Draft Recovery Plan for the Nosa Luta or Rota Bridled White-Eye

(Zosterops rotensis)

Rota bridled white-eye at nest; photo by Fred Amidon, U.S. Fish and Wildlife Service

Draft Recovery Plan for the Nosa Luta or Rota Bridled White-Eye (*Zosterops rotensis*)

(June 2006)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Regional Director, U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

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PRIMARY AUTHORS

Fred Amidon of the Pacific Islands Fish and Wildlife Office, U.S. Fish and Wildlife Service, Honolulu, Hawai`i, prepared this recovery plan. All outreach recovery actions within this plan were developed by Ken Foote, Pacific Islands Fish and Wildlife Office. The monitoring program for the Rota bridled white-eye presented in this plan was developed by Dr. Rick Camp, Hawai`i Cooperative Studies Unit, University of Hawai`i. All maps within this plan were developed with the assistance of Mark Metevier, Pacific Islands Fish and Wildlife Office, U.S. Fish and Wildlife Service. Recovery plan preparation was supervised and edited by Marilet A. Zablan, Gina M. Shultz, and Patrick Leonard, Pacific Islands Fish and Wildlife Office, U.S. Fish and Wildlife Service.

ACKNOWLEDGMENTS

Many individuals and organizations have contributed to the recovery program for the nosa Luta or Rota bridled white-eye. We would especially like to thank the following individuals for their assistance and support: Jeff Burgett (U.S. Fish and Wildlife Service), Scott Derrickson (National Zoo), Nate Hawley (U.S. Fish and Wildlife Service), Curt Kessler (U.S. Fish and Wildlife Service), Shelly Kremer (Commonwealth of the Northern Mariana Islands, Division of Fish and Wildlife), Peter Luscomb (Honolulu Zoo), William McDowell (Audubon Zoo), John Morton (U.S. Fish and Wildlife Service), Bill Rameyer (U.S. Geological Survey), Thalia Sachtleben (Colorado State University), and Estanislao Taisacan (Commonwealth of the Northern Mariana Islands, Division of Fish and Wildlife – retired). We would also like to acknowledge the many researchers whose efforts have helped bring insight into the biology and conservation of the nosa Luta.

EXECUTIVE SUMMARY

Current Status: The Rota bridled white-eye or nosa Luta (*Zosterops rotensis*) was listed as endangered in 2004 (United States Fish and Wildlife Service [USFWS] 2004). As of August 1999, the population on Rota was approximately 1,000 birds and the species' core range consisted of approximately 254 hectares (628 acres) of forest above 150 meters (490 feet) elevation. The nosa Luta has a recovery priority number of 2 on a scale of 1 (highest) to 18 (lowest), reflecting a high degree of threat, strong prospects for recovery, and its taxonomic status as a full species.

Habitat Requirements and Distribution: The nosa Luta is endemic to the island of Rota, Commonwealth of the Northern Mariana Islands. Currently, the species is primarily restricted to mature forests above 150 meters (490 feet) in the Sabana region of Rota. These forests are divided into the following three types based on dominant canopy tree species: 1) mixed oschal (*Hernandia labyrinthica*; a native species) and yoga (*Elaeocarpus joga*; a native species) forest; 2) faniok (*Merrilliodendron megacarpum*; a native species) forest; and 3) sosugi (*Acacia confusa*; an introduced species) forest. Nosa Luta primarily forage in the outer canopy of forests for insects, fruit, or nectar and the majority of the foraging observations have been reported in *Elaeocarpus joga*, *Hernandia labyrinthica*, pengua (*Macaranga thompsonii*; a native species), *Merrilliodendron megacarpum*, and ahgao (*Premna obtusifolia*; a native species). Nosa Luta nests have been reported in *Merrilliodendron megacarpum*, *Hernandia labyrinthica*, *Elaeocarpus joga*, and *Acacia confusa* trees 3 to 15 meters (10 to 49 feet) tall and 2 to 60 centimeters (1 to 24 inches) in diameter.

Threats to Species Recovery: Current threats include habitat loss and degradation, predation by introduced rats (*Rattus* spp.) and black drongos (*Dicrurus macrocercus*), and susceptibility of the single small population to random catastrophic events, such as typhoons. In addition, the establishment of a new predator, such as the brown treesnake (*Boiga irregularis*), or avian diseases, such as West Nile virus, would also threaten the recovery of the species.

Recovery Strategy: Recovery actions in this plan are designed to address the threats to the nosa Luta in order to achieve the recovery goals for this species.

Recovery actions focus on addressing predation by introduced species, preventing the establishment of new predators and avian diseases, protecting and restoring native forests within the nosa Luta's range, and evaluating the need for establishing a second population. The impact of black drongo and rat predation on the nosa Luta population is uncertain. This level of impact will be assessed and used to determine how to prioritize control and eradication activities for these introduced species. Preventing the introduction of new predators, such as the brown treesnake, and new avian diseases, such as West Nile virus, are intended to prevent additional declines in the population while current threats are addressed. Protecting forest habitat within the nosa Luta's range is intended to reduce the decline in available habitat by working with private landowners and public land managers on Rota. Restoring forested habitat within the nosa Luta's range includes developing and implementing forest restoration programs in the Sabana region of Rota. Evaluating the need for establishing a second population is intended to determine if and at what point a captive propagation or translocation program is needed to help prevent the species from going extinct due to random catastrophic events.

Recovery Goals and Objectives: The goal of the nosa Luta recovery program is to downlist the species to threatened status and ultimately to remove the species from the Federal list of Endangered and Threatened Wildlife and Plants (delist). Due to the limited information available to inform long-term recovery planning efforts, the recovery program presented in this plan focuses on the first 10 years of the recovery process, with the immediate goal of halting the population decline of the nosa Luta and preventing the extinction of the species. The primary interim objectives of this recovery plan over the next 10 years are to stop further declines in the range and composition of the nosa Luta population, develop safeguards to prevent the species from going extinct, reverse population declines, and restore the population to at least the abundance level estimated in 1982 (10,000 individuals).

At this time, we have developed only interim downlisting targets for the nosa Luta due to data limitations and potential uncertainties associated with attempting to define more specific and quantitative recovery criteria. Recovery actions intended to acquire the information needed to develop appropriate recovery criteria within the next 10 years are identified in this draft recovery plan.

The population targets for downlisting offered here should be revised, if necessary, based upon any new data gathered during this time. At present, the interim downlisting objectives for the nosa Luta over the next 10 years are as follows:

(1) Arrest the decline in abundance of nosa Luta as evidenced by a stable or increasing population growth trend (finite rate of population increase or λ greater than or equal to 1.0) averaged over a minimum of 5 continuous years and restore the population to at least 10,000 individuals;
(2) Reduce the decline of intact nosa Luta habitat in the species' core range to help prevent further population declines and range restrictions and develop and implement restoration techniques to increase the amount of nosa Luta habitat available for sustaining a population of at least 10,000 individuals;
(3) Assess the impact of black drongos and rats on the nosa Luta population and develop and implement effective methods to control these species, as needed, to decrease their impacts on the nosa Luta as demonstrated by a significant reduction in predation events over 10 years; and
(4) Implement measures to prevent the brown treesnake and other threats, such as West Nile virus, from becoming established on Rota to reduce threats to the nosa Luta population.

Actions Needed: The goal of this recovery plan is to lay the groundwork for reestablishing a viable population of nosa Luta. Therefore, this plan focuses on the following actions to make this possible:

(1) Manage factors affecting viability of the wild population;
To prevent the extinction of the nosa Luta, the highest priority recovery actions are to determine which threat or threats are having the most impact on the species and to address these threats. This is to be accomplished by determining the impact of introduced rats and black drongos on the nosa Luta population and controlling or eradicating these species, as needed (Recovery Actions 1.2.1 and 1.2.2); obtaining additional information on the habitat requirements of the nosa Luta to better protect and manage habitat for the species (Recovery Action 1.1.1); and protecting the remaining forested areas utilized by nosa Luta and restoring degraded and cleared areas in the Sabana region to mature forest (Recovery Actions 1.1.2 and 1.1.3). In addition, preventing the introduction of new nosa Luta

predators, such as the brown treesnake (Recovery Action 1.2.3), and avian diseases, such as West Nile virus (Recovery Action 1.3), is needed to prevent additional declines in the population.

(2) Assess the need and develop a plan for establishing a second nosa Luta population;
Assessing the need for establishing a second population is needed due to the susceptibility of the single current population to random catastrophic events such as typhoons, which could bring the population to the edge of extinction. In order to adequately prepare for this possibility, initial planning for establishing a captive population (Recovery Action 2.1) and/or experimental population (Recovery Action 2.2) is needed.

(3) Develop a public awareness program to promote nosa Luta recovery, including native forest restoration.
Local support for nosa Luta conservation efforts will require programs that inform teachers, students, lawmakers, and community groups. Education packets will be developed for teachers to educate students on nosa Luta conservation (Recovery Action 3.1) and a public awareness campaign will be developed to provide information to the rest of the community about nosa Luta conservation (Recovery Action 3.2). In addition, "hands-on" community outreach activities will be developed and promoted to involve the community in efforts to conserve the nosa Luta and the natural resources of Rota (Recovery Action 3.3).

Estimated Date of Recovery: Uncertainties regarding the role of introduced predators and habitat loss and degradation in the decline and range restriction of the nosa Luta population, and the susceptibility of the population to random catastrophic events, make it difficult to reasonably project the needs of the recovery program beyond a relatively short time frame. Due to these uncertainties, it is not possible to provide an accurate date for recovery at this time. It is expected that it will likely take several decades to fully recover the species depending on the status of threats to the species and the status of the nosa Luta population. We have therefore taken an adaptive management approach to the recovery program for the nosa Luta, in which data gathered during the course of implementing the recovery actions identified in this plan will be incorporated to guide future recovery efforts and to develop and refine the objectives and criteria for recovery, as appropriate. This draft recovery plan for the nosa Luta is

designed to be updated in 5-year increments, to reflect the knowledge gained and consequent refinements to our management program. This draft recovery plan addresses the first 10 years of recovery, with particular emphasis on the initial 5 years of the program. In 5 years, we expect to release an update to this plan, which will summarize relevant data gathered to date and further identify actions needed to advance recovery of the species, as well as propose more refined recovery objectives and criteria based on the gains in knowledge of the species and its threats.

Total Estimated Cost of Recovery: It is not possible to determine the total estimated cost of recovery at this time because it is not possible to estimate the time to recovery (see above). The estimated cost to implement all the recovery actions described in the Implementation Schedule over the next 10 years is $24,760,000. Approximately $13,858,000 of this total cost will be needed during the first 5 years of recovery implementation. The cost of recovery is only an estimate and may change substantially as efforts to recover the species continue. In addition, up to $1,569,000 of the 10-year cost is expected to benefit the endangered trees *Osmoxylon mariannense* (no common name) and *Serianthes nelsonii* (fire tree or trongkon guafi), the endangered Mariana crow or aga (*Corvus kubaryi*), the threatened Mariana fruit bat or fanihi (*Pteropus mariannus mariannus*), and the candidate fragile tree snail (*Samoana fragilis*) and humped tree snail (*Partula gibba*) through habitat protection and restoration in the Sabana region. Up to $18,523,000 of the 10-year cost is also expected to contribute to the recovery of the endangered Mariana crow and the threatened Mariana fruit bat on Rota through brown treesnake interdiction. A detailed cost breakdown with expected annual costs for the first 5 years of recovery implementation is provided in the Implementation Schedule.

The 10-year and first 5-year costs referenced above are broken down by recovery action priority number as follows:

Priority 1 Actions – Those actions that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

First 5 Years:	$8,388,000
Second 5 Years:	$8,396,000
10-Year Total:	$16,784,000

Priority 2 Actions – Those actions that must be taken to prevent a significant decline in population or habitat quality, or some other significant negative impact short of extinction.

First 5 Years:	$4,910,000
Second 5 Years:	$1,554,000
10-Year Total:	$6,464,000

Priority 3 Actions – All other actions necessary to meet recovery objectives.

First 10 Years:	$560,000
Second 5 Years:	$952,000
10-Year Total:	$1,512,000

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I. BACKGROUND AND OVERVIEW

A. Introduction

The Rota bridled white-eye (*Zosterops rotensis*) is known in Chamorro, the native language of Rota, as nosa. As the Chamorro name for the island of Rota is Luta, we hereby refer to the Rota bridled white-eye as nosa Luta to distinguish it from other bridled white-eye species in the Mariana Islands, which are also called nosa or nossa. The nosa Luta is endemic to the island of Rota in the Commonwealth of the Northern Mariana Islands (CNMI). This species is listed as endangered by the United States (United States Fish and Wildlife Service [USFWS] 2004), threatened or endangered by the CNMI (the CNMI makes no distinction between the threatened and endangered categories; Public Law 2-51), and critically endangered by the World Conservation Union (2004). In 1999, the population was estimated to be approximately 1,000 individuals (Amidon 2000, Fancy and Snetsinger 2001) and the species' core range consisted of four patches of forest covering an area of about 254 hectares (628 acres) above 150 meters (490 feet) in elevation (Fancy and Snetsinger 2001). Habitat loss and degradation and predation by introduced rats, or cha'ka[1] (*Rattus* spp.), and black drongos, or sali Taiwan (*Dicrurus macrocercus*), appear to be the primary factors in the decline and range restriction of the species and continue to limit the recovery of the species. The introduction of the brown treesnake or kolepbla (*Boiga irregularis*), and avian disease, such as West Nile virus, to Rota are also important potential threats to the species.

In order to make the most appropriate use of the limited resources available for recovery, we, the U.S. Fish and Wildlife Service, assign a recovery priority number to each listed species (USFWS 1983a,b). The recovery priority number of the nosa Luta is a 2 on a scale of 1 (highest) to 18 (lowest; see Appendix A). This priority ranking reflects that the prospects for recovery and degree of threat are high, the nosa Luta is formally recognized as a full species, and there is no known significant conflict with economic development.

[1] Both the English and Chamorro names for plants and animals referenced will be provided throughout this plan wherever possible.

B. Rota

Rota is the fourth largest island in the Mariana archipelago (Figure 1) and the southernmost island in the CNMI. Rota is approximately 20 kilometers (12 miles) long and 6 kilometers (4 miles) wide with a land area of approximately 86 square kilometers (33 square miles). The Sabana region, a 12-square-kilometer (5 square mile) plateau 450 meters (1,476 feet) in elevation, dominates the western half of the island (Figure 2). Cliffs border the Sabana region on all sides except the northeastern side, where the plateau slopes down to the Sinapalu plateau at 150 meters (492 feet) elevation, which dominates the eastern half of the island. The airport and village of Sinapalo are situated on the Sinapalu plateau. The village of Songsong and the commercial port for the island are situated on the Taipingot Peninsula, a narrow peninsula jutting out to the southwest on the western coast of the island. Fringing reefs surround most of the island.

The island of Rota is a municipality within the CNMI. The human population was 3,283 people in 2000, a 43 percent increase from the 1990 census estimate (U.S. Census Bureau 2001). Rota's climate is tropical marine with high humidity and uniform temperatures throughout the year. Average daytime temperatures are approximately 27 degrees Celsius (80 degrees Fahrenheit) with approximately 200 centimeters (80 inches) of rain annually and about 80 percent humidity. Rainfall averages 27 centimeters (11 inches) per month during the wet season (June to December) and 10 centimeters (4 inches) per month during the dry season (January to May).

The vegetation on Rota has been described in detail by Fosberg (1960), Falanruw *et al*. (1989), and Mueller-Dombois and Fosberg (1998). The vegetation includes primary and secondary limestone forest, atoll forest, agricultural forest, coconut plantations, ironwood or gagu (*Casuarina equisetifolia*) forest, secondary vegetation, open fields, grassland, and urban vegetation (Figure 3; Falanruw *et al*. 1989). Approximately 60 percent of the island is forested (Falanruw *et al*. 1989), however much of this is of medium stature and degraded by development activities, as well as introduced plants and animals (Engbring *et al*. 1986, Mueller-Dombois and Fosberg 1998).

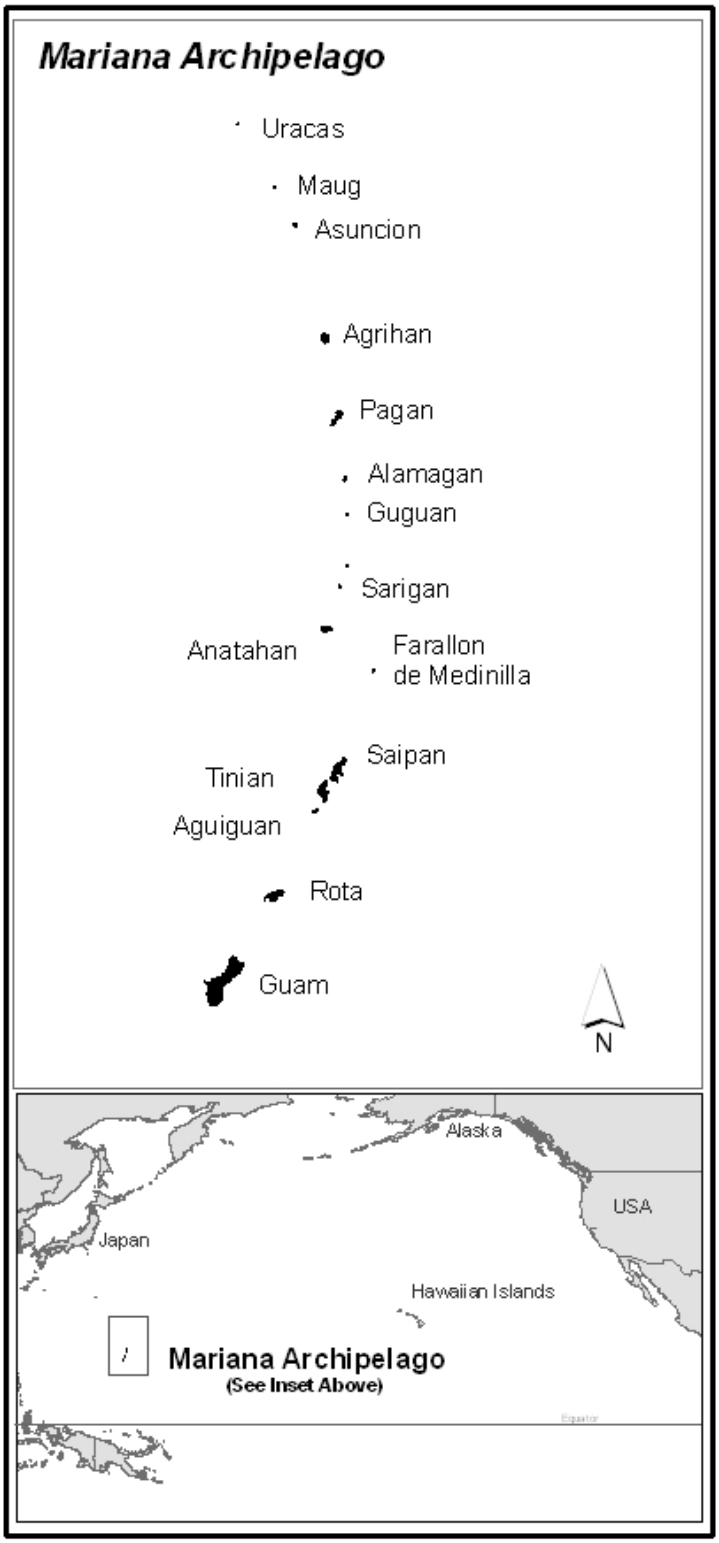
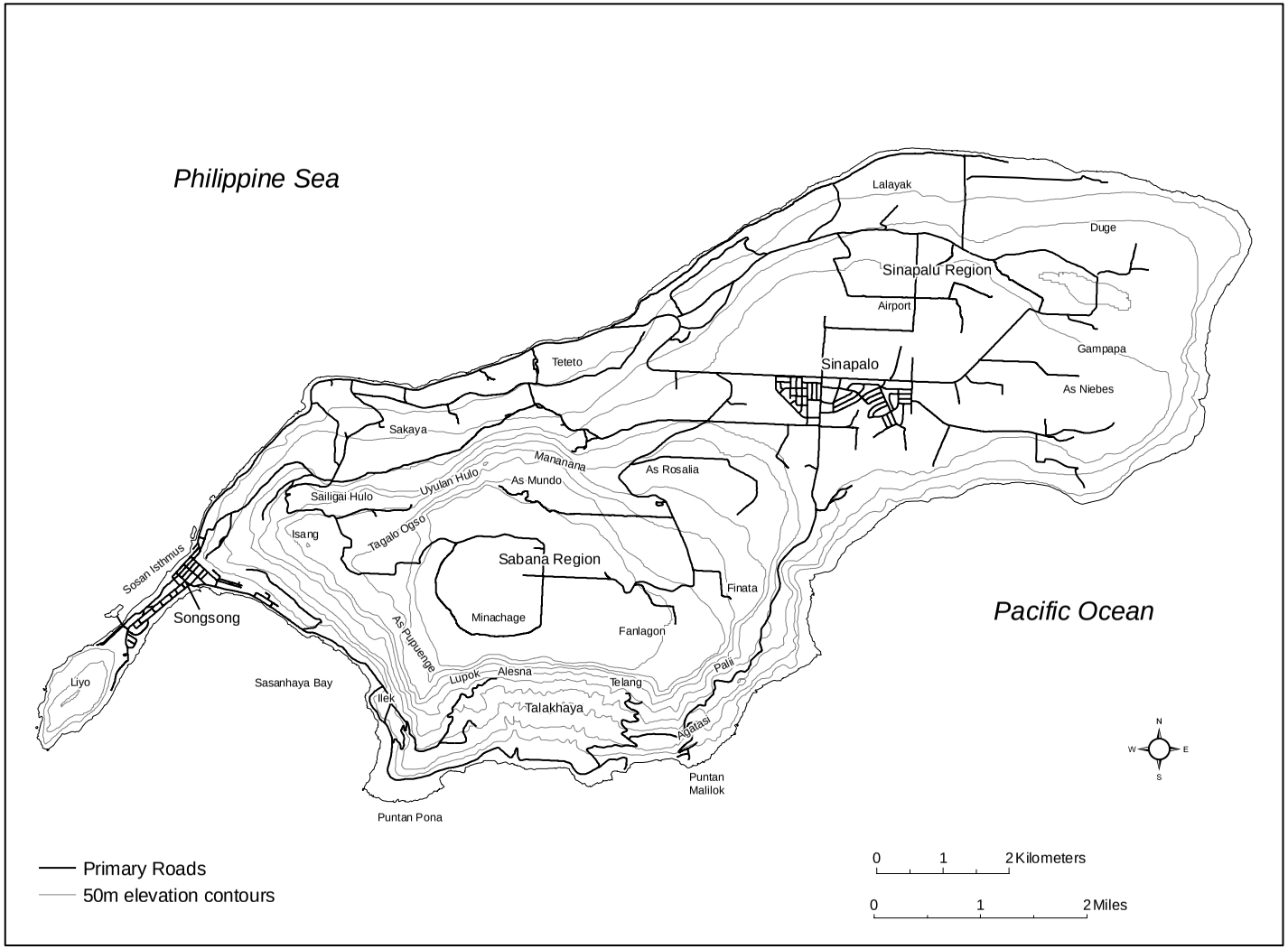


Figure 1. Location and composition of the Mariana archipelago.



Map produced by U.S. Fish & Wildlife Service, May 2005.

Figure 2. Regions of the island of Rota, Commonwealth of the Northern Mariana Islands.

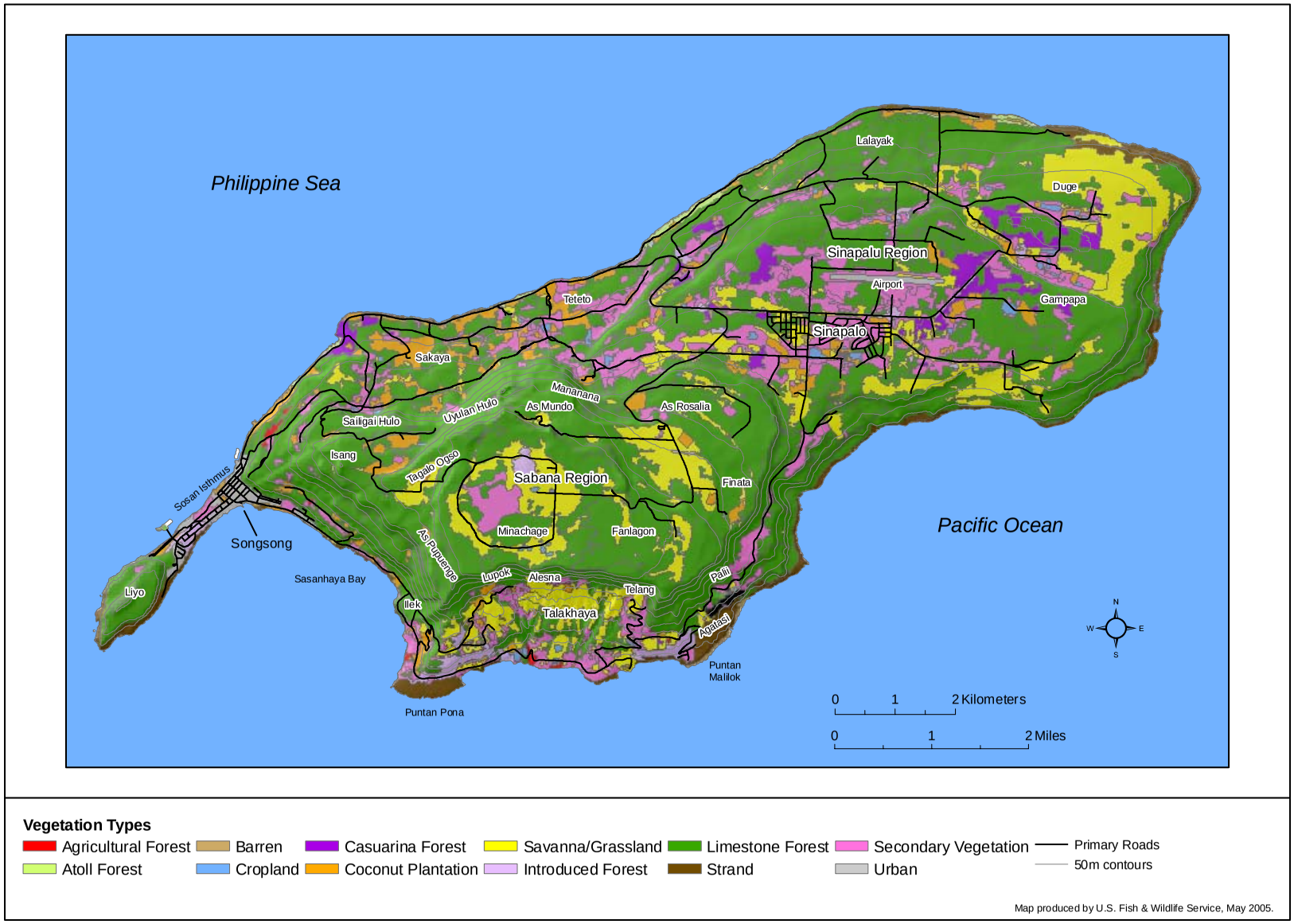


Figure 3. General vegetation types on the island of Rota

C. Species Description and Taxonomy

The nosa Luta is a sexually monomorphic (sexes outwardly similar in appearance) forest bird in the Family Zosteropidae, Order Passeriformes (Figure 4). The name white-eye is derived from the white ring of feathers around each eye. Their plumage is tinged with yellow, and their bill, legs, and feet are yellow-orange (Pratt *et al*. 1987). Wing, tail, and tarsal lengths taken from 21 adult birds averaged 5.6 centimeters (2.2 inches), 3.8 centimeters (1.5 inches), and 2.6 centimeters (1 inch), respectively (S. Derrickson, National Zoo, pers. comm. 1998). Average weights taken from these birds were 9.7 grams (0.34 ounces) for males and 9.2 grams (0.32 ounces) for females.

