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Wildlife and Vegetation Surveys

AGUIGUAN 2002

by
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SURVEYED 14 - 21 MARCH 2002

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Executive Summary

The CNMI-Division of Fish and Wildlife in conjunction with the Tinian Department of Lands and Natural Resources conducted forest bird, swiftlet, vegetation, reptile, rodent, and bat surveys on Aguiguan from 14 - 21 March in 2002. The purpose of the surveys was to assess the status of the island's wildlife populations, especially the number of goats, in preparation for improving management of the island's resources and opening the island to goat hunting once again.

Forest birds were surveyed using Variable Circular Plot (VCP) methodology on 15-20 March, 2002. Listening stations were located 150 m distant from each other along each transect and vegetation was described using the point center-quarter method for each station. The most common forest birds were Bridled white-eyes, Rufous fantails, Golden white-eyes, and Micronesian honeyeaters. Mariana fruit-doves, Micronesian starlings, White terns, and Collared kingfishers were plentiful. White-throated ground-doves, and the endangered Micronesian megapode were uncommon to rare. Forest bird populations appear to have remained stable or increased on Aguiguan over the last 20 years.

Despite extensive surveys focused on the Nightingale reed-warbler, an endangered bird that has been detected in very small numbers on previous visits to the island, no reed-warblers were found during this trip. Mariana swiftlets, another endangered species, were counted as they returned to their roosts in caves in the early evening. Of the 16 caves observed, only six housed swiftlets. Numbers of swiftlets were lower than during previous counts, a cause for concern balanced by the fact that there are many caves on Aguiguan that were not investigated.

Mariana fruit bats were counted in the late afternoons and early evenings. No aggregations or roosts of fruit bats were found during this trip and only low numbers of bats were observed foraging during counts. The number of bats counted during the surveys was similar to those previously noted in 1992 but was half the number recorded in 2000. It is thought that fruit bats on Aguiguan probably number 30-50 individuals at the present time and that the population probably suffers from periodic poaching events.

Pacific sheath-tailed bats were also detected for the first time using an ultrasonic device that brought the high pitched sounds these bats often make to within the range of human hearing. These small bats were found roosting during the daytime in Guano and Pillar caves, and were found foraging in both native forest and over open fields at night. No population estimate was possible from the data collected during this trip, however, a more extensive survey of a large number of caves on Aguiguan is planned for 2003.

Aguiguan's limestone substrate.

Feral goats were counted using transect survey methods and were found in high densities (2 goats/ha) throughout the island. The native forest currently suffers from extreme browsing damage from such high densities of goats. Culling goats is necessary to allow the native forest to recover so that sufficient food resources for wildlife populations such as the Mariana fruit bat can be produced. The feral goat population estimate in March 2002 was 1,143 (range 943 to 2,117) individuals on the island. It is recommended that harvest levels be set by Tinian DLNR so that between 500 and 1,000 individuals are removed each year.

Herpetofauna surveys re-confirmed Campbell's 1995 island records of *Hemidactylus frenatus, Gehyra mutilata*, and *Emoia atrocostata*. It should be noted that *Emoia* atrocostat,a or the Tide-pool skink, had not been collected in the previous Cruz *et al*. 2000 survey. Further documentation is therefore needed to identify if trapping effort or environmental variable(s) play a role trap success of this species. *Rattus* spp. surveys documented six *R. exulans* specimens. It is unlikely that the Black rat *Rattus rattus* has been introduced to Aguiguan at this time, but transports to Aguiguan should be monitored to prevent an accidental introduction. Aguiguan supports an impressive population of Monitor lizards *Varanus indicus* that should be carefully monitored or possibly managed to protect endangered species such as the Micronesian megapode.

Two separate vegetation surveys were initiated on Aquiguan in 2002. The first survey, based on "point center-quarter" methods, was the largest in scope and coincided with the bird surveys using the same transects and stations. The second survey established plots with permanent boundaries that will be photographed at regular intervals. The purpose of the 'photo plot survey' is to learn more about temporal changes. This is particularly important in an environment, such as Aguiguan, were there are non-native animals impacting the forest.

The point center-quarter vegetation survey revealed two trends in forest dynamics. First, Aguiguan's forests in 2002 were dominated by only a few species, with the majority of species being poorly represented. Secondly, seedling recruitment was very low. *Cynometra ramiflora* and *Guamia mariannae* dominated the small and medium tree size and height classes. *Pisonia grandis* dominated the larger size classes. Although a variety of tree species were present in Aguiguan forests, most of these were encountered in lower than expected densities. Examples of species whose density and frequency were low include *Erythrina variegata*, *Psychotria mariana*, *Eugenia palumbis*, *Ficus tinctoria*, *Ficus prolixa,* and *Pandanus* sp.. *Intsia bijuga* and *Melanolepis multiglandulosa* were not recorded by this survey at all.

The purpose of setting up photo plots on Aguiguan was to obtain a baseline for temporal comparisons of vegetation in two different forest habitats. The baseline photos visually document Aguiguan's forest vegetation in the presence of feral animals. Similar phot plots established on Anatahan and Sarigan have documented dramatically how the forests had been destroyed due to feral goats and the recovery of the forests after feral animals were removed. On Aguiguan, photo plots were established in native and in *Leucaena leucocephala* (tangantangan) forest types. The photo plots in both forest types on Aguiguan were species poor. The understory was practically bare. By way of comparison, the tangantangan forests on Saipan appear to be native forest 'nurseries' as they support extensive numbers of native seedlings and young trees developing under their canopies. On Aguiguan, the understories of the *Leucaena* forests are particularly bare.

The forest surveys suggest that a two-fold process is occurring; first that feral animals have been selectively grazing certain species over a long period of time, and second, that intense grazing pressure has suppressed seedling recruitment to a point where the

forest is not perpetuating itself. The species that dominate, *Cynometra ramiflora* and *G. mariannae,* appear to be preferentially avoided by ungulates, and therefore they survive and reproduce in greater numbers than other tree species. Other tree species, possibly being more palatable, are grazed upon more heavily and are therefore not recruited in the forest as frequently.

Additional evidence that supports the conclusion that the feral goat population is too high for the island to sustain was the extensive grazing on bark that was observed incidentally during surveys. Goat grazing on the bark of trees girdles and kills them. When there are no young trees to fill the gaps created by the death of girdled trees, than grasses and weeds that are unpalatable to the animals begin to take root. This is occurring on Aguiguan now as *Lantana camara*, an aggressive and invasive weed, spreads under the forest canopy. Weeds and grasses will come to dominate the understory of the forest because there are no tree seedlings to compete with their spread. In a relatively short period of time, the forest will be gone. After the forest is gone, native wildlife (birds, bats, crabs, etc.) that depend on forested habitat, will decline and could become extirpated from the island in the near future.

I. Introduction

Aguiguan's biotic and abiotic resources have been surveyed several times over the past two decades. It has received attention from the U.S. Department of Agriculture's Soil Conservation Service, which surveyed and classified the soils in 1985 (Young 1989). Archaeological and paleoarcheological surveys were conducted in 1990 (Butler 1992) and 1994 (Steadman 1998), respectively. Biologists have visited the island many times over the decades and have accrued a wealth of information on the island. For example, birds have been surveyed island-wide using variable circular plot methods in 1982

(Engbring *et al*. 1986), 1992 (Craig and Chandran 1992), and 2000 (Cruz *et al*. 2000), while Sheath-tailed bats were surveyed in 1995 (Wiles & Worthington 2002). The island was intensively studied in 1992 and the findings formed the basis of one of the few scientific symposia mounted in the CNMI (Craig 1992). Inclusive surveys of vertebrates were conducted in 2000 (Cruz *et al*. 2000) building on information from field trips conducted by prior CNMI biologists who documented the kinds of seabirds, lizards, bats, rodents, and forest birds that inhabit the island.

Evidence of past human occupation of Aguiguan is abundant adding to speculation about how such past disturbance has contributed to today's forest composition.

These field reports also note persistent problems with large numbers of feral goats (*e.g*., Kosaka *et al*. 1983; Reichel *et al*. 1987; Worthington and Taisacan 1995), reflected in the local name for Aguiguan, Goat Island. Native limestone forest covers a portion of the island, although browse damage by feral goats is effectively preventing regeneration. Aguiguan is currently uninhabited, with the exception of visiting hunters. Much of the vegetation on the island's upper reaches has been severely degraded, allowing unimpeded growth of the noxious weed *Lantana camara*.

Administered by the municipality of Tinian, permission to land on the island is required from the Tinian Mayor's Office. A moratorium on goat hunting (declared and enforced by the municipal government of Tinian) had been in effect from 2000 to 2002. Goat hunting has now been reopened by the municipality, thus providing an opportunity for the Division of Fish and Wildlife to recommend take levels.

The CNMI-Division of Fish and Wildlife in conjunction with the Tinian Department of Lands and Natural Resources conducted forest bird, swiftlet, vegetation, reptile, rodent, and bat surveys on Aguiguan from 14 - 21 March in 2002. The purpose of the surveys was to assess the status of the island's wildlife populations, especially the number of goats, in preparation for improving management of the island's resources and for re-opening the island to goat hunting. The results of these surveys are reported below.

Henry King and Al Reyes assisting with bird surveys.

II. Forest Bird and Mariana Swiftlet Surveys

A. Forest Birds

Methods for surveys and analysis

Forest birds were surveyed using Variable Circular Plot (VCP) methodology on 15-20 March 2002. Teams of three to four people followed four (4) transects described by Engbring *et al*. (1986) that had been used for similar forest bird surveys in 1982 and 1992 (Fig. 1). Listening stations were located 150 m distant from each other along each transect and were documented with GPS readings (see Appendix 1). One person from each team counted birds both visually and by song, estimating the lateral distance to each bird detected. Calibration exercises conducted prior to beginning the survey were intended to reduce variability among observers. Surveys were conducted from dawn until 1000 hours. Vegetation was described for each listening station and results of the habitat survey are reported in a separate section below.

Density estimates for each species were calculated using the computer statistical program DISTANCE (version 3.5, available on the web). Data for each species were examined using histograms and truncated such that 5-10% of the observations were not used to fit the mathematical models. Data were grouped into intervals that allowed a good fit to the half-normal model (intervals and number of groups were different for each species). The χ^2 goodness-of-fit test for all species with the exception of Golden white-eyes ($P > 0.6$) and Mariana fruit-doves ($P > 0.7$) indicated a very good fit between model and data ($P > 0.9$). Data from April 2000 and March 2002 were run

simultaneously with data from similar surveys on Saipan and the northern islands to increase sample size. Densities were calculated for each survey, each island, and each species independently. The fit of the models constructed during data analysis in 2000 was poor (in many cases due to low sample sizes) compared with the algorithms constructed using both 2000 and 2002 data. Thus, density estimates for 2000 reported in Cruz *et al*. 2000 should be discarded and replaced by those reported in Table 2.

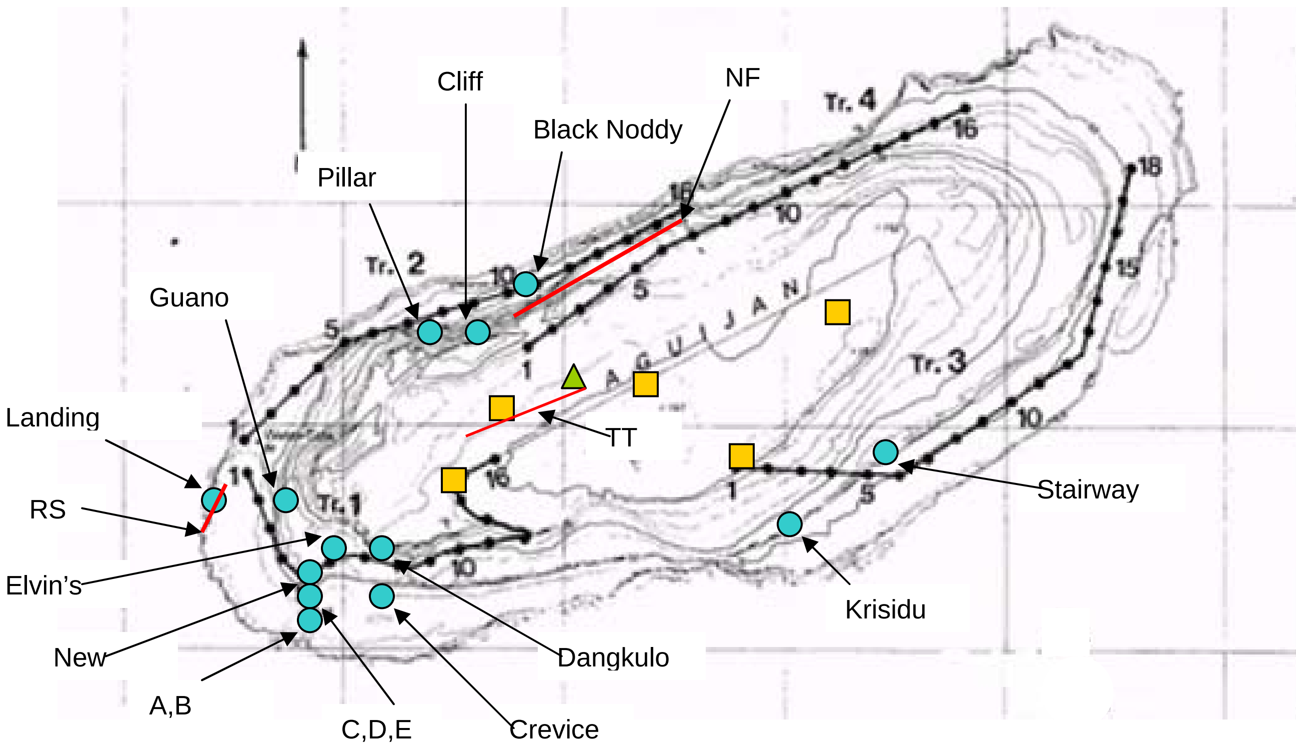

Figure 1. Transects established in 1982 for variable circular plot bird surveys, from Engbring *et al*. 1986. Stations on each transects are 150 m apart. In 2002, 15 stations were re-surveyed on Transect 1, and 16 points were re-surveyed on Transects 2 - 4 (a total of 63 stations). Caves in which Mariana swiftlet and Pacific sheath-tailed bats were surveyed are marked with blue circles. Extra-colonial Mariana fruit bat counts were conducted at sites marked with yellow squares. The field camp is marked with a green triangle, and small mammal and reptile transects are marked in red where RS=Rocky Strand at the Landing Point, NF= Native Limestone Forest, and TT= introduced *Leucaena leucocephala* or Tangantangan Forest.

