2000 Technical Report #7

Wildlife and Vegetation Surveys

PAGAN ***2000***

Conducted
By

CNMI Division of Fish and Wildlife
Wildlife Section

With Assistance
From

The Northern Island Mayor's Office

3-9 AUGUST 2000

Please cite as: Cruz, J., L. Arriola, **N. Johnson, and** ***G*****. Beauprez. 2000.** Wildlife and **Vegetation Surveys Pagan 2000. Technical Report #7 CNMI-DFW,** unpubl.

SUMMARY OF WILDLIFE SURVEYS PAGAN ISLAND

3-9 AUGUST 2000

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Executive Summary

Wildlife habitat throughout the island has been drastically altered by activities of feral animals and by the volcanic eruption in **1981.** Herds of feral cattle, goats, and pigs continue to prevent regeneration of plants, accelerate deterioration around the lakes, and have created areas susceptible to erosion. Pagan was visited from **3-9** August **2000** to assess forest bird, vegetation, fruit bat, lizard, skink, gecko, and rat populations. Bird surveys in areas of particular importance to those interested in establishing homesteads on the island were the main, and on assessing the Micronesian Megapode population were the main focus.

Surveys of forest birds in the northern portions of the island found Micronesian Starlings and Micronesian honeyeaters to be abundant. White terns and Collared kingfishers were common in open fields and ecotones. White-throated ground-doves were scarce and the endangered Micronesian megapode was rare. Megapodes were not detected in areas of colonizing *Casuarina* trees that are beginning to form monocultural stands on several parts of the island.

The forests of Pagan are patchy and fragmented. Several areas certainly have undergone forest degradation due to feral animals and not volcanic activities. The primary vegetation of the areas surveyed is most unfortunately introduced non-native species. There is a staggering amount of *Casuarina equisetifolia* which is a known weed and undesirable tree in Hawaii and Australia. C. *equisetifolia* is forming huge monostands. C. *equisetifolia* is a very poor quality tree for wildlife, native flora species and even human use. The impacts of this species becoming dominant across the island could be devastating. ***Cocos nucifera*** , *Leuceana leucocephala* and ***Jatropha curcas*** are the other most frequent and abundant tree species. These tree species are not particularly favorable wildlife species. In addition there is a complete lack of a seedling understory in the forests. Therefore, there are no young trees to maintain the forests. The results will be degenerating and finally disappearing forests. This is already in progress.

Numbers of both lizards and rats were low on Pagan. Only *Rattus **rattus*** was detected along the small mammal transects. Lizard surveys should be repeated more extensively to confirm an apparent drop in abundance.

One large colony of Mariana fruit bats with 800 bats was discovered. Two additional colonies with populations of **200** and **150** bats respectively were also discovered in the southwest region. This results in a minimum population estimate of **1500** total fruit bats on Pagan which is considerably lower than in **1983 (Wiles** *et al.* **1989).** Sadly except a few sightings fruit bat solitary and small aggregation observations were rare. The bat population decline and possible human wariness due to poaching is quite evident.

The most urgent management suggestion is to immediately initiate a feral animal removal and harvesting plan. The plan should be drawn up by DFW, the former residents of Pagan, and the Office of the Mayor of the Northern Islands. The objective would be to create a protected area and hunting reserve on the southern peninsula so that megapode, fruit bat, and coconut crab populations can recover from the effects of feral ungulates.

Introduction

Pagan is one of the largest (c. 4,770 ha) and most complex of the Northern Islands. Although currently uninhabited, there have been frequent periods of large numbers of residents in the past (*e.g.*, as many as 6,000 Japanese were stationed on Pagan during WWII). Colonization, sugar cane plantation management followed by volcanic eruptions, removal of the human populace, and subsequent growth of feral animal populations have had extensive impacts on both floral and faunal components of the ecosystem.

Mt. Pagan

Pagan's exquisite beauty and wide expanses of level ground make it one of the most suitable islands north of Saipan for development. A number of protected bays to harbor fishermen during storms, a good anchorage, and two semi-protected black-sand beaches make access by far the easiest of any of the northern chain. In addition, an old runway that can still accommodate small planes (despite being cut in length by a lava flow in 1981), greatly facilitates recreational, survey, and scientific access. Pagan enjoys the only raised reef in the northern islands, with a shallow fringing coral reef supporting a multitude of large fish. It is one of the main stops for Marianas fisherman exploiting these waters. Perhaps the island's distance from Saipan, lack of reliable transportation, and copious numbers of flies have kept Pagan from being more fully utilized than it is today. Dung breeding flies can, of course, be reduced by controlling the number of feral animals, as evidenced by the virtual disappearance of flies from post-eradication Sarigan.

Two brackish lakes grace the northwestern side of Pagan and are the only inland bodies of standing water in the Northern Islands. Formerly home to Marianas mallards (*Anas ousteleti*, nanga palao; extinct) Common moorhens (*Gallinula chloropus*, pulattat; endangered), and Nightingale reed-warblers (*Acrocephalus luscinia*, gaga karisu; endangered), habitat disintegration around the lakes (due to volcanic activity compounded by impacts of feral animals) has undoubtedly helped to extirpate these three important birds from the island. The northern portion of the island has been much influenced by the volcanic effluvia from eruptions in 1981 and 1986. It supports large numbers of feral cattle, pigs, goats, and fowl. The southern peninsula currently has active steam vents and probably supports the majority of the remaining populations of Micronesian megapodes (*Megapodius laperouse*, sasangat), Mariana fruit bats (*Pteropus mariannus*, fanihi), and Coconut crabs (*Birgus latro*, ayuyu). Pigs and goats were observed in this sector but not cattle.

Unfortunately, the ecological integrity of Pagan has been compromised by the large number of feral animals that are widely distributed on the island and by the volcanic eruption. Most areas of Pagan bear strong evidence of damage done by feral ungulates. The natural vegetation has been removed through browsing in many places, leaving them open and susceptible to soil erosion. The overall effect is of drying out of the soil and lack of an understory in the forest.

CNMI-DFW was able to conduct bird, bat, coconut crab, and reef surveys of Pagan on 24-31 August 1999. On 3 August 2000 the surveys conducted on Pagan of forest birds, herpetological fauna, Mariana fruit bat, and vegetation. Insects and arthropods were collected opportunistically. Bird surveys were conducted along four transects similar to those of 1999. The only bird transect not repeated in 2000 that was completed in 1999 was on the southern peninsula as it was inaccessible due to rough seas.

Browse line from feral animals evident at the edges of fragmented forest facing Togari Rock east of the airstrip.

Staff from DFW and NIMO (Northern Islands Mayor's Office) were transported to Pagan by the Marlin II. Pagan was departed (for Agrihan) on 9 August just as the effects of nearby tropical storm were hitting the islands. Survey personnel included Paul Reyes (CNMI-DFW) and Jamie Saures (CNMI-NIMO) who conducted the herpetofauna and small mammal surveys. Forest bird, bat, and vegetation surveys were conducted by Nathan Johnson, Laura Arriola and Tina de Cruz (CNMI-DFW). Hunting of feral animals was conducted by NIMO staff and special representatives: Ed, Paul and Pat Santos; Sylverio Mettao; Ino, Ed, and Jess Saures; Victor Romoar; and Romy Wapol. The findings of the 2000 survey trip are reported below and compared to the 1999 surveys whenever possible.

Forest Bird Surveys

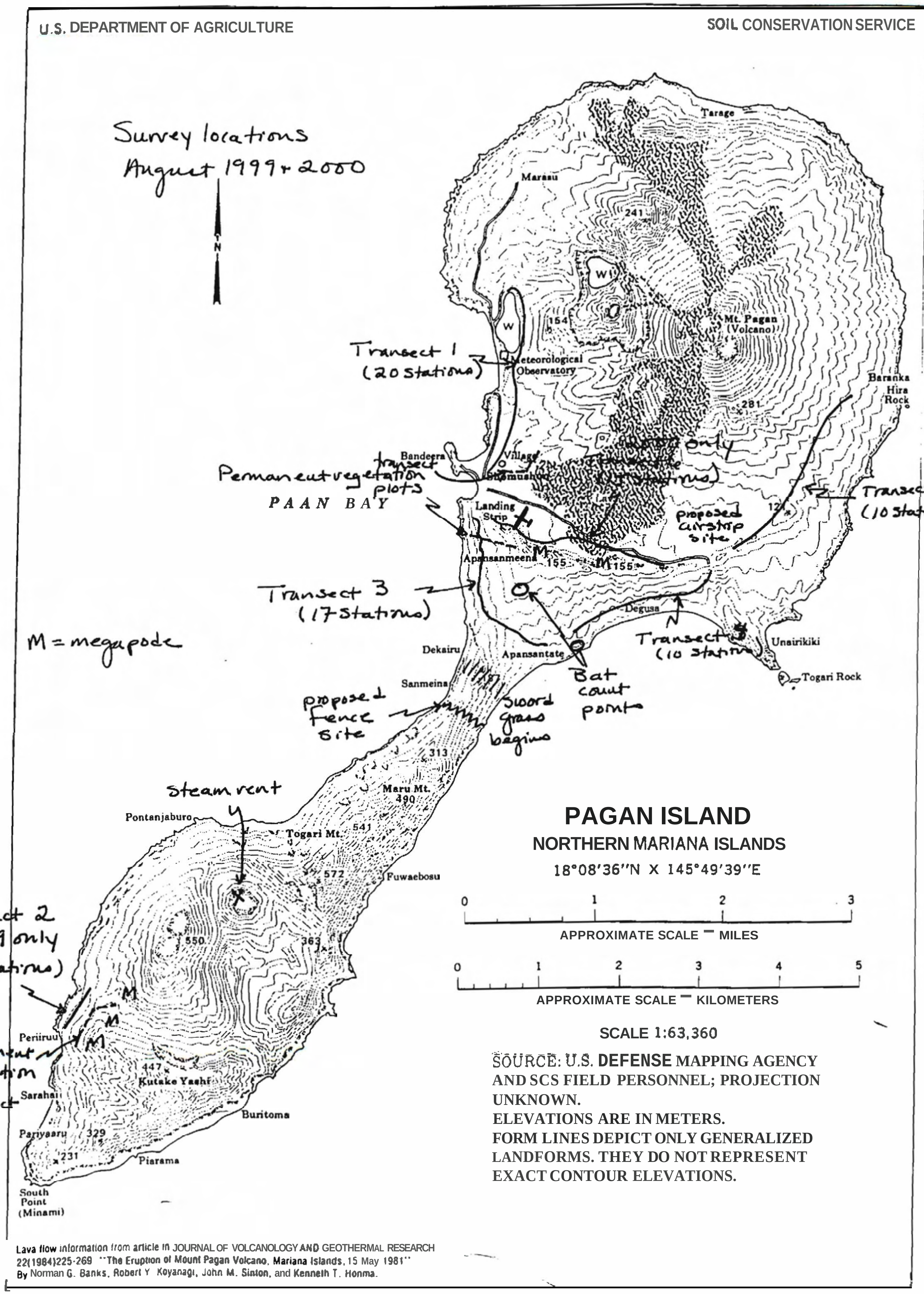
Forest bird surveys were conducted using VCP methodology on 4-7 August 2000. The surveys were conducted in the mornings from 6:00 to 10:30 a.m. Birds were counted after either visual or auditory identification. Count duration was 5 minutes so that results could be compared with those of 1999. The

distance to each detection was estimated. No playbacks were employed and most birds were counted by their song or call notes.

Point counts were performed at permanent stations spaced every 150 m along five transects (Fig. 1). The transects were set to sample different forest habitats, repeating those of 1999, and were composed of between 10 and 20 count stations. Transect 2 on the southern peninsula was not repeated in 2000 due to transportation difficulties in heavy seas. An extra transect (#6) was completed in the northern sector instead. These two transects are included in the general analysis of bird populations on the island for each year, but not included in the paired comparisons of counts per station between years. A total of 72 stations in 2000 were sampled, all located in the northern sector.

Transect 1 runs northward along the old road from the campsite near the landing bay, toward the former village, then onward to the lower lake and ends on the north side of that lake. Transect 3 begins on the south side of the air strip and follows the road up the old caldera ridge, continuing on through native forest to the open fields formed by cattle and goat grazing. Transect 4 begins to the east of the end of the old road heading out past the air-strip. It runs south then southeast through coconut and mixed native forest at the field/forest interface. Transect 5 begins to the north of the same road end and heads to the northeast through Casuarina forest, mixed native forest and field/forest interface. Transect 6 parallels the base of the old caldera through remnant agroforest and native forest spared by the last eruption. Point count stations were not permanently marked but can be relocated using the GPS coordinates in Appendix I.

Transect 6 runs below the escarpment along the cliff edges.



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The most numerous birds this year were Micronesian starlings (*Aplonis* opaca, sali). They were widespread in all sampled habitats and were detected at 88% of our count stations. The number detected this year was demonstrably greater than the number last year (Table 1). Micronesian honeyeaters (Myzomela rubratra, egigi) were also numerous in 2000 but significantly less so than in **1999.** Although they were widespread (detected at over three quarters of the stations) they were detected at over 88% of stations last year. Collared kingfishers (Halcyon chloris, sihek) were more common in 2000 than they were in **1999** and found in twice as many places. White terns (*Gygis* alba) and feral barnyard fowl were also common. White-throated ground-doves (Gallicolumba xanthonura, paluman apaka) and Micronesian megapodes were rare and detected at about the same levels both years.

Table 1. Detections of bird species at 74 stations on Pagan during 4-7 August 2000 and **61** stations during 25-30 August **1999.**

Pagan Bird Species	Number Detected 2000	2000 Mean #/Station (SE)	1999 Mean #/Station (SE)	2000 % Occurrence (#)	1999 % Occurrence (#)	Difference in Means between Years[1]
Collared Kingfisher	**46**	**0.64 (0.093)**	0.16 (0.076)	**45.8% (33)**	**23.0% (14)**	***t*** **= 1.89 P < 0.03**
Micronesian Honeyeater	**148**	**2.06 (0.229)**	**2.75 (0.243)**	**77.8% (56)**	**88.5%** (54)	***t = -4.48 P*** **< 0.001**
Micronesian Megapode	**3**	**0.04 (0.024)**	**0.02 --**	**4.2% (3)**	1.6% **1**	
Micronesian Starling	**248**	**3.44 (0.326)**	**2.18 (0.264)**	**88.9% (64)**	**75.4% (46)**	***t*** **= 2.30 *P < 0.01***
White Tern	**37**	**0.51 (0.130)**	**0.15 --**	**22.2% (16)**	**8.2% (5)**	
White-throated Ground-dove	**10**	**0.14 (0.041)**	**0.08 (0.045)**	**13.9% (10)**	**8.2% (5)**	**t = 0.63 P < 0.266 ns**
Brown Noddy	**2**	**0.03 --**	**0**	**1.4% (1)**	**0**	
Pacific Reef-heron	**1**	**0.01 --**	**0**	**1.39% (1)**	**0**	
White-tailed Tropic Bird	**2**	**0.03 --**	**0**	**1.39% (1)**	**0**	
Feral Fowl	**47**	**0.65 (0.097)**	**Not recorded**	**45.8% (33)**	**Not recorded**	

[1] Data from 48 stations along four transects surveyed both in 1999 and 2000. T-tests performed in Excel using a paired test and one-tailed critical values for P. Note that neither data set is truncated to 75 m radius.

Last year megapodes were detected only on the southern peninsula in an area known as Gapgap. Previously, megapodes were detected in this same area in 1984 (Pratt and Lemke 1984) and were said to be locally common there in **1992**

(Rice and Stinson 1992). They were observed here again this year, anecdotally, by researchers setting up vegetation plots. Nests or signs of nest burrows were not found in this area, although pigs had been routing there extensively. In 2000, megapodes were also detected in the northern sector along Transect 6 in an area isolated by the conjunction of a cliff with a recent lava flow. It is possible that pigs had difficulty in reaching this isolated area—pockets of extant vegetation harboring the birds included ***Alocasia macrorrhiza,*** a favorite pig food that would normally have been dug up by pigs if present. Megapodes were not detected in stands of nearly pure ***Casuarina*** that is colonizing large portions of the volcanic cinder fields (Table 2).

Station samples do not evenly represent different habitat types because transects were not set systematically across the island but disproportionately in different habitats. However, the habitat around point stations could be broadly categorized as forested and non-forested areas. For this, habitats were classified into (1) native and coconut forest mixed; (2) ***Casuarina*** and native forest mixed with ***Casuarina*** forest; and ***(3)*** **open/lava/forest** interface. Detections of birds farther than 75 m from the observer were removed from calculations. Density for each habitat type was completed using fixed radius methodology (Table 2).

Table 2. Density, number per ha[a] and % occurrence (number in parenthesis) of five forest birds within a 75 m-radius plot for three habitats on Pagan during 4-7 August 2000. Count totals running down the column correspond to each habitat across the table.

Bird Species	Count	Native & Coconut Forest $n_{2000} = 17$	Casuarina Forest $n_{2000} = 22$	Open/Forest Interface $n_{2000} = 33$
Micronesian Honeyeater	15 63 67	0.50 64.7% (11)	1.62 95.5% (21)	1.14 72.7% (24)
Micronesian Megapode	1 0 2	0.03 5.9% (1)	-0-	0.03 6.1% (2)
Micronesian Starling	57 42 132	1.89 82.4% (14)	1.08 68.1% (15)	2.26 87.9% (29)
White-throated Ground-dove	5 1 4	0.17 29.4% (5)	0.03 18.2% (4)	0.07 12.1% (4)
Collared Kingfisher	5 8 17	0.17 23.5% (4)	0.21 27.3% (6)	0.29 33.3% (11)

[a] Estimates are based on a 75 m fixed radius estimate calculated from VCP point count data.

Starlings, although common everywhere, appeared most often at the field/forest interface. Honeyeaters were three times more common in ***Casuarina*** than in native/coconut forest but were also quite common at the ecotone between field and forest. White-throated ground-doves were detected most often in native/coconut forest while the Collared kingfisher appeared to be a bird of the open areas. Megapodes were found in native/coconut forest and in patchy forest vegetation, but not in the ***Casuarina*** stands.

The number of each species expected in both forest and ecotone environments was based on habitat-specific means for number of detections per station (Table 3) using fixed radius methods. The estimates of the area of cover for each habitat type are gross judgements and need to be re-evaluated once good aerial surveys of the island are obtained. The estimated numbers from each habitat type were summed to calculate the total island-wide population. A range of population size is presented based on the 95% confidence interval around the mean number of birds.

Table 3. Bird density in 2000 for different habitat types. Estimated densities were summed to provide an island-wide population estimate. Calculations of the area of forest cover are gross estimates: native/coconut forest = 900 ha, ***Casuarina*** forest = 820 ha, and lava/open/forest interface = 3,050 ha.

Bird Species	Habitat	Number per Station	Number Expected in 40 ha	Estimated numbers in each habitat	Island-wide Estimate (95% CI)
Collared Kingfisher	Nativel Coconut Forest	0.29	6.65	150	1,205 (981 – 1430)
	Casuarina Forest	0.36	8.22	168	
	Open/ Forest Interface	0.52	11.64	888	
Micronesian Honeyeater	Nativel Coconut Forest	0.88	19.94	449	5,273 (2,867 – 7,680)
	Casuarina Forest	2.86	64.71	1,326	
	Open/ Forest Interface	2.03	45.88	3,498	
Micronesian Starling	Nativel Coconut Forest	3.35	75.77	1704	9,482 (3,326 – 15,637)
	Casuarina Forest	1.91	43.14	884	
	Open/ Forest Interface	4.0	90.39	6892	

Bird Species	Habitat	Number per Station	Number Expected in 40 ha	Estimated numbers in each habitat	Island-wide Estimate (95% CI)
Micronesian Megapode	**Native1 Coconut Forest**	**0.05**	1.33	30	134 (128 – 141)
	***Casuarina* Forest**	**0**	0	0	
	Open/ Forest Interface	0.06	1.37	104	
White-throated Ground-dove	**Native1 Coconut Forest**	**0.29**	6.65	150	379 (348 – 411)
	***Casuarina* Forest**	**0.05**	1.03	21	
	Open/ Forest Interface	0.12	2.74	209	

The low population size estimated for ground-doves and Megapodes seems reasonable given their extremely limited distribution. Numbers of kingfishers seem to be inflated, which may be an artifact of the analytical method. Estimates of total population size for Starlings and Honeyeaters are consistent with our observations and our experience on the island. These estimates are lower than those made last year (Arriola et *al*. 1999) because (a) the estimates of forested habitat on the island were adjusted downward, and (b) errors in the 1999 calculations.

