POST-DELISTING MONITORING of the TINIAN MONARCH (*Monarcha takatsukasae*)

FINAL REPORT – June 2021

Fred A. Amidon[1], Ann P. Marshall[1], Paul Radley[2,4], and Eric VanderWerf[3]

Tinian Monarch color-banded during the post-delisting monitoring. Photo by E. VanderWerf.

[1]U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, 300 Ala Moana Boulevard, Room 3-122, Honolulu, Hawaii 96850
[2]Division of Fish and Wildlife, Department of Lands and Natural Resources, P.O. Box 10007, Saipan, MP 96950
[3]Pacific Rim Conservation, Honolulu, Hawaii
[4]Hawaii Pacific University, Honolulu, Hawaii

Abstract

The Tinian Monarch (*Monarcha takatsukasae*), locally known as Chichirikan Tinian, is a small forest bird endemic to the island of Tinian in the Commonwealth of the Northern Mariana Islands (CNMI). The species was listed as endangered in 1970 under the Endangered Species Act because its numbers were believed to be critically low as a result of forest loss. Survey data from 1982 indicated that the monarch population had increased or was at least stable and that the primary listing factor, loss of forest habitat, had been ameliorated. The Tinian Monarch was consequently downlisted in 1987 and delisted in 2004. Monitoring conducted between 2006 and 2011, as part of a 2005 USFWS Post-delisting Monitoring Plan for the species included roadside surveys, small-scale early warning plots, and land-use monitoring. Island-wide population surveys were additionally conducted in 2008 and 2013. Results of the roadside surveys indicate a significant decline in counts of Tinian Monarchs from 1999 to 2010, which was consistent with reported island-wide declines from 1996 to 2008. However, increases in island-wide counts in 2013 indicate that the population may be fluctuating temporally. Data from the small-scale plot monitoring indicated an annual adult survival rate of 78%, higher territory turnover rates for females (42%) than males (35%), and an overall territory occupancy rate of 94%. Land-use monitoring, based on satellite imagery and CNMI land clearing permits, indicated an average of 20 hectares of land cleared per year from 2007 to 2010. An unexpected outcome of the monitoring was the observation and identification of avian pox in Tinian Monarchs but its impact on the species is unknown. Quarterly roadside surveys should be continued, and island-wide surveys should be conducted at 5-year intervals to assess changes in the population across the island. Finally, an island-wide conservation plan for the Tinian Monarch should be developed to help manage for the long-term conservation of the species.

Table of Contents

List of Figures

List of Tables

Introduction

The Tinian Monarch (*Monarcha takatsukasae*), locally known as Chichirikan Tinian, is a small forest bird endemic to the island of Tinian in the Commonwealth of the Northern Mariana Islands (CNMI). First described by Takatsukasa and Yamashina (1931), this small (15 centimeters [6 inches]) songbird in the monarch flycatcher family (Monarchidae), has light rufous underparts, olive-brown upper parts, dark brown wings and tail, white wing bars, and a white rump and undertail coverts (Baker 1951). There are some reports that indicate the Tinian Monarch may once have occurred on the island of Saipan, approximately 5 km north of Tinian (Peters 1996). Reports of the species on the small island of Aguiguan, approximately 9 km south of Tinian, have generally been discounted (Engbring et al. 1986).

The Tinian Monarch was listed as endangered in 1970 under the Endangered Species Act (ESA) as its numbers were believed to be critically low because of removal of native forests for sugarcane production by the Japanese before World War II and destruction of forest as a result of this conflict (Baker 1946; USFWS 1970, 1987). Destruction of the native forest actually began in the 18th century when the Spanish used Tinian as a supply island for Guam and introduced large herds of cattle and other ungulates to the island (Fosberg 1960). After World War II, it is believed that the U.S. Department of Defense (DOD) seeded the island with tangantangan (*Leucaena leucocephala*), a rapidly growing tree native to Mexico and Central America, in order to combat erosion (USFWS 1996). Based on reports of monarch numbers after the war, it is likely that while common in small patches of remaining forest, their distribution was highly restricted and their population small because so much of the forest had been destroyed (Downs 1946; Gleize 1945; Marshall 1949; USFWS 1987, 2005).

An island-wide survey of Tinian conducted in 1982 found the Tinian Monarch to be the second most abundant bird on the island with an estimated population of 39,338 birds widely distributed over the island in all forest types (Engbring et al. 1986). Based on these data, the species was downlisted from endangered to threatened in 1987 (USFWS 1987). A life history study conducted in 1994-1995 estimated the monarch's population to be approximately 52,904 birds based on densities in 3 forest types (USFWS 1996). A second island-wide survey of forest birds that used the same transects and methods as in 1982 estimated the species' population at 55,721 birds (Lusk et al. 2000). This latter study also found that vegetation density increased in all forest types since 1982, leading Lusk et al. (2000) to hypothesize that increases in monarch density were correlated with increases in vegetation density. Based on the finding that the Tinian Monarch had increased in number or was at least stable, that the primary listing factor (loss of forest habitat) had been ameliorated, and that the species was not currently threatened by other factors, the monarch was delisted in 2004 (USFWS 2004).

Other threats to the Tinian Monarch include predation by introduced mammals, random demographic fluctuations, disease, and the potential for the introduction of the brown treesnake (*Boiga irregularis*) to Tinian. The brown treesnake is responsible for the extinction and extirpation of 10 of the 13 native forest bird species on Guam (Conry 1988, Rodda et al. 1999, Savidge 1987). The brown treesnake is not established on Tinian but there have been at least seven snake sightings between 1994 and 2003 (Hawley 2002, USFWS 2004). None of the snakes were caught but descriptions of several of them were consistent with the brown treesnake (USFWS 2004). Brown treesnakes could potentially reach Tinian via cargo shipped from Guam, where the snake is well established and occurs in extremely high densities (Rodda et al. 1999, USFWS 2004). It is hoped that measures to control brown treesnakes around ports and the inspection of high-risk cargo leaving Guam will prevent their accidental introduction to other islands. Regardless, the brown treesnakes is thought to in the process of becoming established on Saipan, though clear evidence of establishment or recruitment is lacking (Rodda and Savidge 2007, USFWS 2004).

Section 4(g)(1) of the ESA requires the U.S. Fish and Wildlife Service (USFWS) to implement a system in cooperation with the States to effectively monitor (for no less than five years) the status of all species that have been delisted. The purpose of this post-delisting monitoring is to verify that the delisted species remains secure from the risk of extinction after removal from the protection of the ESA. In 2004, the USFWS published a final post-delisting monitoring plan (PDMP) for the Tinian Monarch (USFWS 2005).

This report summarizes the results of the Tinian Monarch post-delisting monitoring conducted between 2006 and 2011. It specifically outlines the results of the roadside surveys, small-scale early warning system plots, and forest cover monitoring identified in the PDMP. The results of island-wide surveys summarized in Camp et al. (2012) and U.S. Navy (2014) are also discussed in this report.

Methods

Roadside Surveys

Quarterly roadside surveys were conducted at 50 stations distributed around the island of Tinian by staff from the CNMI's Division of Fish and Wildlife (DFW) beginning in 1999 (Figure 1). All surveys were completed between one half-hour before sunrise and 10:30 a.m. and were only conducted under fair weather conditions when winds were judged to be less than three as measured on the Beaufort Scale. Trained observers recorded detections of all birds seen or heard within an unlimited distance from the station during a three-minute period at each station in January, April, July and October annually. Cloud cover, rain, and wind conditions were also recorded.

Trends in Tinian Monarch detections were assessed using generalized linear mixed models (GLMMs) with the lme4 (Bates et al. 2015) and glmmTMB (Brooks et al. 2017) packages in R (R Core Team 2020). Survey station and observer were fitted as random effect variables to account for lack of independence of counts from the same survey stations, not all stations being surveyed in all survey periods, and changes in observers over the survey period. Models were fitted assuming either a negative binomial or poisson distribution and were evaluated using AIC. Model assumptions were tested using residual plots, nonparametric dispersion test, and zero-inflation test from the DHARMa package (Hartig 2020).

Small-Scale Early Warning System Plots

Three small-scale study plots, Santa Lourdes Shrine, the Airport Mitigation Area, and the Seaport Tangantangan Site (Figure 1), were established in Tinian Monarch habitat located near areas where brown trees snakes might arrive on Tinian, such as the airport, seaport, cargo off-loading zone or staging areas, and/or sites that are the ultimate destination of materials brought from the other islands. As Tinian Monarch densities are generally higher in limestone forest

(Camp et al. 2012, USFWS 1996), we focused on establishing study sites in this habitat type. Two sites were established in limestone forest, Santa Lourdes Shrine and the Airport Mitigation Area. However, limestone forest habitat was limited near the Seaport, therefore, the Seaport Tanagantangan Site was established in mixed stand of tangantangan and secondary forest near the port. The Santa Lourdes site was located on the edge of the main village on the island, San Jose, in between the seaport and airport. The Airport Mitigation and Seaport Tangantangan Site were placed near the airport and seaport, respectively.

Tinian Monarchs at each study site were mist-netted, weighed, measured (wing, tarsus, tail, and bill length, and body mass), inspected for health, molt, and breeding condition. Each monarch was fitted with an aluminum band and a unique combination of three colored leg bands, then released unharmed in the same location where they were captured. Feather samples were collected from 61 individuals in 2008 and 2009 for genetic sexing. One individual was sampled twice resulting in 62 samples total. Thirty-five samples were analyzed to determine sex in 2011. Twenty-seven samples from 2008 were initially thought to be lost but were rediscovered in 2016. Two sets of methods, therefore, were employed to sex the samples genetically.

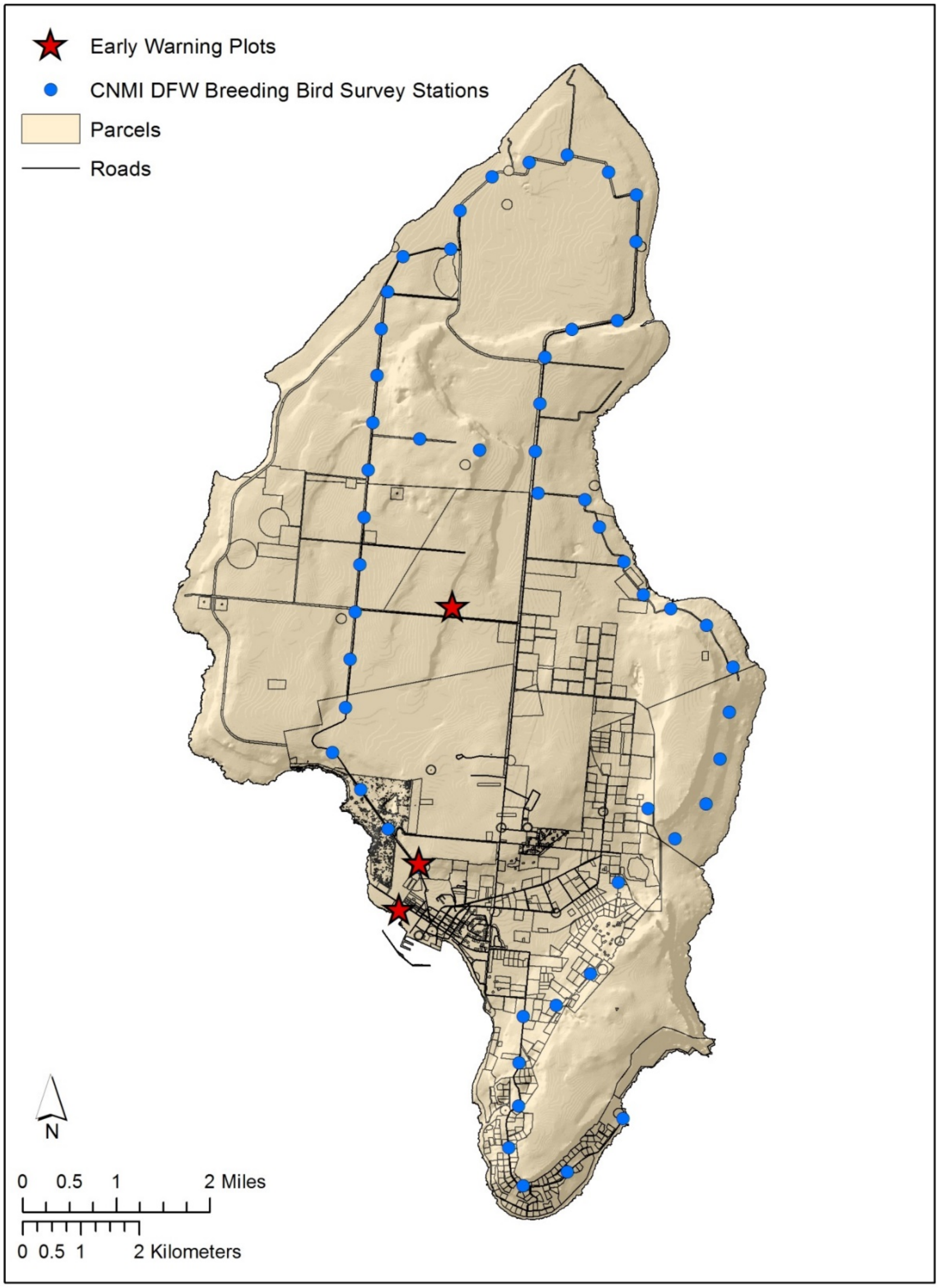


Figure 1. Location of small-scale early warning system plots and breeding bird survey stations on the island of Tinian.

Genomic DNA was extracted from 35 feather samples using the Qiagen Tissue Extraction kit, following the manufacturer's protocol, for the 2011 assessment. All individuals were independently sexed at least twice using protocols described by Fridolfsson and Ellegren (1999). PCR products were verified with agarose gel electrophoresis. The 2016 assessment utilized the remaining 27 feather samples, which were stored at room temperature over 8 years and were considered degraded. As such, the 2016 assessment used the forward and reverse primer set Z37B, described in Dawson et al. (2015). PCR amplification of each sample followed the protocol outlined by Dawson et al. (2015). Genotyping was conducted by the Advanced Studies in Genomics, Proteomics and Bioinformatics facility at the University of Hawaii at Manoa using an Applied Biosystems 3730XL DNA Analyzer. Sex determination through peak visualization was conducted in the PeakScanner vers. 2 (Applied Biosystems).

Banded Tinian Monarchs were initially sexed using a combination of genetic sexing results and information on breeding status (e.g., presence of a brood patch) and breeding pair composition. Morphometric data (i.e., wing, tail, bill, and tarsus length and body mass) from these sexed individuals were then evaluated to determine if the morphometric measurements could be used to sex the remaining unsexed Tinian Monarchs. Overall differences in morphological measurements between the sexes were analyzed with a multivariate analysis of variance (MANOVA) with sex as the response and wing chord, bill length, long tarsus length, tail length, and weight as predictors. One-way Analysis of Variance (ANOVA) was used to check for significant differences in each individual morphometric. A linear discriminant function analysis (DFA) was used to identify the best morphometric characters to predict sex. Models with one, two, or all variables were evaluated. Model performance was based on accuracy scores derived from 5-fold repeat cross-validation. Prior to the MANOVA and DFA, outliers and potential morphological measurement errors were identified using box plots (univariate) and cook's distance (multi-variate). Correlation in morphometric variables was assessed using the Pearson's correlation coefficient and variables with a correlation coefficient of 0.75 or greater were dropped from the analysis. Normality and homogeneity of variance assumptions were tested with quantile-quartile plots, Shapiro-Wilk normality test, and Bartlett's test of homogeneity of variances. All analyses were completed in R using functions from the MASS (Venables and Ripley 2002) and caret (Kuhn 2020) packages.

Territories at each study site were mapped annually by recording the location of all marked and unmarked Tinian Monarchs and their nest sites using general territory mapping methods outlined in Bibby et al. (2000). Whenever possible, territorial and breeding behaviors were noted to delineate territorial boundaries and each site was mapped for at least 5 days by two or more observers. These maps were then used, with the data on marked birds, to estimate overall territory occupancy (i.e., the likelihood a territory would be occupied each year) and territory turnover rates (i.e., the likelihood a banded bird in a territory will no longer occur in a territory the subsequent year) by each sex. Territory occupancy was estimated by comparing territory maps for each study plot for each monitoring year and scoring a territory as occupied or unoccupied each monitoring year. These scores were then used to estimate the likelihood of a territory being occupied from year to year using the island R package (Ontiveros et al. 2019). We assumed all territories were mapped accurately, independent, and equivalent and that the birds occupying each territory were identified correctly. Likelihood of territory turnover for each sex was estimated by comparing territories occupied by a known-sex marked individual from one year to the next. Turnover was calculated as the percentage of territories in one year not occupied by the same individual in the subsequent year. Like the estimate of territory occupancy, we assumed all birds occupying each territory were identified correctly. We examined variation in territory size using a general linear model, with year and site as factors.

We estimated apparent annual survival (φ) and encounter probability (ρ) for banded Tinian monarchs between 2006 and 2010 using Cormack-Jolly-Seber models. We reported apparent annual survival as the population size was unknown and the true fate of marked birds was unknown. Modeling parameters initially included sex and study area as we expected survival and encounter probability could vary between these variables (see Table 5 for a list of the final models evaluated). A goodness of fit test was carried out on a global model (φsex+site. ρsite.) using the median $\hat{c}$ approach. The dispersion parameter indicated moderate over-dispersion ($\hat{c}$= 1.41). Therefore, we adjusted the value of c and conducted model selection using the resulting QAICc values, as recommended by Burnham and Andersen (2002). We considered the model with the lowest QAICc to have the best fit, but also considered models with QAICc values that differed (ΔQAICc) by ≤ 2.0. All analyses were conducted in the statistical program R. Model fitting and testing was conducted using the Marked package (Laake et al. 2013). The mra (McDonald 2018) package was used for global model goodness of fit testing and calculating $\hat{c}$.

