U.S. Fish & Wildlife Service

Draft Revised Recovery Plan for the Sihek or Guam Micronesian Kingfisher
(Halcyon cinnamomina cinnamomina)

Cover photo of #26, the last remaining wild-born Guam Micronesian kingfisher. Courtesy of the Chicago Zoological Society/Photo by Jim Schulz, used with permission.

DRAFT REVISED RECOVERY PLAN
FOR THE SIHEK
OR
GUAM MICRONESIAN KINGFISHER
(*Halcyon cinnamomina cinnamomina*)

(March 2004)

Original plan approved: September 28, 1990
(Native Forest Birds of Guam and Rota of the Commonwealth of the Northern Mariana Islands)

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

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

Date: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

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<http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm> and also at <http://endangered.fws.gov/recovery/index.html>.

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EXECUTIVE SUMMARY

Current Status: The Guam Micronesian kingfisher or sihek (*Halcyon cinnamomina cinnamomina*) was listed as an endangered subspecies in 1984 (United States Fish and Wildlife Service [USFWS] 1984). By 1988, the sihek had been extirpated from the wild and this subspecies is now found only in captivity. As of June 2003, 60 sihek survive in captivity in 11 institutions within the continental United States, and 3 were recently transferred to a new facility on Guam. The sihek has a recovery priority number of 3 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 subspecies.

Habitat Requirements and Limiting Factors: Prior to its extirpation from the wild, the sihek was found only on the island of Guam. This kingfisher utilized a wide variety of habitats on the island including limestone forest, strand forest, ravine forest, agricultural forest, secondary forest, edge habitats, and forest openings. However, mature forests with appropriate nest sites may be an important component of kingfisher reproductive activities. The cavity-nesting sihek apparently requires large, standing dead trees averaging 43 centimeters (17 inches) in diameter in which to excavate their nests (Marshall 1989). Diverse vegetative structure providing a variety of both invertebrate and vertebrate prey, as well as exposed perches and areas of open ground for foraging, are also important.

Habitat degradation and loss, human persecution, contaminants, and introduced species such as disease organisms, cats (*Felis cattus*), rats (*Rattus* spp.), black drongos (*Dicrurus macrocercus*), monitor lizards (*Varanus indicus*), and brown treesnakes (*Boiga irregularis*) have all been suggested as factors in the population decline of this species. However, predation by the brown treesnake is believed to have been the overriding factor in the extirpation of sihek. Factors that continue to prevent the recovery of the sihek include poor reproductive success and high mortality in the captive population and the continued high density of brown treesnakes on Guam. Therefore, the majority of the recovery actions in this recovery plan address the brown treesnake threat and captive propagation issues. Habitat loss and degradation is currently not a major threat due to the availability of suitable forest on Guam. However, this threat may increase as the island of Guam becomes further developed and additional forested areas are cleared or modified and feral ungulate populations remain high.

Recovery Strategy: Recovery actions in this plan are designed to address the threats to the sihek in order to achieve the recovery objectives for this species. Recovery actions focus on increasing the size of the captive population, controlling brown treesnakes, protecting and enhancing habitat for reintroduction, and reintroducing kingfishers into the wild on Guam. Establishing a captive breeding program on Guam may alleviate some of the problems that have been encountered with increasing the captive population in the continental United States. At the same time, continuing efforts to increase reproductive success and decrease mortality in the captive population are also needed to increase the captive population. Controlling brown treesnakes includes development of new control techniques and implementation and testing of existing techniques in the field. Required habitat protection and enhancement includes: protecting sufficient areas from development; controlling ungulates, weeds, and fires; and replanting native plants in degraded areas, as needed. Reintroducing kingfishers to Guam is essential to the recovery of the species, and will involve developing appropriate techniques, selecting and managing suitable release sites, and releasing kingfishers to the wild. Recovery will require the establishment of at least two subpopulations of kingfishers on Guam to reduce the subspecies' vulnerability to environmental fluctuations and natural or unnatural catastrophes. One subpopulation should occur in northern Guam and one in southern Guam.

Recovery Goals and Objectives: The primary goals of this recovery plan are to first downlist the sihek to threatened status, and ultimately to recover the sihek to the point that it may be removed from the Federal list of threatened and endangered species. These goals will be attained by increasing the captive population to a level sufficient to allow reintroductions on Guam, reestablishing a wild population of kingfishers on Guam, and increasing this wild population to attain at least two viable, self-sustaining subpopulations through initial population augmentation and the control of identified threats.

Downlisting Criteria: The sihek may be considered for downlisting from endangered to threatened status when all of the following criteria are met:

Criterion 1: Sihek occur in 2 subpopulations (one in northern Guam and one in southern Guam) of at least 500 adults each;

Criterion 2: Both subpopulations are either stable or increasing based on quantitative surveys or demographic monitoring that demonstrates an average intrinsic growth rate (λ, or lambda) not less than 1.0 over a period of at least 5 consecutive years;

Criterion 3: Sufficient sihek habitat, based on quantitative estimates of territory and home range size, is protected and managed to achieve criteria 1 and 2 above; and

Criterion 4: Brown treesnakes and other introduced predators are controlled over 5 consecutive years at a level sufficient to achieve criteria 1 and 2 above.

Delisting Criteria: The sihek may be removed from the Federal list of endangered and threatened species when all of the following criteria are met:

Criterion 1: Sihek occur in 2 subpopulations (one in northern Guam and one in southern Guam) of at least 1,000 adults each;

Criterion 2: Both subpopulations are either stable or increasing based on quantitative surveys or demographic monitoring that demonstrates an average intrinsic growth rate (λ, or lambda) not less than 1.0 over a period of at least 10 consecutive years;

Criterion 3: Sufficient sihek habitat, based on quantitative estimates of territory and home range size, is protected and managed to achieve criteria 1 and 2 above;

Criterion 4: Brown treesnakes and other introduced predators are controlled over 10 consecutive years at a level sufficient to achieve criteria 1 and 2 above; and

Criterion 5: A monitoring plan has been developed and is ready for implementation, to cover a minimum of 5 years post-delisting, to ensure the ongoing recovery of the species and the continuing effectiveness of management actions.

Actions Needed: The goal of this recovery plan is to reestablish a viable population of sihek on Guam. Therefore, this plan focuses on the following actions to make this possible:

(1) Coordinate and monitor recovery efforts;

(2) Restore populations;

To prevent extinction of the sihek, the highest priority recovery action is to increase the size of the captive population. This is to be accomplished by establishing a captive propagation program for the subspecies on Guam (Recovery Action 2.1.1), increasing reproductive success of the captive population (Recovery Action 2.1.2.1), and decreasing juvenile and adult mortality in the captive population (Recovery Action 2.1.2.2). Once the captive population is of a sufficient size to allow for reintroduction of the subspecies into the wild, sihek should be reestablished on Guam. Reintroduction to Guam requires a thorough reintroduction program (Recovery Actions 2.2.1 – 2.2.8)

(3) Manage factors affecting population viability;

Extensive predator control efforts are needed (Recovery Action 3.1), especially brown treesnake control (Recovery Action 3.1.1). Once sihek have been reestablished in the wild, monitoring for additional threats to the subspecies (Recovery Action 3.2-3.4) would receive increased focus.

(4) Implement habitat protection and management program;

In addition to habitat protection and restoration, predator control efforts would be expanded to additional areas.

(5) Develop a public awareness program for sihek.

Total Estimated Cost of Recovery: Total estimated cost of recovery is $149,950,000 over an estimated 50-year period that may be required to recover sihek. Approximately $40,390,000 of this total cost will be needed during the first 5 years of recovery implementation. The total cost of recovery is only an estimate and may change substantially as efforts to recover the subspecies continue. In addition, up to $135,600,000 of the total cost is expected to contribute to the recovery of the endangered Mariana fruit bat or fanihi (*Pteropus mariannus mariannus*) and the Mariana crow or aga (*Corvus kubaryi*), and will also benefit other listed species on Guam. A detailed cost breakdown with expected annual costs for the first 5 years of recovery implementation is provided in the Implementation Schedule.

The 50-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 subspecies from declining irreversibly in the foreseeable future.

a. 50 Years: $119,240,000+
b. 5 Years: $30,370,000+

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.

c. 50 Years: $16,850,000+
d. 5 Years: $7,510,000+

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

e. 50 Years: $13,860,000+
f. 5 Years: $2,510,000+

Estimated Date of Recovery: Our best estimate at this time is that recovery of the sihek may require approximately 50 years. It is difficult to accurately project a recovery date at this time due to the low number of sihek in the captive population and the extensive efforts needed prior to attempting to reestablish the subspecies in the wild for the purposes of recovery.

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A. Introduction

The Guam Micronesian kingfisher (*Halcyon cinnamomina cinnamomina*), known in Chamorro (the native language of Guam) as sihek, is endemic to the island of Guam. This subspecies is listed as endangered by both the United States (United States Fish and Wildlife Service [USFWS] 1984) and the Territory of Guam (Guam Public Law 15-36). Sihek were last observed on Guam in 1988 (Wiles *et al.* 2003) and are now believed extinct in the wild. Currently, this subspecies is represented only by a captive population of 60 individuals in 11 zoological institutions (E. Bahner, Philadelphia Zoo, pers. comm. 2003). Predation by the introduced brown treesnake (*Boiga irregularis*) appears to have been the principal cause of the wild population's decline and extirpation. Other factors that may have hastened the decline include habitat degradation and loss, competition, pesticides, and avian disease. Factors that continue to limit the recovery of the species include difficulties breeding sihek in captivity and the continued presence of brown treesnakes on Guam.

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 for the sihek is a 3 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 Guam population is at present formally distinguished at the level of a subspecies, and there is no conflict with economic development. New molecular techniques suggest the Guam subspecies may warrant separate species status (S. Haig, U.S. Geological Survey [USGS], pers. comm. 2002), which may shift the ranking of this taxon upwards to a priority two.

The sihek has been listed as an endangered species under the Endangered Species Act (16 United States Code [USC] 1531 *et seq.*) since 1984 (USFWS 1984). A recovery plan for the sihek and four other federally listed avian species on the islands of Guam and Rota (Guam rail [*Gallirallus owstoni*], Mariana crow

[*Corvus kubaryi*], Guam broadbill [*Myiagra freycineti*], and Guam bridled white-eye [*Zosterops conspicillata conspicillata*]) was approved on September 28, 1990 (USFWS 1990). This plan serves as a revision of the 1990 recovery plan for the sihek.

B. Guam

Guam is the largest and southernmost island in the Mariana Archipelago (Figure 1). Guam is approximately 45 kilometers (28 miles) long and 6 to 13 kilometers (4 to 8 miles) wide with a land area of 550 square kilometers (342 square miles). The northern half of the island is a relatively flat limestone plateau formed over volcanic rock and bounded by steep cliffs (Figure 2). Mountainous southern Guam is mostly of volcanic origin with a maximum elevation of 405 meters (1,330 feet). The approximate boundary between northern and southern Guam extends from Hagatna on the west coast of the island to Mangilao on the east side. Fringing reefs surround most of the island (Eldredge 1983).

Guam is an unincorporated territory of the United States. The human population was 154,800 in 2000, a 16 percent increase from the 1990 census estimate (U.S. Census Bureau 2003). Guam's climate is tropical and temperatures remain warm and relatively consistent during the year, ranging daily from 25 degrees to 30 degrees Celsius (77 to 86 degrees Fahrenheit). Rainfall varies considerably among years but averages 218 centimeters (86 inches) annually, most of which falls from July to November. A dry season occurs between January and May when rains diminish to 8 to15 centimeters (3 to 6 inches) per month.

The vegetation on Guam has been described in detail by Fosberg (1960) and Stone (1970). The vegetation on northern Guam includes primary and secondary limestone forest, coconut plantations, secondary vegetation, open fields, and urban vegetation (Mueller-Dombois and Fosberg 1998). While southern Guam is dominated by savanna and ravine forest, other vegetation types include swamp forest, reed marsh, and urban vegetation.