Seabird Surveys

Seabirds at sea were counted along two transects 100 m wide between Saipan and Pagan. Birds were counted from the deck of the Marlin II by one observer from 17:30 to 18:00 on the 2 of August and again from 07:10 to 07:40 on the morning of 3 August. On the transect closest to Saipan, we encountered 4 Red-footed Boobies (Sula sula), 17 Brown Noddies (Anous stolidus), 4 Black Noddies (A. minutus), and 5 Wedge-tailed Shearwaters (*Puffinus pacificus*) for a total of 30 birds. As the boat neared Alamagan, we counted 1 White Tern (Gygis alba), 21 Brown Noddies, 8 Sooty Terns (Sterna fuscata), and 9 Wedge-tailed Shearwaters for a total of 39 birds. These birds are typical of the waters around the Marianas for the time of year and are indicative of a generally low density of seabirds in the archipelago.

Vegetation Surveys

Vegetation surveys were conducted simultaneously with forest bird surveys. Five transects were established with stations 150 m apart. Transect 1 and 5 are in the northwest and northeast respectively on either side of the lava flow. They are predominantly *Casuarina equisetifolia* forests. Transect *6* runs along the bottom of bluff parallel to the airstrip and is mixed. Transect 3 and 4 are situated on the hill south of the airstrip. These transects cut through very patchy and fragmented forest. Vegetation was surveyed using a modified point-centered quarter method (Mueller-Dombois and Ellenberg 1974). Data was only taken on trees 2 m in height and greater. Diameter was taken at breast height (DBH) as some trees in the Mariana Islands are only buttressed at their bases, usually those under 10 cm. Therefore, diameter at the base may lead to overestimates and misleading interpretations. Canopy cover was also estimated for an area of 5 m^2 around the station. Ground cover was estimated for 2 m^2 around the station. The data was analyzed for ground and canopy cover, absolute frequency (the number of stations a species is present in / the total number of stations and expressed as a percent), relative density (the number of individuals of a species/the total number of individuals and expressed as a percent), and diameter at breast height (DBH) size class of species sampled along all transects (Mueller-Dombois and Ellenberg, 1974). Each transect was analyzed individually because it was not spatially appropriate to pool data or the forest between transects was too 'patchy'. For ease of comparison, figures referred to in the text follow this section.

Three additional forest studies were conducted besides the vegetation surveys conducted in conjunction with the bird surveys. One study focuses on the large monotypic stand of *Casuarina equisetifolia* that appears to be expanding its boundaries. The second study established permanent random plots in a remnant native forest. The final study established permanent plots along a transect and habitat gradient in southern Pagan in a region known as Gapgap.

There were a total of 20 tree species found on transects surveyed. This does not of course represent all the species on the island. A broad survey such as this was not designed to attempt detection of rare species. Transect 1 and 5 ran through essentially *Casuarina equisetifolia* dominated forest areas. The absolute frequency (Figs. 2 and 3) and relative density (Fig. 4) of *C. equisetifolia* on both these transects was in some cases three times higher than any other species. Transect 1 had the highest number of trees sampled following into the smallest DBH size class (Fig. 5). This transect was composed of an almost complete monostand of *C. equisetifolia.* Transect *5* was more diverse with seven different tree species present verses four on transect 1 (Fig. 6). The smaller DBH trees (0-5 cm) were composed exclusively of *Psychotria mariana,* a native species, while the 5-10 cm DBH class was more diverse with *Hibiscus tiliaceus, Leucaena leucocephala* and *Ochrosia mariannensis.* The majority of the trees surveyed on transect 5 were either between 5-10 cm or 30-40 cm DBH.

Transect 3 and 4 were dominated by ***Cocos nucifera*** both in relative density (Fig. 7) and absolute frequency (Fig. 2). Transect 3 however also had a large ***Erythrina variegata*** component with relative density and absolute frequency almost matching ***C. nucifera. Erythrina variegata*** was represented in each size class from 5-10 cm up to greater than 70 cm in DBH (Fig. 8). Transect 4 had a small ***E. variegata*** and ***Hibiscus tiliaceus*** component in the 10-20 cm DBH (Fig. 9).

Transect 6 was unique in that it was found to have the greatest number of tree species and they were more evenly distributed than on other transects. The most frequent species found throughout the transect was ***C. nucifera*** followed closely by ***Jatropha curcas*** and ***Mangifera indica*** (Fig. 3). These three species also had the greatest relative density lead by ***M. indica*** (Fig. 10). Both ***J. curcas*** and ***M. indica*** are introduced species. ***Cocos nucifera,*** while widely distributed, is also felt to be introduced (Raulerson and Rinehart 1992). The smaller DBH size classes of trees on Transect 6 contained the fewest number of individuals overall and were represented mostly by ***J. curcas*** (Fig. 11).

The average canopy cover was below 50% for all stations as was the ground cover (Fig. 12). There clearly are gaps in the canopy, most likely due to the lack of juvenile trees or shrubs.

In summary, the areas that were surveyed in this study are predominantly native species. ***Cocos nucifera, C. equisetifola*** and ***J. curcas*** are the most abundant and in the greatest densities. In addition, seedlings are absent in all areas surveyed except for a few smaller ***P. mariana*** trees. The complete absence of a seedling understory is already leading to the fragmentation of forests, the dominance of introduced invasive species and will lead eventually to the loss of native forests altogether. It might be possible to regain some of the forest if feral animals were eradicated immediately. Feral animals eat the understory and cause erosion of topsoil through a variety of activities. Restoration of the forest habitat is the only way to help wildlife populations regain their full potential.

Pagan has some unique native forest pockets that are in need of closer examination. One of these areas begins roughly west of the beginning of transect 5. Transect 5 heads north along a ridge. The pocket forest runs parallel to transect 5 in a depression to the west. The forest is at least 1 km long (north to south) and about 30 m wide. The forest appears to be mostly ***Ochmsia mariannensis*** and ***Neisosperma oppositifolia.*** Other species observed were ***Pouteria obovata, Melanolepis multiglandulosa, Aglaia mariannensis, Aidia cochinchinensis*** and ***Eugenia palumbis.*** A male White-throated Ground-dove was observed feeding on a ***M. multiglandulosa*** fruits in this forest. ***Ochmsia mariannensis*** in what appears to be considerable abundance in this forest has rarely been seen on the other northern islands surveyed, although it appears in the checklist for several of them (Fosberg *et al*. 1979).

The second interesting forest area occurs in the extreme south of the island in a region known as Gapgap. Above the beach on this small inlet there is a ridgeline which is approximately 400 m high. The ascent is littered with large rocks and many steam vents. The plateau at the ridge top works its way into a forest on the northern side. This forest contains several native tree species including ***Guamia mariannae*** which was not seen anywhere else on Pagan or detected on any of the other Northern Islands surveyed during this trip. However, again G. ***mariannae*** is listed as occurring on Pagan as well as several other Northern islands (Fosberg ***et al.*** 1979).

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Figure 2. Absolute frequency of species detected on Transect 1, 3 and 4.

Figure 3. Absolute frequency of species detected on Transect 5 and 6.

Figure 4. Relative density of species surveyed on Transect 1 and 5.

Figure 5. DBH size class and species within each range for Transect 1.

Figure 6. DBH size class and species within each range for Transect 5.

Figure 7. Relative density of species surveyed on Transect 3 and 4.

Figure 8. DBH size class and species within each range for Transect 3.

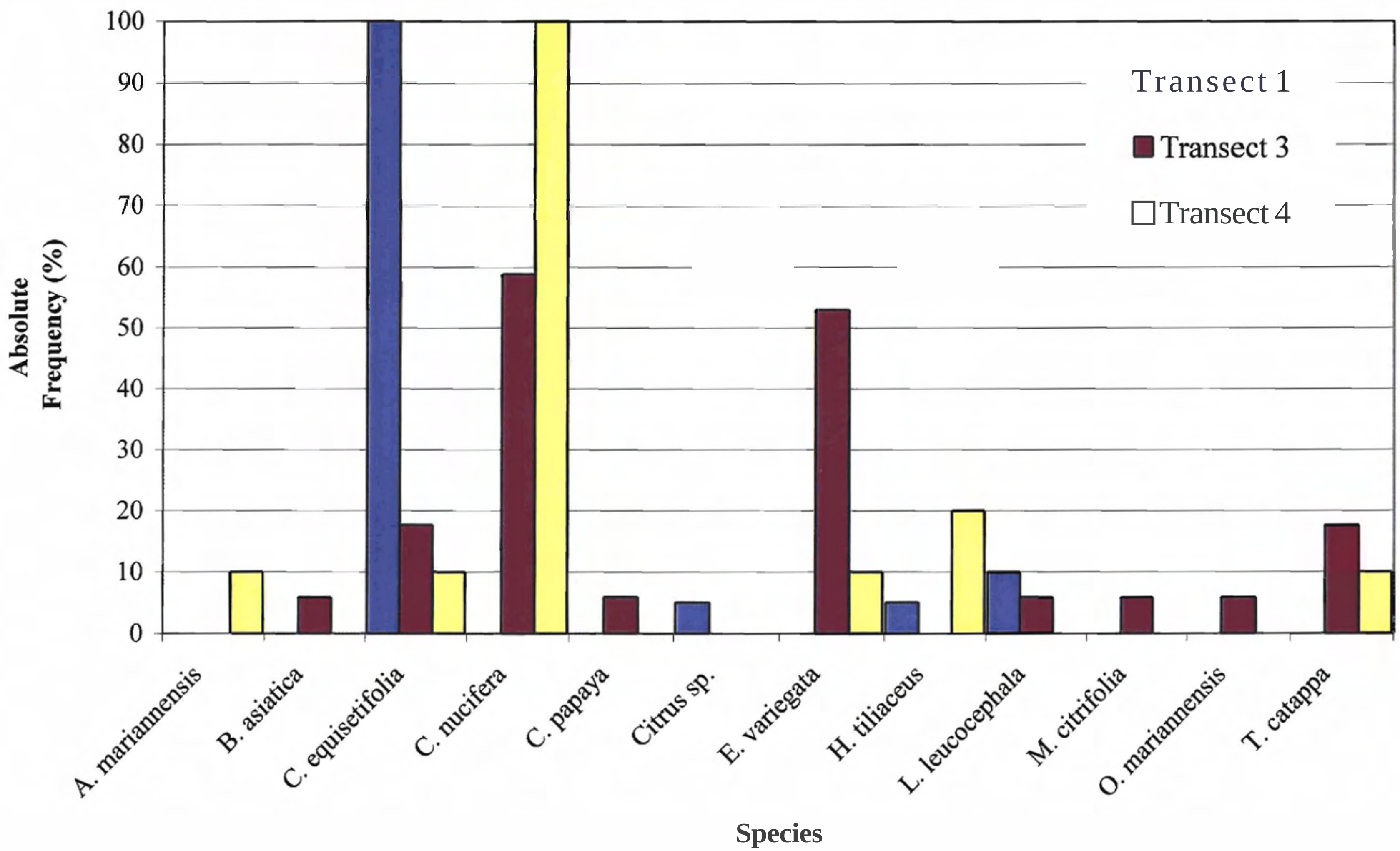
Figure 9. DBH size class and species within each range for Transect 4.

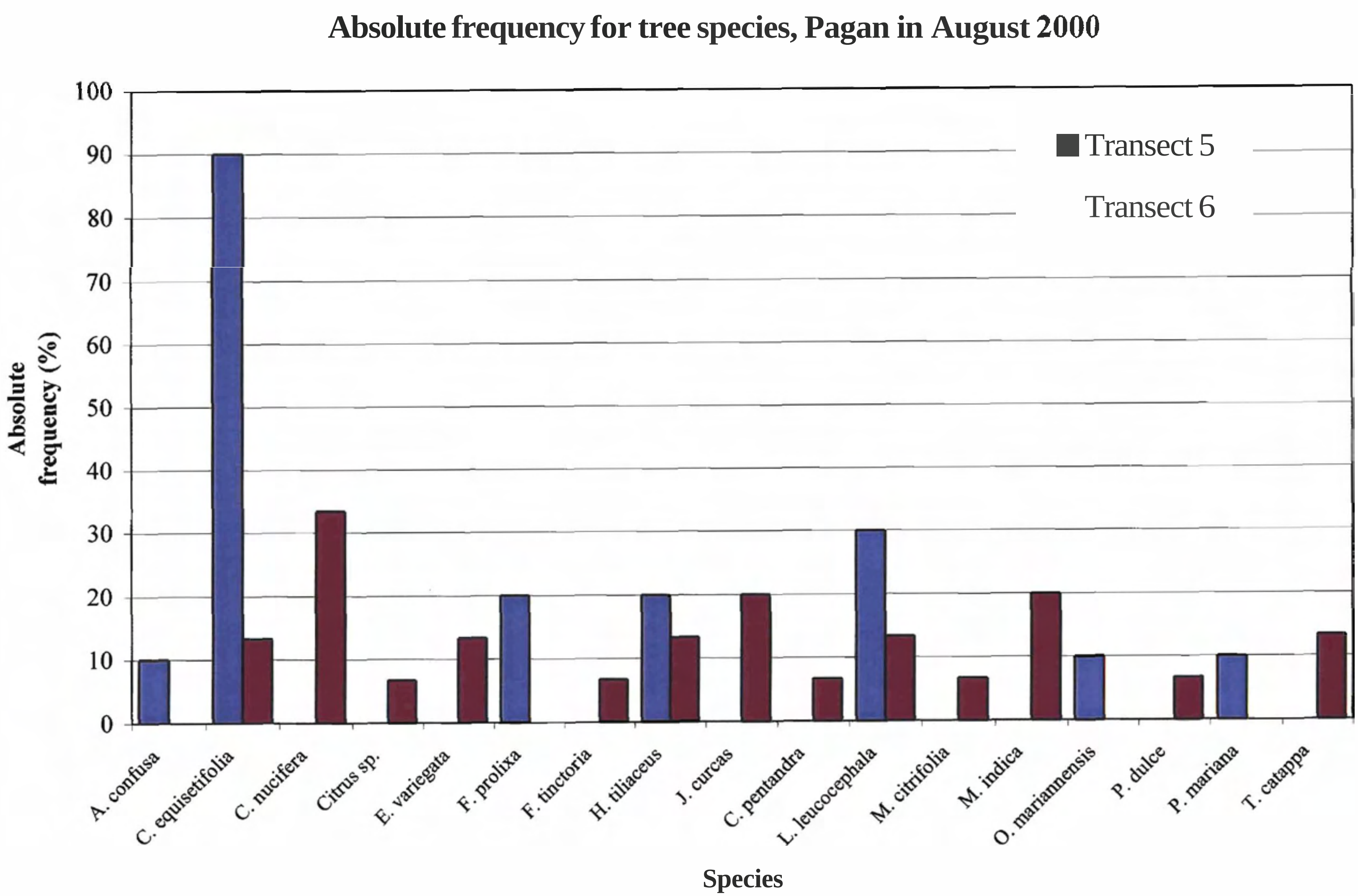
Figure 10. Relative density of species surveyed on Transect 6.

Figure 11. DBH size class and species within each range for Transect 6.

Figure 12. Average canopy and ground cover estimate on all Transects.

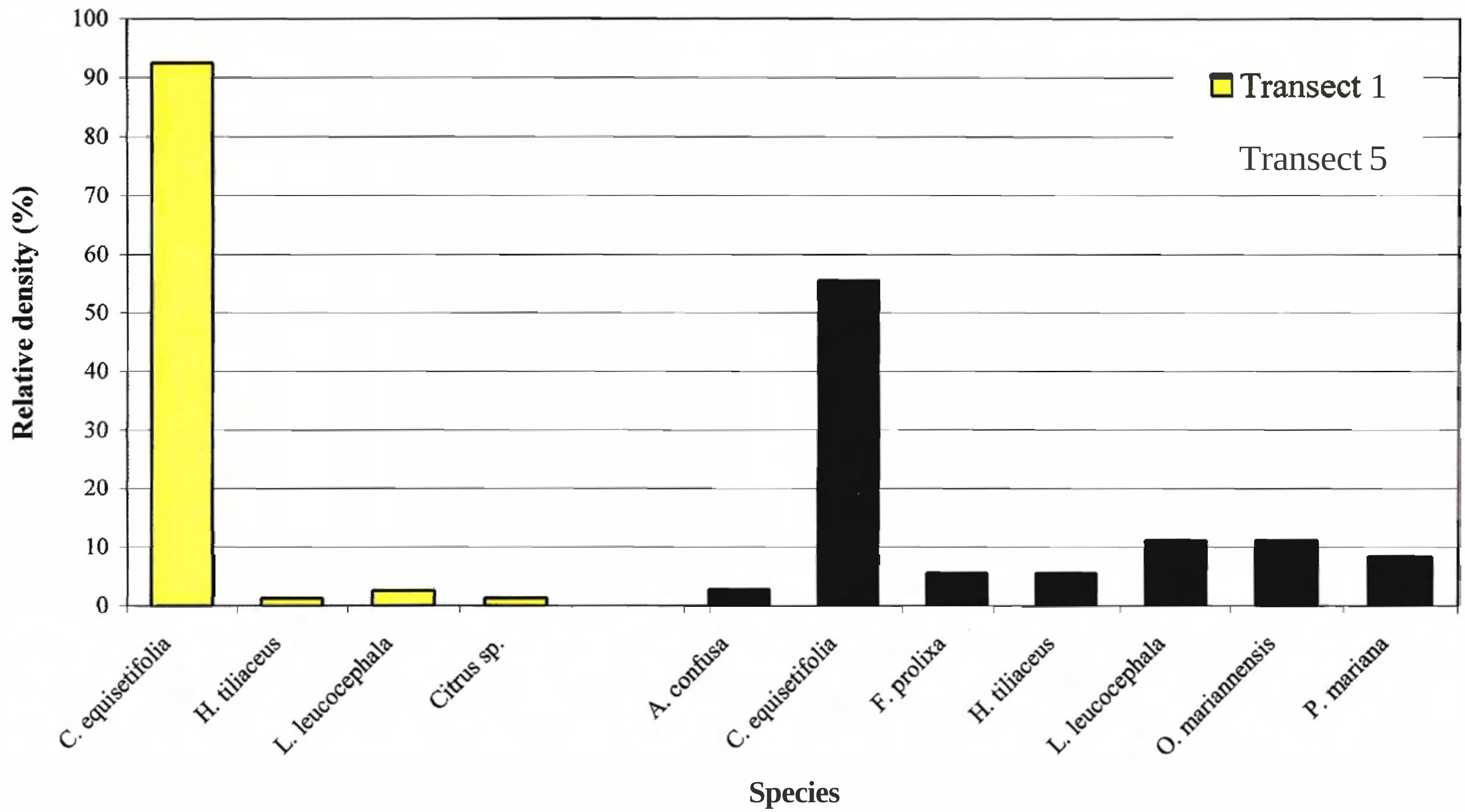
Absolute frequency of tree species, Pagan in August 2000



