

2000 Technical Report #5

Wildlife and Vegetation Surveys

SARIGAN 2000

Conducted
By

**CNMI Division of Fish and Wildlife
Wildlife Section**

With Assistance
From

The Northern Island Mayor's Office

2-8 JULY 2000



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SUMMARY OF WILDLIFE SURVEYS SARIGAN ISLAND

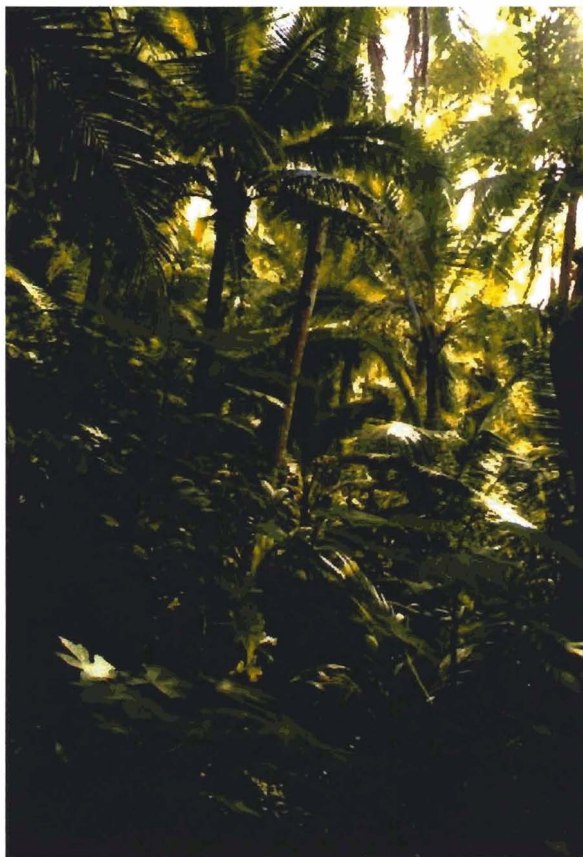
2-8 JULY 2000

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Executive Summary

Personnel from the U.S. Navy, U.S. FWS, CNMI-DFW, and Zoology Unlimited visited Sarigan in 2000 to follow-up on the removal of feral animals and to document the progress of floral and faunal recovery after eradication. Surveys of forest birds, skinks, lizards, small mammals, vegetation, and fruit bats were conducted.

Systematic forest bird surveys detected 381 birds of 5 different species on Sarigan. Micronesian starlings were detected significantly less often in 2000 than in 1999. Mean detections of Micronesian megapodes were slightly higher this year than last, but not significantly. Other forest bird populations appear to be remaining stable. Our population estimates for all species except Collared kingfishers were lower than those estimated using VCP analytical techniques with the 1997 pre-eradication data. However, they are similar to, and a little greater than, those derived in 1999 by USFWS Biologist John Morton.

The vegetation on Sarigan is recovering to some degree from the destruction of feral animals. The native species *Aglaia mariannensis* along with the introduced *Cocos nucifera* and *Hibiscus tiliaceus* were the most common and abundant trees. Seedlings were present in large numbers in the understory. The 13 permanent vegetation plots have had the number of species present double since feral animal removal. However, much of the increase in plant species are introduced weeds. For example the introduced *Operculina ventricosa* (woodrose) was found to be a voracious invader in many plots and throughout the island. A significant increase in the number of seedlings during the 2000 survey was found as compared to the 1997 survey. The increase in the number of seedlings is attributed to the lack of feral ungulates.

Introduction

Feral animal removal from some of the smaller islands of the Northern Marianas chain has been a goal of the Wildlife Program of CNMI-Department of Lands and Natural Resources for many years. It is viewed as a precursor to the establishment of additional populations of endangered species from the southern islands because these populations are most at risk from the introduction of the Brown Tree Snake. After several attempts, Sarigan was selected as the target for eradication of feral ungulates. Political will to remove these animals from Sarigan has remained strong, and the eradication appears to be a success story.

Sarigan is a volcanic island rising steeply to 538 m. According to Morton (2000), most of the north and northwestern slopes are forested (162.5 ha), with patchy stands of trees on the plateau below the main crater. Of the forested area, approximately 133.4 ha are coconut forest and 29.1 ha are native forest.

Another 191.5 ha have either grass or fern cover, while the remaining 106 ha are steep, nearly unvegetated, erosion slopes of the southern exposures.



The steep southern slopes of Sarigan.

Baseline pre-eradication surveys were conducted in order to determine the wildlife species composition and to provide a basis for comparison with later surveys documenting the recovery of the island after eradication. Fancy *et al.* (1999) surveyed forest birds on Sarigan in 1997. Five native forest bird species were observed and their populations estimated using Variable Circular Plot methods and a model fitting analytical program: Micronesian megapode (*Megapodius laperouse*), Micronesian honeyeater (*Myzomela rubratra*), Micronesian starling (*Aplonis opaca*), Collared kingfisher (*Halcyon chloris*), and White-throated ground dove (*Gallicolumba xanthonura*). A pre-eradication vegetation transect with 13 plots was established and a vegetation survey conducted by DFW in February 1997 (Kessler 1997).

In August 1998, DFW staff returned to Sarigan to remove feral animals that were missed in the general campaign and to repeat the vegetation survey. The survey party found one goat remaining. They also found that the number of floral species present had more than doubled since the original survey. The frequency of individual plant species and ground cover increased dramatically and species diversity was greater in each area surveyed within a year of feral animal removal (Arriola and Vogt 1998; Kessler 1998).

In early July 1999, another trip was made to Sarigan in conjunction with the US Navy and the USFWS. The Service established a series of eight permanent transects around the island in order to do vegetation assessments and they conducted point-count surveys of the bird populations on these transects. Zoology Unlimited and DFW staff searched out the remaining feral animals on the island. DFW personnel measured vegetation changes along the pre-eradication vegetation transect, surveyed birds along transects established in 1990 (these are different from those established by the Service in 1999), and surveyed skink and small mammal populations. Mariana fruit bat surveys were conducted by Gary Wiles (from Guam's Department of Aquatic and Wildlife Resources) with assistance from USFWS and DFW staff. Results of these surveys were reported to USFWS by DFW (Arriola *et al.* 1999), Morton (2000), Wiles (1999), and Zoology Unlimited (Kessler 1999).

The July 2000 trip focused on repeating forest bird, herpetological and Mariana fruit bat surveys in order to assess their status 2 years after eradication. The 13 permanent vegetation plots were also re-surveyed. In addition vegetation was sampled in conjunction with forest bird surveys and a new permanent successional study was established. This year bird surveys were conducted along the permanent transects established in 1999. Most personnel arrived by boat (the Marlin II), but the feral animal team came by Americopters in order to search the most difficult parts of the island from the air. The research team departed Sarigan for Anatahan on July 8, 2000.

Survey personnel included Scott Vogt (USFWS), Richard Lazaro (CNMI-DFW) and Larry Stoll (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), and by Sheldon Plentovich and Mick Castillo (USFWS). Searches for remaining feral animals were conducted by US Navy and Zoology Unlimited personnel: Tim and Vilma Sutterfield, Curt Kessler, Mark Severson, and Hoppalong Gideon. We report on the findings of the 2000 survey trip below and compare them with prior findings whenever possible.

Forest Bird Surveys

Forest bird surveys were conducted using VCP methodology on 3-6 July 2000. The surveys were completed in the mornings from 6:00 to 10:30 a.m. with the exception of Transect 4 where 3 stations were counted in the late afternoon. Birds were counted after either visual or auditory identification. Count duration was 5 minutes (for comparative purposes with other northern island counts) plus an additional 3 minutes (total of 8 minutes) so that results could be compared with those of 1999. The distance to each detection was estimated. Playbacks were not employed and most birds were counted by their song or call notes.

Point counts were performed at permanent stations spaced every 100 m along seven transects established in 1999 (Figure 1). The transects were set systematically to sample different habitats and were composed of between 6 and 13 count stations. Transect 7 was not completed because the number of birds present in this area did not merit the effort. Counts at the 6 points closest to the coast on Transect 5 were not finished due to time constraints. A total of 54 were sampled.

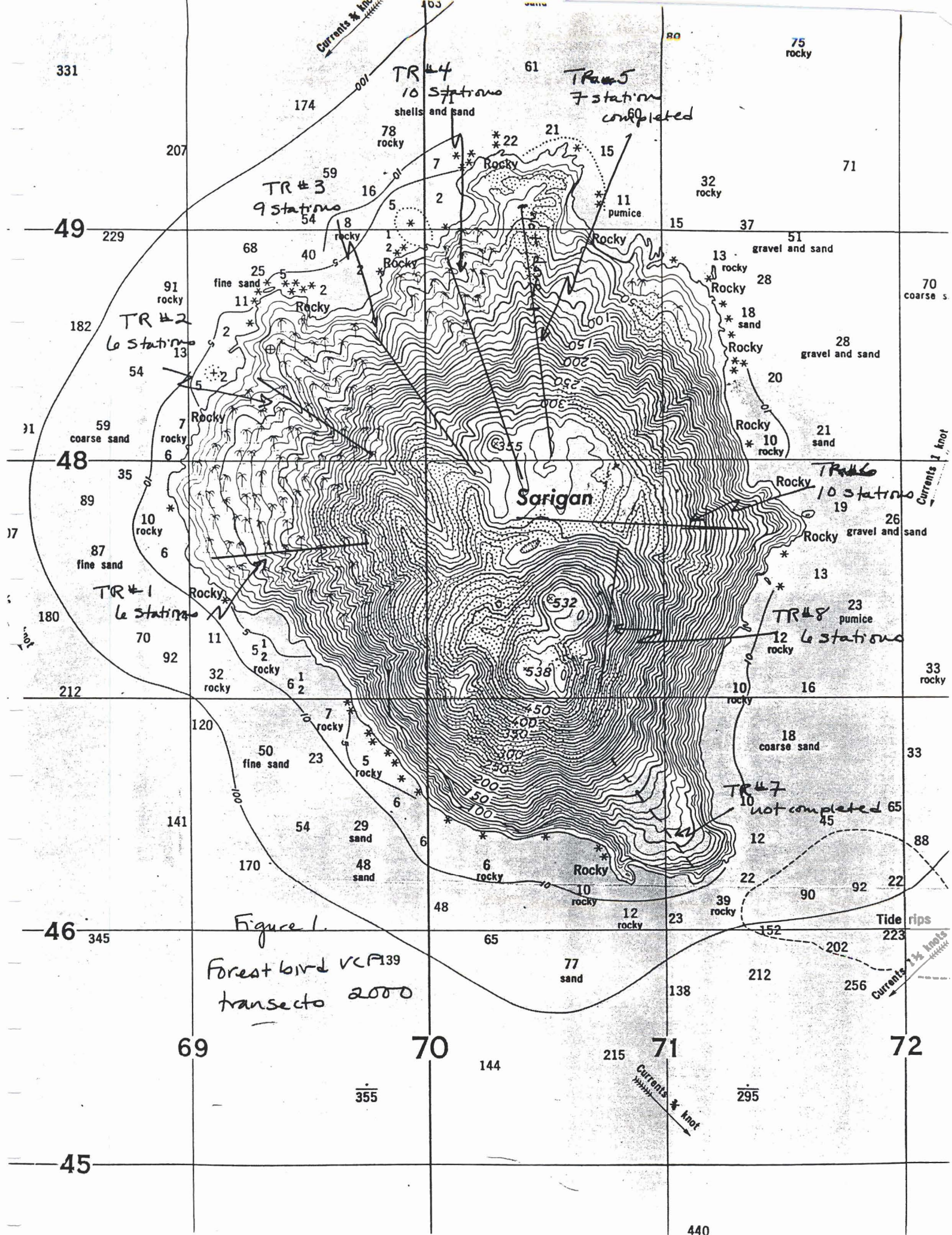
Transects 1, 2, and 3 currently run through thick coconut forest, or coconut forest mixed with native species and some stands of nearly pure native forest. Transect 4 runs through coconut forest near the coast, then mixed coconut and native species, through patches of native forest, and ends in a field/forest interface. The stations on Transect 5 were all in native forest. Transect 6 runs through a grassy field, and Transect 8 is set over an old, completely open lava flow. Point count stations were permanently marked with rebar in 1999 and the transects were re-flagged this year. Point stations can be relocated using the GPS coordinates in Appendix 1.

Table 1. Detections of bird species at 54 stations on Sarigan during 3-6 July 2000.

Sarigan Bird Species	Number Detected 2000	2000 Mean #/Station (SE) ¹	1999 Mean #/Station (SE) ²	2000 % Occurrence (#) ¹	1999 % Occurrence (#) ²	Difference in Means between Years
Micronesian Megapode	79	1.46 (0.252)	1.06 (0.163)	57.4 (31)	51.5 (34)	$t = -0.9$ $P < 0.2$ ns
Collared Kingfisher	70	1.30 (0.159)	1.35 (0.176)	70.4 (38)	66.7 (44)	$t = 0.56$ $P < 0.3$ ns
Micronesian Starling	38	0.65 (0.158)	0.95 (0.174)	33.3 (18)	45.5 (30)	$t = 1.89$ $P < 0.03$
Micronesian Honeyeater	167	3.09 (0.266)	3.17 (0.379)	90.7 (49)	75.8 (50)	$t = 1.38$ $P < 0.09$ ns
White Tern	21	0.39 (0.141)	0.57 (0.147)	13.0 (7)	22.7 (15)	$t = 0.69$ $P < 0.25$ ns
White-throated Ground-dove	3	0.06 (0.031)	0.09 (0.047)	5.56 (3)	6.1 (4)	$t = 0.33$ $P < 0.37$ ns

¹ Data from 54 stations along seven of eight transects surveyed in 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 50 m radius.

² Data from 66 stations along 8 transects in 1999 generously loaned by author (Morton 2000) in order to make comparisons.



The most numerous birds were Micronesian honeyeaters (egigi). Collared kingfishers (sihek) and Micronesian megapodes (sasangat) were plentiful while the Micronesian starling (sali) and White terns were less so. White-throated ground doves (paluman apaka) were rare (Table 1).

Comparing the mean number of detections per station in 2000 with those of 1999 (Table 1) there appeared to be no significant differences for any species except for the Micronesian starling (t -test, $P < 0.03$). The Micronesian starling detection rate was significantly less in 2000 than in 1999. Mean detections of Micronesian megapodes were slightly higher this year than last, but it was not statistically significant. Other bird populations appear to be stable.

Micronesian starlings may be encountering difficulties in foraging or other activities because so many of the trees in the highlands (where they generally reside) are covered with vines. Excessive growth of vines has become obvious on many of the other Mariana Islands and may be a cause for concern as effects on trees could precipitate a trophic cascade. However, Micronesian starlings are common residents of the entire archipelago and a small decline on Sarigan is not cause for immediate concern.

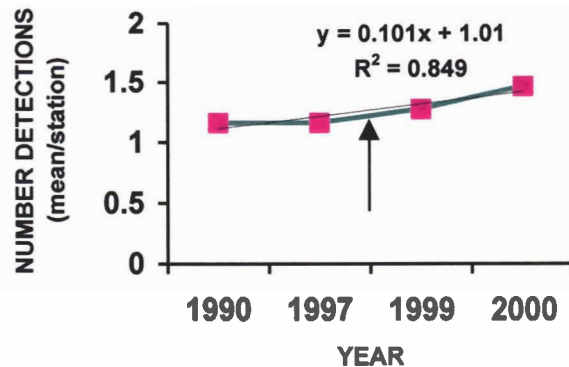


Invasive vines especially *Operculina ventricosa* are rampant over fields and patchy forest canopies.