Figure 4. Rota bridled white-eye or nosa Luta. Photo courtesy of Lainie Berry ©, used with permission.

The nosa Luta was originally classified as one of three subspecies of bridled white-eye (*Zosterops conspicillatus*) found in the Mariana Islands. Stresemann (1931) described subspecies on the islands of Guam (*Z. c. conspicillatus*); Saipan, Tinian, and Aguiguan (*Z. c. saypani*); and Rota (*Z. c. rotensis*; hereby referred to as Guam and Saipan bridled white-eyes and nosa Luta respectively). However, based on recent genetic work (Slikas *et al*. 2000) and observed differences in plumage, vocalizations, and behavior (Pratt *et al*. 1987, Collar *et al*. 1994), the nosa Luta is now considered a full species.

The Saipan bridled white-eye is abundant and widespread on the islands of Saipan (2,221 birds per square kilometer; 5,695 birds per square mile), Tinian (2,931 birds per square kilometer; 7,591 birds per square mile), and Aguiguan (1,930 birds per square kilometer; 4,999 birds per square mile; Engbring *et al*. 1986). Historically, the Guam bridled white-eye was also believed to be abundant

and widespread (Jenkins 1983) although no island-wide surveys were ever completed. The Guam bridled white-eye was federally listed as endangered in 1984 but is now presumed extinct due to predation by the introduced brown treesnake (USFWS 1984, Wiles *et al*. 1995).

D. Population Trends and Distribution

Information about the nosa Luta's population and distribution prior to the late 1970s is limited. Oustalet (1895) described two nosa Luta collected by Marche in 1888 and Takatsukasa and Yamashina (1931) described 20 nosa Luta collected in 1931; however, none of the authors discussed the status of the population or its distribution on Rota. The first published account of the nosa Luta's status was provided by the Naval Medical Research Unit No. 2 expedition in 1945. The members of expedition collected three nosa Luta on "Sosan Isthmus" (also called Taipingot Peninsula) and two at "Mariiru Point" (also called Puntan Malilok) in October 1945 (Figure 2; Baker 1948). Although no surveys of the island were conducted, the report from the expedition states that nosa Luta were "numerous" (Baker 1948).

In 1989, staff from the CNMI Division of Fish and Wildlife (DFW) interviewed six long-time residents of Rota regarding their observations of nosa Luta in the 1950s and 1960s (J. Reichel, unpubl. data). Nosa Luta were reported to be abundant in Songsong Village (Figure 2) until the 1950s or early 1960s. Nosa Luta were also reported in the Sakaya, Telang, and Ilek regions until the 1950s or early 1960s and above the Teteto region in the 1930s (Figure 2). One resident also reported observing nosa Luta in the Gampapa region in the 1950s. However, another resident reported that nosa Luta did not occur in the As Niebes or Duge regions in the mid-1950s.

In 1976, ornithologists visiting Rota reported finding no nosa Luta in lowland areas and observed only three small flocks of nosa Luta in patches of scrubby forest in the Sabana region (Pratt *et al*. 1979). In 1979, Ralph and Sakai (1979) surveyed forest bird and Mariana fruit bat, or fanihi in Chamorro (*Pteropus mariannus mariannus*), populations on Rota over a 6.3-hour period. They observed 48 nosa Luta along a 6.9-kilometer (4.3-mile) transect and estimated the density of nosa Luta at 2.2 birds per hectare (0.9 birds per acre).

However, they did not report any observations on the nosa Luta's distribution. In 1980 and 1981, the Guam Division of Aquatic and Wildlife Resources (DAWR) conducted roadside bird surveys on Rota. They reported nosa Luta detections in the Sabana region but did not calculate density estimates (DAWR, unpubl. data).

The first off-road island-wide survey for forest birds on Rota was conducted in 1982. This survey estimated a population of 10,763 nosa Luta, with 93 percent of the population occurring in the Sabana region (Engbring *et al*. 1986). All but one detection were made above 200 meters (660 feet) in elevation. In 1987, Engbring (1987) conducted additional surveys of Rota's forest birds to evaluate changes in bird densities from the 1982 surveys. Engbring (1987) found a 26 percent reduction in mean number of nosa Luta detected per station between 1982 and 1987, but attributed this to poor survey conditions in 1987.

In 1988 and 1989, Engbring (1989) conducted roadside surveys on Rota to determine if an experimental control program to control the melon fly (*Dacus cucurbitae*), an agricultural pest, impacted bird populations. Engbring (1989) reported a decrease in the number of nosa Luta detected after melon fly control but was not certain if the decline was an actual decline in population or a result of survey conditions. Engbring (1989) did not associate the decline with the experimental control program, and no assessment of the status of the nosa Luta population was provided.

From 1989 to 1991, Craig and Taisacan (1994) conducted nosa Luta surveys along two transects with 33 stations in the Sabana region. They reported a mean of 0.9 birds per station on their two transects, compared to Engbring *et al*.'s (1986) mean of 4.0 birds per station over 66 stations in the Sabana region. This represents a 79 percent decline in the mean number of nosa Luta per station between surveys in 1982 and 1989 to 1990.

In 1994, the U.S. Fish and Wildlife Service (unpubl. data) conducted a survey in the Sabana region specifically for the nosa Luta. Surveys were conducted along five transects surveyed by Engbring *et al*. (1986) in 1982, one transect surveyed by Engbring (1987) in 1987, and six newly established transects. No population estimate was calculated; however, Ramsey and Harrod (1995) calculated a nosa Luta density of 155 birds per square kilometer (401 birds

per square mile) and estimated that the density had declined by 53 percent from the 1982 density estimates of 289 to 295 birds per square kilometer (748 to 764 birds per square mile) for the same survey area.

In 1996, Fancy and Snetsinger (2001) completed an off-road survey of the nosa Luta's population and range. They estimated a total population of 1,167 nosa Luta, with 94 percent of the population occurring in four areas totaling 254 hectares (628 acres; Figure 5) above 150 meters (490 feet) elevation. This estimate represents an 89 percent decline from the 1982 total population estimate of 10,763 birds. In 1998 and 1999, Amidon (2000) conducted bird surveys in 20 study blocks throughout the nosa Luta's range and estimated a total population of 1,092 nosa Luta, or an estimated 90 percent decline in the population since 1982.

In conclusion, the nosa Luta population has experienced a severe decline in both numbers and distribution over the last five decades. Due to the lack of comparable survey information it is not possible to accurately determine the decline of individuals over the full range of this time period. However, the number of individuals appears to have declined by approximately 90 percent since 1982. The population has also experienced an apparent decline in range based on observations of nosa Luta at lower elevations until the 1960s. Since the late 1970s and 1980s until today the nosa Luta has been regularly reported only at high elevations (greater than 150 meters [490 feet]) in the Sabana region of Rota.

E. Life History

1. Behavior

Nosa Luta have been observed making several vocalizations. The most commonly observed vocalization is a call that Pratt *et al*. (1987) described as "a low-pitched *tsheip*." They have also been observed giving a scolding alarm call, often in response to collared kingfishers, or sihek[2] (*Halcyon chloris*); and have been observed singing in the upper branches of canopy trees (Amidon 2000).

[2] Note that "sihek" is a generic Chamorro term for kingfishers. In this plan, "sihek" refers to the collared kingfisher, *Halcyon chloris*, and should not be confused with the endangered Guam Micronesian kingfisher *Halcyon cinnamomina cinnamomina*, which is also referred to as sihek.

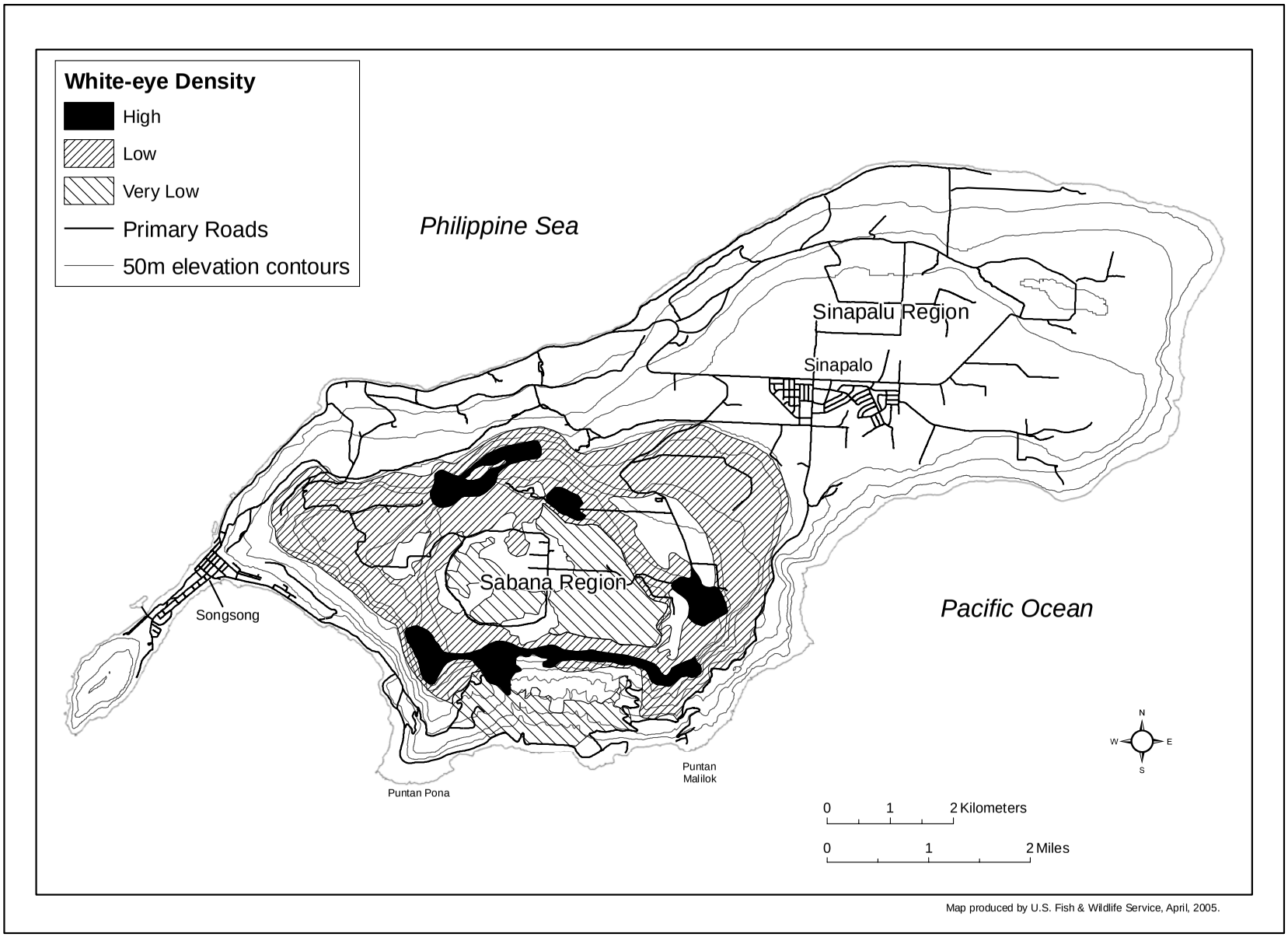


Figure 5. Distribution and densities of nosa on the island of Rota.

Like many of the white-eyes in the family Zosteropidae, nosa Luta are gregarious and are often observed in small groups. These groups typically consist of two to three birds (53 percent, n = 154) and sometimes include rufous fantails, or na'abak in Chamorro (*Rhipidura rufifrons*; Amidon 2000). Based on observations of frequent food begging and mutual preening or allopreening, Craig and Taisacan (1994) and Amidon (2000) believed that these small groups were composed of related individuals. Larger groups of 4 to 5 birds are observed occasionally (18 percent, n = 154) and groups of up to 14 birds are observed very rarely (1 percent, n = 154; Amidon 2000). In contrast, Craig (1989) typically observed Saipan bridled white-eyes in flocks of 10 to 40 individuals. Historically, nosa Luta group sizes were reported to be larger and available evidence indicates that group sizes have decreased as the population declined (Craig and Taisacan 1994, Fancy and Snetsinger 2001).

2. Reproduction

Observations of breeding activity indicate that nosa Luta breed from at least December to August (Lusk and Taisacan 1997; Amidon *et al*. 2004). However, the species may breed year-round, as was reported for the Guam bridled white-eye (Marshall 1949, Jenkins 1983), because nesting has been observed in both the wet and dry seasons. Nosa Luta nests are cup-like and typically suspended between branches and branchlets or leaf petioles (Yamashina 1932, Lusk and Taisacan 1997, Amidon *et al*. 2004). However, one nest was observed suspended from pugua-machena (*Davallia solida*) ferns below the branch of a tree (Amidon *et al*. 2004). Nests appear to be composed of rootlets, woven grass or *Pandanus* spp. fibers, spider webs, light green moss, and a yellow, cottony material (Yamashina 1932, Lusk and Taisacan 1997, Amidon *et al*. 2004). The inner cup appears to be of woven grass or *Pandanus* spp. fibers. Nest dimensions have been recorded for six nests (Yamashina 1932, Lusk and Taisacan 1997, Amidon *et al*. 2004). Mean nest height was 43.2 millimeters (1.7 inches; range 36.0 to 50.0 millimeters [1.4 to 2.0 inches]) and mean cup depth was 28.5 millimeters (1.1 inches; range 25.0 to 30.0 millimeters [1.0 to 1.2 inches]). Mean cup diameter was 43.9 millimeters (1.7 inches; range 44.6 to 50.0 millimeters [1.7 to 2.0 inches]) and mean nest diameter was 62.6 millimeters (2.4 inches; range 57.7 to 70.0 millimeters [2.3 to 2.7 inches]).

Nosa Luta have been reported nesting in the native tree species oschal (*Hernandia labyrinthica*; n = 9), faniok (*Merrilliodendron megacarpum*; n = 27), and yoga (*Elaeocarpus joga*; n = 7), and in the introduced tree species sosugi (*Acacia confusa*; n = 3) between approximately 150 and 460 meters (492 and 1,510 feet) elevation (Lusk and Taisacan 1997; Amidon *et al*. 2004; E. Taisacan, DFW-retired, pers. comm. 2005; F. Amidon, USFWS, unpubl. data). Pratt (1985) also reported finding a nest in a *Hernandia* sp. (presumably *H. labyrinthica* based on the location where the nest was found). The mean distance of 23 nests from the ground was 7.7 meters (25.3 feet; range 2.5 to 12.8 meters [8.2 to 42.0 feet]). The mean height of 18 nest trees was 10.1 meters (33.1 feet; range 3.3 to 14.6 meters [10.8 to 47.9 feet]) and the mean diameter at breast height for 19 nest trees was 28.2 centimeters (11.1 inches; range 2.3 to 60.2 centimeters [0.9 to 23.7 inches]). Mean distances of 19 nests from the trunk of the nest tree was 3.0 meters (9.8 feet; range 0.8 to 6.7 meters [2.6 to 22.0 feet]).

Both male and female nosa Luta incubate, brood, and feed nestlings (Amidon *et al.* 2004). Eggs are light blue and clutch sizes of one to two eggs have been observed (Yamashina 1932, Amidon *et al*. 2004), though clutch sizes of three eggs are possible based on observed clutch sizes for bridled white-eyes on Guam, Tinian, and Saipan (Hartert 1898, Yamashina 1932, Sachtleben 2005). Observations of seven active nests indicate that incubation and nestling periods appeared to be at least 10 and as long as 12 days for nosa Luta (Amidon *et al*. 2004). Sachtleben (2005) reported a 9 to 12 day incubation period and an 11 to 14 day nestling period for the Saipan bridled white-eye. The incubation and nestling periods reported for the green-bellied white-eye (*Zosterops pallidus*) and Japanese white-eye (*Z. japonicus*) were both 10 to 12 days (Broekhuysen and Winterbottom 1968, Isobe 1997) while the incubation and nestling periods for the silvereye (*Z. lateralis*) were 10 to 14 days each (Kikkawa and Wilson 1983). The post-fledging parental attendance period is unknown, but observations of one banded nestling indicate it is at least 8 days (Amidon *et al*. 2004). The estimated durations of post-fledging parental care are approximately 2 weeks for the silvereye (Kikkawa and Wilson 1983) and 15 to 20 days for the Japanese white-eye (van Riper 2000).

3. Food Habits

Very little is known about the food habitats of nosa Luta. They are believed to feed primarily on insects; however, they have been observed foraging on the fruits of amahadyan (*Pipturus argenteus*) and pengua (*Macaranga thompsonii*) trees and probing the flowers, presumably to feed on nectar, of *Elaeocarpus joga*, *Hernandia labyrinthica*, *Macaranga thompsonii*, avocado (*Persea americana*), ahgao (*Premna obtusifolia*), and atoto (*Eugenia thompsonii*) trees (F. Amidon, unpubl. data).

Nosa Luta forage primarily by gleaning insects from leaves and branches of trees (Craig and Taisacan 1994, Amidon 2000). However, they have been observed sallying for insects, probing flowers for insects or pollen, and searching for food in epiphytes and moss (Amidon 2000; F. Amidon, unpubl. data). Nosa Luta typically forage in the outer layer of canopy trees on perches less than 1.0 centimeter (0.4 inches) in diameter (Craig and Taisacan 1994, Amidon 2000). Of 97 nosa Luta foraging observations, the majority were reported in *Elaeocarpus joga* (34 percent), *Hernandia labyrinthica* (13 percent), *Macaranga thompsonii* (10 percent), *Merrilliodendron megacarpum* (9 percent), and *Premna obtusifolia* (9 percent; Amidon 2000; F. Amidon, unpubl. data). However, nosa Luta were also recorded foraging in *Pipturus argenteus*, *Persea americana*, panao (*Guettarda speciosa*), hodda (*Ficus tinctoria*), *Acacia confusa*, mapunyao (*Aglaia mariannensis*), *Eugenia thompsonii*, nunu (*Ficus prolixa*), sumac-lada (*Tarenna sambucina*), and faniok (*Tristiropsis obtusangula* [note same common name as *Merrilliodendron megacarpum*]) trees (F. Amidon, unpubl. data).

Similar to the nosa Luta, Craig (1996) recorded Saipan bridled white-eyes foraging on invertebrates and the seeds, nectar, flowers, and the fruit of 22 native and introduced plant species. Saipan bridled white-eyes forage primarily by gleaning insects from leaves in the outer canopy of limestone and tangantangan (*Leucaena leucocephala*) forests (Craig 1989). However, they have been observed hovering and sallying for insects and probing flowers, apparently for nectar; bark; dead and rolled leaves; and passionfruit (*Passiflora foetida*; Craig 1989). In addition, Saipan bridled white-eye have been observed foraging in the understory of forests, on the ground, and in beggar tick (*Bidens pilosa*) and swordgrass (*Miscanthus floridulus*; Craig 1989, 1996).

F. Habitat Requirements

There has been little research on the habitat requirements of the nosa Luta. Therefore, it is not possible to present a detailed analysis of their habitat needs. However, general habitat associations for the nosa Luta population since 1982 can be inferred from survey data and the results of research by Amidon (2000).

Since the first island-wide forest bird survey in 1982, nosa Luta have been recorded primarily above 150 meters (490 feet) elevation in the Sabana region of Rota (Engbring *et al*. 1986, Engbring 1987, Engbring 1989, Amidon 2000, Fancy and Snetsinger 2001, USFWS unpubl. data). Sightings of nosa Luta have been recorded in limestone forest, introduced *Acacia confusa* forest, introduced *Leucaena leucocephala* forest, and secondary vegetation (Craig and Taisacan 1994; Amidon 2000; Fancy and Snetsinger 2001; F. Amidon, unpubl. data). However, the majority of the nosa Luta sightings have been recorded in limestone forest. For example, of the survey stations where nosa Luta were detected in 1982 (n = 44; Engbring *et al*. 1986) and 1987 (n = 24; Engbring 1987), 89 percent (n = 39) of the stations in 1982 and 79 percent (n = 19) of the stations in 1987 were classified as limestone forest within 50 meters (160 feet) of the survey station by Falanruw *et al*. (1989). Of the remaining stations with nosa Luta detections in 1982, 8 percent (n = 4) were in areas with mixed vegetation types that included some limestone forest and 2 percent (n = 1) were in other forest habitat types (e.g., coconut palm [*Cocos nucifera*] plantation and secondary vegetation). Of the remaining stations with nosa Luta detections in 1987, 21 percent (n = 5) were in areas with mixed vegetation types that included some limestone forest. Further, of the stations with nosa Luta detections in limestone forest in 1982 (n = 39) and 1987 (n = 19), over 60 percent of the areas were dominated by mature limestone forest with large diameter trees (greater than 30 centimeters [11.8 inches] diameter at breast height), high density, and over 70 percent canopy cover (Falanruw *et al*. 1989). A similar pattern was also observed in the 1996 survey by Fancy and Snetsinger (2001) where 73 percent of the nosa Luta locations (n = 62) were recorded in areas classified as mature limestone forest by Falanruw *et al*. (1989).

In 1998 and 1999, nosa Luta habitat relationships were assessed within their current range and across the Sabana region as part of a 2-year study by

Amidon (2000). Forested areas with high densities of nosa Luta (greater than or equal to 2 birds per hectare [5 birds per acre]) had higher densities of epiphytic plants, such as galak (*Asplenium nidus*) and *Davallia solida*, and were primarily composed of *Elaeocarpus joga*, *Hernandia labyrinthica*, *Merrilliodendron megacarpum*, kafu (*Pandanus tectorius*), and *Premna obtusifolia* trees. Other tree species that were regularly recorded in nosa Luta high density areas include *Aglaia mariannensis*, lemai (*Artocarpus atilis*), *Ficus prolixa*, *Ficus tinctoria*, *Guettarda speciosa*, *Macaranga thompsonii*, and *Pisonia umbellifera*. Across their range, nosa Luta were found to be more abundant in areas with higher densities of *Elaeocarpus joga* and high foliage volume. Nosa Luta abundance was also found to have a positive relationship with abundance of *Merrilliodendron megacarpum*. Across the Sabana, nosa Luta were found to be more abundant in areas with high densities of *Hernandia labyrinthica* and where the groundcover species tupunayuyu (*Elatostema* and *Procris* spp.) were present.

G. Critical Habitat

The designation of critical habitat for the nosa Luta was proposed in September 2005 (USFWS 2005). Based on our current knowledge of the life history, biology, and ecology of the nosa Luta, we identified those physical and biological features (primary constituent elements) that we understand to be essential to the conservation of the species. The primary constituent elements for the nosa Luta are:

- Forest above 150 meters (490 feet) elevation containing a midstory and canopy layer, high epiphytic plant volume (typically 11 percent), *Elatostema* and *Procris* spp. on the ground, and yoga, oschal, faniok, kafu, and/or ahgao trees as dominant forest components for foraging, sheltering, roosting, nesting, and/or rearing of young. In addition, the following specific forest components should be present:
    - Yoga, oschal, faniok, pengua, ahgao, amahadyan, avocado, hodda, mapunyao, atoto, sosugi, and/or sumac-lada trees, and/or piao, in the canopy or subcanopy for foraging; and
    - Yoga, oschal, faniok, and/or sosugi trees 3 to 15 meters (10 to 49 feet) tall and 2 to 60 centimeters (1 to 24 inches) diameter at breast height for nesting.

The final rule designating critical habitat is due to the Federal Register in September 2006.

H. Reasons for Decline and Current Threats

In determining whether to list, delist, or reclassify (change from endangered to threatened status, or *vice versa*) a taxon under the Endangered Species Act, we evaluate the role of five factors potentially affecting the species. These factors are:

(A) the present or threatened destruction, modification, of curtailment of its habitat or range;
(B) overutilization for commercial, recreational, scientific, or educational purposes;
(C) disease or predation;
(D) the inadequacy of existing regulatory mechanisms; and
(E) other natural or manmade factors affecting its continued existence.

Among the factors believed to threaten the nosa Luta are: habitat loss or degradation (factor A); predation by introduced rats, black drongos, and other predators (factor C); the accidental introduction of new predators, such as brown treesnakes (factor C); avian disease (factor C); pesticides (factor E); and random catastrophic events, such as typhoons, which may affect the core range of the species and lead to its extinction (factor E). Of these factors, habitat loss and degradation and predation by introduced species are currently believed to be the primary factors in the population decline and core range restriction of the nosa Luta. Currently, overutilization of nosa Luta for commercial, recreational, scientific, or education purposes (factor B) is not known to be a threat. Existing regulatory mechanisms (factor D) also appear adequate, as the nosa Luta is listed as endangered by the Federal government.

1. Habitat Loss and Degradation

According to Kanehira (1936), the island of Rota was covered in impenetrable forest in 1932. By 1935, however, Kanehira found most of the island cleared for sugar cane planting (Figure 6). Clearing for other agricultural activities and phosphate mining (Figure 6) also occurred during the Japanese Administration of

the CNMI (1914 to 1944). Areas where the soil was too thin for agriculture or the terrain was too steep were not cleared (Fosberg 1960). During World War II, Rota was not invaded by U.S. forces but was heavily bombed (Engbring *et al*. 1986). By 1946, approximately one-fourth of the total area of Rota was covered by native forest which was broken into small parcels or located along cliffs (Figure 7; Fosberg 1960). After 1946, many of the cleared areas reverted back to native forest through natural regeneration and by the mid-1980s, Falanruw *et al*. (1989) reported that 60 percent of the island was composed of native forest, although a significant portion of this was in an altered condition. The majority of the mature native forest was found along the cliffs of the Sabana region, with the forest on level portions of the island being mostly secondary growth (see Figure 3). Currently, the amount of native forest remaining on Rota is believed to cover less than 60 percent of the island due to homestead and resort development over the last two decades.

