THE DETERMINATION OF PLANT COMMUNITIES
ALONG A COMPLEX ENVIRONMENTAL GRADIENT AT
HILAAN BEACH, GUAM
by
SHEILA MUNIAPPAN

1976
AN ABSTRACT OF THE THESIS OF Sheila Muniappan for the Master of Science in Biology presented on May 11, 1976.

Title: The Determination of Plant Communities Along a Complex Environmental Gradient at Hilaan Beach, Guam

Approved: 

RICHARD D. KRIZMAN, Chairman, Thesis Committee

A belt transect 5 m x 290 m was established at Hilaan Beach. The transect extended from the beach, through a fresh water cenote and terminated at the base of the cliff which rises to the plateau of northern Guam. All vascular plants within each 5m² subplot were identified and measured. From these data a profile diagram was drawn and species importance values computed, graphed and analyzed by statistical clustering.

Six distinct vegetational communities were distinguished and named according to computed dominance: Scaevola/Messerschmidia, Cocos, Aglaia/Guamia, Pandanus dubius/Marsh Ferns, and Merrilliodendron. Each community was described by species composition and physiognomy. Soil samples were mechanically and chemically analyzed. A strong correlation exists between the number of species present and exchangeable soil potassium, sodium and calcium.
THE DETERMINATION OF PLANT COMMUNITIES
ALONG A COMPLEX ENVIRONMENTAL GRADIENT AT
HILAAN BEACH, GUAM

by

SHEILA MUNIAPPAN

A thesis submitted in partial fulfillment of the
requirements for the degree of

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TO THE GRADUATE SCHOOL:

The members of the Committee approve the thesis of Sheila Muniappan presented on May 11, 1976.

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INTRODUCTION

Long before the discovery of Guam by Magellan in 1521, the indigenous Chamorro people of Guam commonly used plants and their products for food, medicine, and material culture (Safford, 1905). Stone (1970) has reviewed the various botanical expeditions which studied the flora of Guam. Additional significant floristic studies on Guam have been made by Safford (1905), Merrill (1914, 1919), Wagner and Grether (1948), Walker and Rodin (1949) and Stone (1970). In 1960, Fosberg described the vegetation of Guam. Moore (1973) studied the composition of vegetation along a transect at Pagat Point in the northeastern, windward, part of the Island.

Fosberg (1959) states that most forests presently on Guam are of second growth. The original forest that occurred on limestone was of large trees with a thick canopy. A long history of disturbance has left very little original primary forest. These remnants are in scattered patches on the northern plateau, on cliffs and relatively inaccessible terraces around the steep coasts.

The primary purpose of this study is to determine and describe the several plant communities apparent along a complex environmental gradient at Hilaan Beach on the leeward, western, side of Guam, 1.2 km northeast of Naval Communications Station Beach (Figure 1). The environmental gradient is complex because of a substratum cline extending from beach deposits to pitted limestone, an exposure cline away from the seacoast and an especially unique moisture cline involving the presence of Guam's only true fresh water cenote. Associated plant communities affect
Figure 1. Map of Guam with an enlarged detail indicating the location of the Hilaan Beach transect. The transect is approximately 1.2 km north of Naval Communications Station Beach. Detailed map is after USGS, 1968. A major reef-flat hole is indicated by a dotted oval.
considerable change over relatively short distances, are basically undisturbed, well developed, and include rare and localized species. In addition to its scientific value the entire area between NCS Beach and Hilaan Point is of great scenic beauty and it is hoped that this study may somehow contribute to its preservation.
METHODS

Field Methods

The belt transect is useful for the study of gradient changes in vegetation as in profile studies or the analysis of transition zones between communities (Braun-Blanquet, 1932; Oosting, 1956; Kuchler, 1967; Shimwell, 1972). Becking (1957) asserts that subjective selection of sample plots is a major advantage as compared with objective sampling, making it possible to select the most typical sites. These suggestions were utilized in this study.