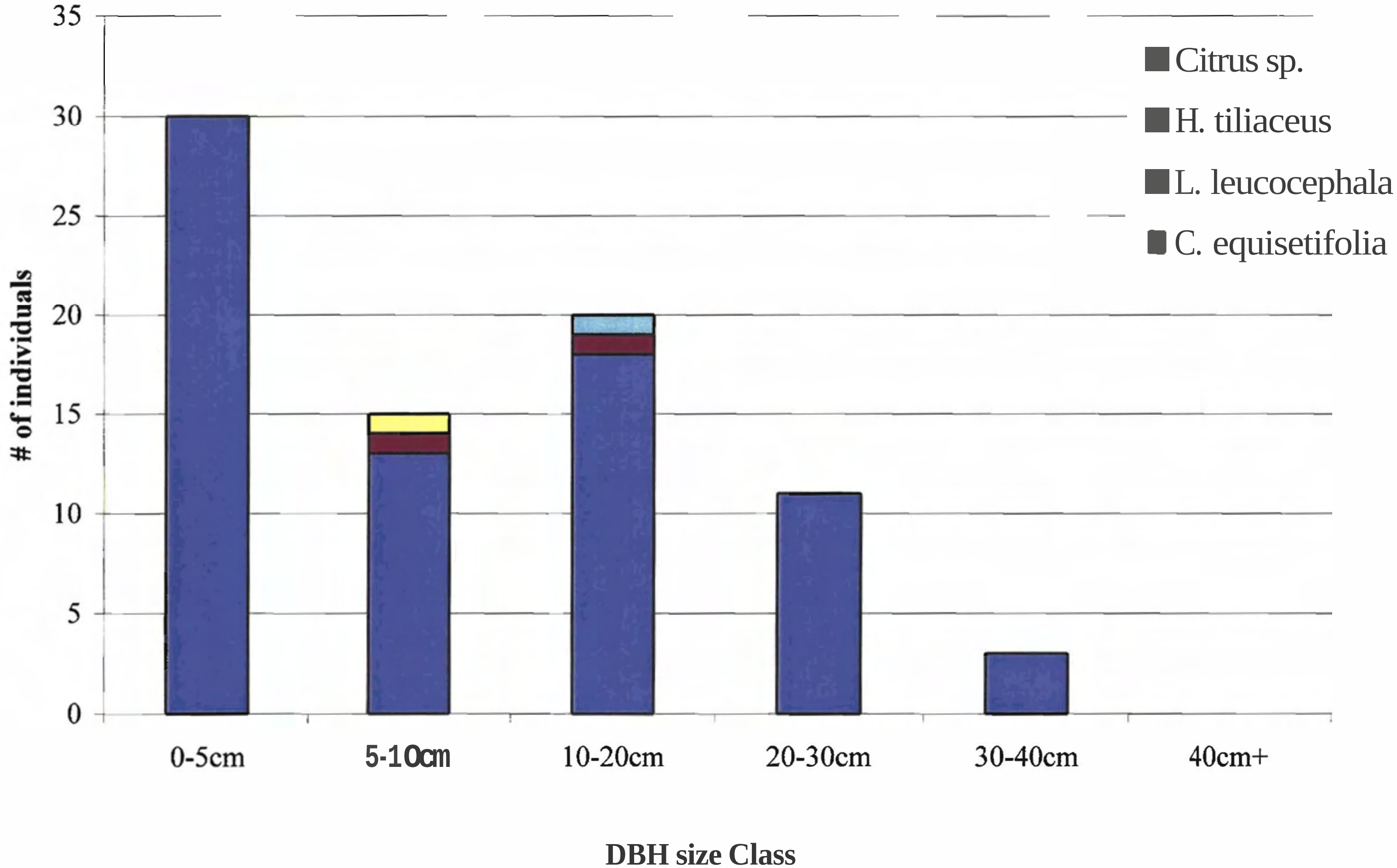


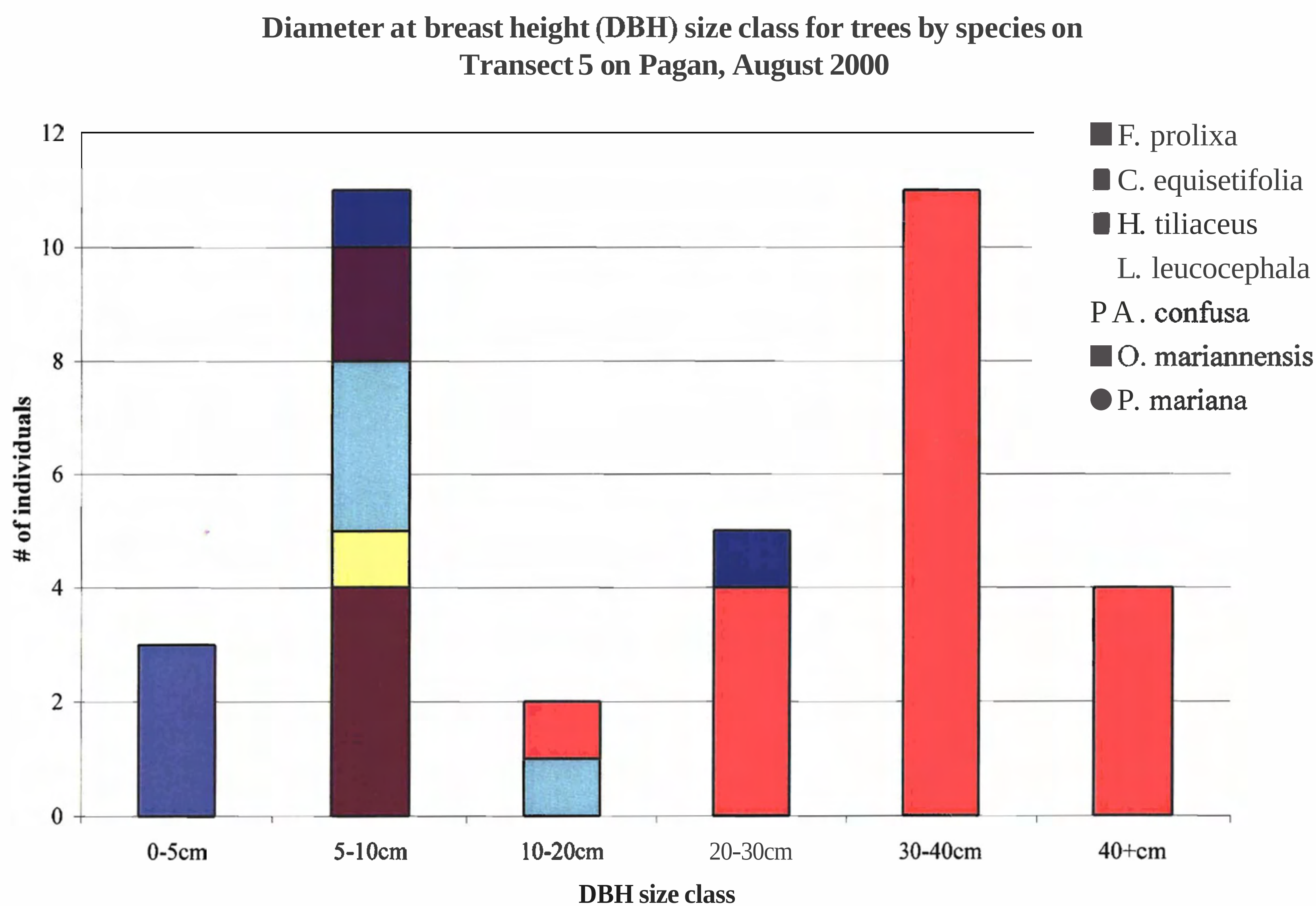
Absolute frequency for tree species, Pagan in August 2000
100
90
80
70
60
50
40
30
20
10
0
Absolute frequency (%)
Transect 5
Transect 6
A. confusa
C. equisetifolia
C. nucifera
Citrus sp.
E. variegata
F. prolixa
F. tinctoria
H. tiliaceus
J. curcas
C. pentandra
L. leucocephala
M. citrifolia
M. indica
O. mariannensis
P. dulce
P. mariana
T. catappa
Species

Relative density for tree species on Pagan, August 2000

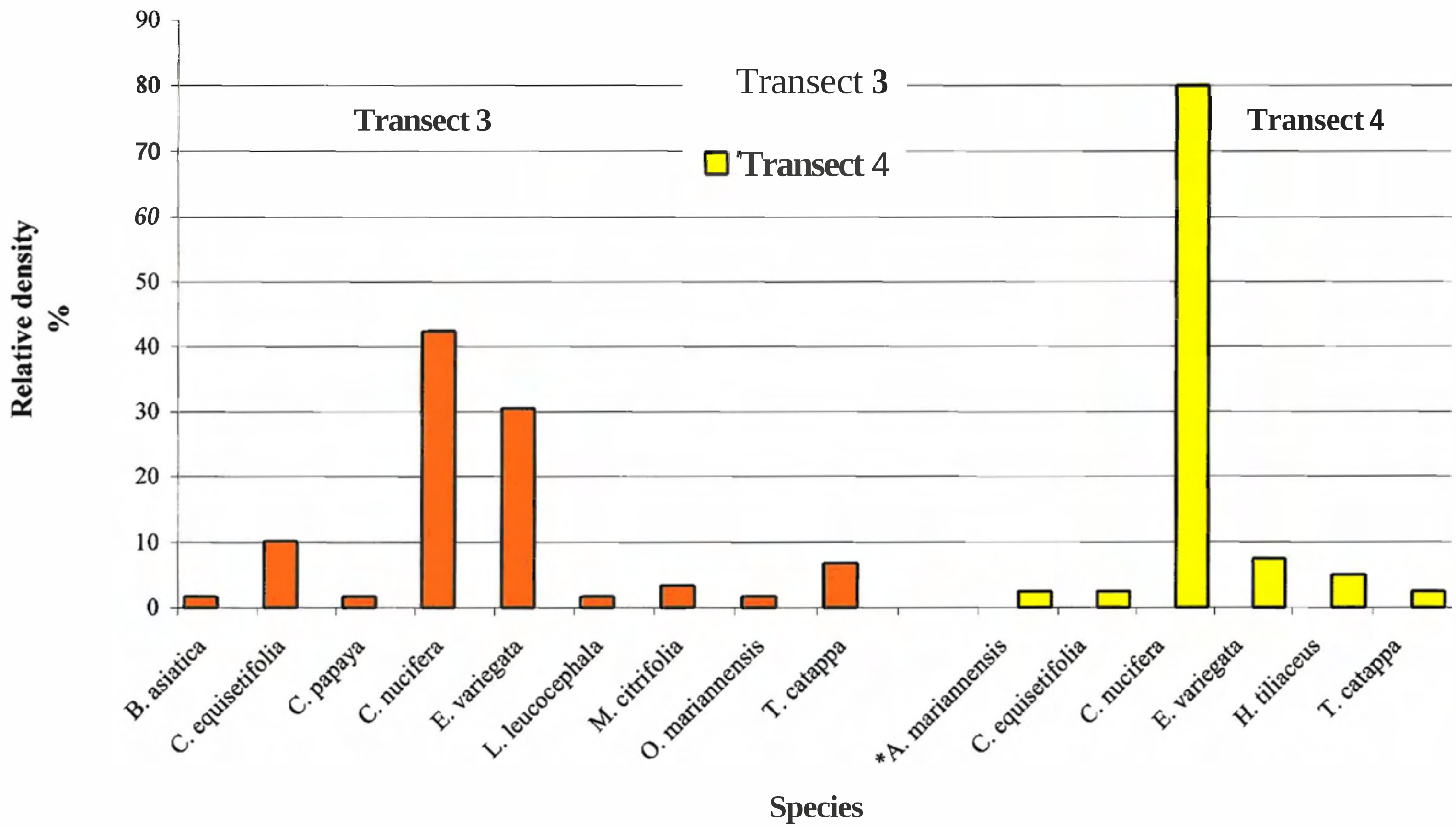


Diameter at breast height (DBH) size class for trees by species on Transect 1 on Pagan, August 2000



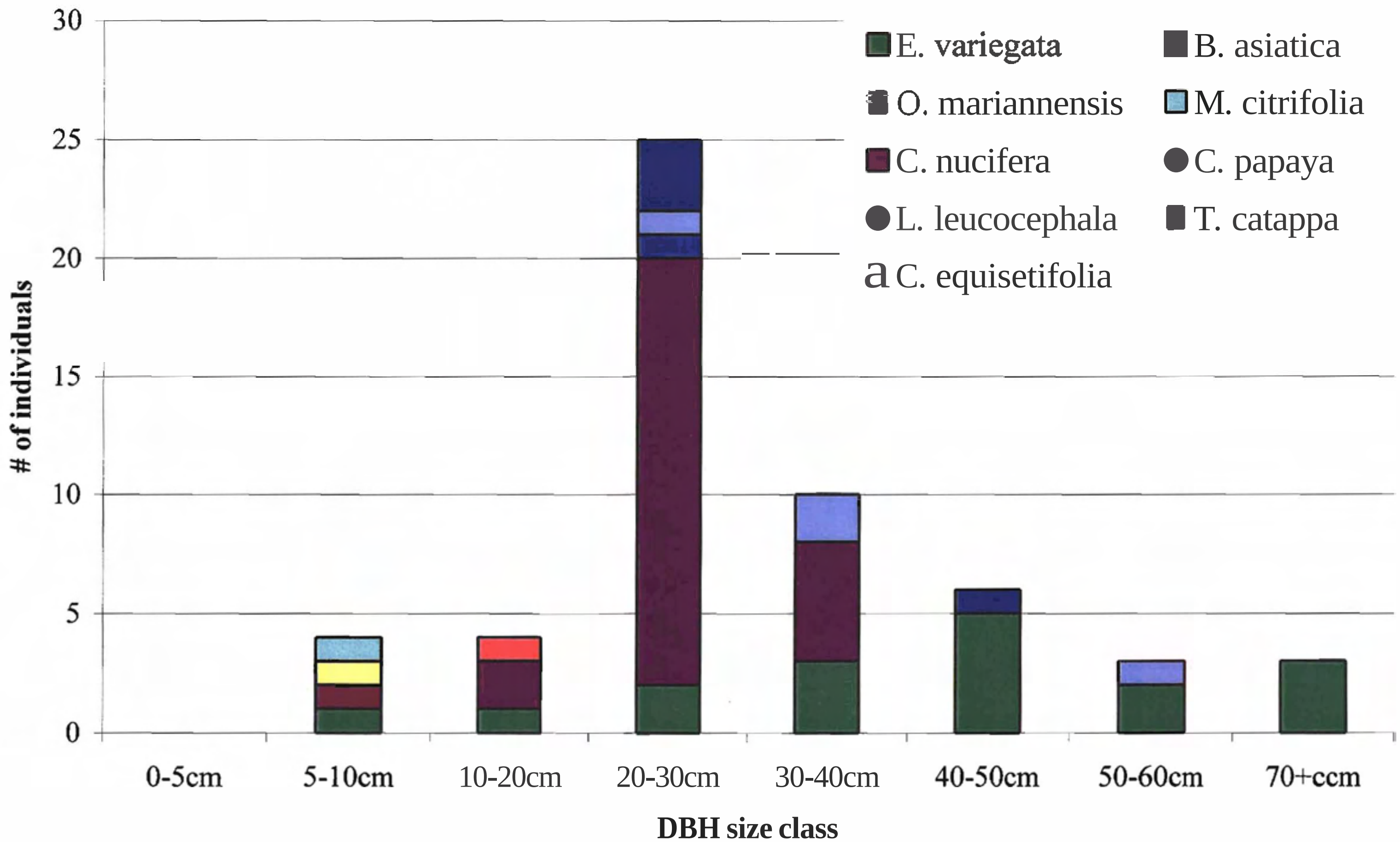

Diameter at breast height (DBH) size class for trees by species on
Transect 5 on Pagan, August 2000
12
10
8
6
4
2
0
# of individuals
0-5cm
5-10cm
10-20cm
20-30cm
30-40cm
40+cm
DBH size class
F. prolixa
C. equisetifolia
H. tiliaceus
L. leucocephala
P A . confusa
O. mariannensis
P. mariana

