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VEGETATION TYPES ON ACID SOILS OF MICRONESIA

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ABSTRACT

The soils and vegetation of the Caroline high islands, Federated States of Micronesia, are being mapped by the U.S. Department of Agriculture's Forest Service and Soil Conservation Service. By the end of 1987, vegetation maps and reports on Kosrae, Pohnpei, Yap, four Truk Islands, and Palau are expected to be available. To compare soil types with vegetation types, vegetation maps were laid onto soils maps of these islands. There may be correlation with individual vegetation species and soil acidity, but no clear correlation was apparent between strongly acid soils and broad vegetation types within the precision of recent soil and vegetation surveys conducted in Micronesia.

INTRODUCTION

USDA Forest Service research in the Western Pacific is conducted by the agency's Institute of Pacific Island Forestry, headquartered in Honolulu, Hawaii. The Institute is part of the Pacific Southwest Forest and Range Experiment Station, with headquarters in Berkeley, California. The Institute maintains field offices in Hilo, Hawaii, and on Yap, Federated States of Micronesia.

The Institute has two research units, Forest Management Research in Hawaii, and American Pacific Island Forestry Research. The main research activities of the Forest Management Research in Hawaii Unit are aimed at maintaining the State's native forests.

The American Pacific Island Forestry Research Unit conducts research in Hawaii, Micronesia, and American Samoa. In Hawaii, the unit is concerned with plantation establishment and development, and includes biomass studies. In Micronesia and American Samoa, the unit is involved with the preparation of vegetation maps, forest inventories, native and introduced species trials, fruit bat biology and management, compilation of local and scientific names of Micronesian trees and shrubs, agroforestry studies, technology transfer, and literature searches for Pacific Basin resources agencies.

BACKGROUND

Quantitative data on the extent and composition of the soils and vegetation of Micronesia were needed for land-use planning. To fill this need, a formal agreement was drawn up between the High Commissioner of the U.S. Trust Territory of the Pacific Islands and two agencies of the U.S. Department of Agriculture -- Soil Conservation Service and Forest Service -- to map the soils and vegetation of Micronesia's high islands.

By mid-1987 vegetation maps and reports for the Caroline islands of Kosrae, Pohnpei, Yap, four Truk islands, and Palau are expected to be available. These publications describe the vegetation types of these islands, and their ecological functions, use, and extent.

This report summarizes findings on vegetation and acid soils of the Caroline high islands in the Federated States of Micronesia (Cole 1987; Falanruw 1987a, 1987b; MacLean 1987; Whitesell 1987).

SURVEY METHOD

Vegetation of the islands surveyed was mapped by using black and white aerial photographs taken in the 1970's at nominal scales of 1:5000 to 1:16,000. Vegetation differences can be recognized by examining photographs stereoscopically for differences in tone, texture, and image patterns. In some cases, individual species can be recognized. Thus, after comparisons of photo imagery with ground conditions, a skilled interpreter becomes proficient at recognizing vegetative types on aerial photos.

Prior to mapping, a vegetation typing scheme was developed. As funds and field time were limited, vegetation types were restricted to those that could be recognized on the photos without intensive ground checking. To qualify for mapping, vegetation type areas had to cover at least 1 hectare and be at least 40 meters wide. Vegetation types less than this area were combined with more extensive types.

Once the classification scheme was developed, types were delineated on the photos by stereoscopic examination and ground checking. The photos were then edited and transferred to base maps at the Forest Service Pacific Southwest Region's Engineering Staff in California. Each type island was numberecd and its area recorded by computer (Table 1).

Table 1. Area of Caroline high islands, by land class and type, 1986*

Land Class and type	Symbol	Hectares					Total
		Pohnpei	Palau	Kosrae	Yap	Truk	
Forest							
Upland forest	UP	12,548	21,891	4,88	2,556	677	42,560
Mangrove forest	MN	5,525	4,708	1,562	1,171	306	13,272
Swamp forest	SW	214	1,680	345	155	-	2,394
Palm forest	PO	1,383	<1	-	-	2	1,385
Dwarf forest	DF	1	-	69	-	-	70
Atoll forest	AT	6	155	-	-	-	161
Plantation forest	PF	6	26	-	-	1	33
Rock Island forest	RI	-	1,116	-	-	-	1,116
Limestone forest	LI	-	1,232	-	-	-	1,232
Casuarina forest	CA	-	451	-	-	-	451
Total Forest		19,683	31,259	6,864	3,882	986	62,674
Secondary Vegetation	SV	1,843	727	1,272	553	252	4,647

Continued...