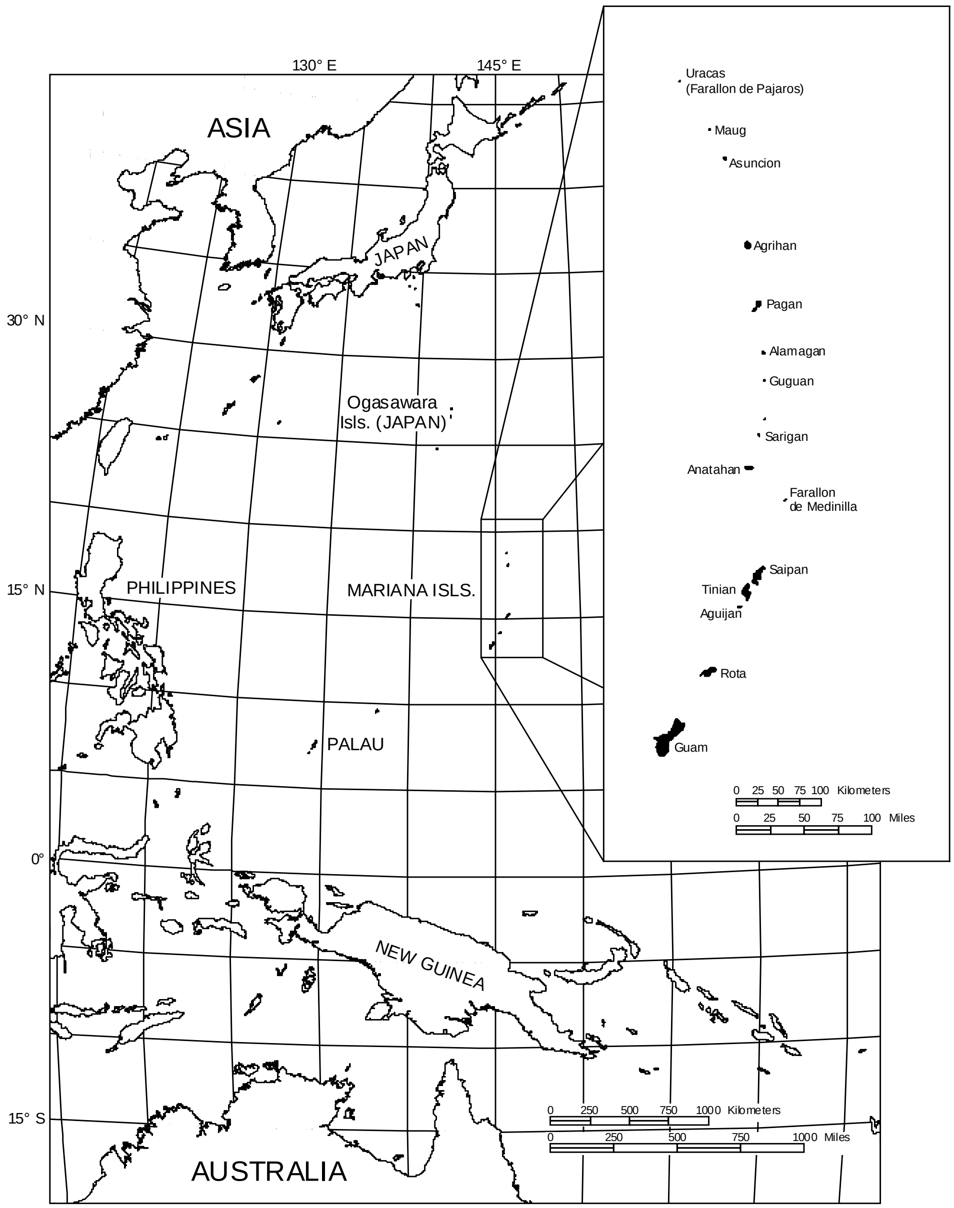
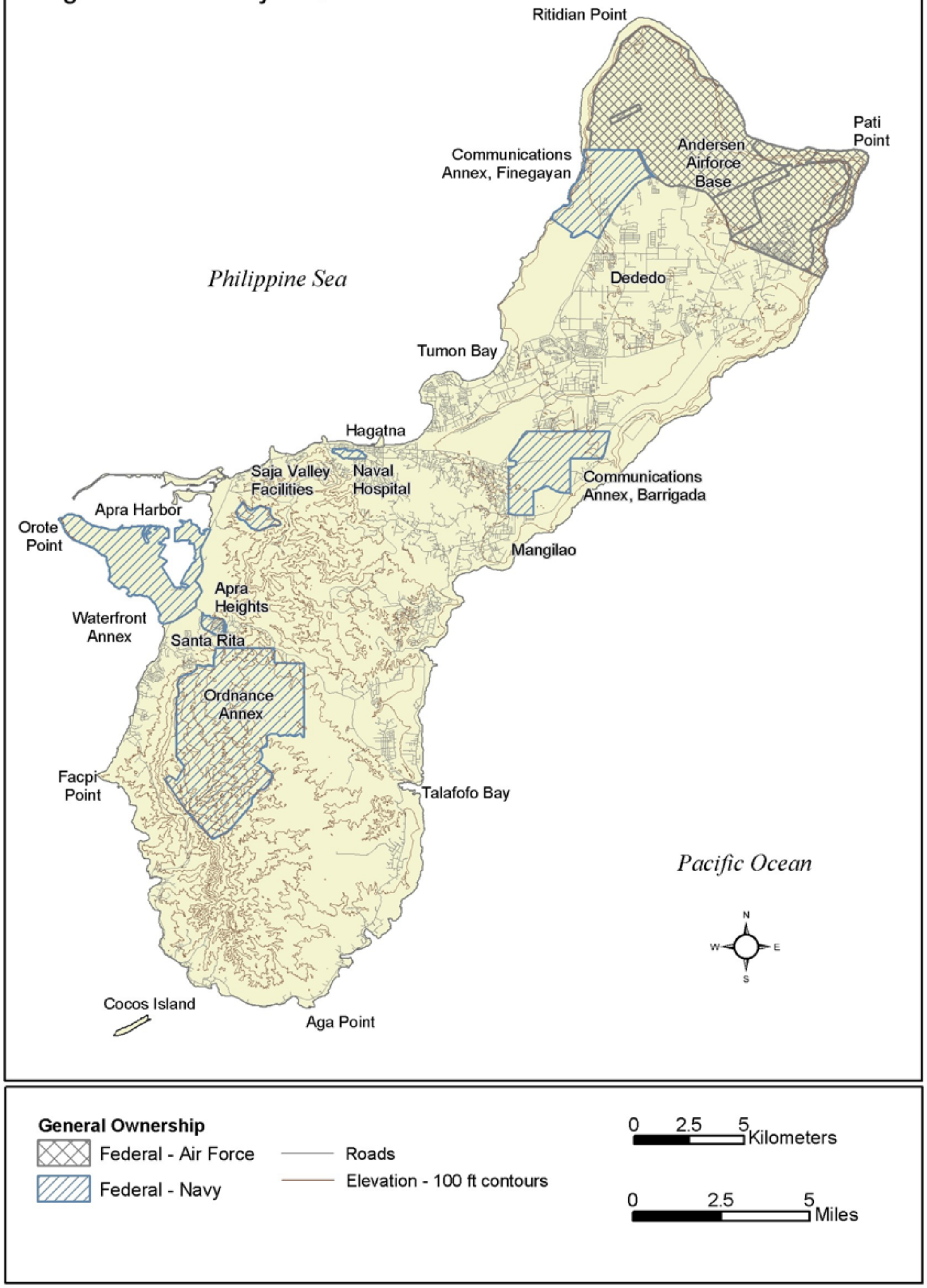


Figure 1. Location and composition of the Mariana Archipelago.

Figure 2. Territory of Guam



C. Species Description and Taxonomy

The sihek is a sexually dimorphic (the sexes are outwardly different in appearance) forest kingfisher (Baker 1951). The adult male has a cinnamon-brown head, neck, upper back, and underparts. A black line extends around the nape and the orbital (eye) ring is black. The lower back, lesser and underwing coverts, and scapular (shoulder) feathers are greenish-blue and the tail is blue. The feet and iris of the eye are dark brown, and the bill is black expect for some white at the base of the lower mandible. The female resembles the adult male, but the upper breast, chin, and throat are paler, and the remaining underparts and underwing linings are white instead of cinnamon. Sihek are relatively small kingfishers, about 20 centimeters (8 inches) in length (Fry et al. 1992). The weight of 16 wild caught males ranged from 50.5 to 63.8 grams (1.8 to 2.6 ounces) (Baker 1951, Jenkins 1983) and the weight of 10 wild caught females ranged from 58.0 to 76.0 grams (2.0 to 2.7 ounces) (Baker 1951). Immature birds resemble the adults, but the brown of the crown is mixed with greenish-blue, the back and wing-coverts are edged with cinnamon; and the chin and throat are whitish (Baker 1951). Underparts are buffy-white in the immature male, but may be paler in the female.

The sihek is one of three extant subspecies of *Halcyon cinnamomina* found in Micronesia (Fry *et al.* 1992). The other two subspecies of Micronesian kingfishers -- *H. c. reichenbachii* and *H. c. pelwensis* -- occur on the islands of Pohnpei (Federated States of Micronesia) and Palau (Republic of Palau), respectively. A fourth subspecies, *H. c. miyakoensis*, once occurred on the Ryukyu Islands, but is now extinct (Fry *et al.* 1992). Recent analyses of mitochondrial deoxyribonucleic acid (DNA) suggest that each of these subspecies is distinct genetically, perhaps sufficiently so as to merit separate species status (S. Haig, pers. comm. 2001). However, further genetic analyses are needed.

Another kingfisher, the mangrove or collared kingfisher (*H. chloris teraokai*), also occurs on the Palau group of islands in Micronesia. The collared kingfisher has a blue or green-blue crown, as opposed to the cinnamon crown of the sihek, and also has a distinctive small white spot on the forehead just forward of the eye. The collared kingfisher is absent from Guam, the native home of the

Guam Micronesian kingfisher, and also from Pohnpei, but is found on the island of Palau along with the Palau Micronesian kingfisher *H. c. pelwensis*.

The sihek is a member of the kingfisher family, Alcedinidae, in the order Coraciiformes.

D. Population Trends and Distribution

Historically the sihek occurred throughout Guam in all habitats except pure savanna and wetlands (Marshall 1949, Baker 1951, Tubb 1966, Jenkins 1983). Baker (1951) described the species as “fairly common” in 1945 and reported that the sihek was primarily a bird of the forest. Although kingfishers[1] were collected and observed in southern Guam in 1945 by Stophlet (1946) and Baker (1948), their numbers decreased sharply over the next two decades. Between 1963 and 1968 only 2 birds were reported during 56 monthly counts in the Fena Lake area, and the sihek was last observed in southern Guam in the 1970’s (Drahos 1977, 2002). During this decline in southern Guam, kingfishers were still found over much of northern Guam into the late 1970’s (Jenkins 1983). In 1981 the northern Guam population was estimated to be 3,023 birds (Engbring and Ramsey 1984). This population subsequently declined rapidly, however, and by 1985 Marshall (1989) reported only 30 sihek in the northern part of the island. The species was believed extinct in the wild by 1988 (Wiles *et al.* 2003).

In response to the widespread decline of Guam’s native birds, in 1983 the American Zoo and Aquarium Association (AZA) initiated the Guam Bird Rescue Project and the kingfisher was identified as a species suited for captive management (Hutchins *et al.* 1996). Between 1984 and 1986, 29 sihek were translocated from Guam to several zoos in the mainland United States to start a captive breeding program. By 1990, the captive population was up to 61 birds in 12 mainland zoological institutions (Figure 3). However, high mortality rates and poor reproduction reduced the total annual population size to as low as 50 birds in 1992 (E. Bahner, pers. comm. 2001). For the next several years the population

[1] In this document, the term “kingfisher” refers to the Guam Micronesian kingfisher unless otherwise noted.

hovered between 50 and 55 birds (Figure 3) as high mortality levels and poor reproductive success continued to hamper attempts to increase the captive population (see Reasons for Decline and Current Threats section, p. 12, for details). In 1998, the population increased slightly to around 60 birds and has remained at approximately that level since that time.