In calculating forest bird population estimates for 2000 and 2002, we grossly estimated from aerial photos by inspection that approximately 275 ha of Aguiguan is forested at this time. From historical accounts it is known that the majority of Aguiguan was under sugar cane production in the 1930's and 1940's. The presence of extensive secondary forest surrounding the relics of agricultural water catchment tanks attests to the re-growth of the forest since that period. We assumed that forest recovery has remained

more or less constant over the last 20 years because Aguiguan remains uninhabited. Feral goats have recently begun to impact forest recovery, however, we believe that the amount of forested area on Aguiguan has not decreased over the past 20 years and, based on anecdotal observations in the area of the air strip, may even have increased over this period.

Megapodes were not widely distributed but appeared to be restricted to small areas of Aguiguan.

Results and discussion

Ten species of birds totaling 1,167 individuals were counted during the survey. On average, 18.5 birds were counted per station, with only one feral rooster (a descendent from domestic stock) and two White-tailed tropicbirds (*Phaethon lepturus*) recorded incidentally. Mariana swiftlets (*Aerodramus bartschi*) were detected while foraging, but more accurate estimates of their numbers are available from departure/arrival counts conducted at nesting caves in the evenings (see Section C below). Of the remaining forest birds (Table 1), the most common were the Bridled white-eye (*Zosterops conspicillatus*), Rufous fantail (*Rhipidura fufifrons*), Golden white-eye (*Cleptornis marchei*), and Micronesian honeyeater (*Myzomela rubratra*). Mariana fruit-doves (*Ptilinopus roseicapilla*), Micronesian starlings (*Aplonis opaca*), White terns (*Gygis alba*), and Collared kingfishers (*Halcyon chloris*) were plentiful. White-throated ground-doves (*Gallicolumba xanthonura*) and Micronesian megapodes (*Megapodius laperouse*) were uncommon to rare. These findings are consistent with forest bird surveys conducted in 2000 (Cruz *et al*. 2000).

Table 1. Numbers of Aguiguan forest birds detected per station over 4 survey years 1982 to 2002. Counts are expressed both as mean number of birds detected per station and as (total number of detections for the species). The total number of stations surveyed was 66 in 1982 and 1992, and 63 in 2000 and 2002. With the exception of White terns and Philippine turtle-doves, for which this count method is not accurate or the sample sizes were too low to calculate densities, numbers of birds detected per station (± 1 standard deviation) are given below the total count for each species.

Bird Species	Total count 2002 # birds/station	Total count 2000 # birds/station	Total count 1992* # birds/station	Total count 1982* # birds/station
Bridled white-eye	472 7.5 (6.84)	218 3.5 (2.44)	514 7.79	411 6.23
Rufous fantail	171 2.7 (1.73)	150 2.4 (1.85)	273 4.14	227.5 3.45
Golden white-eye	153 2.4 (2.12)	147 2.3 (2.42)	245 3.71	223.5 3.39
Micronesian honeyeater	131 2.1 (1.13)	124 2.0 (1.53)	202 3.06	373 5.65
Mariana fruit-dove	102 1.6 (1.02)	76 1.2 (0.92)	138 2.09	381 5.77
Micronesian starling	57 0.9 (1.51)	74 1.2 (1.50)	127 1.92	104 1.58
Collared kingfisher	40 0.6 (0.92)	57 0.9 (1.17)	83 1.26	79 1.20
White tern	52 0.83	42 0.67	113 1.71	113.5 1.72
White-throated ground-dove	12 0.2 (0.40)	16 0.3 (0.74)	8 0.12	9.5 0.14
Micronesian megapode	16 0.3 (0.62)	12 0.2 (0.44)	11 0.17	7 0.11
Philippine turtle-dove	1 0.02	3 0.05	11 0.17	7.5 0.11

* After Craig *et al*. 1992.

With the exception of Bridled white-eyes, the density estimates calculated from surveys in 2000 and 2002 were quite similar (Table 2). The 95% confidence intervals for density estimates overlapped extensively. This suggests that the majority of bird populations remained stable over the 2000-02 period. The density of Bridled white-eyes, however, was significantly greater in 2002 than in 2000.

Golden white-eye

For forest birds, abundance estimates for 2002 were based on the assumption that there were 275 forested hectares left on Aguiguan, and that most forest bird species were distributed throughout that remaining habitat. Megapodes, however, were found to be aggregated in certain areas. For megapodes, therefore, we estimated that they were distributed over approximately 50 ha of the island. Because the following abundance estimates are calculated based on the density of a species per hectare times the number of hectares of available habitat, our abundance figures could be severely affected by under or over estimates of the area of available habitat. For purposes of comparing the status of bird populations across different survey years, the density of birds per hectare gives a more reliable comparison.

Island-wide bird abundances in 2002 are estimated to be about 18,576 Bridled white-eyes (range 15,411 – 22,393); 9,449 Golden white-eyes (range 7,233 – 12,348); 8,951 Rufous fantails (range 7,323 – 10,940); 3,912 Micronesian honeyeaters (range 3,102 – 4,934); 1,686 Micronesian starlings (range 1,092 – 2,599); 149 Mariana fruit-doves (range 91 - 242), 146 White-throated ground-doves (range 77 –275), 132 Collared kingfishers (range 88 - 468), 72 Micronesian megapodes (range 34 – 149). The abundances reported here are substantially greater than those reported by Engbring *et al*. (1986).

Bridled white-eyes were extremely abundant on Aguiguan in 2002

Table 2. Density and island-wide population estimates from 1982 (Engbring *et al*. 1986), 1992 (Craig *et al*. 1992), 2000 and 2002 (this analysis). Calculated densities for 1982 and 1992 are followed by standard deviations (± SD) and island-wide **population abundances** (in bold) given by Engbring *et al*. Island-wide estimates are not available for 1992. Calculated densities for 2000 and 2002 are followed by 95% confidence intervals and **population abundance** (in bold) based on an estimated 275 ha of forested land (out of 718 ha) remaining on Aguiguan for all species except megapodes, which were patchily distributed.

Bird Species	Birds/ha 1982 (± SD) **abundance**	Birds/ha 1992 (± SD) **abundance**	Birds/ha 2000 (95% CI) **abundance**	Birds/ha 2002 (95% CI) **abundance**
Bridled white-eye	19.3 (8.28) **7,431**	219.3 (128.93)	33.2 (26.8 – 41.01) **9,119**	67.6 (56.04 - 81.43) **18,576**
Rufous fantail	3.8 (1.78) **1,472**	52.8 (17.80)	27.7 (21.86 – 35.17) **7,626**	32.6 (26.63 – 39.78) **8,951**
Golden white-eye	6.2 (3.43) **2,366**	49.7 (6.29)	33.4 (24.84 – 44.50) **9,193**	34.4 (26.3 - 44.90) **9,449**
Micronesian honeyeater	5.7 (1.75) **2,195**	23.9 (13.48)	13.1 (10.04 – 17.18) **3,611**	14.2 (11.28 – 17.94) **3,913**

Bird Species	Birds/ha 1982 (± SD) **abundance**	Birds/ha 1992 (± SD) **abundance**	Birds/ha 2000 (95% CI) **abundance**	Birds/ha 2002 (95% CI) **abundance**
Mariana fruit-dove	0.8 (0.35) **292**	2.7 (2.04)	0.7 (0.47 – 1.04) **193**	0.5 (0.33 – 0.88) **149**
Micronesian starling	1.1 (0.88) **428**	4.9 (1.79)	7.7 (5.47 – 10.90) **2,123**	6.1 (3.97 – 9.45) **1,686**
Collared kingfisher	0.1 (0.11) **42**	0.6 (0.16)	0.7 (0.48 – 0.97) **187**	0.5 (0.32 – 0.70) **132**
White-throated ground-dove	0.09 (0.29) **34**	0.4 (0.53)	0.8 (0.37 – 1.79) **223**	0.5 (0.28– 1.00) **146**
Micronesian megapode	0.03 (0.11) **11**	0.04 (0.04)	1.6 (0.86 – 2.97) **80***	1.4 (0.68 – 2.98) **72***

* population estimate based on distribution over approximately 50 ha of forest.

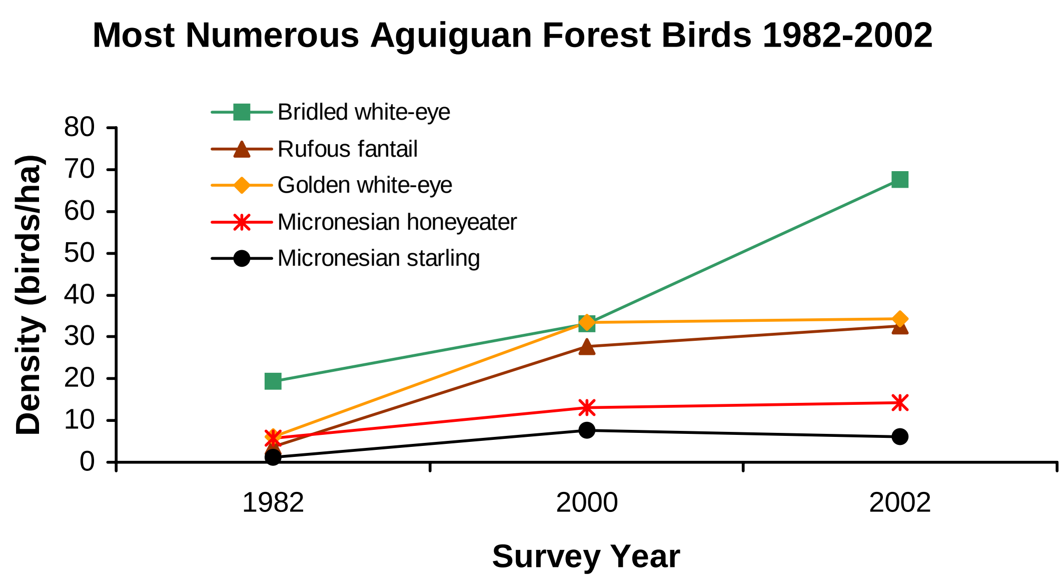

Figure 2. The five most common species of forest birds appear to have been increasing over the last 20 years.

We are confident that our density calculations represent the abundance of birds as we perceived them on Aguiguan in 2000 and 2002. And while Engbring's 1982 work serves as a baseline for comparisons, the density estimates from 1992 appear to be anomalous (Table 2). Craig *et al*. 1992 discussed the difficulties in analyzing their data noting that although count data were remarkably similar between 1982 and 1992 (Table 1), density estimates differed sometimes by an order of magnitude. Based on the similarities between numbers of birds observed per station, they concluded that the populations of most species had changed little on Aguiguan between 1982 and 1992 with the exception of Mariana fruit doves, which they thought had declined. Taking into account that there may be problems with the 1992 densities as they are presented in previous reports, we compared the 1982 density estimates graphically with our own (Fig. 2).

The five most common species of forest birds (Bridled white-eyes, Golden white-eyes, Rufous fantails, Micronesian honeyeaters and Micronesian starlings) appear to have been increasing over the last 20 years in a substantial fashion (Fig. 2). Collared kingfishers and Micronesian megapodes, although less common than the most numerous birds, appear also to have more than doubled in density over the past 20 years (Fig. 3). The variation around the mean density of White-throated ground-doves and Mariana fruit-doves in 1982 falls within the 95% confidence intervals of data from 2000 and 2002 (Table 2), thus indicating that these populations have most likely remained stable over the 20-year period.

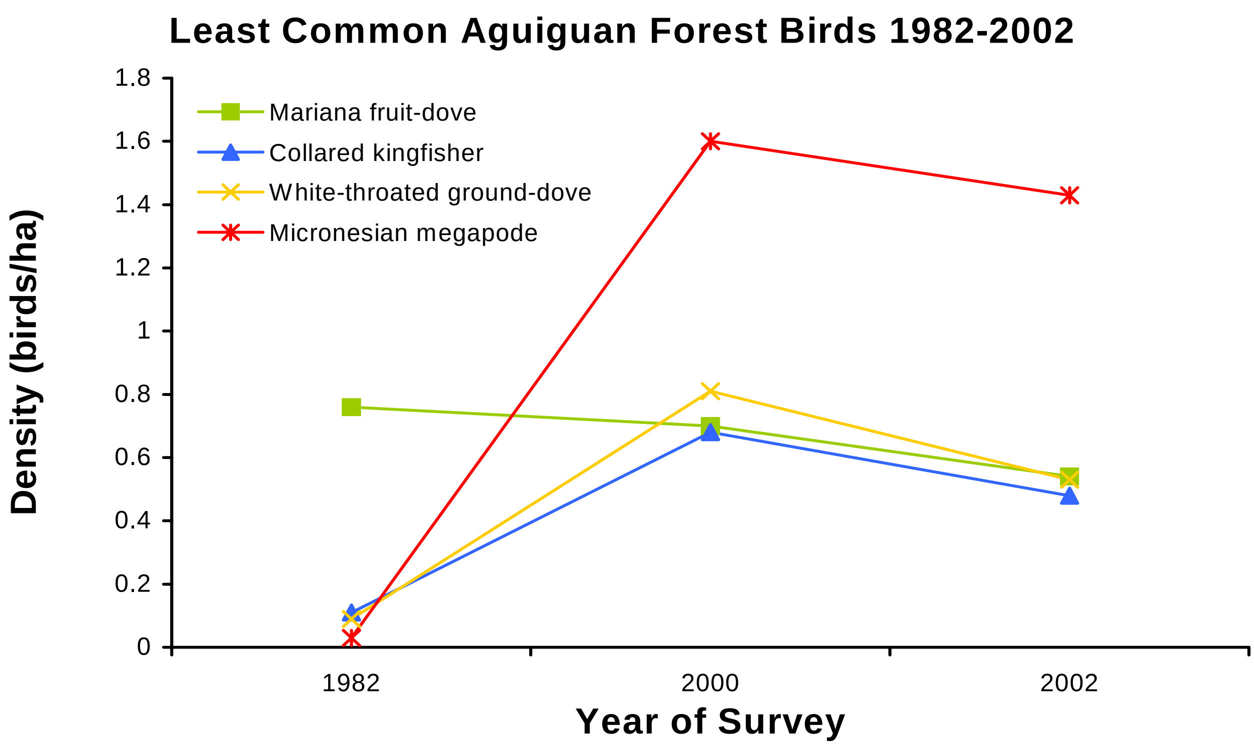

Figure 3. Trends in population sizes of four less common forest bird species on Aguiguan over the last 20 years appear to either remain stable or be increasing.

