FIELD ECOLOGICAL SURVEY OF THE AGANA-CHAOT RIVER BASIN

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in collaboration with

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UNIVERSITY OF GUAM MARINE LABORATORY

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Director

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by

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INTRODUCTION

Guam is presently undergoing a construction boom which will continue for sometime in the future. Dormant real estates, located in the heart of downtown Agana, are now the sites of active construction. In most cases, old buildings are being demolished to make way for modern commercial complexes. With the limited number and high prices of these choice properties, construction is now encroaching into a few of our distinct environments. Such is the case of the Agana-Chaot River Basin which represents the largest expanse of marsh land on Guam.

This report is a field ecological study of the Agana-Chaot River Basin, including the zone of ocean water mixing (estuary) at the mouth of the Agana River. The river basin is located on the west coast of Guam near the center of the island (Figs. 1 & 2) and covers an area of about 8.7 square miles. The basin is situated in the hilly dissected section of Guam and is bounded on the northeast and east by limestone plateau land of northern Guam, on the south side by the low lying alluvial valley floor of the Pago River Valley, on the north side by a narrow strip of coastal low land, and on the southwest side by dissected sloping and rolling land as well as mountainous land.

The mouth of the Agana River is located in Agana Bay on the east side of the Paseo de Susana Park, and empties onto the shallow reef flat platform along the shoreline. Prior to landfilling of the park, the river mouth was connected by a deep natural channel that cuts through the fringing reef platform to the Philippine Sea. This channel is now located on the west side of the park and serves as an access between the Agana Boat Basin and the Philippine Sea.

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METHODOLOGY

The river basin environment is described and divided into ecological units, the biotope (Hesse et al., 1951). The concept normally "embraces the entire complex of habitat conditions in the area defined including substrate, accretional, and erosional processes; hydrologic factors; and life associations," (Cloud, 1959, p. 374). When distinct and consistent variation occurs within the larger biotope unit, it is subdivided into smaller ecological divisions called "facies" (Cloud, 1959). The biotope descriptions are by no means complete, for it is impossible to acquire all or even a major part of the complex parameters which make up these ecological units during the period allotted for the Agana-Chaot River Basin study. These descriptions provide a basic framework which can be expanded upon as more data are acquired, thus, classifying the river basin into the descriptive framework of the biotope unit.

BIOTOPES

General Description

Three biotopes (Fig. 3) are recognized in the Agana-Chaot River Basin.

Biotope I. Wet Land. This biotope consists of the low lying land where the water table is either permanently at the surface or sufficiently close to it to make the soil wet. The wet land is subdivided into three facies.

Facies A. Marsh land - Wet land with predominately herbaceous vegetation.

Facies B. Swamp land - Wet land with predominately woody tree and shrub vegetation.

Facies C. Open water - Regions where open standing or flowing water is present.

Biotope II. Dissected Hilly Land. This biotope consists of rolling hills and slopes that border the wet land regions. It has been eroded into a fine dendritic pattern of dissection. The hilly land is subdivided into two facies.

Facies A. Steep hill and valley slopes - This is hilly land which borders the perimeter of the low wet land regions and the upper parts of the drainage basin.

Facies B. Limestone hummock - This facies consists of low isolated rounded hills and ridges that rise above the general level of the low wet land (Biotope I).

Biotope III. River Estuary. This biotope consists of the zone of salt water mixing at the mouth of the Agana River.

Biotope I - Wet Land

Physiography

Biotope I consists of a broad belt of low marshy and swampy land that trends in a northwest-southeast direction. The biotope is more extensively developed at the northwest end, between the villages of Sinajana and Mongmong, where it attains maximum width of about 3,500 feet (Fig. 4). To the southwest the biotope is irregular in distribution because of low limestone ridges, 20 to 40 feet high, that project into it from the border. The marsh and swamp land narrow to about 500 feet where two of the larger limestone ridges project into it, one from the southwest border at Fagueygao District and another from the northeast border at Lomongan Ifit District. Other limestone ridge complexes are located at Agana Springs, Finenga District, and Utan District (Fig. 5). Southeast of Utan and Finenga Districts the wet land is confined to several narrow fingers, one to the south which follows a valley floor of the Chaot River and another which follows a valley to the east, at Chochogo District (Fig. 6). Maximum penetration of the wet-land into these narrow valley floors is about one mile. A portion of the finger that follows the Chaot River Valley is isolated from the main body of the biotope by a low ridge. The general level of this isolated region is about 20 feet higher than the general level of the main body of the biotope.

In general the wet marsh land and open water regions (Facies A & C) are more or less confined to areas which are lower than the 5 foot contour (see Fig. 3). The swamp land (Facies B) is more predominant in the better drained land between the 5 foot and 10 foot contours. Topography of the marsh land (Facies A) is flat and low and densely covered with herbaceous vegetation. The marsh land is dominated by a tall reed, Phragmites karka (see Fig. 4). Conspicuous limestone hummocks and ridges (Biotope II, Facies B), up to 40 feet in elevation, protrude upward through the general level of the marsh land. These elevated features are covered by woody tree and shrub type vegetation. When viewed from above (see Fig. 4), these hummocks and ridges appear as small islets and peninsulas in a sea of uniform marsh reed vegetation.

The perimeter of the reef marsh land and limestone hummocks is swamp land (Facies B) consisting of a mixture of reed grasses, other herbaceous vegetation, and woody trees and shrubs. The marsh land in the Agana River Basin appears to be in stage of succession leading to a woody type of swamp vegetation. Evidence of this succession is seen in many parts of the marsh, where local patches or single woody plants have invaded the predominant reed grass community.

Rivers and Drainage

The Agana River is poorly defined and silted in, except where it has been channelized through East Agana from its mouth to the bridge on O'Brien Drive (Figs. 7 & 8). South of the bridge, the channel disappears into the thick growth of Phragmites karka reeds and floating Pistia stratiotes (Fig. 9). This thick growth of vegetation, though, actually masks and follows a wide shallow depressed zone which leads to Agana Spring (Fig. 10) and is the probable route of the river before it became silted in and overgrown with vegetation.

According to an account given by Lieutenant (Jr.) Claire C. Seabury, (C.E.C.), U.S.N. (1934), the Agana River was dredged from the "Maxwell Bridge" in Agana, to Agana Springs Reservoir, a distance of over 5,700 feet. A board was appointed by Governor E. S. Roat in March, 1933, to investigate the feasibility of draining the "Agana Swamp" and converting it into arable land. A favorable report was returned and dredging started in June, 1933, by using a floating pontoon hoist with a half cubic yard bucket. At this time the river channel was reported to have been filled with silt and overgrown with cane, so that it could hardly be distinguished. A channel was cut 20 feet wide and 3 feet deep to Agana Springs. Completion of this dredging lowered the river level three feet at Agana Springs and large areas became sufficiently drained to permit cane to be burned; the land was then prepared for corn planting. A 1,500 foot long lateral channel was dredged to the east toward San Ramon Hill about halfway between the "Maxwell Bridge" and Agana Springs. The entire project was completed in February, 1934, and it was estimated that over two thirds of the entire area was drained free from surface water and the ground water level dropped considerably over the entire area. The most apparent result of the dredging was the increased flow of the Agana River, especially during dry periods.

The poorly defined river channel, now observed in the marsh, is probably the river-course, now silted in, that was dredged in 1933-1934 (Fig. 10). A powerline right-of-way and adjacent roadway near the north end of the swamp has altered the normal drainage distribution patterns of the marsh (Figs. 4 & 10). The roadbed is constructed of crushed limestone fill and completely bisects the marsh, thus cutting off the free flow of water, except for a depression located at the east end of the roadway, over which the water flows freely. This depression is located at the same region where the Agana River is shown to cross the roadway on Fig. 3. There is probably some percolation of water through the limestone fill in the roadway.

At Agana Springs, water issues from the argillaceous limestone at an altitude of 5 feet and flows into a concrete reservoir (Fig. 11). Pumps were first installed at the reservoir in 1914 and the water was used for municipal uses. Pumpage records indicate rates of 0.8 mgd during 1937, and 1.5 mgd during 1945, at a chloride content of 20 to 35 ppm (Ward and Brookhart, 1962). Table 1 shows the pumpage rates from 1951 through 1957 by months.

Table 1. Pumpage rates for Agana Springs. Table from Ward and Brookhart (1962).

Pumpage (million gallons)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1951	-	-	-	-	-	-	-	-	-	-	73.83	75.83
1952	74.96	59.66	54.31	49.31	48.61	-	-	54.09	58.14	66.66	70.48	75.64
1953	59.40	56.84	64.02	52.34	45.82	38.73	44.19	61.67	-	68.32	79.84	80.42
1954	60.70	61.30	57.20	53.37	60.31	29.02	59.05	55.41	53.55	40.52	27.58	27.00
1955	27.50	46.07	24.32	23.34	17.43	19.46	20.31	38.41	22.16	18.68	18.67	19.41
1956	21.04	19.62	23.78	27.82	25.44	24.21	19.21	19.77	21.24	20.44	18.98	21.04
1957	30.56	17.62	17.23	23.17	21.31	-	-	-	-	-	-	-

Agana River discharge measurements taken at a low-flow partial-record station near the river mouth in 1962 show a rate of flow ranging from a a high of 1.02 cfs in February, to a low of 0.23 cfs in May (Geological Survey Water-Supply Paper No. 1937). These data are the only flow records of Agana River that could be found.

Slope of the marsh land is from the peripheral border toward the central northwest-southeast axis of the marsh to the Agana River depression and then northward toward the mouth of the Agana River. Slope of the Agana River is about 1 in 390 (Tracey et al., 1959).

The water table in the marsh fluctuates depending upon the season and amount of rainfall. During the wet season a few inches to a foot or more of surface water was observed over most of the marsh and swamp land that was covered by Phragmites karka growth. During the dry season the area covered by surface water is more or less restricted to the river channel and local depressed regions. The water level in the reservoir at Agana Springs is high enough to flow over a low spillway (Fig. 12) during the wet season but is generally below the spillway level during the dry season.

Areas of permanent open water (Facies C) are small in comparison to the areas covered by marsh and swamp land. The largest area of permanent open water is a stretch of the Agana River channel between its mouth and the bridge on O'Brien Drive. Midstream depth along this stretch of the river ranges from 1.5 feet at the mouth of the river to 3 feet at the bridge on O'Brien Drive. The river bottom consists primarily of soft silt, mud, calcareous gravel and small boulders, and trash. Width along the same stretch of river ranges between 20 and 40 feet. Estuarine conditions (Biotope III) are found as far as 800 feet upstream at high tide.

Another small body of open water is found in the reservoir at Agana Springs (see Figs. 11 & 12). Maximum depth in the reservoir was found to be about 9 feet when measured to spillway height. The reservoir is enclosed by concrete retaining walls. The spillway is located on the north wall. The south side of the reservoir consists of a steep limestone slope and the east side is bordered by a narrow band of marsh land.

The reservoir and adjacent areas are leased by the Government of Guam from the U. S. Navy. The organization responsible for acquiring the lease is the Guam Science Teachers Association (GSTA). This organization dredged the silt and trash clogged reservoir and cleared, leveled, and replanted the area adjacent to the north side of the reservoir (Fig. 12). A small picnic area was also established at this time on the hillside to the southwest of the reservoir.