Table 1. Area of Caroline high islands, by land class and type, 1986*

Land Class and type	Symbol	Hectares					
		Pohnpei	Palau	Kosrae	Yap	Truk	Total
Agroforest							
Agroforest	AG	1,945	16	1,861	1,515	66	5,403
Agroforest/ coconuts	AG.CO	9,796	279	926	864	2,312	14,177
Coconut plantation	CO	124	814	-	159	-	1,097
Total Agroforest		11,865	1,109	2,787	2,538	2,378	20,677
Nonforest							
Marsh, fresh water	M.F	149	475	26	165	234	1,049
Marsh, cultivated	M.F.C.	-	134	-	-	-	134
Marsh, saline	M.S	29	25	-	6	-	60
Grasslands	G	1,476	6,783	17	2,175	173	10,624
Strand	S	-	11	-	-	.5	16
Cropland	C	79	203	2	46	4	334
Cropland/sec. veg.	C/SV	-	28	-	-	-	28
Urban	U	180	397	51	244	129	1,001
Urban/cropland	U/C	-	176	-	-	-	176
Urban/agroforest	U/AG	62	61	67	61	-	251
Urban/sec. veg.	U/SV	-	3-	-	-	-	3
Barren	B	2	180	2	8	5	197
Water	W	125	48	99	101	4	574
Total Nonforest		2,102	8,524	264	2,806	554	14,250
TOTAL AREA		**35,493**	**41,619**	**11,187**	**9,779**	**4,170**	**102,248**

*Source: USDA Forest Service (Truk includes Moen, Dublon, Fefan, and Eten. Palau does not include a portion of the Rock Islands).

VEGETATION CLASSES

For mapping purposes, the vegetation of Micronesia was divided into the following four broad land classes:

- Forest -- areas with a predominance of native species, at least 10 percent stocked with live trees.
- Secondary vegetation -- vegetation of recently distrubed areas, somewhat intermediate between forest and nonforest.
- Agroforest -- areas of mixed growth, including trees, cultivated for fuit, wood, and other products.
- Nonforest land -- areas having less than 10 percent tree cover.
- Vegetation types falling within these broad land classes are listed in Table 1.

VEGETATION TYPE DESCRIPTIONS

Major plant species, by vegetation types, were surveyed and recorded (Table 2).

Table 2. Major plant species in the Caroline high islands, by island and vegetation type.

Species	Type	Pohnpei	Palau	Kosrae	Yap	Truk
Acrostichum aureum	M	X	X		X	
Adenanthera pavonina	U	X	X	X		
Alphitonia carolinensis	UP		X		X	
Areca catechu	UP, SW		X		X	
Astronidium kusaianum	DF		X			
Barringtonia racemosa	SW	X	X	X	X	X
Bikkia palavensis	LI, RI		X			
Buchanania engleriana	UP		X		X	
Callophyllum inophyllum	UP	X	X	X	X	X
Campnosperma brevipetiolata	UP	X	X	X	X	
Cerbera manghas	SW	X	X	X	X	X
Clinostigma carolinensis	UP					X
Clinostigma ponapensia	UP	X				
Cordia subcordata	AT	X	X	X	X	X
Cyperus javanicus	M	X	X		X	X
Derris trifoliata	M	X	X	X	X	X
Dolicandrone spathacea	SW		X		X	X
Elaeocarpus carolinensis	UP, DF	X		X		
Exorrhiza ponapensis	PO, UP	X				
Fimristylis spp.	S	X	X	X	X	X
Garcinia ponapensis	UP	X				
Garcinia ponapensis var. trukensis	UP					X
Gleichenia Linearis	G	X	X	X	X	X
Guettarda speciosa	LT, AT	X	X	X	X	X
Heritiera littoralis	SW	X	X	X	X	X
Hibiscus tiliaceus	SV, SW	X	X	X	X	X
Horsfieldia amkaal	SW		X			
Horsfieldia nunu	SW			X		
Intsia bijuga	LI, RI	X	X	X	X	X
Ipomoea per-caprae	S	X	X	X	X	X
Ischaemum spp.	G	X	X	X	X	X
Lumnitzera littorea	MN	X	X	X	X	X
Macaranga carolinensis	SV		X		X	X
Myristica insularis	UP	X	X			
Neubergia celbica	UP		X	X		
Parinari corymboas	UP		X			
Parinari laurina	UP	X	X	X	X	X
Pemphis acidula	AT	X	X	X	X	X
Phragmites karka	M	X	X	X	X	X
Pouteria obovata	UP		X		X	X
Pterocarpus indicus	UP		X		X	X
Ptychosperma hosinoi	PO	X				
Ptychosperma palavensia	LI, RI		X		X	X