The difficulty in judging the lateral distance from an observer to a calling dove, combined with seasonality in the quantity of dove vocalizations, could contribute both to variability in detection rates and in distance estimations. Both factors may affect density calculations causing either over or under estimates. However, because several surveys from Saipan were fit to the mathematical models along with the Aguiguan data, we feel confident that the variation expressed in the data is not due to low sample sizes. We therefore conclude that most, if not all, forest bird species on Aguiguan have sustained and/or increased their populations over the past two decades.

Although only one (1) feral rooster was detected during our VCP surveys, we would like to note the presence of a small population of formerly domestic fowl (*Gallus gallus*) on Aguiguan. We observed several chickens around our camp located on the upper plateau. No chickens were observed elsewhere on the island.

B. Nightingale reed-warblers

Methods for surveys and analysis

Only one Nightingale reed-warbler (*Acrocephalus luscinia*), an endangered species, has been detected during any of the point count surveys conducted over the last 20 years (Craig *et al.* 1992). However, Engbring *et al*. (1986) observed six of these birds during their stay on the island in 1982, Glass (1987) reported sighting several in 1985, while Craig and Chandran (1992) observed two singing males in 1992. Because a small population of this bird would be difficult to detect, we employed play-back methodology in an attempt to elicit a response from this species. For forest bird transects 2 and 4, a tape recording of the reed-warbler's song mixed with call notes was played for one minute after each 5-minute point count. This was followed by a two-minute listening period. A special reed-warbler survey was conducted for 4 hours using recorded vocalizations to elicit responses along Transect 1, the area where the bird had last been seen.

Results and discussion

No reed-warblers were detected during any of the surveys in 2002. However, the tape recordings did attract Golden white-eyes and starlings into close proximity. Engbring *et al*. (1986) and Craig and Chandran (1992) discussed at length the type of habitat in which they located the Nightingale reed-warblers they observed in 1982 and 1992. Their habitat descriptions differed and included native forest (Engbring) and edges (Craig and Chandran). Both types of habitats in the areas where the birds were previously sighted were thoroughly searched in 2002 with negative results. Craig and Chandran also discuss the differences in vocalizations and morphology between the 1982 and 1992 observations. They question the validity of the *A. l. nijoi* subspecific designation for the Aguiguan population, suggesting that the birds sighted were possibly young dispersing from Saipan as opposed to a different subspecies.

Nightingale reed-warbler

Regardless of the specific designation, it is clear from this set of surveys and from others that have been unsuccessful in observing reed-warblers, that currently the population is at best, very small, and at worst, may represent intermittent attempts at colonization from dispersing members of the Saipan population. Witteman (*pers. comm.*) reported a single male reed-warbler from the northeastern portion of the island in 2001. However, the report was based on identification of vocalizations rather than on a confirmed sighting of the bird. Because it has been reported that the long-song of the Golden white-eye (Glass 1987) or the mimicking calls of the Micronesian starling (Craig and Chandran 1992) can be confused easily with that of the Nightingale reed-warbler on Aguiguan, only positive sightings of reed-warblers in the manner exemplified by Craig and Chandran (1992) will confirm the continued existence of the small population previously reported.

C. Mariana Swiftlets

Methods for surveys and analysis

We conducted evening arrival counts of Mariana swiftlets at the entrances of 16 potential roosting caves from 15 – 20 May 2002 (Fig. 1). Caves were chosen based on past reports of potential swiftlet activity and their locations documented with GPS readings (please see Appendix 1). One to two observers positioned themselves in a location near the cave entrance where a good view could be obtained of entering and exiting swiftlets. Observers tried to arrive at cave locations by 1645 h so that counts could begin by 1700 h. Counts ceased after full darkness between 1840 and 1910 h.

Arrival counts were initiated with an original estimate of the number of birds inside of the cave (e.g., 6). All birds exiting the cave were counted as negative numbers while all birds entering the cave were counted as positive. Counts were broken into 10-minute intervals. Some observers recorded the number of birds exiting and the number entering for each 10-minute interval (beginning each interval anew) and then summing both positive and negative numbers for the total arrival count. Other observers kept a cumulative count, recording the total results on the data sheet at the end of each interval. Either count method arrives at the same results. The choice of method rested with the abilities of each observer. The former method (recording exiting and entering activity with each time period, e.g., +4, -9 for 1810 to 1820 h) provides more information on swiftlet activity at each cave.

Mariana swiftlets are one of 24 endangered or threatened species in the CNMI

Because swiftlet counts have been performed only as opportunity allowed on Aguiguan (7 times over the last 17 years), no abundance estimate or trend for the population were attempted. Results were tabulated and are presented below.

Results and discussion

A total of 267 swiflets were detected in six caves during arrival counts in 2002 (Table 3). The following caves appeared to hold no swiftlets at the time of our survey: Caves A, B, C, D, E, Black Noddy, New (#6), Crevice, Krisidu, and Stairway. Caves A-E appear to have very small openings and may not be conducive as swiftlet roosts. One additional cave was found by Elvin Masga that contained a small number of swiftlets. Elvin's Cave will be added to the list of those areas surveyed as frequently as possible for this species.

The number of swiftlets counted at roosting locations during 2002 is the lowest of any of the surveys (excluding the incomplete data of Rice 1992) conducted on Aguiguan. However, the data should be interpreted with caution because of the potential for additional roost sites. Wiles and Worthington (2002) documented the existence of 78 caves on Aguiguan, while noting that many additional caves likely await discovery. The number of caves surveyed for the presence of swiftlets over the years has remained a small percentage of the total number of caves found on the island. Despite this caveat, the apparent decline in the number of swiftlets detected during entrance counts at known roost sites remains a cause for concern.

Table 3. Cave entrance counts of Mariana swiftlets on Aguiguan 1985 – 2002. Caves not surveyed are represented by dashes (--). Caves not discovered until recent years are represented by an asterisk (*). Caves where no evidence of swiftlet presence was found and thus no entrance counts were conducted are denoted by a double cross (‡).

Location	1985[a]	1987[a]	1988[b]	1992[c]	1995[d]	2000[e]	2002[f]
Guano Cave	750	321	332	--	123	337	183
Pillar Cave	100?	89	34	60	65	53	33
Landing Cave	10	16	13	--	2	2	6
New Cave (#6)	*	*	39	--	0	0	0
Black Noddy Cave	10?	--	--	--	145	7	0
Cliff Cave	100?	--	--	40	26	9	31
Elvin’s Cave	*	*	*	*	*	*	10
Dangkulo Cave						‡	4
TOTAL	**970?**	**426**	**418**	**100**	**361**	**408**	**267**

[a] Reichel and Glass 1988
[b] Reichel *et al*. 1988
[c] Rice 1992
[d] Arriola 1998
[e] Cruz *et al*. 2000
[f] current survey

III. Bat Surveys

A. Mariana Fruit Bats

Methods for surveys and analysis

We conducted five extra-colonial station counts of *Pteropus mariannus* at various locations on Aguiguan (Fig. 1) 15 - 20 March 2002. Four of the counting stations had an open view of portions of the plateau in the center of the island and of the surrounding ridges with tracts of native forest. The fifth station, situated at the top of a cliff, overlooked an area composed entirely of native forest.

Bat count station view from the plateau toward the ridges with native forest.

Bat count station overlooking terrace below cliff line.

Extra-colonial counts were conducted in areas that did not contain roosts or aggregates of bats. The observer was located in a position where a broad area of habitat was in good view. The habitat included food plants known to be used by fruit bats on other islands. The observer noted the arc covered by his/her field of view, the trajectory and number of bats flying in and out of the field of view, and the number of bats remaining in the count area. Extra-colonial counts began at 1530 h and continued until full dark at 1900 to 1915 h. Number of bats and bat activity were noted for each 15-minute segment of the count period.

Table 4. Number of *P. mariannus* observed at five evening extra-colonial count stations on Aguiguan, March, 2002. See Figure 1 for station locations.

Station	**Date**	**Observer**	**Time Start**	**Time End**	**# of Bats**	**Time Bats Observed**	**Direction of Flight**
1	3/14/02	JBC	1730	1900	7	1800-1900	W, N, E
1	3/20/02	NBH	?	1905	6	1832-1846	W, E, S
2	3/15/02	JBC	1640	1900	5	1820-1840	E, N, W
3	3/16/02	JAE	1800	1900	3	1845	N
4	3/17/02	JAE	1720	1900	7	1822-1854	N, S, W
5	3/20/02	JAE	1730	1850	1	1733	W

Results and discussion

Low numbers of bats were observed at each extra-colonial count station (Table 4). The numbers of *P. mariannus* observed in 2002 were similar to those observed by DFW staff in 2000 (Cruz *et al*. 2000). None of the station counts resulted in observations of large numbers of bats coming from the same direction. This may indicate that no significant colonies were located near any of the stations.

Mariana fruit bat

Craig and Chandran (1992) reported finding four widely separated roost sights containing between 5 and 14 bats each. During the 2000 expedition, two small aggregates of roosting *P. mariannus* were discovered (Cruz *et al*. 2000). During our survey in 2002, no aggregates of roosting *P. mariannus* were found despite our survey efforts covering extensive areas of the island, including the two areas that held aggregations in 2000.

We counted nearly 30 fruit bats during the extra-colonial surveys and, assuming that some roosts were undetected in 2002, we estimate the number of fruit bats on Aguiguan during our stay ranged from 40-60. This finding is lower than the estimated population of 200 bats in 1988 (Reichel *et al*. 1988), 100-125 estimated in June 1995 (Worthington and Taisacan 1995), and the 150-200 fruit bats estimated island-wide in 2000 (Cruz *et al.* 2000). Our findings are consistent with other reports of least 25 fruit bats in 1984 (Lemke *et al*. 1984), 40 in 1987 (Reichel *et al*. 1987), 30 in 1989 (Rice and Reichel 1989), and 30 in May 1992 (Craig and Chandran 1992). This kind of count-to-count variation precludes any kind of trend analysis, but may reflect either (a) the difficulty in detecting Mariana fruit bats on Aguiguan, (b) the variable nature of the population, or (c) possible episodes of intensive poaching that knock the population back from time to time.

Aguiguan appears to hold only a small population of Mariana fruit bats at this time. Whether the population is experiencing positive or negative growth is unclear. Currently, the Tinian DLNR office is unable to conduct regular patrols on Aguiguan and so the level of poaching on the island is unknown. Because the island remains uninhabited, any population decline that may have taken place in the last few years is most likely due to poaching. Aguiguan is particularly important to conservation efforts of *P. mariannus* as it is a potential source from which dispersing individuals might reach Tinian and Saipan.

B. <u>Pacific Sheath-tailed Bats</u>

Methods for surveys and analysis

We searched Guano, Pillar, Landing, and Elvin's caves; forests; and open fields for *Emballonura semicaudata* using an Ultra Sound Advice™ Mini-3 Bat Detector and visual observations. Cave searches were conducted during the daytime while the bat detector was used during early evening hours on 16 - 20 March 2002 over extensive portions of the island. For bats in flight we report only individuals that were both detected with the ultrasonic device and visually confirmed.

Results and discussion

We counted a minimum of 15 bats departing from Guano Cave between 1833 and 1912 h on 18 March 2002. We then found at least eight individuals roosting inside Guano Cave on 20 March 2002. Bats roosted on exposed vertical walls in moderately dark portions of the cave with forearms spread and used as stabilizers, a position typical of emballonurids. We observed these bats roosting after we had caused a moderate amount of disturbance to the cave so these may not have been in their original positions.

We observed one to four bats circling around the entrance to Pillar Cave between 1845 and 1850 h on 15 March 2002. Pillar and Landing caves were searched intensively for roosting *E. semicaudata* on 20 March 2002. We did not find any bats during either of these searches. Landing Cave is the location of previous sightings of this bat (Glass

and Taisacan 1987; Craig and Chandran 1992), however, the cave is small enough that we believe we would have found bats had they been present at the time of the search. Pillar Cave however, has a much higher ceiling in the dark portions, and so we probably missed finding the bats that we had detected departing from the cave on the earlier date.

Pacific sheath-tailed bat

No bats were found roosting in Elvin's Cave during a quick search on 19 March 2002. We did however observe one to several bats foraging near the entrance to Elvin's Cave and New Cave on the same night. We were unable to either confirm or rule out the possibility that these bats had originated from inside Elvin's Cave or New Cave.

We observed bats foraging in both forests and an open areas. We confirmed a single sighting of a Pacific sheath-tailed bat in an open area. This bat was foraging by circling very rapidly at about 5 - 7 m above the ground around a small patch of several *Casuarina equisitifolia* in an otherwise open field on the central plateau at twilight (1846 h). All other bats were observed in degraded primary forest with very low understory clutter. On several occasions we encountered bats foraging in a very slow manner through the forest understory at a height of about 1.5 – 6 m. These bats often foraged directly in front of our head lamps. The variation observed in flight patterns may indicate a high level of plasticity in foraging behavior.

We hesitate to produce a population estimate based on this quick survey, although Wiles and Worthington (2002) document a combined count of 97 - 99 individuals from

Black Noddy, Guano, Crevice, Cliff and Pillar caves in 1995. Intensive studies focusing on the population status and trends, limiting factors, habitat requirements and life history traits of *E. semicaudata* should be undertaken in the future.

IV. Feral Goat Surveys

Methods for surveys and analysis

Goat and numbers were assessed using strip transects (Sutherland 1996). Three transects counts were conducted following the four bird transects in Fig. 1. The length of each transect was measured with hip chain and traveled at a steady pace on 16 - 20 March 2002. Using a tape measure, we measured lateral distance to animals sighted on either side of the transect up to 60 m. Density of goats and was then calculated using the computer program DISTANCE.

Results and discussion

No pigs were observed on Aguiguan in 2002, but goats were numerous. A total of 112 animals were encountered along the three transects that totaled 6.96 km in length. Of these, 38 were identified as adult females, 33 as adult males, and 41 as juveniles (gender unknown). Average group size was 2 individuals (clusters ranged in size from 1 to 5) and 57 groups were observed.

Density of goats was calculated to be 2.0 goats/ha (range 1.3 to 2.9 per ha) using the computer program DISTANCE for clusters of individuals counted using transect methods. If this density was typical over the entire 718 ha of Aguiguan, then the island-wide population estimate was 1,413 goats (range 943 to 2,117) in March 2002.

Density of goats on Anatahan in April 2002 was estimated to be 1.4 goats/ha using similar survey and analytical methods. Such high densities of feral goats has led to similar forest destruction on both islands. Very little regeneration was occurring in the native forests of Aguiguan with chew marks on trees and bark stripping evident in many places. Craig and Chandran (1992) reported hearing only 3 goats (and seeing none) in 1992, only 10 years prior to this survey. Clearly the goat population has significantly increased in the last 10 years with largely negative consequences for the island's native habitats. Culling 500 to 1,000 animals a year would likely help control the goat population to a significant degree.