Monitoring was conducted at small-scale plots primarily between 2006 and 2010. The Santa Lourdes and Airport Mitigation sites were established and monitored in 2006 while the Seaport Tangantangan site was established in 2007. Monitoring was conducted at all three sites in 2007, 2008, 2009, and 2010. The monitoring in 2010 was originally expected to be the final year of monitoring. However, some funds were obtained to conduct a fifth year of monitoring at the Seaport Tangantangan site in 2011. Therefore, the results for these estimates focus on the 2006 to 2010 monitoring period for the Santa Lourdes and Airport Mitigation sites and 2007 to 2011 for the Seaport Tangantangan site.

Land-use Monitoring

Trends in land use were estimated over the monitoring period using two methods. First, landcover estimates for the island of Tinian were obtained from the Forest Service (Liu and Fisher 2006). These estimates were based on a 2004-2005 mapping assessment using Quickbird and Ikonos satellite imagery of the island and were considered the baseline estimates for habitat availability on the island at the start of the monitoring period. Forest clearings were then identified and mapped on 2010 Worldview 2 satellite imagery of Tinian. If these clearings occurred in areas that were classified as forest in 2005 they were considered forest clearings and the total acreage of forest cleared was estimated for the monitoring period. The second monitoring method involved tabulating applications for habitat clearing to the Division of Fish and Wildlife (DFW) during the monitoring period. All land clearing in the CNMI requires a permit by the Division of Environmental Quality, which includes clearance forms from DFW.

Results

Roadside Surveys

A total of 16 quarterly surveys were conducted on Tinian between November 1999 and July 2010 by CNMI DFW. No surveys were completed during 2001 to 2003 and 2006 to 2009 resulting in large gaps in the data set (Figure 2). The best fitting model for Tinian Monarch detections was the zero inflated negative binomial (ZINB) model with observer as a random effect (Table 1). Tinian Monarchs showed a significant decline in detections between 1999 and 2010 (Table 2, Figure 2).

Table 1. Models evaluated to assess changes in Tinian Monarch roadside counts from 1999 to 2010.

Model	Distribution[1]	AIC	ΔAIC
TIMO ~ Survey + (1|Observer)	ZINB	2028.3	0
TIMO ~ Survey + (1|Observer)	NB	2041.0	12.7
TIMO ~ Survey + (1|Station)	ZINB	2049.2	20.9
TIMO ~ Survey	NB	2049.2	20.9
TIMO ~ Survey + (1|Station)	NB	2050.2	21.9
TIMO ~ Survey + (1|Observer)	PO	2352.7	324.4
TIMO ~ Survey + (1|Station)	PO	2369.4	341.1
TIMO ~ Survey	PO	2419.9	391.7

[1] Zero inflated Negative Binomial (ZINB), Negative Binomial (NB), Poisson (PO).

Table 2. Posterior mean values, standard errors, and 95% credible intervals for the parameters in the zero inflated negative binomial mixture model for Tinian Monarch roadside survey detections.

Coefficient	Mean	Lower 95%	Upper 95%
Intercept	1.003	0.460	1.547
Survey Sequence	-0.020	-0.038	-0.001
Observer (intercept)	0.436	0.242	0.787
Zero Inflation (intercept)	-0.322	-0.670	0.027

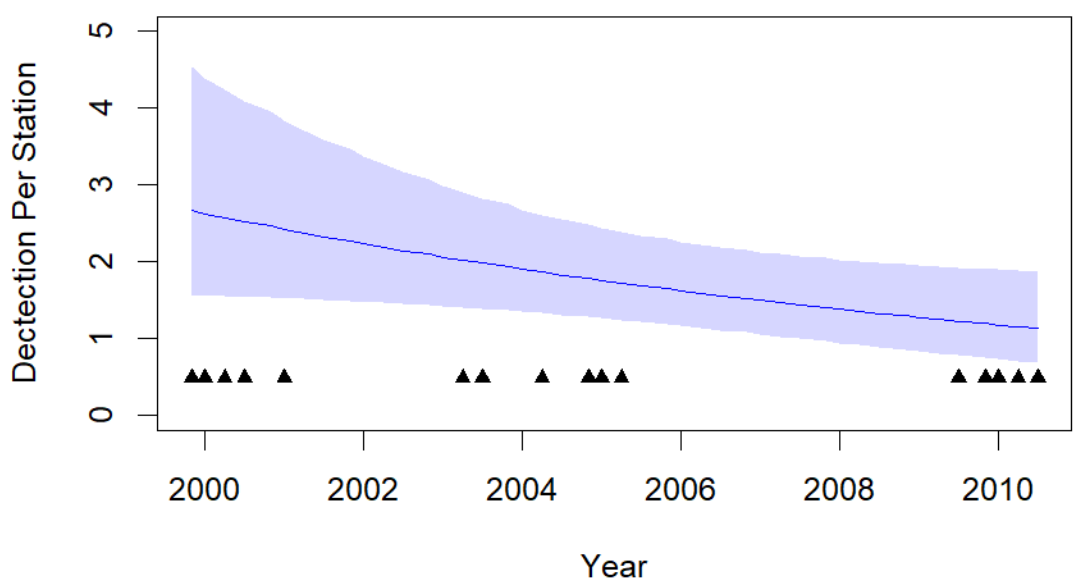


Figure 2. Modelled trend, with 95% confidence interval, of Tinian Monarch detections at roadside stations surveyed from 1999 to 2010. Black diamonds indicate actual survey periods.

Small-Scale Early Warning System Plots

A total of 119 Tinian Monarchs were banded during the 2006-2011 monitoring period; 39 at Santa Lourdes, 51 at the Airport Mitigation, and 30 at the Seaport Tangantangan site (Appendix A). One hundred and five (105) were after hatch year birds, 10 were hatch year birds, and 4 were nestlings. Sexes were identified for 53 after hatch year individuals. One of these individuals (color combination ARRG) had incomplete morphometric measurements and was dropped from the analysis. An additional eight individuals (color combinations AKKP, ARWB, BAWG, BRGA, KBAP, GAGR, RWKA, and WRAG) were found to have extreme or inconsistent measurements, potentially due to measurement or data transcription errors, based on univariate, bivariate, and multivariate assessments. These individuals were also dropped from the morphological assessment resulting in a total sample of 44 birds (25 females and 19 males) available for analysis.

The morphological measurements of the 44 sexed birds were not significantly correlated and all measurements met the assumptions of normality and homogeneity of variance. A multivariate analysis of variance (MANOVA) on the 44 birds showed a significant morphological difference between females and males ($F_{1,38} = 7.369$, $p < 0.001$). All five morphological measurements overlapped between the sexes (Table 3). Of the five measurements evaluated, wing chord was significantly longer for males than females (Table 3).

Table 3. Morphological differences between male and female adult Tinian Monarchs. F values are derived from univariate ANOVA.

Measurement	Sex	n	Mean	SD	F value, df	P value
Wing chord (mm)	Female	25	66.6	1.58	15.471	0.0003
	Male	19	68.7	1.99	1,42	
Tail length (mm)	Female	25	66.3	1.73	1.068	0.31
	Male	19	66.9	2.04	1,42	
Bill length (mm)	Female	25	14.1	0.77	1.526	0.22
	Male	19	14.3	0.83	1,42	
Tarsus length (mm)	Female	25	22.9	0.73	1.239	0.27
	Male	19	22.6	0.82	1,42	
Weight (g)	Female	25	11.8	0.92	1.297	0.26
	Male	19	11.5	0.98	1,42	

Linear DFA models were developed using the morphological data from 44 known sexed individuals. Table 4 summarizes the accuracy assessments of the various DFA models built to discriminate sex using the five morphological variables. The top performing model, based on accuracy was the model which included wing and tarsus measurements (Table 4). The resulting discriminant function (0.657 (wing chord) -1.073 [tarsus length]) had an overall testing accuracy of 78% and a 74% and 80% testing accuracy for males and females, respectively. The model with just wing (0.530 [wing chord]) had an overall testing accuracy of 73% and a 68% and 77% testing accuracy for males and females, respectively. These two models were used to help determine the sex of the 53 unsexed adult Tinian Monarchs for the following survival analysis.

Table 4. Linear discriminant function analysis models for predicting sex of adult Tinian Monarchs based on morphometric measurements. Accuracy scores are averages based on repeated 5-fold cross-validation.

Model	Testing Accuracy (± SD)	Testing Kappa (± SD)
Wing + Tarsus	78 ± 20	0.54 ± 0.41
Wing + Tail + Bill + Tarsus + Weight	77 ± 18	0.52 ± 0.40
Wing + Weight	73 ± 20	0.44 ± 0.43
Wing	73 ± 20	0.45 ± 0.39
Wing + Tail	72 ± 24	0.42 ± 0.49
Wing + Bill	69 ± 20	0.37 ± 0.41
Bill	60 ± 18	0.18 ± 0.38
Tarsus	57 ± 20	0.06 ± 0.40
Tail	57 ± 18	0.07 ± 0.38
Weight	55 ± 16	0.01 ± 0.32

Resight data were available on 104 Tinian monarch at the three study sites (32 at Santa Lourdes, 46 at the Airport Mitigation, and 26 at the Seaport Tangantangan; Appendix B). Due to the limited sample sizes, we only evaluated a limited number of mark-recapture models (Table 5). The model with all parameters constant performed the best (Table 5). Although the model with sex was within 2 ΔQAICc, it had little effect on model deviance and was considered an uninformative parameter as per Arnold (2010). Based on the top model, estimated annual survival was 78% (SE = 3%, 95% CI = 72-83%) and encounter probability was 95% (SE = 2%, 95% CI = 88-98%).

Table 5. Models used to investigate apparent annual survival (φ) and encounter probability (ρ) for Tinian monarchs between 2006 and 2010 on the island of Tinian, Mariana Islands, USA. Subscripts indicate whether parameters differed among groups (e.g., φsex) or were constant (φ). $\Delta QAIC_c$ is the difference from the best model, which had a $QAIC_c = 188.16$, $wQAIC_c$ is the $QAIC_c$ weight, and QDev is the Quasi Deviance.

Model	Number of parameters	$\Delta QAIC_c$	$wQAIC_c$	QDev
φ.ρ.	2	0.00	0.525	369.57
φ_{sex} ρ.	3	1.37	0.264	368.06
φ_{time} ρ.	5	3.22	0.105	362.99
φ_{site} ρ.	4	3.97	0.072	368.94
$\varphi_{sex+site}$ ρ.	5	5.52	0.033	367.62

Territory size was larger in the Seaport Tangantangan site (0.42 ± 0.03 ha) than in the Airport Mitigation and Santa Lourdes Shrine sites (0.12 ± 0.005 ha and 0.13 ± 0.006 ha, respectively; ($F_{2,152} = 147.32$, $p < 0.001$). Territory size did not vary among years so data from all three years were combined.

Data to estimate annual overall territory occupancy and turnover rates by sex were available for the Santa Lourdes and Airport Mitigation sites for the 2006 to 2007, 2007 to 2008, 2008 to 2009, and 2009 to 2010 periods (see Appendix C for annual territory maps). Territory data for the Seaport Tangantangan site were only available for 2008 to 2009, 2009 to 2010, and 2010 to 2011. Monitoring was initiated at this site in 2007. However, only a small area was sampled due to time constraints.

A total of 1.7, 1.2, and 2.7 hectares of forest were consistently sampled at the Airport Mitigation, Santa Lourdes, and Seaport Tangantangan sites, respectively, to measure territory occupancy and turnover between years. The overall annual territory occupancy rate for all study sites combined was 94% (95% CI: 91-97%). Annual territory occupancy for the Airport Mitigation, Santa Lourdes, and Seaport Tangantangan sites was 96% (95% CI: 94-99%), 92% (95% CI: 88-97%), and 90% (95% CI: 89-97%, respectively. Finally, average annual territory turnover rates for males and females over all study sites was 35% (95% CI: 24-46%) and 42% (95% CI: 31-53%), respectively.

An unexpected result of the netting in 2006 was that 15 of the monarchs (39%) had scabby lesions on their feet and toes typical of those caused by avian pox virus (*Poxvirus avium*, Figure 3). Another seven monarchs (18%) had missing or deformed toes typical of healed pox lesions. These pox-like lesions were also observed on monarchs in 2007 and 2009 but not in 2008. In 2007, the prevalence of the lesions (11%) was lower than in 2006 (39%; $X^2 = 8.49$, df = 1, p = 0.004). Lesions were only observed on one monarch in 2009 (3%). This lower occurrence along with the lack of observations of pox-like lesions in 2008 may indicate that we observed the tail end of an epizootic or that it may occur in cycles. In 2006 there was some indication that prevalence of these lesions was higher at the Santa Lourdes Shrine (44%) than at the Airport Mitigation Area (36%). In 2007 prevalence was again higher at Santa Lourdes (19%) than at the Airport Mitigation (0%) and was also high at the Seaport Tangantangan site (20%). The Santa Lourdes Shrine and the Seaport sites are closer to urbanized areas of Tinian where mosquito abundance may be higher due to the presence of standing water in residential structures and abandoned machinery that provide mosquito breeding sites. These sites are also closer to populations of domestic birds such as chickens, which could serve as a reservoir for disease. Strangely, the pox-like lesions were observed only in monarchs and not in any of the other species captured.

Figure 3. Photograph of pox-like lesions on a Tinian Monarch's foot. Photograph by Eric VanderWerf.

Tissue samples were collected in 2006 from lesions on seven monarchs to conduct clinical tests. These samples were collected from monarchs only if there was a loose scab that could be easily removed without injuring the bird or exacerbating the lesion. Drs. Dennis Triglia and Carter Atkinson of the U.S. Geological Service Biological Resources Discipline in Hawaii attempted to test whether those lesions were caused by avian pox virus using tissue culture techniques. They were able to amplify and sequence Avipoxvirus (4b core protein) from one of the cell culture pellets from 2006. A check on Genbank indicates that it is 100% identical to Canarypox that has been reported from both Hawaii and the Galapagos Islands.

Land-use Monitoring

Approximately 165 hectares of forest were cleared on Tinian between 2005-2006 and 2010 based on an assessment of satellite imagery. Sixty-nine percent (114 ha) of this total was potential Tinian Monarch habitat (tangantangan thicket and mixed introduced forest) while the majority of the remainder was shrub and grass areas. If we assume that the clearings occurred consistently over a 5-year period, this would be equivalent to 22.8 ha of Tinian Monarch habitat cleared per year or 33 ha of land cleared per year.

Data on 79 land clearing permits were obtained from DFW for 2007 thru 2010 (DFW, unpubl. data). The area expected to be cleared was not reported for eight of the permits, so those permits were dropped from the analysis. The total acreage cleared under the remaining permits was 78 hectares, with the majority (68%) of the permits being for small areas (< 1 ha). The largest clearing was 20 ha in Kahet Acra in 2007. Based on standard error, the average clearing size was similar between years (Figure 4) and average total area cleared per year was 19.5 ha (± 8.6 SD).

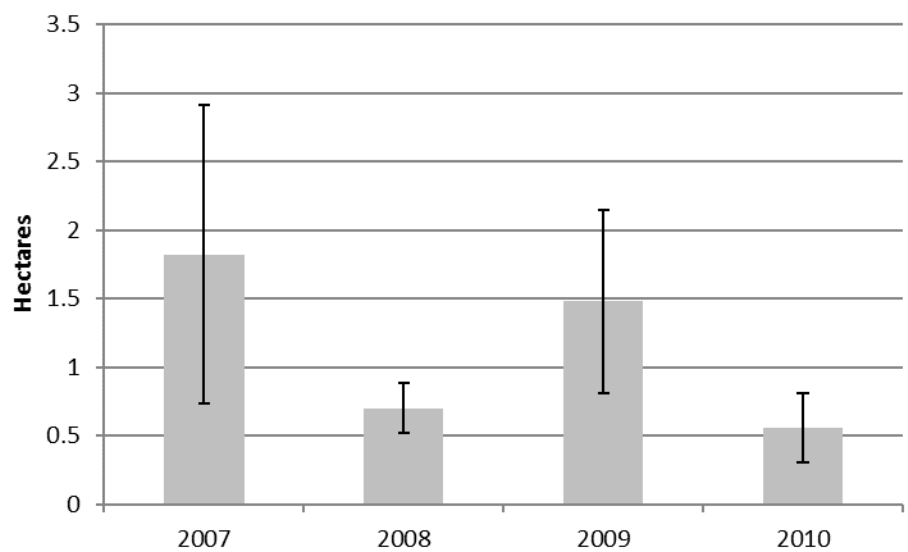


Figure 4. Average clearing size per year (± SE) based on permits for clearing to the Division of Fish and Wildlife in 2007-2010.

Discussion

Results from the roadside surveys showed a significant decline in counts of Tinian Monarchs from 2001 to 2010. This is consistent with the reported island-wide population declines of the species from 1996 to 2008 by Camp et al. (2012). However, it is uncertain if counts remained low between 2010 and 2013, when a subsequent island-wide survey indicated the decline in the island-wide population had reversed to pre-2008 levels (U.S. Navy 2014). The 2013 and earlier island-wide surveys appear to indicate that the Tinian Monarch population may be cycling through time. However, regular quarterly roadside surveys and more frequent island-wide surveys are needed to determine if this is the case (see Recommendations below).