The pre-eradication bird surveys conducted by Craig in 1990 and Craig and Fancy in 1997 (Fancy *et al.* 1999) can only be compared directly with the same

transects revisited by DFW in 1999. For Micronesian megapodes, it has been previously reported that the mean detection rate on those transects rose slightly in 1999 (from a mean of 1.16 detections per station in both 1990 and 1997 to a mean of 1.27). If the mean density of megapodes in forested habitat from the earlier surveys is graphed along with the mean number of detections over all habitats from 2000 (recognizing that different areas were surveyed using similar VCP methods), a slowly increasing trend in megapode numbers since eradication in 1998 is suggested (Figure 2, below).

Mean Detections of Megapodes over a Ten Year Period



The distribution of forest birds on the island is reflected by the summary statistics presented in Table 2. Morton's (2000) categorization of habitat into coconut forest, native forest and nonforested areas has been followed. As post eradication revegetation continues to proceed on Sarigan, these classifications will need to be reassessed. The data was restricted to detections within a 50 m radius of each observation point so that comparisons could be made with the results of the counts in 1999. Collared kingfishers and Micronesian honeyeaters were the most common birds detected in open, unforested patches. Starlings were also detected during the survey in these areas, but far distance estimates precluded including them in the by-habitat analysis that was restricted to detections within a 50 m radius. These birds were making use of small pockets of trees and shrubs in an otherwise inhospitable environment.

Notably absent from nonforested areas were megapodes and White-throated ground doves. White-throated ground-doves were extremely rare, found only along Transects 2 and 3 in dense coconut forest. These birds may be more susceptible to predation by cats than some of the other species. For example, one dove, killed by a cat, was observed in the ravine to the south of the campsite. One cat was killed by hunters in this same general area.

Megapodes were also found only in forested habitats. Megapodes were observed using the patchy forest and field habitat near the upper campsite, but these were excluded from analysis because detection distances were greater than 50 m. Our analysis, therefore, estimates a conservative number of megapodes present on the island.



A forest patch near camp B on Sarigan in July 2000. The endangered Micronesian megapodes are utilizing forest patches.

The distribution of birds reported in Table 2 is gratifyingly similar between 1999 and 2000. There was a slight increase in the number of megapodes detected in the two forest habitats, consistent with the small rise in their overall detection rate. With the exception of the Starling and possibly the White-throated ground dove, bird populations appear to be responding positively to vegetation changes post-eradication on Sarigan. The ground dove is particularly quiet during portions of the year, and detection rates have been consistently low on this island.

Table 2. Density (# per ha \pm SE)^a and occurrence (in parenthesis) of five forest birds within a 50 m-radius plot for three habitats on Sarigan during 3-6 July 2000.

Bird Species	Year	Coconut Forest $n_{1999} = 28$ $n_{2000} = 25$	Native Forest $n_{1999} = 16$ $n_{2000} = 13$	Nonforest $n_{1999} = 22$ $n_{2000} = 16$
Micronesian Honeyeater	1999	4.32 ± 0.83 (27)	2.86 ± 2.17 (12)	0.58 ± 0.49 (6)
	2000	4.13 ± 0.39 (23)	3.13 ± 0.37 (12)	1.04 ± 0.29 (6)
Micronesian Megapode	1999	1.32 ± 0.65 (13)	1.19 ± 0.53 (11)	0.0 (0)
	2000	$2.29 \pm (0.41)$ (15)	1.86 ± 0.50 (8)	0.0 (0)
Micronesian Starling	1999	1.32 ± 0.72 (14)	0.95 ± 0.62 (9)	0.23 ± 0.27 (3)
	2000	0.51 ± 0.21 (4)	1.86 ± 0.42 (8)	0.0 (0)
White-throated Ground-dove	1999	0.14 ± 0.20 (2)	--	--
	2000	0.15 ± 0.0 (3)	--	--
Collared Kingfisher	1999	0.41 ± 0.39 (5)	0.56 ± 0.51 (4)	0.06 ± 0.11 (1)
	2000	0.41 ± 0.13 (6)	0.29 ± 0.23 (2)	0.16 ± 0.09 (2)

^a Estimates follow methods given in Morton (2000) and are based on a 50 m fixed radius estimate calculated from VCP point count data.

The estimated number of detections for each bird species per station was based on habitat-specific means for number of detections per station expect in both forest and nonforest environments (Table 3) using fixed radius methods.

Density and population estimates for the white-throated ground dove however, was not completed because there were not enough detections for an adequate sample size. The density for each species using the fixed radius method agrees with our biological experience on the island.

The surveys in 2000 were conducted virtually at the same time of year as those in 1999. This helped to eliminate confounding by seasonal variation, especially if the birds maintained a relatively fixed annual breeding schedule. Observations of megapodes included many pairs of adults, juveniles and few young chicks. Calling was frequent, but not exaggerated. These are consistent with

observations in 1999, and there were no other overt indications that megapodes were in a totally different portion of the breeding cycle than during the 1999 visit. Detections per station of megapodes, and the total population estimate, show a steady, small increase in numbers in 2000, but one that paired comparisons revealed was not significantly greater than the number of detections in 1999. However, the suggestion of a positive trend, based on mean detections per station from 1990 to 2000, provides a further argument in support of a steadily increasing population in the post-eradication years.

Table 3. Bird density in 2000 for each habitat type. Estimated densities were then summed to provide an island-wide population estimate. Estimates of the area of forest cover follow Fancy *et al.* 1999: native forest = 29.1 ha, coconut forest = 133.4 ha, and nonforest vegetation = 170.5 ha.

Bird Species	Habitat	Number Expected in 40 ha	Estimated numbers in each habitat type	Island-wide Pair Estimate (95% CI)
Collared Kingfisher	Native forest	11.8	8.6	90 (77 – 104)
	Coconut forest	16.3	54.4	
	Nonforest	6.8	27.2	
Micronesian Honeyeater	Native forest	125.4	91.2	818 (393 – 1,246)
	Coconut forest	165.0	550.3	
	Nonforest	41.4	176.6	
Micronesian Starling	Native forest	74.4	54.2	122 (84 – 160)
	Coconut forest	20.4	67.9	
	Nonforest	0	0	
Micronesian Megapode	Native forest	74.4	54.2	360 (183 – 537)
	Coconut forest	91.7	305.7	
	Nonforest	0	0	
White-throated Ground-dove	Native forest	0	0	--
	Coconut forest	6.1	20.4	
	Nonforest	0	0	

Our population estimates for all species except Collared kingfishers were lower than those estimated using VCP analytical techniques with the 1997 data. In fact, the 1997 estimates are about twice the size of our own. This is not surprising given Morton's similar findings in 1999 (Morton 2000), but it is disheartening. The 1997 estimated populations continue to stand as the benchmark against which the post-eradication populations are measured until the data are reanalyzed in a manner more amenable to comparisons.



Field with patch forest at camp B looking up towards the cone of Sarigan in July 2000

Seabird Surveys

Seabirds at sea were counted along three transects 100 m wide between Saipan and Sarigan. Birds were counted from the deck of the Marlin II by an observer from 8:30-9:00, 9:30-10:00, and 10:30-11:00 on July 2, 2000. The first transect was closest to Saipan. We encountered 3 Brown noddies (*Anous stolidus*), 1 Red-footed booby (*Sula sula*), 2 Sooty terns (*Sterna fuscata*), and 1 Wedge-tailed shearwater (*Puffinus pacificus*) for a total of 7 birds.

On the second transect, between Saipan and Anatahan, there were 16 Brown noddies, 3 Red-footed boobies, 7 Wedge-tailed shearwaters, 3 Sooty shearwaters/Short-tailed shearwaters (*Puffinus griseus* or *P. tenuirostris*), 2 Brown boobies (*Sula leucogaster*) and 2 Black noddies (*Anous minutus*) for a total of 33 birds. The third transect was conducted on approach to Anatahan. We observed 1 Wedge-tailed shearwater and 6 Brown noddies for a total of 7 birds. All totaled, we observed 47 seabirds. These birds are typical of the waters around the Marianas for the time of year.

Vegetation Surveys

Vegetation surveys were conducted simultaneously with forest bird surveys. Six transects were established with stations 150 m apart. The vegetation was surveyed using a modified point-centered quarter method (Mueller-Dombois and Ellenberg, 1974). Data was 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. Therefore, diameter at the base may lead to overestimates and misleading interpretations. Canopy cover was also estimated for an area of 5 m² around the station. Ground cover was estimated for 2 m² around the station. The data was analyzed for ground and canopy cover, absolute frequency (the number of stations a species is present / total number of stations and expressed as a percent), relative density (the number of individuals of a species/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).

In addition to the vegetation surveys in conjunction with the bird transects, results of two other studies are included in the appendices. The first study is vegetation monitoring of 13 plots established prior to feral animal eradication in 1997. The second is a vegetation successional study.

There were a total of 11 species found throughout the 6 transects surveyed. Sarigan was very similar to the other Northern Islands surveyed in that *C. nucifera* is a large component of the forests. However, there were also distinct differences from the other Northern islands in size and age distribution of tree species within the forests.

For convenience, all vegetation figures are found at the end of the section. Transects 1, 2, 3 and 4 were predominantly coconut forests. *Cocos nucifera* and *Erythrina variegata* were the most frequent species found on Transect 1 and in the highest relative density (Figure 3 and 4). *Cocos nucifera* and then *Hibiscus tiliaceus* were the most frequent and in the highest relative density on Transect 2 (Figure 3 and 4). Again, on Transect 3 *C. nucifera* had the highest frequency and relative density followed by *Aglaia mariannensis* (Figure 3 and 4). Transect 4 similar to transect 1 was a combination of *C. nucifera* with the greatest

frequency and relative density followed by *E. variegata* (Figure 5 and 6). The notable distinction of Transect 4 was the larger diversity of tree species present.

Transects 1 and 2 had a distinct DBH size class pattern (Figure 7). There were almost no individuals in the middle range DBH size class (5-10cm and 10-20cm). The increase in seedlings represented in the 0-5 cm DBH size class corresponds with growth in the past few years. Transect 3 was distinctive with the heavy *Aglaia mariannensis* growth in the small and mid-range DBH size classes (i.e. 5-10 and 10-20) (Figure 8). Transect 4 had the largest percentage of individuals in the smallest DBH size class (0-5cm)(Figure 18). In addition, Transect 4 also had an even distribution of *A. mariannensis*, *C. nucifera*, *H. tiliaceus* and *C. papaya* through the first three DBH size classes (Figure 18).

Transect 5 was unique in that it was the only transect in which the relatively dominant species was native. *Aglaia mariannensis* was in the greatest relative density and frequency, followed by *C. papaya* (Figure 5 and 6). This transect ran through a patch of native forest which descended towards the lava flow. This is the only place on Sarigan where *Ochrosia mariannensis* was observed, although it is noted in the checklist (Fosberg et al, 1979) as occurring on Sarigan. *Aglaia mariannensis* was a large portion of all the size classes on Transect 5(except for above 30cm) and there was very little *C. nucifera* along this transect (Figure 9).

Transect 6 was primarily field and very open (Figure 10). This transect (along with Transect 5) contains the only representation of *Neisosperma oppositifolia* which is an important Mariana Fruit bat foraging species. *Cocos nucifer* and *N. oppositifolia* are in the greatest relative density and frequency (Figure 5 and 6).

The distinguishing feature of Sarigan was the pattern of tree growth with the smaller or seedling DBH size class. The presence of an understory was in contrast to the lack thereof found especially on Pagan and Anatahan. The difference being the lack of feral animals on Sarigan since 1997 and the overwhelming populations on the other islands. The vegetation difference between Sarigan and either Alamagan or Agrigan may not be as obvious. However, Alamagan and Agrigan both have some means of control on the feral animals. Alamagan has at least 4 dogs which hunt and Agrigan has a resident family.

List of Figures for Vegetation

Figure 3. Absolute Frequency of tree species on Transects 1,2 and 3 on Sarigan, July 2000.

Figure 4. Relative Density of tree species on Transects 1, 2 and 3 on Sarigan, July 2000.

Figure 5. Absolute Frequency of tree species on Transects 4, 5 and 6 on Sarigan, July 2000.

Figure 6. Relative Density of tree species on Transects 4, 5 and 6 on Sarigan, July 2000.

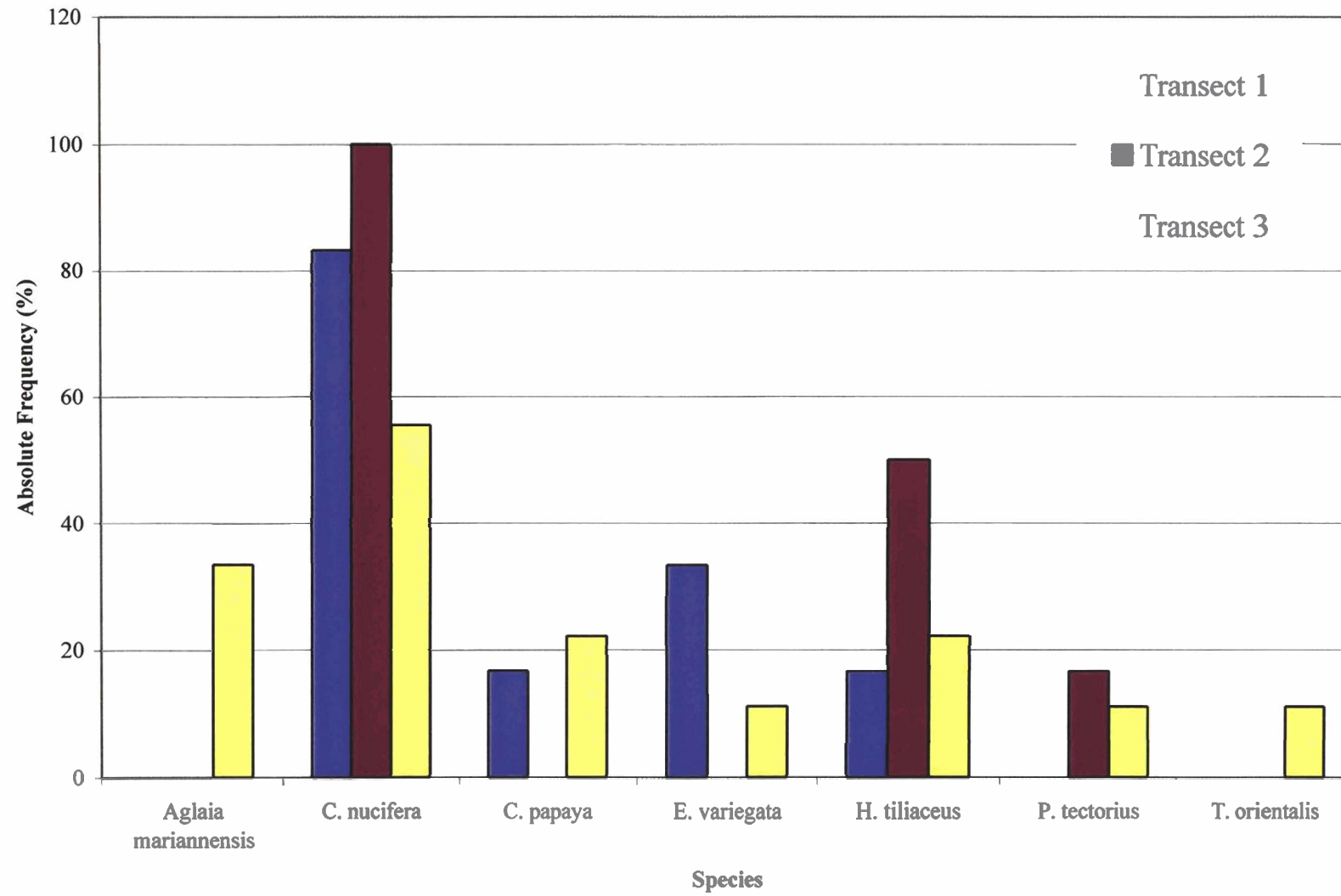
Figure 7. The Diameter at breast height size class and species distribution within size class for trees on Transect 1 and 2 on Sarigan, July 2000.