As of June 2003, the captive population included 60 individuals in 11 captive breeding institutions (E. Bahner, pers. comm. 2003). The participating captive breeding facilities include Disney's Animal Kingdom; San Diego Wild Animal Park; San Diego Zoo; National Zoological Park, the National Zoo's Conservation and Research Center; Brookfield Zoo; Lincoln Park Zoological Gardens; St. Louis Zoological Park; Philadelphia Zoological Gardens; Houston Zoological Gardens; and Milwaukee County Zoological Garden. The most recent population assessment included 30 males, 23 females, and 7 unsexed juveniles hatched in 2003.

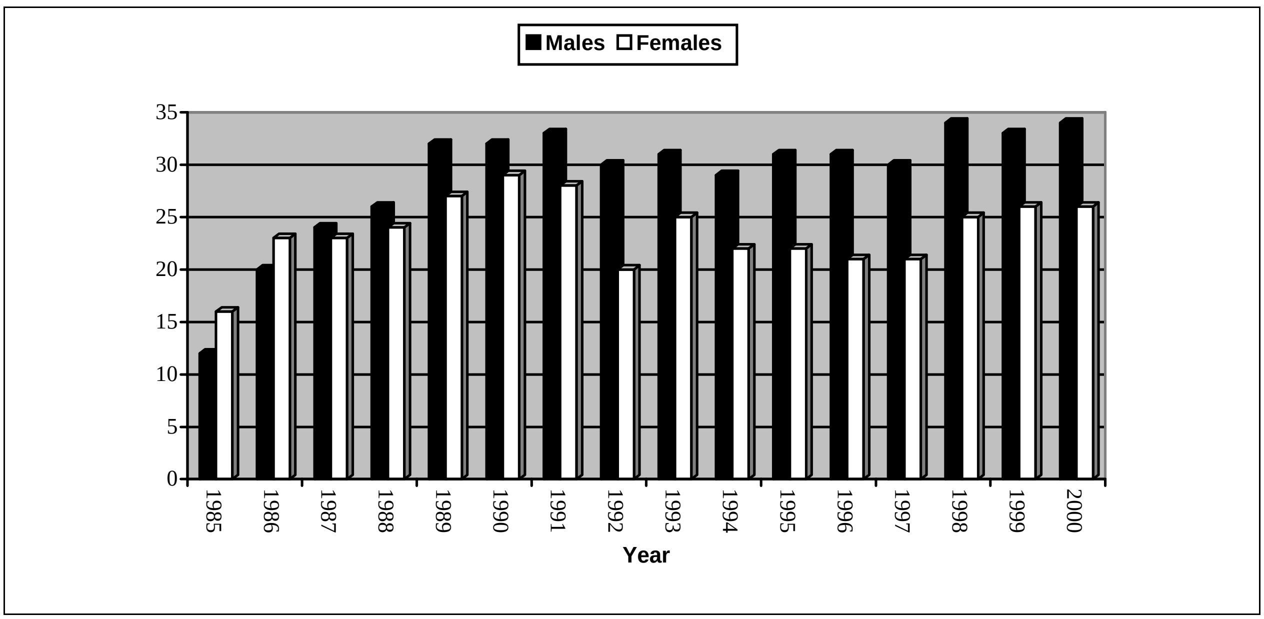


Figure 3. Annual number of male and female sihek held in captivity (Bahner 1998; E. Bahner, pers. comm. 2002).

E. Life History

1. Behavior

Sihek make several vocalizations and can often be heard over a distance of several hundred meters (Jenkins 1983). A loud rattle-like call is given by birds in flight and a shorter version of the rattle-call is given when birds dive from perches to capture prey, when paired birds excavate nests, and during aggressive interactions. Nestlings also produce a rattle-like call when begging for food. A soft scratchy call may be uttered between paired birds in close proximity to one another.

Observations of paired birds, territorial defense, and cavity excavation throughout the year (Jenkins 1983; R. Beck, unpubl. data 1985; J. Marshall and R. Beck, unpubl. data 1985) suggest that sihek maintain long-term pair bonds as has been documented with marked individuals of the related Pohnpei Micronesian kingfisher (*H. c. reichenbachii*; Kesler and Haig, in prep.). Interestingly, approximately one-third of the territories observed in Pohnpei included a non-breeding helper that assisted breeding pairs with territory defense and breeding activities (Kesler and Haig, in prep.). Cooperative breeding, like that observed on Pohnpei, often occurs when habitats are saturated or breeding opportunities are otherwise limited, or competition for high-quality territories is intense (Stacey and Koenig 1990). Although cooperative breeding is a relatively rare breeding strategy among birds, it has arisen several times in the avian order Coraciiformes to which the Guam Micronesian kingfisher belongs (*e.g.*, pied kingfishers [*Ceryle rudis*], white-fronted bee-eaters [*Merops bullockoides*], green woodhoopoes [*Phoeniculus purpureus*], and Puerto Rican todies [*Todus mexicanus*]; Kepler 1972, Stacey and Koenig 1990 and references therein). Whether cooperative breeding occurred in the Guam subspecies of the Micronesian kingfisher is unknown.

Sihek are aggressive toward conspecifics (members of the same species) as well as individuals of other bird species. Jenkins (1983) observed aggressive interactions between male sihek and also between males and females. Sihek have been observed harassing flocks of Guam bridled white-eyes (Marshall 1949) and

Micronesian starlings (*Aplonis opaca*) (Kibler 1950). Such interspecific aggression is probably expressed generally, as individuals of most avian species co-occurring with sihek give alarm calls when kingfishers are nearby (Jenkins 1983).

2. Space Use

Records of distributions and intraspecific territorial behaviors for sihek (Jenkins 1983) suggest that the birds maintained exclusive year-round territories. In Pohnpei, Micronesian kingfishers actively defend territories from all conspecific intrusions. Territories vary in size with location and cover type, but average approximately 10 hectares (25 acres) in the mid-elevation zones. During their 4-year study, Kesler and Haig (in prep.) also found that territorial boundaries were stable within and between years, even when breeding individuals were replaced and neighboring pairs attempted to intrude.

3. Reproduction

Sihek nest in cavities and breeding activity appears to be concentrated from December to July (Marshall 1949, Baker 1951, Jenkins 1983). Nests have been reported in a variety of trees, including *Ficus* spp. (banyan), *Cocos nucifera* (coconut), *Artocarpus* spp. (breadfruit), *Pisonia grandis* (umumu), and *Tristiropsis obtusangula* (faniok) (Baker 1951, Jenkins 1983, Marshall 1989). Pairs may excavate their own nests in soft trees, arboreal termitaria (the nests of termites [*Nasutitermes* spp.]), arboreal fern root masses, or they may utilize available natural cavities such as broken tree limbs (Jenkins 1983, Marshall 1989). Jenkins (1983) observed that some excavated cavities were never reused as nesting sites, which suggests that the process of excavating nest sites may be important in pair-bond formation and maintenance. Cavity excavation precedes egg-laying by about a month, and copulations have only been observed following bouts of nest excavation (Marshall 1989). Excavation behaviors have also been observed on Pohnpei in association with males courting new females (Kesler and Haig, in prep.). Courtship feeding and vocal duetting (simultaneous calling between members of a pair) are common, and presumably function in both pairbond maintenance and territorial maintenance.

Pohnpei Micronesian kingfishers have only been observed to excavate nest cavities in arboreal termite nests (termitaria). These cavities include a spherical nest chamber (averaging 18.0 centimeters [7.1 inches] in diameter) and an entrance tunnel averaging 10.6 centimeters (4.2 inches) long and 5.1 centimeters (2.0 inches) in diameter (Kesler 2002). Kesler (2002) found that termitaria used for nesting are higher from the ground and larger in volume than unused termitaria. He also found no apparent association between nest locations and vegetation characteristics, proximity to foraging areas and forest edge, termitarium substrate, or microclimate temperatures.

Both male and female sihek incubate eggs and brood and feed nestlings (Jenkins 1983). Eggs are white and reported clutch sizes from wild populations (n = 3) were either one or two eggs (Baker 1951, Jenkins 1983, Marshall 1989). Clutch sizes of one to three eggs have been reported in the captive population of sihek (Bahner *et al.* 1998). Pohnpei Micronesian kingfishers also appear to lay one or two egg clutches (D. Kesler, pers. comm. 2002). Incubation, nestling, and fledgling periods for populations of sihek in the wild are unknown. However, incubation and nestling periods of captive birds averaged 22 and 33 days, respectively (Bahner *et al.* 1998). In Pohnpei Micronesian kingfishers, incubation lasts 23 to 24 days, nestlings fledge 26 to 30 days after hatching, and juveniles remain on their natal territories for at least several months (D. Kesler, pers. comm. 2002).

4. Food Habits

Sihek feed entirely on animal matter including skinks (Scincidae), geckos (Gekkonidae), various insects, segmented worms (Annelida), and hermit crabs (*Coenobita* spp.) (Marshall 1949, Baker 1951, Jenkins 1983). Seale (1901) also reported that sihek were known to prey on the chicks of domestic fowl and Marshall (1949) noted fish scales in the stomach contents of collected birds. On Pohnpei, Micronesian kingfishers have been observed capturing and consuming mice as well as chasing and killing chicken chicks (D. Kesler, pers. comm. 2002).

Sihek typically forage by perching motionless on exposed branches or telephone lines and swooping down to capture prey off the ground with their bill (Jenkins 1983). They will also capture prey off nearby foliage and have been observed gleaning insects from bark (Maben 1982). Prey items are normally manipulated in the bill and beaten against a perch before being swallowed whole (Jenkins 1983).

F. Habitat Requirements

Little is known about the habitat requirements of the sihek. Jenkins (1983) reported that the sihek nested and fed primarily in mature limestone forest, mixed woodland, secondary growth stands, and, to a lesser degree, in scrub forest. It was also found in coastal strand vegetation containing coconut palm as well as riparian habitat. However, Jenkins (1983) reported that it was probably most common along the edges of mature limestone forest. Few data exist about specific kingfisher nest sites in the wild, but in one study in northern Guam nest sites were correlated with closed canopy cover and dense understory vegetation. Nest cavities were excavated in the soft, decaying wood of large, standing dead trees averaging 43 centimeters (17 inches) in diameter (Marshall 1989). Sihek also appear to require diverse vegetative structure capable of providing a wide range of both invertebrate and vertebrate prey as well as exposed perches and areas of open ground for foraging (USFWS 2002). Good quality sihek habitat would therefore provide a combination of both closed canopy forest with large, standing dead trees for nesting and areas of open understory or forest edges for foraging (Jenkins 1983, Marshall 1989, USFWS 2002). An area of approximately 10 hectares (25 acres) of such habitat would be needed to support at least one pair of kingfishers (D. Kesler, pers. comm. 2004).

Information from extant populations of the closely related Pohnpei and Palau Micronesian kingfishers may lend insight into the habitat requirements of the Guam birds. Like their Guam counterparts, the Pohnpei Micronesian kingfishers are habitat generalists and occur throughout the island in diverse habitats including urban developments, coastal mangroves, and dwarf forest uplands (Engbring *et al.* 1990, Buden 2000). Mature rainforest is present throughout the island and forms an important component of kingfisher breeding territories. Kesler and Haig (in prep.) examined 16 territories in Pohnpei, and all contained several hectares of rainforest. Kingfisher densities on Pohnpei differ across habitats (Engbring *et al.* 1990; Buden 2000; Kesler and Haig, in prep.) with the highest densities in mangrove (84 birds per square kilometer [218 birds per square mile]) and lowland forests (39 birds per square kilometer [101 birds per square mile), and lower densities in the higher elevations (28 to 31 birds per square kilometer [73 to 80 birds per square mile]; estimates from Engbring *et al.* 1990]. This trend may reflect different resource distributions among habitats. Palau Micronesian kingfishers are primarily a forest species (Marshall 1949; Baker 1951; D. Kesler, pers. comm. 2003). Unlike the Guam and Pohnpei subspecies, the kingfishers on Palau coexist with collared kingfishers (*H. chloris chloris*), which are slightly larger and prefer mangrove and lowland forests (Marshall 1949; D. Kesler, pers. comm. 2003).