The majority of the development on Rota over the last several decades has occurred at lower elevations in the Duge, Gampapa, and Agusan areas of Rota. The majority of the native forest at high elevations in the Sabana region has not been subjected to recent development and large-scale land clearing due to the rugged topography. However, the forests, especially mature native forest, in this region have been degraded or lost due to typhoon damage and subsequent changes in forest structure (Fancy and Snetsinger 2001; J. Morton, USFWS, pers. comm. 2003; E. Taisacan, pers. comm. 2005). Unfortunately, the extent of these changes were not well documented with vegetation surveys. However, it appears that large areas of mature native forest are being converted into *Pandanus tectorius* thickets as canopy trees are damaged during typhoons and then die off. These thickets, along with browsing by introduced Philippine deer, or binadu (*Cervus mariannus*), may be impacting natural regeneration of these forests. This in turn may be limiting the distribution of nosa Luta by reducing the availability of mature native forest in the Sabana region (see Habitat Requirements).

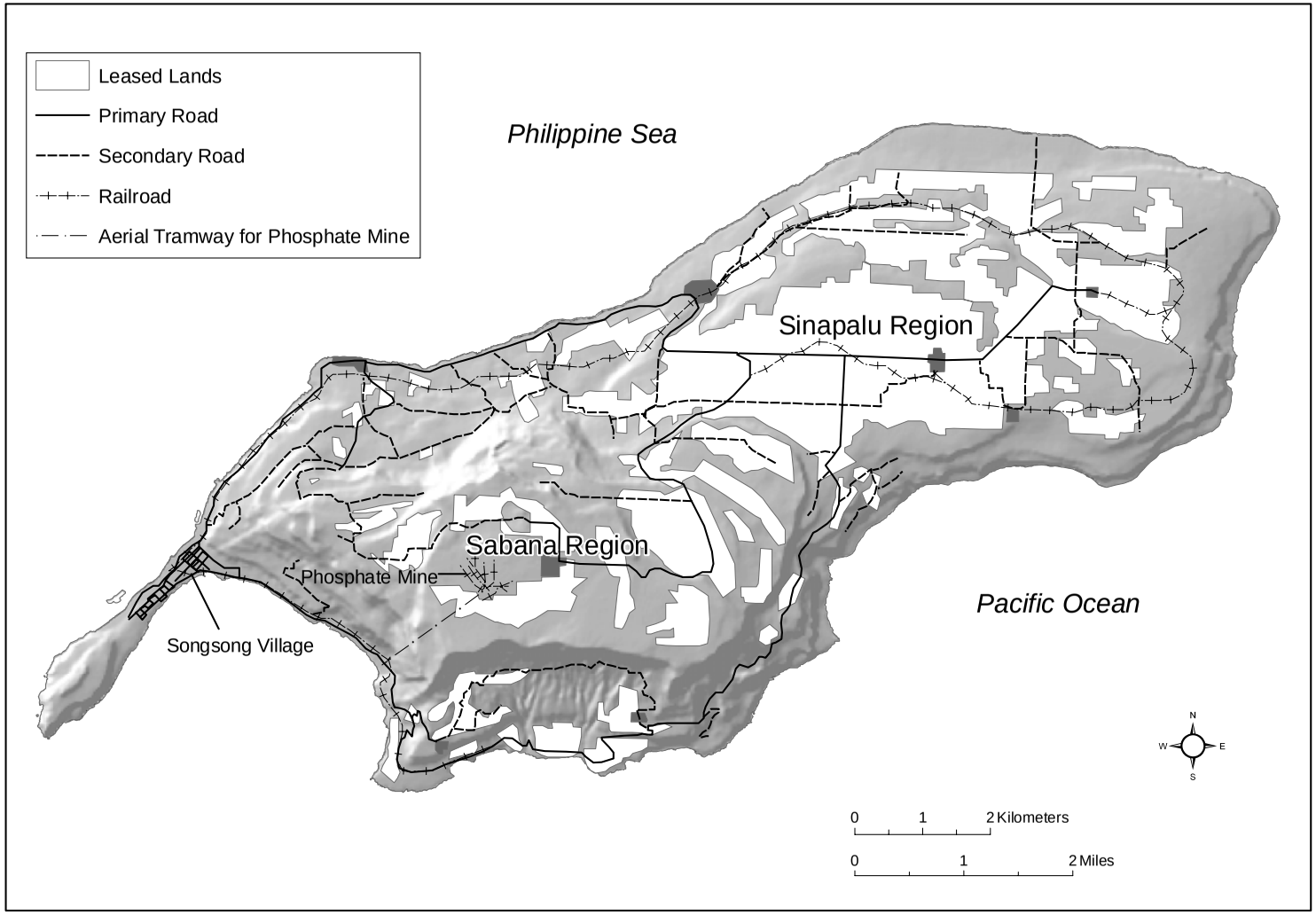


Figure 6. Approximate location of land leased for sugar cane harvesting and phosphate mining operations in 1937. Adapted from Bowers (1950).

2. Avian Disease

Avian malaria and pox have been important factors in the decline of Hawaii's avifauna (Warner 1968, Van Riper *et al*. 1986). The impact of avian disease on the nosa Luta and other native forest birds on Rota is uncertain due to the lack of formal studies. Research on the role of avian disease in the decline of native forest birds on Guam did not identify disease as an important factor (Savidge *et al*. 1992). However, the presence of avian disease has been noted in white-eye populations on Saipan and Tinian (Marshall 1949, Savidge 1986). Savidge (1986) reported during her sentinel studies for work on Guam that of the 63 Saipan bridled white-eyes collected from Saipan, 2 were infected with *Plasmodium* (avian malaria), and 46 were infected with *Haemoproteus*, a red blood cell parasite. Savidge also reported that one Saipan bridled white-eye developed pox-like lesions, but the lesions resolved. In 1993 and 1995, 20 nosa Luta were collected as part of the Mariana Archipelago Rescue and Survey Project (see Conservation Efforts), and screened for avian diseases. No evidence of avian pox, malaria, or other serious disease was reported (G. Olsen, U.S. Geological Survey, Biological Resource Discipline [BRD], pers. comm. 2000).

West Nile virus may pose a significant risk to the nosa Luta if it reaches the Pacific rim. Research indicates that the Japanese white-eye is highly susceptible to West Nile virus (R. Rameyer, BRD, pers. comm. 2005). As a member of the same genus (*Zosterops*), the nosa Luta is also expected to be susceptible. Also, as of January 2005, West Nile virus has been detected in 138 bird species, from 47 states and the District of Columbia and Puerto Rico (CDC 2005). In addition, ribonucleic acid (RNA) of West Nile virus had been detected in 21 mosquito species from 11 genera (*Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Culiseta*, *Deinocerites*, *Mansonia*, *Ochlerotatus*, *Orthopodomyia*, *Psorophora*, and *Uranotaenia*). Three of these mosquito genera that are potential carriers of the virus (*Aedes*, *Anopheles*, and *Culex*) have been reported in the Mariana Islands (Swezey 1942, Bohart 1956, Nowell and Sutton 1977, Savage *et al*. 1993). In an effort to prevent the introduction of West Nile virus to the Mariana Islands, the CNMI and Guam Departments of Agriculture have implemented testing and quarantine requirements for all avian importations (A. Pangelinan, *in litt.* 2003; J. Burgett, USFWS, pers. comm. 2005).

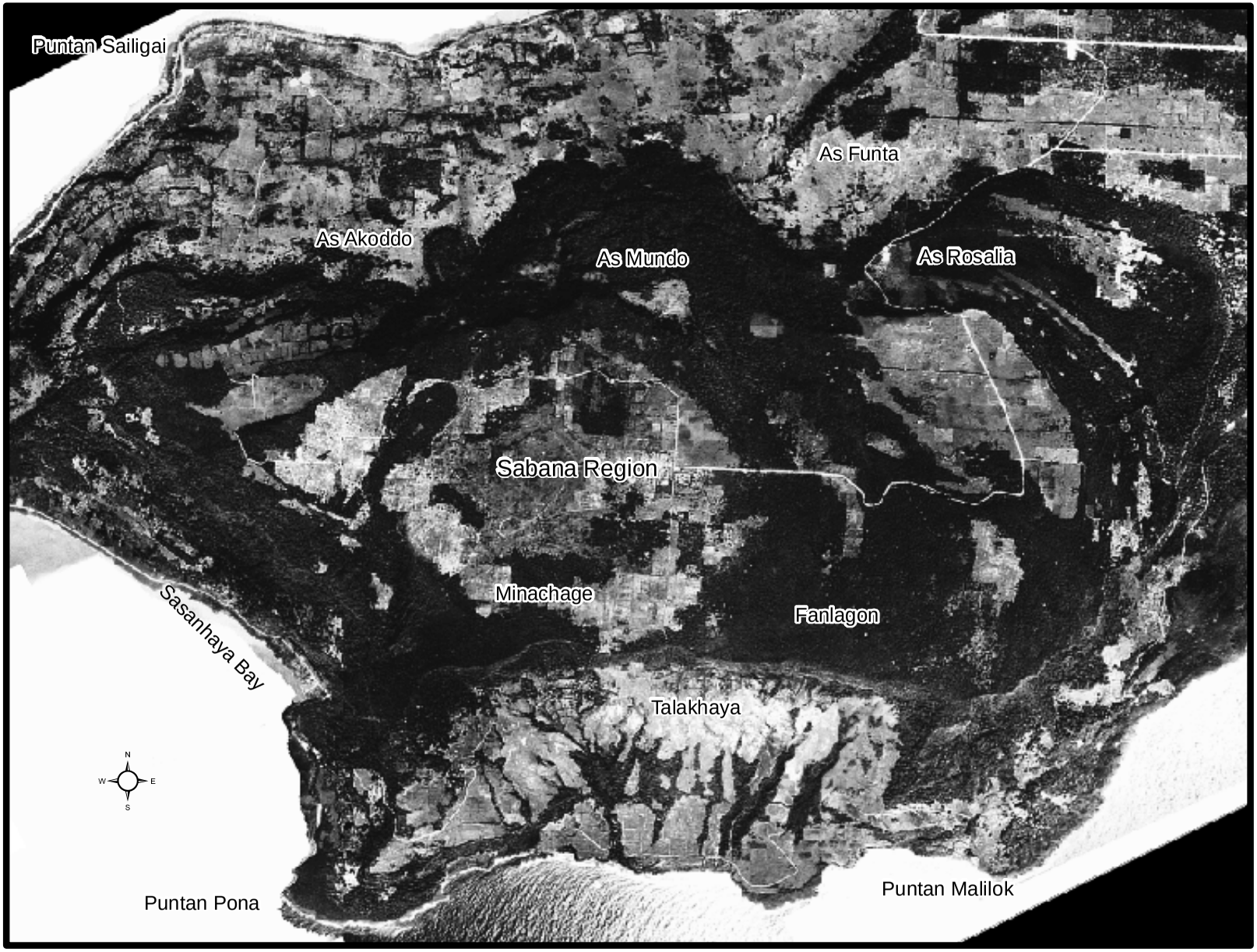


Figure 7. Composite of aerial photographs of the Sabana Region taken in 1946.

3. Predation

a) Black Drongos

The black drongo is a medium sized, all black, bird with a deeply forked tail (Figure 8). They are thought to have been introduced to Rota from Taiwan in 1935 by the Japanese South Seas Development Company to control destructive insects (Baker 1951). Black drongos are also thought to have colonized the neighboring island of Guam on their own in the 1960s (Drahos 2002). Black drongos are primarily insectivorous and typically forage from exposed perches in open areas (Ali and Ripley 1972, Maben 1982). However, black drongos have also been observed eating small birds, including rufous fantails (Drahos 2002, Engbring *et al*. 1986); Mariana swiftlets, or chachaguak (*Aerodramus bartschi*, also federally listed as endangered; Perez 1968); Eurasian tree sparrows (*Passer montanus*; Maben 1982; USFWS, unpubl. data), and nosa Luta (F. Amidon, in prep; discussed below) in the Mariana Islands.

Figure 8. Black drongos in the Pekngasu region of Rota in 2005.

Predation of nosa Luta by black drongos has been proposed to be one of the primary factors in the population decline and range restriction of the nosa Luta (Craig and Taisacan 1994). However, not all researchers agree that black drongos played an important role (Fancy and Snetsinger 2001). Maben (1982) conducted

a study to investigate the possible role of black drongos in the decline of forest birds on Guam. She concluded that it was doubtful that black drongos regularly eat small birds, but also that they could have a local impact on severely depressed populations of such birds. Currently, the one observation of a black drongo eating a nosa Luta by Amidon (in prep.) in 1998 is the only reported observation of black drongo predation on nosa Luta.

Engbring *et al*. (1986) estimated a total of 5,752 black drongos on Rota in 1982. However, surveys in 2003 estimated that the black drongo detections at survey stations have declined by at least 30 percent from the 1982 estimate (Amar *et al*., in review). The cause of this decline is not certain. Reviews of bird survey data on Rota indicate that black drongo detections on the Sabana, the current range of the nosa Luta, are significantly lower than other areas of the island (Amidon 2000). However, black drongo abundance along four transects on the Sabana has significantly increased from 1982 to 1994 while detections of nosa Luta have shown a significant decline during that period (Amidon 2000).

b) Rats

In New Zealand and other Pacific Islands, introduced rats have been found to be important predators of native birds, to the point where they are believed to have caused population declines and the extinction of native species (Atkinson 1985, Robertson *et al*. 1994). Marshall (1962) reported that two species of introduced rat, the black rat (*Rattus rattus*) and Polynesian rat (*Rattus exulans*), occur on the island of Rota. Both of these species were likely introduced to Rota during or prior to the Spanish Administration of the Mariana Islands (1521 to 1898; Johnson 1962). However, Flannery (1995) reported that the black rat is not found in Micronesia, including the Mariana Islands, because it has been excluded by the introduced Asian house rat (*Rattus tanezumi*), which has occurred in Micronesia for over 1,000 years. Whether the rats found on Rota include the Asian house rat and/or black rat is unclear and additional research is needed.

The impact of these introduced rats on the nosa Luta population is also uncertain. Of eight active nosa Luta nests observed in 1999, two were presumed to have been abandoned or predated by an unknown predator while the remaining six nests successfully fledged chicks (F. Amidon, unpubl. data). Surveillance of

six active nests in 2003 and 2004 using video cameras indicate that at least one nest was predated by rats, two nests were predated by other potential predators (unidentified black bird and unknown predator), and three nests successfully fledged young (Kremer and Williams 2003, 2004; E. Taisacan, pers. comm. 2005). Amidon (2000) compared differences in rat densities between the nosa Luta's current range and different areas at lower elevations on the island and found no difference in rat densities. However, the species of rats were not identified in this study so differences in rat densities by species could not be determined. Interestingly, a 2-year study on forest bird nest predators on Saipan did not indicate that rats are major nest predators on forest birds (Sachtleben 2005). Instead, native nest predators such as Micronesian starlings, or sali (*Aplonis opaca*), and collared kingfishers were found to have more impact on nest success. A similar nest predator scenario may also be occurring on Rota; however, specific research on nosa Luta nests is needed to determine if this is the case.

c) Brown Treesnake

The brown treesnake is believed to have been accidentally introduced to Guam from an island near New Guinea (Manus) prior to 1950 (Savidge 1987, Rodda *et al.* 1992). By 1988, the brown treesnake had eliminated most of the native birds on Guam, including the Guam bridled white-eye (Savidge 1987); as well as many other native and exotic species (Fritts and Rodda 1998). Brown treesnakes are not believed to be established on Rota at this time and are not believed to be impacting the nosa Luta population. As of April 2005, the only snake sightings on Rota were of two dead snakes found in cargo arriving on Rota (N. Hawley, DFW, pers. comm. 2005). However, the accidental introduction of brown treesnakes is a constant threat due to cargo and flights from Guam to Rota. Saipan has also reported a large number of brown treesnake sightings and shipments from Saipan to Rota may also be a potential threat as well. Since 1986, more than 74 credible snake sightings have been reported on Saipan and 11 snakes were recovered from these sightings (N. Hawley, DFW, pers. comm. 2005). Also, in 2005, an expert panel set up to review the brown treesnake situation in the Pacific determined that an incipient population of brown treesnake is present on Saipan (Colvin *et al.* 2005).

The establishment of a brown treesnake population on Rota would be expected to completely extirpate the nosa Luta population. Wiles and others (2003) assessed the impacts of brown treesnakes on bird population declines on Guam and found that small forest dwelling birds, like the Guam bridled white-eye, were the first to be extirpated. They also calculated that populations declined by greater than or equal to 90 percent for 13 bird species over an average period of 8.9 years in northern Guam. In addition, over an average of 11.2 years, 10 bird species with substantial populations in northern Guam, including the Guam bridled white-eye, were completely extirpated. For southern Guam, it was estimated that all native forest birds, except for the Mariana swiftlet and Micronesian starling, were extirpated over a period of 27 to 32 years after the snake was introduced to the island. Because Rota is smaller, approximately a quarter of the size of northern (234 square kilometers [145 square miles]) and southern Guam (304 square kilometers [189 square miles]), it is expected that the forest birds on Rota, including the nosa Luta, would be extirpated more rapidly than was observed on Guam if the brown treesnake should become established on Rota.

d) Other Predators

In addition to black drongos, rats, and brown treesnakes, other potential nosa Luta predators include feral cats, or katu (*Felis cattus*); monitor lizards, or hilitai (*Varanus indicus*); collared kingfishers; Micronesian starlings; and Mariana crows, or aga (*Corvus kubaryi*). Both feral cats and monitor lizards are believed to have been introduced to Rota (Steadman 1999). Mariana crows, collared kingfishers, and Micronesian starlings are all native to Rota. The Mariana crow is also federally listed as an endangered species.

Researchers have documented cat predation of forest birds (e.g., van Riper 1978, Tomich 1981, Churcher and Lawton 1987, Woods *et al*. 2003) and sizable feral cat populations are believed to occur on Rota (P. Wenninger, DAWR, pers. comm. 2005). Feral cats may occasionally prey upon nosa Luta when the birds forage close to the ground, but the extent of their impact is unknown. Monitor lizard predation on forest birds is not well documented and their impact on nosa Luta populations is also unknown. Monitor lizards have been reported predating Mariana crow nests on Guam (Aguon and Henderson 1998).

In 2003, video surveillance of a nosa Luta nest documented a predation event by an unidentified black bird, potentially a Mariana crow or Micronesian starling (Kremer and Williams 2004). Currently, Mariana crows are not very common in the Sabana region (Morton *et al.* 1999) and the ranges of the nosa Luta and Mariana crow overlap only along the slopes of the Sabana. Therefore, the effect of Mariana crows on nosa Luta may be limited to infrequent nest predation. Micronesian starlings have been documented to be important predators of forest bird nests on Saipan (Sachtleben 2005) and may also be important nosa Luta nest predators (T. Sachtleben, Colorado State University, pers. comm. 2004). However, their impact on nosa Luta nesting success is unknown at this time. Collared kingfishers have been documented preying on adult or fledgling Saipan bridled white-eyes (Craig 1996) and may also predate their nests (Sachtleben 2005). Collared kingfishers have been observed chasing nosa Luta (F. Amidon, unpubl. data) but no predation events have been documented. However, based on observations of Saipan bridled white-eyes, collared kingfisher predation on nosa Luta adults and nests is also likely. Interestingly, Amidon (2000) analyzed previously collected survey data and reported significant increases in collared kingfisher and Micronesian starling abundances concurrent with a significant decline of nosa Luta abundance along four transects on the Sabana between 1982 and 1994. It is possible that the increase in collared kingfishers and Micronesian starlings in the Sabana region may have contributed to the decline of nosa Luta.

4. Pesticides

Currently, pesticides are not believed to be a threat to the nosa Luta. However, pesticide use may have played some role in the extirpation of the endangered Mariana swiftlet and the sheath-tailed bat, or payesyes (*Emballonura semicaudata rotensis*), from Rota in the 1960s and 1970s (Engbring *et al.* 1986, Lemke 1986). It is also possible that pesticide use may have played some role in the decline and core range restriction of the nosa Luta. For example, the insecticide malathion was sprayed on Rota in 1989 to control the melon fly. Bird survey data at the time did not indicate that the spraying of this insecticide had any impact on bird populations (Engbring 1989). However, the timing of the insecticide application coincides with the decline and range restriction of the nosa Luta between 1982 and 1994 and may have played some role. Also, the apparent restriction in range of the nosa Luta after the 1960s also coincides with the

extirpation of the Mariana swiftlet and sheath-tailed bat. Therefore, large-scale application of pesticides may have impacted the species in the past.

5. Typhoons

Typhoons are a common occurrence in the Mariana Islands. Guam, for example, has been affected by typhoons in 37 of the last 50 years (based on records compiled by U.S. Navy, Joint Typhoon Warning Center) and supertyphoons[3] occur with regularity (about once every 5 to 10 years). There is some evidence that the frequency of severe storms[4] is increasing in the Mariana Islands. With reference to Guam, the historical record shows increasing numbers of mild[5] and severe storms over the last three centuries (Figure 9), as well as in just the last decade (Figure 10). While some underreporting of storms may have occurred in prior centuries, even mild storms were noticed in the colonial era because they destroyed the relatively flimsy structures used for early housing. Furthermore, these data are consistent with trends expected on the basis of increasing sea surface temperatures that have been documented in recent years (*e.g.,* Strong *et al*. 1998; U.S. Department of State 1999).

Typhoons have both direct and indirect effects on birds (Wiley and Wunderle 1993). Direct effects include loss of nests, eggs, and nestlings from high winds or death from exposure to high winds and rain. Indirect effects include the loss or reduction of foraging resources or substrates, increased predation due to the temporary loss of cover, and long-term changes in habitat suitability.

How these direct and indirect impacts specifically affect nosa Luta populations is uncertain due to the lack of data specific to this species. However, nest failure due to typhoons has been reported for the Mariana crow (Morton *et al*. 1999) and likely occurs with nosa Luta as well. Declines in populations of nectivorous and frugivorous birds have been reported in St. John (Askins and Ewert 1991), St. Croix (Wauer and Wunderle 1992), Yucatan (Lynch1991), and

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[3] A "supertyphoon" is a category of severe storm, defined as having gusts exceeding 240 kilometers (150 miles) per hour.
[4] A severe storm has estimated gusts exceeding 160 kilometers (100 miles) per hour.
[5] A mild storm has estimated gusts in the range of 80 to 160 kilometers (50 to 100 miles) per hour.

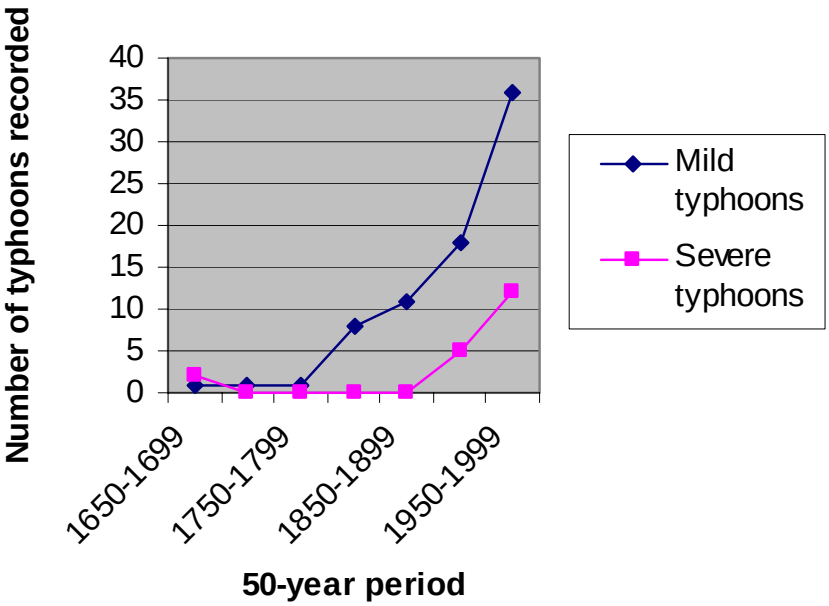

Figure 9. Historical record of mild typhoons (80 kph [50 mph] < estimated gusts < 160 kph [100 mph]) and severe (estimated gusts > 160 kph [100 mph]) typhoons recorded at the U. S. Navy Joint Typhoon Warning Center for Guam.

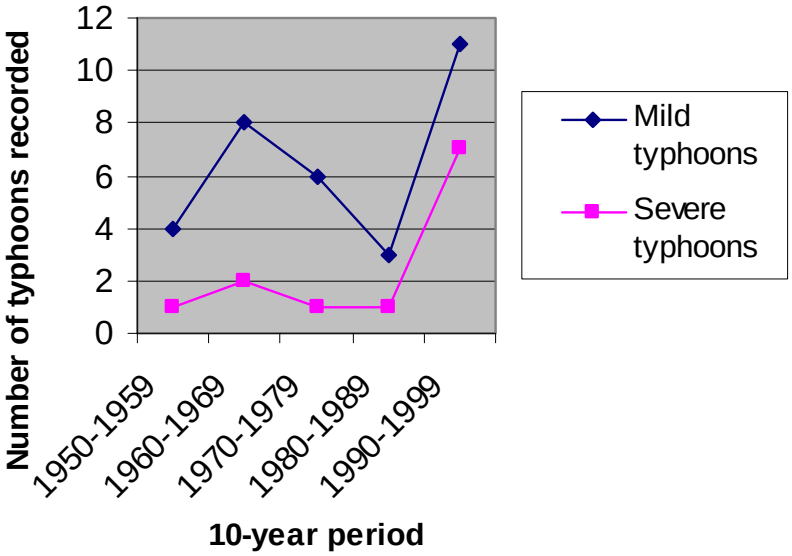

Figure 10. Mild typhoons (80 kph [50 mph] < estimated gusts < 160 kph [100 mph]) and severe (estimated gusts > 160 kph [100 mph]) typhoons recorded at 10-year increments at the U.S. Navy Joint Typhoon Warning Center for Guam from 1950 to 1999.

Jamaica (Wunderle *et al*. 1992) following typhoons, presumably due to the reduction in fruit and nectar sources after storms. Insectivorous birds may also be impacted, at least in the short-term, by reductions in arthropod availability caused by typhoons (Wiley and Wunderle 1993). Wunderle and others (1992) reported the absence of black-and-white warblers (*Mniotilta varia*) and a decline in prairie warblers (*Dendroica discolor*) in Jamaica following Hurricane Gilbert. Like the nosa Luta, both of these warblers forage primarily in the forest canopy and may have been impacted by the extensive damage to canopy trees caused by the storm. It is therefore expected that nosa Luta foraging resources and foraging sites are also impacted by typhoons that may impact nosa Luta population levels.

Long-term changes in the availability of mature forests may also be impacting nosa Luta populations (see also Habitat Loss and Degradation). Typhoon damage to vegetation is typically greatest along edges and on slopes facing the wind (Brokaw and Walker 1991, Frangi and Lugo 1991). Vegetation clearing for agriculture and phosphate mining has fragmented the forests on the Sabana increasing the amount of edge exposed to storms. In addition, large canopy trees are more susceptible to typhoon damage (uprooting, trunk snapping, and broken limbs) than smaller understory trees (Brokaw and Grear 1991, Frangi and Lugo 1991, Reilly 1991, Basnet *et al*. 1992). As these canopy trees are damaged and die off, they open the canopy which can result in long-term changes in forest structure (Brokaw and Grear 1991). The reported conversion of mature forest into *Pandanus tectorius* thickets on the Sabana may be related to this storm damage (see Habitat Loss and Degradation). As these forests are modified, bird populations in the region may also be affected. For example, nosa Luta abundance in the Sabana region declined significantly between 1982 and 1994 while collared kingfisher, Micronesian starling, and black drongo abundances increased (Amidon 2000), presumably due to changes in habitat.