Tinian Monarch annual survival rates (78%, 95% CI = 72-83%) from the small-scale warning plots fell within the lower part of the range of survival rates reported for other Pacific Island monarch flycatchers. Blanvillain et al. (2003) reported annual survival rates ranging from 85-92% for the Tahiti Flycatcher (*Pomarea nigra*). Robertson et al. (1994) reported annual survival rates of 76% for the Rarotonga Flycatcher (*Pomarea dimidiate*) prior to rat control. VanderWerf (2008) reported male and female annual survival rates of 87% and 81%, respectively, for the Hawai`i `Elepaio (*Chasiempis sandwichensis*), and 84% (86% with rodent control) and 55% (82% with rodent control) for male and female O'ahu 'Elepaio (VanderWerf 2009).

We were unable to evaluate potential differences in annual survival by sex in this study due to limited data. Average annual territory turnover rates, however, were higher for females (42%) than males (35%) and studies by Greenberg and Gradwohl (1986) and Woltmann and Sherry (2011) on Central American insectivorous birds showed a consistent relationship between territory turnover and mortality. Additional research on survival rates of male and female Tinian Monarchs may also show a difference between sexes.

Despite having relatively low annual survival for Pacific Island monarch flycatchers, the overall territory occupancy rate was high (94%). No data were collected on nesting success and juvenile survival in this study. However, the high territory occupancy rate may indicate good levels of recruitment. Additional data are needed to confirm this.

Territory size estimates for the Airport Mitigation site were remarkably similar to the average territory size determined for that area in 1994 to 1995, which was 0.12 ± 0.02 ha (n = 17), indicating that the monarch territory sizes remained stable over this period (USFWS 1996). Territory size estimates for the Airport Mitigation site and Santa Lourdes site were also similar, indicating potentially similar estimates for native forest dominated sites. Territory size at the Seaport Tangantangan site, a mixed tangantangan and secondary forest site, was smaller than the territory sizes reported at tangantangan (0.64 ± 0.08 ha (n = 9)) and secondary forest (0.51 ± 0.06 ha (n = 8)) sites sampled in 1995. However, it fell within the range of territory sizes (0.35-0.58 ha) recorded at two tangantangan and two secondary forest territory mapping plots sampled in August 2008 (USFWS 2009).

Comparison with densities derived from point-transect surveys indicate much higher densities in the small-scale plots (Camp et al. 2012, U.S. Navy 2014). For example, Camp et al. (2012) reported densities of 6.5, 5.5, and 4.0 birds per hectare in limestone forest, secondary forest, and tangantangan habitats. These differences are likely due to the areas sampled using each method.

The small-scale plots were limited to three areas of generally contiguous habitat while the point-transect stations generally sample a mosaic of habitats. Sampling small-scale plots over a wider range of areas on Tinian would likely show a broader range of potential densities.

The differences in territory sizes and monarch densities among native dominated, secondary forest, and tangantangan sites may be related to plant diversity. Habitat sampling along bird survey transects on Tinian by Vogt (2009) showed a positive correlation between Tinian monarch detections and tree diversity and native forest sites generally have greater plant diversity than secondary forest and tangantangan sites (Fosberg 1960, Perry and Morton 1999). Higher plant diversity may increase the number of potential foraging and nesting sites available and may have an impact on prey availability. However, further work is needed to confirm this.

As noted in the Results, an unexpected outcome of the monitoring was the observation and identification of avian pox in Tinian Monarchs. Avian pox virus is found worldwide and has been reported in domestic fowl on Guam (Savidge et al. 1992). To our knowledge, however, it has not been reported previously in wild birds in the Mariana Islands. Avian pox is fairly common in Hawaii and is thought to be one of the main threats to many Hawaiian forest birds (Atkinson et al. 2005, VanderWerf et al. 2006, van Riper et al. 2002). Pox has also been recently identified in the Galapagos Islands (Thiel et al. 2005) where it may have been introduced in the 1890s (Parker et al. 2011). Immunity to pox varies substantially among bird species, and many continental species are not seriously affected by the virus. The degree of immunity to pox in birds from the Mariana Islands is unknown. However, we only observed pox-like lesions in monarchs and not in any of the other species captured during the study. Our results also showed a decline in prevalence from a high of 38% in 2006 to 0% and 3% in 2008 and 2009, respectively, indicating we observed the tail end of an epizootic or that it may occur in cycles.

Recommendations

Based on the annual monitoring and this summary assessment we have three sets of recommendations:

1. *Continue Long-term Monitoring* – Tracking changes in Tinian Monarch populations and their habitats is important for ensuring that changes in the population are identified and adequately addressed prior to implementing legal changes to the status of the species. Several monitoring methods were identified in the PDMP, the following three methods are recommended for longer-term monitoring.
    a. *Continue to conduct roadside surveys quarterly* – Historically, the roadside surveys were not consistently implemented due to lack of personnel and other factors. If possible, these surveys should be conducted quarterly with trained personnel to allow for tracking changes in Tinian Monarch detections. An analysis of the full survey dataset should additionally be conducted similar to the work by Ha et al. (2018) for the roadside surveys on Saipan.
    b. *Repeat island-wide surveys at 5-year intervals* – Surveys were conducted in 2008 and 2013. The 2008 survey indicated that Tinian Monarch densities had declined both temporally and spatially (Camp et al. 2012) while the 2013 survey indicated the population had returned to levels similar to the surveys prior to 2008 (U.S. Navy 2014). As the Tinian Monarch population appears to fluctuate it's

recommended that island-wide surveys be conducted at 5-yr intervals for 20 years to better track the population.

c. *Continue land clearing permit monitoring and monitor long-term (~ 10 years) landcover changes using satellite imagery* – Tracking annual land clearing permits and mapping landcover changes using satellite imagery was found to be a useful tool for assessing changes in Tinian Monarch habitats. Though these methods showed little change in the land-use and land-cover on Tinian during the monitoring period, they will be important for tracking changes associated with future projects. For example, several development projects have been proposed and implemented on Tinian since the monitoring period completed in 2011. In 2015 the Department of Defense released a draft environmental impact statement for a CNMI Joint Military Training (CJMT) project. This project proposed to establish a series of live-fire and maneuver ranges and training areas on military leased lands on Tinian, including in or near the Airport Mitigation study plot (U.S. Navy 2015). Areas have been cleared since 2014 for the West San Jose Homestead project and since 2016 for the Altercity Resort (formerly the Plumeria Resort) project, both near the Seaport Tangantangan study plot (U.S. Navy 2015, Willsey in litt. 2016). A Water Transfer Station project was also begun in 2017 in the non-leased area of the island (U.S. Navy 2015).

   Data on land clearing permits should continue to be collected and evaluated regularly to identify spatial trends in development and their relationship to Tinian Monarch habitats. Large-scale land-cover changes should also be evaluated at approximately 10-year intervals using satellite imagery. The NOAA Coastal Change Analysis Program (CCAP) regularly maps landcover in the Mariana Islands, which can be used to track landcover changes spatially. These data can then be tied into roadside and island-wide survey results to evaluate spatial trends in Tinian Monarch populations.

2. *Develop island-wide Tinian Monarch conservation strategy* – Areas needed to ensure the long-term survival of the Tinian Monarch on Tinian have not been identified and, currently, only the Federal Aviation Administration Mitigation Area had been set aside for Tinian Monarch conservation, though even this area is being proposed for clearing as part of a live range (see U.S. Navy 2015). Habitat loss was the main threat that lead to the original listing of this species (USFWS 2004). Evidence from this study and previous research (USFWS 1996) suggests that densities of Tinian Monarchs are highest in native limestone forest. Protecting the remaining forest and restoring other areas may increase the distribution and density of the Tinian Monarch in areas currently not used or with low numbers of birds.

   An island-wide conservation plan would be a helpful tool to identify these areas and help ensure that they be considered in development projects planned for the island. This strategy should be developed in conjunction will all relevant partners (e.g., Tinian Mayor, Tinian DLNR, CNMI DLNR, and U.S. Navy) and should consider Tinian Monarchs throughout the island.

3. *Conduct additional research* – Information about the biology and conservation of the Tinian Monarch is largely limited to data collected in this and the mid-90s study. Currently, there is still not much known about the Tinian Monarch's population dynamics and threats. The following two areas need additional research:

   a. *Population Biology* – Demographic based Population Viability Assessments (PVAs) are important tools for conservation planning and the Tinian Monarch conservation strategy identified earlier would benefit from this type of assessment. However, data on the population biology of the Tinian Monarch are still needed before these assessments can be developed. For example, overall annual survival rates for adults have been estimated, juvenile survival has not been estimated and adult survival rates have not been estimated by habitat or sex. Some data on nesting success were collected during the mid-1990s. However, nesting success data for all habitats is not available. A demographic study, like the Tropical Monitoring Avian Productivity and Survivorship (TMAPS) project on Saipan (Saracco et al. 2014), that collects these data in all forested habitats is needed.

   b. *Avian Pox* – Though this study identified that avian pox occurs in the Tinian Monarch population, its prevalence and impact on the species is unknown. Research on avian poxvirus and Tinian Monarchs is needed to address its potential impact on the species. This study could be conducted in conjunction with the Population Biology study identified previously.

      Avian poxvirus is transmitted primarily by mosquitoes in Hawaii (van Riper et al. 2002, VanderWerf et al. 2006), but it can also be transmitted by physical contact with another bird or an infected surface, such as a branch or nest (Tripathy 1993). In order to prevent potential spread of disease among birds captured during field work we recommend that all equipment be sterilized with a 10% bleach solution after any bird with lesions is captured, including banding pliers, wing ruler, calipers, bird holding bags, and researcher's hands. We also believe it would be useful to sample mosquito populations in different areas of the island to determine where the disease may be coming from. If mosquito breeding sites are located the mosquitoes should be eradicated by removing the sites or by treatment with mosquito larvicides.

Acknowledgements

For permission to conduct this work, advice on logistics, and valuable discussion, we thank Sylvan Igisomar, Laura Williams, Ton Castro, Shelly Kremer, Nate Hawley, Alvin Mosqa, Henry Cabrera, Tony Borja (retired), and Henry King (retired) of the CNMI Division of Fish and Wildlife (DFW), Dr. Ignacio Dela Cruz (retired), Joe Lizama, and Sam Palacios of the CNMI Department of Lands and Natural Resources, Mayor Jose San Nicolas of Tinian, Ike Quichocho and Dr. Tom Arkle of the Mayor's Office, and Anne Brooke and Scott Vogt of the U.S. Navy. We would also like to thank Marilet Zablan of the U.S. Fish and Wildlife Service and Laura Williams of CNMI DFW for their assistance during the annual monitoring.

References

Arnold, T.W. 2010. Uninformative parameters and model selection using Akaike's Information Criterion. Journal of Fish and Wildlife Management 74:1175-1178.

Atkinson, C.T, J.K. Lease, R.J. Dusek, and M.D. Samuel. 2005. Prevalence of pox-like lesions and malaria in forest bird communities on leeward Mauna Loa volcano, Hawaii. Condor 107:537-546.

Baker, R.H. 1946. Some effects of the war on the wildlife of Micronesia. Transactions of the Eleventh North American Wildlife Conference, 1946. American Wildlife Institute, Investment Building, Washington, D.C.

Baker, R.H. 1951. The avifauna of Micronesia, its origin, evolution, and distribution. University of Kansas Publications, Museum of Natural History 3:1-359.

Bates, D., M. Maechler, B. Bolker, and S. Walker. 2015. Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48. doi:10.18637/jss.v067.i01.

Bibby, C.J., N.D. Burgess, and D.A. Hill. 2000. Bird census techniques. Academic Press, London, U.K.

Blanvillain, C., J.M. Salducci, G. Tutururai, and M. Maeura. 2003. Impact of introduced birds on the Impact of introduced birds on the recovery of the Tahiti Flycatcher (*Pomarea nigra*), a critically endangered forest bird of Tahiti. Biological Conservation 109:197-205.

Brooks, M.E., K. Kristensen, K.J. van Benthem, A. Magnusson, C.W. Berg, A. Nielsen, H.J. Skaug, M. Maechler and B.M. Bolker. 2017. glmmTMB Balances Speed and Flexibility Among Packages for Zero-inflated Generalized Linear Mixed Modeling. The R Journal, 9(2), 378-400.

Burnham, K.P. and D.R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer, New York, New York, USA.

Camp, R.J., F.A. Amidon, A.P. Marshall, and T.K. Pratt. 2012. Bird populations on the island of Tinian: Persistence despite wholesale loss of native forests. Pacific Science 66:283-298.

Conry, P.J. 1988. High nest predation by brown tree snakes on Guam. Condor 90:478-482.

Dawson, D.A., P. Brekke, N.D. Remedios, and G.J. Horsburgh. 2015. A marker suitable for sex-typing birds from degraded samples. Conservation Genetics Resources 7:337–343.

Downs, T. 1946. Birds on Tinian in the Marianas. Transactions of the Kansas Academy of Science 49:87-106.

Engbring, J., F. Ramsey, and V.J. Wildman. 1986. Micronesian Forest Bird Survey, 1982: Saipan, Tinian, Agiguan, and Rota. U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Fosberg, F.R. 1960. The vegetation of Micronesia. Bulletin of the American Museum of Natural History 119:1-75.

Fridolfsson, A.K, and Ellegren, H. 1999. A simple and universal method for molecular sexing of non-ratite birds. Journal of Avian Biology 30:116–121.

Gleize, D.A. 1945. Field Notes. Birds of Tinian. Bulletin of the Massachusetts Audubon Society 29:220.

Greenberg, R., and J. Gradwohl. 1986. Constant density and stable territoriality in some tropical insectivorous birds. Oecologia 69:618-625.

Ha, J., J.B. Cruz, S. Kremer, V.A. Camacho, and P. Radley. 2018. Trends in avian roadside surveys over a 20-year period on Saipan, Commonwealth of the Northern Mariana Islands. Pacific Science 72:81-93.

Hartig, F. 2020. DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models. R package version 0.2.7. https://CRAN.R-project.org/package=DHARMa

Hawley, N. 2002. CNMI-DFW Brown Tree Snake (BTS) Interdiction Program Report, July 2002.

Kuhn, M. 2020. caret: Classification and Regression Training. R package version 6.0-85. https://CRAN.R-project.org/package=caret

Laake, J.L., D.S. Johnson, and P.B. Conn. 2013. marked: An R package for maximum-likelihood and MCMC analysis of capture-recapture data. Methods Ecological Evolution 4:885-890.

Liu, Z. and L. Fisher. 2006. Commonwealth of the Northern Mariana Islands vegetation mapping using very high spatial resolution imagery: Methodology. USDA Forest Service, Pacific Southwest Region, Forest Health Protection. McClellan, CA.

Lusk, M., S. Hess, M. Reynolds, and S. Johnston. 2000. Population status of the Tinian Monarch (*Monarcha takatsukasae*) on Tinian, Commonwealth of the Northern Mariana Islands. Micronesica 32:181-190.

Marshall, J.T., Jr. 1949. The endemic avifauna of Saipan, Tinian, Guam, and Palau. Condor 51: 200-221.

McDonald, T. 2018. mra: Mark-Recapture Analysis. R package version 2.16.11. https://CRAN.R-project.org/package=mra

Morton, E.S., K.C. Derrickson, and B.J.M. Stutchbury. 2000. Territory switching behavior in a sedentary tropical passerine, the dusky antbird (*Cercomacra tyrannina*). Behavioral Ecology 11:648-653.

Ontiveros, V.J., JA. Capitan, R. Arthur, E.O. Casamayor, and D. Alonso. 2019. Colonization and Extinction Rates estimated from Temporal Dynamics of Ecological Communities: The island R Package. Methods in Ecology and Evolution, https://doi.org/10.1111/2041-210X.13176

Parker, P.G., E.L. Buckles, H. Farrington, K. Petren, N.K. Whiteman, R.E. Ricklefs, J.L. Bollmer, and G. Jimenez-Uzcategui. 2011.110 years of *Avipoxvirus* in the Galapagos Islands. PLoS ONE 6(1): e15989. https://doi.org/10.1371/journal.pone.0015989

Perry, G., and J. M. Morton. 1999. Regeneration rates of the woody vegetation of Guam's Northwest Field following major disturbance: land use patterns, feral ungulates, and cascading effects of the brown treesnake. Micronesica 31:125-142.

Peters, D.S. 1996. *Monarcha takatsukasae* (Yamashina 1931) - ein Nachweis von Saipan (Aves: Monarchidae). Senckenbergiana Biologica 76: 15-17.

R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Robertson, H.A., J.R. Hay, and E.K. Saul. 1994. Recovery of the Kakerori: an endangered forest bird of the Cook Islands. Conservation Biology 8:1078-1086.

Rodda, G.H. and J.A. Savidge. 2007. Biology and impacts of Pacific island invasive species. 2. *Boiga irregularis*, the brown treesnake (Reptilia: Colubridae). Pacific Science 61: 307-324.

Rodda, G.H., T.H. Fritts, M.J. McCoid, and E.W. Campbell. 1999. An overview of the biology of the brown treesnake (), a costly introduced pest on Pacific islands. Pp. 44-80 *in* Problem Snake Management: the Habu and the Brown Treesnake (G. H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka, eds.). Cornell University Press, Ithaca, New York.

Saracco, J.F., P. Radley, P. Pyle, E. Rowan, and R. Taylor. 2014. Vital Rates of Landbirds on Saipan and Links to Remote-sensed Habitat Data: A Summary of Five Years (2008-2012) of the Tropical Monitoring Avian Productivity and Survivorship (TMAPS) program on Saipan, Northern Marianas Islands. Technical Report, the Institute for Bird Populations, Point Reyes Station, California.

Savidge, J.A. 1987. Extinction of an island forest avifauna by an introduced snake. Ecology 68: 660-668.

Savidge, J.A., L. Sileo, and L.M. Siegfried. 1992. Was disease involved in the decimation of Guam's avifauna? Journal of Wildlife Diseases 28:206-214.

Takatsukasa, S. and Y. Yamashina. 1931. Some new birds from Palau and Mariana Islands. Dobutsu. Zasshi 43: 484-487.