Geology

The wet land of the Agana marsh and swamp is underlain by the argillaceous limestone member (Fig. 13) of the Mariana formation (QTma). During the various Holocene sea level stands, that were higher than the present stand, the entire area now occupied by wet land was probably inundated by the sea forming an embayment. During these higher sea stands, corals and other reef associated organisms probably thrived in the embayment. During the +6 foot sea stand, the region was probably a shallow embayment or mangrove swamp similar to those now found at the head of Mamaon and Manell channels in the Merizo Lagoon (Fig. 1). Borings made in the marsh and swamp land at various places indicate that a layer of bioclastic detrital material overlies the older limestone basement. This recent calcareous detrital material grades upward into a layer of silt clay, muck, and organic deposits which supports a rich growth of marsh and swamp vegetation.

The lithology of the limestone making up the low limestone hummocks and ridges (Biotope II B) located within the low land areas is similar to that of the higher argillaceous limestone slopes (Biotope II A) which border the swamp and marsh land. These features are tentatively mapped as argillaceous limestone of the Mariana formation (QTma) although they may have develcped much later during one of the higher Holocene sea stands as isolated patch reefs.

Soil Description

The predominant soil type developed on the marsh and swamp land of Biotopes I (Facies A, B, and C) is muck (Unit II). Distribution of the muck is shown in Fig. 14. The description of the muck has been taken, in part, from a description of Guam soils by Stensland (In "The Military Geology of Guam, Mariana Islands, Part 1-Description of Terrain and Environment," 1959). The muck, a poorly drained soil, is a mixture of black or very dark-colored, soft, decomposed plant remains with considerable pale-brown to light yellowish-brown fibers and generally enough clay, silt, and limesand or shell fragments to make the mass soft, sticky, and slightly gritty (wet), spongy and plastic (moist), and hard (dry). The muck is in some places interstratified with layers of silty clay a few inches to several inches thick. Light gray mottling is common in these clayey layers. Depth of the muck and interstratified clay ranges from 3 feet to more than 18 feet and averages 7 feet, in a series of random samples. Average thickness of the muck, minus the clay layers, is 6 feet. Grains of limesand and whole or broken shells are noticeable at depths of 3 to 5 feet and, in the coastal or adjacent alluvial flats, are the predominant material immediately underlying the muck. The water table is at or near the surface most of the time. Reaction of the permanently saturated soil is alkaline; reaction of the soil above the level of permanent saturation is neutral to moderately acid.

A mass of floating vegetation, thick enough to support a man's weight occupies a small region choked with Eichhornia crassipes at the head of the Agana River where the Agana Spring empties into the swamp.

Muck is most extensively developed in the reed marsh (Biotope I, Facies A). The swamp land (Biotope I, Facies B) contains considerable muck deposits particularly where it merges with the reed marsh, and is less developed where it grades into the better drained slopes of Biotope II, Facies A and B. The bottom of tne open water areas (Biotope I, Facies C) consists of muck except at Agana Springs where much of the muck deposits have been removed by dredging exposing underlying calcareous deposits.

Underlying regolith or bedrock - This unit is underlain by limesand, limestone, or soft weathered volcanic rock or clay at depths ranging from 3 to more than 25 feet below the surface, but which are commonly between 5 and 20 feet below. Limesand is the material most generally underlying this unit.

Profile description - A profile of Unit 11, in Agana Swamp (Site 38, Fig. 2) is as follows:

1 0 to 6 inches. Black (10 yr. 2/1, moist) to very dark-brown (10 yr. 2/2, moist) silty muck and peat; extremely high in organic matter content; contains some silt; water table surface is at bottom of this layer; pH 7.0.

2 6 to 24 inches. Very dark-brown (10 yr. 2/2, wet) muck; somewhat sticky; contains many fibrous old roots, and some silty clay; pH 7.5.

3 24 to 72 inches. Very dark grayish-brown (10 yr. 3/2, wet) muck, containing partly decomposed plant material; slightly sticky; pH 8.0

D 72 to 84 inches. Gray (2.5 yr. 5/0, wet) silty coarse limesand; sticky; consists largely of subangular to angular shells and fragments of marine animal skeletons; some vegetal organic matter; pH 8.0.

Range in characteristics - Color of the muck is black, very dark brown or very dark gray. The fibrous plant remains are pale brown to yellowish brown. The clayey horizons are commonly mottled with light gray. Density of the natural, saturated soil mass is very low; the soil would not sustain the weight of a person standing on it without the mat of vegetation and root fibers at the surface.

Drainage, erosion, and soil moisture - There is some surface runoff after flooding, and some siltation during flooding. Internal drainage is restricted to a few inches in the upper part during dry weather because of the generally high water table.

Special features - Brackish or slightly saline groundwater is in the estuarine part of this unit adjacent to the sea. Most of the unit supports normal water-tolerant vegetation.

Associated or included soils - This unit is associated with Pago clay (Unit 9), where the Chaot River empties into the southwest corner of the swamp.

Vegetation and use - The large reed Phragmites karka and Hibiscus tiliaceus trees are the predominant vegetation in this unit. Some smaller reeds, Scirpus erectus, and Panicum grass are also on this unit along the north side of the swamp and where narrow strips of swamp land penetrate into the valleys of the hilly land to the southwest.

The unit is all idle land, except where roads have been constructed through it. The Japanese started to construct a drainage-irrigation system in the upper (inland) portion of Agana Swamp, probably intending to grow rice and taro, but the project was barely begun when World War II ended.

Suitability for use - Rice and taro could be grown in part of this unit, as previously proposed by the Japanese. Excavated, dried muck is suitable for use by the small potted-plant nurseries on Guam. It is recommended for use as the main soil ingredient rather than as a fertilizer, however, because the fertility and nitrate concentration in muck is generally not high enough for fertilizer.

Flora and Fauna

Marsh Land (Biotope IA): As described earlier, the most characteristic plant in the marsh land is the vast stand of Phragmites karka (Fig. 15). This reed attains a height of about 15 feet and is so thick that it was unwise to run a transect through this growth. However, recent clearing by J & G Enterprise for a proposed shopping center off Route 4 provided an ideal opportunity to observe other plants, if any, along the periphery of the clearing site. A line transect revealed that the fern, Acrostichum aureum, (Fig. 16) which attains a height of 10 feet, is also very abundant in the marsh area. Phragmites karka made up about 62% of the plants on the transect while Acrostichum aureum made up the remaining 38%. No other plants were found on the transect.

The wild sugarcane, Saccharum spontaneum, was present and abundant on the periphery of the marsh along the powerline coral road.

The marsh area is known to be the last refuge of the endemic nightingale reed-warbler, Acrocephalus luscinia luscinia. Mr. Nick Drahos and Mr. John Jeffrey of the Guam Fish and Wildlife Division, estimate that about six pairs, if any, inhabit the marsh area. This species was last seen by Mr. Jeffrey in 1969. However, the song of this bird has been heard since then. The endemic white-browed rail, Poliolimnas cinereus micronesiae, is also reputed to inhabit the marsh area, but has not been seen in years.

Swamp Land (Biotope IB): The Agana-Chaot River Basin is fringed along the southwestern edge by the tree Hibiscus tiliaceus which is interspersed by stands of Phargmites karka. The Hibiscus tiliaceus swamp here is not as extensive as that found in the Talofofo basin and is never developed as much as the mangrove, Nypa, or Barringtonia swamps as described by Fosberg (1960).

Open Water (Biotope IC): Hydrilla verticillata, Eichhornia crassipes (Fig. 17) and Pistia stratiotes are still present across the road from the spring where the water from the spring spills over into the marsh. The area covered by these two floating aquatic plants is only about 300 sq. ft. since the Phragmites seem to be encroaching toward this area.

The native freshwater eel, Anguilla marmorata, is also said to be abundant in the open water areas as well as in the marsh during the rainy seasons. The eel is often caught in the area for local consumption. Tilapia mosambica is the most conspicuous fish in the open water areas. This species was introduced throughout the island by the Department of Agriculture either in 1954 or 1955 and is now naturalized on Guam. Another species Tilapia zilli was also introduced to Guam's freshwater environment in 1956 and is also present in the open water and marsh area. Macrobrachium lar is also found in the open water and marsh area, but the abundance of this species is not known.

The toad, Bufo marinus, was introduced to Guam from Hawaii in July 1937 by the Department of Agriculture and was first released in the Agana Springs area. The toad was originally brought in to control the black garden slug, Veromicella leydigi. Since this time, the toad has spread throughout Guam and is one of the more dominant organism present around the spring area. Numerous tadpoles can be observed in Agana Spring.

The spring is now becoming the most popular site where various aquatic pets are released. Turtles, carps, goldfish, and guppies can be seen in the Spring; however, none of these introductions have become established.

Biotope II - Hilly Dissected Land

Physiography

Hilly dissected land borders the marshy and swampy (Biotopes IA and IIA) wet land except for a narrow section of low beach terrace deposits where the Agana River flows through the City of Agana (Fig. 3). A steep sloped limestone ridge borders the southwest side of Agana Swamp from the City of Agana to the Chaot River. The elevation of this ridge is generally over 100 feet and at places is slightly over 200 feet. The villages of Agana Heights and Sinajana occupy the ridge top and much of the slopes to the southwest. Some scattered residential dwellings are found on the ridge slope bordering the swamp. Several less steeply sloped peninsulas consisting of low rounded hills (Biotope IIB), generally less than 30 feet in elevation, project into the low swamp land from the higher ridge at Agana, Fagueyao District, Agana Springs, and Finenga District. Most of these low peninsulas are, at present, occupied with residential dwellings.

The northeast side of Agana Swamp is bordered by gentle sloping dissected limestone land. The 100 foot contour level along this side is located considerably farther away from the swamp border. East Agana, Mongmong, and Toto villages border the slopes along this side of the swamp. Several low ridges project into the swamp and marsh land at Utan District. Most of these projections consist of low rounded limestone hummocks (Biotope II, Facies B), usually less than 30 feet in elevation above the general level of the marsh land.

The southeast side of the swamp land is bordered by intricately dissected ridges and hills, generally less than 200 feet in elevation. Much of this region is densely wooded and lacks the dense residential development found along the northeast and southwest borders.

Relief of the hilly land is greatest along the limestone ridge which forms the southwest border of the swamp. Since the swamp itself is less than 10 feet above sea level, the relief of the above ridge, the low limestone slopes to the northeast, and the dissected hills to the southwest are essentially the same as the elevation of the features given above.

The principal slope of the hilly land is toward the swamp basin itself. Slopes in the valley bottoms of the hilly land range from 1 in 20 along the short valley streams to 1 in 100 along the Chaot River. The slopes of the valley sides and hills are steep, particularly along the southwest and southeast side where locally they may be precipitous. The slope generally decreases toward the rounded tops of the hills and ridges. The slope along the northeast side of the swamp is steepest at the immediate border of the marsh and swamp but it decreases into low sloped undulatory land as the unit grades into the limestone plateau land away from the swamp border.