G. Critical Habitat

The designation of critical habitat for the sihek and two other endangered species (the aga or Mariana crow [*Corvus kubaryi*] and fanihi or Mariana fruit bat [*Pteropus mariannus mariannus*]) was proposed in October 2002 (USFWS 2002), but has not yet been finalized.

H. Reasons for Decline and Current Threats

In determining whether to list, delist, or reclassify (change from threatened to endangered status, or *vice versa*) a taxon under the Endangered Species Act (16 USC 1531 *et seq*.), we evaluate the role of five factors potentially affecting the species. These five 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;

(E) other natural or manmade factors affecting its continued existence.

Assessment of these factors can change within or between captive and wild populations and as the status of the taxon changes through time. For example, when the sihek was first listed in 1984, disease was believed to be the primary threat to the species on Guam (USFWS 1984). Since that time predation by the brown treesnake has been identified as the primary threat (Savidge 1987).

Among the factors that have been hypothesized to threaten the sihek are: habitat loss or degradation (factor A), human persecution (factor E), contaminants (factor E), competition with and harassment by black drongos (factor E), disease (factor C), and introduced predators such as cats (*Felis cattus*), rats (*Rattus* spp.), monitor lizards (*Varanus indicus*), and brown treesnakes (factor C) (USFWS 1984, 1990). Of these threats, predation by the brown treesnake is believed to have been the overriding cause of the kingfisher's decline and extirpation on Guam. The primary threats to the current captive population are high mortality and low fecundity, which limit population growth and erode genetic diversity, although the underlying cause(s) of these threats remains to be identified. Currently, overutilization of sihek for commercial, recreational, scientific, or educational purposes (factor B) is not known to be a threat. Existing regulatory mechanisms (factor D) also appear adequate, as the sihek is currently listed as endangered by the governments of both the United States and Guam.

1. Predation by Brown Treesnakes (Factor C)

The brown treesnake is native to coastal Australia, Papua New Guinea, and a large number of islands in northwestern Melanesia. These snakes are long and slender, ranging from 6 grams (0.2 ounces) in weight and a snout-vent length (SVL) of approximately 275 millimeters (11 inches) to 3,000 grams (6.6 pounds) in weight and a snout-vent length of approximately 2,700 millimeters (8.75 feet). Brown treesnakes are excellent climbers. They are active primarily at night and hide during the day in dark crevices and other unexposed areas. They prey on a wide variety of animals depending on the size of the individual snake. Brown treesnakes in captivity eat only geckos when they are first hatched (F. Qualls and C. Qualls, USGS/Colorado State University, pers. comm. 2001), but soon add skinks to their diet. Skinks form the bulk of the diet for snakes in the body size 600 to 1,000 millimeters snout-vent length (23 to 39 inches) (Rodda *et al.* 1999a).

However, brown treesnakes add birds and mammals to their diet when they become reproductively mature (generally at a size of approximately 960 to 1,000 millimeters [37 to 39 inches] snout-vent length) (Savidge 1988).

Brown treesnakes probably arrived on Guam prior to 1950 as passive stowaways in materiel salvaged from an island near New Guinea (Manus) following World War II (Savidge 1987, Rodda *et al.* 1992). Available evidence suggests that brown treesnakes first colonized the Santa Rita/Naval Ordnance area, and then spread progressively across the island, reaching the northernmost point of the island (Ritidian Point) by 1968 (Savidge 1987). Within 20 years, the snake population had reached a peak density of 100 to 120 snakes per hectare (41 to 50 snakes per acre) on Guam. Such a high density of snakes is one to two orders of magnitude higher than would normally be expected for large snakes away from the concentrating effects of water or dens (Rodda *et al.* 1992).

The only native snake on the island of Guam is a tiny blind snake (*Rhamphotyphlops braminus*) that burrows through the soil and feeds on the eggs, larvae and pupae of ants and termites. Guam's native birds were therefore particularly vulnerable to the exotic brown treesnake, as they had not evolved with any snake as a nest predator. By 1988, the brown treesnake had eliminated most of the native birds on the island (Savidge 1987), as well as many other native and exotic animal species (Fritts and Rodda 1998). All but one of Guam's native bird species (the yellow bittern [*Ixobrychus sinensis*]) have shown patterns of decline coinciding with the expansion of the snake's range across the island, indicating an inverse relationship between populations of snakes and birds (Savidge 1987), presumably due to nest predation by brown treesnakes. Conry (1988a) recorded daily egg and nestling mortality by brown treesnakes as high as 21.5 percent in Philippine turtle-doves (*Streptopelia bitorquata*) on Guam. The sihek's decline followed the same pattern as other forest birds on Guam, kingfishers having been first extirpated in the southern and central portions of the island, where the snake first colonized. The last wild sihek were observed in 1988 on Andersen Air Force Base in northern Guam (Wiles *et al*. 1995).

Brown treesnake densities peaked in the mid-1980's and have since declined, but remain at levels that threaten the recovery of the sihek. Current evidence suggests that snake populations in tangantangan (*Leucaena leucocephala*) habitat on Guam range from 20 to 60 snakes per hectare (9 to 26 snakes per acre) (counting only larger snakes over 800 millimeters [31 inches] snout-vent length), while snakes in this size class occur at lower densities (10 to 20 snakes per hectare (4 to 9 snakes per acre) in grassland, ravine forest, or native forest vegetation types (Rodda *et al.* 1999b). Historical fluctuations indicate that brown treesnake densities may recover following overpredation of its prey base and a crash in available food sources (Rodda *et al.* 1992). A population decline in brown treesnakes across Guam between 1985 and 1995 was attributed to the decimation of nearly all native fauna on the island (Rodda *et al.* 1992, 1999a; Fritts and Rodda 1998). The persistence of high densities of treesnakes is attributed to the continuing availability of several species of introduced lizards and rats as potential prey items (McCoid 1997, Rodda *et al.* 1999b). Other exotic avian and mammalian prey may also aid the snake's survival on Guam. Local residents have reported the loss of many domestic birds, as well as some pets, to the nocturnal snake (Fritts and McCoid 1991).

2. Other Introduced Predators (Factor C)

In addition to the brown treesnake, other potential kingfisher predators found on Guam include feral cats, Polynesian rats (*Rattus exulans*), roof rats (*Rattus rattus*), Norway rats (*Rattus norvegicus*), and monitor lizards. The impact of each of these species on sihek is unknown. However, the negative impact of rat (Atkinson 1985, Robertson *et al.* 1994) and cat (Churcher and Lawton 1987) predation on bird populations has been well documented and may threaten recovery of the sihek. Control of brown treesnake populations could potentially increase predation pressure on kingfishers as rat, cat, and monitor lizard populations would undoubtedly increase. However, prior to the invasion of the brown treesnake, the sihek had managed to maintain high population densities even in the presence of these other introduced predators. Interestingly, despite the presence of rats and cats on Pohnpei, the only Micronesian kingfisher nest predation or destruction observed during 4 years of study resulted from humans. Furthermore, aside from the two nests destroyed by Pohnpei residents and one nest with non-viable eggs, every nest observed during fieldwork (n = 35) appeared to successfully fledge young (Kesler and Haig, in prep.). This extremely high nest success suggests that sihek would not be very susceptible to predators other than brown treesnakes. However, the impacts of rats, cats, and other introduced predators will need to be monitored and managed, if necessary.

3. Competition and Harassment by Black Drongos (Factor E)

The black drongo (*Dicrurus macrocercus*), an introduced insectivorous bird, is found on the islands of Guam and Rota. They are thought to have been intentionally introduced to Rota from Taiwan in 1935 by the Japanese South Seas Development Company to control destructive insects (Baker 1948), and they likely dispersed on their own to Guam from Rota sometime in the 1960's (Jenkins 1983). Black drongos are common on Guam and can be observed foraging from exposed perches in open areas surrounded by disturbed vegetation (Maben 1982). Maben (1982) reported harassment of sihek by black drongos and identified the sihek as a possible competitor for prey due to similarities between the species in habitat use, foraging perches, foraging technique, and prey size. Harassment by black drongos and competition with this introduced bird species could potentially affect recovery of the sihek.

4. Habitat Degradation and Destruction (Factor A)

Although little is known about the nature of Guam's vegetation before World War II, progressive alteration of the island's vegetation clearly began with human colonization (Fosberg 1960). On volcanic soils, clearing and burning resulted in large expanses of savanna and secondary forest (Mueller-Dombois and Fosberg 1998). On limestone soils, native forest was cleared and replaced by coconut plantations, open fields and gardens, pasture, and secondary forest (Mueller-Dombois and Fosberg 1998). During World War II, large areas were cleared and some habitat was destroyed during heavy fighting (Fosberg 1960). However, Baker (1946) reported that less than half of Guam had been disturbed by American forces during their occupation of the island between 1944 and 1945.

While large stands of relatively intact native forest can still be found on military lands and in the rugged interior areas of northern and southern Guam, some of these areas will undoubtedly be further fragmented and degraded by development activities and road building in the coming years. Much of the remaining forest has been severely degraded already by introduced Sambar deer (*Cervus mariannus*), feral pigs (*Sus scrofa*), and feral Asiatic water buffalo (*Bubalus bubalis*), which were introduced to Guam in the 1600's and 1700's (Conry 1988b). These introduced ungulates are suspected of significantly impacting native floral communities on Guam by consuming seeds, fruits, and foliage, ingesting or trampling seedlings, and promoting the spread of introduced weeds (Wiles *et al.* 1996). Sambar deer and feral pigs are found throughout Guam. On Andersen Air Force Base, densities of Sambar deer and feral pigs are estimated at 1.8 deer per hectare (0.8 deer per acre) and 0.4 pigs per hectare (0.2 pigs per acre), some of the highest densities recorded in the world (Knutson and Vogt, unpubl. manuscript 2003). Feral Asiatic water buffalo are found only on the Ordnance Annex, where the population is estimated to be at least 300 animals (S. Vogt, U.S. Navy, pers. comm. 2003).

Some degree of habitat alteration may not affect sihek. Because they require open understory forests and forest edges for foraging (Jenkins 1983), fragmented and somewhat degraded habitats may provide useful resources to birds as long as sufficient patches of mature forest can be found nearby for nesting. On Pohnpei, kingfishers do not seem affected by the presence of grazing animals, and in fact seem to prefer foraging in areas where a reduction in grasses and herbs facilitates the detection of terrestrial skinks (Kesler and Haig, in prep.). Nonetheless, Pohnpei Micronesian kingfishers were found in the highest densities in areas without human impacts, such as mangrove forests.

5. Contaminants (Factor E)

Pesticides have been used extensively in the past for agriculture and disease vector control in the Mariana Islands. Following World War II and until the early 1970's, DDT (dichlorodiphenyltrichloroethane, an organochlorine pesticide now known to have adverse impacts on birds and other wildlife) was regularly applied by the military on Guam (Baker 1946, Maben 1980, and Anderson 1981). In addition, Maben (1980) reported that the insecticide malathion, an organophosphate, was applied by the military around beaches and buildings up to three times a week. Malathion was also aerially applied over approximately a third of the island of Guam over 4 days in 1975 to prevent a potential outbreak of dengue fever (Haddock *et al.* 1979). Researchers studying the impacts of pesticides on native forest birds in the 1980's did not believe that pesticides played a major role in the decline of the sihek and other native forest birds on Guam (Grue 1985). However, Drahos (2002) believed that the impact of pesticides on native bird populations has been underestimated and that pesticide use may have contributed to the initial decline of forest birds on Guam, especially in southern Guam. Under current conditions, however, contaminants are not considered a threat to the sihek.

6. Human Exploitation (Factor B)

There are no reported problems with hunting or poaching sihek on Guam. The harvest of sihek has been outlawed for over a century (Executive Order No. 61, Naval Governor of Guam, 1903), but they were largely unprotected until 1981 (Penal Code of Guam 1922, 1947, 1953; Guam Public Law 6-87, 1962; Guam Public Law 16-39, 1981). However, the destruction of nests and persecution of adult Micronesian kingfishers by landowners on Pohnpei has been observed (D. Kesler, pers. comm. 2002). Engbring *et al.* (1990) also reported that the Pohnpei Micronesian kingfisher is considered a pest species because it is believed to prey on small chicks of domestic stock.