Thiel, T., N.K. Whiteman, A. Tirapé, M.I. Baquero, V. Cedeño, T. Walsh, G.J. Uzcátegui, and P.G. Parker. 2005. Characterization of canarypox-like viruses infecting endemic birds in the Galápagos islands. Journal of Wildlife Diseases 41:342-353.

Tripathy, D.N. 1993. Avipox viruses. Pp. 5-15 in Virus infections of Birds (J. B. McFerran and M. S. McNulty, Eds.). Elsevier, New York.

U.S. Fish and Wildlife Service [USFWS]. 1970. Conservation of endangered species and other fish or wildlife. Federal Register 35(106):8491-8498.

U.S. Fish and Wildlife Service [USFWS]. 1987. Reclassification of the Tinian Monarch from endangered to threatened status, final rule. Federal Register 52(65):10890-10892.

U.S. Fish and Wildlife Service [USFWS]. 1996. Wildlife research report for Navy-leased lands on the island of Tinian, CNMI. Prepared for Department of the Navy, PACNAVFACENGCOM, Pearl Harbor, Hawaii.

U.S. Fish and Wildlife Service [USFWS]. 2004. Final rule to remove the Tinian monarch from the federal list of endangered and threatened wildlife. Federal Register 69(182):56367-56373.

U.S. Fish and Wildlife Service [USFWS]. 2005. Final post-delisting Monitoring Plan for the Tinian monarch. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, Hawaii.

U.S. Fish and Wildlife Service [USFWS]. 2009. Terrestrial Resource Surveys of Tinian and Aguiguan, Mariana Islands. U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, Honolulu, HI.

U.S. Navy. 2014. Terrestrial biological surveys on Tinian in support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact

Statement/Overseas Environmental Impact Statement. Department of the Navy, Naval Facilities Engineering Command, Pacific. Hawaii.

U.S. Navy. 2015. Commonwealth of the Northern Mariana Islands Joint Military Training (CJMT) Draft Environmental Impact Statement/Overseas Environmental Impact Statement. Department of the Navy, Naval Facilities Engineering Command, Pacific. Hawaii.

VanderWerf, E.A. 2008. Sources of variation in survival, recruitment, and natal dispersal of the Hawai`i `Elepaio. Condor 110:241-250.

VanderWerf, E. A. 2009. Importance of nest predation by alien rodents and avian poxvirus in conservation of Oahu elepaio. Journal of Wildlife Management 73:737-746.

VanderWerf, E.A., M.D. Burt, J.L. Rohrer, and S.M. Mosher. 2006. Distribution and prevalence of mosquito-borne diseases in O`ahu `Elepaio. Condor 108:770-777.

van Riper, C., III, S.G. van Riper, M.L. Goff, and W.R. Hansen. 2002. Epizootiology and effect of avian pox on Hawaiian forest birds. Auk 119:929-942.

Venables, W.N., and B.D. Ripley. 2002. Modern Applied Statistics with S. Fourth Edition. Springer, New York. ISBN 0-387-95457-0.

Willsey, T. 2016. Personal communication. Email between USFWS PIFWO biologist, Tyler Willisey, and USFWS PIFWO biologist, Mike Richardson, regarding the status of Altercity Resort clearing on Tinian, October 6, 2016.

Woltmann, S., and T.W. Sherry. 2011. High apparent survival and stable territory dynamics of Chestnut-backed Antbird (*Myrmeciza exsul*) in a large Costa Rican rain forest preserve. Wilson Journal of Ornithology 123:15-23.

Appendices

Appendix A - Banding records of Tinian Monarchs caught between 2006 and 2010.
Appendix B – Re-sight records of Tinian Monarchs banded between 2006 and 2010.
Appendix C - Study plot and Tinian Monarch territory mapping figures from the 2007-2010 annual monitoring report

Appendix A: Banding records of Tinian Monarchs caught between 2006 and 2010 during post-delisting monitoring work for the Tinian Monarch. Color codes: AL = Aluminum; BL = Blue; RD = Red; GR = Green; PK = Pink; BK = Black; WH = White. Age codes: AHY = After hatch year: HY = Hatch year: L = Local (not fledged). Sex codes: FB = Female with Brood Patch, FG = Female based on Genetics, FM = Female based on Mate, MG = Male based on Genetics, MM = Male based on Mate, U = Unknown. Pox codes: H = Healthy; A = Active; I = Inactive or healed.

Year	Month	Day	Location	Net	Capture	Prefix	Suffix	Leftleg	Rightleg	Age	Sex	Molt	Wing	Tail	Bill Length	Tarsus long	Tarsus short	Wt bird	Pox status
2006	4	14	Santa Lourdes	1	I	2460	701	AL/BL	BL/RD	AHY	U	Y	71.5	71	15.6	23.9	23	13.4	I
2006	4	14	Santa Lourdes	2	I	2460	702	AL/RD	GR/BL	AHY		N	70	69	15	22.5	22.3	11.3	A
2006	4	14	Santa Lourdes	2	I	2460	703	AL/GR	RD/RD	AHY	FB	N	67.5	68	14	22.3		10.6	I
2006	4	14	Santa Lourdes	1	I	2460	705	AL/PK	GR/GR	AHY	U	N	66	66	14.2	22.4		10.4	A
2006	4	14	Santa Lourdes	2	R	2460	703	AL/GR	RD/RD										
2006	4	14	Santa Lourdes	4	I	2460	706	BL/AL	PK/PK	AHY	U	Y	68	68	14.9	23.2		12.6	H
2006	4	15	Santa Lourdes	3	I	2460	709	GR/AL	RD/BL	AHY	U	Y	70.5	70	15	21.9		11.7	H
2006	4	15	Santa Lourdes	5	I	2460	710	RD/PK	AL/GR	AHY	MM	Y	70	69	15.2	23.6		11.8	A
2006	4	15	Santa Lourdes	5	I	2460	711	BL/GR	AL/PK	AHY	FB	Y	65.5	67.5	14.5	22.7		11.9	A
2006	4	15	Santa Lourdes	1	R	2460	701	AL/BL	BL/RD										
2006	4	15	Santa Lourdes	1	I	2460	714	GR/BL	AL/RD	HY	U	N	66.5	69.5	15.1	23		12.3	A
2006	4	16	Airport Mitigation	2	I	2460	716	GR/RD	AL/GR	AHY	U	N	72	72	14.9	23.2		11.7	I
2006	4	16	Airport Mitigation	2	I	2460	717	PK/GR	AL/BL	AHY	FB	N	67	67	14.9	22.7		13.5	H
2006	4	16	Airport Mitigation	1	I	2460	718	BL/RD	AL/PK	AHY	U	N	72	69.5	15.8	24		12.6	I
2006	4	16	Airport Mitigation	3	I	2460	719	GR/RD	AL/BL	AHY	U	N	70	64.5	15.5	22.6		11.9	H
2006	4	16	Airport Mitigation	1	I	2460	723	BL/AL	BK/RD	AHY	U	Y	69	66.5	15.1	23		12.9	H
2006	4	16	Airport Mitigation	5	I	2460	725	AL/GR	BL/GR	AHY	U	N	71.5	71	15.7	24.4		13	H
2006	4	16	Airport Mitigation	5	I	2460	726	AL/BK	GR/RD	HY	U	N	63.5	65.5	15	23.6		11.6	H
2006	4	16	Airport Mitigation	6	I	2460	727	AL/BL	PK/BL	AHY	U	Y	69.5	69	15	22.6		13.5	H
2006	4	17	Airport Mitigation	6	I	2460	732	RD/AL	PK/GR	AHY	U	N	65	64.5	14.6	23		11.1	H
2006	4	17	Airport Mitigation	8	I	2460	733	PK/AL	BL/BK	AHY	MM	Y	71	70	15.5	23.5		12.6	A
2006	4	17	Airport Mitigation	7	I	2460	734	GR/BK	AL/PK	AHY	FG	Y	68	67.5	14.9	23.5		12.2	H
2006	4	17	Airport Mitigation	7	I	2460	735	AL/RD	BL/RD	AHY	U	N	68.5	70	15.2	22.2		12.1	H
2006	4	17	Airport Mitigation	6	I	2460	736	BL/GR	AL/BK	AHY	U	Y	65.5		14.7	23.4		12.8	H
2006	4	17	Airport Mitigation	4A	I	2460	737	BK/AL	GR/PK	AHY	MM	N	69.5	67.5	15	23.3		13	I
2006	4	17	Airport Mitigation	4B	I	2460	738	GR/PK	PK/AL	AHY	U	N	66.5	69	15.3	22.3		11.9	A

Year	Month	Day	Location	Net	Capture	Prefix	Suffix	Leftleg	Rightleg	Age	Sex	Molt	Wing	Tail	Bill Length	Tarsus long	Tarsus short	Wt bird	Pox status
2006	4	17	Airport Mitigation	4B	I	2460	739	GR/RD	BL/AL	AHY	U	Y	70.5	69.5	15.6	22.7		12.6	A
2006	4	18	Santa Lourdes	6	I	2460	742	GR/PK	RD/AL	AHY	U	N	70	68	15.5	23.2		11.4	A
2006	4	18	Santa Lourdes	6	I	2460	746	RD/GR	AL/RD	AHY	U	Y	70.5	68.5	14.9	23		12.3	I
2006	4	18	Santa Lourdes	8	I	2460	747	AL/PK	BL/GR	AHY	U	Y	71	70	15.3	23.5		12.9	I
2006	4	18	Santa Lourdes	3	I	2460	748	GR/AL	BL/RD	AHY	U	Y	67.5	67.5	14.9	22.9		13.1	H
2006	4	18	Santa Lourdes	9	I	2460	749	BL/GR	BL/AL	AHY	U	Y	66.5	67	13.5	22.3		11.4	H
2006	4	18	Santa Lourdes	8	I	2460	750	BK/AL	PK/PK	AHY	U	Y	65	65	13.9	22.8		11.9	A
2006	4	19	Airport Mitigation	10	R	2460	726	AL/BK	GR/RD	HY									
2006	4	19	Airport Mitigation	9	I	2460	753	PK/BL	PK/AL	AHY	U	Y	72	72	15.1	23.8		13.3	A
2006	4	19	Airport Mitigation	10	I	2460	755	AL/RD	RD/GR	AHY	MM	Y	68	68		23.5		12.5	A
2006	4	19	Airport Mitigation	10	I	2460	760	AL/GR	GR/RD	AHY	U	Y	69.5	71.5	15.3	24.1		12.2	A
2006	4	19	Airport Mitigation	10	I	2460	761	AL/BK	RD/BL	AHY	FB	N	66	67.5	14.3	22.9		11.4	H
2006	4	19	Airport Mitigation	11	I	2460	762	GR/AL	BK/PK	AHY	MG	Y	71.5	70	15	22.5		9.9	A
2006	4	19	Airport Mitigation	10	R	2460	755	AL/RD	RD/GR										
2006	4	19	Airport Mitigation	10	I	2460	763	RD/RD	AL/BL	AHY	FB	Y	66.5	69	14.3	23.5		11.4	A
2006	4	21	Santa Lourdes	11	I	2460	765	AL/BL	GR/BL	AHY	U	Y	65.5	65.5	14	22.2		12.5	H
2007	3	8	Santa Lourdes	2	I	2460	769	BL/BL	GR/AL	AHY	FB	N	66	66	13.3	22.8	22.3	11	A
2007	3	8	Santa Lourdes	2	R	2460	702	AL/RD	GR/BL	AHY		N	69.5	71.5	14.4	22.3	21.8	11.5	I
2007	3	8	Santa Lourdes	3	I	2460	770	BK/RD	BL/AL	AHY	U	N	68.5	68	14.1	23.5	23.1	11.5	H
2007	3	9	Airport Mitigation	5	I	2460	776	AL/PK	WH/RD	AHY	U	N	68	68	14.3	22.9	22.4	12.3	H
2007	3	9	Airport Mitigation	3	I	2460	774	AL/WH	RD/RD	AHY	FB	N	65	66.5	14.5	22.6	22.1	11.6	H
2007	3	9	Airport Mitigation	5	R	2460	725	AL/GR	BL/GR	AHY		N	72	70.5	15.5	25	24.8	13	H
2007	3	9	Airport Mitigation	1	I	2460	772	AL/PK	WH/WH	AHY	U	N	73.5	73	15.1	23.7	23.1	13	H
2007	3	9	Airport Mitigation	3	R	2460	737	BK/AL	GR/PK	AHY		Y	70.5	69	15.1	23.4	23.3	12	I
2007	3	9	Airport Mitigation	1	R	2460	772	AL/PK	WH/WH	AHY									
2007	3	9	Airport Mitigation	1	R	2460	772	AL/PK	WH/WH	AHY									
2007	3	10	Santa Lourdes	1c	R	2460	705	AL/PK	GR/GR	AHY		N	66.5	66	14.9	23.4	23.1	10.9	I
2007	3	10	Santa Lourdes	4b	I	2460	782	AL/BL	WH/GR	HY	U	N	64	67	14.4	23	22.4	11.8	H
2007	3	11	Airport Mitigation	10	I	2460	785	GR/WH	RD/AL	AHY	U	Y	68.5	69.5	15.4	23.1	22.4	12.7	H
2007	3	12	Santa Lourdes	5	R	2460	710	RD/PK	AL/GR	AHY		Y	68.5	70.5	13.9	24.4	23.9	11.1	A
2007	3	12	Santa Lourdes	9	I	2460	789	AL/GR	PK/GR	HY	U	N	65	67	14.6	22.4	21.7	11.4	H
2007	3	12	Santa Lourdes	7	R	2460	710	RD/PK	AL/GR	AHY									

Year	Month	Day	Location	Net	Capture	Prefix	Suffix	Leftleg	Rightleg	Age	Sex	Molt	Wing	Tail	Bill Length	Tarsus long	Tarsus short	Wt bird	Pox status
2007	3	13	Airport Mitigation	7B	I	2460	792	RD/RD	BL/AL	AHY	FB	N	65.5	69	13.9	22.1	21.6	11.6	H
2007	3	13	Airport Mitigation	6	R	2460	727	AL/BL	PK/BL	AHY		N	69	70.5	15	22.5	22.1	12.2	I
2007	3	13	Airport Mitigation	8	R	2460	760	AL/GR	GR/RD	AHY		N	70.5	72	15	26.8	24.7	12.7	I
2007	3	14	Santa Lourdes	10B	I	2460	903	WH/GR	AL/GR	AHY	FB	N	66.5	64.5	14.3	22.4	21.7	10	A
2007	3	14	Santa Lourdes	11	I	2460	799	AL/BL	RD/WH	AHY	U	N	63	66	13.2	22.7	21.9	10.6	H
2007	3	14	Santa Lourdes	11	I	2460	797	AL/RD	GR/WH	AHY	U	N	67	68	14.4	21.7	21.1	11.3	H
2007	3	14	Santa Lourdes	10B	I	2460	905	RD/BL	AL/BL	AHY	MM	N	68.5	67	14.5	22.8	22.1	11	H
2007	3	14	Santa Lourdes	12	I	2460	902	BK/WH	PK/AL	AHY	U	N	69.5	68	14.1	22.6	22	12.4	I
2007	3	14	Santa Lourdes	13	I	2460	904	AL/RD	BK/GR	AHY	U	N	66	67.5	14.6	22.7	21.8	9.4	H
2007	3	14	Santa Lourdes	NEST	I	2460	907	BK/BL	AL/WH	L	U								H
2007	3	14	Santa Lourdes	NEST	I	2460	906	PK/BK	AL/PK	L	U								H
2007	3	15	Airport Mitigation	1A	I	2460	912	GR/AL	GR/BL	AHY	U	N	65	65	13.7	23	22	11.5	H
2007	3	15	Airport Mitigation	12	I	2460	909	RD/BK	PK/AL	AHY	FB	N	65.5	63	14.9	22.7	21.3	11	H
2007	3	15	Airport Mitigation	12	I	2460	911	BL/RD	GR/AL	AHY	MM	N	71	63	15.3	25.6	23.4	11.9	H
2007	3	15	Airport Mitigation	1A	I	2460	908	RD/AL	RD/BL	AHY	U	N	69.5	67	14.7	23.8	22.6	11	H
2007	3	15	Airport Mitigation	NEST	I	2460	915	BK/WH	AL/WH	L	U								H
2007	3	15	Airport Mitigation	NEST	I	2460	914	PK/BK	AL/BK	L	U								H
2007	3	15	Airport Mitigation	1A	R	2460	908	RD/AL	RD/BL	AHY									
2007	3	16	Seaport TT	3	I	2460	918	GR/BL	AL/BK	AHY	FM	N	65	67	13.5	22.4	21.9	11.1	H
2007	3	16	Seaport TT	1	I	2460	916	AL/BL	WH/RD	AHY	MM	N	68.5	69	14.6	23.1	22.8	11.9	A
2007	3	16	Seaport TT	2	I	2460	917	AL/WH	BL/GR	AHY	U	N	70.5	70.5	14.9	23.2	22.8	12.8	H
2007	3	16	Seaport TT	3	I	2460	919	WH/BL	AL/PK	AHY	MM	N	71	67	13.6	23.6	22.2	11.5	H
2007	3	17	Seaport TT	5B	I	2460	923	AL/RD	RD/BL	AHY	U	N	65	64	14.9	22.3	21.1	11	H
2008	2	27	Santa Lourdes	1b	I	2460	924	AL/BL	GR/BK	AHY	U	N	65	63.5	13.1	20.8	19.8	11	H
2008	2	27	Santa Lourdes	1b	R	2460	746	RD/GR	AL/RD	AHY		N	70	68	13.9	23.6	22.8	11.5	H
2008	2	27	Santa Lourdes	6	I	2460	927	AL/PK	PK/WH		U		64		Escape				
2008	2	28	Santa Lourdes	1d	R	2460	746	RD/GR	AL/RD	AHY									I
2008	2	29	Santa Lourdes	3d	I	2460	940	AL/PK	GR/RD	AHY	FB	Y	69	64	12.8	24.4	22.5	12.5	H
2008	2	29	Santa Lourdes	4f	I	2460	942	BK/PK	RD/AL	AHY	U	N	66	62	14.2	22.6	21.4	12	H
2008	2	29	Santa Lourdes	4f	I	2460	943	AL/BL	RD/PK	AHY	U	N	64	63	13.6	24.5	23	11	H
2008	2	29	Santa Lourdes	10c	I	2460	945	RD/WH	PK/AL	HY	U	N	65	64	14.8	23.1	22.2	12.5	H
2008	3	1	Airport Mitigation	3	R	2460	774	AL/WH	RD/RD	AHY		N	65	78.5	12.9	24	23.4	13.5	H