As noted earlier, typhoons are common events in the Mariana Islands. Therefore, a fairly large population distributed across several sections of the Sabana region is unlikely to be severely reduced by a single storm event. However, as the nosa Luta population declines and subpopulations are reduced to smaller patches of forest, it is possible that a single subpopulation could be lost due to a combination of direct and indirect typhoon impacts. Further, as the

number of subpopulations declines the susceptibility of the entire population to storms is increased.

I. Conservation Efforts

Since at least 1982, there has been concern about the long-term conservation of the nosa Luta. The majority of the work on the species has been directed at monitoring. However, several efforts were initiated that have some direct bearing on the conservation of the species.

1. Mariana Archipelago Rescue and Survey Project

In 1993, the Mariana Archipelago Rescue and Survey Project was initiated to develop techniques for the capture, acclimation, transport, and propagation of nosa Luta, Mariana crows, and Mariana fruit doves, or totot in Chamorro (*Ptilinopus roseicapilla*), for potential development of captive propagation programs for these species. Participants in the program included the Philadelphia Zoological Garden, Houston Zoological Gardens, National Zoological Park, Louisville Zoological Garden, Memphis Zoological Garden and Aquarium, Honolulu Zoo, North Carolina Zoological Park, CNMI Division of Fish and Wildlife, and U.S. Fish and Wildlife Service.

As part of the project, 20 nosa Luta were collected from the wild on Rota in 1993 (3 birds) and 1995 (17 birds). Of the 20 birds collected, 5 were females and 15 were males. All of these birds were transferred to the National Zoological Park's Conservation and Research Center in Front Royal, Virginia. As of November 2005, the captive population consists of only six male nosa Luta; the last female died earlier this year (S. Derrickson, pers. comm. 2005). Eggs were produced by three females. However, only two females produced fertile eggs or offspring and no parent-reared birds reached maturity. One male nosa Luta was successfully hand-reared and is currently part of the captive population. Diet was found to be the principal challenge with rearing viable offspring as chick mortalities were related to abnormal bone development (S. Derrickson, pers. comm. 2005). Efforts to manipulate calcium, vitamin levels, and ultraviolet light to address this problem were not successful.

2. Black Drongo Research

Research on black drongos includes efforts to document interactions with native forest birds on Guam, to determine the impact of drongo control on nosa Luta populations, and to develop black drongo control techniques. Maben (1982) studied the foraging techniques, foraging substrata, foraging zones, and prey species of the black drongo on Guam from 1980 to 1981. She also recorded interactions between black drongos and other birds on Guam. Similar research has not been done on Rota where bird populations have not been impacted by the brown treesnake. In 1993 and 1994, biologists with the CNMI Division of Fish and Wildlife conducted a black drongo removal study to determine if drongo removal would increase nosa Luta abundance (Lusk 1993, Worthington and Taisacan 1994). Two transects were established on Rota and efforts to remove black drongos using firearms were conducted along one transect. Unfortunately, the effect of black drongo removal could not be determined due to the difficulty of controlling drongos using firearms (*i.e.*, the birds became wary of humans and fled when approached). In 2004, efforts were undertaken to develop a black drongo trap on Rota (C. Kessler, USFWS, pers. comm. 2005). The design of the trap was being modified to prevent drongos from escaping when it was destroyed in a typhoon. No additional work on trap design or drongo control has been conducted since that time.

3. Sabana Conservation Area

In 1994, part of the Sabana region was designated as a protected area through Rota Local Law No. 9-1 (Figure 11). The purpose of this protected area, according to the law, is to establish a Wildlife Conservation Area to "prohibit persons from engaging in certain activities within the Sabana area that may have an adverse impact on the wildlife and vegetation." The law also calls for groundwater protection, and the continuation of the traditional use of medicinal plants and agricultural practices (CNMI Rota Senate Local Law No. 9-1, 1994). In 1996, a management plan for the Sabana Conservation Area was developed which defined the purpose of the protected area, identified zones for each use (tourism, agriculture, wildlife conservation, firing range, and communication facilities), and suggested rules for each zone (Sabana Protected Area Management Committee 1996). As of 2005, this management plan has not been implemented

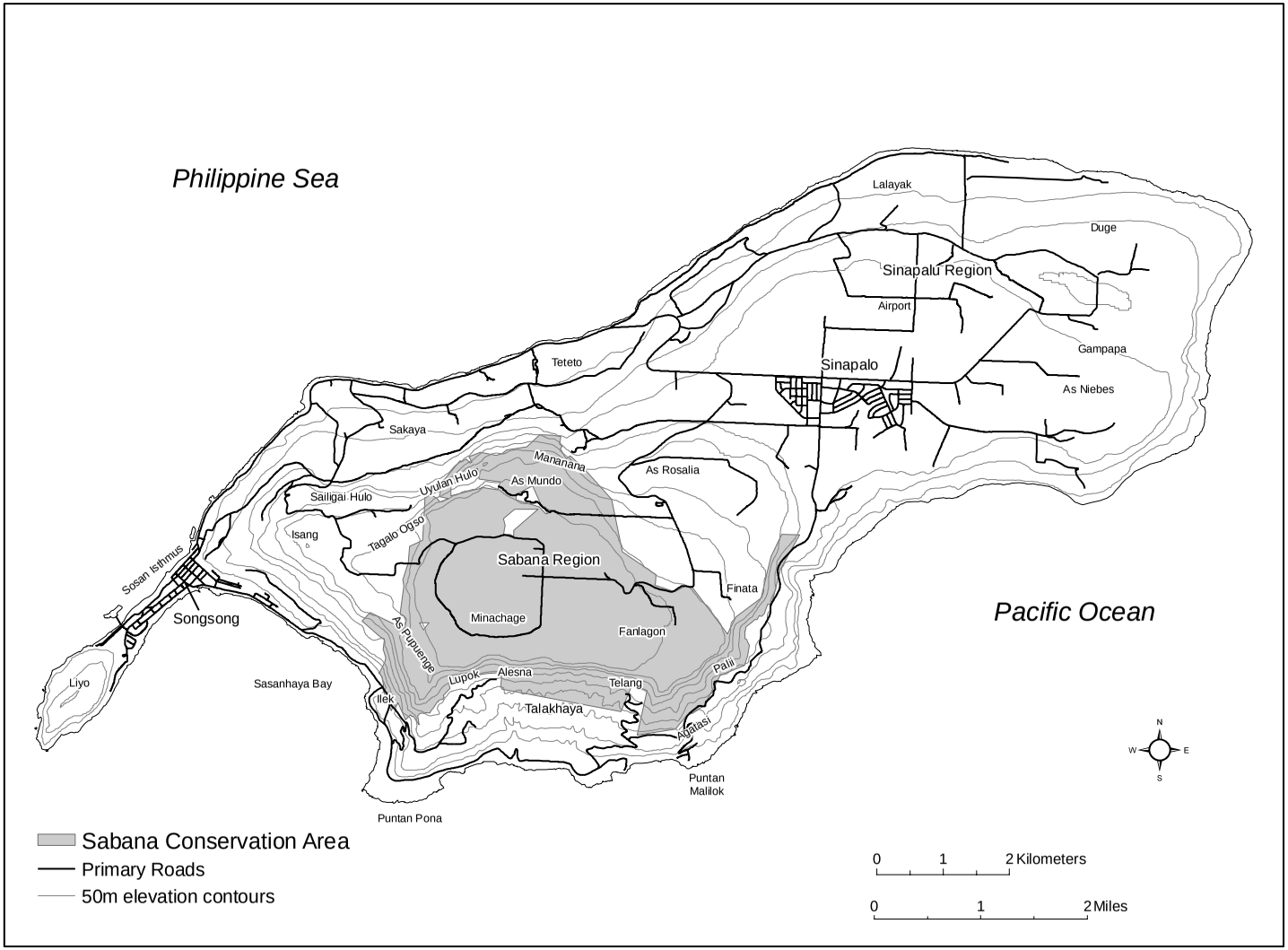

Figure 11. The Sabana Conservation Area on the island of Rota.

and the rules, regulations, and prohibitions have not been promulgated to manage the Sabana Conservation Area as required under Rota Local Law No. 9-1 (L. Williams, DFW, pers. comm. 2005).

4. Public Awareness

A variety of outreach activities have been implemented by the CNMI Division of Fish and Wildlife that focus on the conservation of native species and raising public awareness about brown treesnakes. All of these efforts directly or indirectly support nosa Luta conservation efforts. Outreach activities include wildlife posters, wildlife fact sheets, presentations for school children, and public service announcements. In 1999, the RARE program ("rare animal relief effort") was also started on Rota. This community outreach program focused on the conservation of the Mariana fruit dove or tottot, but also covered basic conservation concepts that are applicable to the nosa Luta.

II. RECOVERY

A. Recovery Strategy

The nosa Luta population is in danger of extinction. The species has experienced a 90 percent population decline since 1982 and the core of the population is now restricted to four areas totaling 254 hectares (628 acres) in the Sabana region of Rota (Fancy and Snetsinger 2001). The exact causes of this decline and range restriction are uncertain. However, available information indicates that habitat loss and degradation and predation by introduced black drongos and rats are all having some impact on the nosa Luta population. Due to its restricted range and small population size, the species is also highly susceptible to random catastrophic events such as typhoons, the accidental introduction of new predators such as the brown treesnake, and avian diseases such as West Nile virus. Therefore, recovery actions will initially focus on protecting and enhancing forests in the Sabana region; determining the specific habitat requirements of the nosa Luta to better manage areas for the species' conservation; assessing the impact of black drongos and rats, and controlling these introduced predators as appropriate; and preventing the introduction of new predators and avian diseases.

In addition, as the single small population of nosa Luta is vulnerable to extinction due to chance events, this plan calls for the careful consideration of the establishment of a second population of the species, either in captivity or in the wild.

Due to the limited information available to inform long-term recovery planning efforts, the recovery program presented in this plan focuses on the first 10 years of the recovery process, with the immediate goal of halting the population decline of the nosa Luta and preventing the extinction of the species. At this point we lack the biological and demographic data needed to determine the population parameters for recovery, and do not fully understand the nature of the threats to the species nor the level to which they must be reduced to support recovery (see Recovery Criteria, below). As further information is gained about the biology and ecology of the species, as well as the nature and relative magnitude of the various threats it faces, the recovery strategies and measures presented in this plan will be reassessed and expanded to provide for the full recovery of the nosa Luta. The interim recovery objectives presented here for the first 10 years of the recovery effort are intended to be updated and revised as the implementation of recovery actions for this species progresses, allowing us to develop a more refined recovery management program as well as scientifically sound recovery criteria (see section D, Recovery Planning, below).

B. Recovery Goals and Objectives

The goal of the nosa Luta recovery program is to downlist the species to threatened status and ultimately to remove the species from the Federal List of Endangered and Threatened Wildlife and Plants (delist). The primary interim objectives of this recovery plan over the next 10 years are to stop further declines in the range and composition of the nosa Luta population, develop safeguards to prevent the species from going extinct, reverse population declines, and restore the population to at least the abundance level estimated in 1982 (10,000 individuals). The secondary objectives are to gather the necessary information on the population dynamics and habitat requirements of the nosa Luta for the effective management of the species and for the development of target population sizes and growth trends needed for recovery, to conduct research to more accurately assess the threats to the species and suggest appropriate methods for

the control of those threats sufficient to allow for delisting of the species, and to establish an outreach program to increase public support for conservation of the nosa Luta.

C. Recovery Criteria

The actual downlisting or delisting of a listed entity (*i.e.*, species, subspecies or distinct population segment) is achieved through a formal rulemaking process. The recovery criteria set forth in a recovery plan are intended to serve as objective, measurable guidelines to assist us in determining when a listed entity has recovered to the point that the protections afforded by the Endangered Species Act are no longer necessary. However, the actual downlisting or delisting process is not solely dependent on achieving the recovery criteria; it is achieved through the formal rulemaking process based upon a five-factor analysis (per section 4(a)(1) of the Endangered Species Act), in conjunction with an analysis of the recovery criteria, that results in a determination that the threats to the listed entity have been sufficiently controlled or eliminated such that downlisting or delisting is warranted. [6]

In order to achieve the goal of first downlisting and then delisting the nosa Luta, we must define specific recovery criteria that demonstrate we have ensured the conservation and survival of the species, and that the threats to the species have been reduced to the point that the protections afforded by the Endangered Species Act are no longer necessary. At this time, we have developed only interim downlisting targets for the nosa Luta due to data limitations and potential uncertainties associated with attempting to define more specific and quantitative recovery criteria. We do not have the information on population dynamics and demographics (for example, data on productivity, survivorship, age structure, sex ratios), and habitat requirements of the species needed to provide a scientifically credible estimate of the target population size, growth rate, distribution, extent and characteristics of the habitat needed for long-term viability of nosa Luta. In addition, we do not fully understand what factors led to the precipitous decline of the species over the last 20 years. For example, although we surmise that habitat degradation and predation by introduced rats and/or black drongos have played a

[6] See page 16 for a discussion of the five factors.

role, the relative impact of each of these factors is not known. Further research on the threats to the species is needed to identify those that pose the greatest risk to nosa Luta, to assess the means of addressing those threats, and to develop objective and measurable recovery criteria that demonstrate how the primary threats to the species have been controlled or eliminated sufficient to warrant downlisting or delisting. Recovery actions intended to acquire the information needed to develop appropriate recovery criteria within the next 10 years are identified in this draft recovery plan.

The population targets for downlisting offered here should be revised, if necessary, based upon any new data gathered during this time. The development of meaningful delisting criteria will also require this new data. At present, the interim downlisting objectives for the nosa Luta over the next 10 years are as follows:

(1) Arrest the decline in abundance of nosa Luta as evidenced by a stable or increasing population growth trend (finite rate of population increase or λ greater than or equal to 1.0) averaged over a minimum of 5 continuous years and restore the population to at least 10,000 individuals;

(2) Reduce the decline of intact nosa Luta habitat in the species' core range to help prevent further population declines and range restrictions and implement restoration techniques to increase the amount of nosa Luta habitat available for sustaining a population of at least 10,000 individuals;

(3) Assess the impact of black drongos and rats on the nosa Luta population and develop and implement effective methods to control these species, as needed, to decrease their impacts on the nosa Luta as demonstrated by a significant reduction in predation events over 10 years; and

(4) Implement measures to prevent the brown treesnake and other threats, such as West Nile virus, from becoming established on Rota to reduce threats to the nosa Luta population.

D. Recovery Planning for the Nosa Luta

As stated previously, our understanding of the threats to the nosa Luta and its biology are limited (see section A, Recovery Strategy, above). These uncertainties make it difficult to reasonably project the needs of the recovery program for the nosa Luta beyond a relatively short time frame. We have therefore taken an adaptive management approach to the recovery program for the nosa Luta, in which data gathered during the course of implementing the proposed recovery actions will be incorporated to guide future recovery efforts and to develop and refine the objectives and criteria for recovery, as appropriate. The recovery plan for the nosa Luta is therefore designed to be updated in 5-year increments, to reflect the knowledge gained and consequent refinements to our management program. This draft recovery plan addresses the first 10 years of recovery, with particular emphasis on the initial 5 years of the program. In 5 years, we expect to release an update to this plan, which will summarize relevant data gathered to date and further identify actions needed to advance recovery of the species, as well as propose more refined recovery objectives and criteria based on the gains in knowledge of the species and its threats.

III. RECOVERY ACTIONS

A. Outline of Recovery Actions

1. Manage factors affecting viability of the wild population
  1.1 Protect and restore nosa Luta habitat
    1.1.1 Conduct additional research on nosa Luta habitat requirements
      1.1.1.1 Evaluate foraging habitat requirements
      1.1.1.2 Evaluate nesting habitat requirements
    1.1.2 Protect and manage forested areas within the nosa Luta's range
      1.1.2.1 Work with interested private landowners to protect and manage nosa Luta habitat on their lands
      1.1.2.2 Work with the Mariana Public Lands Authority to protect and manage nosa Luta habitat on lands they administer
    1.1.3 Improve and restore forested areas within the nosa Luta's range
      1.1.3.1 Evaluate the impact of introduced deer on regeneration of native forest on the Sabana
      1.1.3.2 Develop techniques for restoring native forest within the nosa Luta's range
      1.1.3.3 Develop and implement a reforestation plan for areas in the Sabana region
  1.2 Assess and reduce the impact of introduced predators on nosa Luta
    1.2.1 Evaluate impact of black drongos on nosa Luta and control or eradicate black drongos, as needed
      1.2.1.1 Conduct additional research on methods to control black drongos
      1.2.1.2 Conduct research to determine the impact of black drongos on nosa Luta
      1.2.1.3 Develop and implement a black drongo control or eradication program, if needed
    1.2.2 Evaluate the impact of introduced rats on nosa Luta and control or eradicate rats, if needed
      1.2.2.1 Conduct additional research on nest predation by rats
      1.2.2.2 Develop and implement a rat control or eradication program, if needed
    1.2.3 Prevent the introduction of brown treesnakes to Rota

1.2.3.1 Complete a shipping pathway analysis for cargo going to Rota

1.2.3.2 Construct, utilize and maintain a cargo holding area with a snake barrier at the Rota port

1.2.3.3 Initiate a dog program on Rota for checking cargo

1.2.3.4 Increase trapping and utilize snake toxicants around port facilities

1.2.3.5 Expand public awareness program to Rota

1.2.3.6 Continue and expand brown treesnake interdiction efforts on Guam and Saipan

1.2.3.7 Improve existing brown treesnake detection and trapping measures

1.3 Reduce potential impacts of avian diseases such as West Nile virus on nosa Luta

1.3.1 Continue quarantine measures to prevent introduction of West Nile virus

1.3.2 Test birds for West Nile virus and develop plan for conserving bird populations if it should become established

1.4 Develop and implement a long-term monitoring program for the nosa Luta

2. Assess the need and develop a plan for establishing a second nosa Luta population

2.1 Develop a plan for establishing a captive nosa Luta population and implement, if needed

2.2 Assess feasibility and need for establishing a second wild population of nosa Luta

3. Develop a public awareness program to promote nosa Luta recovery, including native forest restoration

3.1 Develop educator's packets that are integrated into curriculum programs on Rota and focus on the main threats to the species – habitat degradation and loss, and introduced predators

3.2 Develop a public awareness campaign that targets citizens, community groups, and lawmakers

3.2.1 Develop and broadcast Public Service Announcements (PSAs)

3.2.2 Promote a poster and essay contest

3.2.3 Encourage media coverage of environmental issues

3.3 Develop and promote "hands-on" community outreach activities that protect and conserve native species and their habitat

3.3.1 Establish (or upgrade existing) small community-based plant nurseries

3.3.1.1 Conduct a minimum of four community outplanting days each year

3.3.1.2 Conduct a minimum of four community native seed collection days each year

3.3.1.3 Educate schoolchildren on the identification and importance of native plants

3.3.2 Coordinate community involvement in a minimum of three environmental protection activities each year

4. Update the recovery plan

4.1 Conduct research on the population dynamics of the nosa Luta

4.2 Conduct research on the territory and home range requirements of the nosa Luta

B. Recovery Action Narrative

The following actions, presented in the form of a step-down narrative, are those needed to initiate the recovery program for the nosa Luta. Details of the ecology and management techniques relevant to these actions are presented in Part I of this plan.

1. Manage factors affecting viability of the wild population

Habitat loss and degradation and predation by introduced predators are likely impacting the nosa Luta population. In addition, the accidental introduction of new predators and avian diseases also threaten the population. The impacts of all of these current and potential threats need to be assessed and addressed.

1.1 Protect and restore nosa Luta habitat

Nosa Luta appear to have been restricted to high elevation forests in the Sabana region since at least 1975 (Pratt *et al.* 1979). These forests are believed to be important to the nosa so the remaining relatively intact forests should be protected from additional clearing and degraded forests should be restored to create additional habitat.

1.1.1 Conduct additional research on nosa Luta habitat requirements

Research by Amidon (2000) indicated that high elevation forests in the Sabana region appear to be important to the nosa Luta. However,

which components of these forests are important to the nosa is not clear. Additional research on nosa habitat requirements is needed to determine why these forests may be important, and to focus restoration efforts on those characteristics of the forest that are most important.

1.1.1.1 Evaluate foraging habitat requirements

Nosa Luta foraging is restricted primarily to specific patches of forest in the Sabana region. Often, apparently suitable foraging habitat is available adjacent to these areas but is utilized only occasionally by nosa Luta. Research on the foraging habitat requirements of the nosa may explain why particular patches of forest are utilized more heavily than others. This information should then be used to help manage forests as nosa Luta habitat.

1.1.1.2 Evaluate nesting habitat requirements

All of the nosa Luta nests with recorded locations were found in high elevation forest areas on the Sabana, even though apparently suitable forest habitat (*e.g.*, same tree species) was available in areas at lower elevations adjacent to utilized sites. Research on the nesting habitat requirements of the nosa Luta may help explain why certain areas are utilized for nesting. This information should then be used to manage forests for nosa Luta breeding habitat.

1.1.2 Protect and manage forested areas within the nosa Luta's range

The nosa Luta's range consists of forested areas on a matrix of private and public lands. In order to promote the recovery of the nosa Luta, efforts should be undertaken to protect and manage forest on both private and public lands.

1.1.2.1 Work with interested private landowners to protect and manage nosa Luta habitat on their lands

Nosa Luta habitat is found on and adjacent to private lands in the Sabana region. Assistance should be provided to interested landowners to protect, restore, and manage this habitat through programs like the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife program and the Natural Resources Conservation Service's Wildlife Habitat Improvement Program.

1.1.2.2 Work with the Mariana Public Lands Authority to protect and manage nosa Luta habitat on lands they administer

Approximately 75 percent of the nosa Luta's current range is within lands administered by the Mariana Public Lands Authority for people of Marianas descent. Methods to protect and manage these lands should be developed with the Mariana Public Lands Authority, CNMI Department of Land and Natural Resources, and other local and Federal agencies.

1.1.3 Improve and restore forested areas within the nosa Luta's range

In order to promote the recovery of the nosa Luta and provide adequate habitat for the species, selected non-forested and degraded areas within the nosa Luta's range should be restored to mature native forest.

1.1.3.1 Evaluate the impact of introduced deer on regeneration of native forest on the Sabana

Introduced Philippine deer may be negatively impacting the natural regeneration of native forest in the Sabana region. Deer exclosure plots should be established within degraded forest and open fields on the Sabana and monitored to determine how deer exclusion impacts forest regeneration. This information should then be utilized to determine how best to manage any deer impacts on native forest.

1.1.3.2 Develop techniques for restoring native forest within the nosa Luta's range

Techniques for restoring non-forested and degraded areas need to be developed and evaluated to determine the most effective measures for restoring mature forest. These techniques might include determining how to propagate native tree species, how to increase the regeneration of canopy species in degraded areas, and identifying which native tree species are most effective for restoring cleared areas.

1.1.3.3 Develop and implement a reforestation plan for areas in the Sabana region

Once techniques have been developed for restoration of native forest, a plan should be developed for restoring native forest on public lands. This plan should include a map of the locations

where efforts should be expended, a schedule for restoration efforts, a monitoring component, and expected cost of the project. This plan should then be used for obtaining funds to support and implement the program.

1.2 Assess and reduce the impact of introduced predators on nosa Luta

Introduced rat and black drongo populations are likely impacting the nosa Luta population. The extent of this impact needs to be assessed and addressed, as necessary.

1.2.1 Evaluate impact of black drongos on nosa Luta and control or eradicate black drongos, as needed

Black drongos have been observed taking adult nosa and may be preying upon nosa Luta nests; however, the extent of this impact is not known. Research assessing this impact is required, drongo control techniques need to be researched and developed, and the expected cost, effort, and benefit of drongo control needs to be evaluated to determine if drongo control is warranted and a priority based on the other conservation needs of the nosa Luta.

1.2.1.1 Conduct additional research on methods to control black drongos

Previous efforts to control black drongos using firearms indicate that drongos quickly become wary of people, making it difficult to effectively control black drongos using this method. Some efforts were undertaken to develop a black drongo trap but additional work is needed to determine if this technique will be feasible. Therefore, additional research is needed to develop and test effective techniques to control or eradicate drongos.

1.2.1.2 Conduct research to determine the impact of black drongos on nosa Luta

Previous attempts to assess the impact of black drongos on nosa Luta have not been conclusive. This is in part due to the lack of effective methods for long-term control of black drongos (see Recovery Action 1.2.1.1). After, or in conjunction with, the development of control techniques, a study should be conducted to assess the impact of black drongo

control on nosa Luta populations, to determine if control would be beneficial to the nosa Luta.

1.2.1.3 Develop and implement a black drongo control or eradication program, if needed

If it has been determined that black drongo control is beneficial to nosa Luta (Recovery Action 1.2.1.2) and adequate control techniques are available (Recovery Action 1.2.1.1), a black drongo control or eradication plan should be developed and implemented, if warranted.

1.2.2 Evaluate the impact of introduced rats on nosa Luta and control or eradicate rats, if needed

Rat predation on nosa Luta nests is having some impact on the nosa Luta population and is likely having some impact on other native forest birds as well. However, the extent of this impact is unknown and should be evaluated to determine if rat control is an effective management tool for nosa Luta conservation.

1.2.2.1 Conduct additional research on nest predation by rats

An effort is underway using video cameras to determine what species are predating nosa Luta nests. This effort should continue until an adequate sample size is available to provide a clear picture of the primary nest predators. In addition, information about nest predator densities should be collected and the impact of predator control on nest success should be evaluated to determine effective management options for the nosa Luta.

1.2.2.2 Develop and implement a rat control or eradication program, if needed

If rats are found to have a significant impact on nosa Luta (Recovery Action 1.2.2.1), a rat control or eradication plan should be developed and implemented. This plan should identify how the program will be conducted and the information and permits needed to implement the program.

1.2.3 Prevent the introduction of brown treesnakes to Rota

The brown treesnake is not believed to be established on Rota. However, it was recently determined that a snake population is now established on Saipan. The establishment of brown treesnakes on

Saipan increases the likelihood that snakes may become established on Rota due to the shipment of goods from both Saipan and Guam to Rota. Therefore, it is imperative that sufficient effort be undertaken to make sure that brown treesnakes do not become established on Rota.

1.2.3.1 Complete a shipping pathway analysis for cargo going to Rota

To optimize the placement of interdiction resources, a pathway analysis of goods being shipped to Rota is needed. The results of this analysis will be used to prioritize which goods are inspected and where to focus limited resources to increase the likelihood of preventing snakes from getting to Rota (see Recovery Action 1.2.3.6).