Geology

The hilly land is developed upon exposures of Agana argillaceous limestone (QTma) on the southwest and southeast sides of the swamp and non-argillaceous detrital limestone facies (QTmd) on the northeast side of the swamp (Fig. 12). Both of these limestones are of the Mariana formation. The upper headwaters of the Chaot River flows through an isolated exposure of Alifan limestone (Tal).

Agana argillaceous limestone member is a pale-yellow to yellowish-brown clayey limestone that fringes the volcanic mountainous land to the southwest (Fig. 13). The Agana argillaceous member contains 2 to 6 percent of clay disseminated through the rock although local concentrations occur in pores and cavities where it has been concentrated by percolation of water. The lithology of the limestone is variable. Around the swamp it is mostly detrital limestones in which corals are the dominant fossil present. In places the corals are in position of growth mixed with worn coral rubble and at other locations the corals all seem to be worn and fragmented. Except for the absence of clay contaminants, the detrital facies (QTmd) limestone is similar to that of the Agana member.

Soils

Soils are quite variable in thickness, ranging from base exposed limestone bedrock to a thin veneer less than a foot in thickness on some of the steeper valley slopes and crests of hills and ridges. Deposits up to 20 feet or more in thickness are developed on some of the more gentle sloping hills and valleys or where accumulations have occurred in depressions, cracks, and holes.

Five soil types (Units) have been differentiated by Stensland (1959) on the hilly land around Agana Swamp (Fig. 14).

Saipan-Yona-Chacha-Clay (Unit 4) is developed on the gentle sloped hilly land (Facies A) that borders the southwest side of the Agana Swamp and on the low limestone hummocks and ridges (Facies B) within the swamp and marsh land itself. Yona-Chacha clays (Unit 5) is developed on the steep slopes and ridge tops that border the eastern and southeastern part of Agana Swamp. The more gentle sloped hill and ridge tops of

Unit 5 are capped with Toto clay (Unit 2). The above three soils (Units 2, 4, and 5) are developed upon argillaceous limestone (QTma). Guam clay (Unit 1) is developed on the non-argillaceous limestone (QTmd) land bordering the northeast side of Agana Swamp. A narrow land of Pago clay (Unit 9) is developed on the Chaot River Valley floor from the headwaters of the river to the point where it flows into the south projection of the Agana Swamp at Ngachang District.

Following is a general description of the above five soil units that have been summarized from Stensland (1959).

Guam Clay (Unit 1) - This unit is a Lithosolic Latosol consisting of reddish, granular, friable clay, which thinly mantles the non-argillaceous limestone (QTma) land bordering the northeast side of Agana Swamp. Thickness of the soil is generally less than 12 inches but thicker accumulations may be found in local depressions, holes, or cracks. The pH is slightly acidic in the upper parts but grades to slightly alkaline within an inch or two of the underlying limestone. The soil is well drained and water percolates easily through the soil except during times of heavy rainfall. In most locations the soil contains numerous limestone fragments and on the surface protruding limestone rocks. Much of the soil of this unit has been greatly altered by construction of roads and commercial and residential development along the border of the marsh and swamp land.

Toto Clay (Unit 2) - This unit consists of a deep, pale-olive to pale-yellow, reddish-mottled, firm plastic clay Grumusal on limestone. The soil is subject to unusual shrinkage and expansion; it has large cracks in dry weather and is water-logged in wet weather. The pH reaction is acid near the surface and generally alkaline at depths of more than three or four feet below the surface. Depth of the clay over limestone bedrock ranges from 5 to 30 feet. The overall slope of the unit is gentle but the soil surface is uneven, containing alternate small humps and depressions every few feet. The soil is poorly drained because of water catchment in the micro-basins and swelling or expansion in the soil mass when wet.

Saipan-Yona-Chacha Clays (Unit 4) - This unit is an association of three kinds of soil on rolling to moderately hilly slopes. The soil consists of reddish Saipan clay and yellowish or strong-brown Chacha clay on the more steeply sloping hills and valleys and is interspersed with shallow brownish Yona clay on the narrow convex ridgetops. Depth to limestone bedrock ranges between 1 to 10 feet. On steep slopes the soil forms a thin mantle a foot or less in thickness and is thickest on the more gentle sloping regions and in local depressions. The pH reaction is acidic near the surface, and generally alkaline at deeper depths and where it intergrades into the limestone bedrock. The unit is well drained on the ridgetops and slopes, and moderately drained in the valley and local depressed areas.

Yona-Chacha Clays (Unit 5) - This unit consists of shallow, brownish, granular Yona Clay and yellowish or strong-brown, firm plastic Chacha Clay in the deeply dissected topography of the argillaceous limestone. Chacha Clay is found in some of the ridgetops, on lowermost ridge slopes, and in some ravine and sink bottoms. Yona Clay is found on most of the narrow ridgetops and adjacent steep slopes. It is tentatively classed as a Lithosol. Soil on the steep slopes and ridgetops is 6 to 12 inches deep and in some places the bedrock is exposed on ledges, pinnacles, and along very steep escarpments. The more gentle sloping regions have soil accumulations to 3 feet in thickness. Ridgetops and steep slopes are well drained; the valley floors and local depressions are moderately drained. The pH range is similar to that given for Units 4 and 5.

Pago Clay (Unit 9) - This unit is a deep, moderately well drained, non-calcareous alluvial clay developed in sediments derived chiefly from volcanic rocks, but which are laid down and permeated by water containing solutions from limestone. The soil is varicolored, firm, plastic clay, predominantly reddish or yellowish brown, with grey mottling in the lower part. This soil occupies the valley bottom of the Chaot River. The unit is underlain by limestone, limesand, or detrital sediments of volcanic origin. The pH reaction is generally alkaline. Depth of the soil in the river valley is shallow, except for local depressions, and at places the river flows over exposed bedrock. The soil is moderately well drained but is subject to moderate flooding. The pH reaction is generally neutral to slightly acidic above the water table and alkaline below.

Flora and Fauna

Steep Hill and Valley Slopes (Biotope IIA): This facies fringes the Agana-Chaot River Basin proper and is presently undergoing a construction boom. The vegetation is for the most part disturbed and a varied assortment of plant communities can be found throughout this area. Quantitative vegetation analysis was not carried out here. Only a checklist of plants and animals (see Appendix A and B) was made. A summary of the more conspicuous plants will be discussed here.

Along disturbed areas, e.g., roadsides, various herbs can be found. *Bidens pilosa*, *Stachytarpheta indica*, and an assortment of grasses (e.g., Panicum, Cenchrus, and Chloris) are commonly seen. Annona spp., Triphasia trifolia, Pandanus spp., Morinda citrifolia, Samanea saman, Cocos nucifera, and Heterospathe elata represent the larger trees found on the slopes. Leucaena leucocephala (Fig. 18) is by far the most common plant found throughout the area. Momordica charantia, Passiflora foetida, and Mikania scandens are vines which at times completely masks the trees. The latter species also can be found on Phragmites karka, but only on the periphery of the marsh.

Private lots in this area are usually completely cleared of all of the original vegetation prior to housing construction. After completion of the home, an entirely new flora is planted in the yards. These plants fall into two categories - food and ornamental (Table 2). Within the last couple of years, more ornamental plants are being used in landscaping as opposed to past years when only food plants could be found in the yards.

The fauna in the steep hills and valley slopes is diverse and a preliminary listing can be found in Appendix B. Achatina fulica, the African snail, can be singled out as the most dominant organism in this area.

Hummock (Biotope IIB): These islets rising above the low marsh land are also being singled out by future home owners for housing sites (Fig. 5). Three of these hummocks were analyzed for vegetation trends. The three hummocks chosen were in various state of disturbance - 1. undisturbed, 2. partially disturbed, and 3. disturbed. The quarter method was used to analyze the vegetation (Tables 3 and 4) in hummocks 1 and 2; a line transect was used for hummock 3 because of the lack of trees in this recently cleared area.

Table 2. Checklist of cultivated vascular plants found around homes in Agana Swamp.

Food Plants

Areca cathecu L. "betel-nut"
Averrhoa carambola L. "starfruit"
Bixa orellana L. "achiote"
Carica papaya L. "papaya"
Citrus spp. "lemon, lime, orange"
Cocos nucifera L. "coconut"
Colocasia esculentia (L.) Schott "taro"
Mangifera indica L. "mango"
Musa spp. "banana"
Persea americana Miller "avocado"
Psidium guajava L. "guava"
Saccharum officinarum L. "sugarcane"

Ornamental Plants

Acalypha hispida Burm. "red cat-tail"
Acalypha wilkesiana Mueller "copper-leaf"
Alocasia macrorhiza (L.) Schott "giant taro"
Araucaria excelsa (Lamb.) R. Br. "Norfold pine"
Bougainvillea spectabilis Willdenow "bougainvillea"
Cassia fistula L. "golden shower"
Cassia glauca Lamarck
Casuarina equisetifolia L. "ironwood"
Catharanthus roseus (L.) G. Don "periwinkle"
Ceiba pentandra (L.) Gaertn "kapok"
Codiaeum variegatum (L.) Blume "croton"
Cupressus sp.
Delonix regia (Bojer) Rufinesque "flame tree"
Euphorbia pulcherrima Willd. "poinsettia"
Ficus sp.
Hibiscus spp. "hibiscus"
Livistona chinensis (Jacquin) R. Brown "Chinese fan palm"
Malpighia coccigera L. "singapore-holly"
Plumeria rubra L. "plumeria"
Rhoeo discolor (L'Heritier) Hance
Spathodea campanulata P. de Beauvois "African tulip"
Tectona grandis L. "teak"
Thumbergia erecta (Bentham) T. Anderson "bush thumbergia"
Vanda teres X *V. hookeriana* "Miss Joaquin"

Heterospathe elata (IV=107), Triphasia trifolia (IV=68), and Cocos nucifera (IV=29) were the important plants in hummock 1. H. elata (IV=95) and C. nucifera (IV=77) were also found in hummock 2 but Leucaena leucocephala (IV=65) was also abundant.

Hummock 3 which was cleared recently had very few trees. A clone of Bambusa vulgaris, a few large Heterospathe elata on the lower slopes, and individuals of Artocarpus incisus, Annona squamosa and Hibiscus tiliaceus were the only trees present. The most dominant plants on the plateau were young Carica papaya ($\overline{x}$ height=1.3 m, N=20) and low bushes of Leucaena leucocephala ($\overline{x}$ height=1.3 m, N=13). Two line transects showed the following percent cover of the dominant plants.

Leucaena leucocephala	53%
Carica papaya	24%
Passiflora foetida	22%
Heterospathe elata	1%

The average distance between the trees in hummock 1 and 2 were 1.5 m and 1.8 m, respectively. Numerous seedlings of Heterospathe elata and Leucaena leucocephala were present on both hummocks. Cocos nucifera seedlings was also present in hummock 1, while Morinda citrifolia and Melanolepis multiglandulosa seedlings were present in hummock 2. The vine Passiflora foetida was quite common on both hummocks.

If one compares the relative dominance of certain plants found on the three hummocks, a succession trend appears. Heterospathe elata (Fig. 19) is more dominant on undisturbed hummock - undisturbed (42%), partially disturbed (30%) and disturbed (1%). On the other hand, Leucaena leucocephala is much more dominant on the disturbed hummock - undisturbed (2%), partially disturbed (13%) and disturbed (53%).