Year	Month	Day	Location	Net	Capture	Prefix	Suffix	Leftleg	Rightleg	Age	Sex	Molt	Wing	Tail	Bill Length	Tarsus long	Tarsus short	Wt bird	Pox status
2008	3	2	Airport Mitigation	5	R	2460	719	GR/RD	AL/BL	AHY		N	69	65	15.7	22.3	21.1	11.5	H
2008	3	2	Airport Mitigation	2	R	2460	772	AL/PK	WH/WH	AHY		Y	74	72	15.2	23.6	23	13	H
2008	3	2	Airport Mitigation	6	R	2460	739	GR/RD	BL/AL	AHY		Y	71	70	14.5	22.2	21.5	13.5	H
2008	3	2	Airport Mitigation	6	I	2460	950	PK/WH	BL/AL	HY	U	N	66.5	67	13.1	24.6	23.6	12.5	H
2008	3	2	Airport Mitigation	1	I	2460	951	AL/GR	PK/WH	AHY	U	N	69.5	65	14.1	23.9	22.3	13.5	H
2008	3	2	Airport Mitigation	1	I	2460	952	AL/WH	PK/BL	AHY	U	Y	67.5	67	13.9	23.9	23.2	12.5	H
2008	3	2	Airport Mitigation	5	I	2460	953	AL/WH	BK/WH	AHY	U	Y	69	66	14.6	23.5	22.9	13.5	H
2008	3	2	Airport Mitigation	9	I	2460	954	GR/AL	RD/PK	AHY	U	N	69	68	14.6	22.7	21.6	11.5	H
2008	3	2	Airport Mitigation	1B	R	2460	717	PK/GR	AL/BL	AHY		Y	68	67	14.6	22.4	21.7	10	H
2008	3	3	Airport Mitigation	8A	I	2460	964	AL/RD	BK/WH	AHY	MG	N	69	66	15.2	23.7	22.4	12	I
2008	3	3	Airport Mitigation	12	R	2460	733	PK/AL	BL/BK	AHY		N	69.5	69	13.7	25.8	24.8	11	H
2008	3	3	Airport Mitigation	11	R	2460	733	PK/AL	BL/BK	AHY									
2008	3	4	Airport Mitigation	5a	R	2460	719	GR/RD	AL/BL	AHY		N	71	68	15.5	22.3	21.6	12.5	H
2008	3	6	Seaport TT	1	I	2460	967	AL/PK	BL/PK	AHY	U	N	67	64	14	23	22.3	12.5	H
2008	3	6	Seaport TT	6	I	2460	972	AL/WH	RD/BK	HY	U	N	62	62	12.6	22.9	21.7	11.5	H
2008	3	6	Seaport TT	3a	I	2460	974	BL/AL	BL/PK	AHY	U	N	64	63	15.7	23.2	22.1	12	H
2008	3	6	Seaport TT	3a	I	2460	975	RD/AL	BL/WH	HY	U	N	68.5	69	14.6	23	22.2	11.5	H
2008	3	6	Seaport TT	1a	I	2460	976	WH/AL	BK/BL	AHY	U	N	66	64	13.7	23.2	22.6	12	H
2008	3	6	Seaport TT	7	I	2460	977	AL/WH	WH/PK	AHY	U	N	68	67	15.4	23.1	22.4	12.5	H
2008	3	7	Seaport TT	4	I	2460	978	AL/BK	BK/PK	AHY	FB	N	65	63	15.1	24.8	23.7	10	H
2008	3	7	Seaport TT	5	I	2460	980	BL/AL	BK/WH	AHY	MM	N	71	67	13.8	23.5	22.6	12	H
2008	3	7	Seaport TT	5	I	2460	979	AL/WH	PK/WH	AHY	FB	N	64.5	63	14.3	23.5	22.2	11.5	H
2008	3	8	Seaport TT	8	I	2460	981	WH/PK	AL/BK	AHY	U	N	66	64	15.1	23.3	22.5	12	H
2008	3	9	Seaport TT	9	I	2460	997	WH/BL	AL/WH	AHY	U	N	70	69	14.9	23.6	22.9	12	H
2009	3	11	Santa Lourdes	15	I	2460	803	AL/GR	GR/BL	AHY	FG	N	67.5	66	12.9	23.8	25	11.5	H
2009	3	11	Santa Lourdes	9	I	2460	804	AL/RD	WH/BL	AHY	FG	N	72	70	15	23.8	25	12.5	A
2009	3	12	Santa Lourdes	cross	I	2460	805	RD/AL	GR/BK	AHY	U	N	68	63	14.6	22.2	22.7	10.5	A
2009	3	14	Airport Mitigation	1a	I	2460	809	AL/PK	BK/WH	AHY	FG	N	69	67	14.5	22.7	23.6	12.5	H
2099	3	14	Airport Mitigation	4a	I	2460	811	PK/BK	RD/AL	AHY	FG	N	69	69	14.6	22.8	23.8	13.5	I
2009	3	14	Airport Mitigation	1a	I	2460	812	BK/GR	PK/AL	AHY	MM	N	64.5	61.5	13.7	21.7	22.5	12.5	H
2009	3	14	Airport Mitigation	4a	I	2460	813	BL/AL	WH/GR	AHY	FG	N	66	65	14.7	20.8	22	7	H
2009	3	14	Airport Mitigation	4a	I	2460	814	RD/GR	AL/PK	AHY	MG	N	70.5	67	14	21.9	22.6	12	H

Year	Month	Day	Location	Net	Capture	Prefix	Suffix	Leftleg	Rightleg	Age	Sex	Molt	Wing	Tail	Bill Length	Tarsus long	Tarsus short	Wt bird	Pox status
2009	3	14	Airport Mitigation	1b	I	2460	816	GR/BL	PK/AL	AHY	FG	N	64.5	65	13	22.1	23.2	10.5	H
2009	3	14	Airport Mitigation	3	I	2460	819	GR/AL	GR/RD	AHY	FM	N	65.5	65	11.8	23.4	24.8	11.5	A
2009	3	14	Airport Mitigation	3	I	2460	820	BL/AL	BK/BL	HY	U	Y	66.5	58	12.1	24.3	25.8	13.5	H
2009	3	15	Airport Mitigation	10	I	2460	822	RD/WH	BK/AL	AHY	MG	N	64	64	13.5	22.9	23.5	12.5	H
2009	3	15	Airport Mitigation	10	I	2460	823	WH/GR	RD/AL	AHY	MG	N	68.5	65	15.6	22.8	23.6	13	H
2009	3	15	Airport Mitigation	6	R	2460	727	AL/BL	PK/BL	AHY		N	68	63	14.7	21.1	22.3	12.5	A?
2009	3	15	Airport Mitigation	8b	R	2460	964	AL/RD	BK/WH	AHY		N	69.5	65.5	13	23.8	25	12.5	I?
2009	3	15	Airport Mitigation	12b	I	2460	825	PK/WH	RD/AL	AHY	FG	N	64	66.5	12.9	23.2	24.5	12	H
2009	3	15	Airport Mitigation	11	I	2460	826	BL/AL	BL/WH	AHY	FG	N	68.5	68	15.8	22.9	23.5	13.5	H
2009	3	15	Airport Mitigation	8b	R	2460	734	GR/BK	AL/PK	AHY		N	67	64	15.5	22.8	23.5	12	H
2009	3	17	Seaport TT	4	I	2460	827	AL/GR	BK/BL	AHY	FG	N	68.5	65	13	24.6	25.9	12	H
2009	3	17	Seaport TT	1a	I	2460	834	GR/AL	RD/WH	HY	U	T	67	66	14.1	22.4	23.2	13.5	H
2009	3	17	Seaport TT	4	R	2460	916	AL/BL	WH/RD	AHY		N	68	76	14.2	24.5	25.8	12	H
2009	3	18	Seaport TT-Site 2	10	I	2460	853	BL/AL	GR/PK	AHY	FG	N	65.5	65.5	14.5	21.6	22.5	12	H
2009	3	18	Seaport TT-Site 2	14	I	2460	854	BL/PK	AL/BL	AHY	MG	N	66	67	14.4	21.2	22.7	11	H
2009	3	18	Seaport TT-Site 2	16	I	2460	857	WH/RD	AL/GR	AHY	MG	N	70	67	13.4	22.3	23.2	17	H
2009	3	18	Seaport TT-Site 2	13	I	2460	859	BK/GR	AL/BL	AHY	MG	N	65.5	63	13	22.3	23.5	10.5	H
2009	3	18	Seaport TT-Site 2	12	I	2460	860	PK/BK	AL/GR	AHY	MG	N	68.5	68	12.9	21.9	22.5	12	H
2009	3	18	Seaport TT-Site 2	15	I	2460	861	AL/PK	WH/BL	AHY	MG	N	68	64	13.8	21.6	22.3	11.5	H
2009	3	18	Seaport TT-Site 2	12	I	2460	865	RD/AL	GR/BL	AHY	MG	N	67.5	66	14.1	22.1	23	11.5	H
2009	3	18	Seaport TT-Site 2	15	I	2460	870	BK/BL	AL/PK	AHY	FG	N	70.5	78.5	13.9	23.7	24.8	12	H
2009	3	20	Santa Lourdes	9a?	I	2460	873	AL/GR	BL/WH	AHY	FG	N	68.5	65	14.1	23.4	23.9	12	H
2009	3	20	Santa Lourdes	16	I	2460	875	AL/PK	BK/GR	AHY	MG	N	67	65	14.2	22.6	23.2	9.2	H?
2009	3	22	Seaport TT-Area 2	15a	I	2460	876	BL/AL	RD/BL	AHY	FM	N	65.5	65	14.1	22.3	23.3	13	H
2009	3	22	Seaport TT-Area 2	15b	I	2460	877	BK/AL	RD/PK	AHY	MG	N	64.5	64	13.2	21.1	22.1	10.5	H
2009	3	22	Seaport TT-Area 2	15c	I	2460	878	PK/WH	AL/RD	AHY	FG	N	67.5	65.5	13.4	21.9	22.7	11.5	H
2010	3	11	Seaport TT	T2	I	2460	883	RD/BL	RD/AL	AHY	U	N	71.0	69.0	14.1	23.0	22.1	12.5	H

Appendix B: Resights of Tinian Monarchs banded between 2006 and 2010 during post-delisting monitoring work for the Tinian Monarch. Color codes: A = Aluminum; B = Blue; R = Red; G = Green; P = Pink; K = Black; W = White. Age codes: AHY = After Hatch Year; HY = Hatch Year; L = Local (not fledged). Sex codes: M = Male; F = Female; U = Unknown. *Partial observation of band combination.

Location	Band #	Color Combo	Age	Sex	2006	2007	2008	2009	2010
Santa Lourdes	00701	ABBR	AHY	M	Banded	Observed	----	----	----
Santa Lourdes	00702	ARGB	AHY	M	Banded	Recaptured	Observed	Observed	----
Santa Lourdes	00703	AGRR	AHY	F	Banded	----	----	----	----
Santa Lourdes	00705	APGG	AHY	F	Banded	Recaptured	----	----	----
Santa Lourdes	00706	BAPP	AHY	F	Banded	Observed	Observed	Observed	Observed
Santa Lourdes	00709	GARB	AHY	M	Banded	----	----	----	----
Santa Lourdes	00710	RPAG	AHY	M	Banded	Recaptured	Observed	Observed	Observed
Santa Lourdes	00711	BGAP	AHY	F	Banded	Observed	Observed	Observed	Observed
Santa Lourdes	00714	GBAR	HY	U	Banded	----	----	----	----
Airport Mitigation	00716	GRAG	AHY	M	Banded	----	----	----	----
Airport Mitigation	00717	PGAB	AHY	F	Banded	Observed	Recaptured	Observed	Observed
Airport Mitigation	00718	BRAP	AHY	M	Banded	----	----	----	----
Airport Mitigation	00719	GRAB	AHY	M	Banded	Observed	Recaptured	Observed	Observed
Airport Mitigation	00723	BAKR	AHY	M	Banded	Observed	Observed	Observed	Observed
Airport Mitigation	00725	AGBG	AHY	M	Banded	Recaptured	Observed	Observed	----
Airport Mitigation	00726	AKGR	HY	U	Banded	----	----	----	----
Airport Mitigation	00727	ABPB	AHY	M	Banded	Recaptured	Observed	Recaptured	----
Airport Mitigation	00732	RAPG	AHY	F	Banded	Observed	Observed	Observed	Observed
Airport Mitigation	00733	PABK	AHY	M	Banded	Observed	Recaptured	Observed	Observed
Airport Mitigation	00734	GKAP	AHY	F	Banded	Observed	Observed	Recaptured	Observed
Airport Mitigation	00735	ARBR	AHY	M	Banded	----	----	----	----
Airport Mitigation	00736	BGAK	AHY	F	Banded	----	----	----	----
Airport Mitigation	00737	KAGP	AHY	M	Banded	Recaptured	Observed	Observed	----
Airport Mitigation	00738	GPPA	AHY	F	Banded	----	----	----	----
Airport Mitigation	00739	GRBA	AHY	M	Banded	Observed	Recaptured	Observed	Observed
Santa Lourdes	00742	GPRA	AHY	M	Banded	Observed	Observed	Observed	Observed
Santa Lourdes	00746	RGAR	AHY	M	Banded	Observed	Recaptured	Observed	Observed
Santa Lourdes	00747	APBG	AHY	M	Banded	Observed	Observed	----	----
Santa Lourdes	00748	GABR	AHY	F	Banded	----	----	----	----
Santa Lourdes	00749	BGBA	AHY	F	Banded	----	----	----	----
Santa Lourdes	00750	KAPP	AHY	F	Banded	Observed	Observed	Observed	Observed
Airport Mitigation	00753	PBPA	AHY	M	Banded	----	----	----	----
Airport Mitigation	00755	ARRG	AHY	M	Banded	Observed	Observed*	----	----
Airport Mitigation	00760	AGGR	AHY	M	Banded	Recaptured	Observed	Observed	Observed
Airport Mitigation	00761	AKRB	AHY	F	Banded	----	----	----	----
Airport Mitigation	00762	GAKP	AHY	M	Banded	Observed	Observed	Observed	Observed
Airport Mitigation	00763	RRAB	AHY	F	Banded	Observed	Observed	----	----

Location	Band #	Color Combo	Age	Sex	2006	2007	2008	2009	2010
Santa Lourdes	00765	ABGB	AHY	F	Banded	----	----	----	----
Santa Lourdes	00769	BBGA	AHY	F		Banded	----	----	----
Santa Lourdes	00770	KRBA	AHY	F		Banded	----	----	----
Airport Mitigation	00772	APWW	AHY	M		Banded	Recaptured	Observed	Observed
Airport Mitigation	00774	AWRR	AHY	F		Banded	Recaptured	----	----
Airport Mitigation	00776	APWR	AHY	F		Banded	Observed	Observed	Observed
Santa Lourdes	00782	ABWG	HY	U		Banded	----	----	----
Airport Mitigation	00785	GWRA	AHY	M		Banded	Observed	----	----
Santa Lourdes	00789	AGPG	HY	U		Banded	----	----	----
Airport Mitigation	00792	RRBA	AHY	F		Banded	Observed	Observed	Observed
Santa Lourdes	00797	ARGW	AHY	M		Banded	Observed	Observed	Observed
Santa Lourdes	00799	ABRW	AHY	F		Banded	----	----	----
Santa Lourdes	00803	AGGB	AHY	F				Banded	Observed
Santa Lourdes	00804	ARWB	AHY	F				Banded	Observed
Santa Lourdes	00805	RAGK	AHY	M				Banded	----
Airport Mitigation	00809	APKW	AHY	F				Banded	Observed
Airport Mitigation	00811	PKRA	AHY	F				Banded	Observed
Airport Mitigation	00812	KGPA	AHY	F				Banded	Observed
Airport Mitigation	00813	BAWG	AHY	F				Banded	----
Airport Mitigation	00814	RGAP	AHY	M				Banded	Observed
Airport Mitigation	00816	GBPA	AHY	F				Banded	----
Airport Mitigation	00819	GAGR	AHY	F				Banded	----
Airport Mitigation	00820	BAKB	HY	U				Banded	----
Airport Mitigation	00822	RWKA	AHY	M				Banded	Observed
Airport Mitigation	00823	WGRA	AHY	M				Banded	----
Airport Mitigation	00825	PWRA	AHY	F				Banded	Observed
Airport Mitigation	00826	BABW	AHY	F				Banded	----
Seaport TT	00827	AGKB	AHY	F				Banded	Observed
Seaport TT	00834	GARW	HY	U				Banded	----
Seaport TT	00853	BAGP	AHY	F				Banded	----
Seaport TT	00854	BPAB	AHY	M				Banded	Observed
Seaport TT	00857	WRAG	AHY	M				Banded	Observed
Seaport TT	00859	KGAB	AHY	M				Banded	Observed
Seaport TT	00860	PKAG	AHY	M				Banded	----
Seaport TT	00861	APWB	AHY	M				Banded	----
Seaport TT	00865	RAGB	AHY	M				Banded	Observed
Seaport TT	00870	KBAP	AHY	F				Banded	Observed
Santa Lourdes	00873	AGBW	AHY	F				Banded	Observed
Santa Lourdes	00875	APKG	AHY	M				Banded	Observed
Seaport TT	00876	BARB	AHY	F				Banded	Observed
Seaport TT	00877	KARP	AHY	M				Banded	Observed
Seaport TT	00878	PWAR	AHY	F				Banded	Observed
Seaport TT	00883	RBRA	AHY	U					Banded
Santa Lourdes	00902	KWPA	AHY	M		Banded	----	----	----