1.2.3.2 Construct, utilize and maintain a cargo holding area with a snake barrier at the Rota port

To increase interdiction, a cargo holding area surrounded by a brown treesnake barrier needs to be built and used at the Rota port. The barrier design should be similar to the one currently on Saipan and the one scheduled to be built on Tinian.

1.2.3.3 Initiate a dog program on Rota for checking cargo

Dogs trained to locate snakes in cargo are effective at reducing snakes from being transferred between islands (Engeman *et al.* 1998a). Establishing and fully utilizing a dog program on Rota will increase the success of interdiction efforts on Rota.

1.2.3.4 Increase trapping and utilize snake toxicants around port facilities

Brown treesnake trapping and control with toxicants have created snake-reduced zones around port and cargo staging areas (Engeman *et al.* 1998b), reducing the likelihood snakes will enter cargo that will be shipped to other islands such as Rota. In addition, these control measures around port facilities on Rota also increases the likelihood that snakes arriving on Rota will be trapped or poisoned before leaving the port area. Therefore, these control efforts should be increased around ports on Guam, Saipan, and Rota to help prevent the establishment of snakes on Rota.

1.2.3.5 Expand public awareness program to Rota

Saipan has a an elaborate public awareness program for brown treesnakes to assist efforts at keeping additional snakes from getting on the island and to increase reporting of snake sightings on Saipan. Although this program was not initiated until after snakes were reported on Saipan, it has been very successful at increasing public awareness and should be expanded to Rota to assist efforts on that island.

1.2.3.6 Continue and expand brown treesnake interdiction efforts on Guam and Saipan

Much of the cargo that goes to Rota either comes from Guam or through Saipan. Therefore, efforts to prevent snakes from entering cargo being shipped to Rota will also benefit efforts to prevent snakes from becoming established on Rota.

The U.S. Department of Agriculture's Wildlife Services brown treesnake program is attempting to search all cargo going from Guam to the CNMI. As a backup measure, the CNMI Division of Fish and Wildlife is working with Wildlife Services to inspect all "high risk" cargo coming from Guam. However, shipments between Saipan and the other islands in the CNMI are currently not inspected. With the establishment of the brown treesnake on Saipan, the cargo inspection program on Saipan should be extended to include inspection of all cargo going from Saipan to the other islands in the CNMI.

1.2.3.7 Improve existing brown treesnake detection and trapping measures

Measures to control or eradicate brown treesnakes at very low population levels are needed to help prevent snakes from becoming established. Currently, various techniques for controlling snakes have been developed (*e.g.*, traps, toxicant bait stations). However, they should be improved or modified to become more effective at controlling snake populations that are at low (incipient) levels.

1.3 Reduce potential impacts of avian diseases such as West Nile virus on nosa Luta

Avian disease is not believed to have been a factor in the decline and range restriction of the nosa Luta. However, diseases could still affect recovery efforts and should be monitored and controlled. This includes preventing the introduction of exotic diseases and pathogens, including West Nile virus.

1.3.1 Continue quarantine measures to prevent introduction of West Nile virus

The CNMI has quarantine procedures in place to help prevent the introduction of West Nile virus to the CNMI. In addition, the U.S. Postal Service in Hawaii has banned the shipment of birds through the mail. Because all mail to the CNMI first goes through Hawaii, this has reduced the likelihood that West Nile virus will be introduced to the CNMI through this route. These procedures should continue while West Nile virus is a threat. If the postal service ends the ban in Hawaii then the CNMI should consider a ban in the CNMI.

1.3.2 Test birds for West Nile virus and develop plan for conserving bird populations, if it should become established

As of 2005, there is no record of West Nile virus occurring in the CNMI. However, in case the virus arrives, a plan should be in place to protect the native bird species of the islands. This plan should be developed now so that it can be implemented if the virus is confirmed in the CNMI. In addition, a bird testing program is needed to determine if the virus has arrived. A testing program should be developed and implemented so that West Nile virus can be detected as early as possible.

1.4 Develop and implement a long-term population monitoring program for the nosa Luta

Nosa Luta population estimates, trends, and distribution information is needed to determine the effectiveness of the recovery program and to evaluate when and where management actions may be needed. Due to the lack of consistency in methods of previous nosa Luta surveys, this plan includes a draft monitoring program for the nosa Luta (see Appendix D for details). This monitoring program is intended to effectively and efficiently assess the nosa Luta population's size or abundance and

distribution through time. The finalized program should be used to monitor the species.

2. **Assess the need and develop a plan for establishing a second nosa Luta population**

   The nosa Luta is susceptible to any further population declines and to extinction due to random catastrophic events, such as typhoons. The species is likely to remain susceptible to these catastrophes even as many of the management actions outlined in this plan are implemented. It is therefore crucial that efforts to assess the need for creating a second population be initiated early in the recovery process while individuals are still available for creating this second population. This second population could be used for supplementing the wild population on Rota or reestablishing a population on Rota if the species should become extirpated.

   2.1 Develop a plan for establishing a captive population of nosa Luta and implement if needed

   A working group should be created, which includes interested representatives from the U.S. Fish and Wildlife Service, CNMI Division of Fish and Wildlife, and American Zoo and Aquarium Association (AZA), to develop a plan for establishing a captive population of nosa Luta. This plan should include an evaluation of the Mariana Archipelago Rescue and Survey Project (see Conservation Efforts for details of the project) and other efforts to propagate white-eye species in captivity. The purpose of this evaluation is to identify gaps in knowledge and determine additional research needs to optimize a captive propagation program for the nosa Luta. Also, due to the endangered status of the nosa Luta and the importance of maintaining the wild population, the use of surrogate white-eye species for the development of captive propagation techniques should be considered. It is also important that the plan identify when efforts to establish a captive population of nosa Luta should begin, the ideal composition of the captive population, how the birds will be brought into captivity and housed, where the captive population program will be established, and identify the goals of the captive breeding program and participants. Specific tasks should be identified and a timeline for completing the tasks should be specified.

2.2 Assess the feasibility and need for establishing a second wild population of nosa Luta

Review of reintroduction programs indicate that releasing wild born individuals as opposed to captive-reared individuals typically increases the success of the program. In addition, the potential exposure of a captive population to new avian diseases, such as West Nile virus, may prevent the use of individuals exposed to these diseases to supplement or reestablish wild populations on Rota due to the risk of introducing new avian diseases to the island. Therefore, establishing a second wild population of nosa Luta on another island may be beneficial for supplementing or reestablishing nosa on the island of Rota. The available information indicates that the nosa Luta is endemic to Rota and may have habitat requirements that are not widely available in the Mariana archipelago. However, the option of establishing a population on another island should be evaluated as additional information is learned about the species.

3. Develop a public awareness program to promote nosa Luta recovery, including native forest restoration

Fund, support, and promote programs that inform teachers, students, lawmakers, and community groups about the conservation of the nosa Luta to develop public support.

3.1 Develop educator's packets that are integrated into curriculum programs on Rota and focus on the main threats to the species – habitat degradation and loss, and introduced predators

Contract a highly skilled individual with an intimate knowledge of Rota's people and culture and expertise in developing outreach products that comply with local curriculum standards. This individual will help develop educational packets focusing on grades 4 through 6 and high school that incorporate the basic skills (*i.e.*, reading, writing, arithmetic, and science) while creating a positive environmental ethic toward the nosa Luta and its habitat. The packet should also include fun activities related to nosa Luta conservation (*e.g.*, crossword puzzles, word find, scavenger hunt, mini experiments, etc.). Whenever applicable, the Chamorro language and culture should be incorporated into the materials.

After the educator packet is developed, teacher workshops should be conducted to provide proper orientation and guidance for the implementation of the educator's packet. The educator's packet should be utilized for 2 years and its effectiveness evaluated. Results of this evaluation should be used to revise the packet to ensure accuracy and effectiveness. This revised packet should be evaluated and revised as needed.

3.2 Develop a public awareness campaign that targets citizens, community groups, and lawmakers

Develop a media campaign that promotes the conservation of native species and their habitat. Ensure that local citizens have direct involvement in the development and implementation of the campaign. Whenever applicable the Chamorro language and culture should be incorporated into the material.

3.2.1 Develop and broadcast Public Service Announcements (PSA)

Develop and broadcast a minimum of one PSA per year that promotes conservation of nosa Luta (and other native species) and its habitat. Public Service Announcements should utilize radio, television, and print media.

3.2.2 Promote a poster and essay contest

Promote poster and essay contests among local children and adults with prizes awarded from local businesses. Contest themes should focus on native species and habitat protection. The winning selections could be highlighted in a calendar and distributed on Rota.

3.2.3 Encourage media coverage of environmental issues

Encourage media coverage of environmental issues that highlight positive strides by the local community to conserve and protect native species and their habitat.

3.3 Develop and promote "hands-on" community outreach activities that protect and conserve native species and their habitat

Develop a community outreach program that invites the people of Rota to actively participate in conservation activities while learning to appreciate and conserve nosa Luta (and other native species) and their habitat. Whenever applicable the Chamorro language and culture should be incorporated into the materials.

3.3.1 Establish (or upgrade existing) small community-based plant nurseries to promote native forest restoration

Native forest restoration on Rota would be more efficient if native plants grown in local nurseries were utilized. These local nurseries could also be used to promote the propagation and outplanting of native plants. To help promote these conservation efforts, at least one nursery should be set up in a local elementary school and the high school.

3.3.1.1 Conduct a minimum of four community outplanting days each year

To help promote community support for restoration, four community outplantings should be conducted a year. Outplanting sites should focus on areas of high ecological value and high-profile public places (*e.g.*, Talakahya and Sabana region), and should involve school children and other members of the community.

3.3.1.2 Conduct a minimum of four community native seed collection days each year for nurseries

Plants used for outplanting will likely be grown from seeds collected from wild plants on Rota. Collecting native seeds several times a year for the nurseries will ensure genetic integrity and diversity, and allow participants to better understand and appreciate Rota's native plants and their habitats.

3.3.1.3 Educate schoolchildren on the identification and importance of native plants

Developing a strong appreciation and understanding of the natural world is important for promoting conservation. The school nurseries should be utilized to educate school children on the identification and importance of native plant species while beautifying school grounds and providing potential habitat for native animal species. For each native species planted, the students should produce informational signs identifying the species, so eventually schools could have their own native botanical gardens.

3.3.2 Coordinate community involvement in a minimum of three environmental protection activities each year

These activities would include beach clean-ups, streamside clean-ups, soil conservation, Earth Day, and local festivals. These activities will provide participants the opportunity to actively participate in conservation, promote nosa Luta (and other native species) related outreach products, and create community pride.

4. Update the recovery plan

The recovery plan for the nosa Luta should be reviewed and updated periodically, as necessary, as research and management activities progress and as we gain knowledge of the ecology and population biology of the species. The need for the requisite data to develop more precise and biologically accurate recovery criteria is recognized as a high priority.

4.1 Conduct research on the population dynamics of the nosa Luta

Research is needed on the parameters that drive the nosa Luta population to better manage for its long-term conservation and to develop recovery criteria. This research includes estimates of birth and survival rates for different age classes and sources of mortality. Possible population projection models should be evaluated and the research programs assessed to ensure that the necessary data for model inputs are being collected.

4.2 Conduct research on the home range and territory requirements of the nosa Luta

Research is needed on nosa Luta home range and territory requirements to better manage for long-term conservation of the species and to develop recovery criteria.

IV. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows lists and prioritizes the actions and estimated costs for the recovery of the nosa Luta. It is a guide for meeting the recovery goals outlined in this plan. Recovery actions in the Implementation Schedule have been prioritized in a ranking system with each action being assigned a "priority number" from 1 (highest priority) to 3 (lowest priority; see definitions below). The numbers in the Action Number column correspond to the descriptions of recovery actions in the Narrative Outline of Recovery Actions.

Parties with the authority, responsibility, or expressed interest to implement a specific recovery action are also identified in the Implementation Schedule. When more than one party has been identified the proposed lead party is indicated by an asterisk (*). In cases where a lead party has not been identified, each party listed is individually responsible for implementing the recovery action. The listing of a party in the Implementation Schedule does not require, nor imply a requirement, that the identified party will implement the action(s) or secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover the nosa Luta. Also, section 7(a)(1) of the Endangered Species Act (16 USC 1531 *et seq.*) (Act) directs all Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of threatened and endangered species.

Definition of action priorities:

- **Priority 1:** An action that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.
- **Priority 2:** An action that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.
- **Priority 3:** All other actions necessary to meet the recovery objectives.

Definition of action durations and/or cost estimates:

- **Continuous:** An action that will be implemented on a routine basis once begun (for this recovery plan, such actions are projected over a 10-year timeframe).
- **Ongoing:** An action that is currently being implemented and will continue throughout the period covered by this recovery plan (in this case, ongoing actions are projected over a 10-year timeframe). For the purposes of cost estimation, we used our best estimate of the time that may be required to complete the action.
- **Unknown:** Either action duration or associated costs are not known at this time. For the purposes of cost estimation, we used our best estimate of the time that may be required to complete the action.

Threat categories:

We consider the role of five potential factors affecting the species in order to list, delist, or reclassify a taxon. These factors are:

(A) the present or threatened destruction, modification or curtailment of its habitat or range;
(B) overutilization for commercial, recreational, scientific, or educational purposes;
(C) disease or predation;
(D) the inadequacy of existing regulatory mechanisms; and
(E) other natural or manmade factors affecting its continued existence.

Recovery actions are designed to address the threats in the Listing Factor column in order to meet the recovery criteria of recreating a viable, stable population of nosa Luta on Rota, achieving effective predator control, and appropriate management of habitat needed for recovery (see Recovery Criteria section). The majority of the recovery actions in this plan address habitat loss (factor A), predation (factor C), and other natural factors affecting the continued existence of the species (factor E). The overutilization of nosa Luta for commercial, recreational, scientific, or educational purposes (factor B) is not known to be a threat. Existing regulatory mechanisms (factor D) appear adequate, as the nosa Luta is listed as endangered by the Federal government and

consequently receives protection under the provisions of the Endangered Species Act.

Responsible Parties for Action Implementation:

We have the statutory responsibility for implementing this recovery plan. Only Federal agencies are mandated to take part in the effort under section 7(a)(1) of the Act. However, species recovery will require the involvement of the full range of Federal, Territorial, Commonwealth, private, and local interests. The expertise and contributions of additional agencies and interested parties will be needed to fully implement recovery actions and to accomplish public awareness and outreach objectives. For each recovery action described in the Implementation Schedule, the column titled "Responsible Parties" lists the primary Federal and local agencies we have identified as having the authority and responsibility for implementing recovery actions and other groups, partners, and partnerships who are actively involved in recovery.

Key to Acronyms used in the Implementation Schedule:

- **AZA:** American Zoo and Aquarium Association
- **BRD:** United States Geological Survey, Biological Research Discipline
- **DLNR:** CNMI Department of Land and Natural Resources
- **DFW:** CNMI Division of Fish and Wildlife
- **USFWS:** United States Fish and Wildlife Service
- **WS:** United States Department of Agriculture, Wildlife Services

Cost estimates:

The costs of implementing the identified recovery actions are estimated over two timeframes: the first 5 years covered by this recovery plan (5-Year Costs column) and the total costs of recovery over a 10-year period (10-Year Costs column). In some cases, costs could not be determined at this time.

Implementation Schedule for the Draft Recovery Plan for the Nosa Luta or Rota Bridled White-eye

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						10-Year Costs	FY 07	FY 08	FY 09	FY 10	FY 11	5-Year Costs
1	1.1.2.1	A	Work with interested private landowners to protect and manage nosa Luta habitat on their lands	Continuous	USFWS*, DFW	14	0.4	0.4	2.4	0.4	2.4	6
1	1.1.2.2	A	Work with the CNMI to protect and manage nosa Luta habitat on CNMI lands	Continuous	USFWS*, DLNR	65.6	0.8	0.8	20.8	0.8	0.8	24
1	1.2.3.6	C	Continue and expand brown treesnake interdiction efforts on Guam and Saipan	Continuous	WS*, DFW	1,600	160	160	160	160	160	800
2	1.1.1.1	A	Evaluate foraging habitat requirements	4 years	DFW*, USFWS	80	20	20	20	20	-	80
2	1.1.1.2	A	Evaluate nesting habitat requirements	4 years	DFW*, USFWS	80	20	20	20	20	-	80

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Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						10-Year Costs	FY 07	FY 08	FY 09	FY 10	FY 11	5-Year Costs
2	1.1.3.1	A	Evaluate impact of introduced deer on regeneration of native forest on the Sabana	10 years	DLNR*, USFWS	12.4	10.8	-	-	-	0.8	11.6
2	1.1.3.2	A	Develop techniques for restoring native forest within the nosa Luta's range	5 years	DLNR*, USFWS	25	5	5	5	5	5	25
2	1.1.3.3	A	Develop and implement reforestation plan for Sabana region	Continuous	DLNR*, USFWS	25	-	-	-	-	-	0
2	1.2.1.1	C	Conduct research on methods to control black drongos	2 years	WS*, USFWS, DFW	20	10	10	-	-	-	20
2	1.2.1.2	C	Conduct research on impact of black drongos to nosa Luta population	4 years	DFW*, USFWS	40	10	10	10	10	-	40
2	1.2.1.3	C	Develop and implement a black drongo control program, if needed	3 years	WS*, USFWS, DFW	45	-	-	-	-	20	20

Implementation Schedule for the Draft Recovery Plan for the Nosa Luta or Rota Bridled White-eye

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						10-Year Costs	FY 07	FY 08	FY 09	FY 10	FY 11	5-Year Costs
2	1.2.2.1	C	Continue research on nosa Luta nest predators	Ongoing - 2 years to complete	DFW*, USFWS	12	6	6	-	-	-	12
2	1.2.2.2	C	Develop and implement a rat control program, if needed	1 year development control continuous	WS*, USFWS, DFW	TBD	-	-	1	TBD	TBD	TBD
2	1.2.3.1	C	Complete a shipping pathway analysis for cargo going to Rota	2 years	DFW*, WS	10	5	5	-	-	-	10
2	1.2.3.2	C	Construct and utilize a cargo holding area with a snake barrier at the Rota port	Continuous	DFW	27.8	0.4	0.4	20	1	1	22.8
2	1.2.3.3	C	Initiate a dog program on Rota for checking cargo	Continuous	DFW	10	1.5	1.5	1	1	1	5
2	1.2.3.4	C	Increase trapping and utilize snake toxicants around port facilities	Continuous	DFW	20	2	2	2	2	2	10

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Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						10-Year Costs	FY 07	FY 08	FY 09	FY 10	FY 11	5-Year Costs
2	1.2.3.5	C	Expand brown treesnake public awareness program to Rota	Continuous	DFW	84.5	8	0.5	0.5	0.5	0.5	82
2	1.2.3.7	C	Improve existing brown treesnake detection and trapping measures	10 years	WS*, BRD	100	10	10	10	10	10	50
2	1.3.1	C	Continue current quarantine measures to prevent introduction of West Nile virus	Continuous	DLNR*, USFWS	10	1	1	1	1	1	5
2	1.3.2	C	Test birds for West Nile virus and develop bird conservation plan for West Nile virus	Continuous	DLNR*, USFWS	14	5	1	1	1	1	9
2	1.4	A,C,E	Develop and implement a long-term population nosa Luta monitoring program	Continuous	DFW*, USFWS	26.5	3.8	1.5	3.8	1.5	3.8	14.4

Implementation Schedule for the Draft Recovery Plan for the Nosa Luta or Rota Bridled White-eye

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						10-Year Costs	FY 07	FY 08	FY 09	FY 10	FY 11	5-Year Costs
2	2.1	A,C,E	Develop plan for establishing a captive population	2 years	USFWS*, DFW, AZA	2	1	1	-	-	-	2
3	2.2	A,C,E	Assess need for establishing experimental population	2 years	USFWS*, DFW	2	1	-	-	-	-	1
3	3.1	A,C	Develop educator's packet on threats to nosa Luta	5 years	USFWS*, DLNR	16.1	3.4	5.7	3.3	3.3	0.4	16.1
3	3.2.1	A,C	Develop and broadcast Public Service Announcements	Continuous	USFWS*, DLNR	5.6	0.8	0.8	0.8	0.8	0.8	4.0
3	3.2.2	A,C	Promote a poster and essay contest	3 years	USFWS*, DLNR	2.6	1.3	1.1	0.2			2.6
3	3.2.3	A,C	Encourage media coverage of environmental issues	Continuous	USFWS*, DLNR	2.0	0.2	0.2	0.2	0.2	0.2	1.0

Implementation Schedule for the Draft Recovery Plan for the Nosa Luta or Rota Bridled White-eye

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						10-Year Costs	FY 07	FY 08	FY 09	FY 10	FY 11	5-Year Costs
3	3.3.1	A	Establish (or upgrade) small community-based nurseries	Continuous	DLNR	5.4	1.5	1.5	0.4	0.2	0.4	4.0
3	3.3.1.1	A	Conduct four community outplanting days per year	Continuous	DLNR	5.0	0.5	0.5	0.5	0.5	0.5	2.5
3	3.3.1.2	A	Conduct four community native seed collection days per year	Continuous	DLNR	2.0	0.2	0.2	0.2	0.2	0.2	1.0
3	3.3.1.3	A	Educate schoolchildren on the identification and importance of native plants	Continuous	DLNR	2.5	0.3	0.2	0.3	0.2	0.3	1.3
3	3.3.2	A	Coordinate community involvement in three environmental protection activities a year	Continuous	DLNR	5.0	0.5	0.5	0.5	0.5	0.5	2.5
3	4	All	Update the recovery plan	1 year	USFWS	3	-	-	-	-	-	0

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Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						10-Year Costs	FY 07	FY 08	FY 09	FY 10	FY 11	5-Year Costs
3	4.1	All	Conduct research on population dynamics	5 years	DFW*, USFWS	50	-	-	-	-	10	10
3	4.2	All	Conduct research on home range and territory size	5 years	DFW*, USFWS	50	-	-	-	-	10	10
					TOTALS	2,476						1,385.8

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VI. APPENDICES

APPENDIX A

Endangered and Threatened Species Recovery Priority Guidelines

(adapted from USFWS 1983a,b).

Degree of Threat	Recovery Potential	Taxonomy	Priority
High	High	Monotypic genus	1
	High	Species	2
	High	Subspecies	3
	Low	Monotypic genus	4
	Low	Species	5
	Low	Subspecies	6
Moderate	High	Monotypic genus	7
	High	Species	8
	High	Subspecies	9
	Low	Monotypic genus	10
	Low	Species	11
	Low	Subspecies	12
Low	High	Monotypic genus	13
	High	Species	14
	High	Subspecies	15
	Low	Monotypic genus	16
	Low	Species	17
	Low	Subspecies	18

APPENDIX B

Glossary of Technical Terms

arboreal	Living or placed in trees; adapted for life in trees.
avifauna	The bird life or bird community of an area.
epiphytic	An epiphyte is a plant that grows on another plant for support or anchorage (but does not utilize the other plant for water or nutrients, as does a parasitic plant).
extant	Still existing, not extinct.
interspecific	Between different species; between individuals or populations of different species.
intraspecific	Within a species; between individuals or populations of the same species.
ungulates	Hoofed grazing mammals. Typically refers to animals in the orders Perissodactyla (odd-toed animals such as horses) and Artiodactyla (even-toed animals such as cows, sheep, goats, deer, and pigs).

APPENDIX C

Glossary of Scientific, English, and Chamorro Plant and Animal Names Used in the Recovery Plan

TAXONOMIC GROUP	SCIENTIFIC NAME	ENGLISH NAME	CHAMORRO NAME
Mammals	*Cervus mariannus*	Philippine Deer	Binadu
	Emabllonura semicaudata	Sheath-tailed Bat	Payesyes
	Felis catus	Feral Cat	Katu
	Pteropus mariannus mariannus	Mariana Fruit Bat or Flying Fox	Fanihi
	Rattus exulans	Polynesian Rat	Cha'ka
	Rattus rattus	Black Rat	Cha'ka
	Rattus tanezumi	Asian House Rat	Cha'ka
Birds	*Aerodramus bartschi*	Mariana Swiftlet	Chachaguak
	Aplonis opaca	Micronesian Starling	Sali
	Corvus kubaryi	Mariana crow	Aga
	Dendroica discolor	Prairie Warbler	_____
	Dicrurus macrocercus	Black Drongo	Sali Taiwan
	Halcyon chloris	Collared Kingfisher	Sihek
	Mniotilta varia	Black-and-white Warbler	_____
	Passer montanus	Eurasian Tree Sparrow	_____
	Ptilinopus roseicapilla	Mariana Fruit-dove	Totot
	Rhipidura rufifrons	Rufous Fantail	Na'abak
	Zosterops conspicillatus	Bridled White-eye	Nosa
	Zosterops japonicus	Japanese White-eye	_____
	Zosterops lateralis	Silvereye	_____

TAXONOMIC GROUP	SCIENTIFIC NAME	ENGLISH NAME	CHAMORRO NAME
Birds	*Zosterops pallidus*	Green-bellied White-eye	_____
	Zosterops rotensis	Rota Bridled White-eye	Nosa Luta
Reptiles	*Boiga irregularis*	Brown Treesnake	Kolepbla
	Varanus indicus	Monitor Lizard	Hilitai
Tree Snails	*Partula gibba*	Humped Tree Snail	Akaleha'
	Samoana fragilis	Fragile Tree Snail	Akaleha'
Plants	*Acacia confuse*	Acacia, Formosan Koa	Sosugi Formosa
	Aglaia mariannensis	_____	Mapunyao
	Artocarpus atilis	Breadfruit	Dukduk
	Asplenium nidus	_____	Galak
	Bidens pilosa	Beggar Tick	_____
	Casuarina equisetifolia	Ironwood	Gagu
	Cocos nucifera	Coconut Palm	Niyog
	Davallia solida	_____	Pugua-machena
	Elaeocarpus joga	_____	Joga, Yoga
	Elatostema sp.	_____	Tupunayuyu
	Eugenia thompsonii	_____	Atoto
	Ficus prolixa	Banyan	Nunu
	Ficus tinctoria	Fig	Hodda
	Guamia mariannae	_____	Paipai
	Guettarda speciosa	Zebrawood	Panao
	Hernandia labyrinthica	_____	Oschal
	Leucaena leucocephala	Haole Koa	Tangantangan

TAXONOMIC GROUP	SCIENTIFIC NAME	ENGLISH NAME	CHAMORRO NAME
Plants	*Macaranga thompsonii*	_____	Pengua
	Merrilliodendron megacarpum	_____	Faniok
	Miscanthus floridulus	Swordgrass	Neti
	Osmoxylon mariannense	_____	_____
	Pandanus dubius	Screwpine	Pahong
	Pandanus tectorius	Screwpine	Kafu
	Passiflora foetida	Passionfruit	Kinahulo Atadao
	Persea americana	Avocado	Alageta
	Pipturus argenteus	Silvery Pipturus	Amahadyan
	Pisonia umbellifera	_____	None
	Premna obtusifolia	False Elder	Ahgoa
	Procris pedunculata	_____	Tupunayuyu
	Serianthes nelsonii	Fire Tree	Trongkon guafi
	Tarenna sambucina	_____	Sumac-lada
	Tristiropsis obtusangula	_____	Faniok

APPENDIX D

Monitoring Rota Bridled White-eye: Survey evaluation and design of monitoring program

Prepared for
U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, HI

by

Richard J. Camp
Hawaii Cooperative Studies Unit, University of Hawaii at Hilo,
PO Box 44, Hawaii National Park, HI 96718

April 2006

Overview

The objective of this study was to develop a monitoring program to detect changes in the endangered Rota Bridled White-eye *(Zosterops rotensis)* population. I used a systematic planning process to identify monitoring objectives and goals, define tolerable limits on uncertainty, determine the cost and schedule, and define criteria for accepting the final results. Specifically, this monitoring program seeks to effectively and efficiently assess two questions: 1) population distribution through time, and 2) population size or abundance through time. I recommend that managers determine Rota Bridled White-eye distribution every other year using point count methods on a sampling grid of stations placed every 500 m apart. To correct the apparent distribution by detection probability, detectability should be estimated with program Presence on a small grid of 20 stations. A change in occurrence (loss or gain) of a minimum of 50 ha can be reliably detected from this sampling design.

