a close affinity with the Indo-Malaysian flora (van Balgooy 1960). The general physiognomy is characterized by large canopy species with dense under-stories of shrubs, vines, and ferns. In addition, there are portions of the island of scientific interest and aesthetic value, such as the moss forests near the peaks of the highest mountains and the freshwater swamp forests in some of the larger stream valleys.

Table 1. Relationships of habitat and community types to Hosokawa's associations and consociations.

Native rain forest habitat type	Special communities	Elevation limits (m)	Environmental limitations	Hosokawa's classification 1952 - 1954	
				Associations	Consociations
<u>Terminalia carolinensis</u> -- <u>Barringtonia racemosa</u>		1 - 80	Lowland stream valleys--fresh-water swamp	<u>Horsfieldia nunu</u> <u>Cyclosorus heterocarpus</u> (1954)	
		< 260			<u>Terminalia carolinensis</u> (1954) <u>Horsfieldia nunu</u> (1954)
<u>Camptosperma brevipetiolata</u> -- <u>Ixora casei</u>		80 - 250	Foothills--not steep slopes	<u>Camptosperma brevipetiolata</u> <u>Ponapea kusaiensis</u> (1954)	
	<u>Parinari glaberrimum</u>	80 - 400			<u>Camptosperma brevipetiolata</u> (1954)
<u>Horsfieldia nunu</u> -- <u>Syzygium stelechanthum</u>		250 - 480	Usually steep slopes, v 20% Very steep eroded slopes		
	<u>Hibiscus tiliaceus</u>	80 - 400			
		300 - 500			<u>Elaeocarpus carolinensis</u> (1954)
<u>Elaeocarpus carolinensis</u> -- <u>Cyathea ponapeana</u>		480 - 630	High rainfall and humidity on leeward sides On ridges and peaks exposed to winds	<u>Alsophilla ponapeana</u> (1952) (1954)	
	<u>Dicranopteris linearis</u>				

The system used here to describe the vegetation types generally follows that developed by Hosokawa (1952a, 1952b, 1954). My system of habitat types and community types is a reorganization and refinement of the system he used in the Caroline Islands of Micronesia (Table 1). His plant "association" system organizes the different types of vegetation by showing relations between certain species and uses the term "consociation" to show more specific relationships. My system of habitat types emphasizes environmental factors that control the types of vegetation, and uses "community" as a subdivision to show specific, unique floristic relationships existing within certain habitat types. In my floristic description, the term "habitat type" describes vegetation units distinguished by dominant species as well as the environmental factors of geography, slope, prevailing wind, and site exposure. Each habitat type is designated by the dominant canopy species followed by the dominant, or most characteristic, understory species. The understory can include small trees, shrubs, or ferns.

My observations of the native forest were made on numerous excursions into the interior from all sides of the island during my 15 months on Kosrae. My colleague Hans Impola and I wrote floristic descriptions and collected plant specimens for identification on five such trips, covering areas of Mount Matante, Mount Finkol, Mount Wakup, Kapluh Plateau, and Innem River. These areas together provide an excellent representation of all habitat types and environmental conditions on the island.

The floristic descriptions below of each habitat type are limited in detail and do not include complete lists of the plants. Plant lists which included subjective abundance ratings for each species at every location formed the basis for designation of habitat types. This was the method used to determine dominance and to demonstrate the correlations among species and among habitat types. Lists were made during each walk as obvious new vegetation types were encountered. For full names of species, with authors, and Kosraean names, see Table 2.

Table 2. Full names of plant species used in this paper (according to Kanehira 1938, Glassman 1952, Stemmermann and Proby 1978) and their Kosraen names.