Figure 8. The Diameter at breast height size class and species distribution within size class for trees on Transect 3 and 4 on Sarigan, July 2000.

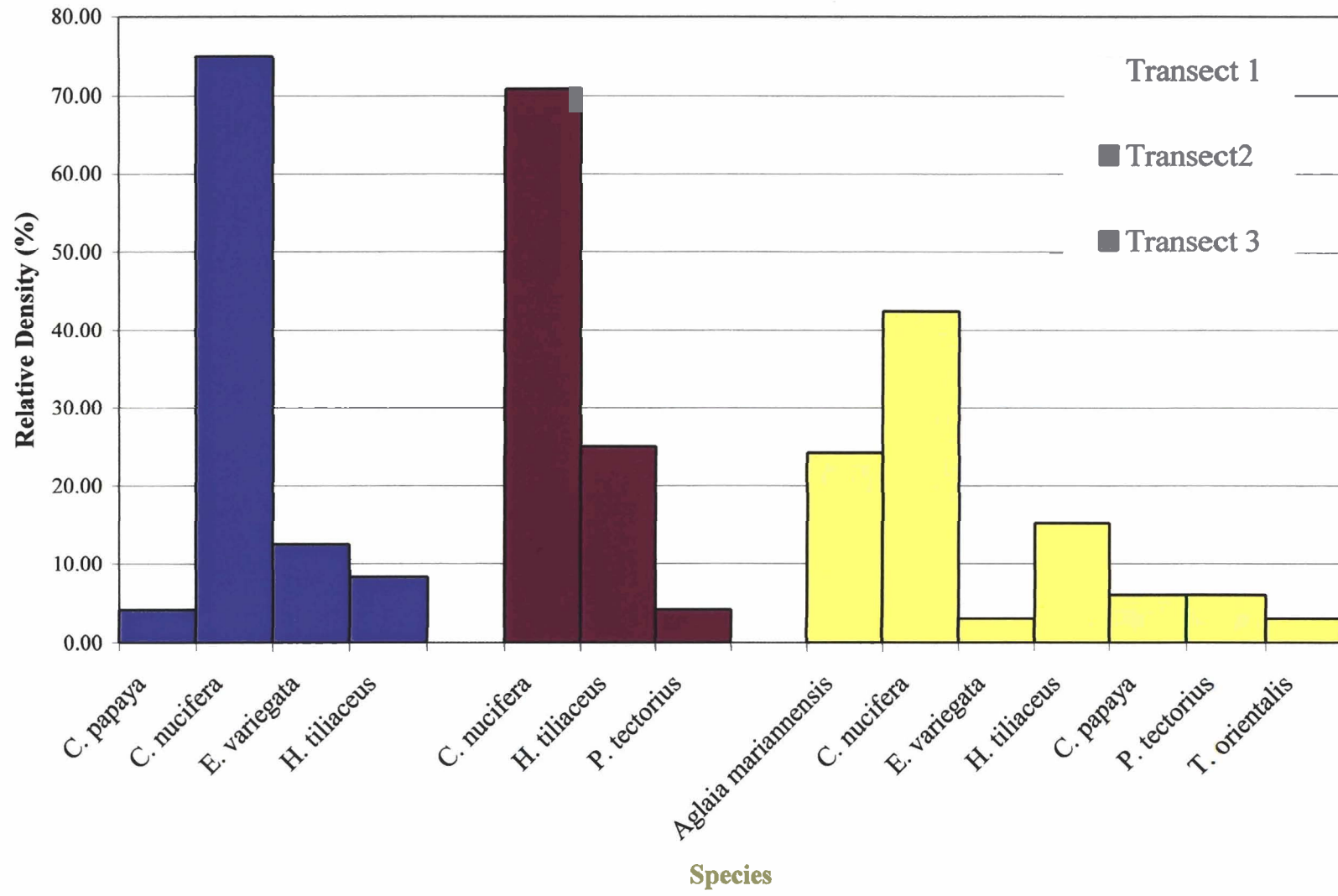
Figure 9. The Diameter at breast height size class and species distribution within size class for trees on Transect 5 and 6 on Sarigan, July 2000.

Figure 10. Average canopy and ground percent cover for all Transects

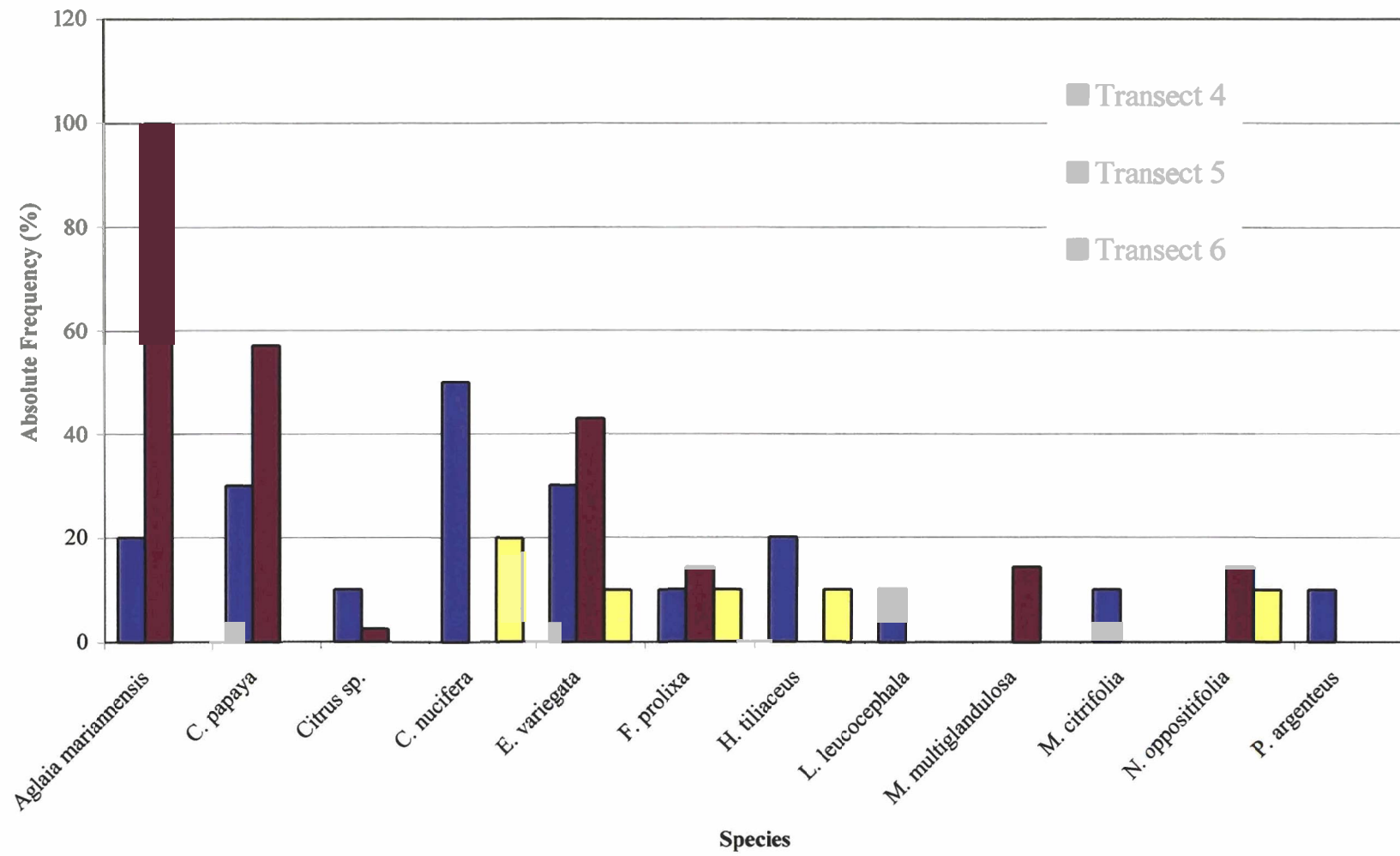
Absolute Frequency for tree species on Sarigan, July 2000



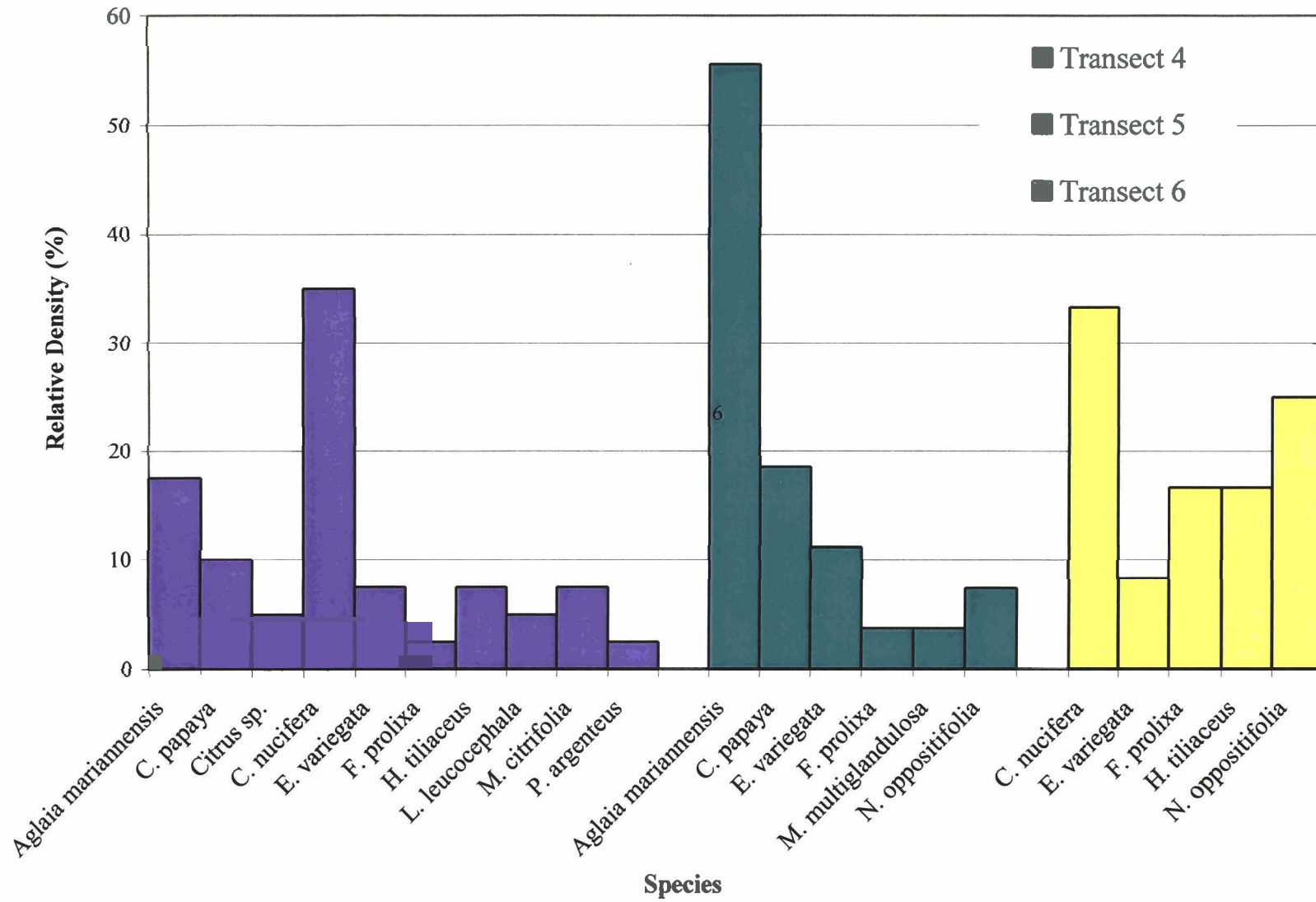
Relative density of tree species on Sarigan, July 2000



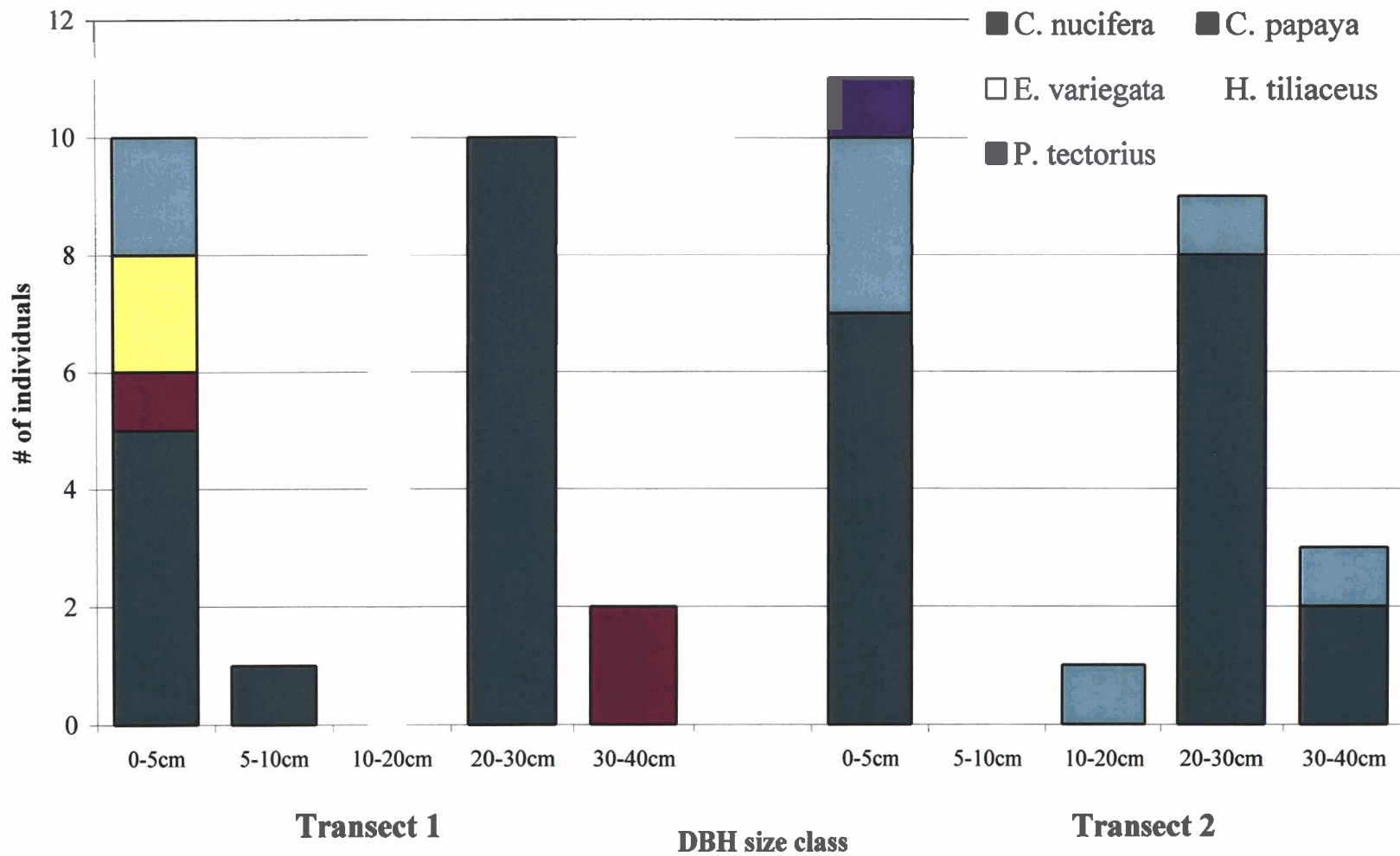
Absolute frequency for tree species on Sarigan, July 2000