Relative density for tree species on Pagan, August 2000

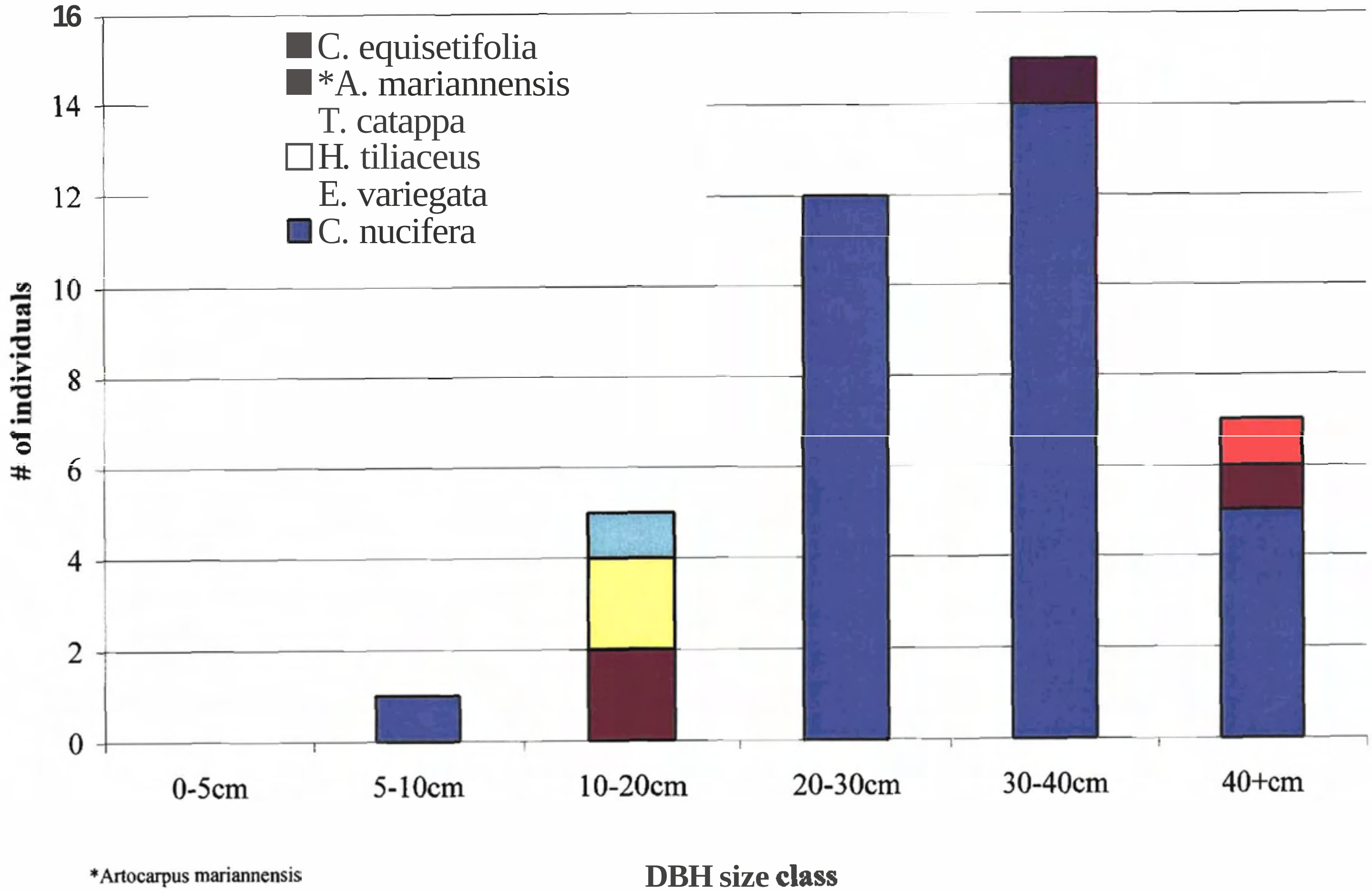


*Artocarpus mariannensis

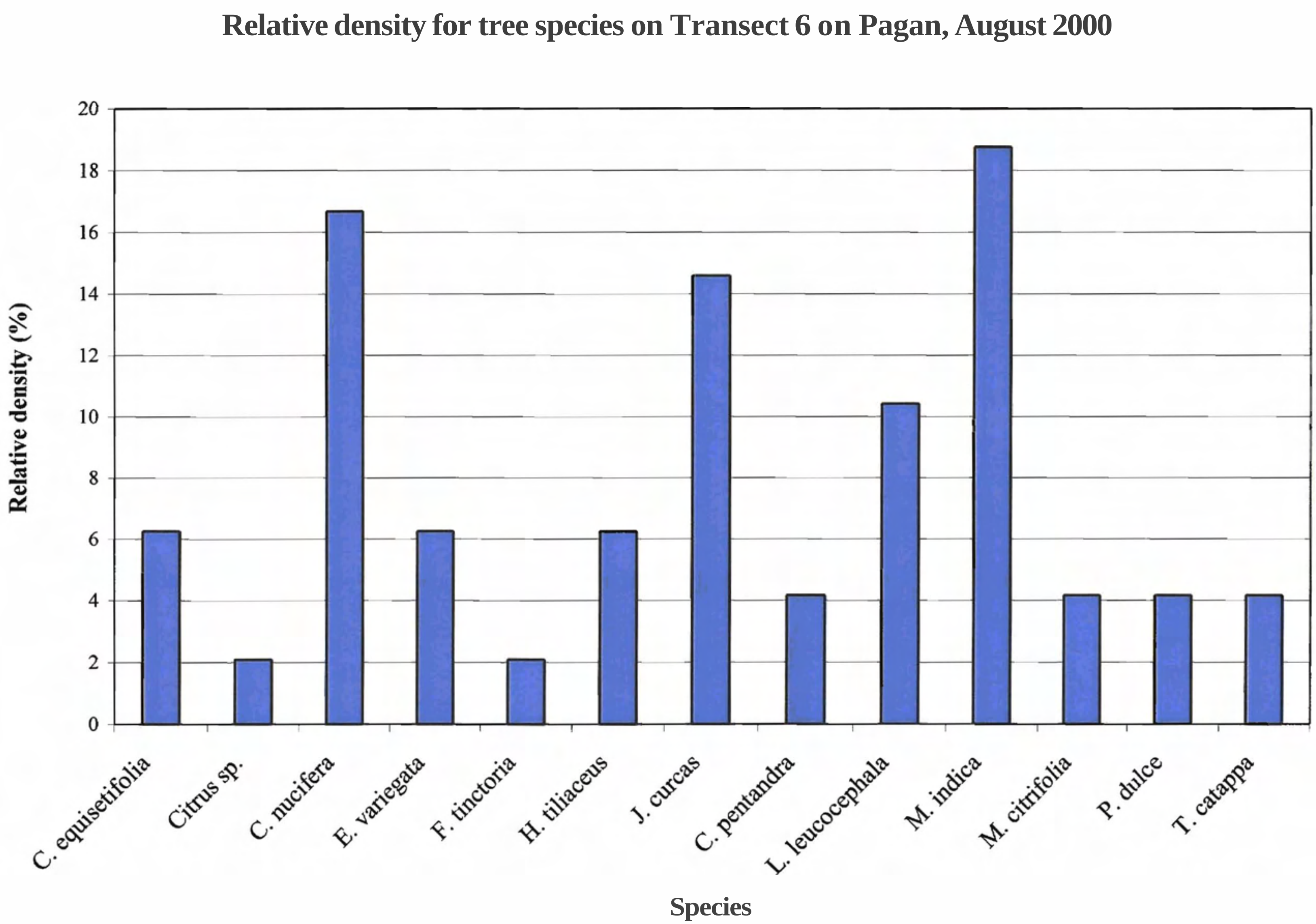
Diameter at breast height (DBH) size class for trees by species on Transect 3 on Pagan, August 2000



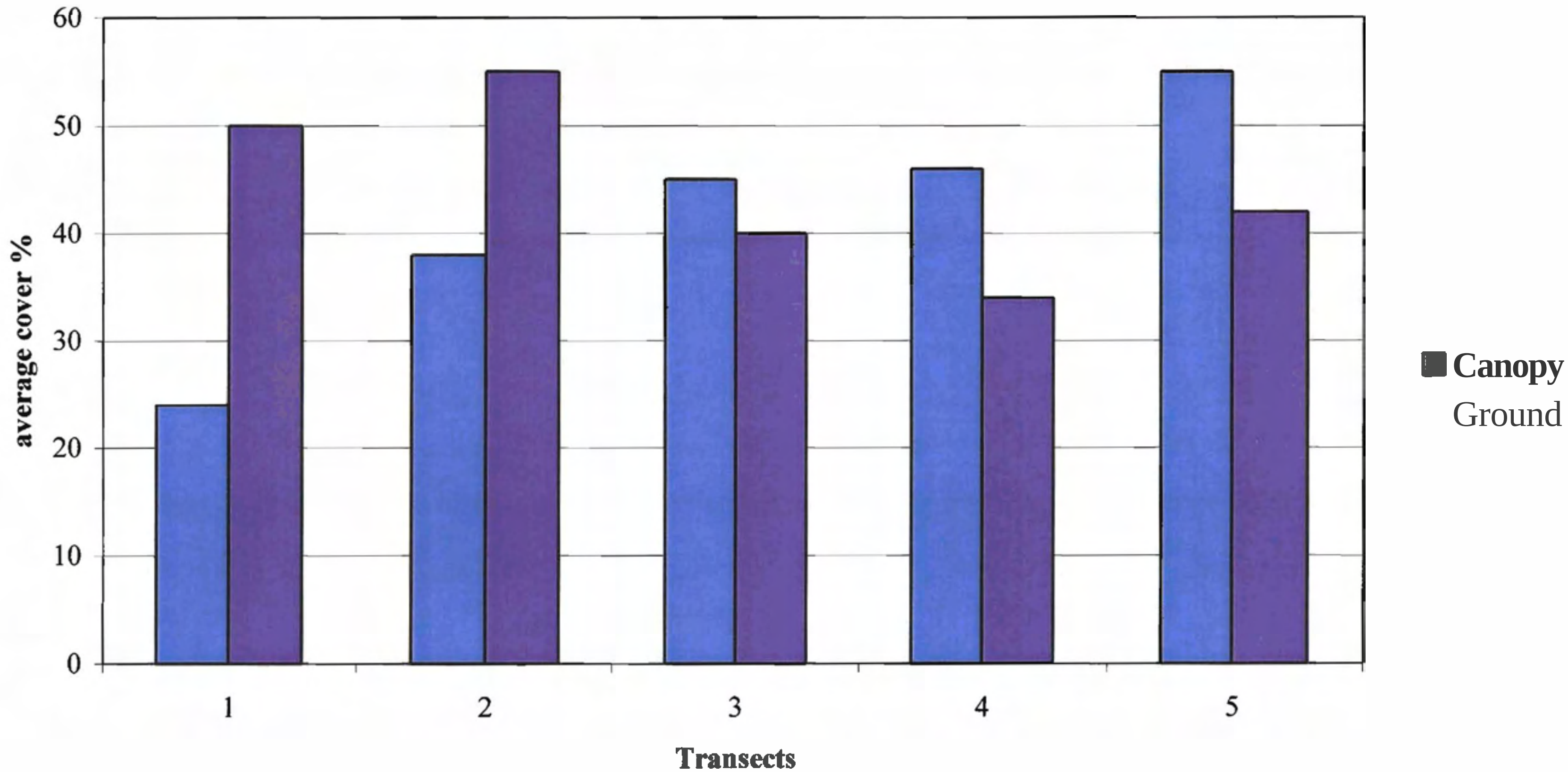
Diameter at breast height (DBH) size class for trees by species on Transect 4 on Pagan, August 2000



*Artocarpus mariannensis


Relative density for tree species on Transect 6 on Pagan, August 2000
Relative density (%)
20
18
16
14
12
10
8
6
4
2
0
C. equisetifolia
Citrus sp.
C. nucifera
E. variegata
F. tinctoria
H. tiliaceus
J. curcas
C. pentandra
L. leucocephala
M. indica
M. citrifolia
P. dulce
T. catappa
Species

Average cover percent for ground and canopy cover for all transects on Pagan, August 2000



Herpetological Surveys

The purpose of the surveys on Pagan were to document the presence and relative abundance of reptiles.

Diurnal lizards were sampled using adhesive mouse traps (Bauer and Sadlier, 1992; Rodda et al., 1993). Two transects were sampled, one in introduced forest and one in native limestone forest (Fig. 13). Ten traps were placed flush with the ground every 25 meters along each transect. Traps were run for 3 consecutive days. Traps were placed in the morning at 0700h and run for 4 hours.

Nocturnal lizards were also sampled using adhesive mouse traps. Two transects were sampled, one in introduced forest and one in native forest. Ten traps were set along each transect, spaced every 25 meters, and were stapled to the trunks of trees 0.5-2.0 meters above the ground. Traps were placed 1 hour prior to sunset and checked the following morning. Traps were run for 3 consecutive nights.

In an attempt to detect the presence of the tidepool skink (*Emoia atrocostata*), 10 adhesive traps were placed for two nights at the beach campsite in rocky strand and grassy habitat. Table 4 shows the results of adhesive trapping for lizards. A total of only 5 lizards were captured: 4 in introduced forest and 1 in native forest. Unfortunately, the species were not recorded. No captures were made along the beach in the tide pool areas. The low capture rates are inexplicable as Scott Vogt had very high capture rates (13.89 Emoia *caeruleocauda* per 100 trap hours in native forest) in 1999 (unpublished data). This low capture rate is disturbing and further investigation should be initiated to determine if there is a decline in overall population of skinks, and the reason for the decline.

Although the mangrove monitor (Varanus *indicus)* was not captured using snare traps on Pagan (Table 5), biologists reported seeing at least 4 monitors in a variety of habitats on the island.

Table 4. Results of adhesive trapping to determine diurnal lizard presence and abundance on Pagan, 3-5 August, 2000.

Habitat	#Traps	#Hours	Trap Hours	#Lizards	Lizards/ 100 Tr Hrs
Rocky Beach	20	8	80	0	0.0
Introduced Forest	57	57	558	4	0.7
Native Forest	60	57	570	1	0.2
Total	137	122	1208	5	0.4

Table 5. Results of monitor lizard snare-trapping conducted on Pagan, 4-7 August, 2000.

Habitat	# Trap Days	# Lizards	Lizards/ 100 trap days
Introduced Forest	28	0	0.00
Native Forest	25	0	0.00
Total	53	0	0.00

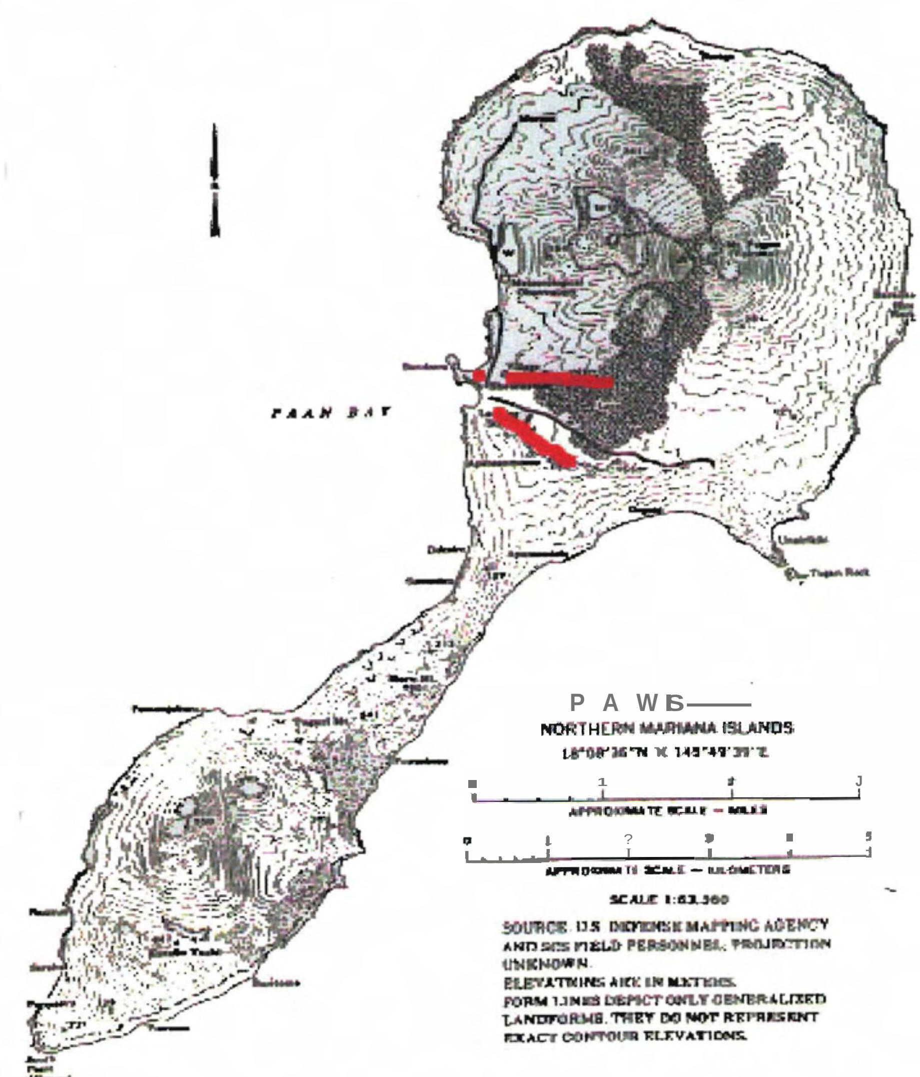


Fig. 13. Pagan transects sampled for reptiles and small mammals.

Small Mammal Surveys

Rats were sampled using Victor rat snap-traps. Three transects were sampled, one in introduced forest, one in native forest, and some traps were also placed near the barracks (Fig. 13). Up to 19 traps were placed on the ground with 25 meter spacing. Traps were run for 3 consecutive nights. Traps were set in the evening and baited with peanut butter and left overnight. Traps were checked the following morning. All rats captured were taken back to base camp, identified to species, and had morphological measurements taken.

The only species of rat captured on Pagan was *Rattus rattus* (Table 6). Rats were more numerous in native forest (12.9 rats/100 trap nights) than introduced forest (0.0 rats/100 trap nights). Overall rat capture rate was 5.1 rats/100 trap-nights (n=8). Rat populations seem to be relatively low on Pagan. This may be due to the large number of feral animals on Pagan keeping the amount of available food for rats low. Additional trapping needs to be conducted to assess rat abundance on Pagan as our surveys were not extensive.

Table 6. Results of snap-trapping to assess rat abundance on Pagan, 4-6 July, 2000.

Habitat	Trap Nights*	# Rats Captured	Rats/100 trap nights
Barracks			
Introduced Forest	95	0	0.0
Native Forest	62	8	12.9
TOTAL PAGAN	157	8	5.1

*Corrected for unavailable traps (Nelson and Clark, 1973).

Mariana Fruit Bat Surveys

There were two evening station counts conducted at stations 1 and 2 (Fig. 15) and two evening departure counts at stations 3 and 4 (Fig. 15). During station counts all bats within a specified range and time are counted. Therefore bats were counted, along with the direction in which they were flying, using binoculars and a high-powered zoom spotting scope. Counts began at about 17:00 and lasted until dark (~19:30).

Departure counts methods are similar to station counts, conducted at the same times using the same methods. Bats at station 3 were counted from a coastal ridge approximately four kilometers away. The station 4 departure count was conducted from the deck of the Marlin II. Departure counts determine the number of bats departing from an actual colony. It is estimated that at least 50% of the bats do not leave the roost until after dark, therefore they are not observable (Stinson *et al.* 1992). Fruit bats have been observed still sleeping on Aguiguan at 18:30, well after dark (Johnson 2000). Consequently, the number of bats counted departing the colony is multiplied by 50% to include bats still on the roost.

In August 1999, CNMI Division of Fish and Wildlife personnel conducted evening bat station counts as well as intense searches for active fruit bat colony sites. No colony was discovered on the 1999 trip. This does not necessarily indicate that a colony was absent from the island. However, methods in searching for and surveying fruit bats as well as locations of evening count stations remained fairly similar in 1999 and 2000.

Two evening station counts each at Stations 1 and 2 (Fig. 16) were completed in 1999. One evening count was performed at both stations on the year 2000 trip. Stations 1 and 2 were located on top of a *Chrysopogon* covered ridge at the northern end of the isthmus. Station 1 overlooked the west side of the isthmus into mostly *Cocos* forest with mixed *Erythrina* and *Terminalia* trees. Station 2 provided an extensive view of the eastern side of the island. About 80% of the forest within this site consisted of *Cocos* forest with the remaining 20% being *Terminalia, Barringtonia*, and *Erythrina* trees.

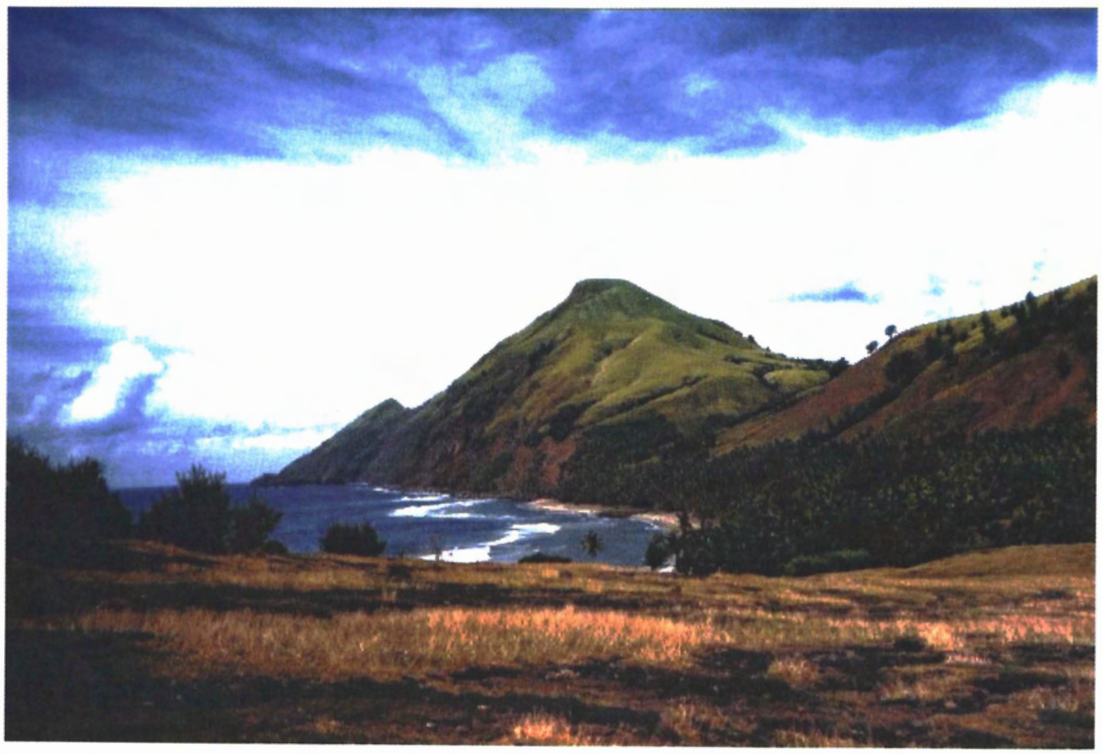
Results from the 1999 and 2000 surveys show that fruit bat activity has remained relatively stable at both stations (Fig. 17). In both years, Station 2 yielded the highest number of individual fruit bats counted (Tables 7 & 8). On the year 2000 count at Station 2, a total of 30 individual fruit bats were tallied entering from the south during the count. This information assisted in the discovery of three colonies on the southeast side of the island.