Continued...

Table 2. Major plant species in the Caroline high islands, by island and vegetation type.

Species	Type	Pohnpei	Palau	Kosrae	Yap	Truk
Rhizophora apiculata	MN	X	X		X	X
Rhizophora mucronata	MN	X	X	X	X	X
Rhus taitensis	SV	X	X		X	X
Samadera indica	SW		X			
Scaevola taccada	AT, S	X	X	X	X	X
Semecarpus venenosus	UP		X		X	
Serianthes kanehirae	UP		X			
Serianthes kanehirae var. yapensis	UP				X	
Sonneratia alba	MN	X	X	X	X	X
Sophora tomentosa	AT		X		X	
Terminalia carolinensis	SW	X				
Tournefortia argentea	AT, S	X	X	X	X	X
Vigna marina	M	X	X	X	X	X

Upland Forest (UP): The upland forest type includes forests other than swamp, mangrove, or limestone. While a number of botanically interesting variations of Micronesian upland forest occur, these variations usually do not provide a distince enough canopy texture on the aerial photos to be consistently demarcated. Thus the distinctions made in our typing are largely based on size and density classes (Table 3).

Table 3. Size and density codes used in the vegetation survey of the Caroline high islands.

Code	Size class	Code	Density class
0	Short, shrub-like stands smaller than 12.5 cm in diameter at breast height (d.b.h)	H	High - crown closure of main canopy over 70 percent.
1	Trees averaging less than 30 cm in d.b.h., but larger than or equal to 12.5 cm in d.b.h.	M	Medium - closure of main canopy over 70 percent.
2	Trees averaging 30 cm or more in d.b.h.	L	Low - crown closure of main canopy less than 30 percent.

Small trees (size class 0) generally indicate a distinctive low scrubby forest most common in shallow ravines in the savanna areas on Palau and Yap. However, most forests in Micronesia are comprised of trees of medium stature, size class 1 (Table 3). A limited area of large forest trees are found in Micronesi (size class 2) except in Kosrae, where 87 percent of the upland forest is composed of larger trees.

Most Micronesian forests have a canopy closure greater than 70 percent and are generally uneven. But a canopy type most notable in Palau has a dense, flat, even texture.

In terms of general species composition, forests of Palau are the most diverse and include a number of endemic species found nowhere else. The extensive forests of Pohnpei and Kosrae also contain many endemic species. Yap has been heavily impacted by large populations of the past and the number of endemics is limited. The precious remnants of native forests in the mountains of the Truk islands of Moen, Fefan and Dublon contain a number of endemic species.

Mangrove Forest (MN): The most distincitve vegetation type in Micronesia are mangroves. These marine forests have specialized roots inundated at least periodically by seawater. Mangroves are best developed in Palau, Pohnpei, Kosrae, and Yap, rspectively; they are the most species rich in Palau, and the least in Yap. They occur at the mouths of rivers and drainage systems, on coastal mudflats, and sometimes offshore islands.

The most common size class of mangroves are trees of medium stature (MN1). A distinctive variation in the mangrove type, are areas of low tangled growth generally found where water circulation is limeted and the soil more firm. These almost impenetrable patches consist mainly of *Rhizophora* spp. with some *Bruguiera gymnorhiza*. Such areas are indicated as MNO on the survey maps. Mangroves with large trees (MN2), do not make up a large percentage of the total mangrove type except on Kosrae, where 67 percent of total mangrove area is typed as MN2. However, this is only 9.4 percent of the total area of Kosrae.