V. Vegetation Surveys

Two separate vegetation surveys were initiated on Aquiguan in 2002. The first survey, "point center-quarter", coincided with the bird surveys and used the same transects and stations. The point center-quarter was the main survey conducted on Aguiguan and was the largest in scope. The second survey established plots with permanent boundaries that will be photographed at regular intervals. The purpose of the "photo plot survey" is to learn more about temporal changes. This is particularly important in

an environment, such as Aguiguan, were there are non-native animals impacting the forest.

Estimating tree height during vegetation surveys along Transect 4.

A. <u>Point center-quarter vegetation survey</u>

Methods for surveys and analysis

Vegetation surveys were conducted simultaneously with forest bird surveys. The purpose of this research was twofold: first to sample habitat at each of the bird listening stations; second to quantitatively describe the forest that remains on Aguiguan. Four transects were established with stations 150 m apart (coincident with bird transects and stations, Fig. 1). Transect 1 consisted of 14 stations; all other transects had 16 stations. The vegetation was surveyed using a modified point center-quarter method (Mueller-Dombois and Ellenberg, 1974). Lateral distance from the station center to the nearest tree in each quarter (delineated by cardinal directions) was measured. The selected trees, two meters in height and greater, were identified to species, the diameter at breast height (DBH) measured, and the height estimated. Canopy cover for each station was estimated using a densiometer and following manufacturer's instructions. Percent ground cover was estimated using the line intersect method placed randomly within a 1m^2 area around the station. The data were analyzed for tree density, absolute frequency, importance value (Mueller-Dombois and Ellenberg, 1974), and percent canopy and ground cover.

Absolute frequency was the number of plots in which a species occurred, divided by the total number of plots, and finally multiplied by 100. The absolute density of all tree species of a specific area (usually 100 m^2) was calculated with the following formula: absolute density = Area/D^2, where 'D' = the mean of all distances for all plots (a maximum of 4 distances per plot). In order to determine the density of specific tree species, the ratio of the number of quarters in which that species occurred to the total

number of quarters was calculated. That ratio was then multiplied by the overall absolute density of trees, yielding the number of trees per 100 m^2 of a specific species. Basal area (BA) was calculated by the formula: $BA = (½d)^2\pi$, where d = diameter of the tree at breast height. Dominance of a species was calculated as the average BA of all plots times species density in 100 m^2 (as calculated above). The importance value was calculated as the sum of the relative dominance, relative density and relative frequency. Relative values were derived taking the ratio of the individual species to the sum of all species.

Results and discussion

The forest vegetation along transects 2, 3 and 4 (Fig. 1) could be generally classified as native forest. The vegetation of transect 1 was open in a few areas and primarily tangantangan forest. In general, the western half of the island extending from the old airstrip and water catchments down to the landing site was either disturbed secondary forest or tangantangan forest.

The overall density of trees, inclusive of all transects, was 8.65 trees/100m^2. Tree density in the native forest (*i.e.*, transects 2, 3, and 4) was 8.72 trees/100 m^2 and in the tangantangan forest (transect 1) was 8.43 trees/100m^2. The trees with the most influence in the study area were *Guamia mariannae*, *Cynometra ramiflora*, *Ochrosia mariannensis, Pisonia grandis*, and *Leucocephala leucocephala*. *Pisonia grandis* had the greatest importance value, followed by *G. mariannae* and *C. ramiflora* (Table 5). *Guamia mariannae* had the greatest overall density (Fig. 4) and frequency (Fig. 5). The average canopy cover ranged from 79% along transect 1 to 95% along transect 2. Ground cover was the least on transect 2 (6%) and greatest on transects 1 and 4 (both 19%) (Fig. 6).

Table 5. Importance Values (sum of relative dominance, relative frequency, and relative density) for trees surveyed on four transects (62 stations) on Aguiguan in 2002.

Species	Relative Dominance	Relative Frequency	Relative Density		Importance Value
Pisonia grandis	81.11	8.86	5.56		95.52
Guamia mariannae	4.03	27.25	33.33		64.61
Cynometra ramiflora	7.18	21.12	22.22		50.52
Ochrosia mariannensis	2.23	12.94	11.11		26.28
Leucaena leucocephala	0.26	4.09	8.73		13.07
Carica papaya	0.15	2.72	3.97		6.84
Aglaia mariannensis	0.05	3.41	1.98		5.44
Premna obtusifolia	0.35	2.72	1.59		4.66
Casaurina equisetifolia	1.03	2.04	1.59		4.66
Erythrina variegata	0.81	2.04	1.19		4.04
Hernandia sonora	0.25	2.04	1.19		3.49
Morinda citrifolia	0.10	2.04	1.19		3.33
Maytenus thompsonii	0.58	1.36	1.19		3.13
Drypetes dolichocarpa	0.30	1.36	1.19		2.85
Psychotria mariana	0.10	1.36	0.79		2.26
Pouteria obovata	1.18	0.68	0.40		2.26
Eugenia palumbis	0.04	1.36	0.79		2.19
Delonix regia	0.07	0.68	0.79		1.54
Ficus tinctoria	0.10	0.68	0.40		1.18
Intsia bijuga	0.09	0.68	0.40		1.16
Polyscias grandifolia	0.00	0.68	0.40		1.08

Micronesian honeyeater on *Erythrina* flower

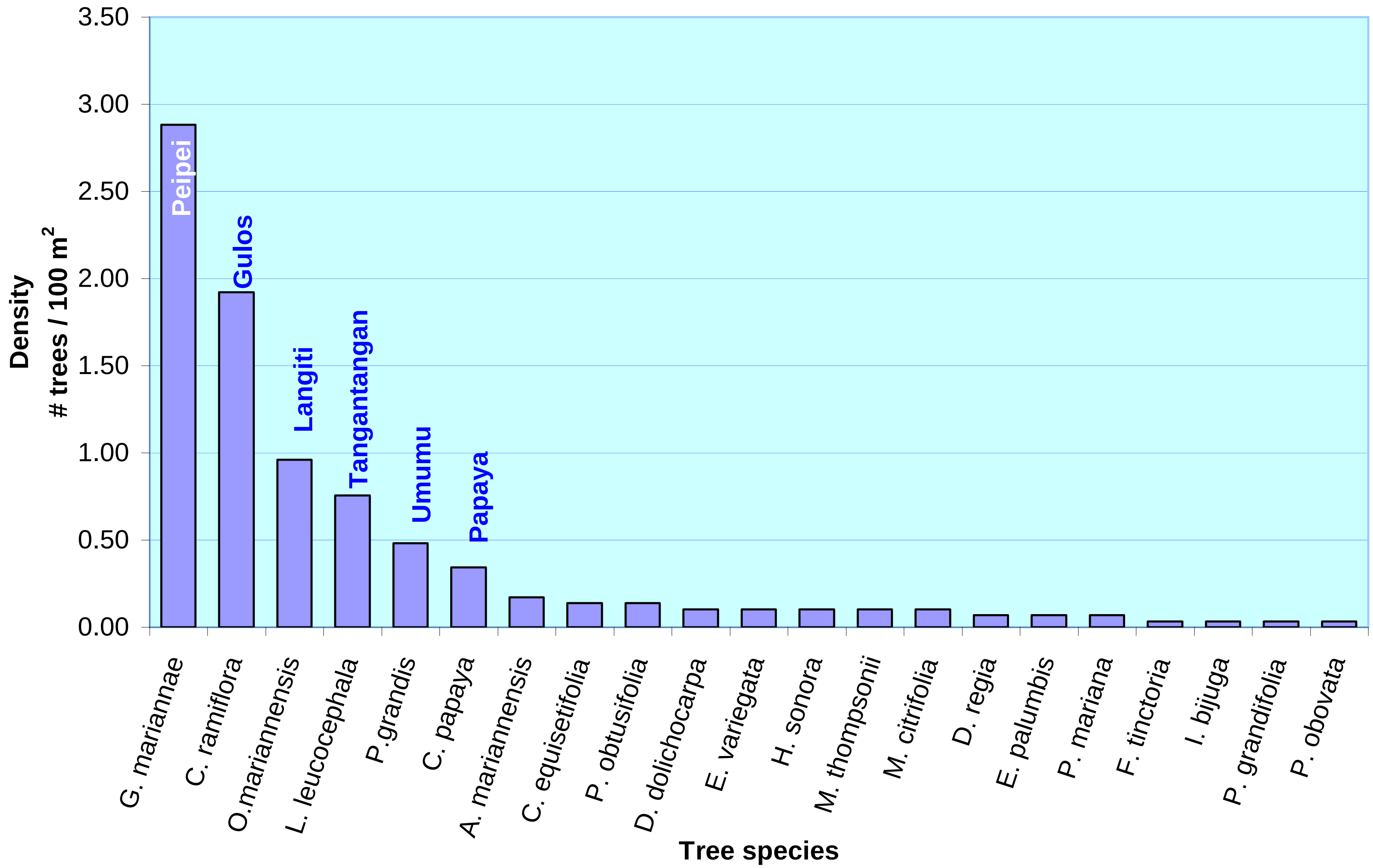

Figure 4. The density (number of trees per 100 m^2) determined from a survey of four transects (a total of 62 stations) on Aguiguan in April 2002.

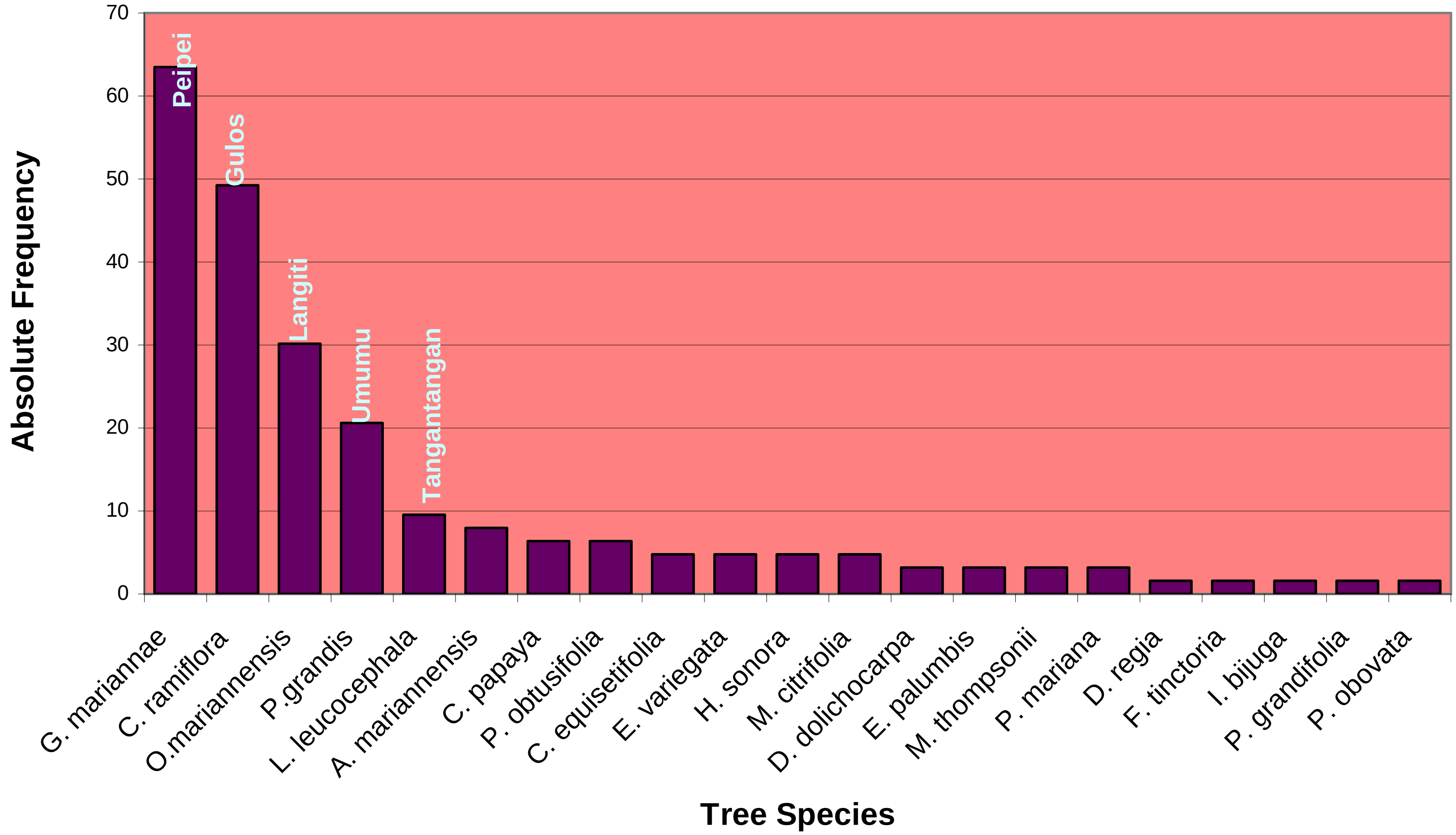

Figure 5. Absolute frequency (relative distribution of trees throughout the island) from 4 transects on Aguiguan in April 2002.