Species	Kosraen Names
<i>Adenanthera pavonina</i> L.	Metkem
<i>Angiopteris evecta</i> (Forst.) Hoffm.	
<i>Antrophyum callifolium</i> Bl.	
<i>Artocarpus atilis</i> (Parkinson) Fosb.	Mos
<i>Asplenium nidus</i> L.	
<i>Astronidium kusaianum</i> Kanehira	
<i>Barringtonia racemosa</i> (L.) Bl.	Kengul
<i>Blechnum orientale</i> L.	
<i>Camptosperma brevipetiolata</i> Volkens	Elak
<i>Cassytha filiformis</i> L.	
<i>Cinnamomum carolinense</i> Koidz.	Masro
<i>Cocos nucifera</i> L.	Koanu
<i>Costus sericeus</i> Bl.	
<i>Curcuma</i> spp.	
<i>Cyathea nigricans</i> Mett.	Po
<i>Cyathea ponapeana</i> (Hosokawa) Glassman Syn. <i>Alsophila ponapeana</i> Hosokawa	Po
<i>Cyclosorus heterocarpus</i> Ching	
<i>Davallia solida</i> (Forst.) Sw.	
<i>Dendrobium carolinense</i> Schltr.	
<i>Dendrobium ponapense</i> Schltr.	
<i>Derris elliptica</i> (Roxb.) Benth.	Op
<i>Derris trifoliata</i> Lour.	Ohsrep
<i>Dicranopteris linearis</i> (Burm.) Underw.	
<i>Elaeocarpus carolinensis</i> Koidz.	Nanek
<i>Elaphoglossum carolinense</i> Hosokawa	
<i>Ficus carolinensis</i> Warb. & Lauterb.	Konya
<i>Ficus tinctoria</i> Forst.	Sr.
<i>Freycinetia</i> spp.	
<i>Hibiscus tiliaceus</i> L.	Lo
<i>Horsfieldia nunu</i> Kanehira	Nunu
<i>Ixora casei</i> Hance	Kalsru
<i>Lycopodium cernuum</i> L.	
<i>Macaranga carolinensis</i> Volkens	Lo-lep
<i>Marattia fraxinea</i> Sm.	
<i>Mecodium polyanthos</i> (Sw.) Copel	
<i>Microsorium scolopendria</i> (Burm.) Copel	
<i>Moerenhoutia hosokawae</i> Fukuyama	
<i>Morinda citrifolia</i> L.	Ee
<i>Musa</i> spp.	Usr
<i>Nephrolepis hirsutula</i> (Forst.) Presl.	
<i>Neuburgia celebica</i> (Koord.) Leenh.	Toa
<i>Pandanus</i> spp.	Meng
<i>Parinari glaberrimum</i> Hassk.	Aset
<i>Phreatia pacifica</i> Fukuyama	
<i>Piper ponapense</i> C. DC.	
<i>Pleuromanes pallidum</i> (Bl.) Presl.	
<i>Polyscias subcapitata</i> Kanehira	
<i>Prosaptia alata</i> (Bl.) Christ.	
<i>Pteris spinescens</i> Presl.	
<i>Ptychosperma kusaiensis</i> (Kanehira) syn. <i>Ponapea kusaiensis</i> Kanehira	Puu
<i>Sciropodendron ghaeri</i> (Gaertn.) Merr.	
<i>Syzygium stelechanthum</i> (Diels) Glassman	Fukunnes
<i>Terminalia carolinensis</i> Kanehira	Ka
<i>Zingiber zerumbet</i> (L.) Smith	

Habitat Types

Terminalia carolinensis -- *Barringtonia racemosa* Habitat Type

This habitat type (C in Fig. 1) occurs below 80 m in the lowland freshwater swamp portions of some stream valleys. It seems to be most prevalent and extensive in the wider valleys where the land flattens and the streams are slowed. The tall *Terminalia carolinensis* trees, with their unique pagoda shape, form a canopy 20 to 30 m above the swamp. The buttresses at the base of the tree rise several meters above the ground and sometimes stretch out 10 m or more from the trunk, serving as a firm anchor for these trees, which, like many others of the tropical rain forest, have shallow root systems. *Horsfieldia nunu* and *Neuburgia celebica* are also common trees in the overstory of this habitat type, but are not nearly as tall and impressive. Common species in the understory are *Barringtonia racemosa*, *Hibiscus tiliaceus*, *Pandanus* spp., *Derris trifoliata*, *Freycinetia* spp., *Scirpodendron gbaeri*. Common ferns, terrestrial and epiphytic include *Asplenium nidus*, *Davallia solida*, *Microsorium scolopendria*, *Antrophyum callifolium*, *Nephrolepis hirsutula*, *Cyclosorus heterocarpus*. Other epiphytes frequently found in this type, all of the Orchidaceae, are *Dendrobium carolinense*, *D. ponapense*, and *Phreatia pacifica*.