Furthermore, I recommend that Rota Bridled White-eye density (or absolute abundance) be determined annually using point transect (also called variable circular-plot) methods. Specifically, count data collected from 150 sampling stations, placed systematically throughout suitable habitat, should be analyzed with program Distance to calculate density estimates. A change in density of 3% or more can be reliably detected over a 10-year period from this study design.

The anticipated cost of determining Rota Bridled White-eye distribution is $5,600 per survey, whereas the annual cost of determining Rota Bridled White-eye density is $15,000. I also provide recommendations for program assessment and possible alternatives if the current monitoring protocol proves to be insufficient.

The Systematic Planning Process

The systematic planning process used a seven-step process following the Data Quality Objectives Process outlined by the Environmental Protection Agency (EPA 2002) and standard experimental design protocol (see Cochran 1977, Manly 1992).

Step 1: State the Purpose or Problem.
Step 2: Identify the Study Question(s).
Step 3: Identify the Inputs to each Study Question.
Step 4: Define the Boundaries of the Study.
Step 5: Define Statistical Parameters.

Step 6: Specify Tolerable Limits on Parameters and Actions.
Step 7: Optimize the Design for Obtaining Data.

Outputs from Steps 1 through 6 influence the choice of sampling design (Step 7). Therefore, in order to select a robust and efficient sampling design each step was addressed and reviewed.

Step 1: State the Purpose or Problem

The initial step is to develop a concise description of the problem. Although this step seems obvious, it provides focus for the rest of the process. The Rota Bridled White-eye (RBWE) was listed as federally endangered in 2004 (USFWS 2004) based on declines in the range of occurrence and population size (Table 1). The listing process requires the development of a long-term monitoring program for the RBWE recovery plan.

Step 2: Identify the Study Question(s).

For the RBWE monitoring program, I address two distinct study questions: 1) is the range (i.e., distribution) of RBWE contracting such that management is required (i.e., what are the trends in distribution over time); 2) is the population size of RBWE declining such that management is required (i.e., what are the trends in abundance over time). Both questions require an assessment of current distribution and abundance, comparisons with previous estimates of distribution and abundance, and a decision regarding how much these parameters must decrease before intervention is necessary (hereafter referred to as the "management threshold").

Step 3: Identify the Inputs to each Study Question.

Identifying changes in the distribution of RBWE requires both historical descriptions of distribution and continued monitoring of distribution. There is much historical data regarding RBWE distribution. For recent accounts, see Amidon (2000) and Fancy and Snetsinger (2001). Historical descriptions of distribution are based upon point transect sampling, roadside counts and area search sampling (Table 1). Fancy and Snetsinger (2001) described the association of RBWE presence with habitat types and mapped distributions (Figure 1). The proposed monitoring program will also require continued surveying to quantify changes in RBWE distribution.

Likewise, identifying changes in the abundance of RBWE requires both historical descriptions of abundance and continued monitoring of abundance. Historical descriptions of abundance are provided by Baker (1951), but see Amidon (2000). Monitoring must continue to track future changes in abundance.

In addition to the baseline distribution and density information, ancillary data will be necessary to improve the statistical efficiency of density and abundance estimators and to better understand potential causes of declining range or abundance. To improve statistical efficiency, habitat types should be stratified (Step 3; Table 2: site-specific covariates). This requires vegetation surveys and aerial photo interpretation. To understand potential causes of trends in distribution or abundance, changes in forest distribution should be monitored because the patchy distribution of RBWE is closely associated with forests (Amidon 2000, Fancy and Snetsinger 2001). In particular, monitoring changes in forest distribution and disturbance level of forests (e.g., relatively pristine forest, mixed native and alien forest) may assist in understanding RBWE's patchy distribution.

Step 4: Define the Boundaries of the Study.

Historically found in diverse habitats throughout Rota (see Amidon 2000), the RBWE is now primarily restricted to forests on the Sabana region above 200 m (Amidon 2000, Fancy and Snetsinger 2001, USFWS 2004; Figure 1). At a minimum, the area monitored should equal the recent distribution of RBWE. Limiting the geographic extent to current species distribution will however not capture any expansion or outward shift in RBWE range, as forests outside the current distribution would not be sampled. Therefore, suitable habitats previously occupied should be monitored for RBWE presence (see Baker 1951, Engbring et al. 1986, Craig and Taisacan 1994) on a consistent yet infrequent basis (e.g., every other year; Figure 1).

RBWE are known to breed between December and August (Table 3), although evidence suggests RBWE may breed year-round. The birds are probably most conspicuous during the breeding season and a short period before initiating nesting while establishing territories and advertising for mates (a general pattern for most passerines). Surveys should be conducted during the breeding season and be coincident with previous surveys (between March and May; Table 1), with sampling occurring between dawn and 4 hours post sunrise when weather patterns are conducive and birds are most conspicuous (Table 4).

Step 5: Define Statistical Parameters.

Statistical parameters are the parameters being estimated by our statistical procedures. For example, parameters of interest include the area occupied, abundance, trend, and coefficient of variation (Table 5). This information was used to identify "preliminary action levels" and "alternative action levels". Preliminary action level is defined as the minimum parameter value necessary for addressing the study questions. Alternative actions are pursued when parameters exceed threshold levels (Table 6).

Step 6: Specify Tolerable Limits on Parameters and Actions.

For each study question threshold levels to activate management actions were established. The parameter of interest and the associated threshold level are presented in Table 5. For each threshold, management actions are recommended. For example, if abundance drops below 500 individuals, I recommend that a captive breeding flock be established to guarantee species persistence and provide a source of individuals for future reintroductions (see USDI 2000). The USFWS and managers should develop additional management actions, with threshold levels, based on the species recovery plan.

Step 7: Optimize the Design for Obtaining Data.

Using an optimal design will yield the most information from data collected. Optimal designs are more likely to yield levels of accuracy and precision necessary for determining trends and responding to potential declines in a timely manner. Different methodologies are necessary to quantify changes in distribution and changes in abundance.

Because managers are often tempted to use indices in lieu of population estimates, I feel this deserves special mention. An index is defined as a metric or parameter that has an unknown relationship with the true parameter of interest. For example, abundance of RBWE could be "indexed" by simply counting birds. However, much theoretical and empirical research shows that inferences based upon indices are often invalid and may be impossible to validate (Anderson 2001). In particular, surveys should account for the probability an individual is detected. The probability of detecting a bird has been shown to vary as a function of observer, weather, and numerous other factors (Ralph and Scott 1981). If detection probability is not accounted for, it is not possible to know if fluctuations in counts represent true population changes or simply variation in detection probability. Widely available software programs, such as DISTANCE, and all the survey methods I recommend, account for variation in detection probability.

All sampling should be conducted at points in a grid or along transect lines (i.e., point transect methods). Distribution should be determined via point count sampling and abundance should be determined via variable circular-plot sampling.

Study question #1 -- The purpose of determining RBWE distribution is to specify where individuals do and do not occur, and then to monitor the distribution through time. The underlying assumption is that species' presence can be reliably detected given sufficient sampling effort. In addition, detection probability may vary spatially and temporally. Therefore, it is necessary to account for the probability of detection for each survey. As important as determining presence, areas without birds (e.g., habitat polygons or stations) need to be identified and quantified. Thus, sampling coverage needs to be reasonably uniform, or else the sampling effort must be measured and accounted for in analyses. Otherwise, species distribution and sampling distribution may be confounded (see Bibby et al. 2000).

Target population for study question #1 -- Determining changes in the RBWE distribution is the first objective of this monitoring program. To ensure that the total extent of the species range can be determined, sampling should include previously occupied habitats that are outside the current distribution (Sabana region above 200 m; Step 4; Figure 1).

Study question #2 -- The purpose of determining the species density is to estimate the size (e.g., numbers of individuals) of the RBWE population and to monitor trends in numbers over time. Fluctuations in the RBWE population need to be measured with confidence. Population estimates may be correlated through time, therefore, it is necessary to account for the probability of detection by survey. Furthermore, the detection probability may be confounded with sampling covariates and the size of populations may vary by habitat. Thus, the allocation of sampling needs to be spread throughout the species' range in habitats likely to be occupied.

Target population for study question #2 -- The second objective of this monitoring program is to detect changes in the population density over time. The RBWE target population is all individuals across the entire species' range (Sabana region above 200 m; Step 4; Figure 1).

Spatial scale and distribution

RBWE are restricted to within the Sabana region, however, they are patchily distributed within the region. Therefore, surveys should be restricted to the region and the

adjacent habitats that may potentially harbor RBWE. Because of the patchy nature of RBWE distribution and dependence on forested habitats (Amidon 2000), several habitat types need not be sampled, including non-forested and agricultural habitats (see Table 7). Sampling units in the occupied or potentially occupied habitats should be distributed to provide maximum coverage of the species' range and sample all likely habitats. The distribution of sampling units and sampling effort should also minimize variability. That is, more sampling units and sampling effort should be allocated to habitats that add to estimator uncertainty.

Monitoring design

Many issues must be addressed when selecting a monitoring design (e.g., observer abilities, autocorrelation, etc.) and many options exist (e.g., mist-netting, line transect, point transect). I used the dichotomous key of Thompson et al. (1998) to help select among various sampling techniques. Point count sampling was selected for study question #1 and point transect sampling was chosen for study question #2

Sampling protocol

Stratified systematic sampling -- A stratified systematic sampling scheme, which is replicated through time, should be employed to monitor RBWE distribution and density. Stratification is a process of dividing the sampling units into non-overlapping strata, based upon population density or habitat classifications, and then sampling within each stratum. Stratification results in smaller variance estimates, allows for estimating parameters for the different strata, and allocates sampling effort more efficiently (see Manly 1992). Because RBWE are not distributed throughout their range, a stratified sampling scheme ensures that the entire population is sampled, yet does not waste effort on unsuitable areas.

Where the survey point is the sampling unit, I recommend using a systematic sample of points located along transect lines and suggest the spacing of points be equal to the distance between transect lines. This design helps to ensure sufficient sample size, maintains independence between sampling stations, and yields more precise estimates than random sampling schemes (see Strindberg et al. 2004).

Replicated through time -- Detecting changes in the RBWE population over time is more important than determining precise population estimates, therefore, the same set of sampling units should be sampled through time (Thomas et al. 2004*a*:99). However, to avoid producing biased estimates, all potentially occupied habitats (regardless of quality or current occupation) need to be sampled. This is because, over time, habitat quality will

change. The risk of sampling the same locations through time is that locations cease to represent the area available to RBWE and resulting inferences may be incorrect.

Study question #1 -- Several studies have sought to determine RBWE distribution (Table 8). Efficient sampling in densely vegetated, patchy and geographically large areas may be accomplished with a point sampling technique. This technique was reached by the following path in the dichotomous key: 1B→3B→10B→14A (Table 9). Presence-absence methods using point count sampling was selected to monitor RBWE distribution. Analytic developments by MacKenzie et al. (2002, 2003), proportion area occupied (PAO), incorporate detection probabilities, making point count sampling more efficient for monitoring RBWE distribution.

Sample size -- PAO monitoring requires estimating the probability of committing a false positive error (capture probability [$\hat{p}$]; designating that the species was absent when it was present). This is accomplished by sampling a subset of the stations several times within the survey period (MacKenzie et al. 2002, 2003). The number of visits at a site is dependent on the detectability of the species, and MacKenzie (n. d.) recommends "a 70% chance of detecting [the species] at least once." Previous surveys on Rota have not been repeated within a season, precluding the calculation of the RBWE detection rate. Therefore, the suggested minimum number of stations sampled, $s = 20$, is recommended. Until data are available, using this value allows for estimating costs. Capture probability may be influenced by many factors including observer, sampling conditions, habitat type, and RBWE density. Therefore, $\hat{p}$ should be estimated for density strata (high and low) to determine if the detection probability is density-invariant or varies by density. Until data are available, it may be assumed that $\hat{p}$ is the same across strata. The other factors may be treated as covariates in the analysis.

The sample size necessary to determine the range and proportion of suitable habitats occupied is dependent on the distance among station locations (see Point sampling layout below).

Survey allocation -- Determining the species' range requires sampling suitable habitats for RBWE occupancy. Unsuitable habitat types (see Table 7) do not require sampling, however, changes in habitat can occur rapidly and should be assessed for their suitability for RBWE frequently (see Habitat sampling below). All suitable habitats that may be occupied or potentially occupied, including those habitats outside the current range, should be monitored. Survey stations should be added in habitats deemed suitable.

Discontinuing surveys of stations in habitats that have degraded and are no longer apparently suitable for RBWE should be carefully evaluated.

Point sampling layout -- Determining the distribution of a species is dependent on the scale, location of sampling units and duration of sampling. Producing reliable distributions requires uniform sampling to avoid map distortion (Sauer et al. 1995), as spatial mapping distribution is based on presence-absence data.

Discerning the boundary of the RBWE range edge requires sampling suitable habitats both within and beyond the current species' range. Using a 500-m grid and overlaying it upon the habitat map (Figure 1) in GIS yields 71 stations (Figure 2). The distance among the stations influences the number of stations sampled, the chance of including unoccupied suitable habitats and the resolution (coarseness) of distribution maps. Widespread placement of sampling units across the region may overestimate species' distribution, especially for species that are rare or occur in low densities, by including habitats that are unoccupied and unsuitable habitats.

Although Ralph et al. (1995) recommend sampling stations be 250 m apart, a grid of stations from 150-500 m, by 50 m intervals, was evaluated for the number of stations (Table 10) and coverage (Figure 2). RBWE do not occupy open, barren and agricultural habitats or land types. Therefore, point count stations were excluded from these habitats. No evidence was found favoring one grid interval over the others (Figure 3). Therefore, an interval distance of 500 m was chosen for logistical reasons.

Sampling procedures -- Sampling procedures should follow the recommendations of Ralph et al. (1995). Each station should be sampled once for 8 minutes, this duration is equivalent to distance sampling procedures (see below). The presence or absence of RBWE should be recorded for three segments of 3-, 2- and the final 3-minute periods. Thus, maximizing sampling effort and compatibility across sampling schemes, where intervals of differing lengths have been used. See Buskirk and McDonald (1995), Lynch (1995), Thompson and Schwalbach (1995), and Welsh (1995) for explanations of why shorter surveys (i.e., 5-10 minutes) are better than longer duration counts. All RBWE detected at a station should be recorded, and the distance from the station center point to the bird measured (following distance sampling procedures). For analyses, the birds detected within a 50 m radius of the station center point can be distinguished from those beyond 50 m. Surveys should only be conducted in appropriate weather (see Table 4) and all data recorded on a standard form (see appendix A in Ralph et al. 1995 for an example). Throughout the monitoring program (i.e., during distance sampling, station

establishment, and other field work) detection/nondetection and sampling covariates (site-specific and sampling-occasion covariates; Table 2) should be recorded. Thus, study question #1 may be evaluated frequently.

Adjusting the occurrence estimate by the detection probability (see Suggested Analysis below) is necessary to produce reliable estimates and account for birds that are present but missed when sampling (MacKenzie et al. 2002, 2003). A subset of the population can be used to determine the detection probability; therefore, the detection probability should be determined from repeated point count surveys from focal sites. The focal locations or sites should be representative of the target population to avoid bias, or multiple sites should be sampled and applied to representative strata. All data should be entered, added to a data repository, tabulated and analyzed promptly (see Suggested Analyses below; Bart 2005).

Study question #2 -- Like the count based sampling technique chosen for study question #1, point transect sampling was chosen for determining RBWE densities and population size. This technique was reached following the path 1B→3B→10A→11A→12A→13A, distance sampling methods, in the dichotomous key (Table 9). Scott et al. (1981) recommended this technique for tropical islands based on research in Hawaii. Furthermore, point transect sampling has been used to survey birds on Rota, including the RBWE (Tables 1 and 11).

Sample size -- In general, the number of sampling units needs to be sufficiently large enough to differentiate between the variability in the population and the variability from sampling. Using equation 7.17 from Buckland et al. (2001:246) yields the total number of stations needed to ensure a desired coefficient of variation. Detailed information is not available on flock size or the variability of flock size, therefore, flock size is assumed to have negligible influence on the encounter rate, and sample size (k) is adjusted upward *a posterior* by 30% (to account for RBWE flocking behaviors.). The number of sampling stations is then

$$k = \left(\frac{b}{\left\{ CV\left(\hat{D}\right) \right\}^2} \right) * \left(\frac{k_o}{n_o} \right) \qquad \text{(Buckland et al. 2001:245)}$$

The coefficient of variation, $CV\left(\hat{D}\right)$, was solved for CV = 10, 20 and 30% and the encounter rate was derived from Engbring et al. (1986) and Ramsey and Harrod (1995) for transects from the Sabana region. In 1982, 86 stations were sampled and 88 RBWE

were detected, resulting in an encounter rate of 1.02 (n/k). Whereas the encounter rate during the 1994 survey was 1.46 (n = 86; k = 59) (Table 12). The value of b is given by

$$\hat{b} \approx n_o * \left\{CV\left(\hat{D}\right)\right\}^2 \qquad \text{(Burnham et al. 1980:35)}$$

and using data from both 1982 and 1994 results in $\hat{b}$ = 4.5 and 5.6, respectively (values from Ramsey and Harrod 1995). These values fall outside the expected range of 1.5 and 3.0 (Burnham et al. 1980) or 2-4 (see Buckland et al. 2001:242). Sample size increases with increasing values of b; therefore, observed values of b were used in the sample size calculations for each year respectively. Sample size required to produce estimates with CV of 10, 20, and 30% range from 43 to 440 stations (Table 13). Adjusting these sample sizes for the effect of flocking yields sample sizes of 56 to 572.

Observed coefficients of variation were 0.1275 and 0.2145 for 1982 and 1994 surveys, respectively. The number of stations sampled in the Sabana region closely approximates the adjusted number of stations recommended to produce a CV of 30%. If the RBWE population declines, it may be expected that variance will increase, as seen between the 1982 and 1994 surveys. Therefore, more stations should be sampled to account for the increasing variability and maintain low CV to facilitate trend detection. Funding and other sampling constraints prohibit sampling more than about 150 stations, however, this number of stations should be sufficient to produce CV ≤ 20% (Table 13).

Survey allocation -- Stratifying survey allocation, or the number of stations, by the density of strata can help to minimize the total abundance variability. Buckland et al. (2001:247) shows that allocation of effort is proportional to the area and density of the strata, where the proportion of samples is ($k_v = A_v\sqrt{D_v}$), if the density function ($h_{(0)}$) is constant across stratum and model assumptions are met. Analysis of strata data from Fancy and Snetsinger (2001) suggests allocating approximately 30% and 70% of the stations to low- and high-density stratum, respectively. Sampling 150 stations then results in 45 stations established in the low-density stratum and 105 stations in the high-density stratum. It is not possible, however, to allocate 70% of the sampling effort to the high-density stratum due to the small, patchy distribution and required spacing interval among stations. Therefore, the 150 stations were allocated to suitable habitat above 200 m elevation in the Sabana Region regardless of density strata.

Point transect layout -- A systematic design, stratified by habitats and density, will produce more evenly distributed sampling units across the region (Buckland et al. 2001). Sampling for density estimates is restricted to suitable habitats within the current range

above 200 m (Table 7), however allocation of stations proportional to the area and density of strata is difficult due to the limited extent and patchy distribution of the high-density stratum (see Survey allocation above).

Using the existing transect and station layout has advantages and limitations. Resampling stations allows for analysis of trends using repeated measures and the existing network of trails are the greatest advantages. However, this layout does not follow a systematic design and may actually yield biased estimates if the sampling units were not randomly chosen. No evidence was found indicating that previous transect placement was not randomly or stratified randomly chosen. Therefore, the advantage of using the existing transects outweighs potential bias. Two point transect layout schemes were developed. The first layout uses the existing transects, whereas the second layout follows a systematic design.

Most of the stations along 4 transects (transects 6, 7, 8 and 12) were sampled during the 1982 and 1994 surveys (see Ramsey and Harrod 1995). In an effort to retain as many previously sampled stations as possible, these 66 stations were included in the layout. Sampling these 66 stations allows for repeated measures analysis (statistically required when the same stations are measured more than once) to extend back two decades. The remaining non-overlapping transects in the Sabana region were included in the selection process. I randomly located 150 points in the Sabana Region using a series of random numbers, limited between 1 and 150. (Figure 4). The existing transect closest to the random point was selected. Random points and the closest associated transect were selected until 150 stations were chosen. This process yielded a total of 148 stations on 10 transects (Figure 5) including transects 6, 7, 8, and 12 established in 1982, transects 2 and 5 established in 1989, and transects 15, 16, 18 and 20 established in 1994.

The second point transect layout was developed following a systematic design. A random starting point was selected from a grid of 100 points in the southeast portion of the Sabana Region and 10 transects of 15 stations were spaced 1.5 km apart (Figure 6). Stations were located at intervals of 150 m along transects.

Sampling procedures -- Distance sampling procedures should follow the recommendations of Buckland et al. (2001) to ensure that model assumptions are met. Each station should be sampled for 8 minutes, where the duration matches previous surveys (see sources in Table 8). The distance, measured to the nearest meter, to all RBWE detected at each station should be recorded, and if recording does not interfere with sampling, the detections should be recorded for three segments of 3-, 2-, and the

final 3-minute periods. Station and sampling conditions and covariates (Table 2) should also be recorded for each station. Surveys should be conducted during appropriate sampling conditions and all data recorded on a standard form. All observers should receive rigorous training and calibration, including training in species identification by vocalizations and distance measure estimation for birds heard but not seen, prior to each survey (Kepler and Scott 1981). Data should promptly entered, tabulated and analyzed, and added to a data repository (see Suggested Analyses below).

Point transect sampling can be used to survey for multiple species simultaneously. If sampling other birds does not interfere with RBWE sampling, all birds detected should be recorded during surveys, processed and analyzed to determine patterns.

Sampling period and frequency

The RBWE population is partially open (births and deaths occur), i.e., recruitment may occur between sampling occasions. Therefore, the sampling time frame, or sampling period, should be carefully considered so that the same target population is sampled (i.e., breeding birds). Engbring et al. (1986) noted that RBWE are visually conspicuous, highly mobile and call frequently. However, their calls are soft and may be missed, especially in adverse weather. These behaviors are further supported in Table 3. Sampling when the species is most conspicuous is necessary, therefore, monitoring programs typically survey during the breeding season (e.g., North American Breeding Bird Survey). RBWE probably breed year-round, however, breeding was observed between March and June (Lusk and Taisacan 1997), and December through August (Amidon 2000). Two additional factors need to be considered in determining the sampling period. Typhoons may influence RBWE distribution and breeding patterns. The typhoon season is year-round, but is most intense between June and December (http://en.wikipedia.org). Sampling before the typhoon season, yet within the breeding season, restricts surveys to the months of March to May.

Furthermore, an important component of the monitoring program is to detect changes in the population. Therefore, it is important to maintain the program's continuity over time, including sampling during the same period. Surveys of RBWE have been conducted throughout the year (Table 1); however, only surveys in 1982, 1987, 1988-1989 and 1994 surveyed using point transect methods. Subsequent surveys used either area searches (Fancy and Snetsinger 2001) or point count (Amidon 2000) methods. By combining the above information, sampling should occur between March and May to ensure that the population is closed temporally (an assumption of PAO) and that the birds

are conspicuous. Sampling during this period will allow for future population estimates to be compared against the 1982 and 1994 surveys.

Consistency in sampling is of utmost importance. Sampling the same set of grid points and stations should be used to determine change in distribution and density. Likewise, consistency in sampling frequency is needed, especially with regards to equal time steps (e.g., sampling every 1, 2, or 5 years). Given that the time steps are equal, sampling frequency is a balance between the number of years of monitoring required to detect a decline given annual rates of decline and the coefficient of variation. Assuming a one-to-one relationship between alpha and power (Gibbs 2000, Di Stefano 2003), power to detect a trend should be assessed at 0.80 using an alpha-level of 0.20. The CV of density for years 1982, 1994 and 1996 is 0.058 (Figure 7). Assuming that sampling error (e.g., variability due to measurement error) is negligible, then the source of observed variability is from process error (i.e., long-term variability in the population). Power to detect a 1-10% annual rate of decline in RBWE over 5-15 years of annual sampling is given in Table 14. Sufficient power (≥ 80%) was observed for annual surveys over a 15-year period for annual declines of ≥ 1% and for declines of ≥ 3% if surveyed for 10 years. A decline of 20% of the RBWE population (5% per time step) could be detected in 5-years of annual surveys. Annual sampling is suggested for study question #2 – determining population density. Sampling to determine species distribution on the sampling grid should be conducted every other year.

Cost-effective sampling assessment

Because funding is limited, the benefits of adding survey components (e.g., method, effort, allocation, fieldwork, analysis, evaluation and dissemination) must be balanced by the cost of those components. I use the model of Carlson and Schmiegelow (2001) to quantify the cost of different sampling strategies as:

$$\text{Cost} = s[\$_e + (f * r * \$_v)],$$

where *s* is the number of stations, *f* is the sampling frequency, *r* is the number of surveys, $\$_e$ is the cost of establishing a site, and $\$_v$ is the cost of sampling a site.

Because locating and marking sites (i.e., cutting and flagging transects) is required annually, the cost model can be simplified to

$$\text{Cost} = s[\$_e + (r * \$_v)].$$

This likely inflates the long-term costs if establishing sites requires less effort in subsequent surveys.

Estimates of costs were provided by the USFWS (F. Amidon, pers. comm.) and are based on the 2003 Mariana crow survey (Table 15). These estimates account for

labor, equipment, travel, and access costs, but underestimate the total costs of monitoring, as they do not include costs of administration, data analysis and management, program evaluation, and dissemination of information.