Location	Band #	Color Combo	Age	Sex	2006	2007	2008	2009	2010
Santa Lourdes	00903	WGAG	AHY	F		Banded	Observed	----	----
Santa Lourdes	00904	ARKG	AHY	F		Banded	Observed	Observed	Observed
Santa Lourdes	00905	RBAB	AHY	M		Banded	Observed	Observed	Observed
Santa Lourdes	00906	PKAP	L	U		Banded	----	----	----
Santa Lourdes	00907	KBAW	L	U		Banded	----	----	----
Airport Mitigation	00908	RARB	AHY	M		Banded	Observed	----	----
Airport Mitigation	00909	RKPA	AHY	F		Banded	Observed	Observed	Observed
Airport Mitigation	00911	BRGA	AHY	M		Banded	Observed	----	----
Airport Mitigation	00912	GAGB	AHY	F		Banded	Observed	----	----
Airport Mitigation	00914	PKAK	L	U		Banded	----	----	----
Airport Mitigation	00915	KWAW	L	U		Banded	----	----	----
Seaport TT	00916	ABWR	AHY	M		Banded	Observed	Recaptured	----
Seaport TT	00917	AWBG	AHY	M		Banded	----	----	Observed
Seaport TT	00918	GBAK	AHY	F		Banded	Observed	----	----
Seaport TT	00919	WBAP	AHY	M		Banded	Observed	Observed	----
Seaport TT	00923	ARRB	AHY	F		Banded	----	----	----
Santa Lourdes	00924	ABGK	AHY	F			Banded	----	----
Santa Lourdes	00927	APPW	U	F			Banded	Observed	
Santa Lourdes	00940	APGR	AHY	F			Banded	Observed	Observed
Santa Lourdes	00942	KPRA	AHY	F			Banded	----	----
Santa Lourdes	00943	ABRP	AHY	F			Banded	Observed	Observed
Santa Lourdes	00945	RWPA	HY	U			Banded	Observed	
Airport Mitigation	00950	PWBA	HY	U			Banded	----	----
Airport Mitigation	00951	AGPW	AHY	M			Banded	Observed	Observed
Airport Mitigation	00952	AWPB	AHY	F			Banded	----	Observed
Airport Mitigation	00953	AWKW	AHY	M			Banded	----	----
Airport Mitigation	00954	GARP	AHY	M			Banded	----	----
Airport Mitigation	00964	ARKW	AHY	M			Banded	Recaptured	Observed
Seaport TT	00967	APBP	AHY	M			Banded	Observed	Observed
Seaport TT	00972	AWRK	HY	U			Banded	----	----
Seaport TT	00974	BABP	AHY	F			Banded	Observed	Observed
Seaport TT	00975	RABW	HY	U			Banded	----	----
Seaport TT	00976	WAKB	AHY	F			Banded	Observed	Observed
Seaport TT	00977	AWWP	AHY	M			Banded	Observed	Observed
Seaport TT	00978	AKKP	AHY	F			Banded	Observed	----
Seaport TT	00979	AWPW	AHY	F			Banded	Observed	Observed
Seaport TT	00980	BAKW	AHY	M			Banded	Observed	Observed
Seaport TT	00981	WPAK	AHY	F			Banded	----	----
Seaport TT	00997	WBAW	AHY	M			Banded	Observed	Observed

Appendix C: Tinian Monarch territory mapping figures from the 2007-2011 annual monitoring reports.

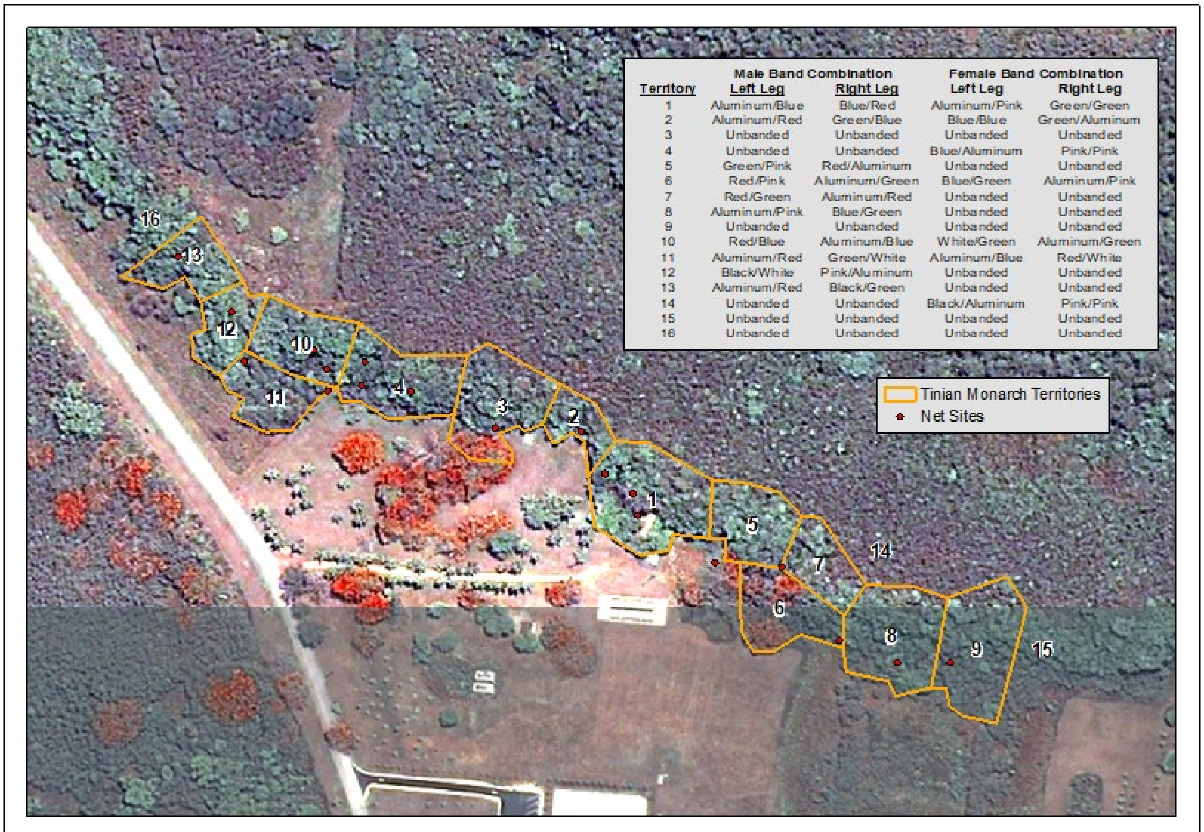
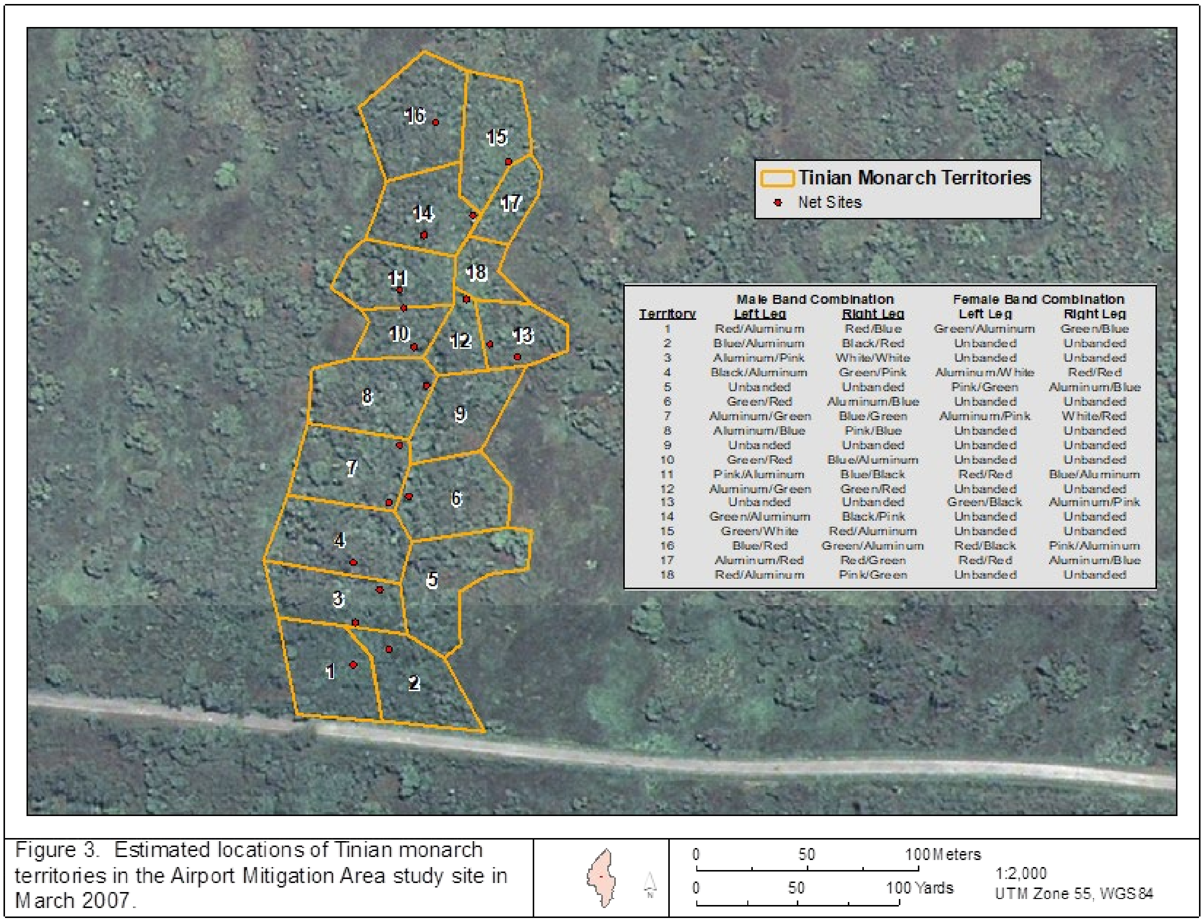


Figure 2. Estimated locations of Tinian monarch territories in the Santa Lourdes study site in March 2007.

Map 1. Estimated locations of Tinian monarch territories in the Santa Lourdes study site in March 2007.



Territory	Male Band Combination Left Leg	Male Band Combination Right Leg	Female Band Combination Left Leg	Female Band Combination Right Leg
1	Red/Aluminum	Red/Blue	Green/Aluminum	Green/Blue
2	Blue/Aluminum	Black/Red	Unbanded	Unbanded
3	Aluminum/Pink	White/White	Unbanded	Unbanded
4	Black/Aluminum	Green/Pink	Aluminum/White	Red/Red
5	Unbanded	Unbanded	Pink/Green	Aluminum/Blue
6	Green/Red	Aluminum/Blue	Unbanded	Unbanded
7	Aluminum/Green	Blue/Green	Aluminum/Pink	White/Red
8	Aluminum/Blue	Pink/Blue	Unbanded	Unbanded
9	Unbanded	Unbanded	Unbanded	Unbanded
10	Green/Red	Blue/Aluminum	Unbanded	Unbanded
11	Pink/Aluminum	Blue/Black	Red/Red	Blue/Aluminum
12	Aluminum/Green	Green/Red	Unbanded	Unbanded
13	Unbanded	Unbanded	Green/Black	Aluminum/Pink
14	Green/Aluminum	Black/Pink	Unbanded	Unbanded
15	Green/White	Red/Aluminum	Unbanded	Unbanded
16	Blue/Red	Green/Aluminum	Red/Black	Pink/Aluminum
17	Aluminum/Red	Red/Green	Red/Red	Aluminum/Blue
18	Red/Aluminum	Pink/Green	Unbanded	Unbanded

Figure 3. Estimated locations of Tinian monarch territories in the Airport Mitigation Area study site in March 2007.

Map 2. Estimated locations of Tinian monarch territories in the Airport Mitigation study site in March 2007.

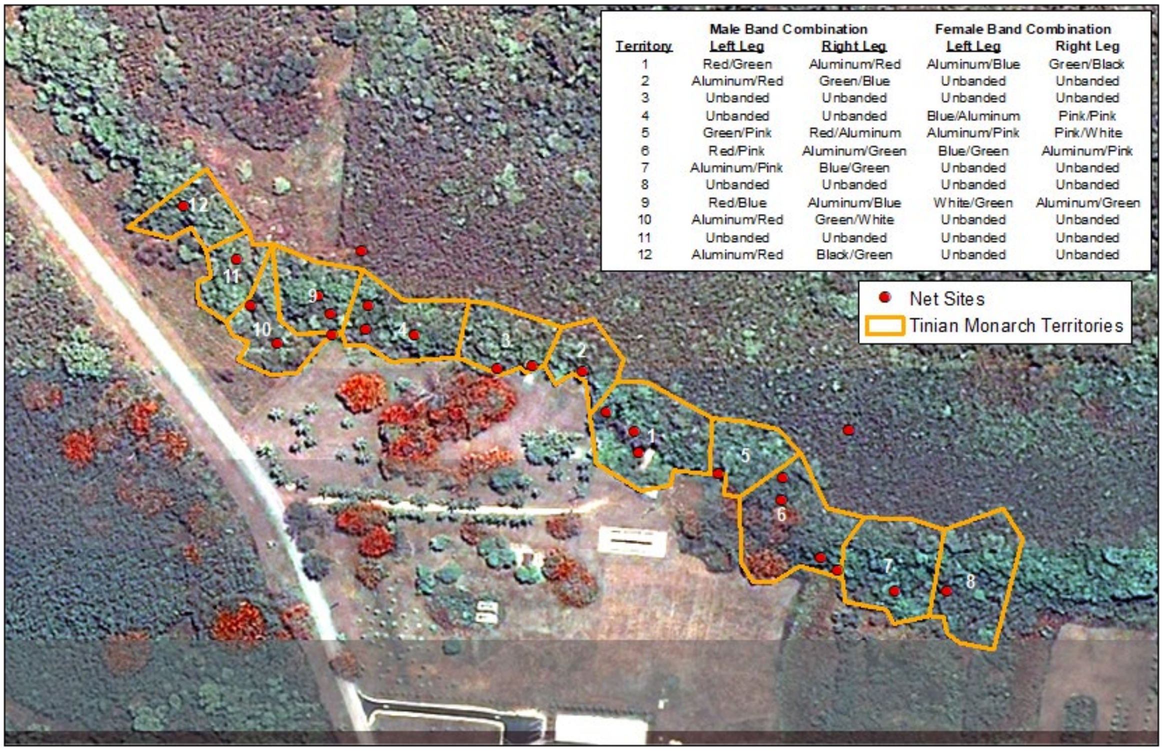
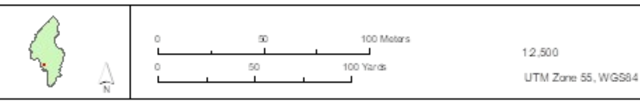
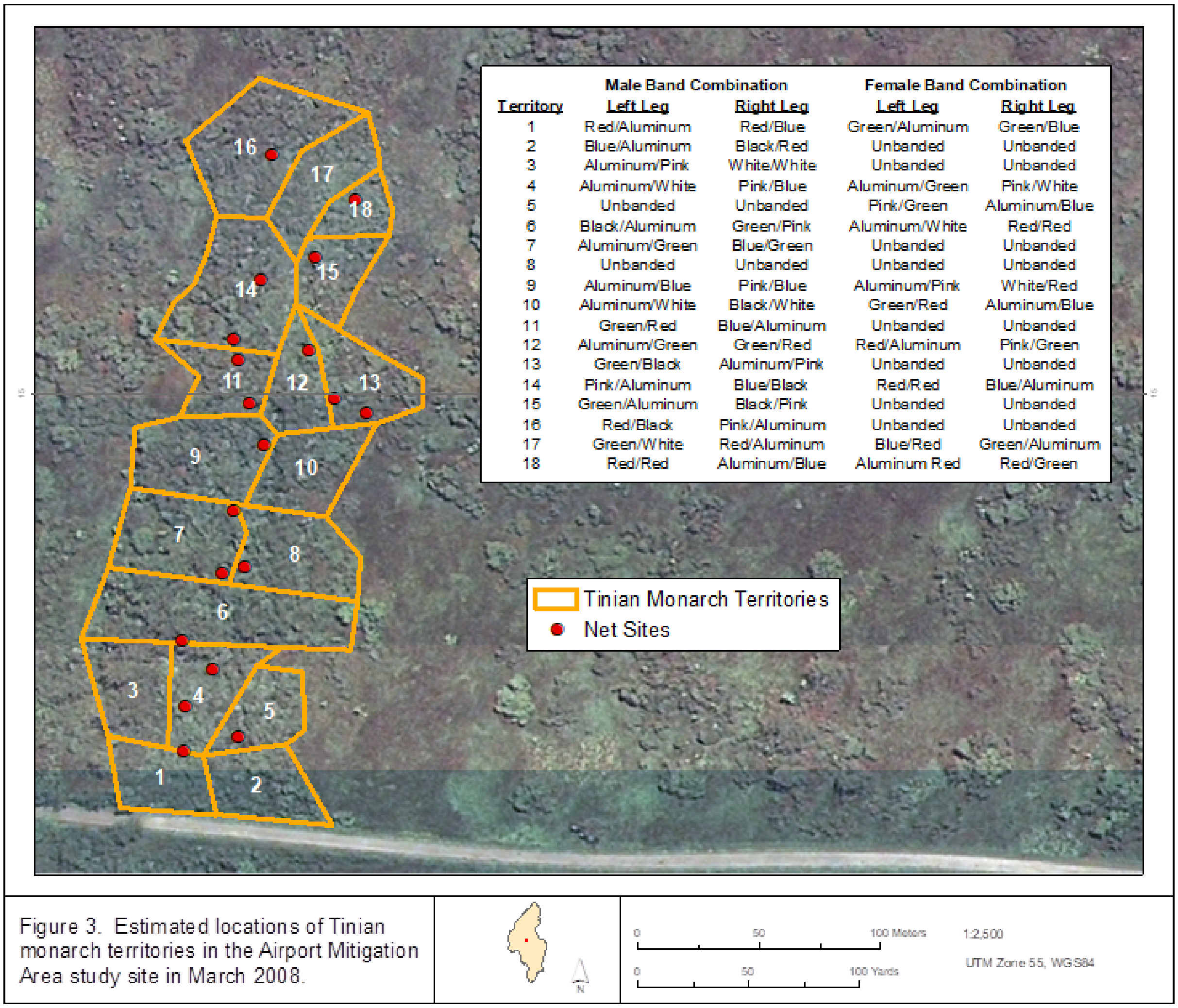


Figure 2. Estimated locations of Tinian monarch territories in the Santa Lourdes study site in March 2008.