Table 3. Relative frequency, relative density, relative dominance, and importance value of vascular plants found in an undisturbed hummock. December 5, 1973.

Species	No. Pts. of Occur. (N=18)	No. of Trees	Total Circum. (cm)	RF	RD	RDo	IV
1. *Heterospathe elata*	14	26	1066	29	36	42	107
2. *Triphasia trifolia*	13	22	240	28	31	9	68
3. *Cocos nucifera*	3	4	418	6	6	17	29
4. *Annona reticulata*	4	5	207	8	7	8	23
5. *Hibiscus tiliaceus*	4	5	205	8	7	8	23
6. *Cananga odorata*	2	3	151	5	4	6	15
7. *Annona squamosa*	2	2	44	5	3	2	10
8. *Leucaena leucocephala*	2	2	48	5	3	2	10
9. *Artocarpus incisus*	1	1	97	2	1	4	7
10. Unidentified sp.	1	1	18	2	1	1	4
11. *Melanolepis multiglandulosa*	1	1	13	2	1	1	4
TOTAL	47	72	2507	100	100	100	300

Table 4. Relative frequency, relative density, relative dominance, and importance value of vascular plants found in a partially disturbed hummock. October 1973.

Species	No. Pts. of Occur. (N=12)	No. of Trees	Total Circum. (cm)	RF	RD	RDo	IV
1. *Heterospathe elata*	9	17	604	29	36	30	95
2. *Cocos nucifera*	6	9	770	19	19	39	77
3. *Leucaena leucocephala*	8	13	247	25	27	13	65
4. *Morinda citrifolia*	2	2	32	6	4	2	12
5. *Annona squamosa*	1	1	90	3	2	5	10
6. *Intsia bijuga*	1	1	53	3	2	3	8
7. *Hibiscus tiliaceus*	1	1	51	3	2	3	8
8. *Samanea saman*	1	1	43	3	2	2	7
9. *Triphasia trifolia*	1	1	10	3	2	1	6
10. *Melanolepis multiglandulosa*	1	1	25	3	2	1	6
11. *Bambusa vulgaris*	1	1	11	3	2	1	6
TOTAL	32	48	1946	100	100	100	300

Biotope III - Agana River Estuary

Physiography

The estuary of the Agana River is located on the east side of the Paseo de Susana Park (Figs. 2 & 20). It is quite small in extent and its channel has been altered greatly by the construction and development in the City of Agana. Salinity measurements taken at the mouth of the river indicate that ocean water mixing (estuarine conditions) extends upstream approximately 800 feet during high tides and 600 feet during low tides. The mouth of the river originally discharged onto the Agana reef flat platform and was connected to the sea by a deep fringing reef flat channel. The inner part of the channel has been filled in by the land fill at the Paseo de Susana and the outer part is now used as an access channel to the Agana Boat Basin.

The salinity ranges from a high of 22.2°/₀₀ at the river mouth (Sta. 1 & 2) and gradually decreases upstream to 0.5°/₀₀ at Sta. 9 (see Fig. 3).

The width of the Agana River ranges from 35 feet during high tide to 27 feet during low tide at the mouth, and from 36 to 28 feet between the estuary and the bridge on East Saylor Street, at which point the river becomes overgrown with vegetation (Fig. 9). Depth nowhere exceeds 3 feet, but may be higher during the wet season when there is a greater rate of discharge.

Midstream current velocity in the river mouth (Sta. 1) taken during low tide on December 8, 1972, was 0.11 feet per second (Jones & Randall, 1972). No perceptible current flow could be detected during high tides at Sta. 1 on three occasions from December 14 through December 17, 1972.

The river bottom substrate consists of a thin layer of soft black mud and silt over limestone detrital material. Examination of the sediments revealed a reducing environment where at some stations bubbles were observed escaping from the soft sediments. The river banks consists of detrital limestone material, similar to that found on the river floor, mixed with limesand similar in composition to Shioja soil described below. Elevation of the river banks ranged from 2 to 8 feet in height.

Geology and Soils

The estuary is located on a coastal terrace that forms the northwest border of the swamp and marsh land. Originally, the terrace (Fig. 13) consisted of unconsolidated beach deposits (Qrb) but has been since greatly disturbed and altered by the development of the City of Agana and East Agana.

Originally, the soil of the beach terrace consisted of a light-colored limesand intermixed with some darker organic material (Shioja Soil Unit 12) but has since been greatly altered.

Flora and Fauna

The intertidal zone on the banks of the estuary is dominated by a lush growth of grass which we have been unable to identify. Only a few euryhaline benthic algae (Table 5) were collected in the area. <u>Enteromorpha</u> compressa, a green alga, is by far the most dominant species in

Table 5. Relative abundance, relative frequency, relative dominance, and importance value of benthic algae found in Agana River estuary.

Species	RA	RF	RD	IV
A. MOUTH OF AGANA RIVER[1]				
Enteromorpha compressa	39	40	60	139
Centroceras clavulatum	43	40	25	108
Boodlea composita	16	14	13	43
Feldmannia indica	1	4	<1	<6
Padina tenuis	<1	2	<1	<4
B. JUST SEAWARD OF BRIDGE[2]				
Enteromorpha compressa	100	100	100	300

1 Algal Cover (75%), Silt and Cobbles (25%).

2 Algal Cover (63%), Silt and Cobbles and Sand (37%).

the estuary as analyzed by the point method. Centroceras clavulatum, a red alga, is also abundant but restricted towards the mouth of the estuary.

Schools of juvenile mullet (Mugil sp.) are frequently seen in this area. Although Tilapia mosambica was observed under the bridge, this species is much more numerous upstream. A checklist of other fishes can be seen in Appendix B.

The dominant invertebrates in the estuary were the crustaceans and mollusks. See Appendix B.

HISTORICAL AND CULTURAL IMPORTANT SITES

There are two sites which are considered important, historically and culturally, in the Agana-Chaot River Basin. The historical site is the little known Spanish Dike which is reported on by Emilie Johnston in this section. On the other hand, the culturally as well as educational site, is the Agana Spring Nature Preserve.

Spanish Dikes

by

Emilie G. Johnston

One of the least known relics of the Spanish regime on the island of Guam is a series of dikes in the heavy growth of the Agana Swamp. The large fertile swamp area, called the CIENEGA, challenged several Spanish governors who felt that the area held great potential for growing rice. The expenditure of large amounts of time, money and effort never produced the desired results. Later American governors met with very little more success.

Governor Villalobos (1831-1837) ordered the Agana River to be diverted to run parallel to the sea through the City of Agana. Water from the stream was used for washing and bathing but was too brackish for drinking. Villalobos' report refers to a rough stone dike with a wooden bridge in the center for easy crossing.

Governor Felipe de la Corte (1855-1866) was greatly concerned with the health of people living in Agana. He blamed winds from the swamp for bringing colds and other ailments to the city. He recommended that the swamp be drained and planted with coconuts, bamboo and other trees to purify that fever-breeding spot.

According to notes made by William E. Safford from records in the archives of Agana, Governor Manuel Brabo y Barrera (1875-1880) was responsible for ditching the swamp and setting prisoners to work planting rice. The project was not successful for the swamp did not drain properly.

By the time of Governor Olive y Garcia (1884-1885) the dikes had been preserved in fairly good condition, but were heavily overgrown and hidden by vegetation. Olive's report refers to the dikes as made of mamposteria by the Presidio (at that time almost synonymous with Public Works). Any parts of the dikes which had been made of wood, such as the flood gates, had long rotted away. The project for draining the swamp to grow rice had been abandoned. Olive suggested that the Cienega return to its former status of communal property for growing taro and corn, or for pasture.

Governor Leary, the first American governor (1899-1900) was greatly disturbed by the unhealthy conditions he found in the City of Agana. He, and other governors who followed him, enforced strict sanitation rules to improve living conditions. Drainage of the swamp was considered many times over the years.

Finally in March 1933 Governor Edmund S. Root took definite action. He appointed a board to investigate the feasibility of draining the swamp and converting it into arable land. The committee gave a favorable report and work began in June 1933. A channel twenty feet wide and three feet deep was cut into the cane growth to the Agana Springs Reservoir.

When the project was completed in February the following year, the water level had dropped so that some of the land was suitable for planting corn. Months later it was reported that the work had by no means solved the problem completely, for constant maintenance and further work should be done. The Spanish dikes apparently were not encountered for the report does not mention them.

The heavy bombardment which caused the destruction of Agana during World War II resulted in the Agana River returning to nearer its former short outlet to the sea. The Spanish dikes appear undisturbed by this action.

More recent attempts to open the area have also been abandoned. In the late nineteen sixties the El Centro 4-H Club of Didigue, Sinajana, cleared around the dikes to preserve fresh water fish for sport fishing. Constant maintenance is still needed because the swamp vegetation grows so rapidly.

The site of these Spanish dikes is often listed among areas of historical value for the island. It has very low priority, at present, for further development. Today the dikes can be located by only the most determined hikers who wield sharp machetes and follow knowledgable guides.

Agana Springs Nature Preserve*

Agana Springs is located about one mile up the Agana River valley along the steep southern margin of the swamp where a small impounded

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*Extracted from Guam Science Teachers Association (1970).

pond is found. The source of the spring water is probably from the compact jointed Alifan limestone which underlies the Agana argillaceous member of the Mariana Limestone. The total area of the springs and immediate swamp is 24.91 acres.

Prior to World War II, the American Navy began tapping Agana Springs for drinking water and eventually built a small reservoir and pumping facility. The water was chlorinated and introduced into the island-wide water system. Twenty percent of the island's water originated from Agana Springs during the period of 1948 to 1952.

In May of 1957, Agana Springs was abandoned by the Navy as a source of drinking water due to pollution in the form of the common intestinal bacteria E. coli. The water became polluted as a result of the population growth in Sinajana village (located above the springs), and the subsequent lack of sanitary facilities there.

From 1957 until 1969, Agana Springs was completely neglected. The area surrounding the springs was used as a dump for abandoned vehicles, and for trash of every description. A thick cover of vegetation completely covered the standing water within the reservoir. During peak years, the water from the springs spilled into the vast marsh region known as Agana Swamp at a rate of two million gallons daily. The flow of water was greatly restricted by the encroachment of vegetation.

In 1967, the Guam Science Teachers Association began exploring the feasibility of renovating Agana Springs and using the area as a nature preserve (portions of Agana Swamp, which borders the springs, is Government of Guam property and designated by Executive Order as a conservation preserve). The first license for this purpose was issued by the Navy in April , 1969. A renewal of the license was granted subsequently in February, 1970 and February, 1971. The fourth license issued by the Navy in February, 1972 was for five years.

The Agana Springs Nature Preserve is presently being cared for by the Guam Science Teachers Association and is the major fresh-water field site on Guam. Hundreds of students from the elementary level to the college level have observed and studied the diversity of plants and animals found here.