Study Question #1 -- Total costs of determining the range of RBWE can be split into the cost of determining detection probability and the cost sampling the distribution of RBWE. To determine detection probability, I recommend sampling the subset of 20 stations, a minimum of 4 times, each time RBWE distribution is determined (see MacKenzie n.d.). Cost of sampling a subset of 20 stations 4 times annually is $2,160. For assessing distribution, sampling the 71-point count stations of the 500-m grid, at $48 per station, will cost $3,408; the total cost of sampling stations and assessing detectability is $5,568 (= $3,408 + $2,160).

Study Question #2 -- I recommend establishing 150 sampling stations. The minimum number of stations required to attain the desired level of precision increases as density of RBWE decreases. Therefore, the number of sampling stations should reflect desired precision at the level of RBWE density that triggers management action. At $100 per station, I expect the cost of sampling 150 stations once annually is $15,000.

Habitat sampling

Falanruw et al. (1989) produced a habitat map for Rota and the Sabana region. This map demarcates habitat types and provides broad scale habitat information (i.e., macro scale classification of dominant vegetation). The habitat types can be categorized as suitable or unsuitable for RBWE (Table 7). However, over time habitats can change and periodic surveying is required to maintain the maps usefulness. Periodic surveying, every 3-5 years for example, should record standard habitat variables at each bird sampling station (Table 16). This information can be used to update the habitat map, assess if suitable or unsuitable for RBWE occupancy, and may be useful for understanding bird-habitat relationships and other, more advanced analyses.

Suggested analyses

Surveys should be tabulated and analyzed promptly, I recommend annually. This will allow for rapid detection of patterns and evaluate population parameters to threshold levels and take alternative actions if required. Suggested analyses are divided into two groups: (1) methods that summarize and tabulate the surveys and RBWE detections, and (2) analytical techniques that address the study questions.

General description and summary of surveys are recommended. Deviation from the monitoring protocol should be described and assessed for adverse impacts (e.g., change in sampling methods or survey locations may cause estimator bias). Survey dates should be compared to the breeding season, and macro weather conditions and patterns (e.g., El Nino). Any changes in habitat strata, changes due to typhoons or development for example, should be acknowledged and station layout assessed. If other bird species are recorded, a summary of the avifauna assemblage, abundance (index or absolute measures) and patterns should be described. In addition, summary of indicator species (i.e., competitors, predators and indicator species) should be described.

General description and summary of RBWE detections are recommended. Summaries of stations sampled, sampling conditions, station to habitat strata relationships, and naive frequency of occurrence and relative abundance (i.e., birds per station) should be calculated. Furthermore, RBWE detections (e.g., % heard vs. seen, % by detectability code, etc.) should be described and assessed for adverse impacts. Trends are not reliable during the first 5-15 years and about 10 surveys are necessary to reliable track changes (Hatfield et al. 1996). Therefore, species range maps should be created and visually compared. Mapping serves as a quick tool to help illuminate sampling discrepancies and biases.

Study question #1 focuses on determining the proportion area occupied by RBWE and tracking changes in this measure. Program PRESENCE (URL: http://www.proteus.co.nz) can be used to evaluate and incorporate covariate variables, evaluate and incorporate stratification where necessary, and calculate the detection probability. MacKenzie and Kendall (2002) describe how the detection probability may be incorporated in estimating a direct measure of the proportion area occupied. Analysis of trends can be accomplished with z-tests for end-point comparisons, and linear or higher order regression analysis for time series data.

Determining and tracking trends of RBWE density is the focus of study question #2. Program DISTANCE (Thomas et al. 2004*b*; URL: http://www.ruwpa.st-and.ac.uk/distance) can be used to evaluate and incorporate covariate variables, estimate direct measures of density, and calculate standard error and 95% confidence intervals using bootstrap procedures. Data from both the distance sampling and PAO surveys (if distance measures are recorded during PAO counts) can be used to estimate RBWE densities. The detection function should be evaluated by density strata and pooled where possible. Similarity of detection functions should be evaluated according to the key model selected and incorporating the low-density data as a covariate to the high-density

data (see Buckland et al. 2004 for procedures), and data pooled or stratified as necessary. Estimates of birds that were detected as individuals should be analyzed separately from birds detected as clusters and the estimates combined to yield a total population estimate (Buckland et al. 2001). Analysis of trends can be accomplished with z-tests for end-point comparisons, and linear or higher order regression analysis for time series data. Repeated measures that account for temporal and spatial autocorrelation should be used for tracking trends in time series data.

Population measures and trends should be compared to threshold levels and appropriate actions taken (Tables 5 and 6). Prompt assessment and evaluation may allow for sufficient time to take alternative actions and establish field protocols. If alternative actions are required, the appropriateness of the current study design should be assessed and any changes (e.g., station placement, sampling protocol) evaluated to ensure that monitoring program goals and study questions might be achieved.

Monitoring program assessment and evaluation

For a monitoring program to be successful, I recommend that monitoring objectives and techniques be reviewed on a regular basis. This ensures that the program objectives, goals and study questions might be achieved, and that the program is appropriate and incorporates any techniques that will improve the overall scheme (e.g., reallocation of stations, use of new sampling or analytical techniques). Complete evaluation of the program should be conducted every 5-10 years, whenever a management action is triggered, or whenever the consistency of the scheme is interrupted. Furthermore, all products (e.g., reports or publications) should be peer-reviewed for quality assurances.

Acknowledgements

I thank F. Amidon supplying survey and RBWE biological information, and for his comments on the manuscript. Comments from J. Citta and J. Foster greatly improved this manuscript. The USFWS supplied base coverages in GIS. The opinions expressed in this product are those of the author and do not necessarily represent the opinions of the University of Hawaii or the U.S. Government.

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Table 1. Details of RBWE surveys.

Study Question	Survey Year	Survey Period	Survey Area	Survey & Analytical Methods	Strata	Source
1 & 2	1982	Mar-Apr	Whole Island	Point transect & VCP	None	Engbring et al. (1986)
1 & 2	1987	Apr	Sabana & Tatgua	Point transect & VCP	None	Engbring (1987)
1 & 2	1988-89	Aug, Dec & Aug	Whole Island <200m	Point transect & VCP	None	Engbring (1989)
1 & 2	1989	Jan-Aug	Sabana	Point transect & count	None	Craig & Taisacan (1994)
1 & 2	1990-91	Jun-Jan	Sabana	Point transect & count	None	Craig & Taisacan (1994)
2	1994	May	Whole Island	Point transect & VCP	None	Ramsey & Harrod (1995)
1 & 2	1996	Sep	Sabana	Area search	Habitat type & density of RBWE	Fancy & Snetsinger (2001)
1	1998	Jun-Aug	Sabana	Point count	Habitat type & density of RBWE	Amidon (2000)
1	1999	Jan-Aug	Sabana	Point count	Habitat type & density of RBWE	Amidon (2000)

Table 2. Information required for addressing study questions.

Study Question	Variables	Required Data	Sources of Data	Survey Methods
1	Detection/ Nondetection	Detection (1) & nondetection (0) data by station & survey	Surveys of RBWE at *n* sites	Point count surveys over RBWE range
1	Detection probability	Detection (1) & nondetection (0) data by station & survey	Surveys of RBWE at *N* sites over *T* occasions in time	Repeated point count surveys from focal sites
1	Sampling covariates: Site-specific	Site-specific covariates: habitat type, patch size, generalized weather patterns (e.g., wet/dry season, El Nino), breeding season	Covariates recorded during surveys of RBWE at *N* sites over *T* occasions in time	Point count surveys over RBWE range and focal sites
1	Sampling covariates: Sampling-occasion	Sampling-occasion covariates: cloud cover, precipitation, wind, gust, time of day, observer	Covariates recorded during surveys of RBWE at *N* sites over *T* occasions in time	Point count surveys over RBWE range and focal sites
2	Distance measurements	Estimates of distance (to nearest meter) from each detected RBWE to station center point	Distance measurements recorded for each observation during surveys of RBWE at *N* sites	Point-transect count (i.e., variable-circular plot) surveys over RBWE range

Table 2. Continued, page 2 of 3.

Study Question	Variables	Required Data	Sources of Data	Survey Methods
2	Flock size	The number of individuals within the flock	Size of flock recorded for each observation during surveys of RBWE at *N* sites	Point-transect count (i.e., variable-circular plot) surveys over RBWE range
2	Detection type	(1) Heard but not seen during count; (2) first detected by sight during count; (4) heard first then later confirmed during count	Detection type (i.e, 1, 2, & 4) recorded for each observation during surveys of RBWE at *N* sites	Point-transect count (i.e., variable-circular plot) surveys over RBWE range
2	Detection code	(1) Dense Forest with a closed canopy and thick understory, visibility 15 m or less in all directions; (2) forest with open understory and relatively complete canopy, visibility 15-50 m; (3) like #2, but visibility is over 50 m in 5-20% of area surrounding observer; (4) visibility over 50 m in 20-50% of area; (5) open field or nearly open field, visibility 50 m or more in over 50% of area surrounding observer.	Detection code (i.e, 1, 2, 3, 4 & 5) recorded during surveys of RBWE at *N* sites	Point-transect count (i.e., variable-circular plot) surveys over RBWE range

Table 2. Continued, page 3 of 3.

Study Question	Variables	Required Data	Sources of Data	Survey Methods
2	Sampling covariates: Site-specific	Site-specific covariates: habitat type, detectability code, generalized weather patterns (e.g., wet/dry season, El Nino), breeding season	Covariates recorded during surveys of RBWE at *N* sites	Point-transect count (i.e., variable-circular plot) surveys over RBWE range
2	Sampling covariates: Sampling-occasion	Sampling-occasion covariates: cloud cover, precipitation, wind, gust, time of day, observer	Covariates recorded during surveys of RBWE at *N* sites	Point-transect count (i.e., variable-circular plot) surveys over RBWE range

Table 3. Characteristics of RBWE biology that may influence sampling.

Study Question	Time Budget	Agonistic Behavior	Territoriality	Nesting System
1 & 2	Proportion of conspicuous behaviors: foraging ≈ 57%, vocalization ≈ 7%, movement ≈ 4% (total = 68% [Amidon 2000]).	Unknown[1]	Flocks occupy areas at least 150 m in diameter with intervening areas unoccupied (Craig & Taisacan 1994), defense unknown.	Defense – unknown, incubation – both adults, tending young – both adults.

Study Question	Singing & Calling	Sex Ratio	Conspicuousness
1 & 2	Seasonality – unknown, frequency – unknown, location – from canopy trees.	Unknown[2]	Gregarious species most often found in small family flocks and call frequently.

Study Question	Foraging System	Flock Size	Breeding Periods	Typhoon Influences
1 & 2	Gleans insects from tree canopy, specifically in the periphery of the canopy. Also known to take seeds, nectar, flowers and fruits (Craig and Taisacan 1994, Amidon 2000).	2-3 birds (max. = 14 birds) (Amidon 2000).	Dec-Aug[3]	Alters habitat[4] and may disrupt breeding.

[1] Although specific agonistic behavior has not been determined RBWE forage in small family flocks (2-14 birds [Amidon 2000]), in addition to foraging in mixed species flocks, specifically with rufous fantails (*Rhipidura rufifrons*).
[2] No evidence was found indicating the sex ratio of RBWE, however, several authors noted that birds were often observed in small flocks and Craig and Taisacan (1994) further noted that flocks were observed at the same location on repeated visits with no birds observed in the intervening space. Therefore, I assume that the species has a 1:1 sex ratio.
[3] From Amidon (2000). Lusk and Taisacan (1997) observed RBWE breeding between March and June. It is likely that RBWE breed year-round.
[4] Typhoons may alter RBWE distribution, where birds may disperse to lower elevations and into unsuitable habitats (Amidon 2000). The change in distribution may be a result of habitat damage by typhoons. As the forest recovers, it is expected that RBWE will reoccupy damaged limestone forests.

Table 4. Practical constraints that need to be taken into consideration in the design and scheduling of the sampling program.

Study Question	Constraints	Characteristics[1]	Population Affected[2]
1 & 2	Dense vegetation[3]	Sound is attenuated and visibility hindered or blocked by vegetation, with impact increasing with increasing density of the vegetation. Densely vegetated habitats need to be sampled and a Habitat Code (see Ramsey and Harrod 1995) assigned to east sampling unit (e.g., station). Possible influence of vegetation density may then be accounted for as a categorical covariate in PAO and density analyses.	Increasing vegetation density and amount of background noise negatively influences the ability to detect and accurately estimate distance measurements to birds within strata categories (e.g., birds within code 0 habitats are more negatively affected than birds in code 5). RBWE populations in codes 0-2 may be under represented, resulting in biased population estimates.
1 & 2	Highly topographic areas	Highly topographic areas prohibit random, or stratified random, placement of sampling units. Safety of field personnel supercedes sampling areas or habitats that pose unrealistic risks. No methods to minimize this constraint are recommended.	RBWE populations in highly topographic areas may not be adequately surveyed or under represented in the study design. This may bias population estimates of the entire population, but especially populations within these areas or habitats.
1 & 2	Isolated areas	Isolated areas do not appear to be a constraint based on placement of previous sampling transects. However, any isolated areas need to be determined and appropriately sampled.	RBWE populations in isolated areas may not be adequately surveyed or under represented in the study design. This may bias population estimates of the entire population, but especially populations within these areas or habitats.

Table 4. Continued, page 2 of 4.

Study Question	Constraints	Characteristics[1]	Population Affected[2]
1 & 2	Season	Seasonality may affect detection probabilities due to altered bird behavior (e.g., reduced singing and calling). Sampling within the same season through time standardizes any negative influences of season. Engbring (1989) noted that numbers of birds detected in December was substantially lower than August surveys.	The entire RBWE population responds to seasonal influences.
1 & 2	Diurnal period	Diurnal period, or time of day, may influence RBWE probability of detection as bird behavior changes throughout the day. Sampling from dawn to 4 hrs post sunrise standardizes any negative influences of diurnal period, and this constraint can be accounted for as a categorical covariate in PAO and distance analyses.	Birds detected later in the day may be less detectable than birds that are more conspicuous in the early morning.
1 & 2	Cloud cover	Although sampling may occur during all levels of cloud cover, estimated in 10% categories from 0 to 100%, this categorical covariate should be accounted for in PAO and density analyses.	Amount of cloud cover may interfere with seeing RBWE, especially birds that are silhouetted against the sky, although this relationship may not be linear.
1 & 2	Rain[4]	Survey only when rain levels are less than 4, and account for rain as a categorical covariate in PAO and density analyses.	Increasing rain intensity negatively influences the ability to hear bird calls and alters bird behavior of the entire population. In addition, rain intensity effects on detectability are compounded with bird distance from the station center point.

Table 4. Continued, page 3 of 4.

Study Question	Constraints	Characteristics[1]	Population Affected[2]
1 & 2	Wind	Survey only when wind levels are less than 5 on the Beaufort scale, and account for wind as a categorical covariate in PAO and density analyses.	Increasing wind speed negatively influences the ability to hear bird calls and alters bird behavior of the entire population. In addition, wind speed effects on detectability are compounded with bird distance from the station center point.
1 & 2	Gust	Survey only when gust levels are less than 5 on the Beaufort scale, and account for gust as a categorical covariate in PAO and density analyses.	Increasing gust speed negatively influences the ability to hear bird calls and alters bird behavior of the entire population. In addition, gust speed effects on detectability are compounded with bird distance from the station center point.
1 & 2	Observer	Qualified, trained and calibrated observers should conduct surveys to reduce errors and ensure that survey methods are followed.	Inexperienced and un-calibrated observers may increase sampling errors (e.g., misidentifying species and inaccurately estimating distances to birds) to the entire population. In addition, errors may not be consistent, prohibiting identification of problems or accounting for errors.

[1] Methods to minimize constraints and when to sample.
[2] Portion of the RBWE population that may not be sampled.
[3] Limited from 0 to 5, a code is assigned to each station that corresponds to the thickness of vegetation structure and the amount of background noise, where Code = 0 corresponds to very low detectability, and Code = 5 corresponds to unlimited visibility and unencumbered hearing. Exact criteria for each category needs to be determined and each observer calibrated to representative standards.

Table 4. Continued, page 4 of 4.

[4] Limited from 0 to 4, a code is assigned to each station that corresponds to the intensity of rain, where 0 = no rain, 1 = mist (fog), 2 = light drizzle, 3 =light rain, and 4 =heavy rain.

Table 5. Basis for setting management actions. The USFWS and managers should develop additional management actions, with threshold levels, based on the species recovery plan.

Study Question	Timeframe (years)	Triggers	Alternative Action(s)
1	3	Area occupied declines by 50 ha	1) Conduct vegetation and habitat assessment of occupied and recently vacated areas to determine composition and structural differences/changes, and mitigate any changes (e.g., reforestation, remove invasive plants). 2) Determine if recently vacated areas are sink habitats. 3) Proceed from using a naïve estimator to using a state-based estimator.
1	3	Area occupied declines by 100 ha	Proceed from using a state-based estimator to a resight estimator.
2	25	$\hat{N} < 500$	Establish a captive breeding flock to ensure species remains extant where individuals may be released into safe habitats.
2	5	3% decline	Continue distance sampling, and estimate rate of growth and birth/death rates from demographic study.
2	1	CV > 55%[1]	Continue distance sampling, and estimate rate of growth and birth/death rates from demographic study.

[1] Coefficient of variation (CV) threshold level determined as the mean of the CV of counts from time series studies of small birds (mean CV = 56.9%; Gibbs 2000).

Table 6. Transition between estimators determined by threshold level or condition that would necessitate sampling with a more intensive yet precise technique (Decision Rule).

Study Question	Decision Rule
1	A naïve estimator using presence and absence data is adequate to determine species range and distribution, unless: • The detection probability varies among surveys (year-to-year differences) (TBD); • The detection probability varies among strata (see Table 7 for details) (TBD); • The detection probability varies among sampling covariates (see Table 2 for details) (TBD), or; • Species range or distribution changes sufficiently to activate a threshold trigger (see Table 5 for details). Then proceed to using a state-based estimator that allows for incorporating and accounting for differences in variables (e.g., detection probabilities, proportion of area occupied).
1	A state-based estimator using presence and absence data form repeated sampling is adequate to determine species range and distribution, unless: • Obtaining the sample size necessary to adequately estimate model variables (parameters) is logistically (sampling, analytical or statistical variability) infeasible, or; • Species range or distribution changes sufficiently to activate a threshold trigger (see Table 5 for details). Then proceed to using a resight method to determine species range and distribution. See Bibby et al. (2000) and Table 9 for description of sampling design, sampling protocols and procedures.
2	A distance sampling based estimator using point transect (variable circular plot) sampling is adequate to determine population density and size, unless: • The variability is large enough to preclude precise estimation (see Table 5 for details), or; • The population declines sufficiently to activate a threshold trigger (see Table 5 for details). Then proceed to using demographic methods to determine population parameters and sources of demographic variability. See Martin et al. (1997) for description of sampling design, sampling protocols and procedures for breeding bird research.

Table 7. Strata with homogeneous characteristics.

Study Question	Strata	Homogeneous Characteristics
1	Historical distribution	Suitable habitat[1] on Sabana above 100 m.
1 & 2	RBWE areas occupied	Locations where RBWE were detected in 1996 (Fancy and Snetsinger 2001) and 1998-1999 (Amidon 2000).
1 & 2	Elevation	Elevation stratified between 100-200 m (includes historical elevation occupied by RBWE), elevation stratified above 200 m (includes the lowest elevation of RBWE observed between 1998-1999 [Amidon 2000]).
1 & 2	Habitat type[1]	Suitable habitat comprised of native limestone forest, secondary vegetation and introduced forest.
2	RBWE density	Habitats with density <2 birds/ha and >2 birds/ha (Fancy and Snetsinger 2001), surveys conducted by Amidon (2000) revealed that RBWE were patchy distributed within the high-density areas.
2	RBWE density variance	TBD[2]

[1] Craig and Taisacan (1994) documented RBWE in native forests that varied from stunted and open to closed and mature forests. Suitable habitat as defined and classified by Falanruw et al. (1989), Amidon (2000) and Fancy and Snetsinger (2001), and includes native limestone forest (58% area), secondary vegetation (13%) and introduced forest (1%). Native limestone forest was further classified as mature, young or disturbed limestone forest (Amidon 2000). In addition, Amidon further classified introduced forest as tangan-tangan forest (*Leucaena leucocephala*) and bamboo thicket (*Bambusa vulgaris*). Unsuitable habitat types include introduced ironwood thickets (*Casuarina equisetifolia*), agroforest, grassland, strand, urban, cultivated, and barren (sum equals 28% of area; Amidon 2000).
[2] TBD = to be determined.

Table 8. Details of RBWE occurrence. NP designates information not provided. Note that sampling methods and analyses differed among studies.

Year	Month	Breeding Season	Presence	Absence	Freq Occur[1]	Variance	# Transects	# Stations	Counts	Source
1982	Mar-Apr	Yes	Yes	Yes	0.58	Not calculated	14	254	508	Engbring et al. (1986)
1987	Apr	Yes	Yes	Yes	0.43	Not calculated	6	76	182	Engbring (1987)
1988 - 1989	Aug, Dec & Aug	Yes	Yes[2]	No	0.20	36% CV	8	164	1,169	Engbring (1989)
	Aug 88				0.32	18% CV	8	164	368	Engbring (1989)
	Dec 88				0.09	14% CV	8	164	432	Engbring (1989)
	Aug 89				0.20	16% CV	8	164	369	Engbring (1989)
1989	Jan-Aug	Yes	Yes	No	Pooled with 1990-91					
1990 - 1991	Jun-Jan	Both	Yes	No	8.6[3]	Not calculated	NP	NP	NP	Craig & Taisacan (1994)

[1] Frequency of occurrence calculated as the number of stations occupied divided by counts.
[2] Presence presented by transect and count.
[3] Calculated as birds per 10 counts.

Table 9. Dichotomous key to select population estimators (adapted from Thompson et al. [1998]).

1a)	A complete count is possible	2
1b)	A complete count is not possible	3
2a)	All birds can be counted within each plot	Site counts
2b)	All breeding territories, pairs and associated nests can be located within each plot	Total mapping
3a)	Individuals can be caught and uniquely marked	4
3b)	Individuals cannot be caught	10
4a)	Element is mobile (i.e., birds)	5
4b)	Element is immobile (e.g., nests)	7
5a)	Individuals are completely contained within a given plot	6
5b)	Not as above	8
6a)	Time period is short enough to treat population as closed	7
6b)	Not as above	9
7a)	There are at least 100 individuals and capture probability > 0.3	Mark-resight
7b)	Not as above	10
8a)	Individuals can be equipped with radio transmitters	NOREMARK
8b)	Not as above	10
9a)	Population is geographically closed and there is no heterogeneity in capture probability or behavioral response to capture method	Jolly-Seber open population model
9b)	Not as above	10
10a)	Perpendicular distance to bird can be recorded	11
10b)	Not as above	14
11a)	Every individual on line or point can be located	12
11b)	Not as above or methods to adjust for incomplete detection are not feasible	14
12a)	Individuals do not move in response to observer	13
12b)	Not as above	14

Table 9. Continued, page 2 of 2.

13a)	Adequate numbers of individuals or groups of individuals can be detected for reliable model selection	Distance sampling methods
13b)	Not as above	14
14a)	Only data on species occurrence required	Presence-absence methods
14b)	Uncorrected counts of all individuals detected on a plot	Relative index methods

Table 10. Number of point count stations in the Sabana region given uniform placement of stations at different intervals (Distance apart). The pool of sampling stations was further reduced to include only those stations that were within suitable habitats in the 100-200 m and > 200 m elevation contours. Ralph et al. (1995) suggest monitoring for distribution on a grid of stations with 250 m intervals (bold)

	Elevation	
Distance apart	100-200 m	>200 m
150	204	613
200	103	344
250	**68**	**217**
300	52	164
350	40	115
400	29	89
450	21	62
500	20	51

Table 11. Details of RBWE density. NP designates information not provided. Note that sampling methods and analyses differed among the studies.

Year	Month	Season	Density	Variance	Population Estimate	Source
1982	Mar-Apr	Yes	291.34[1]	37.16	10,763	Engbring et al. (1986)
1994	May	Yes	155.1[2]	NP	NP	Ramsey & Harrod (1995)
1996	Sep	No	115.70	19.40	1,165	Fancy & Snetsinger (2001)

[1] Density value based on analysis by Ramsey and Harrod (1995).
[2] Density value from addendum to Ramsey and Harrod (1995).

Table 12. Number of RBWE detected on 1982 and 1994 surveys of transects on the Sabana region, Rota. Transect number and number of stations from Recovery Plan, Appendix E. Number of RBWE detected and number of stations sampled, in parentheses, are presented.

	Survey	
Transect Number	1982	1994
5	0 (17)	
6 and 7	72 (37)	
8	16 (15)	
9	0 (17)	
16		13 (10)
21		40 (14)
22		0 (13)
23		3 (6)
24		29 (11)
25		1 (5)
Total	88 (86)	86 (59)

Table 13. Sample size needed to produce density estimate coefficient of variation ($CV\left(\hat{D}\right)$%) of 10, 20 and 30% using number of stations and RBWE detected on the Sabana region, and *b* = 4.5 (1982) and *b* = 5.6 (1994). Sample sizes were adjusted upward by 30% to account for RBWE flocking behaviors.

$CV\left(\hat{D}\right)$%	Survey	
	1982	1994
10	440	384
20	110	96
30	49	43
Adjusted upward by 30% (=*k**1.30)		
10	572	499
20	143	125
30	64	56

Table 14. Power to detect a 1-10% annual rate of decline in RBWE over 5-15 years of annual sampling given CV = 0.0576, alpha-level = 0.20, one-tailed significance test to detect a decline in density, with CV constant with abundance and equal intervals between sampling. Power calculated using program Trends (Gerrodette 1987). Bold text indicates adequate power (≥ 80%) to detect a negative trend.

	Annual Rate of Decline				
Duration	1%	3%	5%	7%	10%
5-years	38	79	**98**	**100**	**100**
10-years	78	**100**	**100**	**100**	**100**
15-years	**99**	**100**	**100**	**100**	**100**

Table 15. Estimated costs of for 1 local biologist to conduct 2003 Mariana Crow Survey.

2003 Mariana Crow Survey[1]	
Number of stations sampled (s):	199 stations on 14 transects
Number of surveys (visits; r):	1
Number of field days:	46
Actual costs[2]	
Number of observers:	6
Establishing sites:	$57.82
Surveying sites:	$40.18
Estimated cost to conduct survey by local biologists[3]	
Number of observers:	1
Establishing sites:	$28
Surveying sites:	$20

[1] This survey included sampling locations outside the RBWE distribution and beyond the Sabana region. Surveys conducted outside the Sabana region could be reallocated to within the RBWE distribution.
[2] Wages estimated at $25/hr = $9,200 (establish = $5,400, survey = $3,800), hotel rates at $35/night (double occupancy) = $1,000, vehicle rental at $65/day = $700, per diem at $40/day = $2,100, and travel (for biologists from Saipan, Hawaii and the mainland) estimated at $6,400.
[3] Wages estimated at $25/hr = $9,200 (establish = $5,400, survey = $3,800) for biologists from Rota.