Relative density of tree species on Sarigan, July 2000

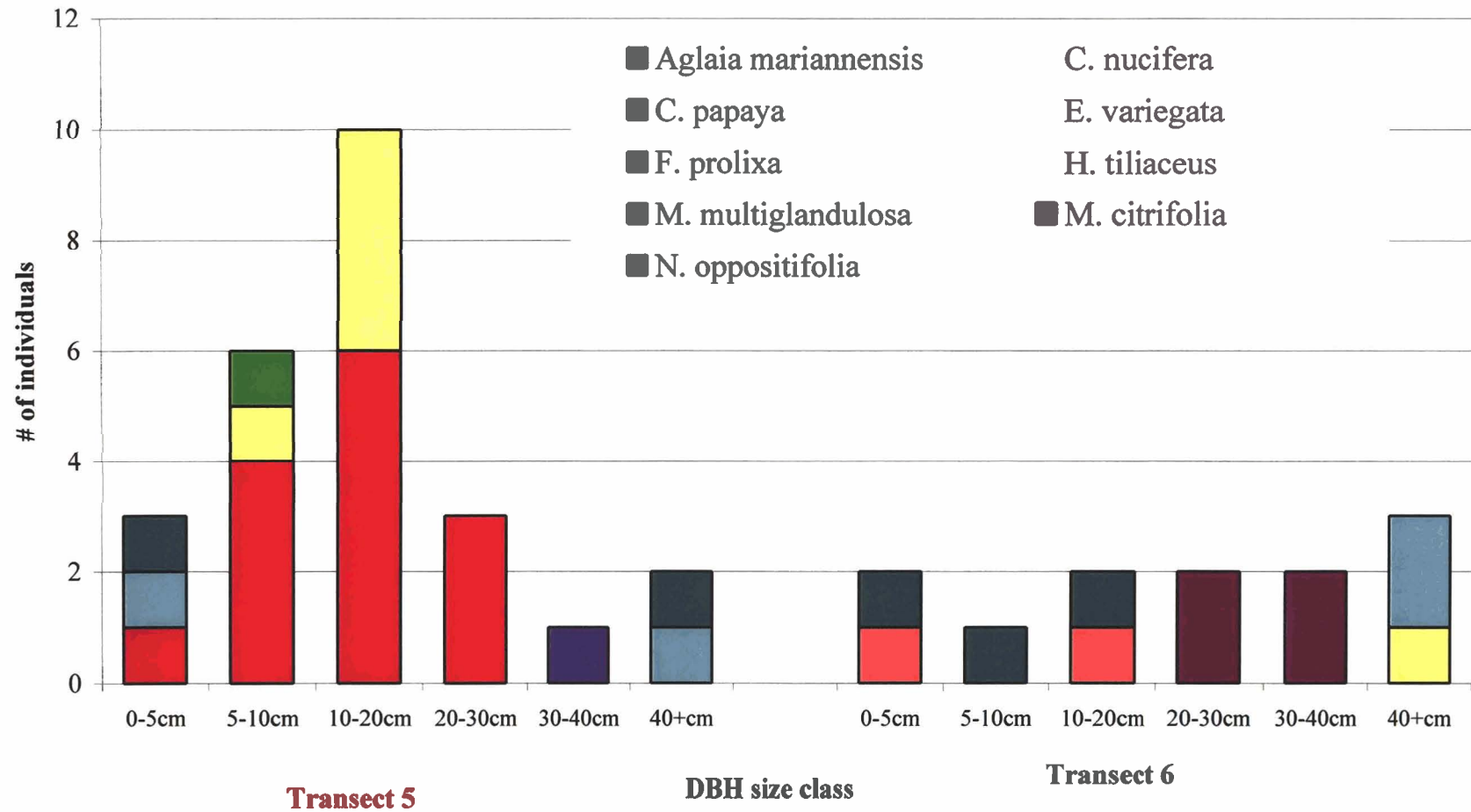


**Diameter at breast height (DBH) size class for trees by species on
Transect 1 and Transect 2 on Sarigan, July 2000**

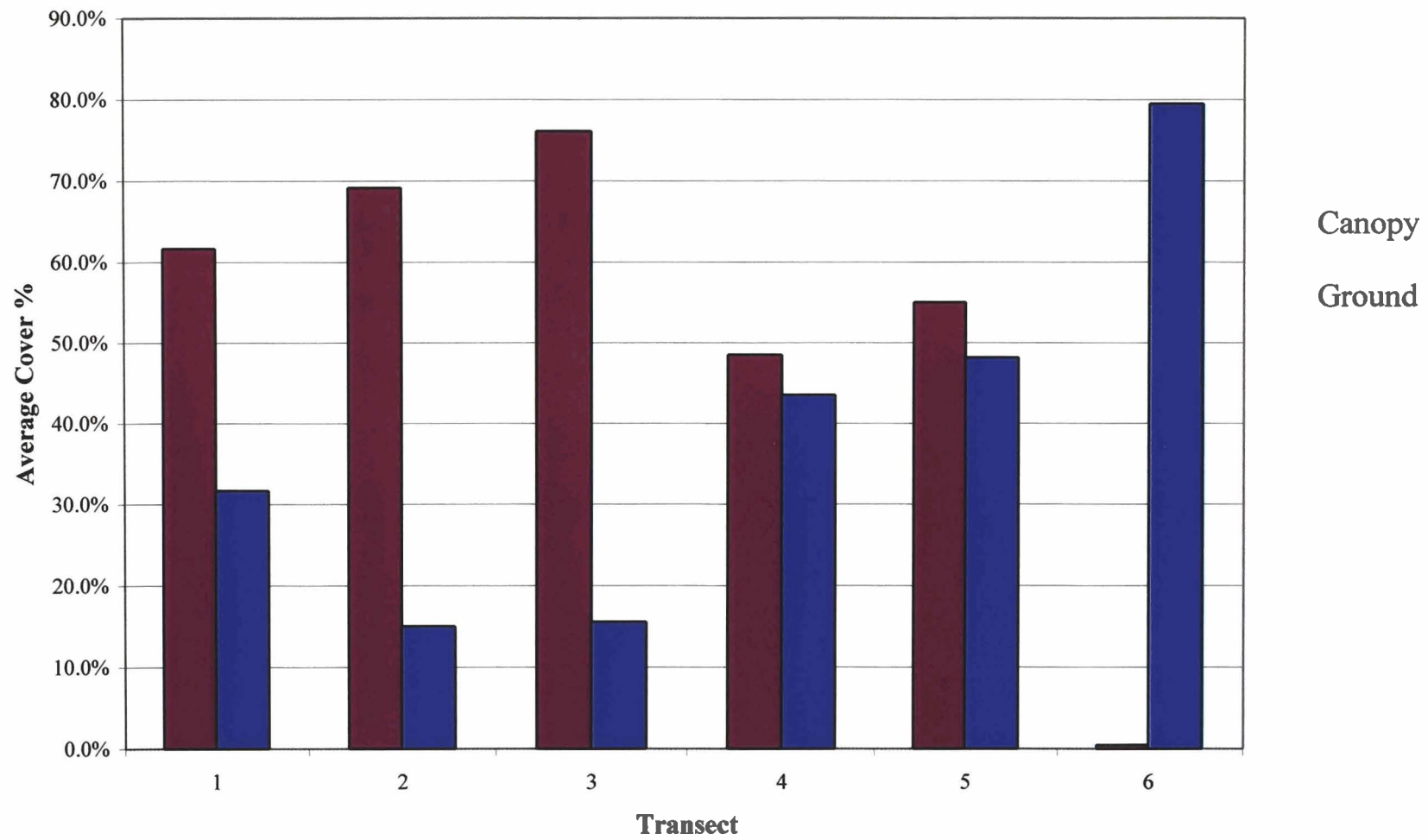


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**Diameter at breast height (DBH) size classes for trees by species for
Transects 5 and 6 on Sarigan, July 2000**



**Average ground and canopy cover percent for all
Transects on Sarigan, July 2000**



Herpetological Surveys

The purpose of the herpetological surveys on Sarigan was to document the presence and relative abundance of reptiles.

Diurnal lizards were sampled using adhesive mouse traps (Bauer and Sadler, 1992; Rodda et al., 1993). Two transects were sampled, one in mixed coconut forest and one in native limestone forest (Figure 11). Ten to fifteen traps were placed flush with the ground every 5 meters along each transect. Traps were run for 2 consecutive days. Traps were placed in the morning (0800-1000h) and run for 5-7 hours. All lizards captured were taken back to base camp, measured, and identification was verified.

Nocturnal lizards were not sampled due to a shortage of adhesive traps. One species of gecko, *Gehyra mutilata*, was documented visually.

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. No tidepool skinks were captured in this habitat, however, one *Cryptoblepharus poecilopleurus* was captured. *C. poecilopleurus* accounted for only 2.7% of the total captures of skinks, but was captured in all habitats sampled.

Tables 4 and 5 show the results of adhesive trapping for lizards. Five species of lizards were documented. The blue-tailed skink (*Emoia caeruleocauda*) was the most abundant lizard captured (n=203), accounting for 92% of the total skinks captured. Additionally, *Emoia slevini* accounted for 5.4% of the total skinks captured. Scott Vogt previously reported a capture rate of 0.02 captures/trap-hour for *E. slevini* (unpublished data) on Sarigan. Our capture rate was slightly higher at 0.03 captures/trap-hour. Additional surveys need to be conducted to determine if *E. slevini* is actually increasing in population.

The mangrove monitor (*Varanus indicus*) was also documented on Sarigan. Biologists reported seeing numerous monitors in a variety of habitats on the island. Additionally, three specimens were captured, euthenized, and had their gastrointestinal tracts removed and preserved for later analysis of diet. That analysis is not complete as of the writing of this report.

Table 4. Results of adhesive trapping to determine diurnal lizard presence and abundance on Sarigan, 3-7 July, 2000.

Habitat	#Traps	#Hours	Trap Hours	#Lizards	Lizards/ 100 Tr Hrs
<u>Ground Trapping</u>					
Rocky Beach	20	13.82	138.2	1	1.00
Coconut Forest	24	14.28	171.4	73	43.00
Native Forest	30	13.15	197.3	147	75.00
Total	74	41.25	506.8	221	44.00

Table 5. Presence and abundance of lizards trapped on Sarigan, 3-7 July, 2000.

	Rocky Beach	Coconut Forest	Native Forest	Total
Family Scincidae				
<i>Cryptoblepharus poecilopleurus</i>	1	3	2	6
<i>Emoia caeruleocauda</i>		66	137	203
<i>Emoia slevini</i>		4	8	12
Family Varanidae				
<i>Varanus indicus</i>		3		3
Totals	1	76	147	224

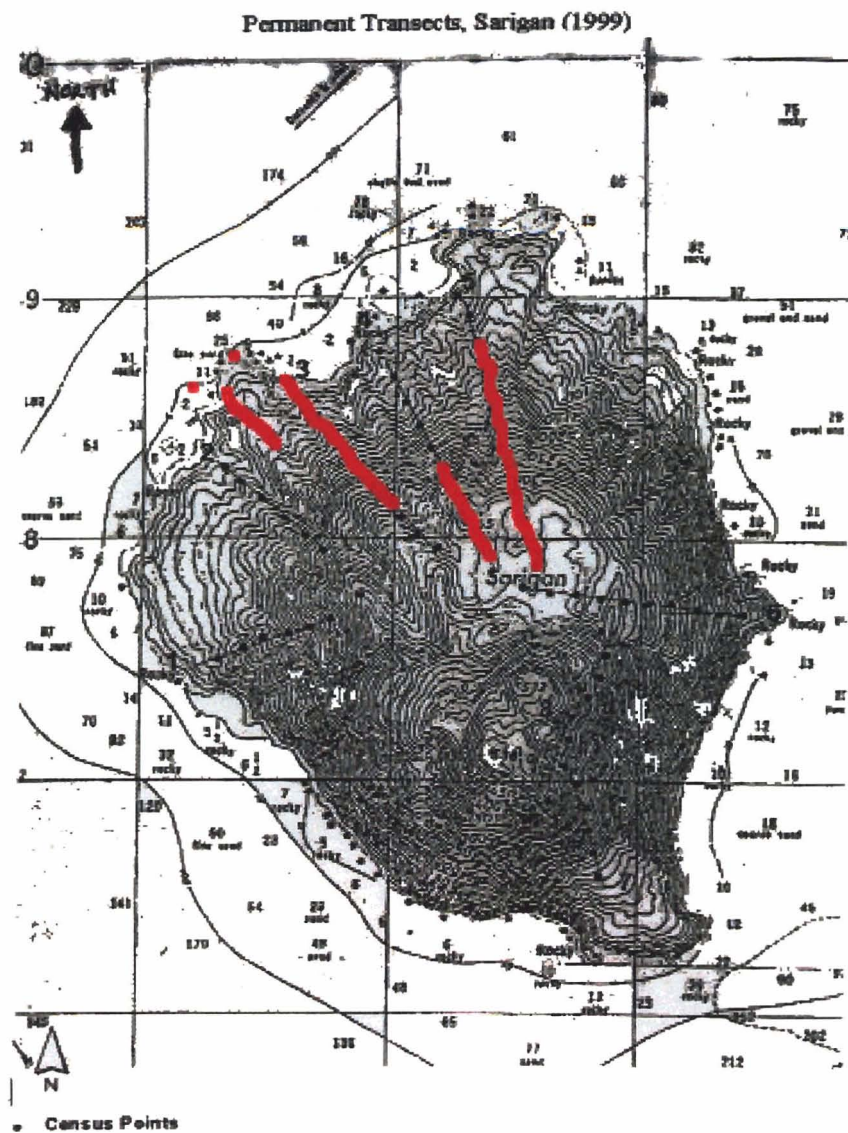


Figure 11. Sarigan island showing transects sampled for reptiles and small mammals.

Small Mammal Surveys

Rats were sampled using Victor rat snap-traps. One transect (#3) was sampled in mixed coconut forest (Figure 11). Twenty-five 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 Sarigan was *Rattus exulans* (Table 6). Rats were more numerous in coconut forest than native forest. This was similar to Vogt's findings from 1999 (unpublished data). Rat capture rate was 2.6 rats/100 trap-nights (n=3). Rat populations seem to be relatively low on Sarigan, however, they may be increasing. Scott Vogt had a capture rate of 3.2 rats/100 trap nights in native forest in 1999 (unpublished data), whereas our capture rate was 5.7 rats/100 trap nights. This increase in capture rate may be due to the removal of goats several years ago. With more vegetation producing more seeds and fruit, the rat population may be on the rise. Additional trapping needs to be conducted to assess rat abundance on Sarigan as our surveys were not extensive.

Also of note was one female feral cat that was shot by Scott Vogt near the campsite. The stomach and intestines were removed and placed in alcohol for later analysis.

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

Habitat	Trap Placement	Trap Nights*	# Rats Captured	Rats/100 trap nights
Mixed Coconut Forest	ground	53	3	5.7
Native Forest	ground	62	0	0.0
TOTAL SARIGAN		115	3	2.6

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

Mariana Fruit Bat Surveys

Mariana fruit bats (*Pteropus mariannus*) were surveyed on Sarigan July 2-8, 2000. The objective of the fruit bat surveys was to estimate the population size of the island and to obtain any valuable behavioral, foraging, or roosting observations.

Mariana fruit bats were frequently observed during the daytime and evening hours on Sarigan. Solitary bats were a common sight flying above and landing within the *Cocos nucifera* forest along the west side of the island. A number of fruit bats were observed flying above the forest towards the southwestern corner of the island. In the evenings fruit bats were regularly seen landing in the *Terminalia catappa* and *Cocos* trees in and around Camp A (Figure 12). Two small groups of 5 fruit bats as well as one colony of 63 animals were discovered while on Sarigan.