Recently, reports have been made of people using the Spring as a swimming area. This prompted the Guam Environmental Protection Agency to add this area in their routine monitoring sites. According to Dr. Oscar Levand, two coliform samples have thus far been taken. The first sample taken on June 11, 1974 revealed a very high coliform count; the second sample obtained on June 25, 1974 showed the Spring to be in an unpolluted state (40 viable _E. coil_ per 100 ml of water). Future samplings will provide some indication on the probable cause of the high counts recorded the first time.

SENSITIVITY OF ENVIRONMENT
TO ACTIVITIES OF MAN

Marsh and swamp land are regions where the water table is close to or permanently at the surface. To maintain this type of habitat at Agana Swamp, the most critical factor, then, is to maintain the water table at its present level or within its annual range of fluctuation.

Dredging and land-filling are two activities which would most influence the water table. Dredging or channelization of the Agana River would most certainly lower the general water table as a whole, reduce the area of surface water coverage, and reduce the total area of swamp and marsh land. A lowering of the water table would cause the peripheral areas of the swamp to undergo a successional trend from a wet land community to a community presently bordering the swamp.

Land-filling reduces the total area of the wet land. It could also change water table levels and the present drainage pattern in the swamp depending upon the location and extent of the fill. Land-filling across narrow necks of swamp land could act as a dam and cause flooding or "dead water" areas in certain parts of the swamp. This is particularly true in the fingers of the swamp and marsh land at the southeast end of Agana Swamp. A good example of where drainage patterns have been altered is found where a roadway bisects the northwest end of the swamp along a "power-pole" right-of-way. During periods of heavy rainfall, an observable difference in water table height was noticed between the two sides of the roadway.

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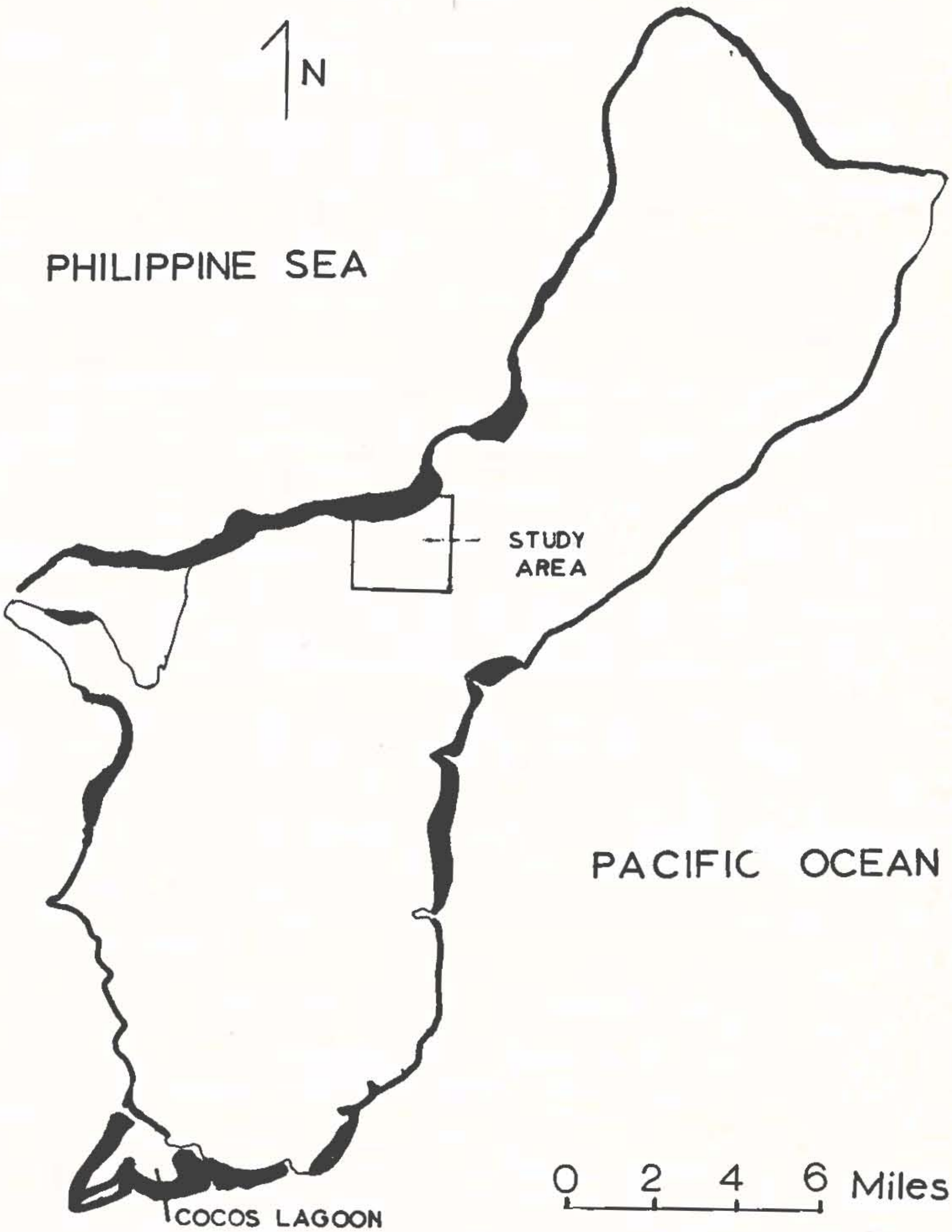


Figure 1. Map of Guam showing study site location.

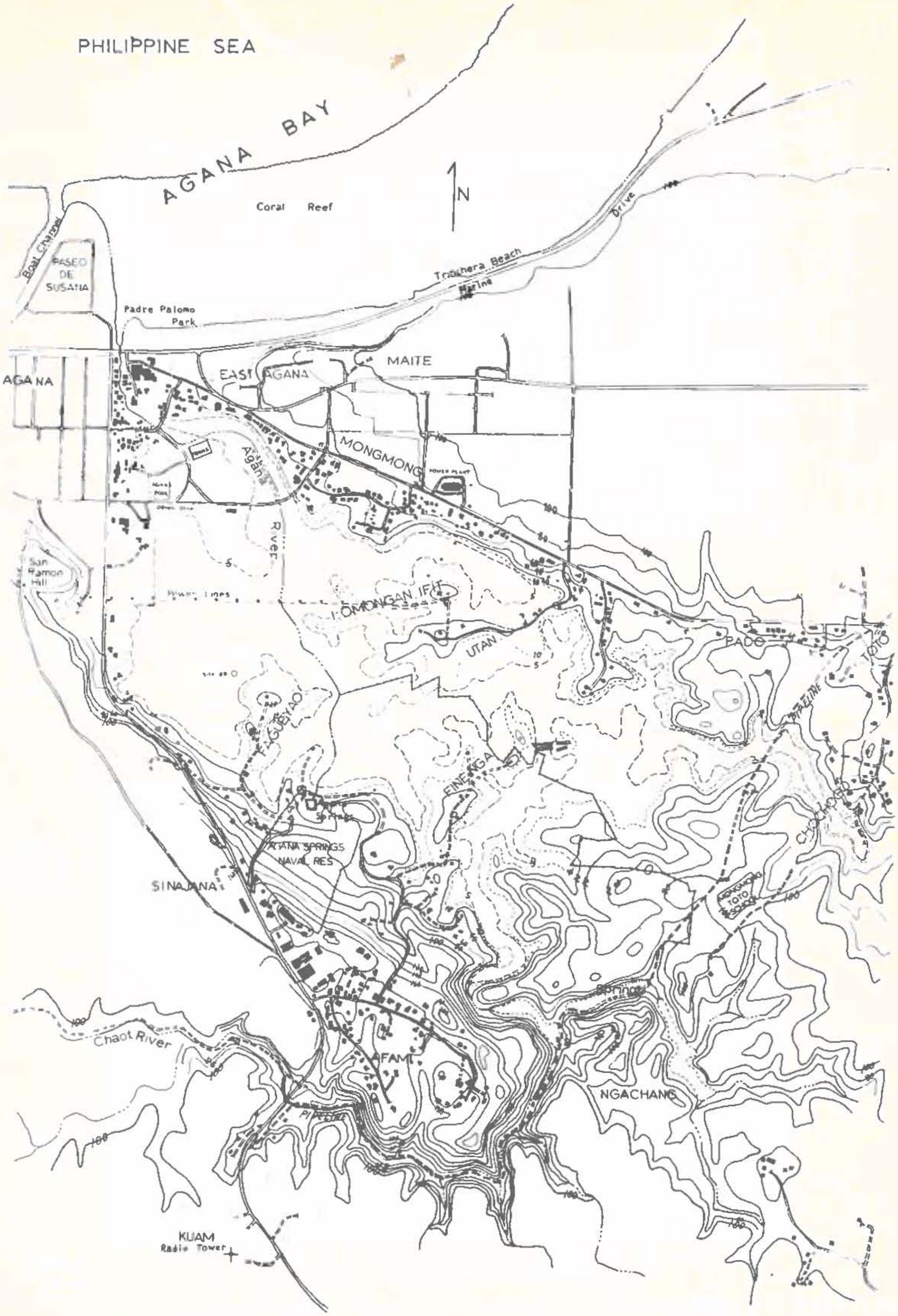


Figure 2. Map of study area.