During the evening station counts at Station 2 in both 1999 and 2000, a fair number of fruit bats were observed flying north above the ocean between 0-500 meters offshore. This occurrence appeared to be more frequent on the year 2000 trip. Also in 2000, a "line of fruit bats" was observed approximately 500 meters offshore in the direction of Alamagan. The observer is confident that these fruit bats were flying from Alamagan to Pagan.

It is highly likely that fruit bats do travel between the islands in the Mariana archipelago either in search of a more abundant food supply or as a result of colony disturbances, such as illegal hunting. The distances between the Mariana Islands range from 3-65 miles. One other species of *Pteropus, P. vampyrus*, is known to fly up to 31 miles each night in search of food (Lim 1966). Therefore,

Mariana fruit bats are probably quite capable of traveling the 37 miles from Alamagan to Pagan.

Station 3 was located on the eastern side of the island and overlooked the southeastern portion of Pagan. Fruit bat activity was high from the beginning of the count (17:50) until dark (19:10). Bats departed the roost in groups of up to 8 individuals and as many as 15 animals were observed flying together above the colony site. A majority of the bats departed to the north-northwest of the colony site. However, a fair number traveled overhead to the north. Interestingly, one fruit bat was observed flying to the north at about 300-400 feet above the ground. This bat's flight was monitored carefully with the spotting scope. It had appeared that the fruit bat did not descend, but continue to the north towards Agrihan.



Mariana fruit bat departure count station 3

Table 7. Results of Mariana Fruit Bat Evening Station Counts on Pagan, August 2000

Station	Date	Depart N	Enter N	Depart E	Enter E	Depart S	Enter S	Depart W	Enter W	Remain	Total
1	4 August	1	0	0	0	0	0	0	0	0	1
2	4 August	4	2	0	0	3	30	0	0	4	40

Table 8. Results from Mariana Fruit Bat Evening Station Counts on Pagan, August 1999

Station	Date	Depart N	Enter N	Depart E	Enter E	Depart S	Enter S	Depart W	Enter W	Remain	Total
1	27 August	9	0	0	0	0	9	0	0	0	9
2	27 August	0	0	0	0	31	31	0	0	21	53
3	27 August	5	0	0	0	0	0	0	0	0	5
4	27 August	21	0	0	0	2	2	4	0	5	34
1	28 August	3	0	1	2	1	1	0	0	8	16
2	28 August	44	0	0	0	2	44	0	0	16	62

A total of 326 fruit bats were counted departing from one of the colony sites along the southeast side of the island (Table 9). From the vantage point at Station 3, it was difficult to determine from which or from how many of the aggregations the fruit bats were departing from. Therefore, we did not multiply the number of bats counted by 50%, because the number of colony sites was unknown at the time of the survey.

However, on 8 August, we were graciously provided boat transportation to the southeastern region of the island to search for active fruit bat colonies. A departure count was completed from the deck of the Marlin II fishing vessel (Station 4) [Fig. 15] from 17:20 to 19:00 using binoculars. Groups 1, 2, and 3 were discovered during the count period (Table 10). Seas were choppy, which made it difficult to observe roosting bats and their tree species of choice. Fruit bat activity was extremely high from this station. A total of 581 bats were counted from what later was confirmed as three separate colony sites (Table 9).

At the lower colony site (Group 1) [Table 10], approximately 381 fruit bats were tallied while departing the roost site. Fruit bats were noted as hanging in *Cocos* trees. As indicated in Table 10, other tree species, likely to contain fruit bats were present, but rough seas prevented any confirmation of these observations. A majority of the bats departed and traveled to the south-southwest. Group 1 was described as "boiling with bats" by Marlin II crewmembers. Throughout the count, it was not uncommon to see at least 10-20 bats circling above the colony site. From the high levels of activity, which continued until dark with bats still circling the roost, we estimate this colony to contain a minimum of 800 fruit bats.

Table 9. Number of Individual Mariana Fruit Bats Counted during two Evening Departure Counts on Pagan, August 2000

Station	Date	Number of individual fruit bats counted departing
3	5 August	326
4	8 August	581

Two smaller colonies (Groups 2 and 3) made up the remaining 200 bats counted during the evening departure count. Fruit bats were observed departing from two different locations along the upper ridgeline above (west) Group 1 (Fig. 15). Activity was moderate as approximately 125 fruit bats were counted in Group 2 and nearly 75 animals in Group 3 (Table 10). No positive identification was obtained on habitat and roosting tree species because the roost sites were a great distance from the boat (1-1.5 kilometers) and seas were choppy. The number of fruit bats counted at Groups 2 and 3 was multiplied by 50% to obtain the estimate in Table 10.

Based on the evening station count results, the departure count results, and individual sightings, we estimated that Pagan to supported about 1,500 Mariana Fruit Bats in 2000. This number is notably lower than the 1983 estimate of 2,500 fruit bats by Wiles *et al.* (1989) [Table 11]. On the 1983 trip, a colony estimated at 2,000 fruit bats near the Bulitoma region and a possible group of 75-100 animals at Fuwaebosu were discovered (Wiles *et al.* 1989) [Fig. 14]. Stinson *et al.* (1992) revisited the Bulitoma region during a 1992 field trip and found no fruit bats present, but located a group of 207 bats less than one kilometer southwest of Togari Mountain [Fig. 14]. It is important to note the concentration of known Mariana Fruit Bat colony sites in the south-southeastern regions of Pagan (Fig. 14) because these areas are more difficult to access than the plains of the northern regions.

It is interesting to note the location of the three fruit bat colonies (Groups 1, 2, and 3) within the extremely steep and inaccessible regions of the island.

In the case of Pagan, it is possible that an intelligent creature such as the Mariana fruit bat has chosen to roost within this particular habitat and terrain over the last 17 years in avoidance of poaching activities.

Table 10. Mariana Fruit Bat Colonies observed on Pagan, August 2000

Group	Date of Observation	Habitat Description	Elevation (m)	Species and # of Roost Trees	# of Bats Counted	Estimated # of Bats Present
1	8 August	Steep terrain with native forest (*Elaeocarpus, Cocos, Pouteria, Terminalia,* & *Erythrina*)	250	Many bats were roosting in *Cocos* & possibly more species, but difficult to observe because of motion of boat.	381	800
2	8 August	Top of ridgeline	530	???	125	250
3	8 August	Top of ridgeline	450	???	75	150

Table 11. Minimum population estimates of Mariana Fruit Bats for Pagan in 1983 & 2000

Year	Minimum Population Estimate
1983	2,500
2000	1,500

Mariana fruit bats were observed roosting and/or resting within the following two tree species: *Cocos nucifera* and *Casuarina equisetifolia*. Solitary fruit bats were

observed on occasion roosting in *C. equisetifolia* trees. A majority of the roosting and resting was carried out in *Cocos* trees. During evening station counts at Station 2, fruit bats were commonly seen landing and flying from *Cocos* trees.

Evidence of Mariana fruit bat feeding sign was noticed on the ripe fruits of *Terminalia catappa, Pandanus tectorius,* and *Ochrosia mariannensis*. Attempts were made to obtain fruit bat feeding observations within a pocket of native forest near VCP Forest Bird Transect 5. It was common to see ripe *O.mariannensis* fruits on the ground with bat teeth marks in them. *T. catappa* was not as ripe as expected, so only minimal feeding signs were present. On one occasion during an evening station count at Station 2, one fruit bat was observed flying with a ripe *T. catappa* fruit in its mouth. Partially eaten *P. tectorius* fruits were observed on the ground below the ridgeline east of camp. *Cocos nucifera* was observed flowering, but no confirmed foraging events were recorded.

There is a diverse selection of food available to Mariana Fruit Bats on Pagan (Table 12). The important food species on Pagan are likely to be *Terminalia, Pandanus, Ochrosia, Erythrina, Artocarpus,* and *Mangifera indica.*
There does not seem like there is much *Artocarpus* available. *Mangifera* was not fruiting during our visit in 2000, but there is an expanse of trees present below the ridgeline east of camp. Fruit bats have been observed foraging on the mango fruits on many occasions (Eddie Santos, *pers. comm.*). Unfortunately, this area of forest is easily accessible by poachers and shotgun shells have been discovered there as well.

It is important to recognize that Mariana Fruit Bat numbers have declined on the island of Pagan. Factors possibly attributing to this decline include:

1) habitat degradation by feral animals such as feral goats (*Capra hircus*), feral pigs (*Sus scrofa*), and cattle. Feral animals and their degrading effects to the habitat were noted on numerous occasions on the 1999 and 2000 trips to Pagan. Even on a 1984 trip to Pagan, Lemke *et al.* (1984) record that "wildlife habitat throughout the island has been altered dramatically by activities of feral animals".

2) Illegal hunting activities pose a negative threat to the status of the fruit bat population on Pagan. Pagan contains easy beach landings that make it more accessible to humans than the other islands in the archipelago. Also, traveling throughout the island by foot is simple because of the trails that feral animals have created and the lack of understory. On the 1999 trip, seven expended .410 shotgun shells were discovered along a trail east of camp (Johnson & Arriola 1999). Along the same trail, two recently expended .410 shotgun shells were also found on the year 2000 trip. Two additional 1-2 month old .410 shotgun shells were recorded along VCP Forest Bird Transect 3.

Table 12. Fruiting and Flowering Flora/Available Food for Mariana Fruit Bats on Pagan 3-9 August 2000

Species	Fruiting-S Flowering-F
Melanolepis multiglandulosa	FS
Artocarpus altilis	S
Pouteria obovata	F
Neisosperma oppositifolia	S
Aglaia mariannensis	S
Pandanus tectorius	FS
Cocos nucifera	FS
Morinda citrifolia	FS
Ochrosia mariannensis	FS
Psychotria mariana	FS
Terminalia catappa	S
Barringtonia asiatica	FS
Eugenia palumbis	FS
Ficus prolixa	S
Ficus tinctoria	S
Casuarina equisetifolia	S
Hibiscus tiliaceus	F
Trema orientalis	S
Leucaena leucocephala	FS
Guamia mariannae	S
Aidia cochichinensis	FS
Premna obtusifolia	FS
Carica papaya	FS
Psidium guajava	S

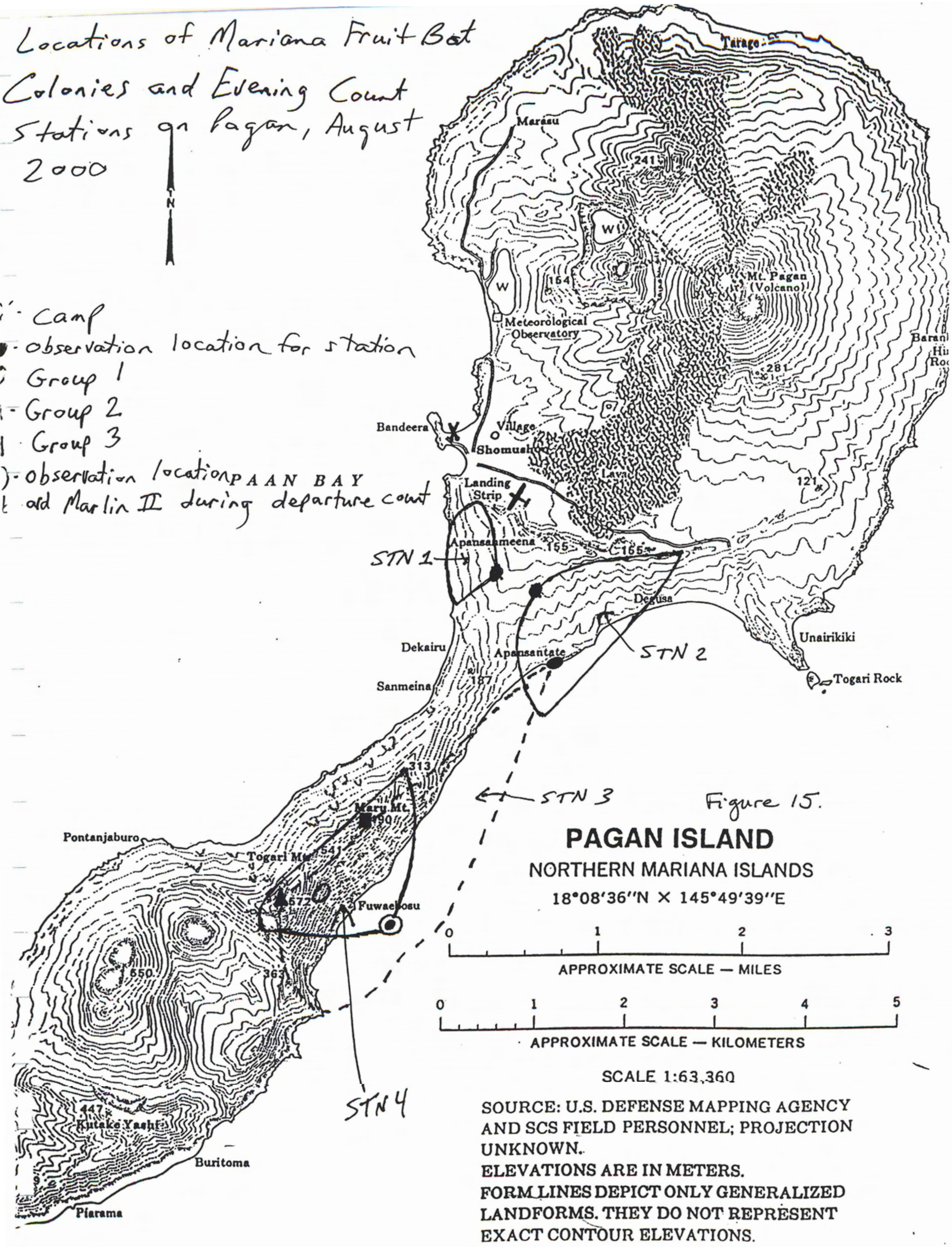
List of Figures

Figure 14. Locations of Mariana fruit bat colonies and evening count stations on Pagan, August 2000.

Figure 15. Locations of Mariana fruit bat colonies in 1983, 1992 and 2000.

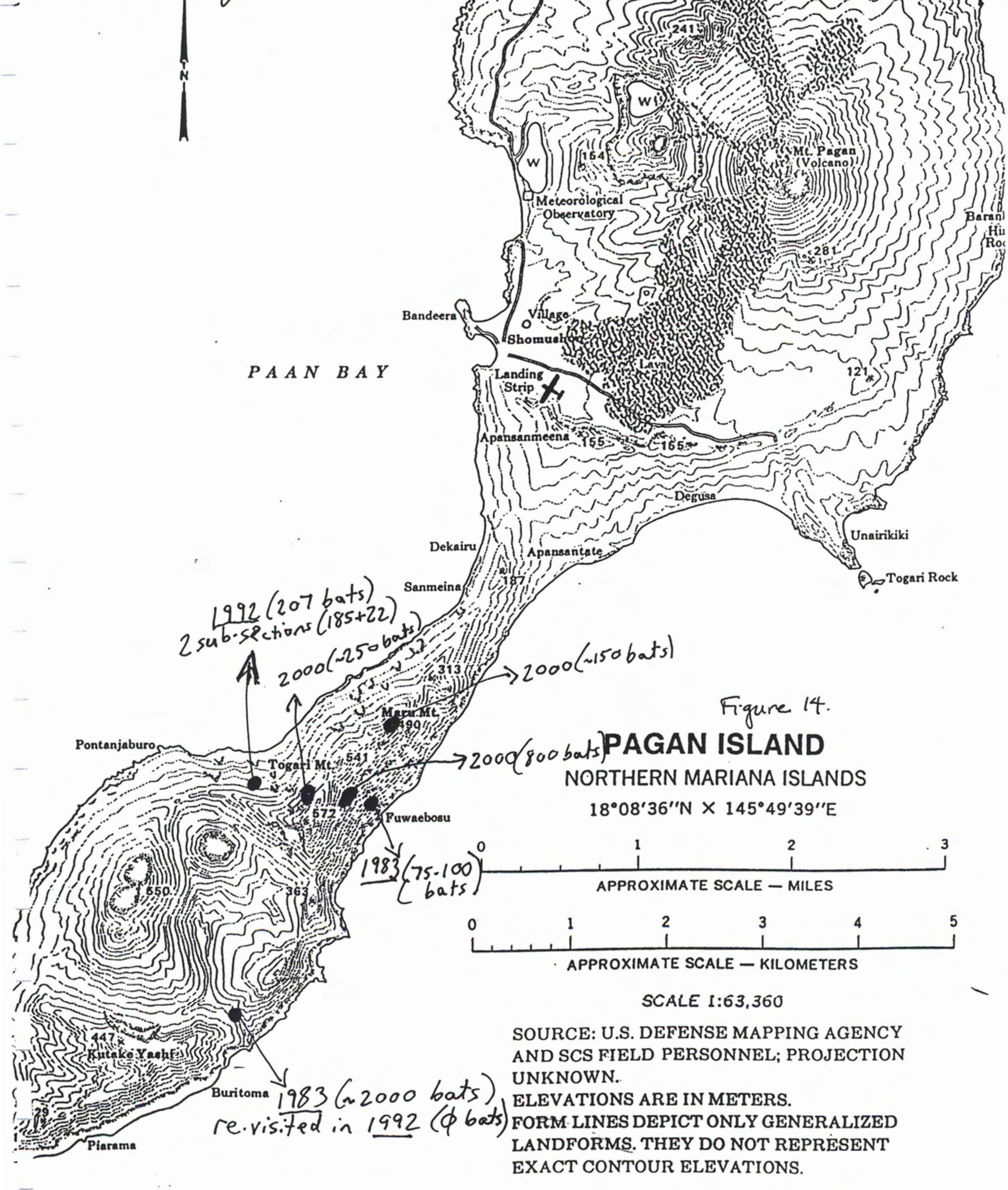
Figure 16. Location of Mariana evening count stations in 1999

Figure 17. Number of Mariana fruit bats counted during evening station counts on Pagan in August 1999 and 2000.



Locations of Mariana Fruit Bat Colonies and Evening Count Stations on Pagan, August 2000
N
Camp
observation location for station
Group 1
Group 2
Group 3
observation location
and Marlin II during departure count
PAAN BAY
Tarage
Marasu
241
Mt. Pagan (Volcano)
154
W
Meteorological Observatory
281
Bandeera
Village
Shomushon
Lava
121
Landing Strip
Apansaameena
155
165
STN 1
STN 2
STN 3
STN 4
Degusa
Unairikiki
Dekairu
Apansantate
Togari Rock
Sanmeina
187
313
Maru Mt.
490
Pontanjaburo
Togari Mt.
572
Fuwaefosu
650
363
447
Kutake Yashi
Buritoma
Piarama
Figure 15.
PAGAN ISLAND
NORTHERN MARIANA ISLANDS
18°08'36"N X 145°49'39"E
0 1 2 3
APPROXIMATE SCALE — MILES
0 1 2 3 4 5
APPROXIMATE SCALE — KILOMETERS
SCALE 1:63,360
SOURCE: U.S. DEFENSE MAPPING AGENCY AND SCS FIELD PERSONNEL; PROJECTION UNKNOWN.
ELEVATIONS ARE IN METERS.
FORM LINES DEPICT ONLY GENERALIZED LANDFORMS. THEY DO NOT REPRESENT EXACT CONTOUR ELEVATIONS.

Locations of Mariana Fruit Bat Colonies in 1983, 1992, and 2000 on Pagan.