Map 3. Estimated locations of Tinian monarch territories in the Santa Lourdes study site in March 2008.



Territory	Male Band Combination Left Leg	Male Band Combination Right Leg	Female Band Combination Left Leg	Female Band Combination Right Leg
1	Red/Aluminum	Red/Blue	Green/Aluminum	Green/Blue
2	Blue/Aluminum	Black/Red	Unbanded	Unbanded
3	Aluminum/Pink	White/White	Unbanded	Unbanded
4	Aluminum/White	Pink/Blue	Aluminum/Green	Pink/White
5	Unbanded	Unbanded	Pink/Green	Aluminum/Blue
6	Black/Aluminum	Green/Pink	Aluminum/White	Red/Red
7	Aluminum/Green	Blue/Green	Unbanded	Unbanded
8	Unbanded	Unbanded	Unbanded	Unbanded
9	Aluminum/Blue	Pink/Blue	Aluminum/Pink	White/Red
10	Aluminum/White	Black/White	Green/Red	Aluminum/Blue
11	Green/Red	Blue/Aluminum	Unbanded	Unbanded
12	Aluminum/Green	Green/Red	Red/Aluminum	Pink/Green
13	Green/Black	Aluminum/Pink	Unbanded	Unbanded
14	Pink/Aluminum	Blue/Black	Red/Red	Blue/Aluminum
15	Green/Aluminum	Black/Pink	Unbanded	Unbanded
16	Red/Black	Pink/Aluminum	Unbanded	Unbanded
17	Green/White	Red/Aluminum	Blue/Red	Green/Aluminum
18	Red/Red	Aluminum/Blue	Aluminum Red	Red/Green

Map 4. Estimated locations of Tinian monarch territories in the Airport Mitigation Area study site in March 2008.

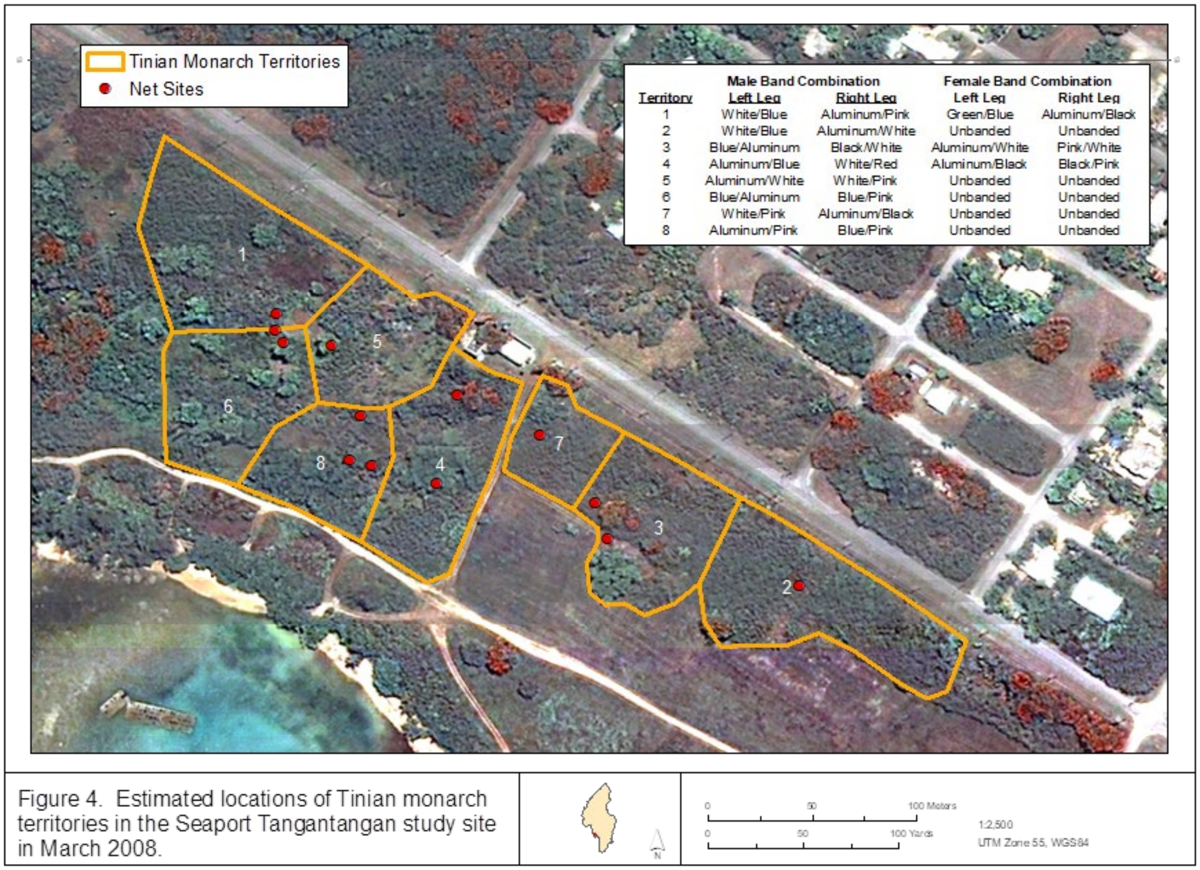
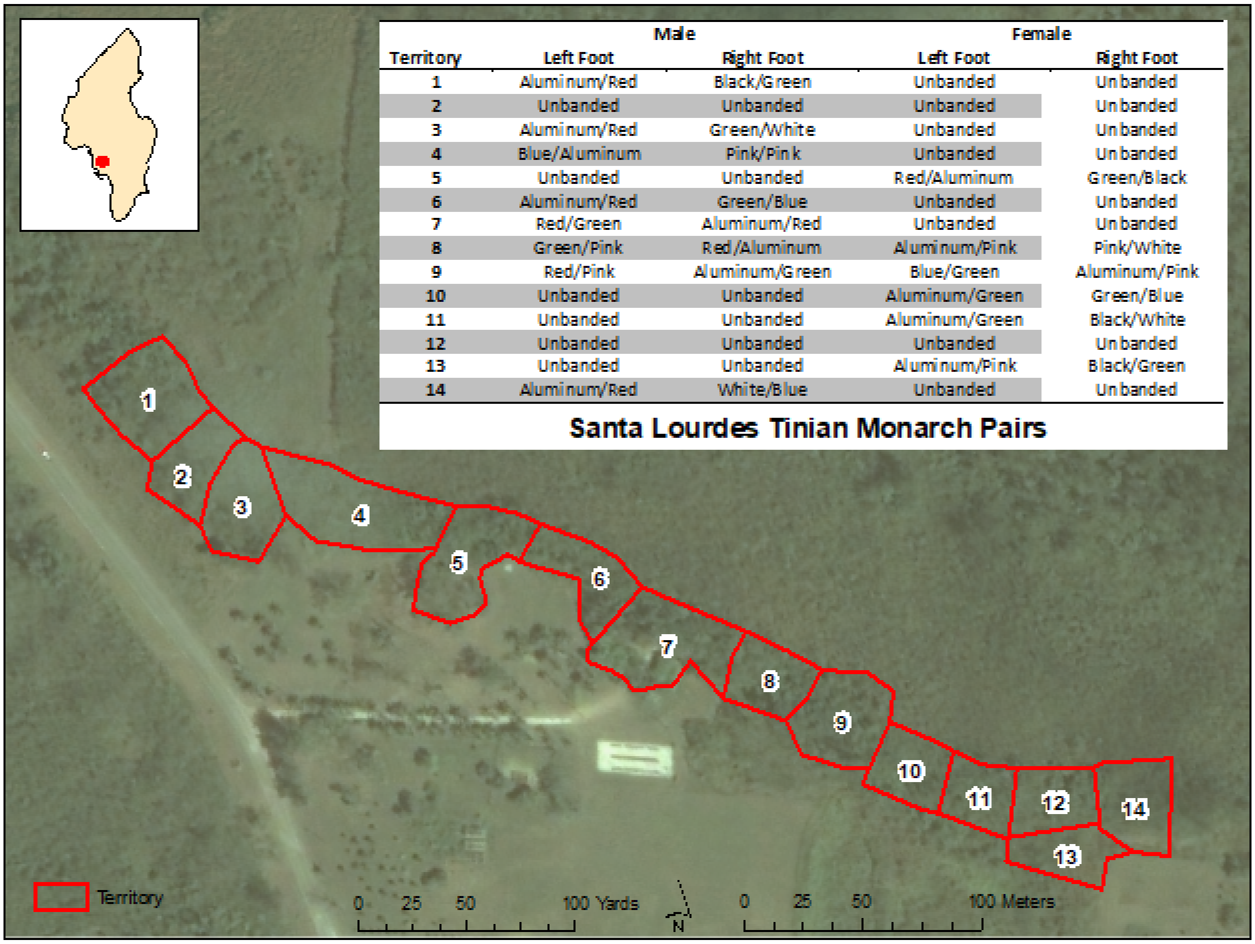


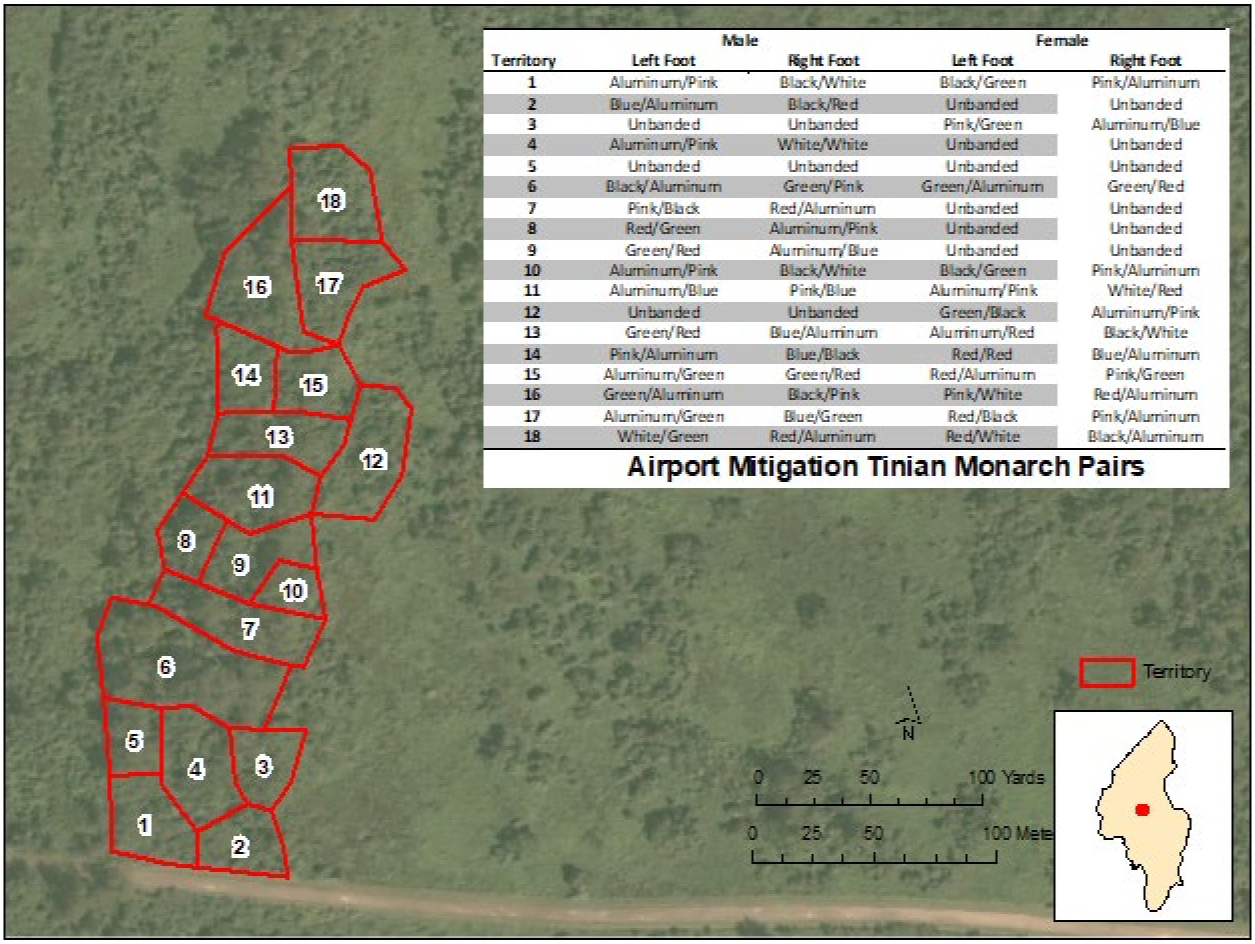
Figure 4. Estimated locations of Tinian monarch territories in the Seaport Tangantangan study site in March 2008.

Map 5. Estimated locations of Tinian monarch territories in the Seaport Tangantangan study site in March 2008.



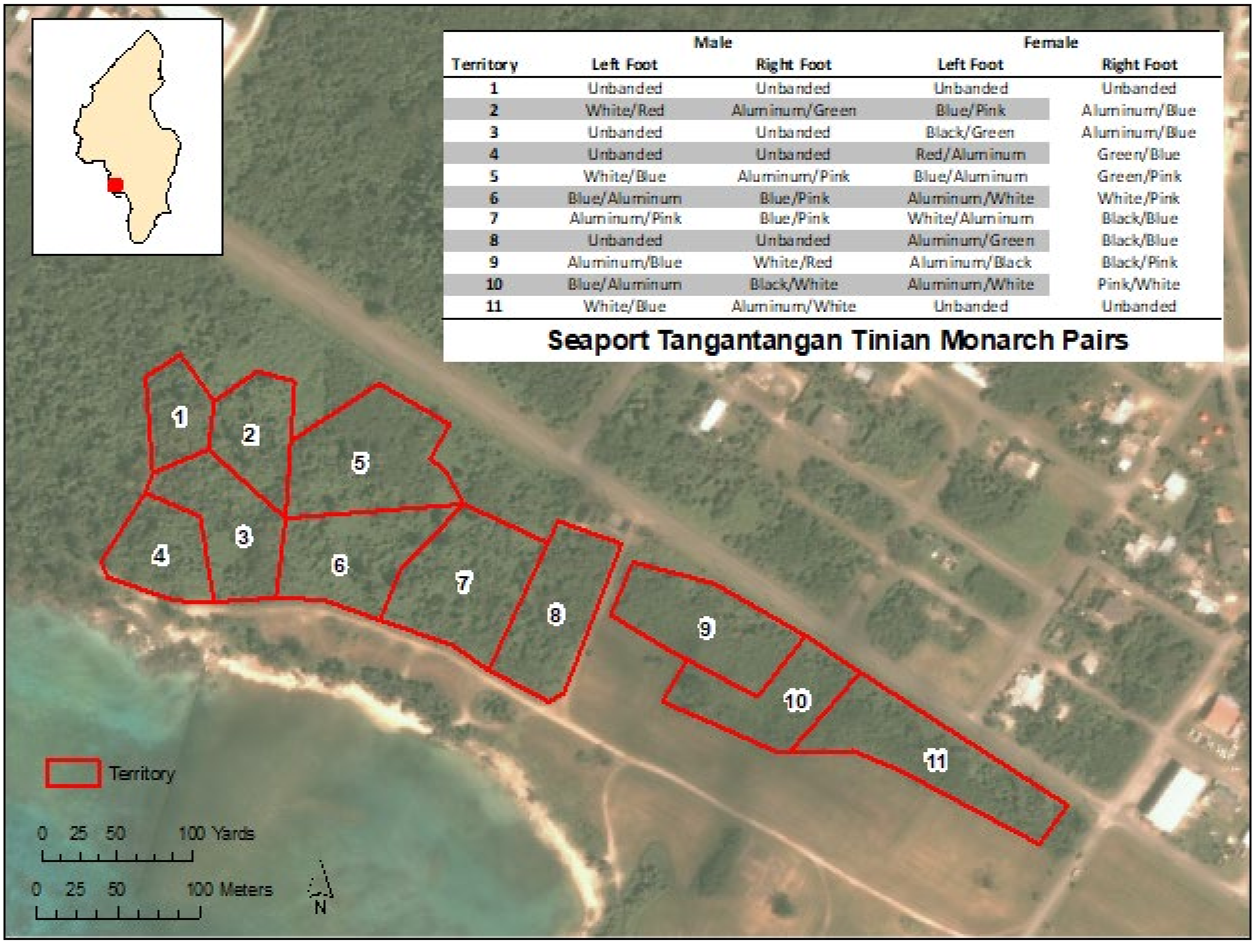
Territory	Male Left Foot	Male Right Foot	Female Left Foot	Female Right Foot
1	Aluminum/Red	Black/Green	Unbanded	Unbanded
2	Unbanded	Unbanded	Unbanded	Unbanded
3	Aluminum/Red	Green/White	Unbanded	Unbanded
4	Blue/Aluminum	Pink/Pink	Unbanded	Unbanded
5	Unbanded	Unbanded	Red/Aluminum	Green/Black
6	Aluminum/Red	Green/Blue	Unbanded	Unbanded
7	Red/Green	Aluminum/Red	Unbanded	Unbanded
8	Green/Pink	Red/Aluminum	Aluminum/Pink	Pink/White
9	Red/Pink	Aluminum/Green	Blue/Green	Aluminum/Pink
10	Unbanded	Unbanded	Aluminum/Green	Green/Blue
11	Unbanded	Unbanded	Aluminum/Green	Black/White
12	Unbanded	Unbanded	Unbanded	Unbanded
13	Unbanded	Unbanded	Aluminum/Pink	Black/Green
14	Aluminum/Red	White/Blue	Unbanded	Unbanded

Map 6. Estimated locations of Tinian monarch territories in the Santa Lourdes study site in March 2009.