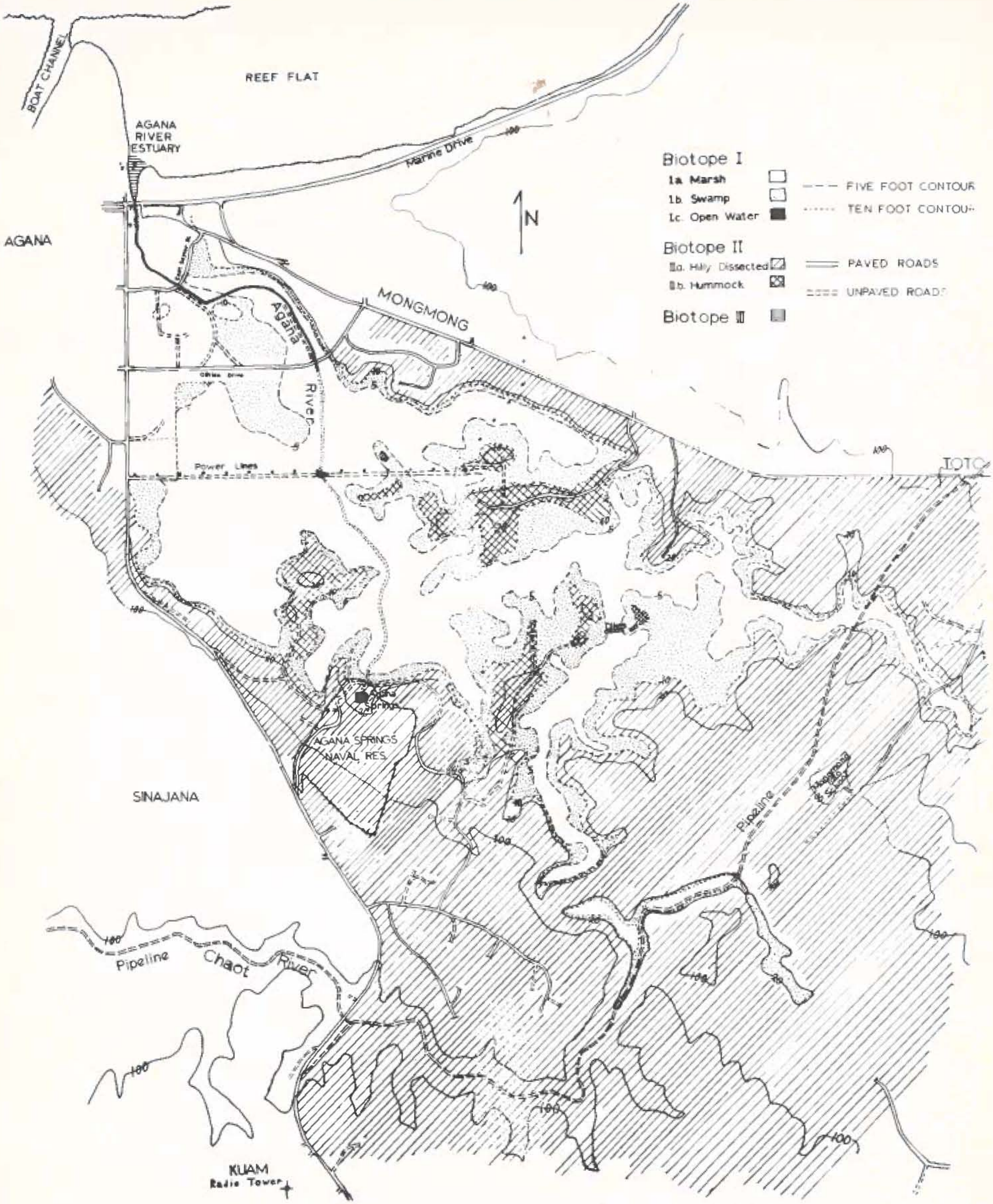


Figure 3. Map showing locations of Biotopes and associated Facies.

Figure 4. Northwest end of Agana Swamp. The villages of Sinajana and Mongmong are visible in the foreground and background, respectively. A nearly pure stand of Phragmites karka dominates the marsh land at this end of the swamp.

Figure 5. Limestone ridges and hummocks at Lomongan Ifit District.

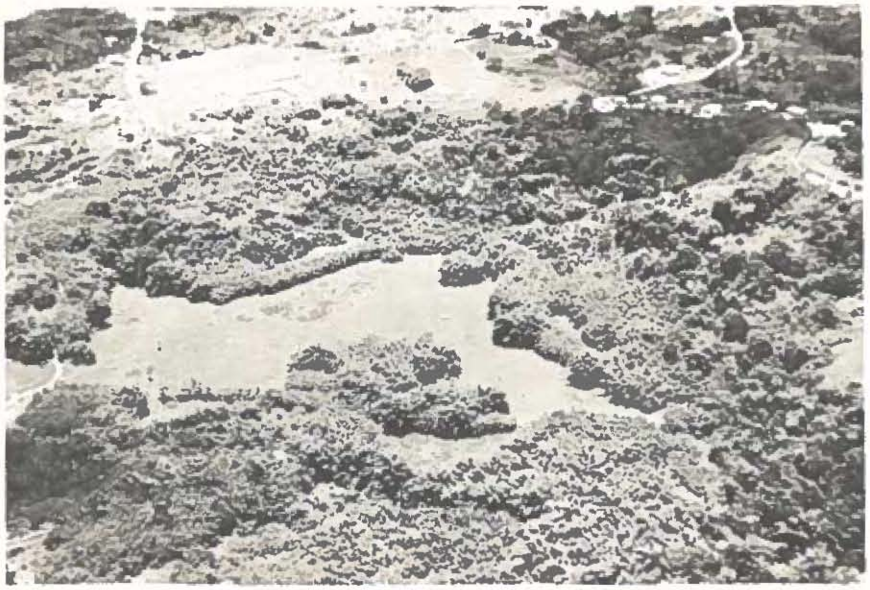


Figure 6. Narrow finger of swamp and marsh land near Chochogo District.

Figure 7. Agana River at O'Brien Drive bridge.

Figure 8. A channelized part of the Agana River located between East Taylor Street and O'Brien Street bridges.

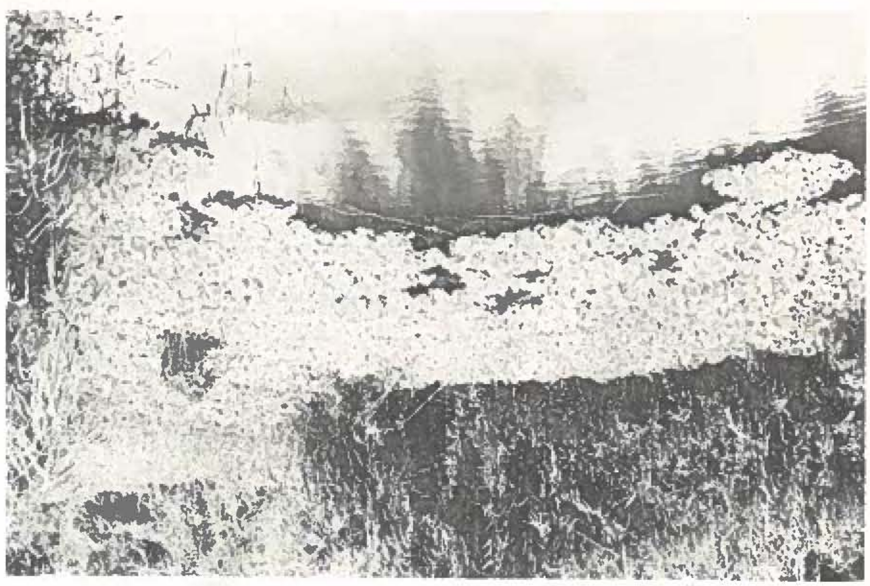


Figure 9. Agana River south of O'Brien Drive bridge disappears into a dense growth of floating *Pistia stratiotes* and *Phragmites karka* reeds.

Figure 10. Aerial view of the northwest end of Agana Swamp. Point X marks the probable course of the vegetation choked Agana River.

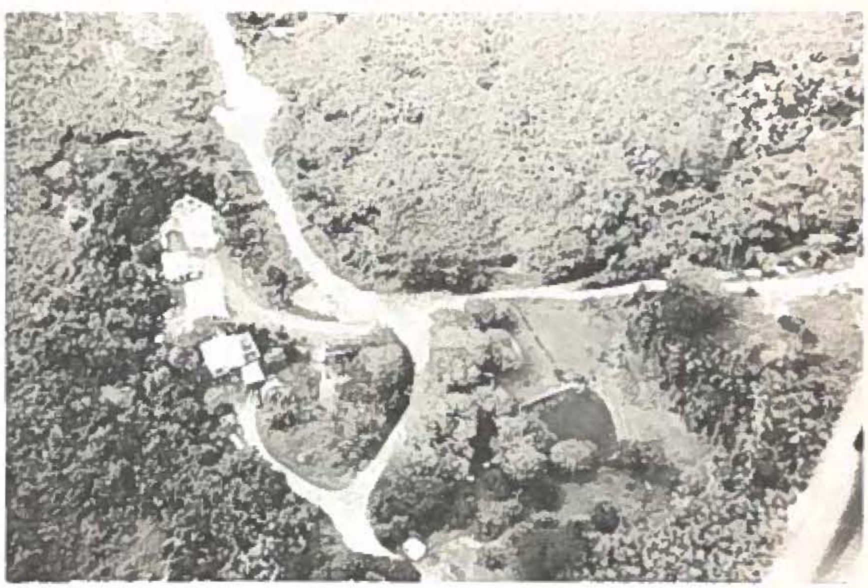
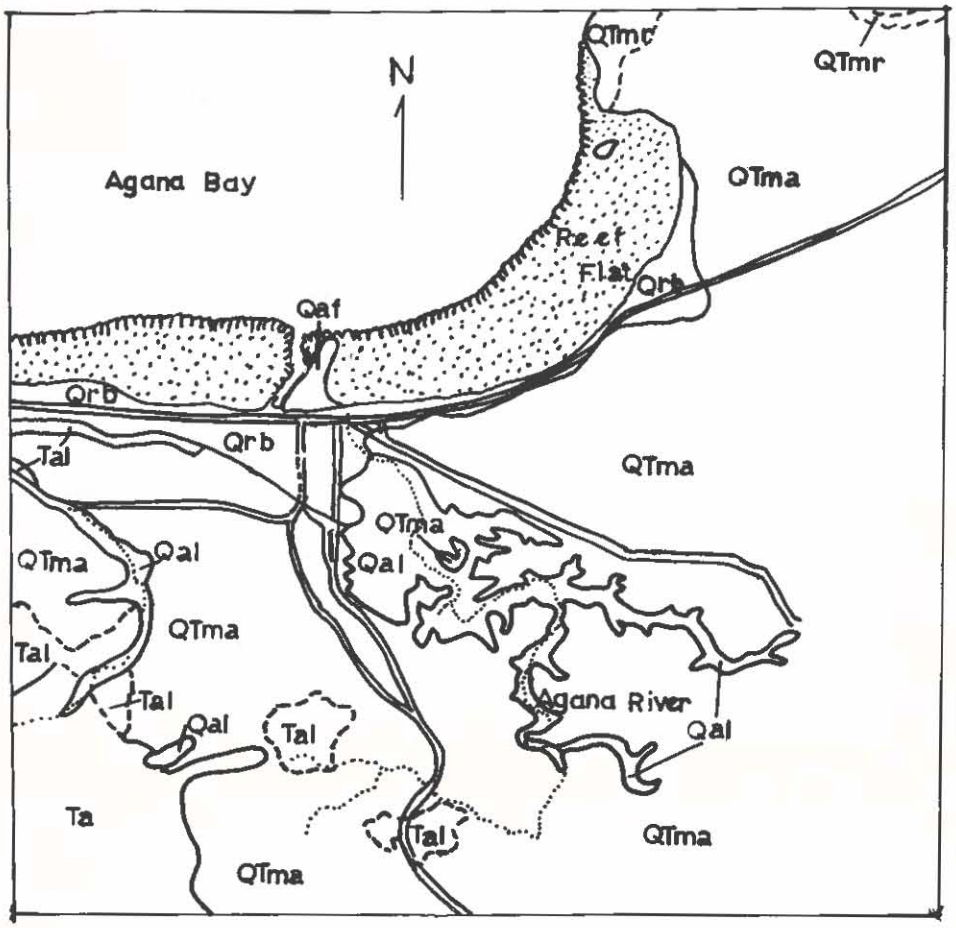


Figure 11. Aerial view of Agana Springs.

Figure 12. Agana Springs and "planted" zone north of the spillway.



LEGEND FOR GEOLOGIC MAP

Qaf - Artificial fill
Qrb - Beach deposits
Qal - Alluvium

Mariana limestone:
Qtmr - Reef facies
Qtma - Agana argillaceous member

Tal - Alifan limestone

Alutom formation:
Ta - Alutom formation
- Reef margins and reef flats

Figure 13. Geologic map of Agana-Chaot River Basin. Figure modified from Tracey et al. (1964).