Locations of Mariana Fruit Bat Evening Count Stations on Pagan, August 1999

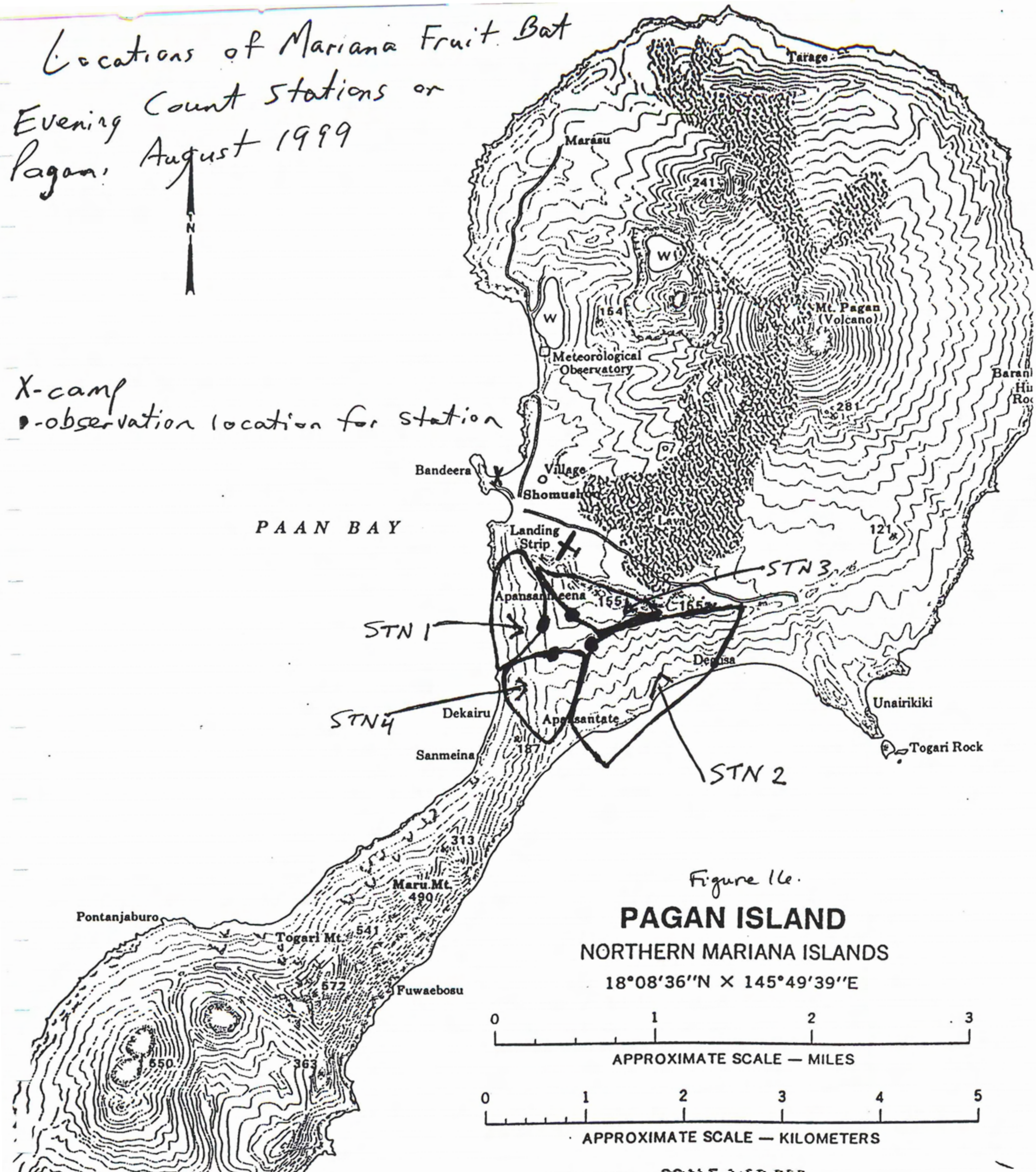


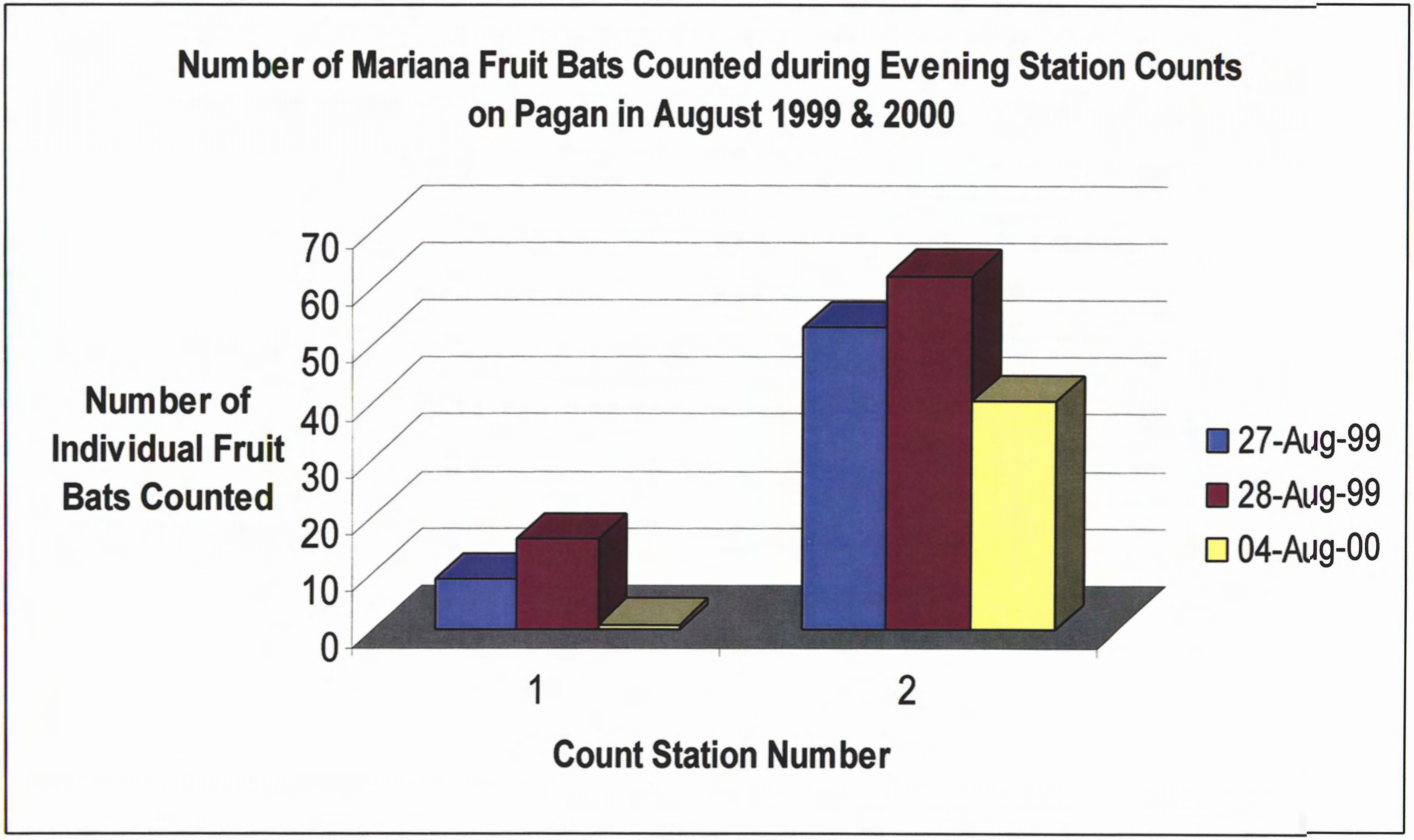
Figure 16.

PAGAN ISLAND

NORTHERN MARIANA ISLANDS

18°08'36"N × 145°49'39"E

SOURCE: U.S. DEFENSE MAPPING AGENCY AND SCS FIELD PERSONNEL; PROJECTION UNKNOWN.
ELEVATIONS ARE IN METERS.
FORM LINES DEPICT ONLY GENERALIZED LANDFORMS. THEY DO NOT REPRESENT EXACT CONTOUR ELEVATIONS.


Number of Mariana Fruit Bats Counted during Evening Station Counts on Pagan in August 1999 & 2000
Number of Individual Fruit Bats Counted
70
60
50
40
30
20
10
0
1
2
Count Station Number
27-Aug-99
28-Aug-99
04-Aug-00

Other Notes of Interest

Feral animal damage to the vegetation and general ecology of Pagan is obvious. Browse lines over two meters high on trees, lack of regeneration in the forest, and absence of vines that have invaded forests on other islands over the past three years all attest to the extent of their influence. No immediate estimates of the numbers of feral animals are available, but there are large herds of feral cattle (in the high hundred of heads), feral pigs are abundant, herds of feral goats occupy the southern peninsula, and even feral fowl are numerous (see bird surveys). The level terrain and numerous game make for excellent and easy hunting.

Centipedes remain numerous in the camping area between the two bays.

Management Recommendations

- We concentrated our surveys on parts of Pagan that are primary sites for homesteads of returning residents. With the exception of areas of native and agroforest at the base of the old caldera and just to the south of its rim, we found no species of biological concern that would impede the plans for homesteads. Areas of particular sensitivity, such as those mentioned above, the areas around the two lakes, and the southern peninsula should be omitted from the homestead lottery.

- Areas from which ash is mined commercially should have erosion and sedimentation control plans well worked out. Erosion is a serious problem where this material has been deposited and disturbing the surface layers may exacerbate it. An environmental impact statement should include the effect that disturbing the ash by removal will have on the surrounding environment including ocean waters. This plan should include how the site will be re-vegetated after the contractors leave.

- DFW has been discussing how to approach the feral animal problem on Pagan with the former residents and NIMO. It seems possible that some accord can be reached for both harvesting a portion of the population and for eliminating the majority of animals from the southern sector. From the Wildlife perspective, the southern peninsula seems to hold most of the remaining species of concern, such as megapodes, fruit bats, and Coconut crabs. The northern portion of the island seems ideally suited for agricultural purposes and for eco-tourism development. We suggest that in 2001, NIMO and DFW search out funds for the construction of a short fence across the isthmus separating the northern and southern sections. A survey of that area by the Historic Preservation Office should be undertaken before plans are

firmed up (many pre-conquest artifacts remain on both sides of the isthmus). The construction of the fence might begin as early as 2002, with the intent of procuring additional funding for the removal of animals from the southern peninsula only.

- More extensive herpetological surveys should be conducted to confirm the status of skinks and lizards on Pagan.

Acknowledgments

This project was funded through a cooperative agreement between the U.S. FWS and CNMI-DLNR (#12200-0-J001) and we very much thank our sponsors in the Service. The herpetological and small mammal surveys were conducted by Paul Reyes (CNMI-DFW) and Jamie Saures (CNMI-NIMO). Forest bird, bat, and vegetation surveys were conducted by Nathan Johnson, Laura Arriola and Tina de Cruz (CNMI-DFW). Feral animal hunting was conducted by the personnel from NIMO who aided us in every way possible: Ed Santos, Pat Santos, Paul Santos, Ino Saures, Ed Saures, Victor Romoar, Romy Wapol, and Jess Saures. Captain Sylverio Mettao provided safe small boat transportation to and from the Marlin II and over to the southern peninsula. We would like to thank the Marlin II and her crew for getting us to Pagan and off again despite the weather.

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APPENDIX 1

GPS Coordinates of VCP bird survey point stations on Pagan 3-9 August 2000. Habitat classifications are as follows: 1 = open/volcanic; 2 = *Casuarina* forest; 3 = mixed native/*Casuarina* forest; 4 = forest/field interface; 5 = mixed native forest; 6 = coconut forest; and 7 = ravine coconut forest.

			GPS Coordinates		Habitat
Island	Transect	Station	55Q	UTM	Type
Pagan	1	1	368748	2004523	4
Pagan	1	2	368894	2004531	2
Pagan	1	3	369054	2004579	1
Pagan	1	4	369121	2004715	1
Pagan	1	5	369160	2004871	1
Pagan	1	6	369232	2004973	1
Pagan	1	7	369324	2005066	1
Pagan	1	8	369209	2005147	1
Pagan	1	9	369125	2005268	2
Pagan	1	10	369056	2005399	2
Pagan	1	11	369113	2005500	2
Pagan	1	12	369184	2005639	2
Pagan	1	13	369186	2005794	2
Pagan	1	14	369232	2005927	2
Pagan	1	15	369312	2006071	2
Pagan	1	16	369354	2006237	3
Pagan	1	17	369339	2006428	2
Pagan	1	18	369258	2006572	2
Pagan	1	19	369270	2006721	3
Pagan	1	20	369149	2006734	2
Pagan	3	1	368634	2004050	3
Pagan	3	2	368707	2003974	5
Pagan	3	3	368758	2003816	5
Pagan	3	4	368784	2003671	5
Pagan	3	5	368859	2003573	4
Pagan	3	6	368936	2003480	3
Pagan	3	7	368988	2003364	3
Pagan	3	8	368995	2003221	4
Pagan	3	9	369070	2003125	5
Pagan	3	10	369080	2002958	4
Pagan	3	11	369081	2002815	1
Pagan	3	12	369057	2002668	4
Pagan	3	13	369043	2002528	1
Pagan	3	14	369152	2002444	1
Pagan	3	15	369216	2002308	4
Pagan	3	16	369637	2002297	7
Pagan	3	17	369428	2002279	7
Pagan	4	1	371576	2003142	4
Pagan	4	2	371533	2002975	1
Pagan	4	3	371417	2002875	4
Pagan	4	4	371271	2002887	6
Pagan	4	5	371089	2002832	4

Island	Transect	Station	GPS Coordinates 55Q	UTM	Habitat Type
Pagan	4	6	370939	2002861	4
Pagan	4	7	370724	2002817	5
Pagan	4	8	370562	2002811	4
Pagan	4	9	370413	2002716	7
Pagan	4	10	370324	2002627	4
Pagan	5	1	371624	2003306	4
Pagan	5	2	371767	2003362	5
Pagan	5	3	371905	2003422	2
Pagan	5	4	372053	2003457	2
Pagan	5	5	372173	2003551	3
Pagan	5	6	372302	2003617	2
Pagan	5	7	372430	2003695	3
Pagan	5	8	372578	2003732	3
Pagan	5	9	372725	2003750	5
Pagan	5	10	372858	2003770	1
Pagan	6	1	368855	2004055	4
Pagan	6	2	368961	2003907	1
Pagan	6	3	369105	2003811	1
Pagan	6	4	369268	2003800	5
Pagan	6	5	369387	2003697	5
Pagan	6	6	369485	2003577	5
Pagan	6	7	369644	2003571	5
Pagan	6	8	369806	2003552	4
Pagan	6	9	369891	2003439	7
Pagan	6	10	370062	2003425	1
Pagan	6	11	370216	2003385	1
Pagan	6	12	370377	2003444	1
Pagan	6	13	370513	2003447	4
Pagan	6	14	370650	2003424	5
Pagan	6	15	370790	2003325	4

APPENDIX 2
Pagan Forest Studies

Casuarina equisetifolia Forest Study

Methods

The study area is a *Casuarina equisetifolia* forest of approximately 4 ha located adjacent to the airstrip in the northern part of the island. The survey was conducted in August 2000. Tree species were surveyed using the point centered-quarter method (Mueller-Bombois and Ellenberg 1974) along two transects. Each transect was 150 m in length and there were 10 stations per transect, each station was 15 m apart. Only trees greater than 1 m in height were measured. One transect ran parallel to the runway, roughly west to east. The other transect was perpendicular to the runway, roughly north to south. Canopy cover was estimated using a densiometer according to the instructions. The data was analyzed for mean distance from tree to point, absolute density and absolute frequency, relative frequency, relative density, importance value (Mueller-Bombois and Ellenberg 1974), diameter at breast height (DBH) size class, height class, and canopy cover.

Results

The only two species found in this forest were *Casuarina equisetifolia* and *Jatropha curcas*. Only one individual of *Jatropha curcas* was recorded along the transect. Aside from the recorded individual only 5 other individuals were seen within the study area. *Casuarina equisetifolia* is the dominant species in this forest with an absolute frequency of 100%; that of *J. curcas* was 5%. The relative density and importance value of *C. equisetifolia* were by far the greatest (Table 1). Aside from the *J. curcas* there were two seedlings of what appeared to be *Aidia cochichinensis* which were 8 cm in height and therefore fell under the size threshold. The mean distance to the center point of each station was 3.88 m sd +/- 2.35 (n=80). The absolute density was 6.63 trees per 100 m^2. The average canopy cover for the whole forest was 88.84% (sd 2.92, n=20).

Table 1. Relative density, dominance ad frequency used to determine I.V. (Importance value) and then rank for a *C. equisetifolia* forest on Pagan, August 2000

	Relative Density	Relative Dominance	Relative Frequency	I. V.	Rank
C. equisetifolia	98.75	4.066	95.24	198.05	1
J. curcas	1.25	0.051	4.76	6.06	2

The height class distribution of trees (primarily *C. equisetifolia*) was skewed with the majority of the population taller than 7 m (Fig. A1). However, in DBH size class the majority of the individuals are clustered under 30 cm (which is still fairly large). The exception is in the 1-5 cm size class which is 50% less than either the 5-10 cm or 10-15 cm classes (Fig. A2).

Discussion

There are not well documented reports about the introduction of *C. equisetifolia* to Pagan or any of the northern islands. The occurrence of *C. equisetifolia* and the location of many old stands along shorelines and clifflines leads to the speculation that this species may have been introduced as erosion control. On Saipan and Tinian it has often been introduced for these purposes. The earliest report of *C. equisetifolia* near the study site is from 1978 (Ludwig 1978), when *Casuarina equisetifolia* was reported as being present around the outer lake and in the village area. However, large dominating stands are not noted. Both areas are in the vicinity of the study site. Anecdotally, employees of the Northern Islands Mayors Office who have visited Pagan many times over the last decade indicated that the areas covered have increased. Basic ecological descriptions of *C. equisetifolia* forests have not been previously conducted in the Mariana Islands. General observations, however, have led to the speculation that this species once it is established, is able to exclude native species that are important wildlife habitat.