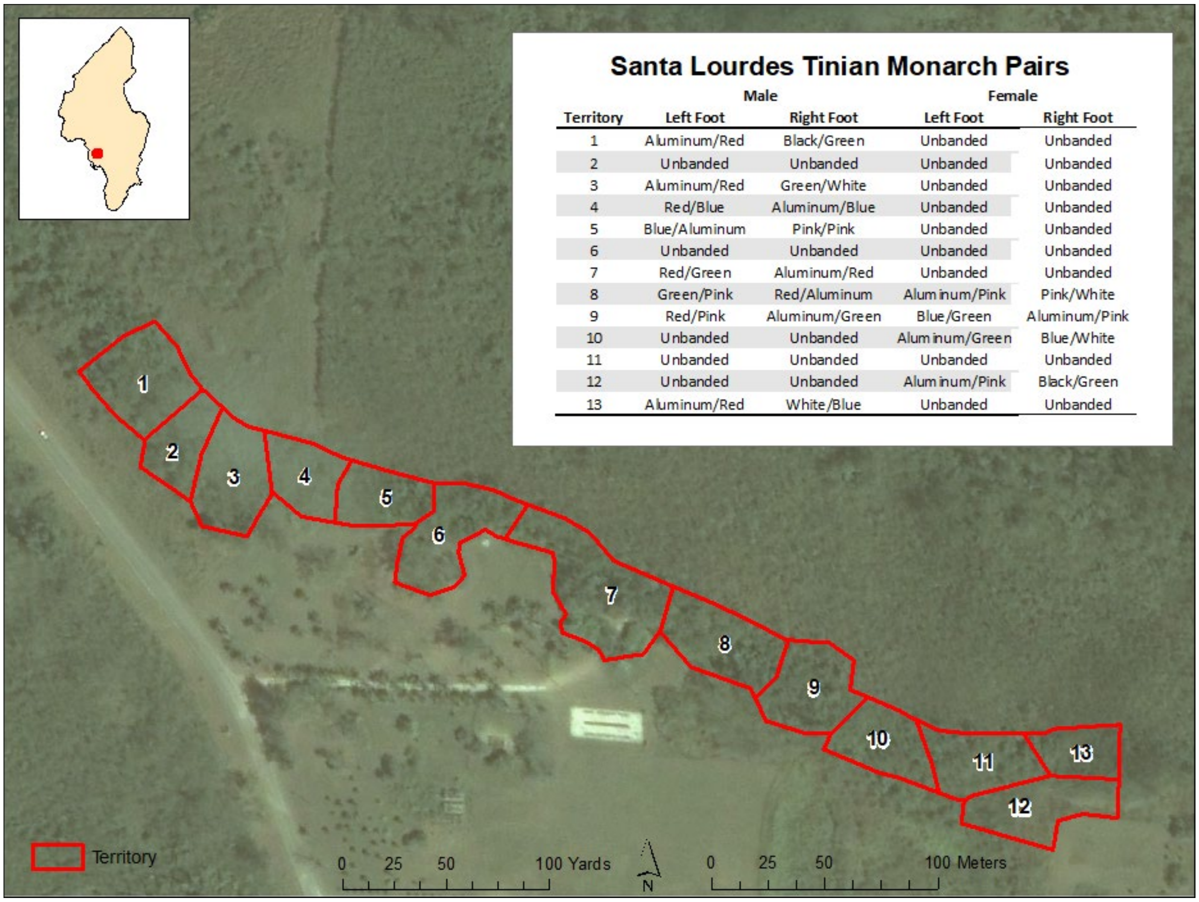


	Male		Female	
Territory	Left Foot	Right Foot	Left Foot	Right Foot
1	Aluminum/Pink	Black/White	Black/Green	Pink/Aluminum
2	Blue/Aluminum	Black/Red	Unbanded	Unbanded
3	Unbanded	Unbanded	Pink/Green	Aluminum/Blue
4	Aluminum/Pink	White/White	Unbanded	Unbanded
5	Unbanded	Unbanded	Unbanded	Unbanded
6	Black/Aluminum	Green/Pink	Green/Aluminum	Green/Red
7	Pink/Black	Red/Aluminum	Unbanded	Unbanded
8	Red/Green	Aluminum/Pink	Unbanded	Unbanded
9	Green/Red	Aluminum/Blue	Unbanded	Unbanded
10	Aluminum/Pink	Black/White	Black/Green	Pink/Aluminum
11	Aluminum/Blue	Pink/Blue	Aluminum/Pink	White/Red
12	Unbanded	Unbanded	Green/Black	Aluminum/Pink
13	Green/Red	Blue/Aluminum	Aluminum/Red	Black/White
14	Pink/Aluminum	Blue/Black	Red/Red	Blue/Aluminum
15	Aluminum/Green	Green/Red	Red/Aluminum	Pink/Green
16	Green/Aluminum	Black/Pink	Pink/White	Red/Aluminum
17	Aluminum/Green	Blue/Green	Red/Black	Pink/Aluminum
18	White/Green	Red/Aluminum	Red/White	Black/Aluminum

Map 7. Estimated locations of Tinian monarch territories in the Airport Mitigation study site in March 2009.



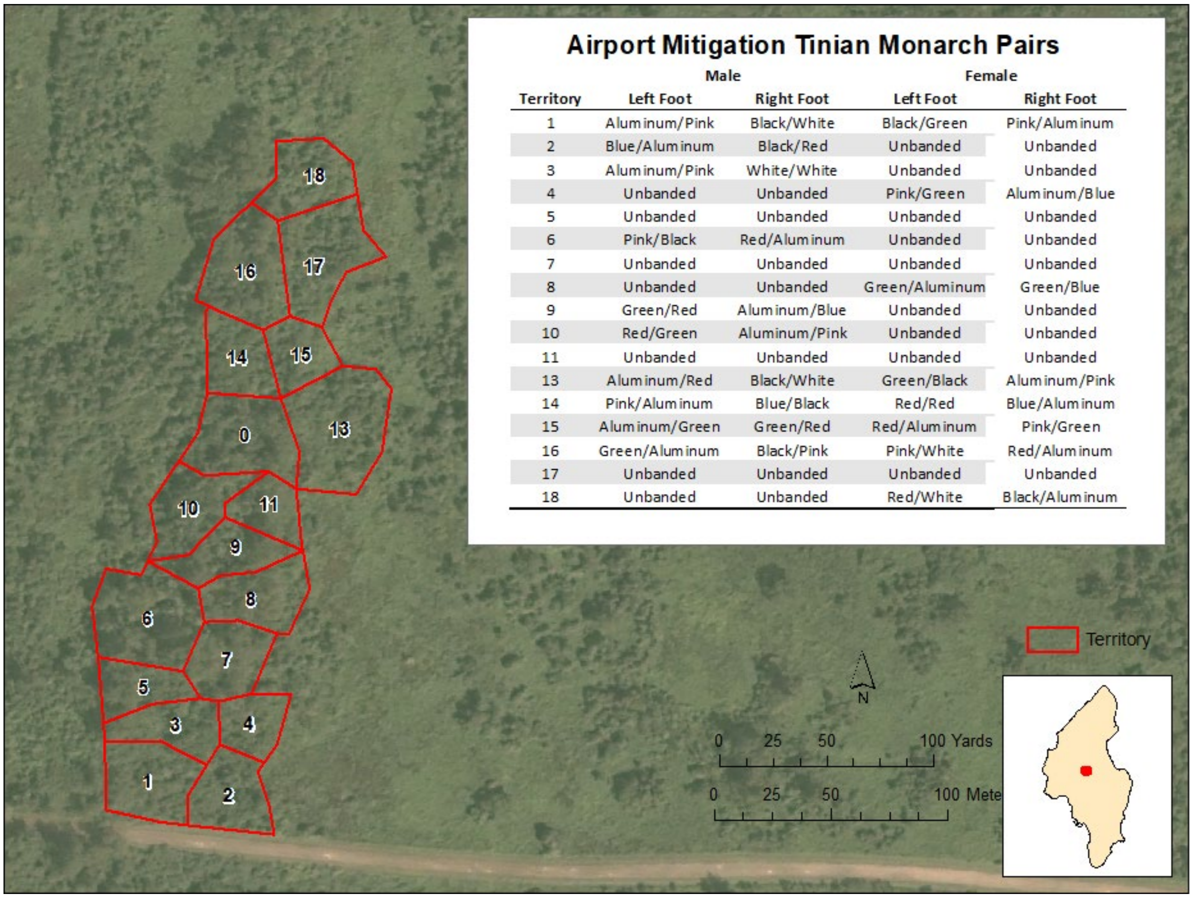
Map 8. Estimated locations of Tinian monarch territories in the Seaport Tangantangan study site in March 2009.



Santa Lourdes Tinian Monarch Pairs

	Male		Female	
Territory	Left Foot	Right Foot	Left Foot	Right Foot
1	Aluminum/Red	Black/Green	Unbanded	Unbanded
2	Unbanded	Unbanded	Unbanded	Unbanded
3	Aluminum/Red	Green/White	Unbanded	Unbanded
4	Red/Blue	Aluminum/Blue	Unbanded	Unbanded
5	Blue/Aluminum	Pink/Pink	Unbanded	Unbanded
6	Unbanded	Unbanded	Unbanded	Unbanded
7	Red/Green	Aluminum/Red	Unbanded	Unbanded
8	Green/Pink	Red/Aluminum	Aluminum/Pink	Pink/White
9	Red/Pink	Aluminum/Green	Blue/Green	Aluminum/Pink
10	Unbanded	Unbanded	Aluminum/Green	Blue/White
11	Unbanded	Unbanded	Unbanded	Unbanded
12	Unbanded	Unbanded	Aluminum/Pink	Black/Green
13	Aluminum/Red	White/Blue	Unbanded	Unbanded

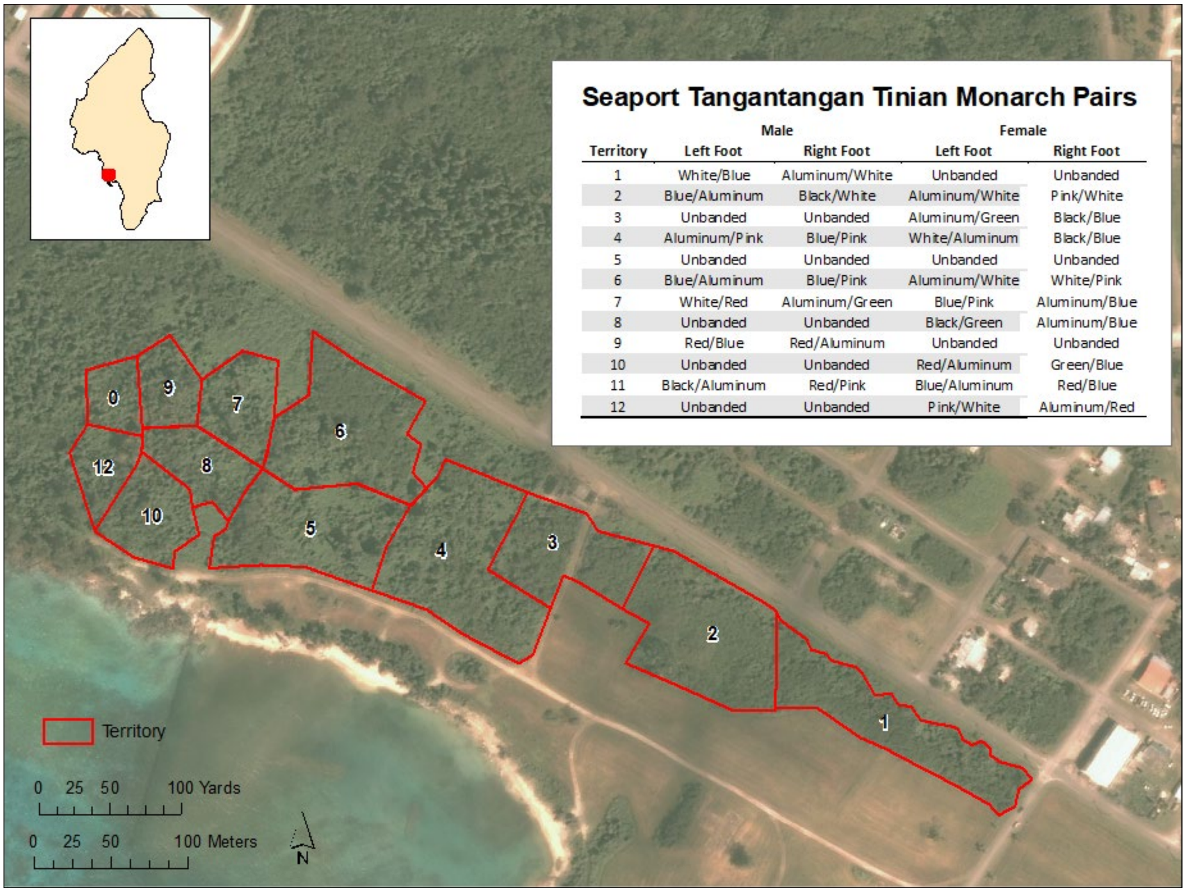
Map 9. Estimated locations of Tinian monarch territories in the Santa Lourdes study site in March 2010.



Airport Mitigation Tinian Monarch Pairs

	Male		Female	
Territory	Left Foot	Right Foot	Left Foot	Right Foot
1	Aluminum/Pink	Black/White	Black/Green	Pink/Aluminum
2	Blue/Aluminum	Black/Red	Unbanded	Unbanded
3	Aluminum/Pink	White/White	Unbanded	Unbanded
4	Unbanded	Unbanded	Pink/Green	Aluminum/Blue
5	Unbanded	Unbanded	Unbanded	Unbanded
6	Pink/Black	Red/Aluminum	Unbanded	Unbanded
7	Unbanded	Unbanded	Unbanded	Unbanded
8	Unbanded	Unbanded	Green/Aluminum	Green/Blue
9	Green/Red	Aluminum/Blue	Unbanded	Unbanded
10	Red/Green	Aluminum/Pink	Unbanded	Unbanded
11	Unbanded	Unbanded	Unbanded	Unbanded
13	Aluminum/Red	Black/White	Green/Black	Aluminum/Pink
14	Pink/Aluminum	Blue/Black	Red/Red	Blue/Aluminum
15	Aluminum/Green	Green/Red	Red/Aluminum	Pink/Green
16	Green/Aluminum	Black/Pink	Pink/White	Red/Aluminum
17	Unbanded	Unbanded	Unbanded	Unbanded
18	Unbanded	Unbanded	Red/White	Black/Aluminum

Map 10. Estimated locations of Tinian monarch territories in the Airport Mitigation study site in March 2010.



Territory	Male Left Foot	Male Right Foot	Female Left Foot	Female Right Foot
1	White/Blue	Aluminum/White	Unbanded	Unbanded
2	Blue/Aluminum	Black/White	Aluminum/White	Pink/White
3	Unbanded	Unbanded	Aluminum/Green	Black/Blue
4	Aluminum/Pink	Blue/Pink	White/Aluminum	Black/Blue
5	Unbanded	Unbanded	Unbanded	Unbanded
6	Blue/Aluminum	Blue/Pink	Aluminum/White	White/Pink
7	White/Red	Aluminum/Green	Blue/Pink	Aluminum/Blue
8	Unbanded	Unbanded	Black/Green	Aluminum/Blue
9	Red/Blue	Red/Aluminum	Unbanded	Unbanded
10	Unbanded	Unbanded	Red/Aluminum	Green/Blue
11	Black/Aluminum	Red/Pink	Blue/Aluminum	Red/Blue
12	Unbanded	Unbanded	Pink/White	Aluminum/Red

Map 11. Estimated locations of Tinian monarch territories in the Seaport Tangantangan study site in March 2010.

Map 12. Estimated locations of Tinian monarch territories in the Santa Lourdes study site in March 2011.

Map 13. Estimated locations of Tinian monarch territories in the Seaport Tangantangan study site in March 2011.