These freshwater swamps typically have fewer species than nearby upland types, possibly because of limited soil aeration. Other important factors which may control the occurrence of this habitat type are relatively flat terrain, poor site drainage, and proximity to a stream. This type has two distinct forms, each representing a different stage of succession. The climax or the undisturbed type has a canopy totally dominated by *T. carolinensis*. The other form could be described as secondary vegetation, with *H. nunu* the dominant tree species. This successional stage is evidently the result of cutting of the *Terminalia* on certain sites by the Japanese during their occupation of Kosrae, to clear land for farming and obtain lumber. On some of these disturbed sites *Terminalia* seedlings are reappearing, but on other sites, the soil has been significantly changed and there is no regeneration.

The best places to view relatively undisturbed *T. carolinensis* stands are in the Okat and Yela River Valleys in Tafunsak Municipality. However, trails through this vegetation type are normally muddy and present difficult passage. A portion of these areas might well be preserved for its unique and interesting vegetation.

This type was recognized by Hosokawa (1954) as the "*Terminalia caro-*

linensis consociation of the *Horsfieldia nunu-Cyclosorus heterocarpus* association." I consider it to be the lowest elevation extension of the upland native rain forest still existing on Kosrae. Hosokawa (1952a) extended this upland forest type lower in elevation to include his "*Barringtonia racemosa* consociation," which occurs at the interface between freshwater and saline swamps. I prefer to separate this consociation from the upland forest because apparently it occurs as a separate habitat type in the lowlands. In addition, the vegetation there has been constantly under the significant influence of human disturbance in recent decades, and probably earlier as well.

Camptosperma brevipetiolata -- *Ixora casei* Habitat Type

This type (D in Fig. 1) is the next highest in elevation, occurring at 50 to 250 m elevation, and is restricted to the foothills adjacent to the coastal plain. It is limited to gentle slopes, on most of which it has been preempted by the Micronesian food plants, breadfruit (*Artocarpus atilis*), coconut (*Cocos nucifera*), and banana (*Musa* spp.) Hosokawa (1954) included this type in his *Camptosperma brevipetiolata* consociation of the *Camptosperma brevipetiolata* - *Ponapea kusaiensis* association.

Where this habitat type has been left undisturbed, *Camptosperma brevipetiolata* and *Adenantha pavonina* are codominant in the overstory canopy. These two species are the tallest trees in this type, but are usually less abundant than *H. nunu*. Other trees present but less common in the overstory are *Neuburgia celebica*, *Elaeocarpus carolinensis*, *Ficus tinctoria*, *Hibiscus tiliaceus*, *Pandanus* spp., *Syzygium stelecbanthum*, and two unidentified species. The shrub stratum is most typically dominated by the regeneration of the tree species mentioned, the shrub *Ixora casei* with its red cymose inflorescence, the tree fern *Cyathea nigricans*, and the large terrestrial fern *Marattia fraxinea*, as well as such shrub species as *Morinda citrifolia* and occasionally *Macaranga carolinensis*. The canopy has three levels, the dominant tree species at 20 to 25 m, the second-level trees at 15 to 20 m, and the shrub and the tree fern stratum from 2 to 10 m. *Ixora casei* is included in the name of this habitat type because of its close association with the geographical restrictions of this type, not its relative abundance. Other common fern genera are *Cyclosorus*, *Nephrolepis*, *Pteris*, *Asplenium*, *Davallia*, and *Microsorium*. The well-represented lianas include *Freycinetia* spp., *Piper ponapense*, *Derris elliptica*, and *D. trifoliata*. Herbs are mostly of the *Zingiberaceae*, the most common representatives being *Zingiber zerumbet*, *Costus sericeus*, and *Curcuma* spp.

The large tree species *Adenanthera*, *Camptosperma*, and *Horsfieldia* found in this habitat type seem to approach conditions of optimum growth, whereas the same species occurring in other habitat types are noticeably smaller. This habitat type provides the greatest potential for producing wood products, particularly with these indigenous species. The Kapluh Plateau in Malem Municipality is an extensive area of this habitat type that has been left relatively undisturbed and should be considered for conservation forest designation.

Parinari glaberrimum Community

At the upper elevations of the *Camptosperma brevipetiolata* -- *Ixora casei* habitat type, homogeneous stands of *Parinari glaberrimum* occur. This tree species can grow in very dense stands and normally attains a height of 10 to 15 m. These stands, as a vegetational community, rarely cover more than 1 ha, but are a unique part of the rain forest. The *Parinari* canopy is so dense that little light penetrates. Consequently, the undergrowth consists only of various ages of regenerating *Parinari*. Occasionally, terrestrial ferns may creep in on the edges of the community, but only the leafless parasitic vine *Cassytha filiformis* was found to be common.