7. Avian Disease (Factor C)

Avian malaria and pox have been important factors in the decline of Hawaii's avifauna (Warner 1968, Van Riper *et al.* 1986). Although disease was not an important factor in the decline of Guam's forest birds (Savidge *et al.* 1992), a number of avian pathogens have been identified on Guam that could impact the recovery of the sihek. Avian tuberculosis, a contagious disease caused by the bacterial pathogen *Mycobacterium avium*, has been a significant source of mortality in captive sihek (9 of 40 [22.5 percent]) adult deaths) (Junge 1998). Silva-Krott *et al.* (1998) determined that *M. avium* does exist on Guam, but there has never been a recorded case of mortality due to avian tuberculosis. Savidge *et al.* (1992) also noted that *Salmonella newport*, *S. waycross*, *S. oranienburg, S.*

amager, *Candida tropicalis*, Newcastle disease, and influenza virus have been reported in both native and introduced bird species on Guam.

West Nile virus may pose a significant risk to sihek in the continental United States and on Guam if it reaches the Pacific rim. As of June 2003, West Nile virus had been detected in over 138 species of birds, including the related belted kingfisher (*Ceryle alcyon*), from 44 states and the District of Columbia (CDC 2003). West Nile virus was detected in one sihek that died at the National Zoological Park (E. Bahner, pers. comm. 2003), so the Park has since been vaccinating their sihek (R. Junge, Saint Louis Zoo, pers. comm. 2002). As of 2001, ribonucleic acid (RNA) of West Nile virus had been detected in 21 mosquito species from 8 genera (*Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *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, Savage *et al.* 1993). In an effort to prevent the introduction of West Nile virus to the island, Guam's Department of Agriculture recently implemented new testing and quarantine requirements for all avian importations.

8. Limited Population Growth in Captivity (Factor E)

Initial efforts to breed sihek in captivity were successful. However, high embryonic, young adult, and adult mortality rates in conjunction with limited reproductive success began to plague efforts to increase the captive population once it had reached 60 individuals (Hutchins *et al.* 1996). One problem associated with reproductive success has been difficulty in forming successful breeding pairs. Fewer than half of the pairs successfully produce offspring (Baltz 1998) and the sex ratio has been consistently skewed toward males since the late 1980's due to higher levels of female mortality (Figure 3). Poor egg viability and abnormal parental behavior (presumed cannibalism) have also been identified as problems. Of the 778 eggs produced under captive conditions up to 1997, 20 percent (159 eggs) were broken, 41 percent (318 eggs) were infertile, and the remaining 39 percent (301 eggs) were fertile. Sixty-nine percent of the embryos that died in the shell were artificially incubated (Bahner *et al.* 1998). Seventy-four percent of the parent-reared chicks lost prior to fledging disappeared from the nest, presumably due to cannibalism by the parents. In adults, in addition to avian tuberculosis (22.5 percent of deaths; see Disease, above), other sources of mortality in the captive population have included stress, pair aggression, and nutritional deficiencies (Hutchins *et al.* 1996, Bahner *et al.* 1998).

As long as the captive population size remains small, the loss of genetic diversity will be accelerated. This loss can reduce fitness and evolutionary flexibility, and lead to an increasing probability of extinction. Since the captive breeding program began, one of its main goals has been to maintain or increase genetic diversity above 90 percent heterozygosity. However, maintaining genetic diversity will be difficult due to the inability to pair all individuals, low reproductive success, and high mortality rates. The current captive population originated from only 17 of the 29 founders brought into captivity (Haig *et al.* 1995). The genetically effective population size (N_e) of the captive population is 22.6 and the estimated mean inbreeding coefficient (F) is currently 0.021 (E. Bahner, pers. comm. 2003). This inbreeding coefficient is expected to rise with time due to the small size of the captive population and limited pairing options. Current estimated gene diversity is 91.2 percent and is projected to drop below the 90 percent gene diversity threshold in a few years (Bahner and Lynch 2003).

I. Conservation Efforts

The 1990 recovery plan for the sihek identified the following six main objectives to achieve the recovery of the sihek:

(1) develop a captive breeding program;
(2) reduce avian mortality in the field;
(3) provide maximum legal protection for kingfisher habitat;
(4) conduct additional research and surveys;
(5) develop methods for reintroduction;
(6) develop a public awareness program.

Specific recovery actions were identified for each of these objectives. Progress in attaining these objectives has been achieved to varying degrees as discussed below.

1. Captive Breeding Program

Captive breeding of sihek was initiated in 1984 as part of the Guam Bird Rescue Project (Hutchins *et al.* 1996). Twenty-nine sihek were captured in the years 1984 (21 birds) and 1986 (8 birds) and transferred to zoos in the continental United States for captive breeding (Bahner 1988). The first hand-reared and parent-reared chicks were hatched in 1985 (Bahner 1988) and the captive population had increased to 61 birds by the end of 1990 (Bahner 1998). Unfortunately, the population declined to 50 birds in 1992 and has since hovered around 55 birds with adult mortalities balanced by juvenile recruitment (Bahner 1993, Hutchins *et al.* 1996).

Currently, the captive propagation program is managed under the American Zoo and Aquarium Association's Species Survival Plan in close cooperation with the Guam Division of Aquatic and Wildlife Resources. The Species Survival Plan management group consists of a coordinator, representatives from each captive breeding institution, two nutrition advisors, a veterinary advisor, a pathology advisor, an education advisor, two advisors from the population management committee, a Guam representative, and a liaison from the U.S. Fish and Wildlife Service.

Since the captive breeding program began, there have been extensive efforts to increase the captive population, maintain genetic diversity, and address potential problems with the program (Hutchins *et al.* 1996, Bahner *et al.* 1998). Annual studbooks, which provide input on optimal pairings and efforts to increase the captive population, have been published since 1988 (Bahner 1988-1996, 1998, 1999, 2001). Formal master planning for the population occurred in 1989, 1993, and 2001 to help in long-term planning for the captive population (Bahner 1993). In 1996, an action plan was published which discussed many of the problems facing the captive population and provided a guide for efforts needed to help increase the population's size (Hutchins *et al.* 1996). In 1998, a husbandry manual was published to standardize husbandry procedures among participating institutions, provide a review of effective husbandry procedures, and facilitate the gathering and exchange of data (Bahner *et al.* 1998). Consolidation of the captive population to fewer institutions and development of a keeper training program have also helped to standardize procedures among institutions and optimize efforts to increase the population (Hutchins *et al.* 1996).

In addition to the planning and management efforts above, there has also been research on increasing the captive population and maintaining genetic diversity. Research on the basic life history of the wild population of sihek was done by Marshall (1989) and used to help captive breeding efforts. Because the sihek is extinct in the wild, research on the breeding biology and life history of Micronesian kingfishers is also underway with the Pohnpei subspecies (Kesler 2002; D. Kesler, pers. comm. 2003). The genetic diversity of the captive population (Haig and Ballou 1995) and genetic relationship among the founders of the captive population (Haig *et al.* 1995) was studied. Research on the behavioral (Baltz 1998) and hormonal aspects (Fowler and McGill 2002) of kingfisher pairs was undertaken. Finally, research continues on the adequacy of kingfisher diets, pathology, and behavior (E. Bahner, pers. comm. 2003).

Some of the problems associated with the captive propagation efforts on the mainland may be related to different climatic conditions relative to the kingfisher's native Guam, as well as the lack of appropriate nesting logs or natural foods (Hutchins et al. 1996; Kesler and Haig, in press). Breeding kingfishers on Guam in their native climate, with natural nesting substrates and foods available at a facility dedicated to kingfisher propagation, may alleviate some of the factors that have hampered the captive breeding efforts thus far. In September 2003 three male sihek were transported from the mainland to a captive breeding facility built on Guam and operated by the Guam Division of Aquatic and Wildlife Resources. These individuals were transported first to ensure the safety of the transfer effort before any of the more valuable breeding females are transferred to the island. The transfer was successful, laying the foundation for the transport of a breeding pair to the new facility sometime in the near future.

2. Reduce Avian Mortality in the Field

Efforts to reduce avian mortality in the field have primarily focused on the brown treesnake. However, there has also been research conducted on the potential impacts of avian disease (Savidge *et al.* 1992, Silva-Krott *et al.* 1998) and contaminants (Drahos 1975, Grue 1985) on wild populations. Work has also been done on the potential impacts of competition between black drongos and kingfishers (Maben 1982).

a. Brown Treesnake Control

Since the brown treesnake was identified as a major factor in the decline of Guam's native birdlife (Savidge 1987), extensive research has been initiated to develop and implement control methods. Research has focused on the biology of the brown treesnake, the development and testing of control techniques, and the development and testing of interdiction techniques (see Reasons for Decline and Current Threats, p. 12). Interdiction efforts are focused primarily on preventing the establishment of brown treesnakes on islands other than Guam. Because the current goal of this recovery plan is to reestablish sihek on Guam, interdiction is not discussed here. Additional information on the biology of the brown treesnake and interdiction efforts is summarized by Rodda *et al.* (1999c), and is also available on the websites of the U.S. Geological Survey Biological Research Division at <http://www.invasivespecies.gov/profiles/bts.shtml> and U.S. Department of Agriculture Wildlife Services at <http://www.aphis.usda.gov/ws/btsproj.html>.

The three most commonly utilized methods for controlling brown treesnakes in conservation situations are trapping, exclusion barriers, and snake toxicants in experimental situations. Snake traps consist of a cylindrical wire mesh body capped on the ends by inward-pointing funnels. A live rodent is placed in a snake-proof area within the trap to motivate snakes to enter (Rodda *et al.* 1992). Traps can be placed in a wide variety of locations and are used for control at both site-specific and landscape levels. Site-specific applications include trapping around Mariana crow nests, often in conjunction with barriers (see below), and around Guam rail and Mariana crow captive breeding pens on Guam. Landscape-level trapping includes perimeter-trapping experiments in southern Guam and area-trapping experiments in a 42-hectare (104-acre) portion of the Munitions Storage Area on Andersen Air Force Base. All of these applications have reduced snake numbers and benefited conservation efforts on Guam.

Snake exclusion barriers are either temporary or permanent structures that restrict the movement of snakes. An electrical barrier was developed for protecting active Mariana crow nests from predation and was found effective (Aguon *et al.* 2002). This technique could also be applied to sihek nesting trees. Bulge, vinyl, and masonry barriers were developed specifically for interdiction efforts (Perry *et al.* 1996, 1998, 2001), but only the bulge barrier has been used for endangered species conservation efforts. This effort was initiated in 1998 and involved retrofitting a cyclone fence around Area 50, a 24-hectare limestone forest area in Northwest Field on Andersen Air Force Base, with a bulge barrier. Once the barrier was in place, the area was trapped for snakes. Results from this experiment suggest a substantial and sustained reduction in snake numbers. However, the fact that snake captures continued at a low level throughout the experiment indicates leakage through the barrier and/or the presence of untrappable snakes. Plans are now underway to construct a test masonry barrier around Area 50 and around the Munitions Storage Area. The results of these experiments should determine if trapping and/or toxicant use in conjunction with snake barriers is an effective conservation technique.

A variety of toxicants have been tested for their effectiveness at killing brown treesnakes by oral ingestion or dermal absorption (Savarie and Bruggers 1999; Savarie *et al*. 2000, 2001). Acetaminophen has been shown to be toxic to brown treesnakes in both laboratory and field efficacy trials (Savarie *et al*. 2001, Johnston *et al*. 2002). In 2002, the Animal and Plant Health Inspection Service received a registration under the Federal Insecticide, Fungicide and Rodenticide Act (17 USC 136 *et seq*.) from the U.S. Environmental Protection Agency allowing the use of dead mice treated with 80 milligrams of acetaminophen to control brown treesnakes on Guam and the Northern Mariana Islands. This registration allows mice baits to be applied in either bait stations, or by hand and aerial broadcast methods. Bait stations are constructed from polyvinyl chloride (PVC) tubes 5 to 10 centimeters (2 to 4 inches) in diameter and 30.5 to 46 centimeters (12 to 18 inches) long and are hung horizontally approximately 1.2 meters (4 feet) off the ground on trees, fences or other structures. Concerns for risk to sihek, Mariana crow and other nontarget species resulted in the development of a new vertical bait station design; recent tests of the new design (smaller PVC tubes open only on one end and hung vertically with the open end down) have shown that snakes take mice equally as well as with the horizontal stations. This configuration should significantly reduce any potential hazards to nontarget species. In addition to the bait stations, aerial bait delivery systems are being designed for snakes (Shivik *et al*. 2002). The dropped baits become entangled in the forest canopy, reducing the number landing on the forest floor, thereby reducing the number of nontarget species potentially impacted by baits. Hand and aerial broadcast application will be beneficial for treating areas such as cliff lines or areas of dense forest where the establishment and maintenance of bait stations is impractical. The use of acetaminophen-treated bait has enormous potential to aid in recovery efforts of endangered species on Guam.