Swamp Forest (SW): Swamp forest occur where soils are inundated with fresh or slightly saline water. Most such habitat occurs in low wet areas just inland of mangroves; above tidal influences but lower than the surrounding terrain. Other swamp areas are found where water collects inlow areas long rivers and in areas of impeded drainage.

Swamp forests are best developed in Palau and Kosrae. Extensive areas of Ka (*Terminalia carolinensis* Kaneh.) occur on Kosrae. Especially species rich swamp forests occur along the Alimokan River in Ngetpang Bay on the west coast of Babelthaup Island, Palau.

Palm Forest (PO): The palm forest type includes areas where palm species other than coconut and *Nypa* sp. make up more than 50 percent of the canopy. Such forests are most notable on Pohnpei where there are dense stands of native palms in the upland forests.

On Palau, palms generally occur in the understory of Babelthaup island's forests, or as trees emerging from rock island vegetation. Although Palau has the most species of native palms, they were not generally demarcated as they are not predominant in the upper canopy.

Dwarf Forest (DF): The dwarf forest type consists largely of the moss forsts of Kosrae and Pohnpei. These low forests occur in the cloud zone of mountain tops and ridges. They consist of stunted trees covered with mosses, ferns, fern allies and orchids, and othe plants. The understory and ground are covered with similar growth. These moss forests contain man unique native species. Although of considerable scientific interest and ecological importance, this type does not stand out on aerial photos, therefore, little was delineated on our maps.

Atoll Forest (AT): Atoll forests consist of a characteristic collection of hardy species generally occurring toward the interior of larger atols, and just inland of strand on sandy or rocky coasts of low and high islands. Where present, atoll forests generally occur in bands too narrow to qualify for demarcation, except on Kayangel and Angaur.

Plantation Forest (PF): Planted forests are limited to small stands of trees planted for comercial purposes during the period 1914-1945, when Japan occupied Micronesia, and to species introduction trials established in Palau, Pohnpei, and Mariana Islands.

Limestone Forest (LI): The limestone forest type is found mainly on limestone island of the Mariana Islands and the southern and rock islands of Palau. It is most common on Angaur and Pelilieu. The species composition of limestone forest varies on these islands, there being a number of endemic species present, especially in the Mariana Islands. The physiognomy is similar, however, with scrubby and tall trees often growing on almost bare rock. The humus from falling leaves and other debris provide a sustained cycling of nutrients.

Rock Island Forest (RI): The vegetation of the raised coralline "rock islands" of Palau is a subtype of limestone forest which has been separately demarcated, indicating its uniqueness. The species composition of these islands is rich and diverse from islet to islet.

Casuarina Forest (CA): In areas such as coastal Angaur and Pelilieu, dense stands of *Casuarialitorea* L. syn. (*C. equisetifolia* L.) occur. These stnads are distinct on aerial photos, and where dense, the ground is covered with a thick carpert of needles which inhibits other vegetative growth.

AGROFOREST (AG)

Agroforests have been developed by Micronesians, sometimes with the assistance of fruit bats in spreading seeds. It consists of a mixture of food and other useful and ornamental trees and plants generally occurring in the area of villages. On the aerial photos, scattered coconut trees are an indicator of agroforest, as are breadfruit trees, and the presence of village dwellings. The canopy is often uneven and may be interspersed with open areas of taro patches, open canopy gardens, and areas of secondary vegetation too small to be demarcated as separate types.

Most agroforests include coconut trees. If coocnut trees make up at least 20 percent of the canopy, the area was classified as AG.C. If the percentage of coconut trees is over 70, the area was typed as coconut plantation, CO.

The largest percentage of agroforest is found in Truk where the type consists largely of a mix of coconut and breadfruit trees. The most diverse and developed agroforest is found on Yap (Falanruw, 1985).

SECONDARY AND WEEDY VEGETATION (SV)

Areas of small weedy trees, shrubs, vines, and grasses growing in recently disturbed areas are classified as secondary vegetation. On aerial photos, secondary vegetation is characterized by a low, uneven canopy, more sparse than forest types, and with a hazy texture, especially when vines are abundant.