A belt transect 5 m wide and 290 m long was established perpendicular to the shore at Hilaan Beach. The entire transect was consecutively divided into 5 m² subplots and numbers were assigned to each. The first subplot was adjacent to the level of mean high tide and the last was at the base of the cliff which rises to the plateau of northern Guam. There were 58 contiguous subplots. To include the greatest possible number and diversity of plant communities the transect was aligned to bisect a nearly circular, 34 m diameter, cenote. Subplots 41 through 49 are within this fresh water filled limestone sink-hole.

All vascular plants rooted within the transect were identified and measured one subplot at a time. Height was determined with the aid of an extendible 9.9 m measuring pole. Trunk diameters at breast height (DBH) were taken most often with a diameter tape. Crown diameter and the position of each plant was noted. These measurements plus additional notes and sketches were eventually used to draw a profile diagram which was repeatedly checked and modified in the field.
Diameter at breast height and crown diameter were converted to area at breast height and area of crown. All measurements were then summed for species. Species data were then divided by subplot sums to obtain relative figures. For each subplot relative density, relative height, relative area at breast height, and relative crown area were computed for each species. These figures were summed for each species in each subplot to obtain species importance values. These composite values were used to reflect the distribution of species along the transect.

Species importance values were also used in a Fortran IV computer program to explore Sørensen's formula for the coefficient of community. Sørensen (1948) gives the similarity coefficient as $K = \frac{a+b}{2C}$. Where $C$ is the number of species which two subplots have in common. The number of species in each of the two subplots is represented by $a$ and $b$. This was used to find the similarity coefficient of all possible pairings within the 54 subplots with rooted vegetation. The resultant data were eventually used to compile a cluster diagram.

The relative humidity of the air near the cenote and at the beach was measured with a Bacharach sling psychrometer. This was performed at about noon during each visit. Air and water temperature at the cenote and at the seashore were determined with a Weston mercury-in-glass thermometer. Thermographs, Bacharach Case Model 14-7030 with a seven day movement, were occasionally used to record temperatures near the cenote and near the beach.

Visits to the study site for the purpose of collecting data commenced on May 24, 1975 and continued until March 27, 1976. About 41 days were spent in the field. Numerous herbarium specimens were
collected and phenological observations recorded. Vouchers will be de­
posited in the University of Guam Herbarium.

Plant identifications were achieved mainly by reference to The
Flora of Guam (Stone, 1970). Additional aid was obtained by comparisons
with herbarium specimens and with the help of local authorities.

Soil Laboratory Methods

In each terrestrial subplot five soil samples were collected from a
depth of 2 to 20 cm. These samples were pooled in the laboratory, air
dried with the aid of an electric fan, and crushed with a wooden mallet.
Portions passing through a 0.825 mm sieve were used in the determination
of pH, salt concentration, and soil texture. Subsequent portions which
passed through a 0.5 mm sieve were used to determine organic matter
and the major cations. A Beckman pHASAR-I digital pH meter utilizing a
1:1 ratio of soil to water was used to measure pH. Texture, particle
size distribution, was performed by the hydrometer method of Bouyoucos
(1951). Salt concentration was determined through electrical conductance
expressed in micromhos per cm using a 1:1 soil: water extract and a
Beckman solu-bridge. Measurements of organic matter made use of the
Walkley-Black method (Jackson, 1958).

The major cations sodium, potassium, calcium, and magnesium were
extracted using a normal ammonium acetate pH 7±.05 solution. A 1:10
soil to ammonium acetate ratio was used. For calcium and magnesium
determinations, a portion of the extracts were diluted to volume with a
1560 ppm lanthanum oxide solution to control interferences. Levels of
the major cations were determined using a Perkin Elmer Model 305B atomic
absorption spectrophotometer.
RESULTS AND DISCUSSIONS

Figure 2 is an illustration of the profile of plants 1 m or taller occurring within the entire 5 m x 290 m transect. This type of figure was developed by Richards (1952). Such a diagram can be used as a laboratory tool in determining plant communities along a transect. It can further be used to explore the exact nature of community boundaries and the presence of ecotones. It is also helpful in examining community physiognomy, i.e., trunk and crown character, stratification and species arrangement. Many of these observations are difficult to conclude while in the field. One can only stand and inspect one small part of the forest at a time and it is quite difficult, even for the experienced field botanist, to analyze a complex forest or transect without the aid of such a figure or model.