Unfortunately, all three of these control techniques have limitations. Snake trapping is expensive, and its effectiveness is significantly reduced when prey densities are high, when small and/or untrappable snakes are present (trials show that small snakes are less likely to be captured in traps), and when there is immigration from non-control areas (Rodda *et al.* 1999b). Toxicants, such as acetaminophen, appear to also have the same constraints as those encountered by snake trapping (size selectivity, likelihood of reduced effectiveness in high prey environments, and immigration from non-control areas). Snake barriers are relatively costly and with current funding levels may be impractical for the long-term protection of the large areas needed to recover the Micronesian kingfisher on Guam. Hopefully, the limitations of these techniques can be overcome through their continued refinement and the development of new control methodologies.

In addition to traps, barriers, and toxicants, research has also been conducted on possible biocontrol agents (Nichols 2000, Dobson and Altizer 2001). An overview of the potential feasibility of biocontrol for brown treesnake population suppression has been completed (Dobson and Altizer 2001). This document reviews all potential snake pathogens and models potential feasibility of generalized biocontrol agents to steer research efforts in directions that yield the greatest chance of success. This report is being reviewed and revised by an internationally recognized group of vertebrate biocontrol, reptile pathogen, and wildlife experts. Efforts have also been made to identify potential *paromyxovirus* (Nichols 2000) and *haemogregarine* parasites. However, it should be noted that neither of these agents appear to be optimal for the task at hand and biocontrol may not yield total eradication.

b. Other Sources of Avian Mortality

In addition to work on brown treesnakes, there has also been some research done on the role of avian disease (Savidge *et al.* 1992), contaminants (Grue 1985), and competition with black drongos (Maben 1982) in the decline of sihek. None of these factors are considered to have been major factors in the extirpation of this species from Guam (see Reasons for Decline and Current Threats, p. 12). The potential impact of predators other than brown treesnakes on sihek was not assessed, as there was no opportunity to do so before the wild population had gone extinct. However, continuing research on Pohnpei Micronesian kingfisher population dynamics will provide valuable insight into the potential effects of rat and cat predation on Micronesian kingfishers. In addition, an effort is underway to obtain Environmental Protection Agency registration for use of diphacinone bait stations on Guam. Bait stations, and hand and aerial broadcast applications of diphacinone, would be useful in controlling rat populations if this should be necessary for recovery of the sihek.

3. Habitat Protection

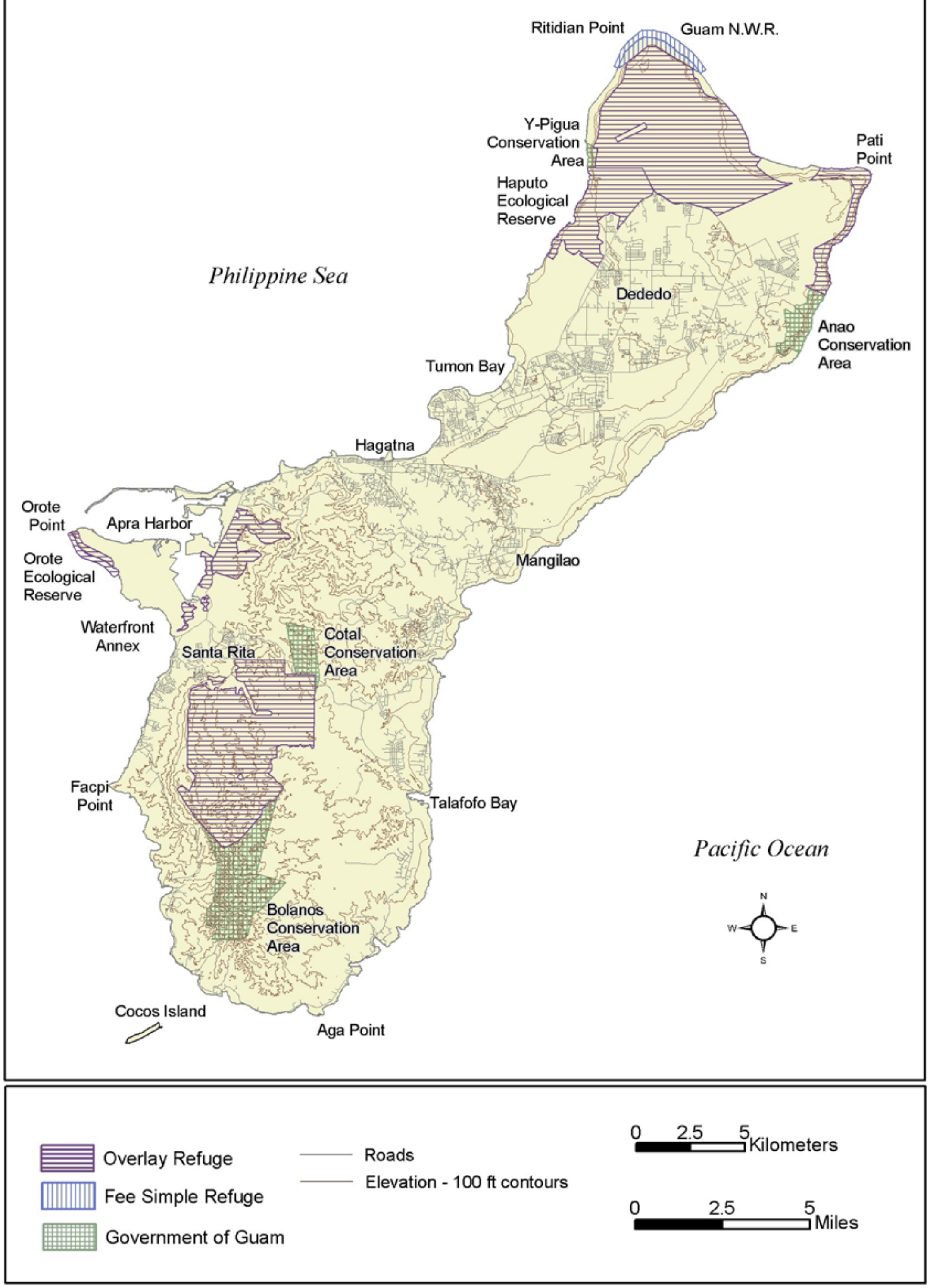
a. Protected Areas

Both northern and southern Guam maintain large tracts of forested lands that have been protected from development, agriculture, and public access since World War II as parts of Andersen Air Force Base and Commander of Naval Forces in the Mariana Islands (U.S. Navy). The latter includes the Naval Computer and Telecommunications Station in northern Guam, and the Waterfront Annex (*i.e.*, “Big Navy”) and Ordnance Annex in southern Guam. Andersen Air Force Base and the Naval Computer and Telecommunications Station contain much of the remaining good quality limestone forest on northern Guam, while the Ordnance Annex contains the core of southern Guam’s forests.

In 1994, 9,300 hectares (22,980 acres) of land owned by the U.S. Navy and U.S. Air Force were incorporated into the Guam National Wildlife Refuge (Figure 4). The Guam National Wildlife Refuge is an "overlay refuge" – although the lands remain in the ownership of the Department of Defense, they are co-managed with the U.S. Fish and Wildlife Service as a wildlife refuge. Within this refuge, there are several designated conservation areas. Andersen Air Force Base set aside the 281-hectare (694-acre) Pati Point Natural Area in 1973, an area that contains the primary roost site of the endangered Mariana fruit bat (*Pteropus mariannus mariannus*) on Guam (Wiles *et al.* 1995), and that also supported sihek in 1981 (Engbring and Ramsey 1984). In 1985, the U.S. Navy designated the 131-hectare (324-acre) Haputo Ecological Reserve at the Naval Computer and Telecommunications Station and the 66-hectare (163-acre) Orote Ecological Reserve on the Waterfront Annex. Approximately 102 hectares (252 acres) of the Haputo Ecological Reserve is terrestrial and contains forested habitat important to the conservation of the sihek. Approximately 12 hectares (30 acres) of the Orote Ecological Reserve is terrestrial and contains habitat that could be utilized by sihek. However, the forest in this reserve area is isolated from other large tracts of forest on Guam. On the Ordnance Annex, the Navy has established "No Disturbance" areas with respect to military training around Mt. Almagosa (due to the unusual flora surrounding it) and Mahlac Cave (due to the presence of the federally endangered Mariana swiftlet [*Aerodramus bartschi*] colony). These areas contain forested habitat important to the conservation of the sihek.

Additionally, the Government of Guam established four reserves (1,700 hectares [4,200 acres] total) for habitat protection. The Anao and Y-Pigua Conservation areas are located in the north, and the Cotal and Bolanos Conservation areas in the south (Figure 4). These lands are under the jurisdiction of the Chamorro Land Trust Commission of the Government of Guam. The Commission has the authority to change the status of these lands to non-conservation areas as they deem appropriate.

Figure 4. Conservation areas on the island of Guam



b. Feral Ungulate Management and Removal

To date, there has been no large-scale control or removal of ungulates on Guam. Several attempts have been made to completely remove resident Sambar deer and feral pigs from Area 50, a 24-hectare (59-acre) patch of limestone forest surrounded by a chain-link fence on Andersen Air Force Base, but these have been unsuccessful (D. Vice, Guam Division of Aquatic and Wildlife Resources, pers. comm. 2002).

Immunocontraception is currently being used in an attempt to control the feral Asiatic water buffalo population on the Naval Ordnance Facility. This program was implemented in 1996 to reduce habitat degradation and erosion caused by the water buffalo (U.S. Navy 2001). To date, this program appears to have had some success controlling water buffalo population (S. Vogt, pers. comm. 2003). However, the Navy is considering lethal control measures to further reduce the population.

4. Public Awareness

A wide variety of public education and outreach activities have been implemented by the Guam Division of Aquatic and Wildlife Resources, focusing on the conservation of native species and the biology and ecological impacts of brown treesnakes. All of these efforts directly or indirectly support sihek conservation efforts. Outreach activities include wildlife posters, wildlife factsheets, curricula and presentations for school children, and newspaper articles. In addition to efforts on Guam, many of the captive breeding institutions in the mainland United States have incorporated information about the decline and conservation of Guam's native forest birds, including the sihek, into their exhibits, publications, and outreach programs.

II. RECOVERY STRATEGY

The current primary threats to the sihek are limited population growth in captivity and the difficulty of reestablishing a population on Guam due to the presence of brown treesnakes. In addition, other threats such as disease, habitat loss, and other potential predators, such as rats, could also impact recovery. Therefore, recovery actions will focus on increasing the size of the captive population, controlling brown treesnakes, protecting and enhancing habitat for reintroduction, and reintroducing kingfishers into the wild on Guam. Establishing a captive breeding program on Guam may alleviate some of the reproduction and mortality problems that may be associated with environmental factors and nesting substrate availability in the captive population in the mainland United States. Efforts to increase reproductive success and decrease mortality in captivity will continue. Controlling brown treesnakes includes development of new control techniques and implementation and testing of existing techniques in the field. Habitat protection and enhancement includes protecting sufficient areas of habitat from development, controlling ungulates, weeds, and fires, and replanting degraded areas with native plants, as needed. Currently sihek are found only in captivity, therefore reintroducing these kingfishers to Guam is essential to the recovery of the species. Reestablishing a self-sustaining population in the wild will involve developing techniques for successfully releasing sihek, identifying optimal locations for release, managing release sites for successful reestablishment, and, finally, conducting the release of kingfishers to the wild.