The lack of a *C. equisetifolia* undestory, as evidence by the smallest DBH size class and height classes, indicates a lack of recruitment. There is also, obviously, a lack of any native species recruitment as well. The lack of recruitment may be due to the presence of feral animals. However, there are other possibilities as well. There may not be enough light for seedling recruitment as the stand appears fairly mature, or the microhabitat of the understory could be inhospitable even for seedlings of *C. equisetifolia*. It has been speculated (Stone 1970) that the thin branches which litter the understory have an allelopathic effect. The native species suppression is likely a combination of feral animal activity in conjunction with exclusion by *C. equisetifolia*. A comparison study of a similar area lacking feral animals would be helpful in elucidating these issues. Further study is needed as the *C. equisetifola*

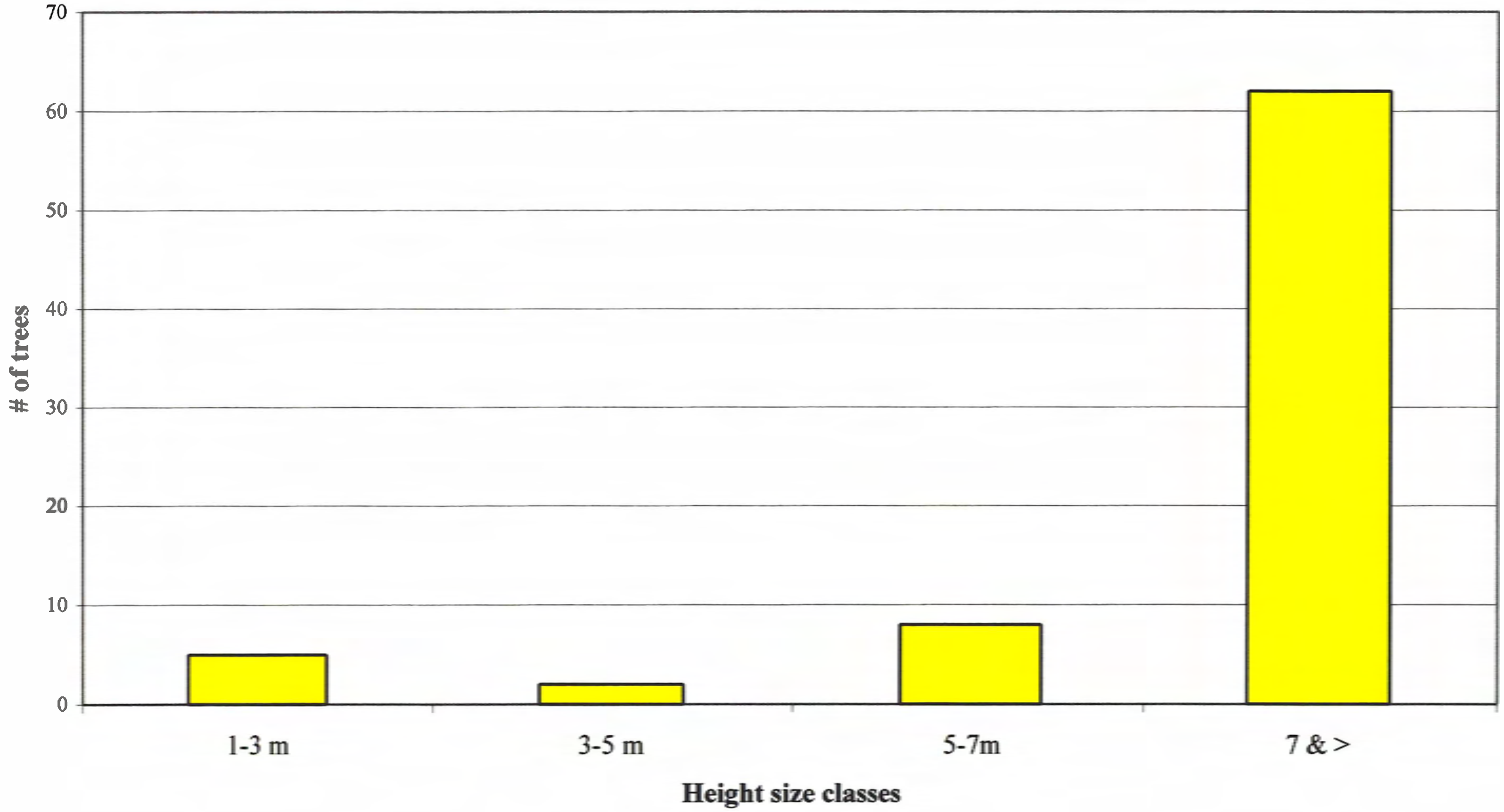
forested area appears to be expanding and excluding native species utilized by wildlife.

List of Figures for Appendix 2

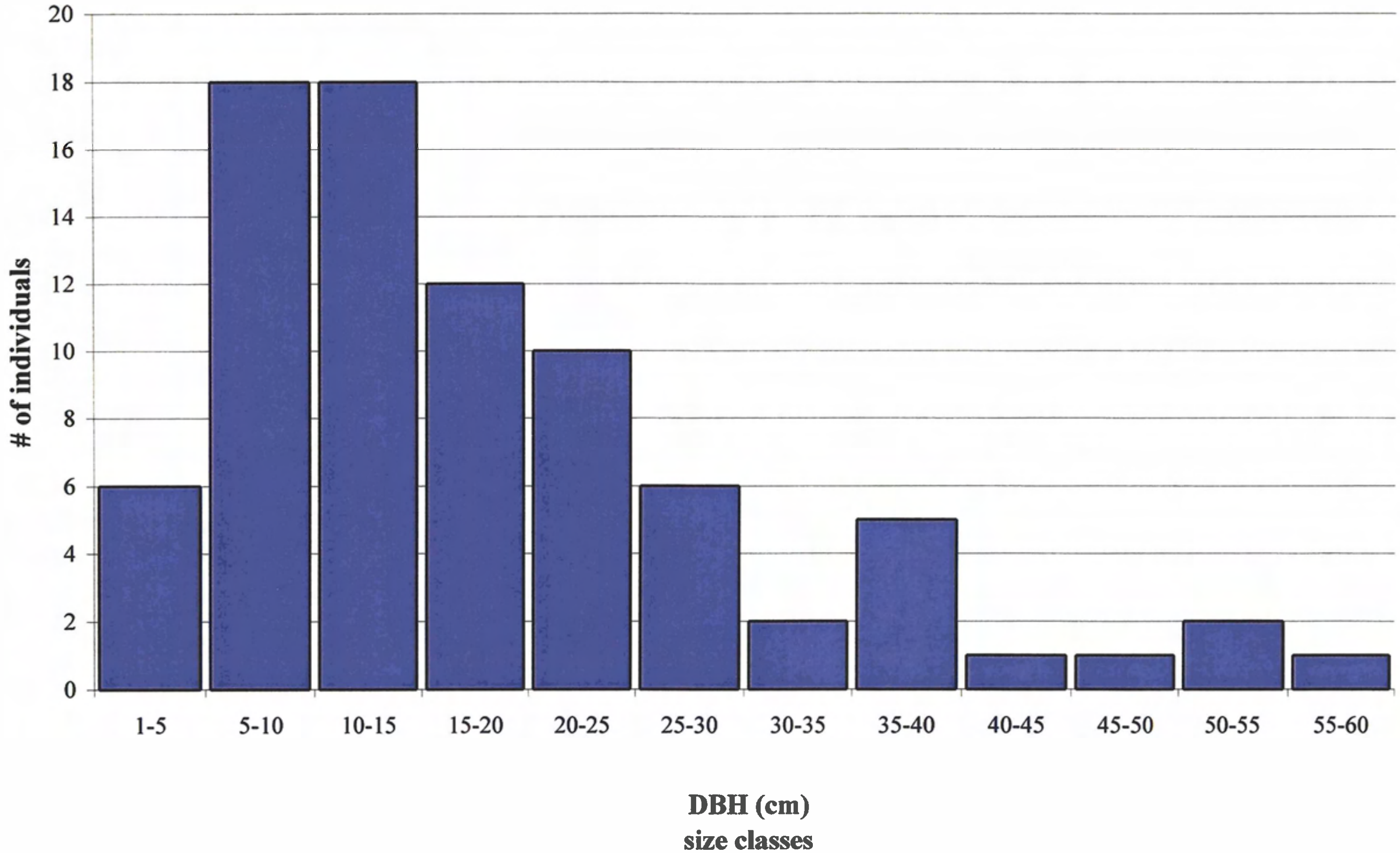
Figure 1. Height size class of trees (dominant *C. equisetifolia*) in a forest on Pagan.

Figure 2. DBH size class of trees in a dominant *C. equisetifolia* forest on Pagan.

Height size class of trees in dominant *C. equisetifolia* forest on Pagan, August 2000



DBH size class of trees in a dominant *C. equisetifolia* forest on Pagan, August 2000



Appendix 3

Gapgap Permanent Vegetation Plots

Gapgap is located on the southwest coastline of Pagan. The ridge above the coast harbors some of the most intact native forest. It is the only forest in all the northern islands were *Guamia mariannae* was observed during these trips. Micronesian megapodes were observed in this forested region along with Micronesian Honeyeaters and Micronesian starlings. The area is also heavily populated by feral goats. During this trip wild pigs were not observed but were observed in 1999. The ridge slope which begins about 200 m from the coastline has scattered pockets of steam vents. The steam vents and native forest combined should make a highly productive habitat for Micronesian megapodes. The main threat here is the destructive forces of the feral animals.

The area is most easily accessible by small boat. However, in high surf conditions the landing is very difficult as it is necessary to pull up next to large basalt jetties. It was only possible to spend one day in this region because of weather conditions that made it impossible to travel by water and make the landing a second time.

Methods

Six permanent vegetation monitoring stations were established. The sole purpose was to monitor vegetation over time and possibly gain more knowledge as to the temporal and structural destructiveness of feral animals. The number of plots was limited by the amount time available for establishing plots and data collection. The vegetation transect runs through different habitats and elevations. The plots are 100 m apart and permanently marked with rebar. The plots were surveyed using a modified point-centered quarter method. Tree species were identified in each quarter, diameter at breast height, and height were recorded. Herbaceous species in a 1 m^2 area around the rebar were collected. Ground cover was estimated by randomly placing a meter tape within the 1 m^2 area and recording the cover every 10 cm. This sample was used to estimate the cover for the plot. Canopy cover was estimated using a densiometer according to the instructions. Pictures were taken of every station bearing directly north and centering around the rebar.

Results

Casuarina equisetifolia has the greatest relative density (Fig. 1) but it is only present in half of the plots (Fig. 2). *Aglaia mariannensis* and *Psychotria mariana* are both also present in half of the vegetation plots with a frequency of 50% (Fig. 2). *Aglaia mariannensis* is prevalent, as is *P. mariana* in the smaller DBH sizes and *C. equisetifolia* is present as larger trees (Fig. 3). This pattern is very similar

to that of in height class distribution: *P. mariana* and *A. mariannensis* are present in the smaller classes and *C. equisetifolia* in the larger (Fig. 4). The ground cover at stations 1, 2 and 6 is considerably less that other stations. These are densely covered areas as noted by the corresponding canopy cover (Fig. 5). Stations 2 and 3 are located on a steep hillside which has dispersed *C. equiseifolia*.

<u>List of Figures for Appendix 3</u>

Figure 1. Relative Density of tree species recorded from 6 vegetation plots each 100m apart along a transect.

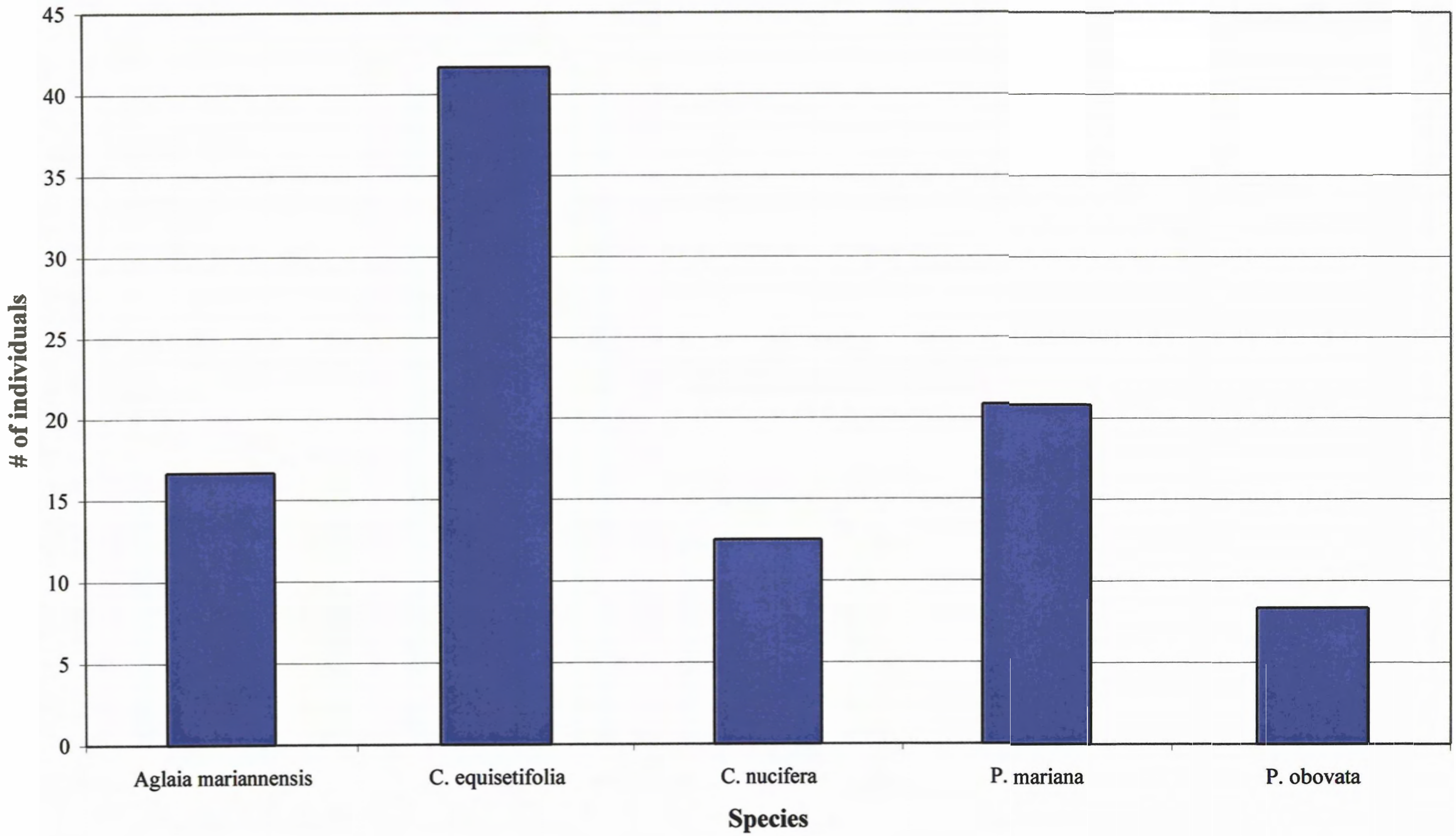
Figure 2. Absolute Frequency of tree species recorded from 6 vegetation plots each 100m apart along a transect in Gapgap on Pagan.

Figure 3. DBH size class of tree species recorded from 6 plots each 100m apart along a transect in Gapgap on Pagan.

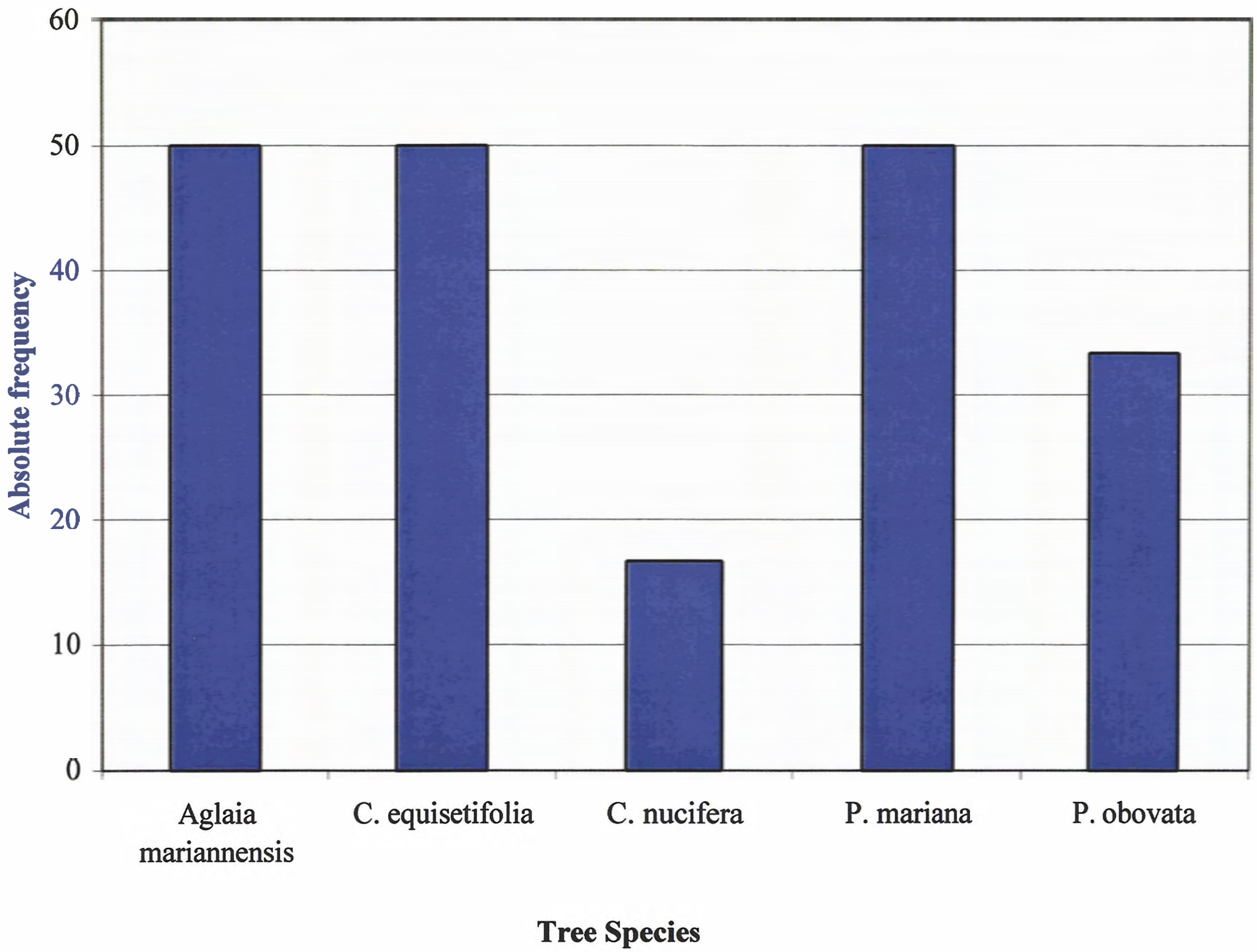
Figure 4. Height class of tree species recorded from 6 plots each 100m apart along a transect in Gapgap on Pagan.

Figure 5. Average Ground and Canopy cover of 6 plots each 100m apart along a transect in Gapgap on Pagan.