NONFOREST

Strand Vegetation (S): The designation of strand vegetation is used to distinguish the charcteristic collection of species generally occurring on sandy and rocky coralline coasts of low

and high islands. While present on some coasts of all islands, this type is generally too narrow to be demarcated separately.

Marsh (M): Areas without trees, dominated by grasses, sedges, and other herbaceous growth growing in standing water most of the year are classified as marshes. Graminoid marshes give a characteristic smooth texture on the aerial photos. Saline and freshwater marshes are demarcated separately.

The most common marshes are those filled wtih the tall reed, *Phragmites*, and those which have been converted to taro patches. Many taro patches are, however, below the minimal area for demarcation, and are usually combined with the agroforest type.

Savanna/Grasslands (G): Savanna grasslands are areas of low herbaceous cover. Shrubs and trees are widely scattered if present. The soil is generally clay and often poorly drained.

Presence of some endemic species in the savanna type, especially in the Mariana Islands and Palau, suggests that the habitat has long been present at least on these islands. The current extent of this vegetation appears, however, to also result from the destruction of forests by repeated burnings. This condition has resulted in the loss of the humus layer and exposure of the top soil to heavy rains and intense radiation. Such areas become degraded and unproductive. These frequent fires select against trees and favor a series of fire-adapted species. While species composition of these savanna grasslands is changing with the introduction of exotics, the physiognomy remains the same. A number of subtypes of svanna grasslands were demarcated on our vegetation maps.

Barren (B): Areas with no vegetation such as airports, roads, and areas where vegetation is so sparse that it is not apparent on aerial photos were classified as "barren."

Cropland (C): Land with a low herbaceous cover of cultivated crops was designated as "cropland" in the surveys.

Urban (U): Areas with a high percentage of buildings, roads, filled barren land, and others are categorized as urban. Some village areas where houses are relatively dense and trees sparse, have been typed as a subdivision of the urban type. Others with at least five percent agroforest trees are included in the agroforest category.

VEGETATION AND SOIL ACIDITY

To see if highly acid soils (pH 3.8 - 5.5) were correlated with vegetation, we compared the two by using the Soil Conservation Service's soils maps of the region (Larid 1982, 1983a, 1983b; Smith 1983a, 1983b) and the Forest Service's vegetation maps of the same islands. Highly acid soils were identified on the basis of the pH values for the surface and subsurface horizons. In this way, the extent of acidic soils in the region was studied (Figure 2). The vegetation of these highly acidic areas was determined by either preparing transparent overlays of the vegetation maps or by manually transferring the vegetation types to the soils maps.

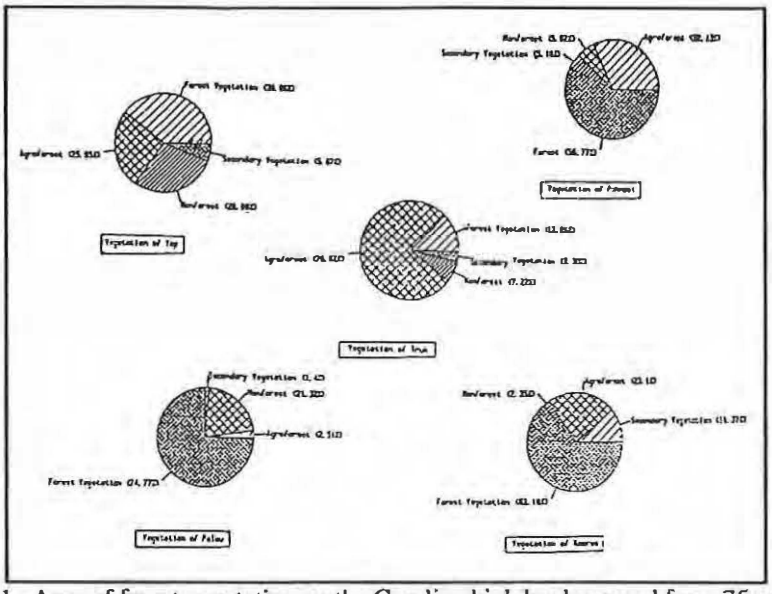

Figure 1. Area of forest vegetation on the Caroline high lands ranged from 75 percent on Palau to about 13 percent on Truk.