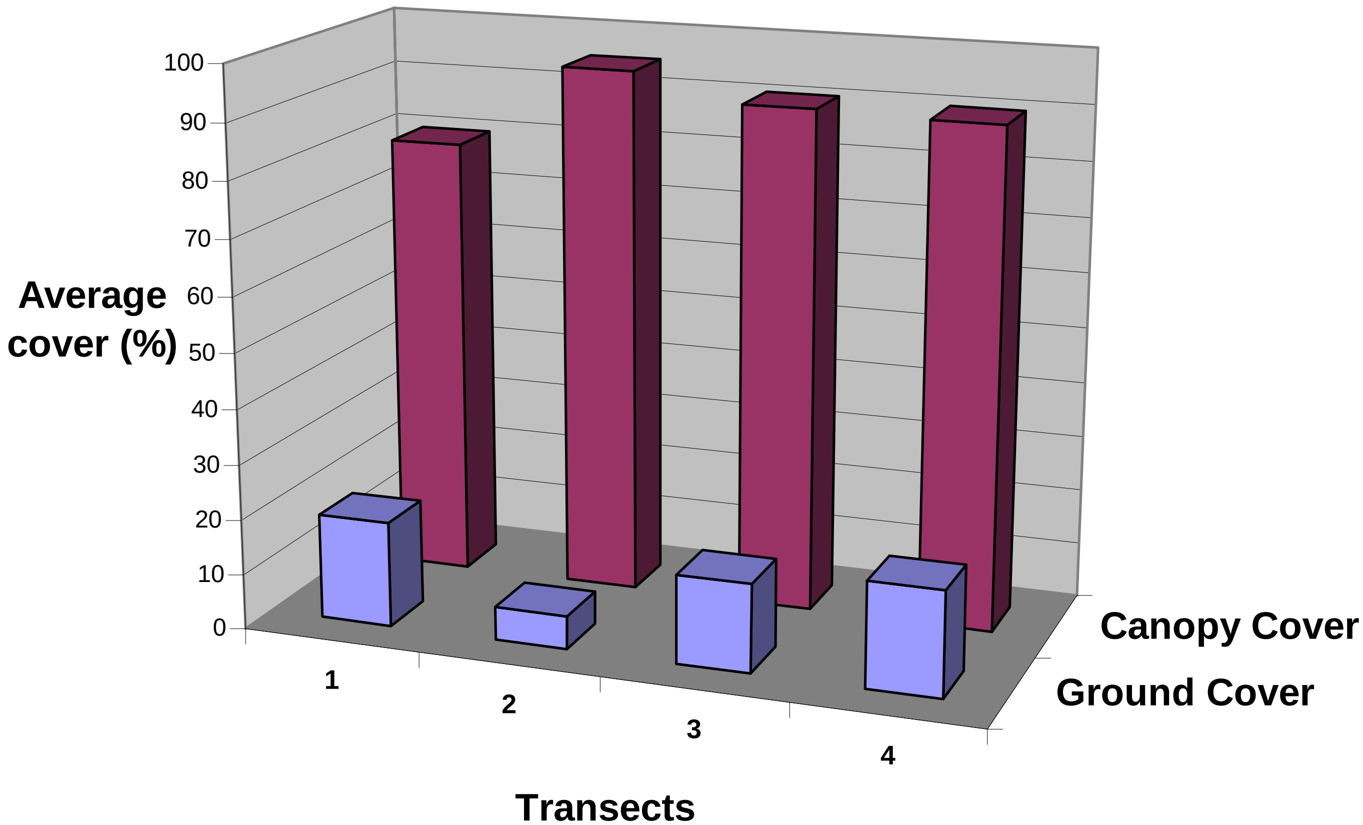

Figure 6. Average percent canopy cover and ground cover of transect stations on Aguiguan in April 2002.

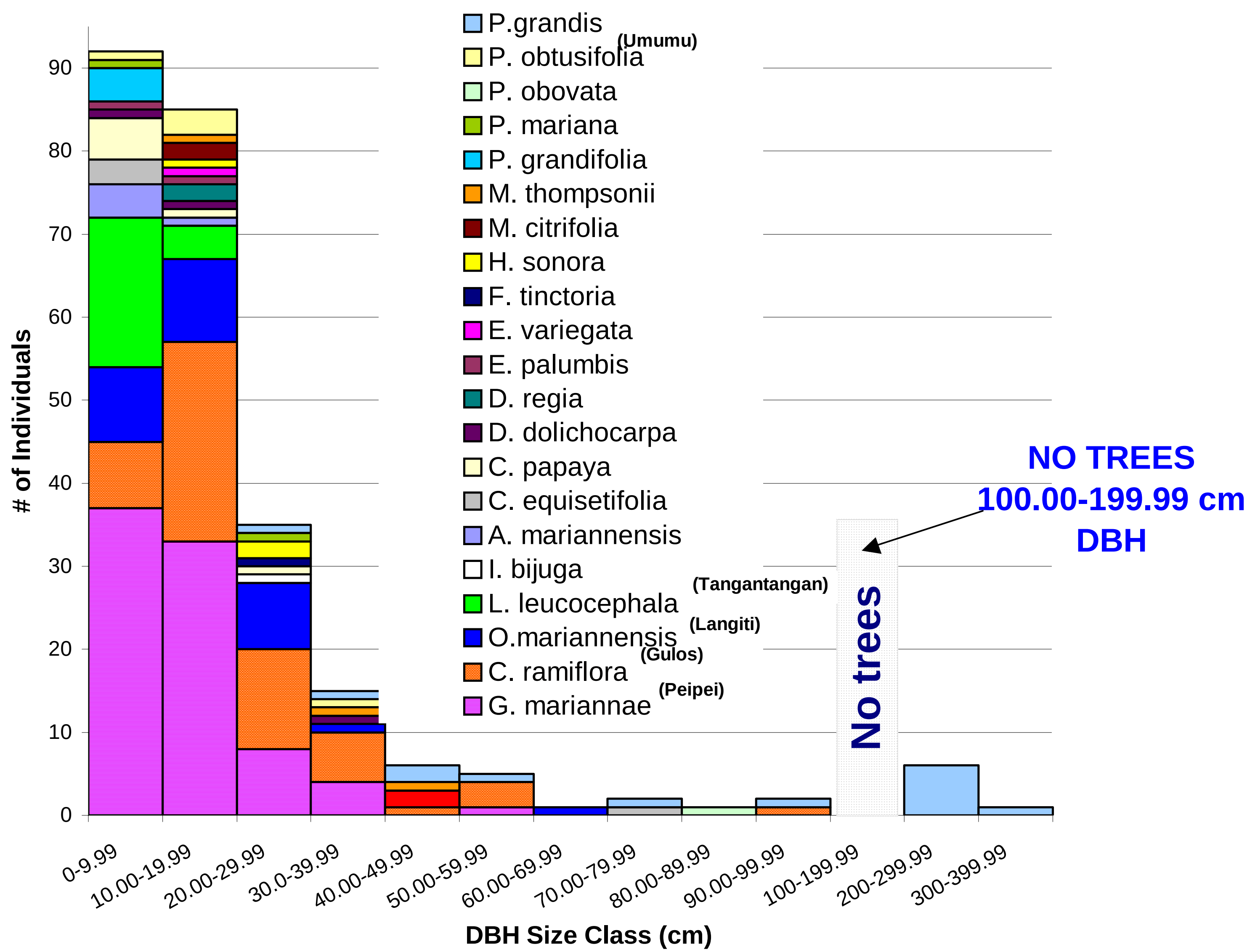

Figure 7. Diameter at breast height (DBH) size classes for trees on 4 transects on Aguiguan in April 2002.

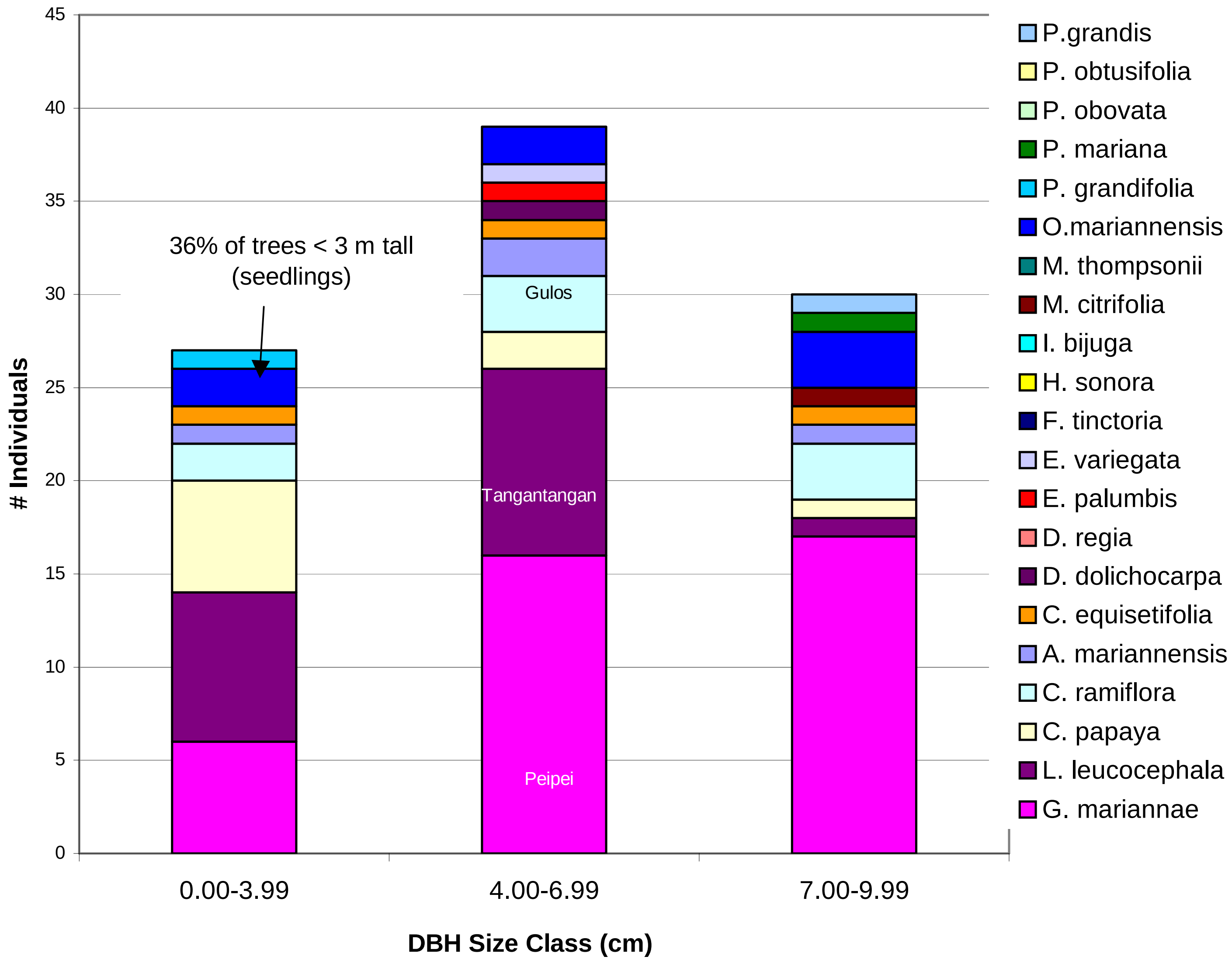

Figure 8. Species distribution in DBH size classes < 10 cm for four transects in April 2002.

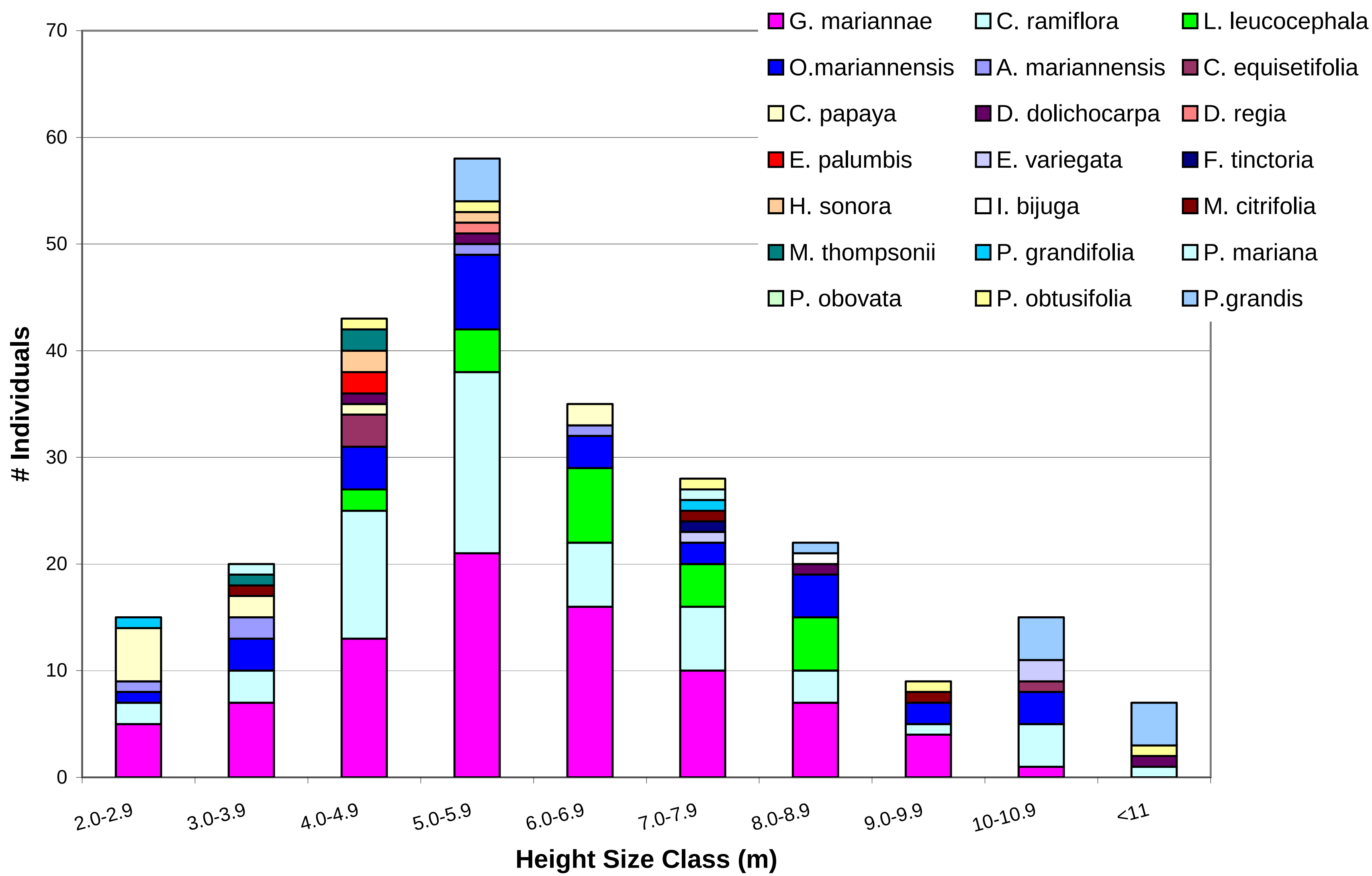

Figure 9. Height size classes of trees on four transects on Aguiguan in April 2002.

Most trees we surveyed (>50%) were less than 20 cm DBH (Fig. 7). There were no trees with DBH from 100-199.99 cm. Within the smaller size classes (< 20 cm), *C. ramiflora* and *G. mariannae* were the dominant species (Fig. 7). *Pisonia grandis* was the only species found during this survey in the very largest size classes (i.e., over 200 cm in DBH) (Fig. 7). Within the 3-3.99 cm DBH size class, 36% were < 3 m in height (Fig. 8).