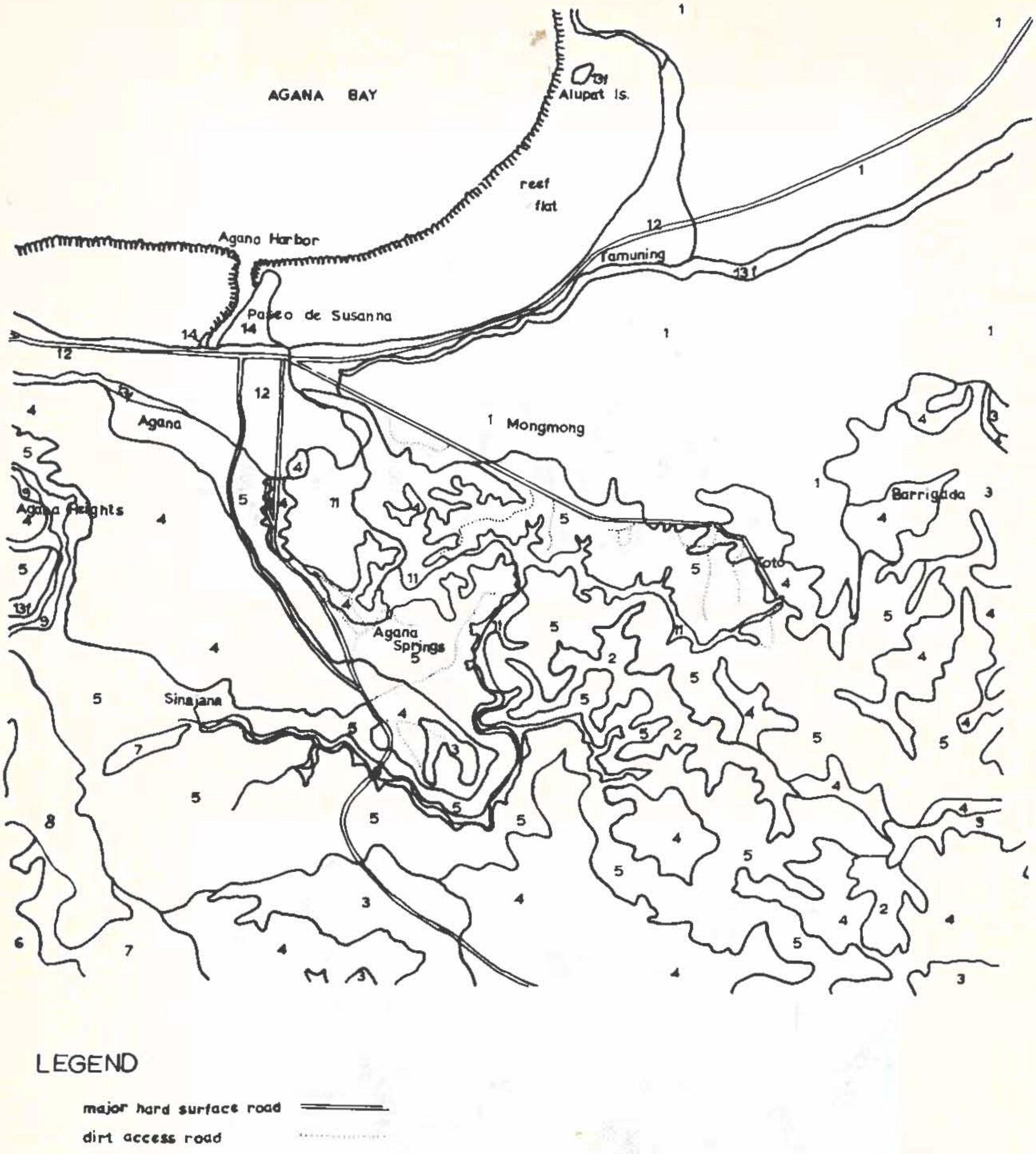


Figure 14. Soil map for Agana-Choat River Basin. (From Stensland *in* Tracey *et al*., 1959:pl. 15, sheet 5). 1. Guam Clay, 2. Toto Clay, 3. Chacha-Saipan Clay , 4. Saipan-Yona-Chacha Clays, 5. Yona-Chacha Clay , 6. Atate-Agat Clay, Hilly, 7. Agat-Asan-Atate Clay, Hilly, 8. Agat-Asan Clay and Rock Outcrop, Very Hilly to Steep, 9. Pago Clay, 11. Muck, 12. Shioya Soil, 13f. Limestone Rock Land, Steep, 14. Made Land.

Figure 15. Tall reed, Phragmites karka, about 12-15 feet high, dominates most of the marsh land (Biotope IA).

Figure 16. Giant swamp fern, Acrostichum aureum, is found associated with Phragmites karka reed in the marsh land of Biotope IA.

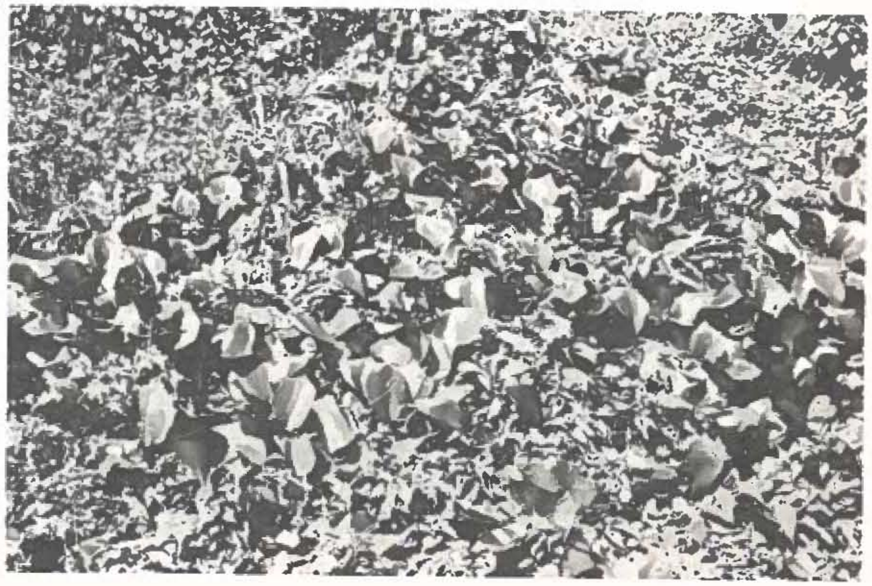


Figure 17. Floating aquatic vegetation, Eichhornia crassipes, is common in the open water areas of Biotope IC.

Figure 18. Vegetation of disturbed area (Biotope IIA), showing various grasses and Leucaena leucocephala shrubs.

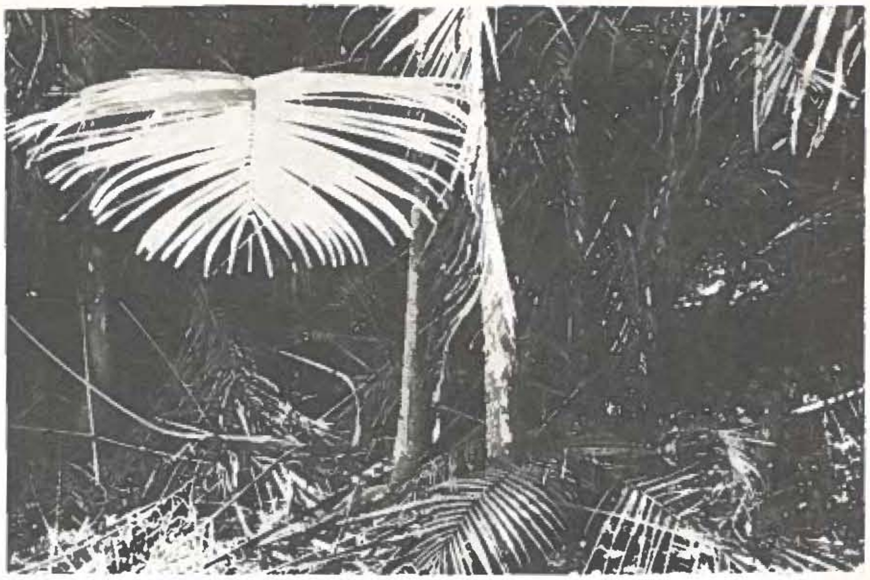


Figure 19. Heterospathe elata in undisturbed hummock.

Figure 20. Estuary of the Agana River.

APPENDIX A

FLORA OF THE AGANA-CHAOT RIVER BASIN

Species	Life Form[1]	Status[2]	BIOTOPES WET LAND A	WET LAND B	WET LAND C	DISSECTED HILLY LAND A	DISSECTED HILLY LAND B	RIVER ESTUARY
DIVISION CYANOPHYTA								
Nostocaceae								
Anabaena sp.		N			X			
Oscillatoriaceae								
Schizothrix calcicola (Ag.) Gomont		N			X			X
Microcoleus lyngbyaceus (Kutz) Crouan		N						X
DIVISION CHLOROPHYTA								
Boodleaceae								
Boodlea composita (Harv.) Brand		N						X
Codiaceae								
Avrainvillea obscura J. Ag.		N						X
Dasycladaceae								
Neomeris annulata Dickie		N						X
Desmidiaceae		N			X			
Microsporaceae								
Microspora sp.		N			X			
Oedogoniaceae								
Oedogonium sp.		N			X			
Ulvaceae								
Enteromorpha compressa (L.) Grev.		N						X

Species	Life Form	Status	BIOTOPES WET LAND A	B	C	DISSECTED HILLY LAND A	B	RIVER ESTUARY
DIVISION PHAEOPHYTA								
Dictyotaceae								
Padina tenuis Bory		N						X
Ectocarpaceae								
Feldmannia indica (Sonder) Womersley & Bailey		N						X
DIVISION RHODOPHYTA								
Ceramiaceae								
Centroceras clavulatum (C. Ag.) Montagne		N						X
DIVISION PTERIDOPHYTA								
Aspidiaceae								
Heterogonium pinnatum (Copel.) Holttum	H	N		X		X	X	
Davalliaceae								
Davallia solida (Forster fil.) Swartz	E	N				X	X	
Nephrolepis hirsutula (Forster)								
Hymenophyllaceae								
Cephalomanes boryana (Kunze)van den Bosch				X				
Parkeriaceae								
Ceratopteris thalictroides (L.) Brongniart					X			
Polypodiaceae								
Pyrrosia adhascens (Swartz) Ching	E	N				X	X	
Pteridaceae								
Acrostichum aureum L.	H	N		X				