Figure 3 shows the distribution of species along the transect and is patterned after illustrations by Whittaker (1967). It was constructed by plotting the importance value (sum of relative density, relative area at breast height, relative height and relative crown area) of a species in each subplot in which it occurs and connecting these points with a curved line. This was repeated for the 22 species with greatest transect species importance values (Table 1). Detailed data are presented in Appendix A. The area under each curve is relative to the proportion of available spatial niche occupied by each species. Species are generally independently distributed along the transect, and discrete communities with definite composition and sharp boundaries are not common.
Figure 2. Profile diagram of the 5 m x 290 m transect. Height scale and subplot numbers are indicated. The lower strip of the diagram is a continuation of the upper strip. Arrows and numbers indicate the several communities. All individual plants taller than 1 m are included. See Table 1 for key to species abbreviations.
Figure 3. Distribution of species along the transect. Importance values for species in each subplot are plotted for the entire transect and these points have been connected by smoothed lines. The several communities are indicated by arrows and numbers. Letters refer to species as indicated in Table 1.
Table 1. Relative importance percent (RIP), growth-form, Raunkier life-form, and origin of on-transect plant species greater than 1 m tall. Species abbreviations as used in Figures 2, 3, and 4.

<table>
<thead>
<tr>
<th>Plant species</th>
<th>Abbr.</th>
<th>R.I.P.</th>
<th>Growth-Form¹</th>
<th>Life-Form²</th>
<th>Origin³</th>
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<td>Mu</td>
<td>0.02</td>
<td>V</td>
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<td>Indig</td>
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</table>

1 Growth-Form
- Bles - Broad leaved evergreen shrub
- Blet - Broad leaved evergreen strangling tree
- Blets - Broad leaved evergreen thorn shrub
- Blet - Broad leaved evergreen tree
- Rt - Rosette tree

2 Life-Form
- E - Epiphyte
- Ch - Chamaephyte

3 Origin
- En - Endemic
- Intro/nat - Introduced and naturalized

E/t - Epiphyte/terrestrial
F - Fern
Fo - Forb
Gr - Graminoid
To - Terrestrial orchid
G - Geophyte
P - Phanerophyte
Indig - Indigenous
Intro/not nat - Introduced and not naturalized
Species less than 1 m tall (Table 2) were not included in the above mentioned computations.

The coefficient of similarity (Figure 4) was used as a basis for cluster analysis. A set of subplots is joined into a cluster on the basis of species shared. The highest values in the similarity matrix are located to identify subplots that form the nucleus of the first cluster. The similarity level is then decreased by 0.1 and a search is made for new clusters. By 'single-linkage' additional subplots are then admitted to the first cluster. The process is repeated until all clusters have finally merged into a single cluster containing all of the subplots. Cluster analysis establishes internally homogeneous groups. Subplots within each group are relatively similar in their species composition.

Communities

By integrating the information gleaned from Figure 2, 3 and 4, six plant communities were identified along the transect. They are:

1) **Scaevola/Messerschmidia**, 
2) **Cocos**, 
3) **Mikania**, 
4) **Aglaia/Guamia**, 
5) **Pandanus dubius/Marsh Ferns**, and 
6) **Merrilliodendron**.

In naming communities generic names are used for mono-specific species. See Table 3 for an indication of the subplots occupied by each community and a complete list of vascular plants occurring in each community. Also included are corresponding species importance values.
Table 2. Transect density, growth-form, life-form, and origin of or-transect species less than 1 m tall. Abbreviations are as used in Table 1.