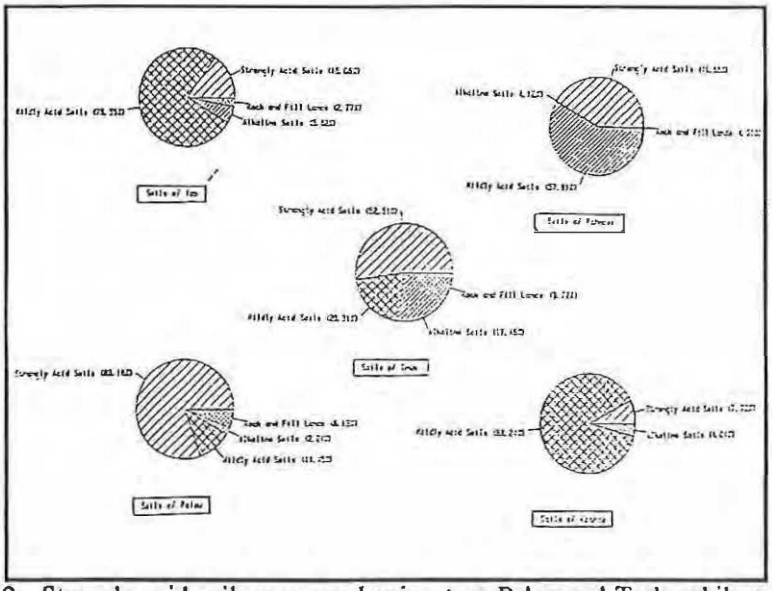

Figure 2. Strongly acid soils were predominant on Palau and Truk, while mildly acid soils were so on Kosrae and Yap in the Caroline high islands.

On Palau the three major acidic soil series - the Aimilii, Babelthaup, and Palau -- represent 60 percent of the land are (Smith, 1983b) and support a wide range of vegetation types include upland forest, svanna, swamp forest, secondary vegetation, and agroforest. Similar trends were found on Pohnpei where the Sonahnpil, Dolekei, Tolonier, and Umpump acidic soil series generally supported mixed upland forest, agroforest, palm forest, and substence farming, while the savanna/grasslands were separately mapped as the acidic Fomseng Variant.

Four acidic soil series are present on Kosrae: The Ngerungor, Sonahnpil, Tolonier, and Umpump. The Ngerungor series is vegetated with swamp forest and wetland taro cultivation; the Sonahpil series supports secondary vegetation, upland forest, grassland, and cropland; the Tolonier and Umpump series are vegetated with upland forest, agroforest, and open cultivation.

Acid soils are represented on Truk by two soil series: The Ngerungor series, which is genrally vegetated with secondary vegetation, marsh, and wetland taro cultivation; and the Tolonier series, which supports upland forest, savanna, and agroforest.

On Yap, four acidic soils are found: the Dechel, Gagil, and Mesei series, and the Tabecheding varient. The Dechel, Mesei, and Tabecheding soils are associated with waterlogged conditions and support freshwater marsh, wetland taro, wetland savannah, or swamp forest. The Gagil series is vegetated by savannah/grasslands and some upland forest.

As evident in the wide range of vegetation types found on the highly acid soils of the Caroline islands, limited correlation was found between vegetation types and soil acidity. It may be that correlation exists between individual species and soil acidity, but within the precision of the soil and vegetation surveys we found no such correlation.

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Marjorie C. Falanruw, a research biologist with the Pacific Southwest Station's American Pacific Islands Forestry Unit, is stationed in Yap. She hold degrees in biology from the University of California (bachelor's, 1965) and the University of Guam (master's, 1969). Thomas G. Cole, a forester with the research unit in Honolulu, was a Peace Corps volunteer in Palau (1977-79). He received a bachelor's degree in forest science (1977) from Texas A&M University. Craig D. Whitesell, a research forester, is leader of the Station's American Pacific Islands Forestry Research Unit in Honolulu. He has a bachelor's degree in forest management (1951) from West Virginia University and a master's in silviculture (1954) from Duke University.

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