At Camp B (Figure 12), fruit bats were commonly observed flying into and out of the isolated stand of native forest (in a depression) that is surrounded by *Miscanthus* grassland, along the north side of the volcanic crater, and over the campsite in the mornings and evenings.

Methods

In order to obtain a practical population estimate of Mariana fruit bats on Sarigan, two different types of counts were performed: (1) evening station (extra-colonial) counts were carried out from designated stations on land where the observer could clearly count flying fruit bats in the evenings; (2) one direct count was conducted at the discovered colony site on the southeast side of the island. Both utilized either binoculars or a high-powered zoom spotting scope. A total of seven evening station (extra-colonial) counts were conducted at seven different stations throughout the island (Figure 13). The counts were conducted between 16:30 and 19:30.

In 1999, personnel from Guam's DAWR, CNMI Division of Fish and Wildlife, and U.S. Fish and Wildlife Service surveyed fruit bats on Sarigan. Surveys were completed at four different stations (Wiles 1999). During the 2000 visit, 3 stations previously surveyed were surveyed again. Also, 4 new count stations were surveyed (Table 7).

Table 7. Mariana Fruit Bat Evening Count Station Descriptions, July 1999 & 2000

Station #	Description
1	This count site was located on the island's west shore and provided an extensive view of the steep hillsides and cliffs along the southwest coast (Figure 13). About 25% of the area was forested, with two-thirds of this being <i>Cocos</i> forest.
2	This count was made from one of the VCP forest bird survey stations (Transect 4, Station 3) [Figure 13] overlooking the forest below to the main camp along the northwest coast. The entire area was covered in <i>Cocos</i> (90%) and native (10%) forest.
3	This count site was located at 350 m elevation on a hilltop overlooking the vicinity of the old basaltic lava flow at the north end of Sarigan (Figure 13) and consisted of 60% <i>Chrysopogon</i> grassland, 30% native forest, and 10% <i>Cocos</i> forest.
4	This count site was located on the east side of the island at mid-slope (about 200-250 m elevation) and provided a view extending from the shoreline to the top of the island's tallest peak (Figure 13). The count was conducted to determine if sizable numbers of bats were dispersing into the forested northern third of the island from the south end. <i>Chrysopogon</i> grass with a few scattered <i>Cocos</i> trees (60%) and <i>Nephrolepis</i> ferns (40%) comprised most of the area.
5	This station site was located at the concrete benchmark along the northwest coast near Camp A. Fruit bats were counted within this station, which extended from the benchmark throughout the <i>Hibiscus/Cocos</i> forest up to the west side of the main craters (Figure 13). The station was comprised of 80% <i>Cocos/Hibiscus</i> forest and 20% <i>Chrysopogon</i> grassland.
6	This station was located at 350 m elevation on a hilltop overlooking the northeastern region of the island (Figure 13). The station was composed of <i>Chrysopogon</i> grassland (70%), groups of <i>Cocos</i> trees (10%), and an area of native forest consisting of <i>Aglaia mariannensis</i> , <i>Neisosperma oppositifolia</i> , and <i>Ficus</i> spp trees.
7	This station was located below a grove of <i>Cocos</i> trees about 100 m southwest of Camp B (Figure 13). The count site was overlooking the isolated stand of native forest ("depression") that is surrounded by <i>Miscanthus</i> grassland.
8	This count site was located 30 m west of VCP forest bird Station 1, Transect 4 and also overlooked the isolated stand of native forest ("depression") that is surrounded by <i>Miscanthus</i> grassland (Figure 13).

NOTE- Stations 1-4 were completed during 1999 survey (Wiles 1999)
Stations 2-4 were repeated and 5-8 completed in 2000

Evening Station Count Results

Results from the July 2000 Mariana Fruit Bat evening station counts on Sarigan are illustrated in Table 8. A short synopsis of results from each station count is presented below.

Station 1- An evening station count was not performed at this station in July 2000.

Station 2- A fair number of fruit bats were recorded within this station (Table 8). No evident colonies or flyways were discovered. Most of the bats were observed departing to the north.

Station 3- There were moderate levels of fruit bat activity in this site (Table 8). Almost 50% of the bats recorded actually remained within the station boundaries, which assisted the observer in discovering a small aggregation of potentially 15-20 animals. A majority of the bats were foraging in the native forest throughout the count.

Station 4- The highest numbers of fruit bats were recorded at this site (Table 8), leading the observer to an active fruit bat colony on 7 July. During the station count, 63 of the 66 bats departed to the north through the count area and over the top of the main volcanic crater.

Station 5- A fair number of fruit bats were recorded at this count site (Table 8). Approximately 82% (18 of 22) of the bats observed in this station were either traveling south over the highest ridgeline or remained within the count site boundaries. The fruit bats that remained were noted landing in *Cocos* and *Terminalia* trees near Camp A.

Station 6- Reasonable numbers of bats were counted at this particular count site (Table 2). Most of the activity was along the northeast edge of the station above the stand of native forest. Fruit bats were observed flying in and out of this area, which may suggest the existence of a small group.

Stations 7 & 8- Results from these two stations are subjective (Table 8). Total numbers depicted in Table 2 are based on actual fruit bat detections, not individuals counted. Both stations overlooked an isolated stand of native forest that is surrounded by *Miscanthus* grassland. The stand of native forest exists within a depression of unknown depth. An attempt was made to reach the edge of the depression, but the thick *Miscanthus* prevented any further travel. So, the actual number of individual fruit bats was difficult to count, but there was a high level of foraging activity. It seems likely that this area is utilized in the form of a foraging ground for Mariana Fruit Bats on Sarigan. It is also possible that this region is used as a roosting territory for solitary bats. There were no obvious indications of a colony or aggregation present

Table 8. Results of Mariana Fruit Bat evening station counts on Sarigan, July 2000

tation #	Date	Depart to N	Enter from N	Depart to E	Enter from E	Depart to S	Enter from S	Depart to W	Enter from W	Remain- ing	Total
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA^o
2	5 July	13	5	2	7	1	5	0	1	1	20
3	5 July	0	0	7	7	1	0	9	1	14	34
4	6 July	63	0	0	0	0	0	3	0	0	66
5	3 July	3	1	0	0	9	2	0	0	9	22
6	4 July	2	0	0	0	0	0	0	0	6	8
7	5 July	0	5	12	17	21	29	19	7	0	110*
8	6 July	7	3	10	36	57	37	9	2	4	95*

^o- Station Count not performed at this station

*- Totals are based on actual fruit bats detected, not individuals counted. Stations 7 and 8 overlooked an isolated stand of native forest that is surrounded by *Miscanthus* grassland. The stand of native forest exists within a depression of unknown depth. So, the actual number of individual fruit bats was difficult to count, but there was a high level of foraging activity. It is possible that this area is a common foraging ground for Mariana Fruit Bats on Sarigan.



Marianas fruit bat station count #5 from the benchmark at Camp A

Count numbers from stations 2 and 3 were similar between the 1999 and 2000 counts (Table 9). The dramatic increase is obviously at Station 4. This suggests

that fruit bats have moved from a previous colony site, which was not detected in 1999, or the aggregations that were discovered in 1999 have formed a colony together. Estimates of six aggregations that were discovered along the eastern and southeastern areas of the island in 1999 totaled to approximately 43-75 fruit bats (Wiles 1999). All but one of those six 1999 aggregation sites was surveyed on the year 2000 trip.

Table 9. Total number of Mariana Fruit Bats Viewed from Designated Stations on Sarigan, July 1999 and July 2000

Station	# of Bats July 1999 ¹	# of Bats July 2000
1	15	Not Available
2	26	20
3	44	34
4	19	66

¹ Wiles 1999. 2-7 July

The positioning of the colony of fruit bats along the steep southeastern slope of Sarigan suggests the possibility that all of the 1999 aggregations have combined to form one colony. This may be due to the availability of an abundant food supply that is in close proximity to the colony, or the possibility of any illegal hunting activities. No evidence of illegal hunting was discovered on the year 2000 trip. However, a total of five expended shotgun shells, with the appropriate small shot for fruit bats, were recorded on the 1999 trip (Wiles 1999).

A variety of circumstantial evidence suggests that poaching of fruit bats may not be as common on Sarigan as islands such as Anatahan and Pagan. The population estimates of fruit bats have been relatively stable through the 1983, 1997, 1999, and 2000 field trips to Sarigan (Table 12), essentially the past 17 years. The bats of group 3 (Figure 13) were almost oblivious to a nearby human presence. Bats which are subjected to heavy poaching pressure on Guam, Rota, Pagan and Anatahan are tremendously skittish and will not tolerate a humans nearby. Sarigan is not as near a large human population center, i.e. Saipan and it is not as easy to physically traverse the topography as in Pagan. Therefore, it may be less of a desirable hunting destination by would be poachers.

Group Observations

Fruit bat Group 1 (Table 10) was discovered during an evening station count from Station 3 on 5 July. A total of five fruit bats were observed roosting in at least two *Pisonia grandis* and one *Ficus* sp. trees. A moderate number of bats



Fruit bat colony on Sarigan, July 2000

flying above the roosting trees indicated the possible presence of a group of 15-20 animals. This group was located approximately 400 meters east of a group of 17 bats (Wiles 1999) discovered in 1999.

Fruit bat Group 2 (Table 10) was located 6 July along the *Chrysopogon* covered ridge on the eastern side of the island. Five fruit bats were observed roosting together in a Cocos tree. This group was present in approximately the same location as a group of 6 fruit bats (Wiles 1999) recorded in 1999.

The 63 fruit bats of group three were discovered on 7 July (Table 10). The bats were the “unconcerned” with his presence. Observations were made approximately 5-10 meters downwind of the colony for one hour. A total of 57 fruit bats were observed roosting in a *Ficus prolixa* tree, while the other six animals used a *Hibiscus tiliaceus* tree for roosting. Additional fruit bats appeared to be concealed under *H. tiliaceus* leaves. This colony was estimated to contain a minimum of 75 fruit bats. Most of the animals were wrapped up and resting, yet aware of the observer’s presence. None of the fruit bats immediately departed the roost. Instead, they remained calm and continued with their activities, which included “wrestling” with one another, wing flapping (possibly a cooling mechanism), grooming, and obnoxious vocalizing. This suggests that if poaching of fruit bats were frequent on Sarigan, the colony would have almost certainly dispersed instantly.

The manes of the fruit bats in the colony appeared to vary in coloration from chocolate brown to a sandy brown color to even an orange-yellow shade. While the fruit bats wrapped up and resting, it was difficult to obtain the sexual orientation of the colony. However, two adult females and one adult male were confirmed, as well as an approximately one year-old pup. No pups were observed in tow with females.

There was one other interesting observation worth noting that occurred at the fruit bat colony. On two separate occasions, two different bats were observed defecating in flight approximately 40 meters away from the roost. After defecating, both bats flew around shortly and returned to the roost. This may suggest that by defecating a fair distance away from the roost, the possibility of attracting predators (i.e. rats and monitor lizards) is potentially reduced. Descriptions of fruit bat Group 3 are discussed in the text above.

Table 10. Colonies or small aggregations of Mariana Fruit Bats observed on Sarigan, July 2000

Group #	Date of Observation	Habitat Description	Elevation (m)	Species and # of Roost Trees	# of Bats Counted	Estimated # of Bats Present
1	5 July	Large stand of native forest	125	<i>Pisonia grandis</i> (2) & <i>Ficus</i> spp.(1)	5	15-20
2	6 July	<i>Chrysopogon</i> covered ridge with scattered <i>Cocos</i> trees	225	<i>Cocos nucifera</i> (1)	5	5
3	7 July	Steep <i>Miscanthus</i> ravines with scattered native tree species	500	<i>Ficus prolixa</i> (1) & <i>Hibiscus tiliaceus</i> (1)	63	75

Food Selection

Evidence of Mariana fruit Bat feeding sign was noticed on the ripe fruits of *Pandanus tectorius* and *Terminalia catappa*. Much of the feeding sign (i.e. teeth marks, imprints of pallets, and fresh ejecta) upon *P. tectorius* fruits was discovered and collected below *Cocos nucifera* trees along the west coast of the island. It seems likely that fruit bats obtained the fruits from other areas of the island and utilized this region as a roosting/feeding region in the evenings and early mornings.

The outer rinds of ripe *T. catappa* fruits were also observed with fruit bat teeth marks on them near the main camp, where there were a high concentration of *T. catappa* trees. In the evenings, fruit bats were seen regularly landing and vocalizing within these *T. catappa* trees in proximity to the main camp.

During an evening station count on 5 July between 1825-1830 hours, one pregnant female fruit bat was observed consuming ripe *Ficus tinctoria* fruits. In the southwestern corner of evening station count Station 6, a grove of *Neisosperma oppositifolia* trees is present. The fruits of *N. oppositifolia* are considered to be one of the many selected food items for *P. mariannus* (Fujita & Tuttle 1991). This region was searched thoroughly for any evidence of fruit bat feeding sign. No feeding sign was discovered, but it is believed that fruit bats frequent this area when the fruits become ripe.

Sarigan contains a diversity of food for bats (Table 11). After the 1998 elimination of 904 feral goats (*Capra hircus*) and 68 pigs (*Sus scrofa*) from the island, it is believed that no more feral ungulates are present on Sarigan (Zoology Unlimited LLC 1998). It is expected that seedlings and saplings will increase in density within the understory and benefit fruit bats, as well as native avian species.

On the year 2000 trip to Sarigan, the observer noticed a significant change in forest composition within the Cocos forest (along the westside of the island) since his March 1997 visit. The vegetation in the understory is now considerably more dense, namely the increased presence of Cocos seedlings and saplings. From a 1997 trip, the observer recalls the understory of this forest as being extremely open and simple to walk through. Other tree species which were observed growing as seedlings within the Cocos dominated forest in 2000 included *Erythrina variegata*, *Aglaia mariannensis*, *Melanolepis multiglandulosa*, *Hibiscus tiliaceus*, *Terminalia catappa*, *Ficus tinctoria*, and *Morinda citrifolia*.

Table 11. Fruiting and Flowering Plants Available to Mariana Fruit Bats on Sarigan 2-8 July 2000

Species	Fruiting-S Flowering-F
<i>Cocos nucifera</i>	F
<i>Terminalia catappa</i>	FS
<i>Carica papaya</i>	FS
<i>Hibiscus tiliaceus</i>	F
<i>Premna obtusifolia</i>	FS
<i>Ficus prolixa</i>	S
<i>Aglaia mariannensis</i>	FS
<i>Pipturus argenteus</i>	S
<i>Morinda citrifolia</i>	FS
<i>Neisosperma oppositifolia</i>	FS
<i>Ficus tinctoria</i>	S
<i>Citrus</i> spp.	S
<i>Areca</i> spp.	S
<i>Pandanus tectorius</i>	S
<i>Barringtonia asiatica</i>	FS

Roosting/Resting Tree Selection

Mariana fruit bats were observed roosting and/or resting within the following tree species on the year 2000 trip to Sarigan: *Ficus prolixa*, *Ficus tinctoria*, *Hibiscus tiliaceus*, *Terminalia catappa*, *Cocos nucifera*, *Aglaia mariannensis*, *Carica papaya*, *Pipturus argenteus*, *Trema orientalis*, *Artocarpus* spp., *Pisonia grandis*, and *Erythrina variegata*.

The colony of 63 bats on the southeast side of the island was roosting within *Ficus prolixa* and *Hibiscus tiliaceus* trees (Table 10). The other two groups of bats that were discovered used *Cocos nucifera*, *Pisonia grandis*, and *Ficus* spp. as roosting trees (Table 10). The remaining species of trees mentioned above were utilized for either resting and/or foraging purposes.