Horsfieldia nunu -- *Syzygium stelechanthum* Habitat Type

This type occurs on relatively steep slopes (E in Fig. 1). On Kosrae, the slope increase typically occurs at an elevation of about 250 m. The type begins here and extends to about 480 m. This is the most extensive forest type on the island. This type is mostly included in Hosokawa's (1954) consociation of *Elaeocarpus carolinensis* in the *Camptosperma brevipetiolata* - *Ponapea kusaiensis* association. The relationship of this habitat type to his older association, *Camptosperma brevipetiolata* - *Elaeocarpus carolinensis* (Hosokawa 1952), is probably a local refinement of an additional consociation.

Horsfieldia nunu is the dominant tree species throughout this habitat type, but is less abundant at the upper elevations. Other common tree species are *Elaeocarpus carolinensis*, *Ptychosperma kusaiensis* (syn. *Ponapea kusaiensis*), *Camptosperma brevipetiolata*, *Ficus carolinensis*, and *Hibiscus tiliaceus*. The less common tree species are *Neuburgia celebica*, *Astronidium* sp., *Pandanus* sp., *Cinnamomum carolinense*, and *Terminalia carolinensis*. The overstory canopy is again in three levels, the top two blending together, comprised of various-aged common tree species. As one enters this habitat type from a lower elevation, there is a noticeable decrease in height of the canopy.

Syzygium stelecbanthum is abundant, forming a lower, third level in the canopy as a small tree or shrub, and is joined by the tree ferns at this level. There is an increase in the tree fern *Cyathea nigricans* and a general decrease in the other terrestrial ferns found under the canopy in the lower, less steep habitat types. The epiphytic ferns, *Asplenium nidus*, *Davallia solida*, and *Antrophyum* sp. continue to occur frequently, and are joined by several genera of the Orchidaceae. The most common lianas are *Freycinetia* spp. and *Piper ponapense*. Herbs found to be common members of this habitat type are of the Zingiberaceae, with *Costus sericeus* and *Zingiber zerumbet* being the most abundant.

Generally, the typical species are encountered as one travels on steep spur ridges within the habitat type. The large *Ficus carolinensis* trees, typically found along these ridges, present an awesome sight with their large spreading branches and the adventitious root systems common to other banyans. Many of the trails following the ridges are forced to pass through the root system of these trees.

One other unique aspect of this habitat type is the surprising occurrence of *Terminalia carolinensis* near the top of many ridges. These trees were previously thought to occur only in the freshwater swamps of the lowland coastal plain. These were seen in extremely steep, protected pockets on the leeward side of the main ridges at the upper limit of this habitat type. These trees were recognized from a distance by their distinguishing pagoda shape, with most of the sightings from the top of Mount Finkol, looking into the heads of drainages on the Utwe side of the island.

Hibiscus tiliaceus Community

Within the *Horsfieldia nunu-Syzygium stelecbanthum* habitat type, there are extensive stands of *Hibiscus tiliaceus*. These tend to be on steep, eroded rocky slopes. The disturbance here seems to be natural, whereas the species' occurrence in lower habitat types of lesser slope is generally on abandoned agricultural land. Therefore, this community appears to be a natural component of the *H. nunu-S. stelecbanthum* type, and should not be regarded as a successional stage. Rarely were any successional species encountered, indicating that *H. tiliaceus* is the climax species. I suspect the presence of *Hibiscus* as the climax species could be unique to Kosrae, a result of the radically steep slopes, which are not as common on the other high islands of the Carolines.

Elaeocarpus carolinensis — *Cyathea ponapeana* Habitat Type

This last habitat type occurs at the top of the island (G in Fig. 1). It has been referred to by other authors as the "moss forest" and here includes the dwarf vegetation of open crests and ridges (F in Fig. 1). Floristic composition and specific environmental conditions were described in depth by Hosokawa (1952 a) for his *Alsophila ponapeana* association. He put the elevational limits for the moss forest on Kosrae at 480 to 654 m and noted this to be considerably lower than moss forests of other parts of the world. He attributes this fact to special climatic conditions characteristic of the high islands of Kosrae and Ponape, caused by their high elevations relatively close to the surrounding ocean. As the tradewinds hit the islands, they are rapidly moved upwards and cooled, resulting in large amounts of rain around the peaks. Therefore, moisture conditions on these islands are similar to those of tropical continental mountains where other moss forests occur.