The number of trees surveyed < 4 m in height (essentially seedlings) was approximately 50% of the number of trees 4 - 6 m in height. *Guamia mariannae* and *C. ramiflora* were both present as an almost constant percentage of the population throughout all size classes under 7 m. *Guamia mariannae* averaged 36% (± SD 5.4%) and *Cynometera ramiflora* averaged 20.5% (± SD 6.7) of the population less than 7 m in height (Fig. 9).

The vegetation survey revealed two trends in forest dynamics. First, Aguiguan's forests in 2002 were dominated by only a few species, with the majority of species being poorly represented. Secondly, seedling recruitment was very low. *Cynometra ramiflora* and *Guamia mariannae* dominated tree size and height classes through 49.9 cm DBH and 8.9 m in height. *Pisonia grandis* dominated the larger size classes. These three species had importance values that were more than double the value for any other species. There were a variety of tree species present in Aguiguan forests (Figs. 7 – 9), however, most of these were encountered in lower than expected densities. Examples of species whose density and frequency were low include *Erythrina variegata*, *Psychotria mariana*, *Eugenia palumbis*, *Ficus tinctoria*, *Ficus prolixa,* and *Pandanus* sp.. *Intsia bijuga* and *Melanolepis multiglandulosa* were not recorded by this survey at all.

It is difficult to determine if these observations are related to the presence of feral animals at various population levels in the past or to some other causal factor. For instance, past catastrophic events, such as typhoons, could influence forest composition dramatically. Also, there is a plethora of evidence that human alteration of Aguiguan was extensive in the past and selective uses for some species may make them scarce now. As an example, *Intsia bijuga* was logged heavily, as evidenced by many cut stumps that still persist. *Intsia* is relatively termite resistant, which made it desirable for construction purposes. The complete lack of any trees in the very large size class of 100-199.99 cm DBH suggests some disturbance in the past that wiped out a large segment of the forest population. How long ago the disturbance occurred is difficult to determine because research on tree growth rates is non-existent in the Marianas. It is possible that the combination of human activity, natural events and large feral animal populations explains the unexpected forest composition.

The forest survey data suggests that a two-fold process is occurring; first that feral animals have been selectively grazing certain species over a long period of time, and second, that intense grazing pressure has suppressed seedling recruitment to a point where the forest is not perpetuating itself. The species that dominate, *Cynometra ramiflora* and *G. mariannae,* appear to be preferentially avoided by ungulates, and therefore they survive and reproduce in greater numbers than other tree species. Other

tree species, possibly being more palatable, are grazed upon more heavily and are therefore not recruited in the forest as frequently.

The conclusion that the feral goat population is high enough to affect forest recruitment detrimentally is based on the low proportion of seedlings (36%) between 2-3 m in height in the 0-3.99 DBH size class. Normally, this size class would have the greatest abundance of trees between 2 - 3 m in height. Typically as trees mature, grow larger, and out-compete each other for resources, the number of trees decreases. Therefore, in a healthy forest, it is expected that there will be few individuals of large DBH and many individuals of the smallest DBH size class. However, on Aguiguan the highest abundance of trees occured in the 4.00 - 6.99 cm DBH size class. This indicates that most, if not all, tree seedlings are not maturing. If this condition is not reversed, there will be no younger trees to replace the mature 'adult' trees when they die, resulting in the loss of the Aguiguan forest.

Additional evidence that supports the conclusion that the feral goat population is too high for the island to sustain was the extensive grazing on bark that was observed incidentally during surveys. Goat grazing on the bark of trees girdles and kills them. When there are no young trees to fill the gaps created by the death of girdled trees, than grasses and weeds that are unpalatable to the animals begin to take root. This is occurring on Aguiguan now as *Lantana camara*, an aggressive and invasive weed, spreads under the forest canopy. Weeds and grasses will come to dominate the understory of the forest because there are no tree seedlings to compete with their spread. In a relatively short period of time, the forest will be gone. After the forest is gone, native wildlife (birds, bats, crabs, etc.) that depend on forested habitat, will decline and could become extinct on the island in the near future.

There are three possible courses of action that Tinian DLNR could take with respect to forest health. The first two assume that it is desirable to maintain at least the same amount of forested land on Aguiguan as currently. This is, of course, the only way to ensure that forest-dependent wildlife populations continue to persist. The first possible course of action is to increase hunting effort, either by allowing more hunters on the island (*i.e.,* issuing more hunting permits) or by attempting to encourage more goat hunting activity if interest is low. The second strategy to preserve the environment is to eradicate goats entirely from the island. The third course of action is to maintain current conditions, *i.e.,* maintain the status quo. If a course of no action is chosen it should be recognized that, in our professional opinion, it will result in further degradation of the forest and subsequent loss of wildlife populations.

Lantana camara

B. Photo plot surveys

The purpose of setting up photo plots on Aguiguan was to obtain a photographic baseline for temporal comparisons of vegetation in two different forest habitats. The baseline photos visually document Aguiguan's forest vegetation in the presence of feral animals. On Anatahan, transects with photo plots were established in 1996, and re-photographed in 2000, 2002, and 2003. The vegetative changes in the Anatahan photo plots showed visually and dramatically how the forest had been completely destroyed due to feral goats in just four short years. On Sarigan, photo plots were established prior to feral animal removal and re-photographed several times between 1995 and 2002. After near devastation of the forest on Sarigan, the photo plots documented the recovery of the forest after feral animals were removed.

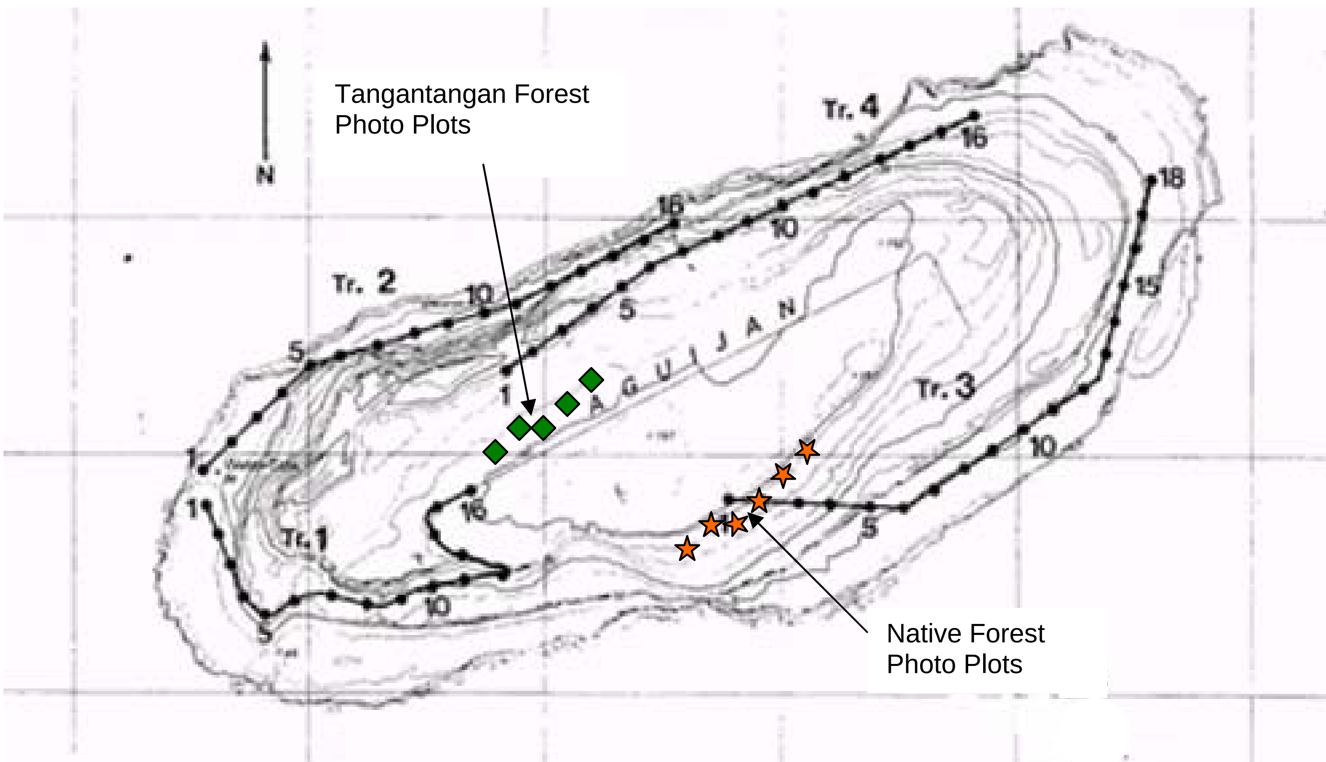

Figure 10. Location of native and tangantangan forest photo plots on Aguiguan in 2002. See Appendix 2 for actual photos of plots.

Methods for surveys and analysis

Six permanent photo plots were established in a native forest and five in *Leucaena leucocephala* (tangantangan) forest (see Appendix 2). The native forest plots were set in the area that corresponds with the beginning of transect 3. The *Leucaeana* plots are located in the forest adjacent to the water catchments near the old runway/road (Fig. 10). The 2 m x 2 m plots were spaced 50 m apart along a transect

and were surveyed using point center-quarter methods. Trees, shrubs, and seedlings were identified within each plot. In addition, a $1m^2$ herbaceous quadrat was randomly placed within a $2m^2$ area around the plot center and all herbaceous species were identified. Trees were measured for DBH and height was estimated. Percent ground cover was estimated using the line-intersect method and percent canopy cover was estimated using a densiometer according to the manufacturer's instructions. Absolute frequency (number of plots within which a species occurs ÷ total number of plots * 100) was calculated for trees, seedlings, and herbs (Mueller-Dombois and Ellenberg 1974).

Results and discussion

The native forest plots contained four tree species (Fig. 11). *Guamia mariannae* and *C. ramiflora* were the most widely distributed. There were a total of 44 seedlings throughout the six plots. The most widely distributed seedling was *C. ramiflora* (Fig. 11). There were three herbaceous species that occurred in the native forest plots; *Chromolaena odorata* was the most frequent (Fig. 12). Ground cover in the native forest plots averaged 5% (± SD 12.25), however; cover was not evenly distributed among plots (Fig. 13). Canopy cover throughout the plots averaged 94% (± SD 0.094) (Fig. 14).

The *Leucaena* forest plots contained no additional tree species or seedling species beyond those found in the native forest. Three seedlings were found which corresponded to 60% absolute frequency (Fig. 11). Two herbaceous species were identified; *B. brownei* and one unknown species (Fig. 12). Ground cover was variable between plots (Fig.13) with an overall average of 28% (± SD 26.8). Canopy cover (Fig. 14) in the *Leucaeana* forest plots averaged 88% (± SD 1.96).

The photo plots in both native and *Leucaena* forest types on Aguiguan are species poor. The understory is practically bare. By way of comparison, in similar forest types on Saipan (that lack ungulates), seedling numbers and species diversity are much greater than on Aguiguan. The *Leucaena* forests on Saipan appear to be native forest 'nurseries' as they support extensive numbers of native seedlings and young trees developing under their canopies. On Aguiguan, the understories of the *Leucaena* forests are particularly bare.

In addition, it was noted that throughout the *Leucaena* forest on Aguiguan goats are beginning to eat the bark from the trees. If the ungulate pressure is not controlled the forest is going to open up and fragment very rapidly. Stripping bark will increase the speed at which trees die. Once trees within a closed canopy forest die, forest gaps open up. The gap, or space between trees, allows in sunlight. If tree seedlings are not available to grow in the gap (because they are eaten by goats as soon as they sprout) then the space does not become filled by a new tree. This opens an avenue for invasive species. *Lantana camara,* an invasive species, is a huge problem on Aguiguan and will invade these forests gaps very quickly. *Lantana* will establish within a relatively short period of time in an understory, especially in sunlit gaps. In order to halt the deterioration of the forest, and the spread of undesirable plant species, the ungulate population must be controlled immediately and with a long-term management plan.

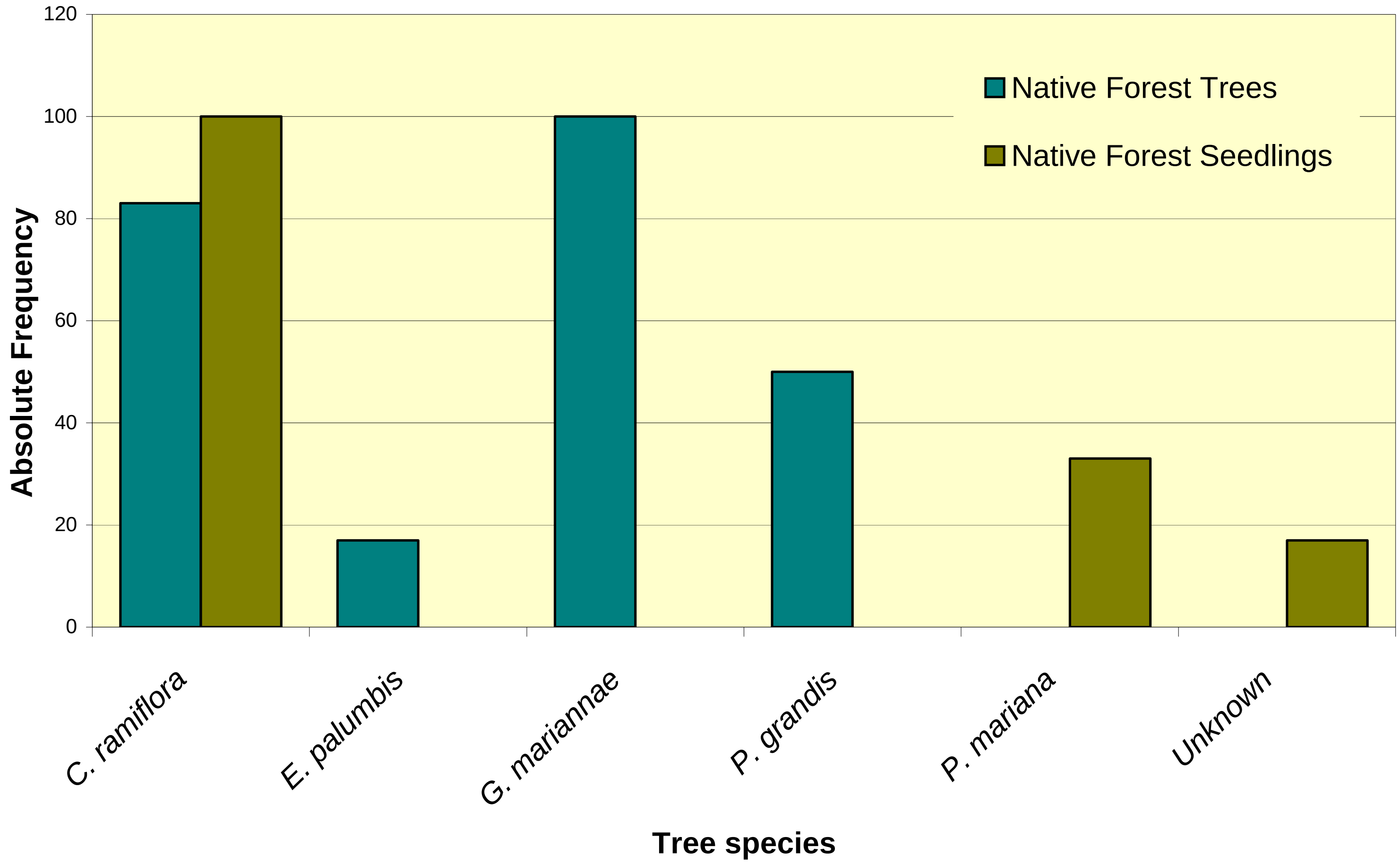

Figure 11. Absolute frequency (relative distribution of trees) of tree and seedling species in native forest plots (*n* = 6) on Aguiguan in April 2002.