Total Population Estimate

Based on all of the individual fruit bat sightings, evening station counts results, and direct colony count results, we estimate Sarigan to contain a minimum of 150-200 Mariana fruit bats. Sarigan has not been notorious for containing large fruit bat colonies. Previous trips to the island have reported only smaller aggregations ranging from eight to potentially 40 animals (Wiles *et al.* 1989, Rice 1990, Zoology Unlimited LLC 1998, Fancy *et al.* 1999). This contrasts with

Guguan, an island 42 miles to the north and 80 hectares smaller in size, which contains a fruit bat colony of approximately 200 animals (Johnson 2001).

Total population estimates have remained fairly stable throughout the last 17 years (Table 6). In 1983, Wiles *et al.* thought there to be 125 fruit bats on Sarigan (1989), while in 1997, Fancy *et al.* estimated Sarigan to contain 170 animals (1999). On a 1999 field trip to Sarigan, Wiles estimated approximately 150-200 fruit bats on the island (1999). Rice *et al.* feel that with close to 2 square km of potential habitat, Sarigan's carrying capacity is no more than 200 fruit bats (1990). The fact that the fruit bat population has remained constant over the last 17 years suggests the possibility that migration between islands may be an irregular occurrence.

Table 12. Minimum population estimates of Mariana fruit bats on Sarigan in 1983, 1997, 1999, and 2000.

Year	Minimum Population Estimate
1983 ²	125
1997 ³	170
1999 ¹	150-200
2000	150-200

¹ Wiles 1999. 2-7 July

² Fancy *et al.* 1999. March

³ Wiles *et al.* 1989. August-September

List of figures

Figure 12. Bat station survey locations on Sarigan, July 2000

Figure 13. Location of colonies and small aggregation of Mariana fruit bats, July 2000

Locations of colony and small aggregations of fruit bats on Sarigan, July 2000.

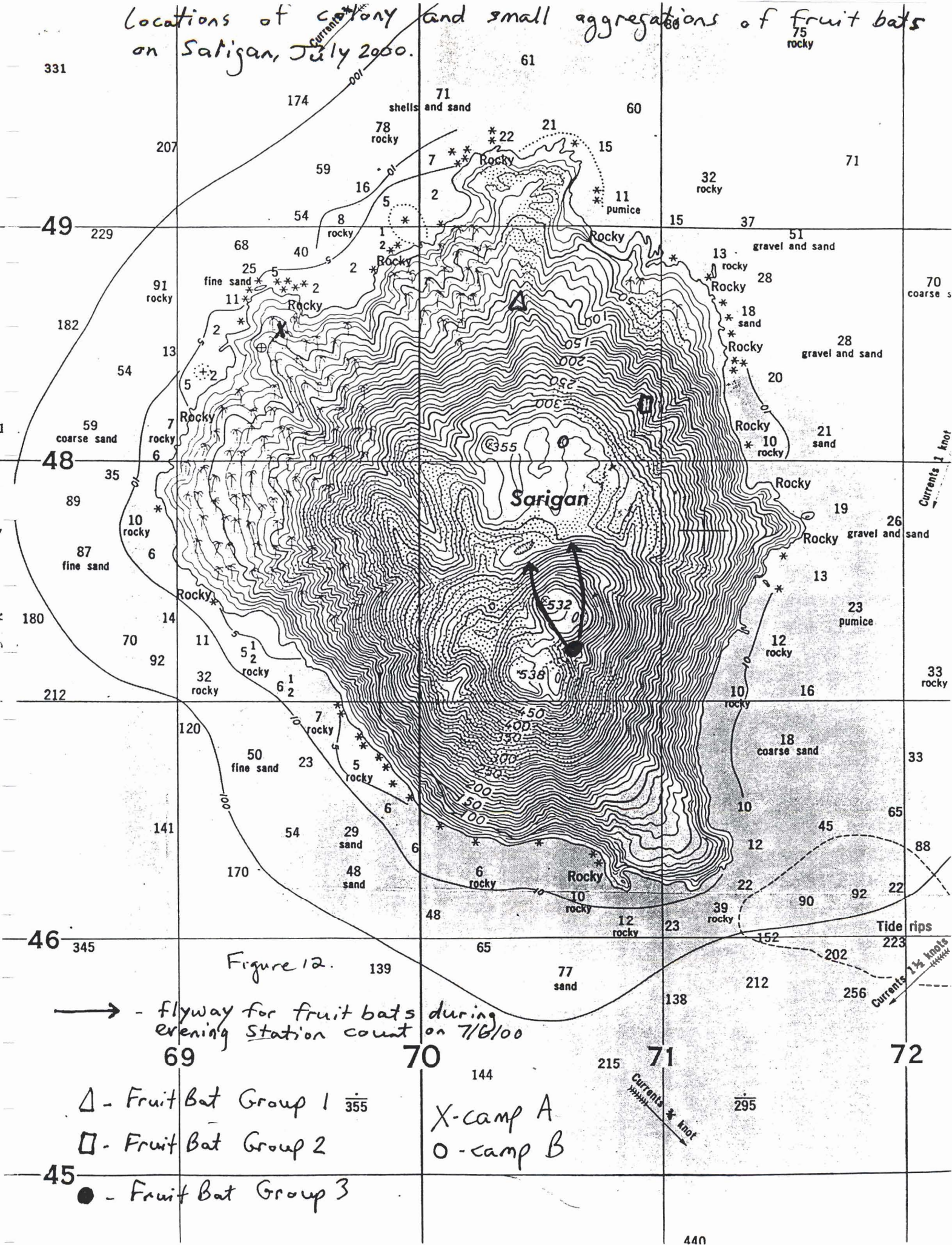


Figure 12.

→ - flyway for fruit bats during evening station count on 7/6/00

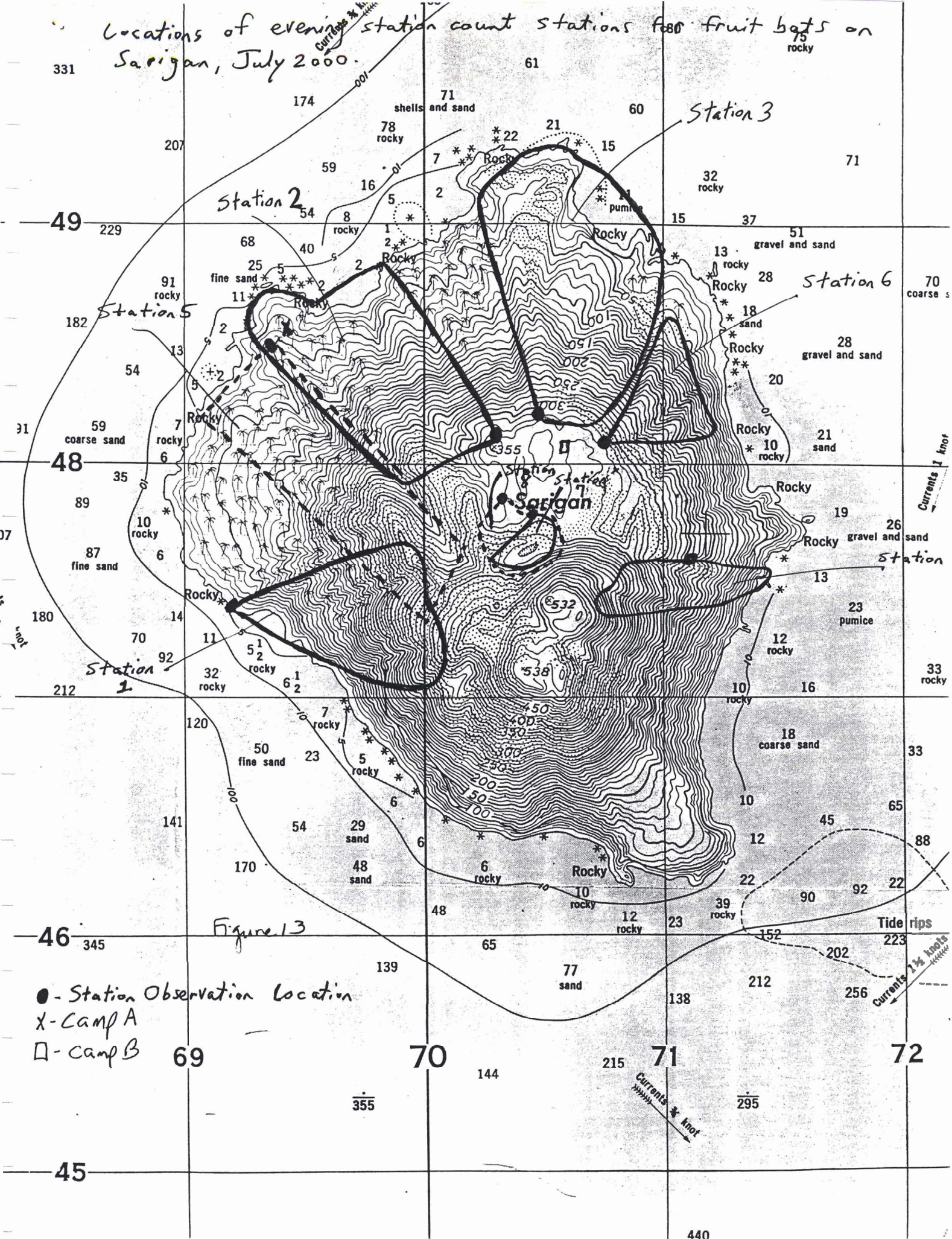
△ - Fruit Bat Group 1

□ - Fruit Bat Group 2

● - Fruit Bat Group 3

X - camp A
O - camp B

Locations of evening station count stations for fruit bats on Sarigan, July 2000.



● - Station Observation Location
 x - Camp A
 □ - Camp B

Figure 13

Management Recommendations

- Obtain the forest bird VCP data for the 1997 survey and re-analyze so that side by side comparisons can be made with post-eradication bird surveys.
- Conduct cat removal from Sarigan in preparation for translocation of endangered species.
- Conduct ecology study of the Micronesian megapode to document breeding behavior and begin assessment of the bird's population parameters.
- Further Mariana fruit bat research on Sarigan. Research should include population surveys and habitat use surveys. Sarigan is unique in that there are no feral animals, bats are not skittish due to extensive hunting and there is a wide diversity of native plant species.

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We very much appreciate John Morton's willingness to share his survey data with us so that we might make the appropriate comparisons.



Hats for hunting, Sarigan July 2000

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APPENDIX 1

GPS coordinates of point count stations on the VCP survey transects. Habitat has changed with time since eradication and new classifications may become necessary in the future. Key to USFWS habitat codes: 2 = Coconut forest, 3 = native forest, 1 = other. Key to DFW habitat codes: 1 = open field/rocky, 2 = Coconut forest, 3 = Agro-forest, 4 = Mixed secondary forest, 5 = Coconut and native or coconut and hibiscus forest, 6 = native forest, 7 = Pandanus/Swordgrass, 8 = Field/forest interface.

Island	Transect	Station	GPS Coordinates		2000 Habitat	1999 USFWS Habitat
			55Q	UTM		
Sarigan	1	1	370055	1847183	2	2
Sarigan	1	2	369191	1847149	3	2
Sarigan	1	3	369090	1847115	4	2
Sarigan	1	4	368998	1847080	2	2
Sarigan	1	5	368921	1847046	2	2
Sarigan	1	6	368824	1847008	1	2
Sarigan	2	1	369307	1847522	5	2
Sarigan	2	2	369162	1847504	5	2
Sarigan	2	3	369082	1847535	5	2
Sarigan	2	5	368955	1847667	5	2
Sarigan	2	6	368869	1847730	5	2
Sarigan	3	1	369665	1847455	6	2
Sarigan	3	2	369583	1847498	6	2
Sarigan	3	3	369522	1847569	7	2
Sarigan	3	4	369448	1847649	6	2
Sarigan	3	5	369379	1847715	2	2
Sarigan	3	6	369315	1847783	2	2
Sarigan	3	7	369228	1847833	2	2
Sarigan	3	8	369167	1847889	5	2
Sarigan	3	9	369109	1847970	5	2
Sarigan	4	1	369884	1847411	8	6
Sarigan	4	2	369829	1847502	8	6
Sarigan	4	3	369778	1847589	6	6
Sarigan	4	4	369737	1847679	6	6
Sarigan	4	5	369696	1847764	8	6
Sarigan	4	6	na	na	5	6
Sarigan	4	7	369589	1847938	2	2
Sarigan	4	8	369534	1848033	5	2
Sarigan	4	9	369488	1848142	2	2
Sarigan	4	10	369433	1848234	2	2
Sarigan	5	1	370414	1847363	6	6
Sarigan	5	2	370020	1847476	6	6
Sarigan	5	3	369999	1847570	6	6
Sarigan	5	4	369969	1847667	6	6
Sarigan	5	5	369932	1847722	6	6
Sarigan	5	6	369906	1847825	6	6
Sarigan	5	7	369900	1847917	6	6

Island	Transect	Station	GPS Coordinates		2000 Habitat	1999 USFWS Habitat
			55Q	UTM		
Sarigan	6	1	369994	1847292	1	1
Sarigan	6	2	370095	1847270	1	1
Sarigan	6	3	370196	1847264	1	1
Sarigan	6	4	370293	1847246	8	1
Sarigan	6	5	370388	1847236	1	1
Sarigan	6	6	370473	1847227	1	1
Sarigan	6	7	370564	1847226	1	1
Sarigan	6	8	370656	1847202	1	1
Sarigan	6	9	370742	1847189	1	1
Sarigan	6	10	370832	1847183	1	1
Sarigan	8	1	370298	1847116	1	1
Sarigan	8	2	370315	1847023	1	1
Sarigan	8	3	370293	1846935	8	1
Sarigan	8	4	370251	1846860	1	1
Sarigan	8	5	370188	1846786	1	1
Sarigan	8	6	370719	1846696	8	1

APPENDIX 2

Vegetation survey of 13 permanent plots on Sarigan before and after feral animal eradication

Methods

Thirteen vegetation plots were established along a transect on Sarigan in 1996. The transect runs from Camp A (see map Figure 1) SW up a ridgeline and across habitat types. The plots were originally surveyed in February 1997 before feral goats and pigs were eradicated from the islands. The plots were subsequently surveyed in August 1998, July 1999 and most recently in July 2000. The vegetation was surveyed by using a modified point-centered quarter method. All herbaceous species within 2m² area around the permanent rebar were identified. Ground cover of the 2m² area was visually estimated by dividing it into 4 quarters and estimating each quarter. The canopy cover was determined using a densiometer according to the instructions. The data was analyzed for species richness, frequency, canopy and ground cover and average diameter at breast height (DBH) for each year. The average DBH of each year was subjected to an ANOVA using Minitab (1997). Pictures were taken all years at each station. The pictures are presented by Curt Kessler (Kessler, 2001)

Results

The number of species has continued to increase (Figure A2) although the magnitude is not as great this past year as in between the '97 and '98 or 98 and 99 surveys.

Frequency of several species has remained constant from 1998 to 1999. In general the frequency of the herb species present in the plots remains similar to the past survey with the continuing exception of *Pteris quadriaurita* and *Ageratum conyzoides*. *Pteris quadriaurita*, which is an endemic fern, has continued to decrease in frequency until it was only found in one plot during the July 2000 survey (Figure A4). *Ageratum conyzoides* has increasingly become exclude at the same time as the frequency of other species increased. The frequency of grasses has changed little (Figure A5). The vegetation plots have hosted a total of three species over the past 2 years, although the composition has undergone mild changes *Chrysopogon aciculatus*, the only grass present in 1997 still has the greatest frequency. The July 2000 survey yielded a greater number of tree species present within the vegetation plots (Figure A3). In 1997 there were 4 tree species present as compared with 9 in the July 2000 survey. *Premna obtusifolia*, *Trema orientalis* and *Erythrina variegata* var. *orientalis* all increased in frequency.