I found that moss forests on Kosrae tend to be more common and more developed on the leeward sides of the highest mountains, possibly indicating a low tolerance for direct wind and driven rain.

The canopy of the habitat type consists of the tree *Elaeocarpus carolinensis* as the dominant and *Astronidium kusaianum* as a small tree or shrub. Less common tree species are *Camptosperma brevipetiolata*, *Cinnamomum carolinense*, and *Ptychosperma kusaiensis*. *Cyathea ponapeana* is also common in the canopy, although it is usually below the dominant trees. Therefore, I prefer to include it in the shrub layer. Other common species in the shrub layer are *Astronidium kusaianum*, *Polyscias subcapitata*, *Syzygium stelechanthum*, and the terrestrial ferns *Marattia fraxinea*, *Angiopteris evecta*, and *Pteris spinescens*. Of the abundant epiphytic ferns, the following are common: *Elaphoglossum carolinense*, *Prosaptia alata*, *Pleuromanthes pallidum*, and *Mecodium polyanthos*. Other important epiphytes are many of the Orchidaceae, of which only two were identified; *Moereboutia hosokawae* and *Phreatia pacifica*. *Freycinetia* spp. continue to be the most common lianas.

The trees and larger plants of this habitat type tend to be stunted and bent or slanting, rarely reaching a height greater than 5 m. Several inches of green-to-reddish-brown bryophytes envelop and hide most of the ground, the larger branches, and the tree trunks. The extremely high humidity common to this forest type may be caused by the water retention ability of this bryophyte layer.

Dicranopteris linearis Community

On exposed peaks and ridges included in the *Elaeocarpus carolinensis*-*Cyathea ponapeana* type is a community type dominated by the fern species *Dicranopteris linearis* (F in Fig. 1). This is described by F. R. Fosberg (1960) as "dwarf vegetation on open crests." Occasionally, stunted *Elaeocarpus carolinensis* and *Astronidium kusaianum* appear, but they are essentially the only remnants of the lower types. Other ferns and fern-like plants found were *Blechnum orientale* and *Lycopodium cernuum*. Where the ground is not thickly covered by the fern *Dicranopteris linearis*, deep tussocks of moss occur. High rainfall and exposure to high winds are probably the main determinants of this community type.

Discussion

This description of the undisturbed native upland forest flora of Kosrae introduces a system of organization for the local vegetation that is specific for this island. The change in terminology from Hosokawa (1952a, 1952b, 1954) is intended to give a clearer identity to each unit. The system is useful to ecologists and land managers for natural resource inventories and evaluations, and as a guide for more detailed study of specific types of local vegetation. These habitat and community types are developed specifically for the island of Kosrae, thus avoiding the problems in Hosokawa's and Fosberg's systems which were created to cover the entire group of high islands in the Carolines. All habitat and community types have the same general elevational limits regardless of aspect. Tradewind exposure is the dominant factor relative to aspect. Moss forests are limited to the leeward west aspect of high mountain tops and the *Dicranopteris linearis* community type is on the wind exposed peaks and ridges. The coastal plain and its corresponding habitat and community types are more developed on the windward, east side of the island.

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References Cited

- Fosberg, F. R.** 1960. The vegetation of Micronesia. Bull. Amer. Mus. of Nat. Hist. 119(1):31.
- Glassman, S. F.** 1952. The flora of Ponape. B. P. Bishop Mus. Bull. 209:152.
- Hosokawa, T.** 1952a. A plant-sociological study in the mossy forests of Micronesian Islands. Mem. Fac. Sci. Kyushu Univ., Ser. E. 1:65-82.
- _____. 1952b. A synchrological study of the swamp forests in the Micronesian Islands. Mem. Fac. Sci. Kyushu Univ., Ser. E. 1:101-123.
- _____. 1954. On the *Campnosperma* forests of Yap, Ponape, and Kusaie, in Micronesia. Mem. Fac. Sci. Kyushu Univ., Ser. E. 1(4): 219-243.
- Kanehira, R.** 1938. New or noteworthy trees from Micronesia (XX). Bot. Mag. Tokyo 52:235-239.
- Stemmermann, L., and F. Proby.** 1978. Inventory of wetland vegetation in the Caroline Islands. Vol. 1 and 2, VTN Pacific Corp., Honolulu.
- van Balgooy, M. M. J.** 1960. Preliminary plant-geographical analysis of the Pacific -- the distribution of phanerogam genera. Blumea 10(2):385-430.