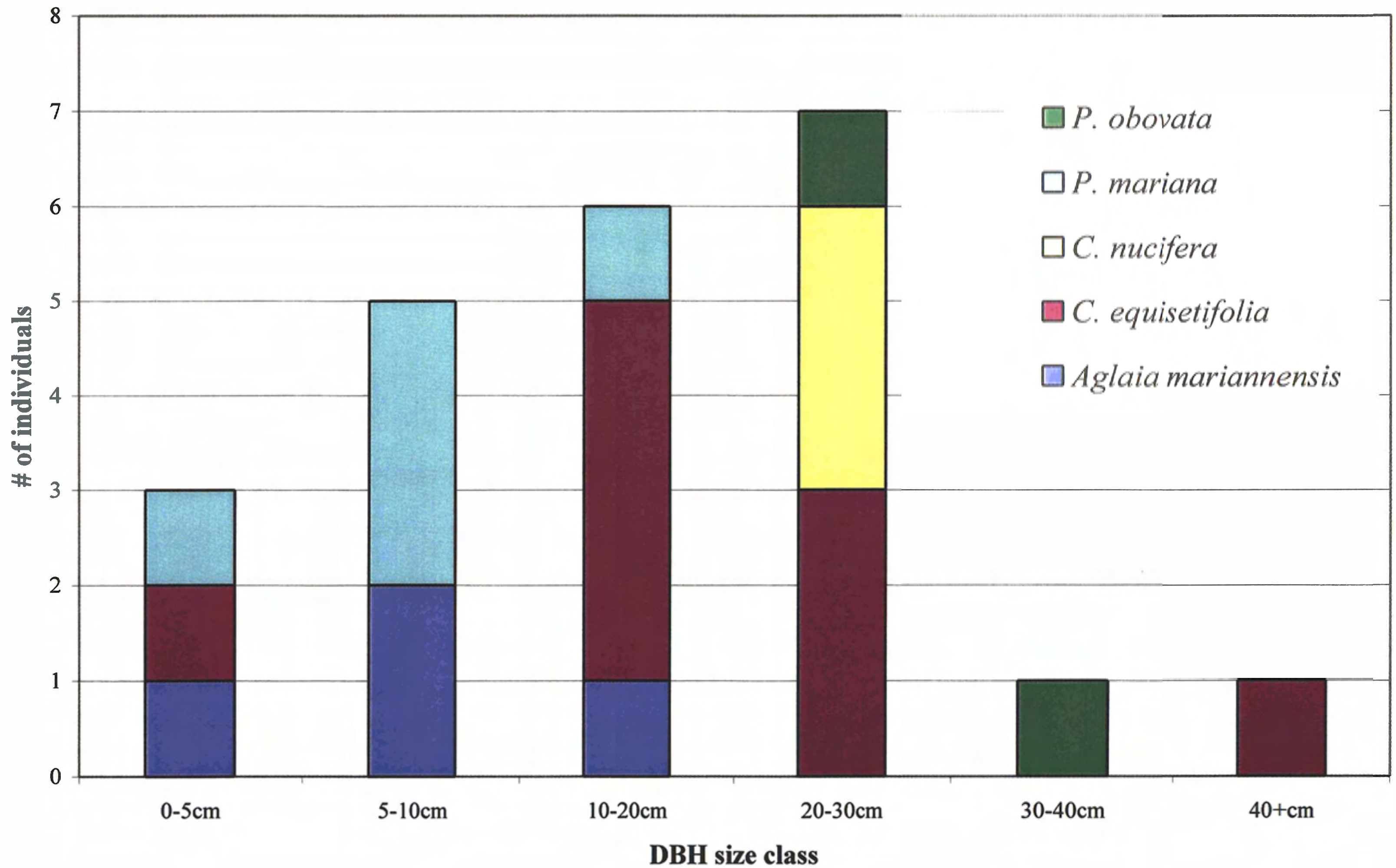
Relative density of tree species from 6 vegetation plots in the Gapgap area on Pagan, August 2000



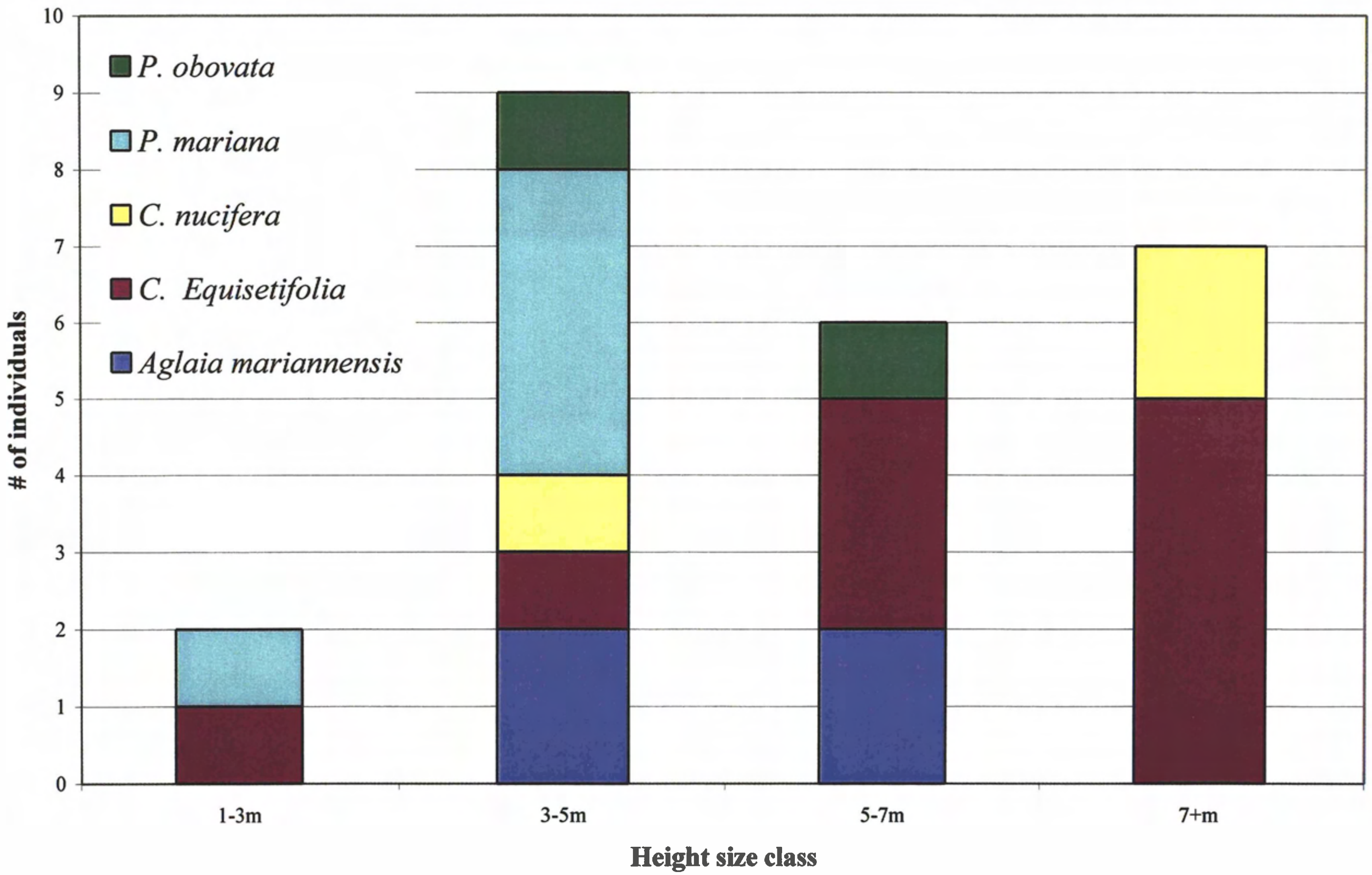
Absolute frequency of tree species from 6 vegetation plots in the Gapgap area on Pagan, August 2000



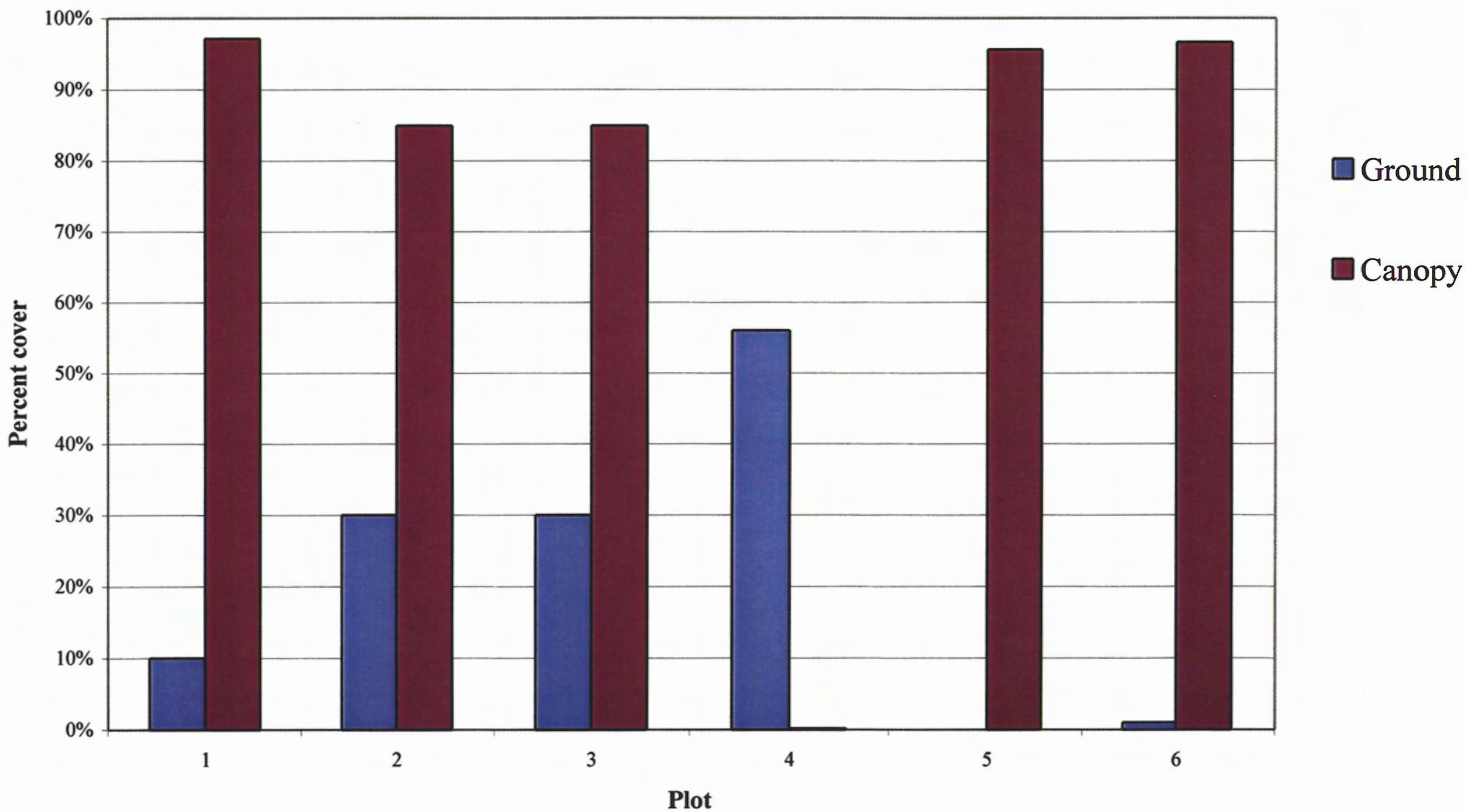
DBH size class of tree species recorded from 6 vegetation plots in Gapgap on Pagan, August 2000



Height class of tree species recorded from 6 plots in Gapgap on Pagan, August 2000



Average Ground and Canopy cover of 6 plots in Gapgap on Pagan, August 2000



Pagan Gapgap Station 1

Habitat: Coconut forest

Point-centered Quarter:

Plot	Quarter	Species	DBH	Height	Distance	Bearing
1	NW	C. nucifera	28.16	12	3.2	350
1	NE	Aglaia mariannensis	6.36	4	0.7	80
1	SW	C. nucifera	24.81	8	1	168
1	SE	C. nucifera	24.81	4.5	4.3	252

North facing Picture:

Pagan Gapgap Station 2

Habitat: Grass covered slope with scattered C. equisetifolia.

Point-centered Quarter:

Plot	Quarter	Species	DBH	Height	Distance	Bearing
2	NW	C. equisetifolia	20.04	10	60	300
2	NE	C. equisetifolia	19.41	8	7	64
2	SW	C. equisetifolia	22.27	8	5.3	150
2	SE	C. equisetifolia	11.45	7	7	248

Pagan Gapgap Station 3

Habitat: Patchy grass covered steep slope, few trees

Point-centered Quarter:

Plot	Quarter	Species	DBH	Height	Distance	Bearing
3	NW	C. equisetifolia	16.22	6	75.9	312
3	NE	C. equisetifolia	22.91	7	4.4	40
3	SW	Aglaia mariannensis	9.54	3.5	50	140
3	SE	P. mariana	9.23	4	40	210

Pagan Gapgap Station 4

Habitat: Grass covered ridge edge with nearby steam vents

Point-centered Quarter:

Plot	Quarter	Species	DBH	Height	Distance	Bearing
4	NW	C. equisetifolia	n/a	n/a	125	290
4	NE	C. equisetifolia	16.86	4	35.1	50
4	SW	C. equisetifolia	48.00	10	27.5	108
4	SE	C. equisetifolia	2.55	2	40	235

Pagan Gapgap Station 5

Habitat: Native forest.

Point-centered Quarter:

Plot	Quarter	Species	DBH	Height	Distance	Bearing
5	NW	P. mariana	15.59	4	4.5	300
5	NE	Aglaia mariannensis	16.22	6	2	54
5	SW	P. obovata	25.13	6	2.4	100
5	SE	Aglaia mariannensis	7.16	6	1.9	224

Pagan Gapgap Station 6

Habitat: Native forest

Point-centered Quarter:

Plot	Quarter	Species	DBH	Height	Distance	Bearing
6	NW	P. mariana	3.98	3	1.8	280
6	NE	P. mariana	8.43	4	1.9	30
6	SW	P. mariana	9.07	4	3.59	130
6	SE	P. obovata	38.97	5	3.78	200

Appendix 4

Mid-Plateau Remnant Forest

Methods

The study area is approximately 2 ha located on the plateau south of the airstrip. This area consists of highly fragmented native forest with a large population of feral pigs, goats and cows. The study site is one of the largest contiguous forest patches in this area, which extends for about 2 km. The site is approximately 300 m x 60 m. Within the study site eight 5 m x 5 m permanent plots were randomly chosen using a grid and a random numbers table. Height and diameter at breast height were measured on all tree species 1 m or greater. The herbaceous species in a $1m^2$ area around the rebar were identified. Canopy cover was estimated using a densiometer according to the instructions. Ground cover was estimated 1 m^2 around the rebar by dividing the area into quarters and estimating each quarter. The data has been analyzed for height and DBH size class, density, absolute frequency (# of plots a species occurs in/total # of plots, expressed as %) and dominance (the mean basal area/tree of each species). There has not been sufficient time to finish and draw conclusions between gathering the data and this report. The proportion completed is presented below.

Results

Further analysis of this data is still required. The dominant trees in the forest patch are *E. variegata* and *C. nucifera*. They also have the greatest density. The third most dominant tree is *T. catappa* however it is not third in density. The most frequent tree species is *E. variegata* followed by *C. nucifera, Aglaia mariannensis* and *Pandanus tectorius* (Table 1).

Both the DBH and height class distribution revealed an overstory of *E. variegata* and *C. nucifera* with an understory of a variety of different native plants. In both DBH and height class sizes approximately 50% of the trees were in the older and larger size classes (Fig. 1 and 2). The average canopy cover for the forest was 94% (sd=2.35, n=8) and the average ground cover was 4.4% (sd=6.4, n=8).

Table 1. The dominance, density and the absolute frequency of tree species present in random permanent plots in a 2 ha fragmented native forest highly utilized by feral ungulates on Pagan in August 2000.

	Dominance		Density	Absolute Frequency
Species	Mean BA /tree	rank	#of trees /100m2	% plots
E. variegata	1181.25	1	2.5	37.5%
C. nucifera	1059.90	2	2.5	25.0%
T. catappa	908.74	3	0.5	12.5%
P. tectorius	506.15	4	1	25.0%
O. mariannensis	450.49	5	0.5	12.5%
P. obovata	402.59	6	1.5	12.5%
A. mariannensis	83.46	7	1.5	25.0
M. Citrifolia	83.40	8	0.5	12.5%
N. oppositifolia	73.94	9	1	12.5%

Discussion

The population of understory species and younger (*i.e.* seedlings) appears very low. On Sarigan, where the vegetation is beginning to come back after eradication of ungulates, the smaller size classes (both in height and DBH) form a larger percent of the whole population than is seen in this forest on Pagan. It is alarming that there is a complete lack of *T. catappa*, a major bat foraging species in the understory. These trees definitely are reproducing, as huge quantities of the nuts were seen all over the forest floor. Feral pigs were foraging on the nuts, so it is possible that foraging pressure is extremely high and that seedlings are browsed as well.

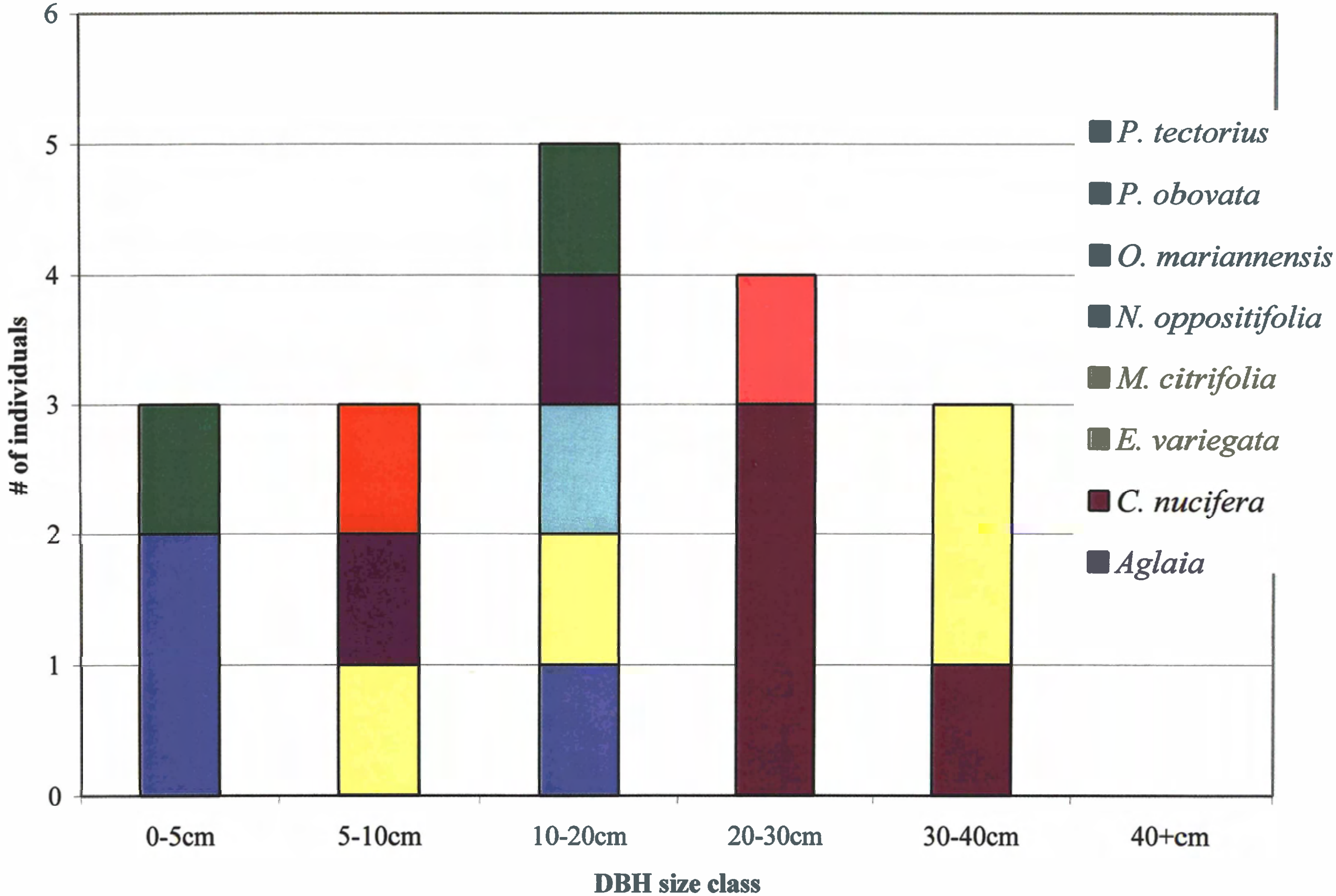
The lack *of E. variegata* in the middle range height or DBH classes is also cause for concern. *E. variegata* is an important wildlife tree, especially in the Northern Islands. Bats have been regularly observed in *E. variegata* foraging on the flowers on Sarigan. Micronesian Honeyeaters also forage in them. *E. variegata* is an important habitat component of the native forest as it is the most abundant and dominant upper canopy species in many areas.

List of Figures

Figure 1. Diameter at breast height size classes for tree species in random permanent plots in a 2 ha native forest with a high feral ungulate population on Pagan in August 2000.

Figure 2. Height size classes for tree species in random permanent plots in a 2ha native forest with a high feral ungulate population on Pagan in August 2000.

Diameter at breast height size classes for tree species in random permanent plots in a 2 ha native forest with a high feral ungulate population on Pagan, August 2000.



Height size classes for tree species in random permanent plots in a 2 ha native forest with a high feral ungulate population on Pagan, August 2000.