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<th>Plant species</th>
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<th>Growth-Form</th>
<th>Life-Form</th>
<th>Origin</th>
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Figure 4. Cluster analysis of subplots. The similarity coefficients are expressed by horizontal lines. A value of 1.0 indicates that those subplots share all species. The several communities are emphasized by arrows and numbers. Letters refer to species as indicated in Table 1.
Table 3. Composition of communities along transect. Species importance values (SIV) are given. Relative importance percents (RIP) are in reference to each community. Species without values are less than 1 m tall. See Tables 1 and 2 for a list of complete scientific names.

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<th>R.I.P.</th>
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5. Pandanus dubius/Marsh Ferns (45-47 no vegetation)

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and relative importance values as computed on a community basis for individuals 1 m or taller. Additional species represented only by individuals less than 1 m tall are also listed. A discussion of each community follows.

1) Scaevola/Messerschmidia Community

These two tree species form a discrete strand community slightly above the wave splash zone. It forms a continuous belt along adjacent sandy beaches but is replaced by Pemphis acidula on rocky cliffs and headlands. Although rooted only in subplot 2, the crowns of individuals extend well into subplots 1 and 3. Both species tend to branch low so that their crowns actually begin at ground level and extend to a height of about 7 m. A rather dense hedge-like barrier is thus formed. This community does not share species with the remainder of the transect and statistically joins the transect with a very low (0.04) similarity coefficient.

2) Cocos Community

This community is a near consociation as Cocos obtains a relative importance value within this zone of about 92%. This community is actually an abandoned coconut plantation which was originally planted and probably maintained until World War II. The oldest trees are quite regularly spaced and now act as seed trees. Piles of germinating and rotting nuts have accumulated beneath their crowns. Although frequent gaps occur, probably from wind-throw and old age death, the crowns of mature trees form a nearly continuous canopy between 9 and 20 m in height. The taller individuals generally occur further from the sea. The crowns of sub-adults form an open stratum between 4 and 10 m.
Juveniles and seedlings develop an often dense stratum less than 3 m tall. Twenty-two adults, 37 subadults and 299 juveniles, and seedlings were counted on subplots within this community. Statistically four subcommunities are evident. Most are dependent upon the appearance of secondary species. Many coconut trunks are laden with epiphytic ferns including: *Asplenium nidus*, *Nephrolepis hirsutula*, *Phymatodes scolopendria*, *Davallia solida*, *Pyrrosia adnascens* and *Vittaria elongata*.

3) **Mikania Community**

This very weedy and viny zone includes subplots 17 through 22. It begins quite abruptly with the discontinuation of *Cocos* and terminates gradually as it blends into a taller forest. It extends laterally in this same relative position and suggests being an ecotone. *Mikania* and four other species of vines densely wrap all trees and shrubs into a tangle which is very difficult to traverse. An even canopy of stratified tree crowns is absent. This results in a very irregular, lumpy appearance. Similarity coefficients identify four subdivisions within this zone. It is interesting to note that old Chamorro artifacts, especially pot sherds, are common on these subplots. Latte sites are found in this community slightly south of the transect (Reinman, 1968).

4) **Aglaia/Guamia Community**

Subplots 24 through 39 are occupied by a well developed forest of small to large trees with few low branches and little undergrowth. It presents minor problems when traversing on foot. Both *Aglaia* and *Guamia* are relatively small trees (averaging 2.3 cm and 2.7 cm DBH; 5 m and 6.6 m height, respectively) but their high density results in large relative importance values within the community. An important
intrusion of Merrilliodendron occurs in subplots 34 through 38; this species forms a consociation later in the transect.

The largest trees of the transect Artocarpus mariannensis, Guettarda speciosa, Pisonia grandis and Ficus prolixa occur in this community but because of their sparse density they rank low in importance value. Because of their height they act as emergent trees which jut above the surrounding vegetation. They form a nearly continuous overstory canopy between 7 and 22 m. A second stratum of tree crowns composed of Aglaia, Guamia, Dendrocnide latifolia, Eugenia reinwardtiana, and Annona squamosa is apparent between 5 and 15 m. It again is basically continuous but tends to be depressed when beneath the crowns of overstory species. A third stratum of mostly small trees occurs below 5 m. Members of this stratum are mostly new species not seen in the upper strata, e.g., Pandanus dubius, Triphasis trifolia, Cycas circinalis, P. fragrans, Streblus pendulinus, and Planchonella obovata but some are juvenile individuals of species normally found in the uppermost and intermediate strata.