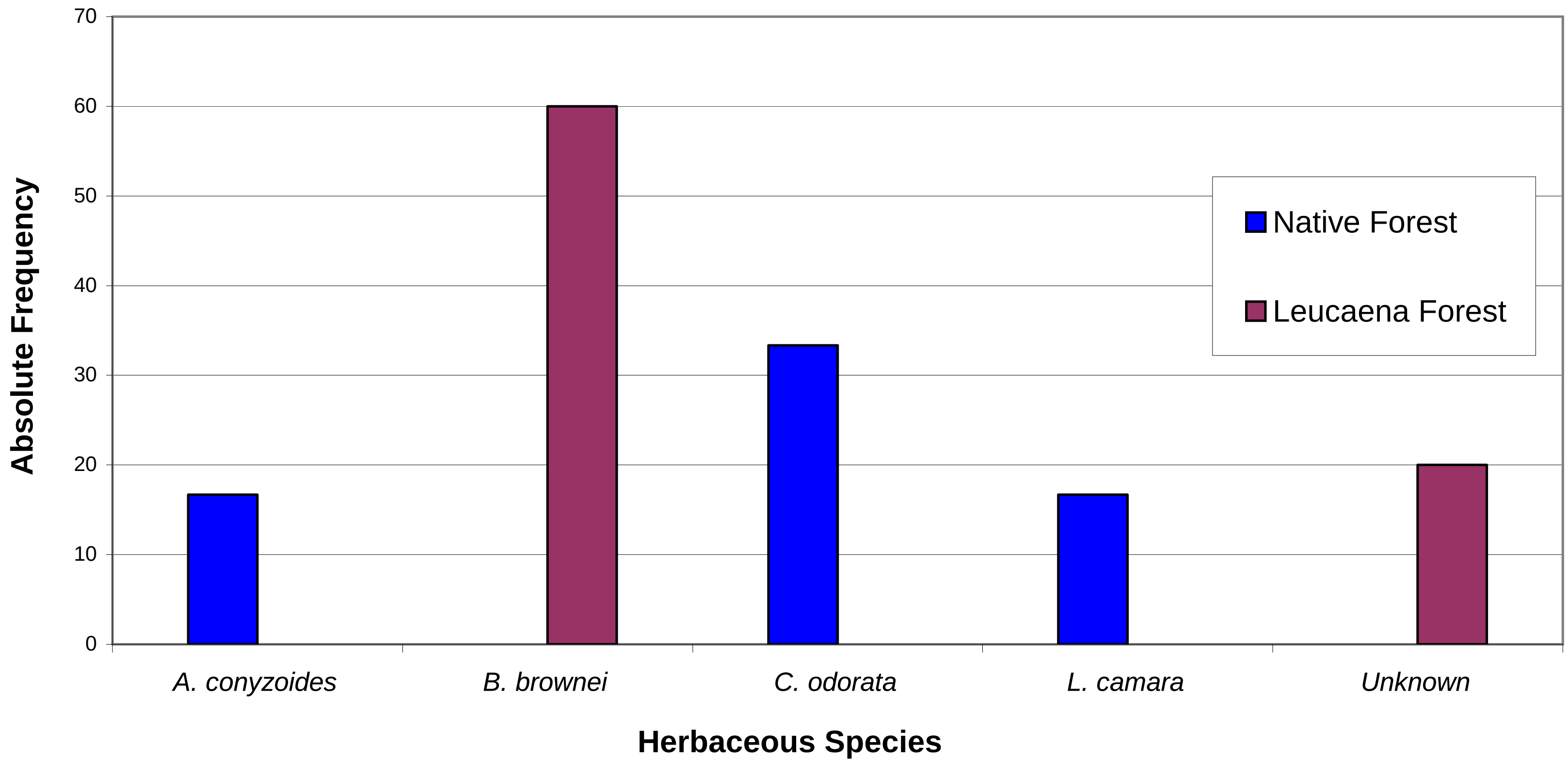

Figure 12. Absolute frequency (relative distribution) of herb species in native forest plots (*n* = 6) and *Leucaena* forest plots (*n* = 5) on Aguiguan in April 2002.

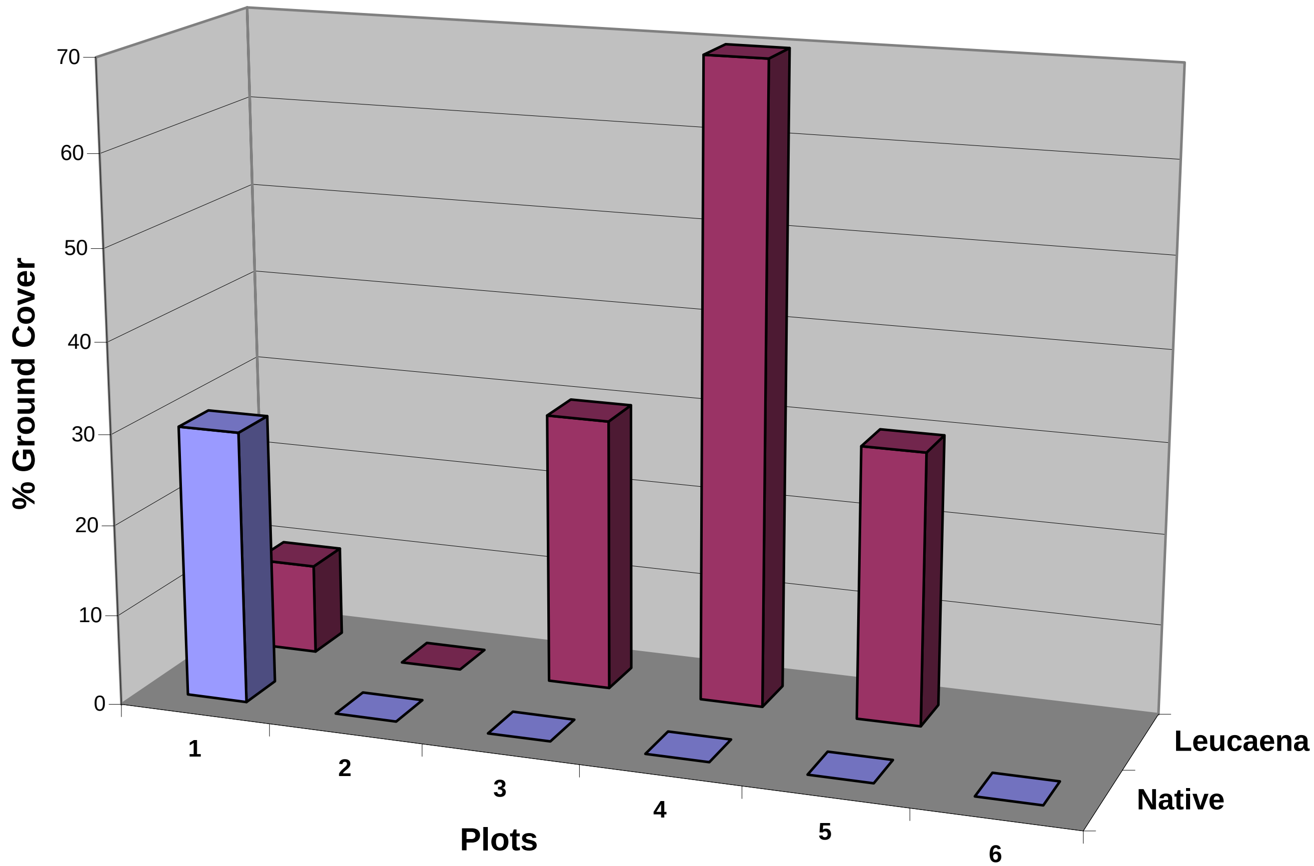

Figure 13. Ground cover in native forest (*n* =6) and *Leucaena* forest (*n* = 5) plots on Aguiguan in April 2002.

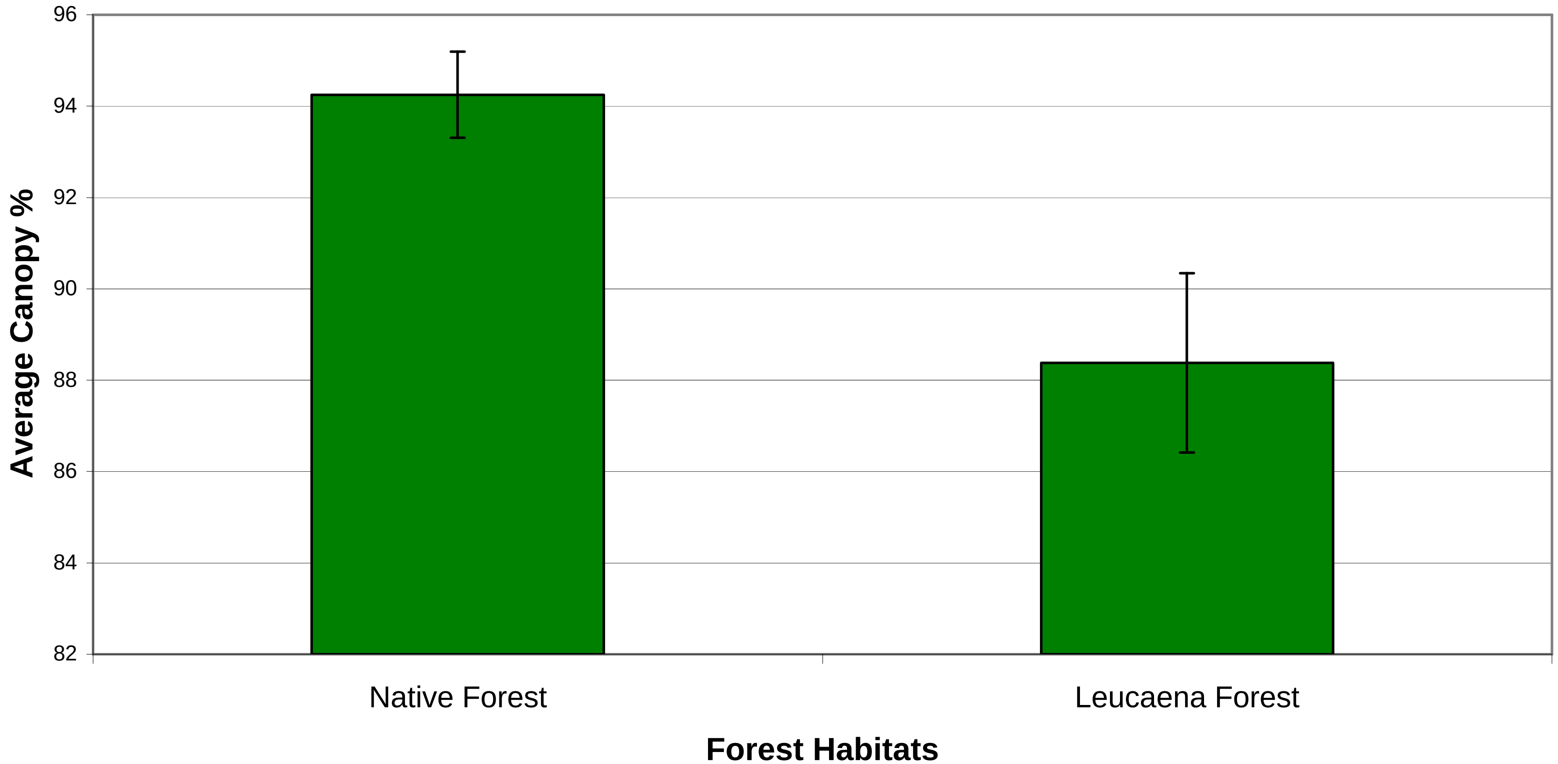

Figure 14. Average canopy cover for native forest (n = 6) and *Leucaena* forest (n = 5) plots on Aguiguan in April 2002.

The photo plots were not established for the purpose of drawing conclusions based on statistical analysis. These plots visually document forest conditions at particular points in time. It is our intention to photograph the plots again within a few years. The visual comparison of photos over time is a tool that demonstrates qualitatively the changes (or lack thereof) with changes in the presence of feral animals on Aguiguan. Based on the extensive data collected during the point center-quarter survey, we believe that Aguiguan's forests are not sustainable given current feral animal population levels.

VI. Herpetological and Small Non-Volant Mammal Surveys

Methods for surveys and analysis

Three distinct habitats were sampled (Fig. 1); rocky strand/grassy habitat, native limestone forest, and an introduced *Leucaena leucocephala* (tangantangan) forest to determine the presence, abundance, and habitat preference of diurnal and nocturnal lizards. Along the native limestone forest and *Leucaena* forest transects twelve trapping stations were established at 25 m intervals. One Victor® sticky-glue trap was placed flush with the ground at each station to sample diurnal lizards (Bauer and Sadlier 1992; Rodda *et al*. 1993). Traps were placed in the morning (0700-0830 h) and run for four to six hours on three consecutive days. Nocturnal lizards were also sampled along the native limestone forest and *Leucaena* forest transects using one Victor® sticky-glue trap stapled to the trunk of a tree at a height of 0.25-1.0 m at each station. Traps were placed one hour prior to sunset and checked the following morning (0700-0800 h).

Trapping stations were placed along the rocky strand area near the Landing Point at sites likely to capture *Cryptoblepharus poecilopleurus* (the Snake-eyed skink) and *Emoia atrocostata* (the Tide pool skink). Seventeen trapping stations were established and run for four consecutive hours capturing 15 diurnal lizards (Table 6).