The number of seedlings has steadily increased since feral animal eradication in March 1997. The average DBH of trees has significantly decreased since 1997 ($p < 0.05$) (Figure A6).

Ground cover (Figure A8) and canopy cover (Figure A7) has generally increased steadily in most plots. The greatest ground cover increases are in plots 1, 2 and 3, which in Feb. 1997 were bare ground. In stations 5, 6 and 10 a notable decrease has occurred in ground cover. These stations are in forested plots and have continued to increase in canopy cover (Figure A7) over the past three years.

Discussion

The increase in the number of species, ground cover and the number of seedlings are all signs that Sarigan has some recovery potential. However, the data collected also reveals some serious management issues that will need to be monitored closely if the goal is for Sarigan to support native wildlife. While the number of species present in the plots did increase, most of these species were of the weedy and opportunistic variety. In many cases these are not an increase in native flora which is of value to local wildlife. The best example is with the alarming spread of *Operculina ventricosa* over most the low grasslands and covering almost all seedlings under 2m. In 1999, *O. ventricosa* was limited more to patches. Seedlings that were sprouting up in field were not covered by the vine. In July 2000 however, short grass fields were covered with *O. ventricosa* as well as just about every seedling within the grass areas. In addition, *O. ventricosa* has begun to grow over the canopy of forest fragments. If the vine continues with this growth pattern it will begin to choke individual trees, destroying forest fragments and new seedling recruitment. *Operculina ventricosa* is an introduced herbaceous vine in the cucumber family. It is used locally by farmers as cow fodder. The common name is 'wood rose' because the calyx of the flower turns wood and persists as it dries. *Calopogonim mucunoides* is also in abundance but not to the degree of *O. ventricosa*. Often times herbaceous vines such as *O. ventricosa* will die back and therefore not become a large problem. The lack of competition, competitors and very wet dry seasons for the last 3 years (Carruth 2000) all may contribute to the success of *O. ventricosa*. The development of *O. ventricosa* needs to be monitored in an attempt to determine if this invasive foreign species will inhibit forest restoration.

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Figure A2. Total numbers of plant species before and after eradication, Sarigan.

Figure A3. Frequency of tree species found on Sarigan before and after feral animal eradication.

Figure A4. Frequency of herb species found on Sarigan before and after feral animal eradication.

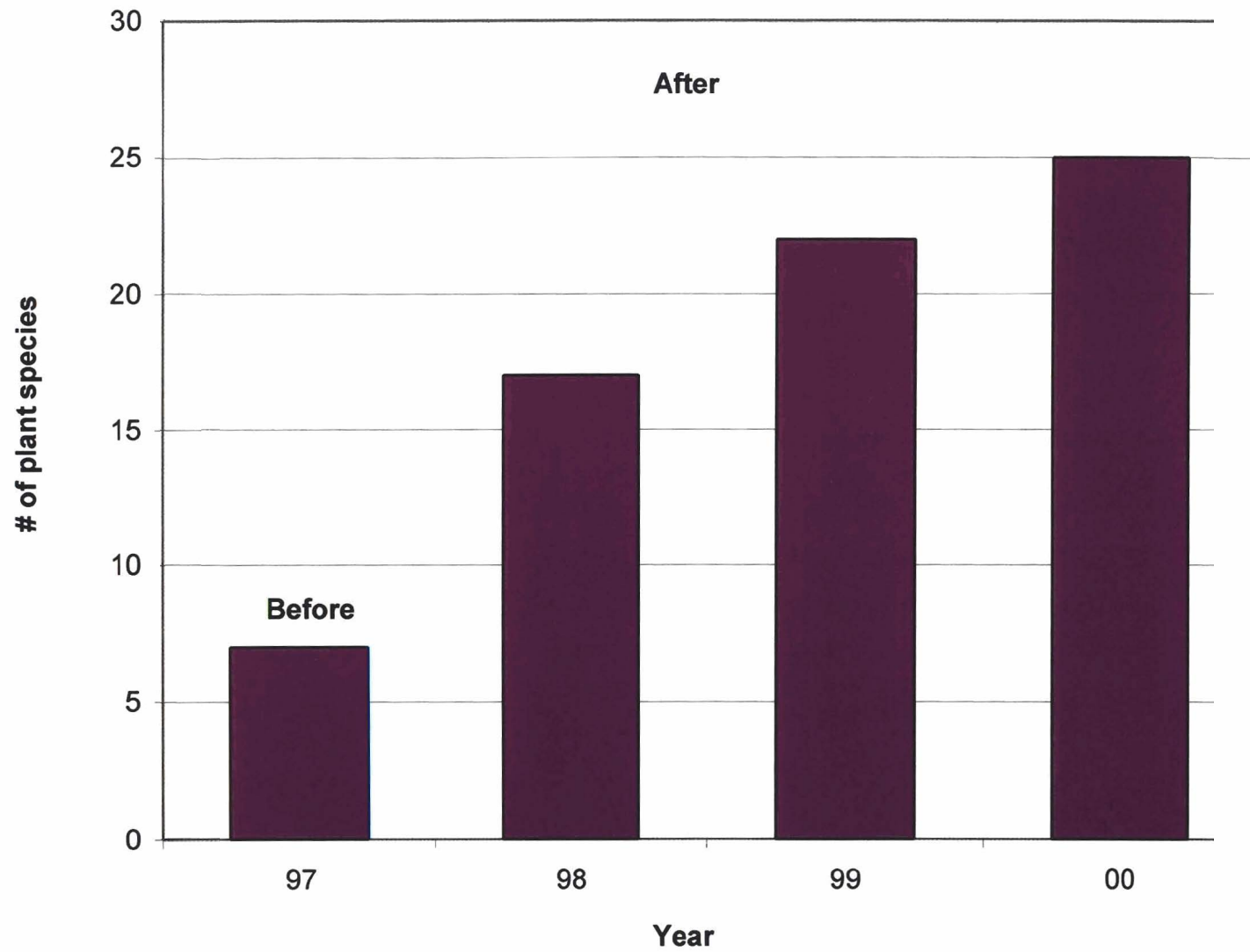
Figure A5. Frequency of grass species before and after eradication on Sarigan.

Figure A6. Average DBH of trees on Sarigan before and after feral animal eradication.

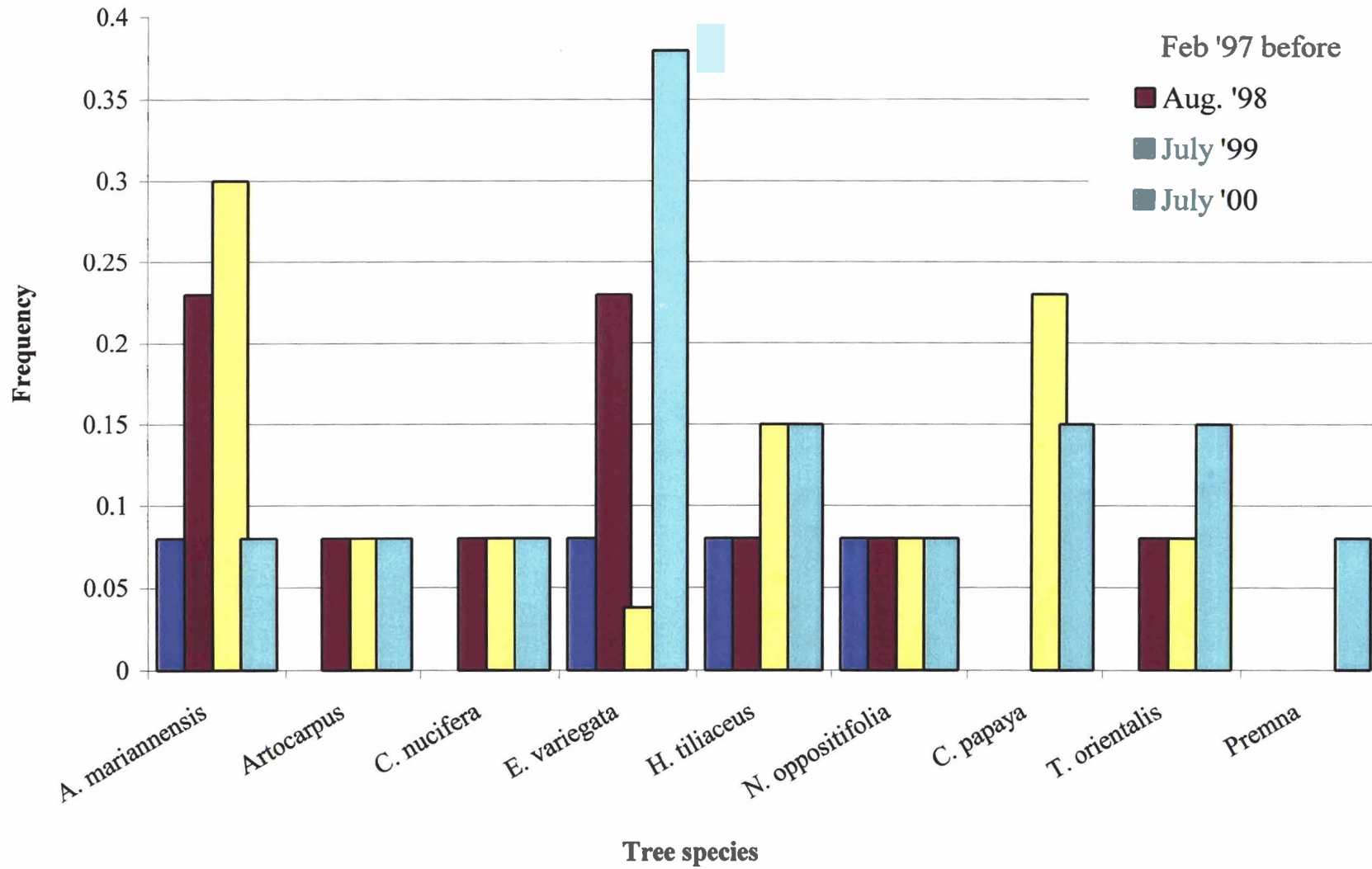
Figure A7. Canopy cover on Sarigan before and after feral animal eradication.

Figure A8. Ground cover on Sarigan before (Feb. 1997) and after feral animal eradication (July 1999 & July 2000).

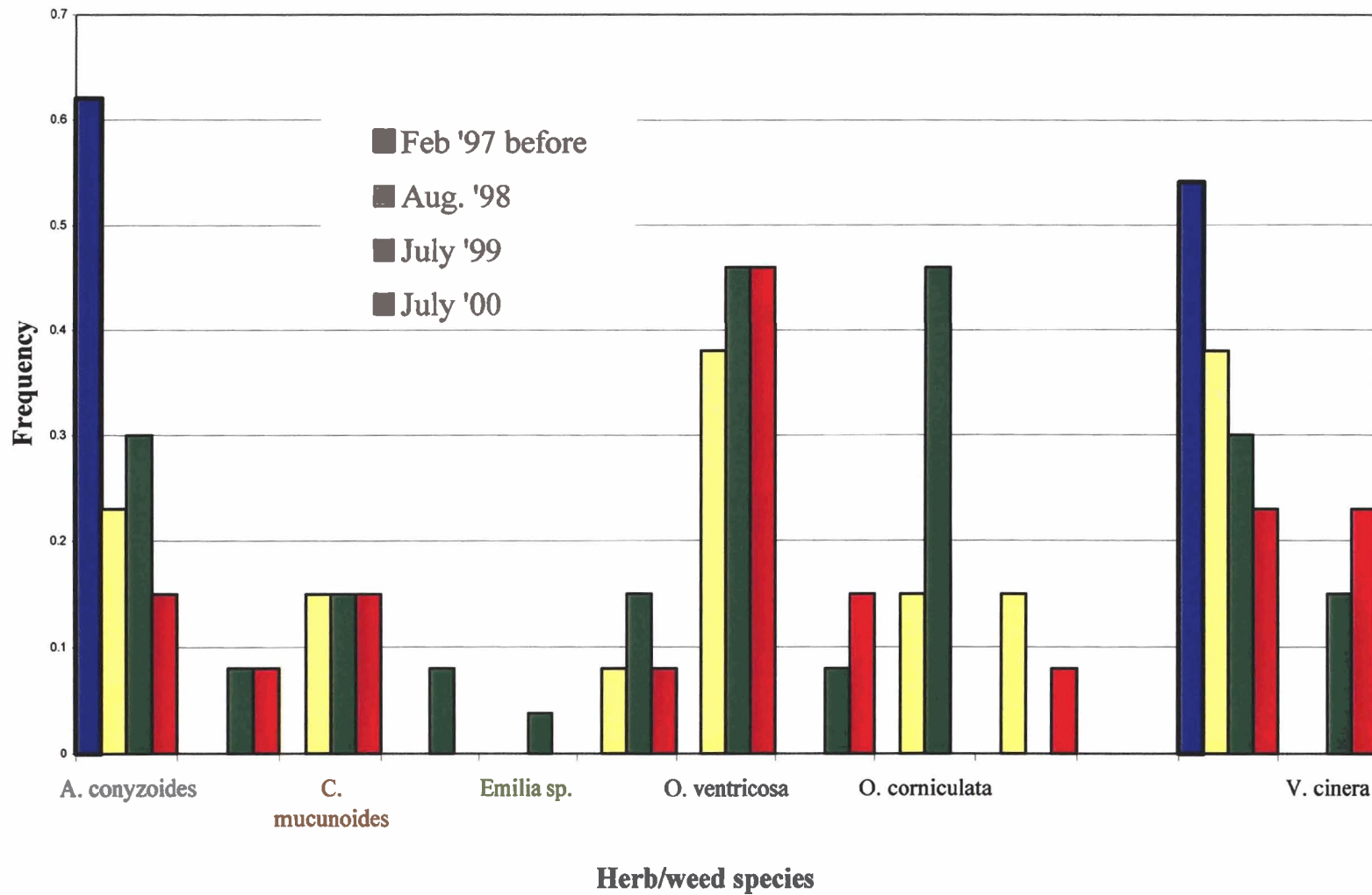
Total numbers of plant species before and after eradication, Sarigan