Six subcommunities are apparent. Subplots 34 through 38, because of the presence of Merrilliodendron, are removed in the cluster analysis to combine with community number 6. The remaining five subcommunities are determined by Aglaia/Guamia, Ficus prolixa, Artocarpus mariannensis and Claoxylon mariannum.

Numerous large clumps of the epiphytic fern Asplenium nidus are a characteristic feature of this community. Vines are not especially noticeable and other than Flagellaria indica and Mucuna gigantea they are lacking. This community terminates as it grades into the Pandanus dubius dominated zone at the edge of the cenote.
5) **Pandanus dubius/Marsh Ferns Community**

Subplots 40 through 44 on the near side of the cenote and subplot 48 on the far side, contain this community. It begins as *P. dubius* replaces the trees of the previous community. This occurs about 20 m from the flooded edge of the cenote. Because of the low branching, trunkless character and stilt roots of *P. dubius* this zone is very difficult to penetrate. Individual plants reach a height approaching 8 m. The belt of *Pandanus* trees extends into the water and to inspect them one must climb through their roots and branches while wading in soft ooze. At a point where the water is about 0.5 m deep *Pteris tripartita* grows intermingled within the *Pandanus*. At a depth of about 1 m both species terminate. A band of *Acrostichum aureum*, about 3 m wide, then extends to a water depth of about 1 m. The remainder of the pool, subplots 45 through 47, is open water reaching 2.3 m in depth and is free of major vegetation. The bands formed by *Pandanus* and the marsh ferns tend to encircle the majority of the cenote but are lacking on the generally rocky northwestern side. *Ficus prolixa* falsely obtains a large importance value within this community because of the presence of several displaced individuals. Where the transect leaves the far side of the cenote the marsh ferns are lacking and only a narrow band of rather small *Pandanus* are present.

6) **Merrilliodendron Community**

*Merrilliodendron* forms a near consociation within subplots 49 through 58, plus its earlier insertion into subplots 34 through 38. Mature trees form a nearly continuous canopy between 8 to 18 m in height. Those individuals nearest the cenote tend to lean to take advantage of
the open space it presents. An intermediate stratum of subadults occupies the 5 to 14 m height. Numerous juveniles less than 5 m tall form a third stratum. The ground is often nearly carpeted with seedlings, the vast majority of which will not survive. As in the Aglaia/Guamia community there are numerous, often large, clumps of epiphytic ferns. This forest is quite free of shrubs and low branches and is comparatively easy to walk through. The community ends abruptly as one encounters the boulders which are strewn at the base of the cliff.

Fosberg (1959) describes the Artocarpus forest of the northern plateau of Guam as a discontinuous overstory of Artocarpus and Ficus. Beneath this is a continuous second story of lesser trees and an understory which is not sharply separated. This study was conducted at the base of the plateau within an area sheltered by the cliff. In such locations the overstory trees are often closer together and form the nearly continuous canopy reported in this study.

Moore (1973) studied a limestone forest on the windward coast of Guam. He found Mammea and Eugenia to be dominant. In the present study on the leeward side of the island Mammea was absent and Eugenia occurred only in small numbers.