Monitor lizards (*Varanus indicus)* were sampled along two transects adjacent to those established to sample diurnal and nocturnal reptiles. Twelve flat loop snare traps, similar to bird of prey traps (Berger and Mueller 1959) were placed every 50 m and baited with approximately one pound of fresh goat meat. The loop snare traps were baited at 0800 h and run for three consecutive days. Each trap was monitored every ten to twelve hours and re-baited if necessary. Relative abundance of monitor lizards was also carried out by visual survey. The number of monitor lizards sighted walking to and from survey transects were recorded against time.

Victor® snap-traps were used along each of the two forest transects to document the species of *Rattus* present on the island. Two traps were placed at each station, one positioned in a tree at a height of approximately 0.5 –1.0 m and the other flush to the ground. Each trap was baited with peanut butter, set one hour prior to sunset (1800 h), and checked the following morning (0730-0830 h).

Table 6. Comprehensive description of adhesive trapping transects established to assess lizard presence and abundance in native limestone forest and introduced forest on Aguiguan, March 14-21, 2002 as compared to surveys by Campbell (1995) and Cruz *et al*. (2000).

Introduced Forest						
Date	# Traps	Transect Length (m)	Survey Type	Placement	Survey Hours	Trap Hours
3/15/2002	13	325	nocturnal	tree	14	182
3/16/2002	24	300	diurnal	ground/tree	8	192
3/17/2002	13	325	nocturnal	ground/tree	14	182
3/17/2002	24	300	diurnal	ground/tree	8	192
3/18/2002	13	325	nocturnal	tree	14	182
3/18/2002	24	300	diurnal	ground/tree	8	192
Total March 2002 (this survey)	**111**	**1875**	**NA**	**NA**	**66**	**1122**
Total April 2000 (Cruz *et al*.)	72	1800	NA	NA	57	2036
Total May-June 1995 (Campbell)	74	1850	NA	NA	NA	1378
Native Forest						
3/17/2002	12	300	nocturnal	tree	14	168
3/17/2002	24	300	diurnal	ground/tree	8	192
3/18/2002	12	300	nocturnal	tree	14	168
3/18/2002	24	300	diurnal	ground/tree	8	192
3/19/2002	12	300	nocturnal	tree	14	168
3/19/2002	24	300	diurnal	ground/tree	8	192
Total March 2002 (this survey)	**108**	**1800**	**NA**	**NA**	**66**	**1080**
Total April 2000 (Cruz *et al*.)	72	1800	NA	NA	56	1998
Total May-June 1995 (Campbell)	95	2375	NA	NA	NA	2073

Results and discussion

Eight of the fifteen known lizard species in the Marianas were documented during this investigation; *Emoia caeruleocauda, Emoia atrocostata, Cryptoblepharus poecilopleurus, Lepidodactylus lugubris, Gehyra mutilata, Gehyra oceanica, Hemidactylus frenatus,* and *Varanus indicus*. In 1995, *Hemidactylus frenatus, Gehyra mutilata*, and *Emoia atrocostata* were documented for the first time on Aguiguan by Campbell. Cruz *et al*. also documented *Hemidactylus frenatus and Gehyra mutilata* in 2000, but failed to capture *E. atrocostata.*

We captured nine *E. atrocostata* within four hours time (0800-1200 h) in 2002 while utilizing 17 sticky traps near the rocky strand at the Landing Point. Cruz *et al*. (2000) utilized 13 sticky traps at the same rocky strand and documented only 2 lizards, neither

of which were *E. atrocostata.* This suggests temporal, tidal, or population fluctuations in *E. atrocostata* and warrants further investigation (Table 7).

Tide pool skink *Emoia atrocostata*

Table 7. Results of diurnal and nocturnal adhesive trapping Aguiguan, March 14-21, 2002 as compared to Cruz *et al*. (2000) where *Ec = Emoia caeruleocauda, Ea = Emoia atrocostata, Cp = Cryptoblepharus poecilopleurus, Ll = Lepidodactylus lugubris, Gm = Gehyra mutilata, Go = Gehyra oceanica, Hf = Hemidactylus frenatus,* and *Vi = Varanus indicus*.

Habitat	# Traps	# Hours	Trap Hours	# Lizards	*Ec*	*Ea*	*Cp*	*Ll*	*Gm*	*Go*	*Hf*	Vi	Lizards /100 Tr Hrs 2002	Lizards /100 Tr Hrs 2000
Diurnal Trapping														
Rocky Strand	17	4	68	15	1	9	5	0	0	0	0	0	22.05	2.37
Introduced Forest	39	18	702	22	18	0	0	0	0	0	0	4	3.13	6.63
Native Forest	36	18	648	4	4	0	0	0	0	0	0	0	0.62	2.48
Total	92	40	1418	41	23	9	5	0	0	0	0	4	2.89	4.13
Nocturnal Trapping														
Introduced Forest	39	42	1638	3	2	0	0	0	1	0	0	0	0.18	0.56
Native Forest	36	42	1512	11	0	0	0	0	3	0	7	1	0.73	0.28
Total	75	84	3150	14	2	0	0	0	4	0	7	1	0.44	0.42
Aguiguan Total	167	124	4568	55	33	9	6	0	4	0	7	5	1.2	1.85

It should be noted that *Gehyra oceanica* and *Lepidodactylus lugubris* were not documented during transect surveys but were collected by hand capture. *G. oceanica* was encounter at the entrances of Krisidu and Guano cave, while *L. lugubris* was found in the native limestone forest near the entrance of Krisidu cave. A *Ramphotyphlops braminus* (blind or worm snake) was also hand collected in a rotten *Ceiba pentandra* (Kapok tree) at an introduced *Leucaena leucocephala* (tangantangan) forest edge.

Loop snare traps captured six *V. indicus* in the introduced forest and four *V. indicus* in the native forest habitat. These figures are considerably lower than captures in 2000 (Cruz *et al*. 2000; Table 8). The lower number of captures in 2002 may reflect the monitor hunting activity of the Tinian Department of Lands and Natural Resources (DLNR) Conservation Officers who typically utilized lead-base control on the monitor population in an effort to protect species such as the Micronesian megapode. This type of control tends to remove the larger, easier to identify individuals from the population (Don Reyes, Tinian DLNR Conservation Officer *pers. comm*.), leaving the smaller (< 300 mm snout-vent length [SVL]) individuals that predate and scavenge smaller prey. The hunting activity may produce a bias in the age-size structure of the population that was reflected in the capture of five small monitors (average SVL 220 mm) on sticky traps during the surveys. We also encountered predation of small diurnal lizards caught by sticky traps during transect surveys.

Table 8. Results of monitor lizard snare-trapping and visual surveys conducted on Aguiguan Campbell 1995, Beauprez 2000, and Hawley 2002.

Survey Year	Habitat	# Trap Days	# Lizards	Lizards/100 Trap Days
2000	Introduced Forest	32	11	34.4
2002	Introduced Forest	36	6	16.6
2000	Native Forest	21	7	33.3
2002	Native Forest	36	4	11.1
		# Hours	# Individuals	Lizard/Hr. Obs.
1995	Savannah	3.4	25	7.3
2000	Introduced Forest	0.47	5	10.6
2002	Introduced Forest	6	32	5.3
1995	Native Forest	3.7	10	2.7
2000	Native Forest	2.2	19	8.6
2002	Native Forest	2	13	6.5

We encountered *V. indicus* relatively frequently during visual surveys. Consistent with findings reported in Cruz *et al*. (2000) and Campbell (1995), we documented an average of 5.3 individuals per hour in the introduced forest and 6.5 individuals per hour in the native limestone forest habitat.

Snap-trap surveys documented seven *Rattus exulans,* six from the introduced *Leucaena leucocephala* (tangantangan) forest transect and one individual from the native limestone forest transect. Trap predation was clearly evident at 15 of the 36 native limestone forest trap stations possibly by coconut crabs or monitor lizards and therefore may account for the low trap success. A total of six coconut crabs were trapped in native limestone forest and 3 from introduced *Leucaena* forest. J. Esselstyn also observed several *Rattus sp.* in a coconut stand north east of camp but unfortunately no specimens were collected for documentation. All rats were identified by morphological characteristics following Campbell 1995.

Joe Gonzales getting ready for lizard surveys.

VII. Management Recommendations

The first and foremost need for management of Aguiguan's biotic community is to either control, or preferably eradicate, the population of feral goats. The damage that goats have done to the island's vegetation is extensive. Regeneration within forests is

virtually non-existent. Extensive fields of introduced plants, which provide little benefit to native wildlife, dominate large tracts of the island. The current intensity of browse by goats is more than can be sustained by native vegetation. If the goat population is not reduced, it will only be a matter of time before Aguiguan's native forest succumbs. This will result in a loss of habitat and the likely extirpation of local bird, bat, invertebrate, and plant populations.

Once an effective goat control or eradication program has been established, it would be beneficial to begin restoring areas that have been taken over by exotic plants. For reforestation techniques suitable for Aguiguan, see Cruz *et al*. (2000). An entirely forested Aguiguan would make an ideal wildlife sanctuary because of its remote location and lack of human residents. This greatly reduces the likelihood that populations of introduced predators (*i.e*., Brown treesnakes and Black rats) will become established.

Additionally, some important research questions remain unanswered. These include:

1. Where and how does Aguiguan's population of Megapodes nest?

2. What has allowed the Pacific sheath-tailed bat to persist on Aguiguan and what are its limiting factors?

3. Do Nightingale reed-warblers occasionally visit Aguiguan, or are they entirely absent from the island?

4. What environmental variable might explain the population fluctuations in *Emoia atrocostata* at the Landing Point?

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Aguiguan 2002 survey team: standing (l-r) Henry King, Don Reyes, Laura Williams, Al Reyes, Jake Esselstyn; seated (l-r) Nathaniel Hawley, Joe Gonzales, Elvin Masga, Rob Ulloa (Tina de Cruz not pictured).

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A long day's journey into night

APPENDIX 1

GPS coordinates for bird and vegetation survey transects and for entrances to swiftlet caves where arrival counts were conducted in 2002.

			GPS Coordinates		
Island	Transect	Station	55Q	UTM	Notes
Aguiguan	1	4	342614	1641869	
Aguiguan	1	5	342679	1641741	
Aguiguan	1	6	342697	1641570	
Aguiguan	1	7	342723	1641448	
Aguiguan	1	8	342784	1641352	
Aguiguan	1	9	342943	1641380	
Aguiguan	1	10	343061	1641417	
Aguiguan	1	11	343212	1641388	
Aguiguan	1	12	343327	1641399	
Aguiguan	1	13	343470	1641447	
Aguiguan	1	14	343581	1641549	
Aguiguan	1	15	345560	1641614	
Aguiguan	1	16	343517	1641727	
Aguiguan	1	17	NONE		
Aguiguan	1	18	NONE		
Aguiguan	2	1	342686	1641876	
Aguiguan	2	2	342801	1641973	poor coverage
Aguiguan	2	3	342881	1642106	poor coverage
Aguiguan	2	4	342919	1642240	
Aguiguan	2	5	343001	1642336	
Aguiguan	2	6	343257	1642463	
Aguiguan	2	7	343268	1642489	
Aguiguan	2	8	343401	1642474	
Aguiguan	2	9	343681	1642536	
Aguiguan	2	10	343683	1642539	
Aguiguan	2	11	343808	1642597	
Aguiguan	2	12	343951	1642660	
Aguiguan	2	13	344040	1642768	
Aguiguan	2	14	344160	1642861	
Aguiguan	2	15	344288	1642902	
Aguiguan	2	16	34420	1642969	GPS MISSING A DIGIT
Aguiguan	3	1	344804	1641844	
Aguiguan	3	2	344804	1641844	
Aguiguan	3	3	344923	1641815	
Aguiguan	3	4	345043	1641722	
Aguiguan	3	5	345165	1641777	
Aguiguan	3	6	345270	1641811	
Aguiguan	3	7	345376	1641808	
Aguiguan	3	8	345494	1641878	
Aguiguan	3	9	345616	1641949	

Island	Transect	Station	GPS Coordinates 55Q	UTM	Notes
Aguiguan	3	10	345751	1642057	
Aguiguan	3	11	345869	1642138	
Aguiguan	3	12	345977	1642227	
Aguiguan	3	13	346077	1642317	
Aguiguan	3	14	346195	1642394	
Aguiguan	3	15	346296	1642500	
Aguiguan	3	16	346379	1642607	
Aguiguan	4	1	344256	1642585	poor coverage
Aguiguan	4	2	344394	1642685	
Aguiguan	4	3	344503	1642806	
Aguiguan	4	4	344603	1642837	
Aguiguan	4	5	344742	1642948	
Aguiguan	4	6	344856	1643027	
Aguiguan	4	7	344987	1643092	
Aguiguan	4	8	345138	1643165	
Aguiguan	4	9	344415	1642788	
Aguiguan	4	10	344298	1642675	poor coverage
Aguiguan	4	11	345266	1643183	
Aguiguan	4	12	345407	1643236	
Aguiguan	4	13	345540	1643295	
Aguiguan	4	14	345694	1643278	
Aguiguan	4	15	345830	1643246	
Aguiguan	4	16	345980	1643205	
Aguiguan	KRISIDU CAVE		344987	1641521	
Aguiguan	STAIR-WAY CAVE		345320	1641785	
Aguiguan	BLACK NODDY CAVE		344562	1643005	
Aguiguan	PILLAR CAVE		343100	1642433	30 m away from entr.
Aguiguan	GUANO CAVE		342874	1641361	
Aguiguan	LANDING CAVE		342547	1641995	
Aguiguan	A CAVE		NONE		
Aguiguan	B CAVE		342905	1641179	Error? see cave E
Aguiguan	C CAVE		342887	1641161	
Aguiguan	D CAVE		NONE		
Aguiguan	E CAVE		342905	1641179	Error? see cave B
Aguiguan	NEW CAVE (#6)		343191	1641756	
Aguiguan	CREVICE CAVE		NONE		
Aguiguan	DUNGKULO CAVE		343268	1641484	
Aguiguan	ELVIN'S CAVE		343189	1641665	
Aguiguan	CLIFF CAVE		NONE		

APPENDIX 2

Vegetation Photo Plots established on Aguiguan in April 2002

Native Forest Plot 1

Native Forest Plot 2

Native Forest Plot 3

Native Forest Plot 4

Native Forest Plot 5

Native Forest Plot 6

Leucaena Forest Plot 1

Leucaena Forest Plot 2

Leucaena Forest Plot 3

Leucaena Forest Plot 4

Leucaena Forest Plot 5