Table 16. Habitat variables and measurement methods. Adapted from Bibby et al. (2000:271).

Variable	Measurement method
Vegetation community or land cover type	Assignment of vegetation to standard classification land cover types developed in Falanruw et al. (1989) and Amidon (2000).
Natural or introduced forest	Assignment by criteria developed in Amidon (2000).
Canopy height	Assignment by criteria developed in the National Vegetation Classification System (NVCS; FGDC 1997).
Canopy cover	Assignment by criteria developed in the NVCS (FGDC 1997).
Subcanopy and shrub density (vertical foliage density at various heights)	Assignment by criteria developed in the NVCS (FGDC 1997).

Figures

Figure 1. Map of current RBWE distribution based on information from Amidon (2000) and Fancy and Snetsinger (2001).

Figure 2. Map of point count sampling stations in suitable habitat in the Sabana region.

Figure 3. Graph illustrating the relationship between the number of stations to be sampled and grid intervals. Stations between 100-200 m elevation in suitable habitat are depicted as squares, whereas stations above 200 m elevation in suitable habitat are designated as diamonds.

Figure 4. Location of previously surveyed transects and stations (colored dots) on Sabana Region, Rota. Random points, depicted with +, used to randomly select transects.

Figure 5. Transects selected for determining RBWE population estimates from previously surveyed sites.

Figure 6. Transects selected for determining RBWE population estimates based on a schematic design. First transect located 936 m from randomly selected point. Several transects (6 and 8-10) extend into unsuitable habitat or beyond the 100 m elevation. Stations from these transects could be allocated to transects 1-3 and 5 extending them through suitable habitats within the 100 m elevation, yielding 150 stations.

Figure 7. RBWE density expressed as a function of year. Trend using linear regression produced the equation $y = -12.130x + 24334$, $F = 144.63$, $P = 0.05$, $R^2 = 0.99$. Standard error of the regression is 10.80 and the grand mean of the density estimates is 187.38, which results in CV = 0.0576 (= 10.80 / 187.38).

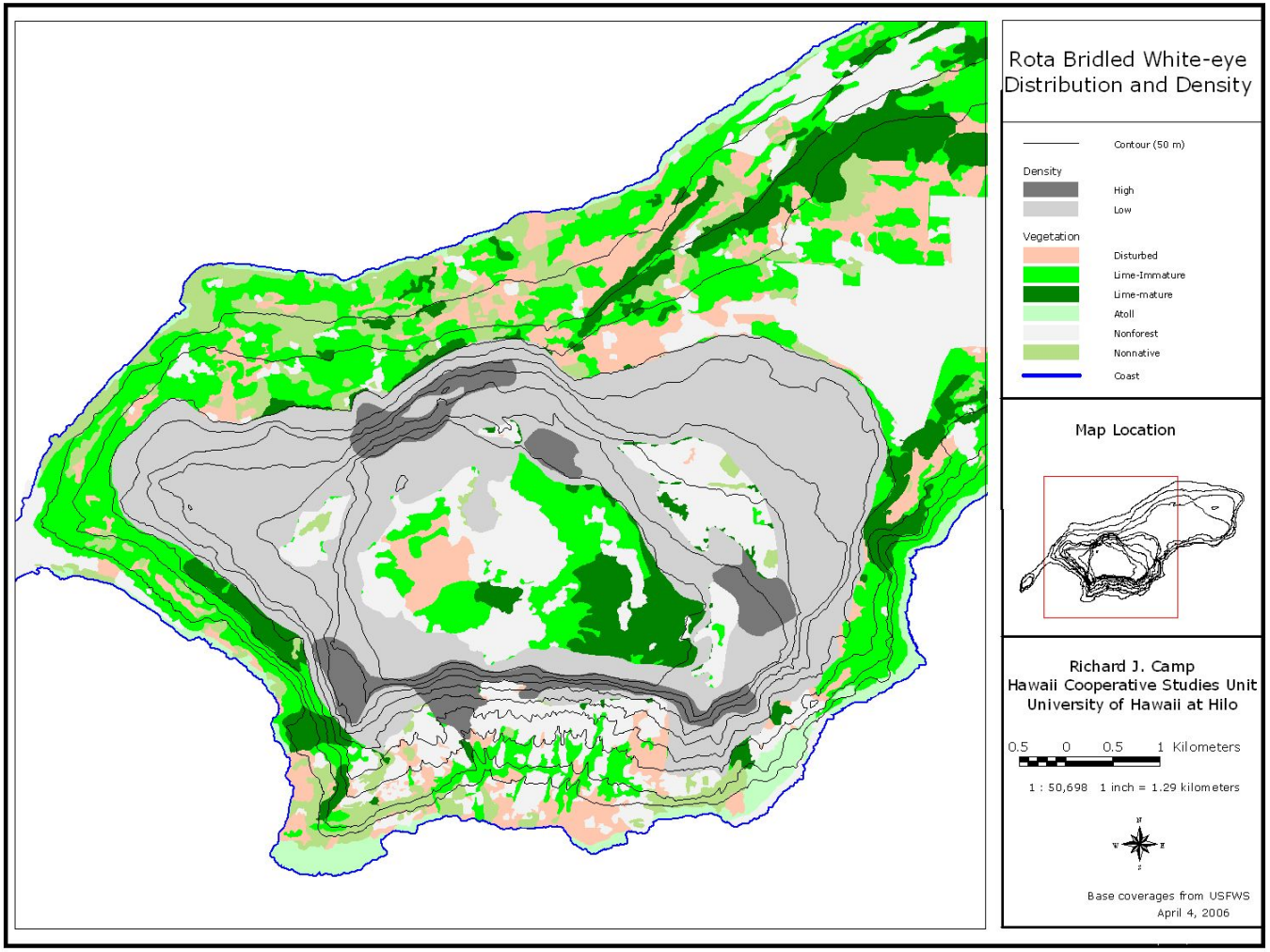

Figure 1. Map of current RBWE distribution based on information from Amidon (2000) and Fancy and Snetsinger (2001).

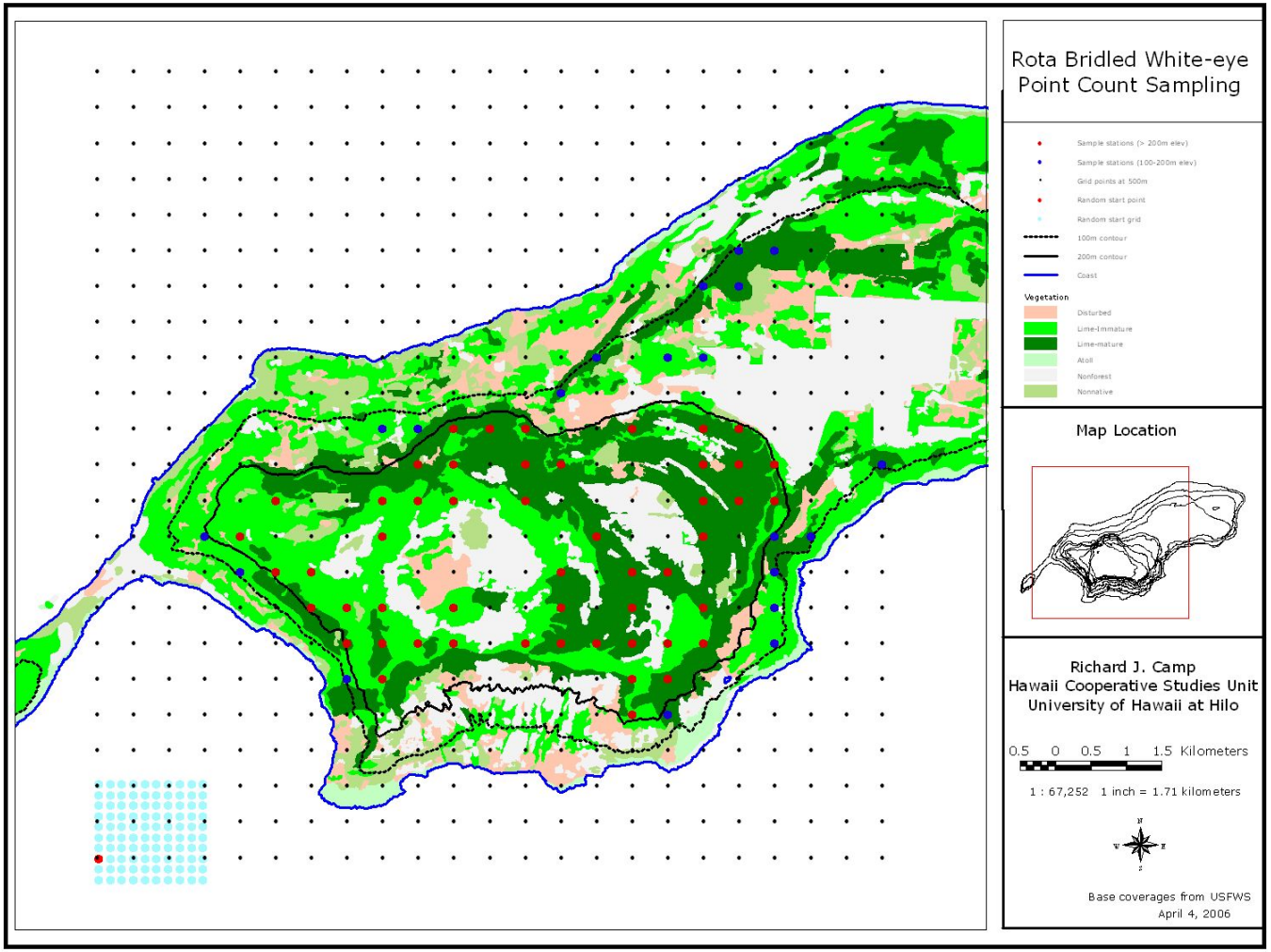

Figure 2. Map of point count sampling stations in suitable habitat in the Sabana region.

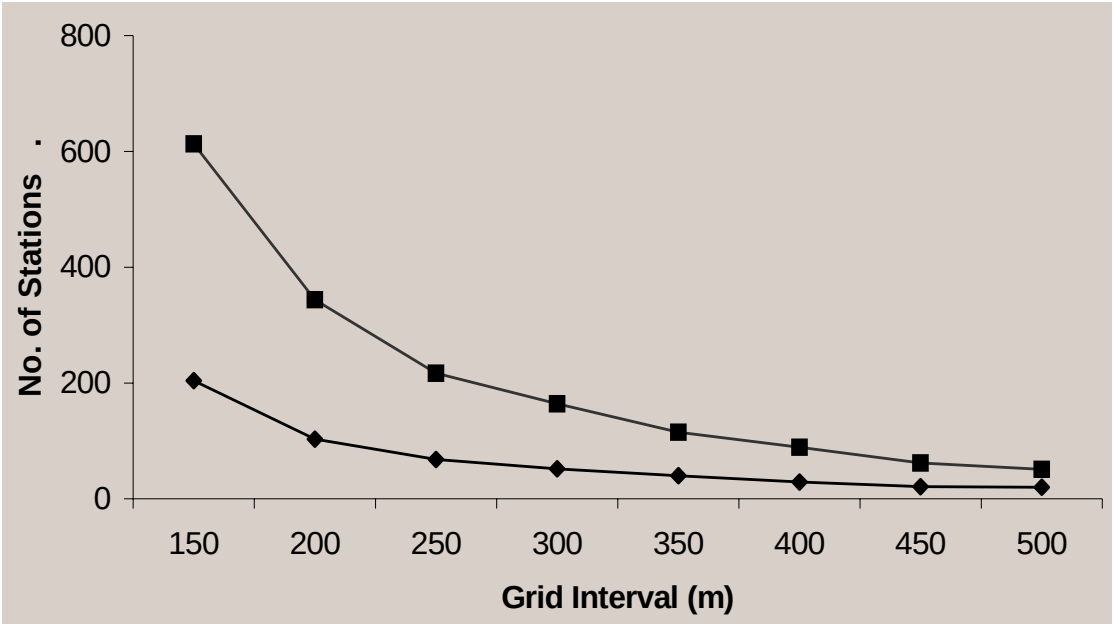

Figure 3. Graph illustrating the relationship between the number of stations to be sampled and grid intervals. Stations between 100-200 m elevation in suitable habitat are depicted as squares, whereas stations above 200 m elevation in suitable habitat are designated as diamonds.

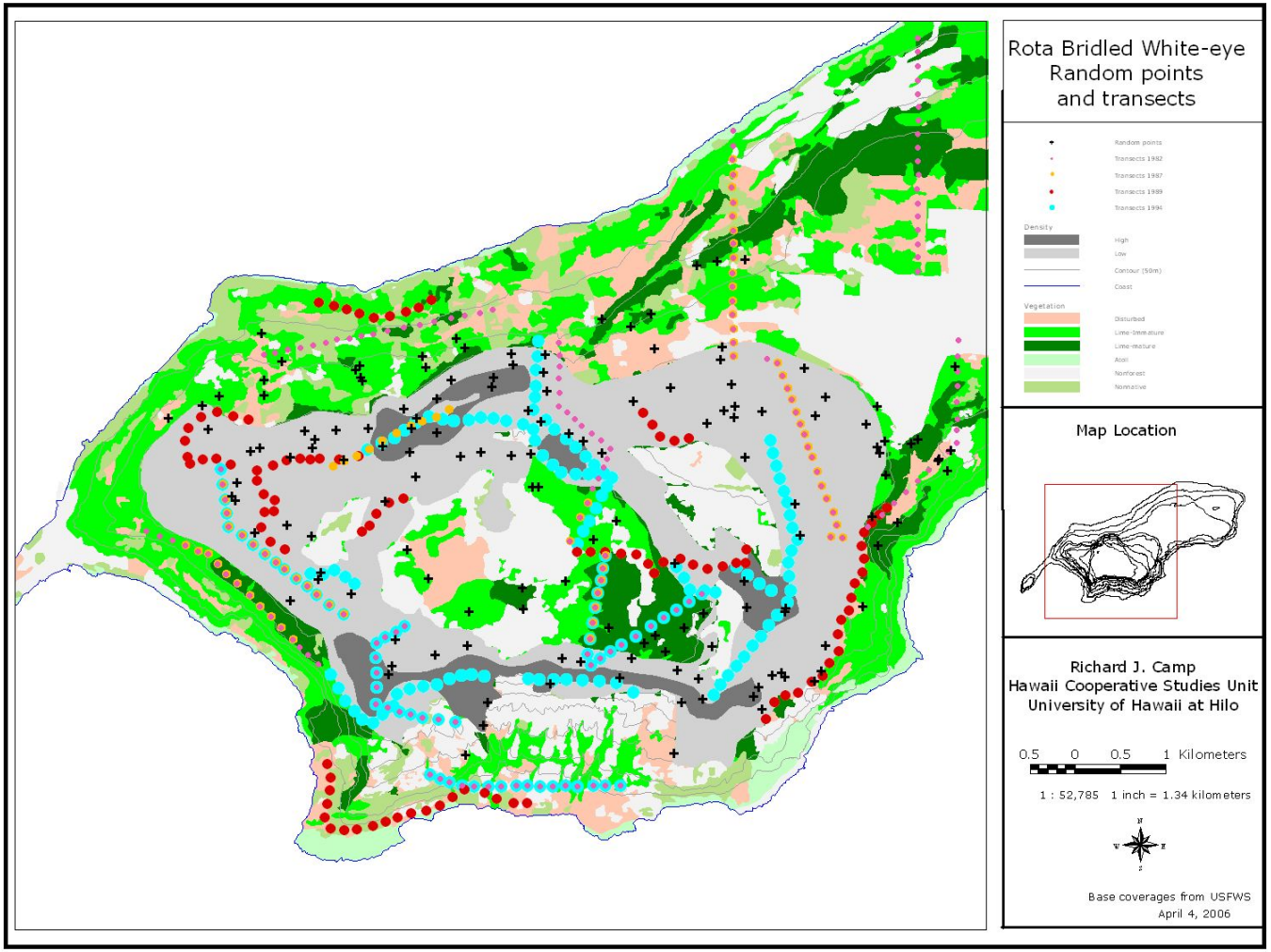

Figure 4. Location of previously surveyed transects and stations (colored dots) on Sabana Region, Rota. Random points, depicted with +, used to randomly select transects.

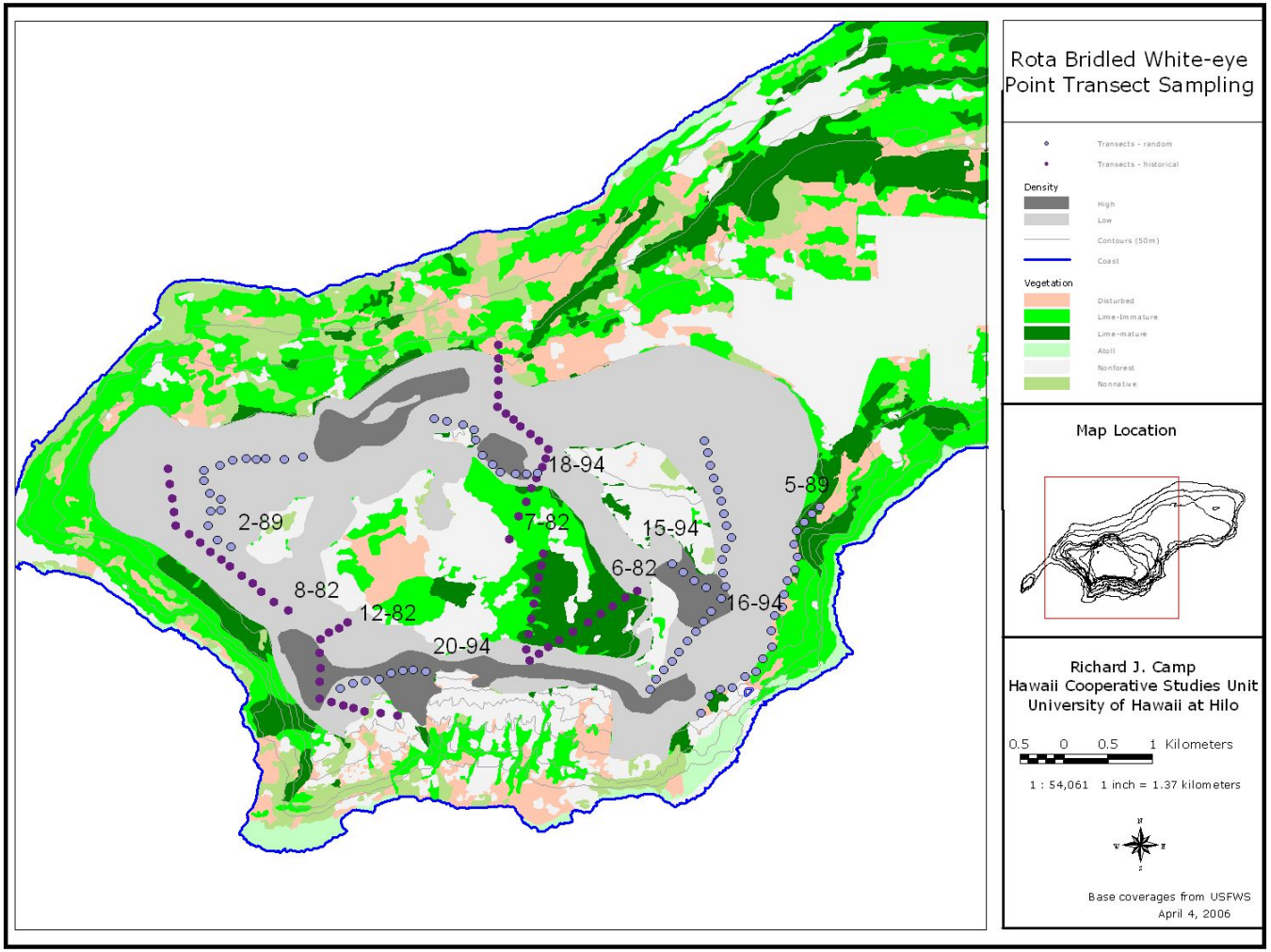

Figure 5. Transects selected for determining RBWE population estimates from previously surveyed sites.

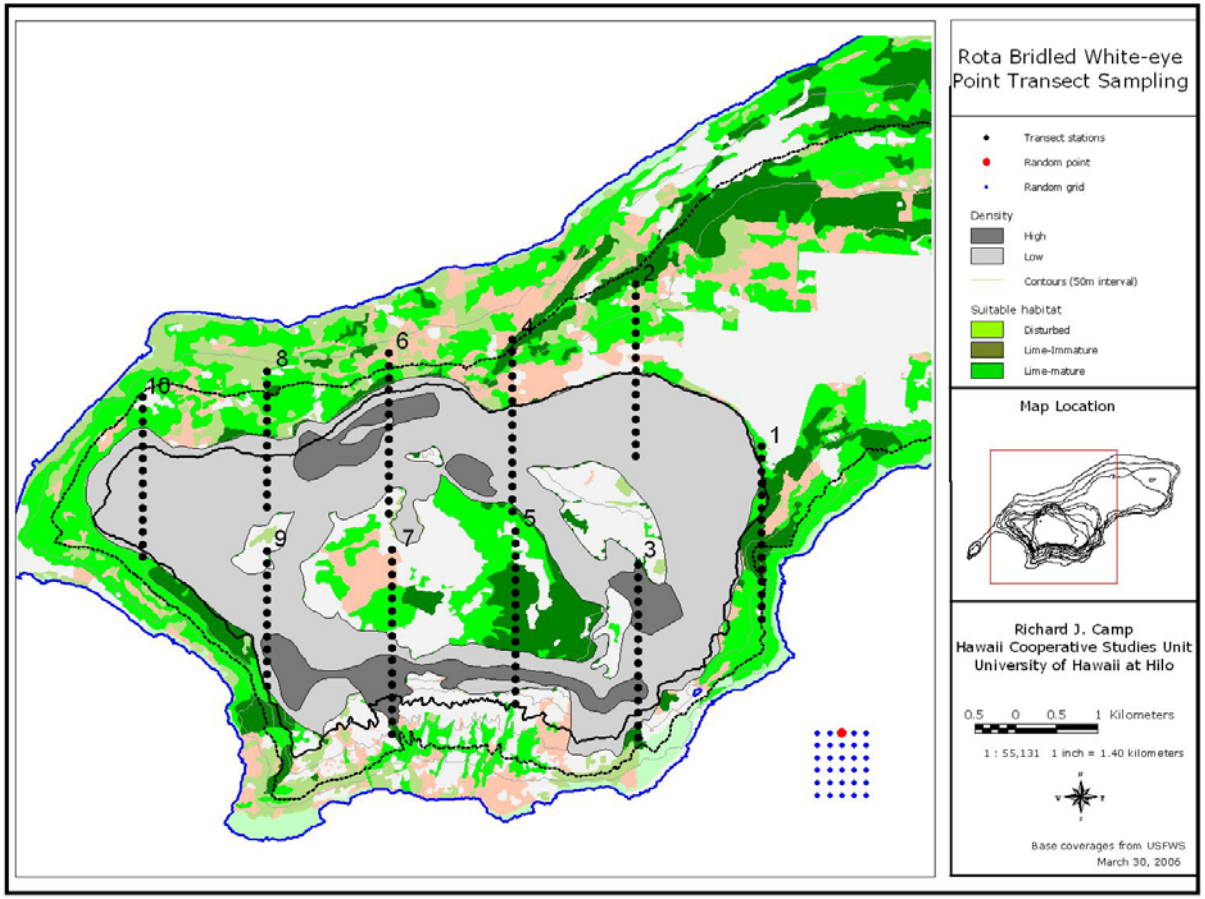

Figure 6. Transects selected for determining RBWE population estimates based on a schematic design. First transect located 936 m from randomly selected point. Several transects (6 and 8-10) extend into unsuitable habitat or beyond the 100 m elevation. Stations from these transects could be allocated to transects 1-3 and 5 extending them through suitable habitats within the 100 m elevation, yielding 150 stations.

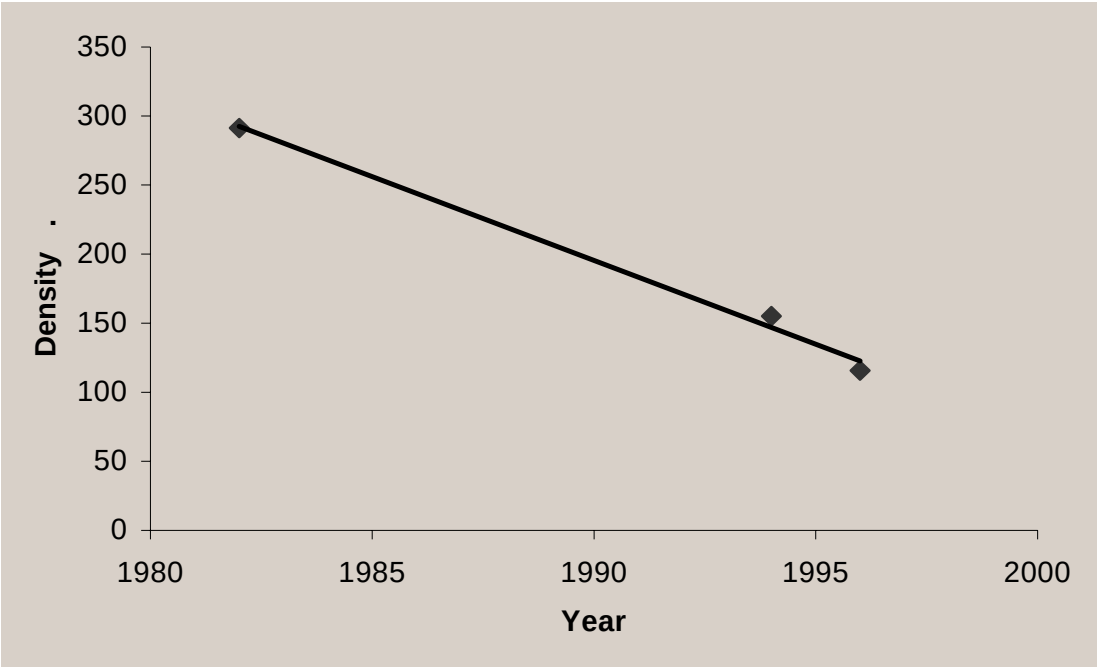

Figure 7. RBWE density expressed as a function of year. Trend using linear regression (Thomas et al. 2004*a*) produced the equation $y = -12.130x + 24334$, $F = 144.63$, $P = 0.05$, $R^2 = 0.99$. Standard error of the regression is 10.80 and the grand mean of the density estimates is 187.38, which results in CV = 0.0576 (= 10.80 / 187.38).

Region 1
U.S. Fish and Wildlife Service
Ecological Services
911 NE. 11th Avenue
Portland, Oregon 97232-4181

June 2006