Three tree strata are typical of highly developed tropical rain forests (Richards, 1952). The strata described in this study are of short stature when compared with the tropical rain forests of Africa, South America and Southeast Asia. This may be a reflection of evolutionary selection under typhoon pressure. Hence Stone (1971) suggests the name, "typhoon forests".
Figure 5. Number of species of vascular plants occurring in each subplot along the transect. A maximum of 20 species is achieved in subplot 32. The cenote is centered in subplot 46.
Figure 6. Species/area curve. The cumulative total of vascular plant species is plotted on area in square meters. Area is summed as one traverses the transect.
Figure 7. Relative importance percent plotted on species sequence. The resultant sigmoid curve on semilogarithmic coordinates indicates a log-normal distribution.
The tabulation of growth-form (Whittaker, 1975) of the 55 species of vascular plants in the transect reveals: 44% to be broad leaved evergreen trees; 14% vines; 10% epiphytes; 9% rosette trees; 7% forbs; 4% broad leaved evergreen shrubs; 4% terrestrial/aquatic ferns; and 2% each of broad leaved evergreen strangling trees, broad leaved evergreen thorn shrubs, graminoids and terrestrial orchids. See Table 1 for a growth-form determination of each species. The three dominant categories are those growth-forms which typify tropical forests (Richards, 1952).

A re-tabulation according to Raunkier's life-forms (Whittaker, 1975) indicates: 75% phanerophytes (perrenating bud high in air); 11% epiphytes (entire plant removed from the ground); 7% chamaephytes (bud near the ground); and 4% each of hemi-cryptophytes (bud on surface of ground) and geophytes (bud well buried). This tabulation also reflects typical tropical forests, perrenating buds removed from the protection of the ground. See Table 1 for a life-form determination of each species. Similar percentages were found by Richards (1952) in New South Wales, Australia and by Whittaker (1975) in India.

If the same species are tabulated by origin (Stone, 1970) it is seen that: 7% are endemic to Guam or the Mariana Islands; 75% are indigenous (occurring in Guam prior to human habitation); 9% are introduced and naturalized; and 9% are introduced and not naturalized. See Table 1 for the origin of each species. The introduced species are contained in the Cocos community, Mikania community and Aglaia/Guamia community. It was also noted that all of the endemic species were found in the Aglaia/Guamia community.
Plank buttressing of the lower trunk, though weakly developed, is apparent in *Artocarpus mariannensis*. Both species of *Pandanus* exhibit stilt (=prop) roots. *Ficus prolixa* is a typical strangler with aerial roots. These several features are commonly found among tropical trees.

Species taller than 1 m and present within the transect were statistically examined by the variance/mean ratio method (Whittaker, 1975) to determine their type of horizontal distribution. Ninety-eight percent were resolved to be of the clumped type of distribution and two percent (*Davallia solida*) were of the regularly spaced type. None were randomly distributed.

Phenological observations were made during visits to the study site. It was generally noted that there are two flowering seasons. The primary flowering period is in June but there is a secondary period in November. The later period involves the reflowering of many of those species which flowered earlier.

**Environmental and Edaphic Factors**

Water temperature of the cenote (\(\bar{x} = 26.4^°C\), range 21.5 - 29.4°C) was consistently lower than reef-flat sea temperature. It was also observed that cenote water temperature was always cooler than adjacent ambient air, while sea temperature was warmer than adjacent ambient air. Further, water and air temperature at the cenote were cooler and fluctuated less than corresponding temperature at the sea.

In July thermographs were kept for a week near the cenote and near the beach. Daily air temperature fluctuation at the cenote averaged 23.3 - 26.7°C while at the beach it was 25.6 - 30°C.
Relative humidity near the cenote was consistently higher than on the open beach. Mid-day values were generally 90% and 80%, respectively. During rainy days relative humidity was generally uniform at both locations.

The general character of the substratum along the transect is: deep sand (mostly coral fragments) from subplot 1 through 15; gravelly limestone from subplot 16 through 24; deeply pitted coralline limestone with small pockets of soil occurring throughout the remainder of the transect. The cenote is within the latter zone but is edged and lined with soft ooze.

Soil texture analysis (Figure 8) reveals that all of the soils are highly sandy but the proportion of sand gradually decreases along the transect. Silt and clay show a reverse trend. The percent of organic matter increases to reach a high several subplots before the cenote.

Calcium obtains the highest value of the major cations. It is followed by potassium, sodium and magnesium (Figure 9). The first three ions increase in quantity along the transect to reach peaks several subplots before the cenote. Magnesium remains quite low and constant throughout the transect. Readings of ions within the water of the cenote are included in Figure 9.