Enhancing the captive population, controlling brown treesnakes, developing reintroduction techniques, and protecting and enhancing habitat are the first steps toward recovery, and each of these actions is currently underway. A new captive breeding facility has been constructed on Guam, and recently the first birds were transferred from the mainland in anticipation of starting a new captive breeding program on the island. Actual releases of birds into the wild will commence when brown treesnake numbers are controlled in suitable habitats. Ideally, release of kingfishers will occur after successfully increasing the size of the captive population so that optimal numbers of kingfishers are available for release. However, if efforts to increase the captive population are not successful, it will be necessary to consider release of kingfishers from the available population. After kingfishers become reestablished on Guam, recovery should be reassessed to determine the steps needed for downlisting and then delisting the subspecies.

Recovery requires that there be at least two viable subpopulations of kingfishers on Guam to reduce the subspecies' vulnerability to environmental fluctuations and catastrophes. At a minimum one subpopulation should occur in northern Guam and one in southern Guam. This distribution will help reduce the impact of any potential natural or unnatural catastrophes on the subspecies.

A. Recovery Goals, Objectives, and Criteria

1. Recovery Goals and Objectives

The primary goals of this recovery plan are to downlist the sihek to threatened status and ultimately to remove the sihek from the Federal list of threatened and endangered species (delist). These goals will be attained by increasing the captive population to a level sufficient to allow reintroductions on Guam, reestablishing a wild population of kingfishers on Guam, and increasing wild populations of kingfishers on Guam to two viable, self-sustaining subpopulations through population augmentation and controlling the identified threats to the subspecies.

2. 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 upon 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.

In this revised plan, criteria for downlisting and delisting are based on reaching population goals and removing or reducing and controlling threats to the sihek. The criteria for downlisting and delisting the sihek incorporate the two primary threats of predation by introduced predators and habitat loss. However, new threats to the subspecies may arise as recovery efforts continue. These threats will need to be monitored and addressed appropriately. If these new threats should become significant, the recovery criteria below will need to be revised.

Reassessment of the recovery criteria may also be appropriate as our knowledge regarding the sihek increases over time. As little is currently known about sihek population biology, the population goals provided in the criteria are based on limited information, including: (1) Micronesian kingfisher population estimates and densities from forest bird surveys on Guam (Engbring and Ramsey 1984), Pohnpei (Engbring *et al.* 1990), and Palau (Engbring 1992); (2) collared kingfisher population estimates and densities from forest bird surveys on Saipan, Tinian, and Rota (Engbring *et al.* 1986); and (3) information available on the biology of Micronesian kingfishers on Guam and Pohnpei. These goals should be revised when a wild population is reestablished on Guam and more is learned about the population biology of the sihek in its native habitat. Likewise, more specific information regarding the quantity of sihek habitat needed and levels of brown treesnake control required to achieve the population goals set in this plan are not currently known. The criteria addressing these threats will thus be subject to refinement as our understanding of sihek ecology improves through the implementation of the recovery actions outlined in this plan.

Downlisting Criteria. The sihek may be considered for downlisting from endangered to threatened status when all of the following criteria are met:

Criterion 1: Sihek occur in 2 subpopulations (one in northern Guam and one in southern Guam) of at least 500 adults each;

Criterion 2: Both subpopulations are either stable or increasing based on quantitative surveys or demographic monitoring that demonstrates an average intrinsic growth rate (λ, or lambda) not less than 1.0 over a period of at least 5 consecutive years;

Criterion 3: Sufficient sihek habitat, based on quantitative estimates of territory and home range size, is protected and managed to achieve criteria 1 and 2 above; and

Criterion 4: Brown treesnakes and other introduced predators are controlled over 5 consecutive years at a level sufficient to achieve criteria 1 and 2 above.

Delisting Criteria. The sihek may be removed from the Federal list of endangered and threatened species when all of the following criteria are met:

Criterion 1: Sihek occur in 2 subpopulations (one in northern Guam and one in southern Guam) of at least 1,000 adults each;

Criterion 2: Both subpopulations are either stable or increasing based on quantitative surveys or demographic monitoring that demonstrates an average intrinsic growth rate (λ, or lambda) not less than 1.0 over a period of at least 10 consecutive years;

Criterion 3: Sufficient sihek habitat, based on quantitative estimates of territory and home range size, is protected and managed to achieve criteria 1 and 2 above; and

Criterion 4: Brown treesnakes and other introduced predators are controlled over 10 consecutive years at a level sufficient to achieve criteria 1 and 2 above; and

Criterion 5: A monitoring plan has been developed and is ready for implementation, to cover a minimum of 5 years post-delisting, to ensure the ongoing recovery of the species and the continuing effectiveness of management actions.

III. RECOVERY ACTIONS

The goal of this recovery plan is to reestablish a viable population of sihek on Guam. Therefore, this plan focuses on the following actions to make this possible:

(1) Coordinate and monitor recovery efforts;

(2) Restore populations (includes increasing the size of the captive population in mainland institutions and on Guam, as well as development of a detailed reintroduction program);

(3) Manage factors affecting population viability (particularly predator control);

(4) Implement habitat protection and management program; and

(5) Develop a public awareness program for sihek.

Due to the limited information available on the Guam subspecies of Micronesian kingfisher and the extremely small population available for conservation of the subspecies, many of the actions described below involve the Pohnpei subspecies or another surrogate species.

A. Step-Down Outline of Recovery Actions

1. Coordinate and monitor recovery efforts
    - 1.1 Maintain an active Recovery Committee
        - 1.1.1 Coordinate recovery actions with other recovery and ecosystem management efforts
        - 1.1.2 Develop 5-year recovery milestones
        - 1.1.3 Periodically review and update recovery plan
            - 1.1.3.1 Review recovery efforts annually
            - 1.1.3.2 Update or revise recovery plan as needed
    - 1.2 Develop recovery subcommittees
    - 1.3 Monitor recovery efforts
2. Restore populations
    - 2.1 Captive management
        - 2.1.1 Establish a sihek breeding program on Guam
            - 2.1.1.1 Build and maintain kingfisher breeding pens

2.1.1.2 Complete staffing of facility

2.1.1.3 Transfer kingfishers to Guam

2.1.1.3.1 Transfer two or three genetically well-represented males to Guam

2.1.1.3.2 Transfer established breeding pair

2.1.1.3.3 Plan transfers of additional kingfishers

2.1.2 Increase size of the sihek captive population

2.1.2.1 Increase reproductive success

2.1.2.1.1 Assess effects of environmental factors on reproductive success

2.1.2.1.1.1 Evaluate environmental enrichment and reproductive success

2.1.2.1.1.2 Evaluate climate, photoperiod, and reproductive success

2.1.2.1.1.3 Evaluate nest logs and reproductive success

2.1.2.1.2 Assess effects of adult weight on reproductive success

2.1.2.1.3 Assess effects of age on reproductive success

2.1.2.1.4 Assess effects of hand-rearing on reproductive success

2.1.2.1.5 Develop methods to establish pairs

2.1.2.1.6 Review artificial incubation techniques

2.1.2.1.7 Study cannibalism

2.1.2.1.8 Continue stress hormone research

2.1.2.2 Decrease juvenile and adult mortality

2.1.2.2.1 Collect and analyze pathology data

2.1.2.2.2 Prevent disease

2.1.2.2.3 Standardize husbandry techniques and increase training

2.2 Reintroduce sihek to Guam

2.2.1 Develop and test reintroduction strategies to increase likelihood of successful releases

2.2.1.1 Review other reintroduction programs

2.2.1.2 Develop and test reintroduction methods on collared kingfishers

2.2.2 Determine potential release sites on Guam

2.2.2.1 Assess habitat characteristics and potential territory distribution

2.2.2.1.1 Obtain/Construct Geographic Information System database of landscape/vegetation characteristics

2.2.2.1.2 Evaluate habitat suitability of potential reintroduction sites

2.2.2.2 Assess historical distribution of sihek

2.2.2.3 Assess brown treesnake densities

2.2.2.4 Assess management potential of release site

2.2.3 Evaluate kingfisher dispersal, movement, and habitat use

2.2.3.1 Complete Pohnpei Micronesian kingfisher mark-relocate and telemetry studies

2.2.3.2 Expand mark-relocate and telemetry studies to reintroduced sihek

2.2.4 Develop a population model

2.2.5 Determine number of kingfishers needed for successful release

2.2.6 Develop reintroduction plan for sihek

2.2.7 Reintroduce sihek to the wild

2.2.7.1 Establish a subpopulation in northern Guam

2.2.7.2 Establish a subpopulation in southern Guam

2.2.8 Monitor sihek in the wild

2.2.8.1 Gather data on post-release survival of kingfishers for refining release strategies

2.2.8.2 Provide long-term monitoring of the sihek population

2.2.8.2.1 Update population model (see recovery action 2.2.4) with results from sihek reintroduction efforts

2.2.8.2.2 Develop efficient and effective methods for surveying the population

2.3 Assess the need for wild back-up populations outside Guam

3. Manage factors affecting wild population viability

3.1 Control and eradicate predators

3.1.1 Control and eradicate brown treesnakes

3.1.1.1 Delineate snake-threshold densities using surrogate native species

3.1.1.2 Refine snake-threshold density estimates for sihek

3.1.1.3 Improve existing brown treesnake control measures

3.1.1.3.1 Develop effective artificial attractants

3.1.1.3.2 Improve trap designs to increase snake capture rate

3.1.1.3.3 Develop methods for sequentially controlling or eliminating brown treesnakes from large areas inside and outside snake exclosures

3.1.1.3.4 Develop "kingfisher safe" acetaminophen bait stations

3.1.1.3.5 Determine what, if any, non-target risk exists for kingfishers by the aerial broadcast of snake toxicants

3.1.1.3.6 Develop methods for accurately quantifying brown treesnake densities in snake-reduced areas

3.1.1.3.7 Develop and test brown treesnake barrier designs

3.1.1.4 Continue to fund research to develop new brown treesnake control techniques

3.1.2 Control rats if necessary

3.1.2.1 Monitor impact of rat predation on sihek to determine the need for rat control

3.1.2.2 Continue efforts to register an aerial broadcast rodenticide for use on Guam

3.1.3 Assess impact of other sihek predators

3.1.4 Prevent accidental or intentional introduction of new avian predators to Guam

3.2 Assess the need for black drongo control

3.3 Reduce potential impacts of avian disease on sihek populations

3.4 Translocate individuals from north or south subpopulations if necessary

4. Implement a habitat protection and management program

4.1 Maintain and/or protect reserve habitat on Guam

4.1.1 Guam National Wildlife Refuge

4.1.1.1 Ritidian Point

4.1.1.2 Overlay refuge

4.1.2 Government of Guam Conservation Areas

4.2 Improve and manage habitat on Guam

4.2.1 Assess suitability of habitat on Guam

4.2.2 Develop a kingfisher habitat management plan

4.2.3 Implement the kingfisher habitat management plan

5. Develop a public awareness program for sihek

5.1 Fund, support, and promote programs that inform teachers, and that educate students, lawmakers, local public and visitors

5.1.1 Fund and support teacher education programs that promote native species conservation

5.1.1.1 Institute core curriculum programs at the University of Guam and community colleges that emphasize native species and ecosystem conservation for elementary and high school teacher education programs

5.1.1.2 Develop and distribute educational materials that provide teachers with "student friendly" information about native species and ecosystems

5.1.1.2.1 Work with local teachers to develop lessons on native species and ecosystems for use in the classroom

5.1.1.2.2 Make educational materials easily available

5.1.1.2.3 Update and revise materials

5.1.2 Create a clearinghouse, such as a website, for information and education materials about Guam's native species

5.1.3 Continue to provide information and promote awareness of the harmful effects of alien species, such as the brown treesnake, to native species and ecosystems

5.2 Use a professional marketing agency and business marketing techniques (television, radio, internet, newspaper and magazine articles and advertising) to promote awareness of the uniqueness of Guam's native species and gain local support for endangered species and related conservation issues

5.2.1 Conduct market research on the public's knowledge of native species and attitudes towards conservation to provide the information to develop the most direct ways to inform the public and gain support for native species

5.2.2 Promote and fund the development of public service announcements for television and radio about native species and their habitat

5.2.2.1 Assist in the development of public service announcements about native species by providing local television stations with footage of native species with natural sounds and suggest their use as background visuals or sounds during credits for local or other programming

5.2.2.2 Use local "heroes," entertainers, sports figures, or other role models, to promote local pride in native species

5.2.2.3 Promote the use of prize-winning contests, with sponsors, on local radio, television stations and newspapers to promote native species awareness

5.2.2.4 Fund weekly or monthly programs in newspapers or on radio or television stations that provide a short informative environmental education story

5.2.3 Promote private business use of native species likenesses, images and names on old and new products and use them in advertising and logos

5.3 Promote the creation of and support for "Friends" groups, partnerships, environmental outreach programs and other groups to provide awareness and support for conservation of the sihek and other species endemic to Guam

5.3.1 Recruit, train and support volunteer community leaders to organize outreach, native species educational and awareness programs at the community level
   5.3.1.1 Support conservation outreach organizations to promote conservation at a "grassroots" level
   5.3.1.2 Develop a "mentor" program where natural science professionals provide field opportunities for young people to learn about Guam's native species
   5.3.1.3 Support the use of volunteers in projects that will contribute to the enhancement of native habitat and increase the level of awareness and pride in native species within the local populace
5.3.2 Develop and support partnerships with other conservation agencies, local interest groups and private landowners

B. Narrative Outline of Recovery Actions

1. Coordinate and monitor recovery efforts

Due to the complexity of issues associated with sihek recovery, a coordinated recovery effort is needed. In addition, the effectiveness of this effort will be related to how well the program is monitored and adapted to address new situations.