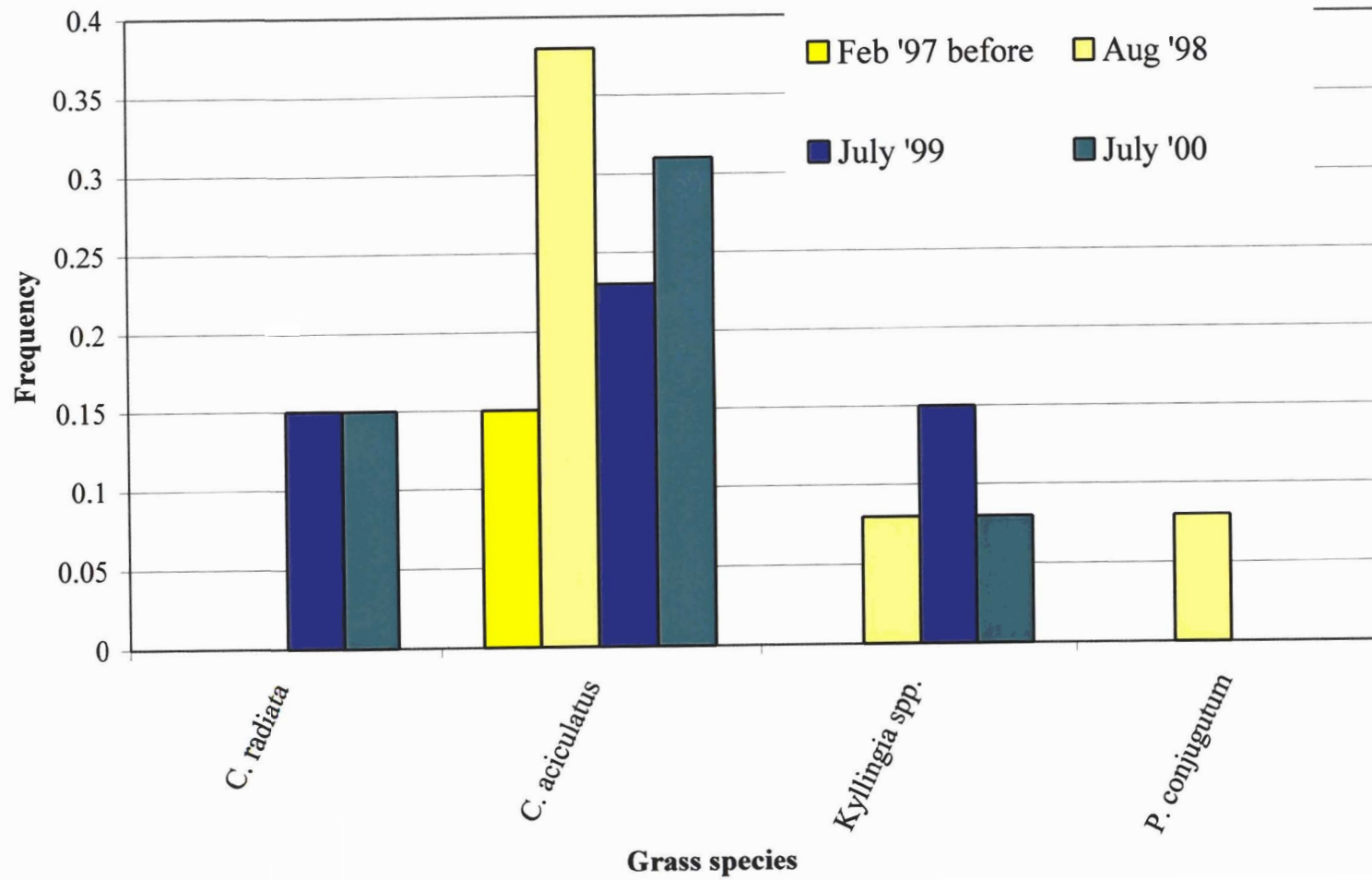
Frequency of tree species found on Sarigan before and after feral animal eradication



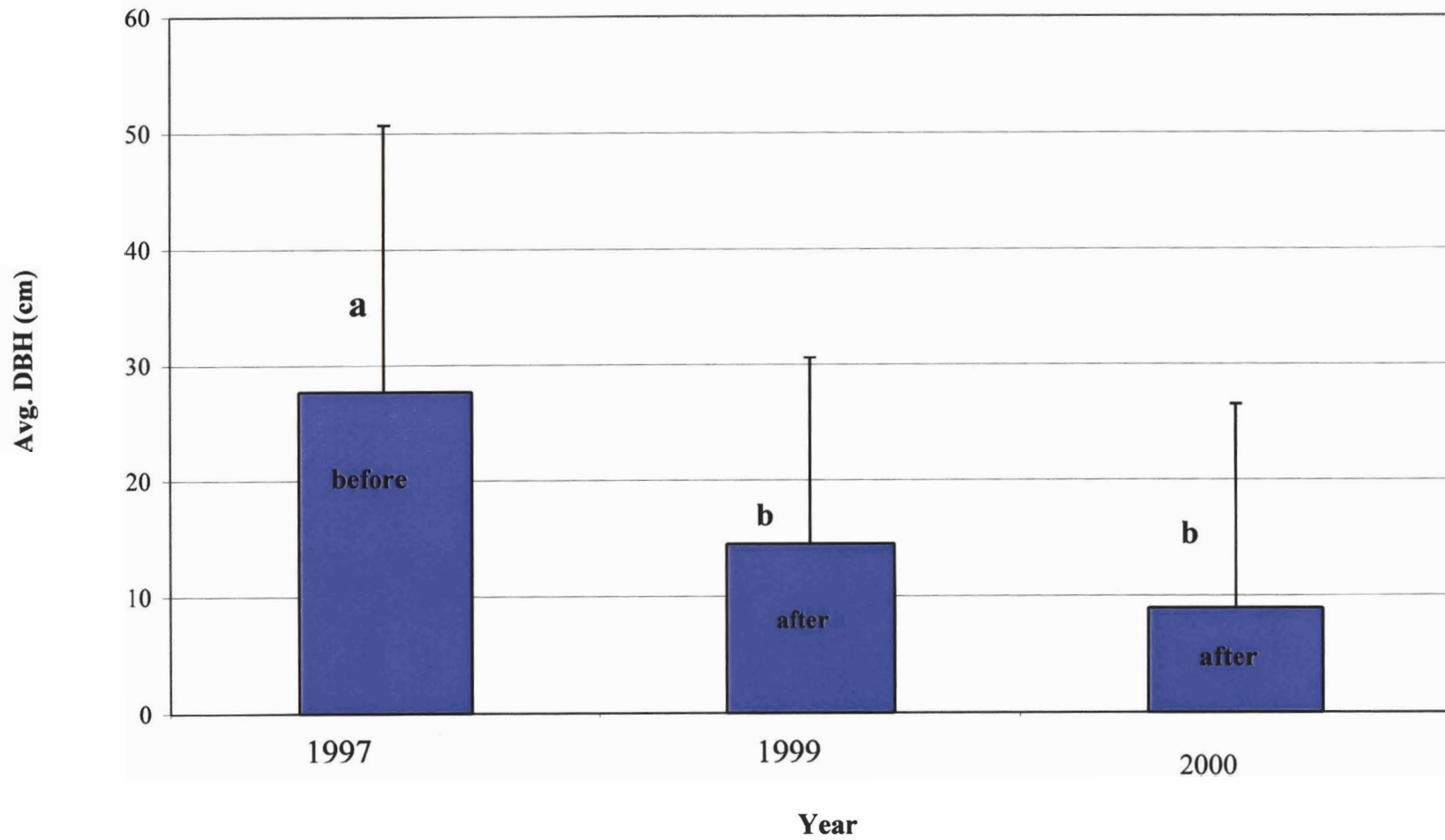
Frequency of herbs and weeds on Sarigan before and after feral animal eradication



Frequency of grass species before and after eradication on Sarigan

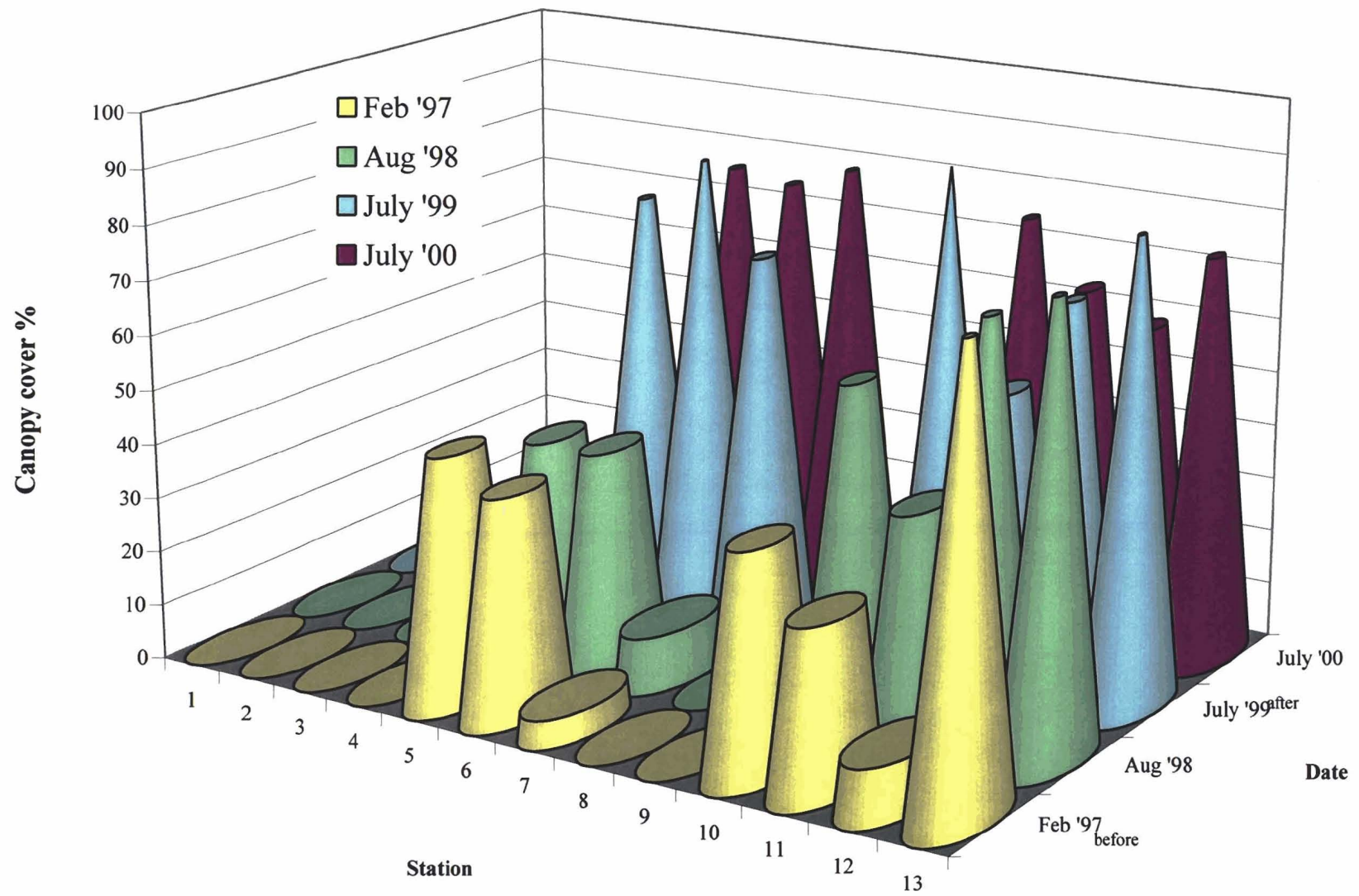


Average DBH of trees on Sarigan before and after feral animal eradication

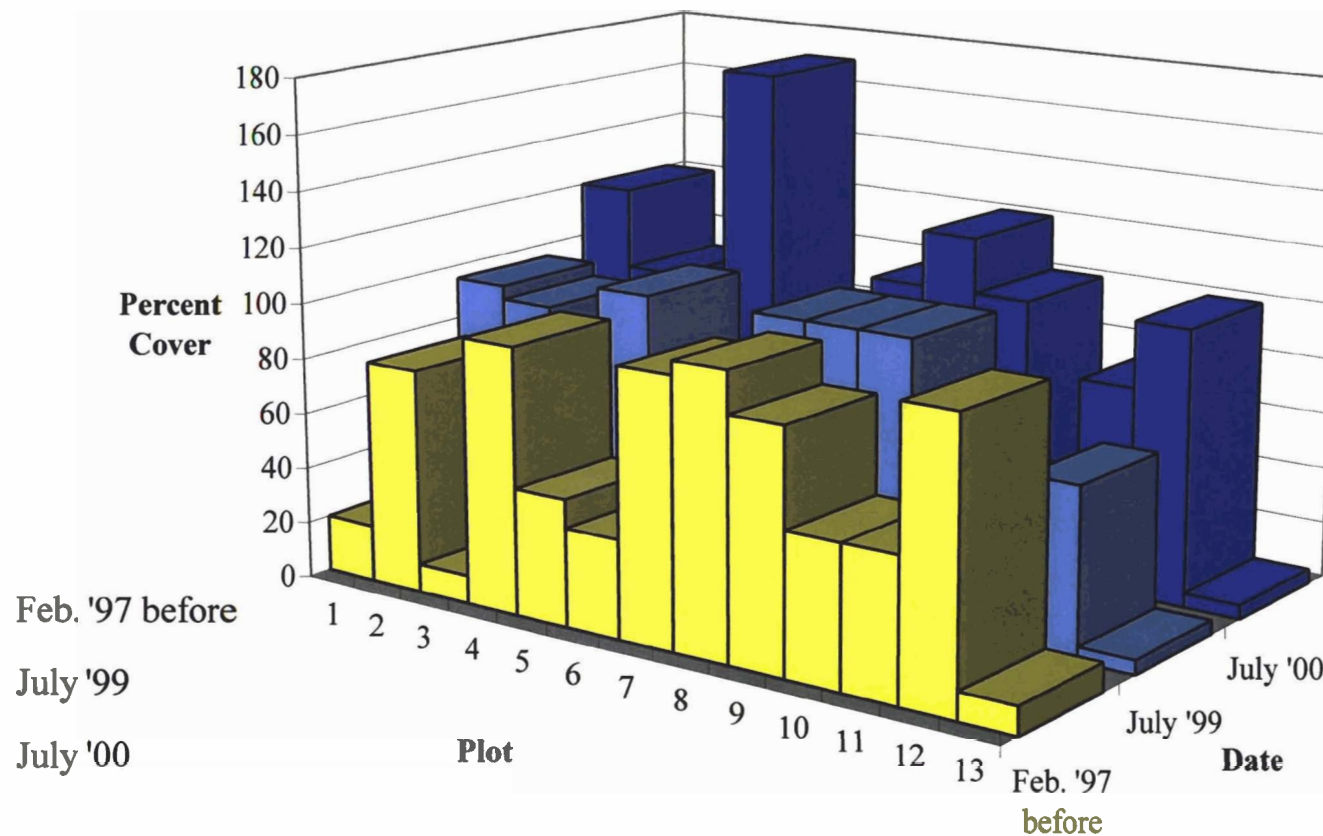


Note: years with same letter are not significantly different ($P < 0.05$)

Canopy cover on Sarigan before and after feral animal eradication



Ground cover on Sarigan before and after feral animal eradication



APPENDIX 3

Succession Vegetation Transect

Methods

A 150 m transect was established on the ridgeline above camp A and south of camp B. The study site was chosen for its accessibility and also its juxtaposition between two native forest fragments and the likelihood that it was once completely forested. The transect is 150 m running N-S between two the native forest fragments and through a field which is a slight depression. The ends of the transect are marked permanently with rebar. Seedlings and mature trees were all sampled using a modified line intersect method (Bullock, 1998). All tree species along the transect were measured for height, diameter at breast height (DBH) and distance of trunk from the transect line. Canopy cover was measured using a densiometer according to the instructions.

Herbaceous ground cover was sampled using 0.5m² quadrat which was placed randomly along the transect every 5 m. The species within each herb quadrat was identified and the percent cover of each species was estimated visually by dividing the quadrat into 4 quarters.

Three soil core samples were taken every 50 m along the transect for a total of 9 samples. The cores were kept from contamination by foreign airborne seeds. Each soil core was 2 cm³. The soil samples are currently being air-dried. After drying they will be placed in shallow trays, the soil will be watered until moist and they will receive indirect natural sunlight. Plants will be grown until the species is identifiable.

Results

A total of 7 tree species were identified along the line transect. The tree species found in the greatest abundance were *Morinda citrifolia*, *Aglaia mariannensis*, and *Erythrina variegata*, respectively. Seedlings appear to be somewhat spatially clumped along the transect. The *A. mariannensis* seedlings all were present under the canopy of the large *E. variegata* tree on the southern side of the transect. Whereas, the *M. citrifolia* and *E. variegata* seedlings all were located along the transect and clumped more near the center (Figure A9). The area where the seedlings are clumped corresponds to lower points along the depression of the valley that the transect runs through. Further, analysis of all data collected will be performed but was not possible due to time constraints.

List of Figures

Figure A9. Distance and height of tree species along a 150 m transect on Sarigan two years after eradication of feral animals

Distance and height of tree species along a 150 m transect two years after eradication of feral animals on Sarigan, July 2000