Soil pH is shown in Figure 10. The first three subplots gave values higher than the pH of sea water (8.03). The remainder of the transect produced readings near pH 8. This is undoubtedly because of the alkaline nature of the limestone substratum. Water from the cenote had a pH of 7.28.
Figure 8. Mechanical analysis and organic matter content of soil within the transect. Percent sand, silt, clay and organic matter were determined for each subplot. The gap indicates the location of the cenote.
Figure 9. Sodium, potassium, magnesium and calcium concentrations within the transect. All, except calcium, generally increase as one moves away from the beach.
Figure 10. Soil pH and total salt concentration within the transect. Both determinations are relatively constant and lack distinct trends. A high salt concentration is evident within the water of the cenote.
Total salt concentration (Figure 10) along the transect is quite constant. Water from the cenote gave high readings. See Appendix B for details of soil analyses.

The species/area curve (Figure 6) and the species on subplots (Figure 7) showed the number of species to generally increase along the transect. The number of species occurring in each subplot was also statistically examined by regression analysis to determine their relationship with 10 different soil factors. Resultant correlation coefficients (r) are given in Table 4. Six factors showed significant relationships. Four did not. The six significant factors sand, silt, organic matter, potassium, sodium, and calcium are graphed in Figure 11.

Similar results are seen in the literature. Wikum and Wali (1974) resolved from a study in North Dakota that there was a high correlation between the number of species present, and potassium and calcium in the soil. Richmond and Mueller-Dombois (1972) did not observe significant correlation between species and salt concentration and pH in a study conducted in Oahu, Hawaii.
Table 4. Regression values of species on soil factors. Correlation coefficients (r) and levels of probability for the number of species occurring in a subplot in relationship to area and 10 different soil factors.

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<td>Clay</td>
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Figure 11. Relationship between number of species present in a subplot and six significant soil factors.
CONCLUSIONS

Quantitative investigations utilizing three major analytical devices, i.e., the profile diagram, plotted species importance values and statistical clustering, resulted in the determination of six vegetation communities. The communities named for dominant or co-dominant species as determined by computed species importance values are: 1) Scaevola/Messerschmidia; 2) Cocos; 3) Mikania; 4) Aglaia/Guamia; 5) Pandanus dubius/Marsh ferns; and 6) Merrilliodendron.

Though individual species are independently distributed along the gradient the several communities are recognizable by species composition and physiognomy. Boundaries between the first two communities are quite discrete while boundaries between the remaining communities are indistinct. Ecotones are narrow or nonexistent.

A total of 55 species of vascular plants were identified within the transect. The major growth-form is broad leaved evergreen tree, 44%. The most complex community Aglaia/Guamia contained 32 species and a vertical structure of three nearly continuous tree strata. The simplest community, Scaevola/Messerschmidia, contained only three species and formed a narrow hedge-like band just above the beach.

Pandanus dubius dominates the marsh community which occurs at the edge of the cenote which is bisected by the transect. A second less mesic environment is occupied by a consociation of a tree rare on Guam, but locally abundant, Merrilliodendron megacarpum.

Strong statistical correlations exist between the number of species
occurring within a subplot or community and increased amounts of soil potassium, sodium, and calcium.
LITERATURE CITED


U.S.G.S. 1968. Dededo; Ritidian Point, Guam. 1:24000 map series.


# APPENDIX A

## SUMMARY OF FIELD DATA FOR PLANTS ONE METER AND TALLER

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<tr>
<th>Subplot</th>
<th>Species</th>
<th>Density</th>
<th>Area at Height Breast Height (m)</th>
<th>Crown Area (Cm²)</th>
<th>Relative Density Area</th>
<th>Relative Crown Area</th>
<th>Relative Crown Height</th>
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**Note:** The above table presents data on the density, area at breast height, height, crown area, relative density, relative crown area, and relative crown height for various species. The species are listed with their respective attributes and numerical values. The table also includes columns for the importance value, indicating the relative significance of each species within the study area.
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## APPENDIX B

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