Species	Life Form	Status	BIOTOPES WET LAND A	B	C	DISSECTED HILLY LAND A	B	RIVER ESTUARY
DIVISION ANTHOPHYTA Dicotyledon								
Acanthaceae								
<u>Beloperone</u> <u>guttatus</u> Brandegee	S	I				X		
Annonaceae								
<u>Annona</u> <u>muricata</u> L. "laguana"	T	I				X		
<u>Annona</u> <u>reticulata</u> L. "annonas"	T	I^N				X	X	
<u>Annona</u> <u>squamosa</u> L. "atis"	T	I^N				X	X	
<u>Cananga</u> <u>odorata</u> (Lam.) Hook. "ilang-ilang"	T	I^N				X	X	
Cariacaceae								
<u>Carica</u> <u>papaya</u> L. "papaya"	T	I^N				X	X	
Compositae								
<u>Bidens</u> <u>pilosa</u> L.	H	I^N				X	X	
<u>Mikania</u> <u>scandens</u> (L.) Willd.	V	I^N	X	X				
Cucurbiaceae								
<u>Momordica</u> <u>charantia</u> L. "almogosa"	V	I^N				X	X	
Euphorbiaceae								
<u>Melanolepis</u> <u>multiglandulosa</u> (Reinwardt) Reichb. "alom"	T	N				X	X	
Labiatae								
<u>Hyptis</u> sp.	H	I		X				
<u>Mentha</u> <u>arvensis</u> L. "yerba buena"	H	I				X	X	

Species	Life Form	Status	WET LAND A	WET LAND B	WET LAND C	DISSECTED HILLY LAND A	DISSECTED HILLY LAND B	RIVER ESTUARY
Leguminosae								
Abrus precatorius L. "kolales halomtano"	V	I^N				X	X	
Adenanthera pavonina L.	T	I				X		
Cassia alata L. "take-biha"	T	I^N				X		
Desmanthus virgatus (L.) Willd.	S	I^N				X	X	
Dolichos lablab L. "cheribilla apaka"	V	I				X	X	
Intsia bijuga (Colebr.) O. Kuntze "ifil"	T	N				X	X	
Leucaena leucocephala (Lam.) DeWit	T	I^N				X	X	
Mogonia strobilifera (L.) R. Br.	S	I^N				X	X	
Mucuna gigantea (Willd.) DC.	V	N				X		
Peltophorum pterocarpum (DC.) Backer	T	I^N				X	X	
Pithecellobium dulce (Roxb.) Bentham "kamachile"	T	I				X		
Samanea saman (Jacquin) Merrill "monkeypod"	T	I^N				X	X	
Malpighiaceae								
Malpighia coccigera L.	S	I				X		
Malvaceae								
Abelmoschus moschatus (L.) Medicus	H	I		X				
Hibiscus tiliaceus L. "pago"	T	N		X		X	X	
Malvastrum coromandelianum (L.) Garcke	S	I^N				X	X	
Moraceae								
Artocarpus incisus (Thunb.) L.f. "lemae"	T	I				X	X	
Myrtaceae								
Psidium guajava L. "abus"	T	I				X		
Oxalidaceae								
Averrhoa bilimbi L. "bilimbi"	T	I				X		
Passifloriaceae								
Passiflora foetida L.	V	I^N				X	X	
Piperaceae								
Piper guahamense DC. "pupulu-n-aniti"	S	N				X	X	

Species	Life Form	Status	BIOTOPES WET LAND A	B	C	DISSECTED HILLY LAND A	B	RIVER ESTUARY
Polygonaceae								
Antigonon leptopus Hooker & Arnott	V	I				X		
Rubiaceae								
Morinda citrifolia L. "lada"	T	N				X	X	
Rutaceae								
Triphasia trifolia (Burm. f.) P. Wils. "lemon-china"	T	I^{N}				X	X	
Solanaceae								
Cestrum diurnum L. "tinta'n-china"	S	I^{N}				X	X	
Tiliaceae								
Muntingia calabura L. "manzanilla"	T	I^{N}		X		X		
Verbenaceae								
Lantana camara L. "lantana"	S	I				X	X	
Stachytarpheta indica (L.) Vahl	H	I^{N}				X	X	
Vitex parviflora Jussieu	T	I^{N}				X	X	
Monocotyledon								
Araceae								
Alocasia macrorhiza (L.) Schott "papao-atolong"	H	I		X		X	X	
Colocasia esculentia (L.) Schott "suni"	H	I		X		X	X	
Pistia stratiotes L.	H	I			X			
Ceratophyliacea								
Ceratophyllum demersum L.	H	N			X			
Cyperaceae								
Cyperus spp. (various species)	H			X		X		X
Gramineae								
Bambusa blumeana Schultes "piao lahe"	T	I				X	X	

Species	Life Form	Status	BIOTOPES WET LAND A	B	C	DISSECTED HILLY LAND A	B	RIVER ESTUARY
Bambusa vulgaris Schroder "piao paluoan"	T	I				X	X	
Cenchrus echinatus L.	H	I^N				X	X	
Digitaria sp.	H	I^N				X	X	
Eragrostis pilosa (L.) Beauvois	H	I^N		X				
Panicum maximum Jacquin	H	I^N				X	X	
Paspalum sp.	H	I^N				X	X	
Phragmites karka (Retz.) Trin.	H	N		X	X			
Saccharum spontaneum L.	H	I^N			X			
Setaria pallide-fusca (Schumacher) Stapf & C. E. Hubbard	H	I^N				X	X	
Hydrocharitaceae								
Hydrilla verticillata (L.f.) Royle	H	N			X			
Orchidaceae								
Spathoglottis plicata Blume	H	T				X		
Taeniophyllum mariannense Schlechter	E	N				X	X	
Palmae								
Cocos nucifera L.	T	I^N		X		X	X	
Heterospathe elata Scheffer	T	N				X	X	
Pandanaceae								
Pandanus fragrans Gaud. "kafu"	T	N				X	X	
Pontederiaceae								
Eichhornia crassipes (Mart. & Zucc.)	H	I	X		X			

1 Life Form - herb (H), vine (V), epiphyte (E), shrub (S), tree (T).

2 Status - endemic (E), native (N), introduced (I), introduced and naturalized (I^N).

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APPENDIX B

FAUNA OF THE AGANA-CHAOT RIVER BASIN

Species	BIOTOPES I Wet Land	 II Dissected Hilly Land	 III River Estuary
PHYLUM PROTOZOA			
Vorticellidae			
Vorticella sp.	X		
PHYLUM ARTHROPODA Class Crustacea			
Atyidae			
Caridinides wilkinsi Calman			X
Grapsidae			
Sesarma sp.			X
?Varuna laterate (Fabr.)			X
Paguridae			
Clibanarius sp. 1 "hermit crabs"			X
Clibanarius sp. 2 "hermit crabs"			X
Palaemonidae			
Macrobrachium lar (Fabricius)	X		
Palaemon sp.			X
Portunidae			
Lupocyclus sexspinosus Leene			X
PHYLUM MOLLUSCA Class Gastropoda			
Achatinidae			
Achatina fulica Bowdich		X	
Cerithiidae			
Cerithium nodulosus (Bruguiere)			X

Species	BIOTOPES I Wet Land	 II Dissected Hilly Land	 III River Estuary
Cypraeidae			
Cypraea moneta (Schilder)			X
Muricidae			
Morula granulata (Duclos)			X
Neritidae			
Nerita plicata L.			X
Quoyia decollata (Quoy & Gaimard)			X
Septaria porcellana (Linnaeus)	X		
Strombidae			
Strombus mutabilis (Swainson)			X
Class Pelecypoda			
Cardiidae			
Fulvia sp.			X
Veneridae			
PHYLUM ECHINODERMATA Class Echinoidea			
Toxopneustidae			
Tripneustes gratilla (Linnaeus)			X
Class Holothuroidea			
Holothuriidae			
Bohadschia marmorata (Jaeger)			X

Species	BIOTOPES I Wet Land	 II Dissected Hilly Land	 III River Estuary
PHYLUM CHORDATA			
Class Osteichthyes			
Anguillidae			
Anguilla bicolor McClelland	X		
Anguilla marmorata Quoy & Gaimard	X		
Apogonidae			
Apogon sp. 1			X
Apogon sp. 2			X
Balistidae			
Rhinecanthus aculeatus Linnaeus			X
Chaetodontidae			
Chaetodon lunula (Lacepede)			
Cichlidae			
Tilapia mosambica (Peters)	X		X
Tilapia zilli (Geruais)	X		
Clariidae			
Clarias batrachus (Linnaeus)	X		
Cyprinidae			
Cyprinus carpio Linnaeus	X		
Eleotridae			
Eleotris fuscus (Schneider)	X		
Gobiidae			
Chonophorus guamensis (Valenciennes)	X		
Periophthalmus koelreuteri (Pallas)			X
Stiphodon elegans (Steindachner)	X		
Labridae			X
Mugilidae			
Mugil sp.			X

Species	BIOTOPES I Wet Land	II Dissected Hilly Land	III River Estuary
Mullidae			
Mulloidichthys samoensis (Gunther)			X
Parupeneus barberinus (Lacepede)			X
Muraenidae			
Uropterygius micropterus (Bleeker)			X
Poeciliidae			
Gambusia affinis (Baird & Girard)	X		
Poecilia reticulatus (Peters)	X		
Pomacentridae			
Abudefduf sp.			X
Scorpaenidae			X
Synodontidae			
Saurida gracilis (Quoy & Gaimard)			X
Tetradontidae			
Arothron hispidus (Lacepede)			X
Arothron meleagris Bloch & Schneider			X
Class Amphibia			
Bufonidae			
Bufo marinus (Linnaeus)	X	X	
Class Reptilia			
Colubridae			
Boiga irregularis Merrem		X	

Species	BIOTOPES I Wet Land	 II Dissected Hilly Land	 III River Estuary
Iguanidae			
Anolis carolinensis Voigt		X	
Scincidae			
Emoia callisticta werneri (Voigt)		X	
Typhlopidae			
Typhlops braminus (Daudin)		X	
Testudinidae			
Pseudemys scripta (Schoepff)	X		
Varanidae			
Varanus indicus (Daudin)		X	
Class Aves			
Ardeidae			
Ixobrychus sinensis (Gmelin) "Chinese least bittern"	X	X	
Alcedinidae			
Halycyon cinnamomina cinnamomina Swainson "Micronesian kingfisher"		X	
Columbidae			
Gallicolomba xanthonura xanthonura (Temminck) "white-throated ground dove"		X	
Streptopelia bitorquata dusumieri (Temminck) "Philippine turtle dove"		X	
Dicruridae			
Dicrurus macrocercus harterti S. Baker "black drongo"	X	X	
Laridae			
Gygis alba candida (Gmelin) "fairy tern"		X	

Species	BIOTOPES I Wet Land	II Dissected Hilly Land	III River Estuary
Muscicapidae			
Rhipidura rufifrons uraniae Oustalet "rufous-fronted fantail"		X	
Ploceidae			
Munia atriaeupilla "rice bird"	X	X	
Passer montanus "European tree sparrow"	X	X	
Rallidae			
Gallinula chloropus guami Hartert "gallinule"	X	X	
**Poliolimnas cinereus micronesiae* Hachisuka "white-browed rail"		X	
Rallus owstoni (Rothschild) "Guam rail"		X	
Scolopacidae			
Erolia acuminata (Horsfield) "sharp-tailed sandpiper"		X	
Gallinago megala Swinhoe "marsh snipe"	X	X	
Sturnidae			
Aplonis opacus guami Momiyama "Micronesian starling"		X	
Sylviidae			
**Acrocephalus luscinia luscinia* (Quoy & Gaimard) "nightingale reed-warbler"	X		
Class Mammalia			
Muridae			
Rattus exulans Peale "Polynesian rat"		X	

*Endangered