1.1 Maintain an active Recovery Committee

The recovery committee serves as a forum in which stakeholders discuss issues affecting recovery and through which effective and coordinated recovery strategies are developed and implemented. The committee should include members with useful technical expertise, along with representatives of agencies, organizations, and landowners that will participate in the recovery program. At a minimum, the following agencies should be represented and participate actively on the committee: U.S. Fish and Wildlife Service; Guam Division of Aquatic and Wildlife Resources; participating institutions of the Guam Micronesian Kingfisher Species Survival Plan; U.S. Air Force; U.S. Navy, U.S. Geological Survey, Biological Research Division; and U.S. Department of Agriculture, Wildlife Services. Technical disciplines that should be represented on the committee include, but are not necessarily limited to: kingfisher biology, brown treesnake biology, wildlife biology, population biology, veterinary medicine, habitat ecology, captive management, and endangered species reintroduction.

1.1.1 <u>Coordinate recovery actions with other recovery and ecosystem management efforts</u>

Due to the similarities in recovery issues for listed species on Guam and the Mariana Islands, it is recommended that the recovery committee coordinate with other recovery groups and keep abreast of ecosystem management efforts. Disseminating meeting minutes and holding concurrent meetings may help achieve this goal.

1.1.2 <u>Develop 5-year recovery milestones</u>

The recovery actions outlined in this revised plan include a wide range of activities that will require many years to achieve. In order to keep recovery efforts focused and properly assessed, 5-year recovery milestones should be developed.

1.1.3 <u>Periodically review and update recovery plan</u>

1.1.3.1 <u>Review recovery efforts annually</u>

The recovery committee should meet annually, or more often if necessary, to review the status of recovery implementation and need for additional planning. This information should be included in the meeting minutes and used to monitor the need for updates to the recovery plan.

1.1.3.2 <u>Update or revise recovery plan when needed</u>

The recovery plan should be updated or revised to keep it current and useful. Updates would include relatively minor changes to the plan that do not alter the overall direction of the recovery effort. A revision is required when major changes to the Recovery Strategy, Recovery Objectives or Criteria, or Recovery Narrative are necessary. It is tentatively anticipated that revisions may be needed approximately every 5 years.

1.2 <u>Develop recovery subcommittees</u>

Recovery of the sihek requires expertise on a wide range of recovery issues. In order to address each of these issues and limit the overall size of the recovery committee, recovery subcommittees dealing with the following aspects of kingfisher recovery should be formed: captive management, reintroduction efforts, habitat restoration, and outreach. Each of these subcommittees should include at least one member of the recovery committee that will serve as spokesperson for the subcommittee. These subcommittees should meet regularly when appropriate. For example, the reintroduction subcommittee may not need to meet until after a captive population is established on Guam. The U.S. Fish and Wildlife Service Guam Micronesian kingfisher recovery coordinator should serve as a liaison for each subcommittee.

1.3 <u>Monitor recovery efforts</u>

A successful recovery program requires frequent and regular monitoring and reporting of recovery efforts. Each recovery action includes a monitoring step that will allow review of the efforts to determine the most effective recovery methods.

2. <u>Restore populations</u>

Recovery of the sihek requires that a wild population be reestablished on Guam. However, this requires that the size of the captive population be increased and that kingfishers be reintroduced into the wild when circumstances allow.

<u>2.1 Captive management</u>

A successful captive management program is the first step toward recovery of the sihek. This program includes both captive propagation efforts on Guam and in zoos on the continental United States.

2.1.1 <u>Establish a sihek breeding program on Guam</u>

Some of the problems associated with breeding sihek in mainland institutions may be related to the climate, availability of nesting logs and natural foods, and limited time and staff to care for kingfishers (Hutchins *et al.* 1996; Kesler and Haig, in press). Breeding kingfishers on Guam may alleviate some of these problems and result in an increase in the size of the captive population.

2.1.1.1 Build and maintain kingfisher breeding pens

Initially, three captive breeding pens and six holding pens should be built on Guam at the Department of Aquatic and Wildlife Resources captive rearing facilities. These pens should be built to the specifications suggested by other captive rearing facilities and able to withstand weather conditions on Guam. As the captive breeding program develops, additional pens should be built as needed.

2.1.1.2 Complete staffing of facility

The captive rearing facility should have appropriate numbers of staff to care for their captive population of kingfishers. This staff should include a supervisory aviculturalist, assistant aviculturalist, and technicians.

2.1.1.3 Transfer kingfishers to Guam

2.1.1.3.1 Transfer two or three genetically well-represented males to Guam

Due to the limited number of sihek and the potential hazards associated with transporting kingfishers to Guam, two or three genetically well-represented male sihek will be transferred first. This will allow any potential problems to be identified before the more valuable female sihek are transported to Guam.

2.1.1.3.2 Transfer established breeding pair

After the male sihek are transferred to Guam, an established breeding pair will be transferred to begin captive breeding efforts on Guam. Transferring an established pair will increase the likelihood the pair will breed successfully in the facility on Guam.

2.1.1.3.3 <u>Plan transfers of additional kingfishers</u>

Additional sihek should be transferred to Guam as birds and space become available. Status reviews of the captive population and transfer recommendations should be formulated twice annually until recovery is secured.

2.1.2 <u>Increase size of the sihek captive population</u>

Recovery of the kingfisher requires that the captive population be increased to sufficient numbers to allow for eventual reintroduction to the wild (see Recovery Action 2.2.7). The captive population can only be increased if mortality is decreased and reproductive success is increased.

2.1.2.1 <u>Increase reproductive success</u>

Reproductive success has been limited by difficulty forming breeding pairs, infertile eggs, embryonic death, and loss of parent-reared chicks shortly after hatching. A wide variety of factors may be influencing reproductive success at each stage of the process. All of these factors need to be assessed to determine their effect on reproduction so that methods can be developed to increase reproductive success.

2.1.2.1.1 <u>Assess effects of environmental factors on reproductive success</u>

2.1.2.1.1.1 <u>Evaluate environmental enrichment and reproductive success</u>

The cage environment in which captive kingfishers are kept varies widely among institutions and may play a role in reproductive success. Data should be gathered on environmental enrichment and compared with reproductive success to help identify how the cage environment may be improved to increase reproductive success.

2.1.2.1.1.2 <u>Evaluate climate, photoperiod, and reproductive success</u>

For many bird species, reproductive behavior is triggered by subtle changes in environmental factors, such as daylight regimen, type of lighting, changes in food availability or type, and humidity (Hutchins *et al.* 1995). Data on all of these factors should be gathered and analyzed. If appropriate, the results should be used to help increase reproductive success.

2.1.2.1.1.3 <u>Evaluate nest logs and reproductive success</u>

In many avian species, mating behavior is stimulated by the selection and preparation of the nest site. A study is needed to help identify factors related to nest log selection. This will assist managers in providing birds with suitable nest sites.

2.1.2.1.2 Assess effects of adult weight on reproductive success

Captive Micronesian kingfishers have a tendency to become obese, which may affect their ability to reproduce (Hutchins *et al.* 1996). Data should be collected on body weights on all pairs and analyzed to help identify the relationship between weight and reproductive success. This information could then be used to help identify an appropriate diet.

2.1.2.1.3 Assess effects of age on reproductive success

Age similarities and differences in paired birds are known to affect reproductive success (Marzluff and Balda 1988). Data should be collected and analyzed to assess the relationship between the relative age of paired birds and reproductive success.

2.1.2.1.4 Assess effects of hand-rearing on reproductive success

Hand-rearing of sihek was initiated to help improve chick survival. However, hand-rearing may impact breeding behavior, including the ability of hand-raised birds to raise offspring and form pairs (Myers *et al.* 1988, Hutchins *et al.* 1995). The impact of hand-rearing on the fitness of sihek should be assessed as soon as practicable.

2.1.2.1.5 Develop methods to establish pairs

Historically, less than half of the sihek pairs in captivity have produced offspring (Baltz 1998). Allowing birds to select their mates is important to establishing a successful pair and reproductive success (Yamamoto *et al.* 1989). However, developing the most effective method of introducing male and female kingfishers has been difficult (Baltz 1998). Data on introduction techniques and associated behaviors must be collected and analyzed to develop an effective technique. Standard methods of acclimating, introducing and observing sihek pairs will facilitate the identification of reproductively compatible pairs to increase breeding success. Recent research on kingfisher stress and sex hormones (Fowler and McGill 2002) may also be helpful in establishing compatible pairs (see recovery action 2.1.2.1.8).

2.1.2.1.6 Review artificial incubation techniques

About 69 percent of the embryos that died in the shell were artificially incubated although only 32 percent of the fertile eggs were artificially incubated (Bahner *et al.* 1998). Inappropriate artificial incubation protocols may contribute to embryo death (Kuehler and Good 1990). A review of techniques is warranted to make certain that all participating institutions are following the appropriate incubation protocols.

2.1.2.1.7 Study cannibalism

Of the chicks parent-reared since 1997, about 74 percent disappeared from the nest. It has been assumed that a missing chick signifies parent cannibalism; however, it has never been observed so its frequency and the conditions under which it occurs are unknown. Time-lapse video studies should be used to investigate parental behavior and nestling mortality.

2.1.2.1.8 Continue stress hormone research

High stress levels can impact reproductive success. In addition, monitoring stress levels could be used to establish pairs and evaluate husbandry techniques. Research on kingfisher stress and sex hormones by Fowler and McGill (2002) should continue and be used to modify and develop husbandry procedures.

2.1.2.2 Decrease juvenile and adult mortality

Mortality in young adult and adult sihek has been linked to avian disease (*e.g.*, avian tuberculosis) and may be linked to stress and inadequate nutrition.

2.1.2.2.1 Collect and analyze pathology data

Data on the causes of young adult and adult mortality should continue to be collected and then evaluated to identify potential ways of decreasing young adult and adult mortality.

2.1.2.2.2 Prevent disease

The captive population on the mainland may be exposed to a wide variety of avian diseases because they are housed in institutions with a large number of avian species. Protocols developed in the husbandry manual (Bahner *et al.* 1998) should continue to be followed, improved upon, and updated as needed. In addition, research on treatment and prevention of avian disease should continue.

2.1.2.2.3 Improve and standardize husbandry techniques and increase training

Sources of mortality are easier to identify and prevent if all facilities are using similar husbandry techniques. The husbandry manual and keeper training program are effective means to standardize techniques and share experiences. The husbandry manual should continue to be used and its contents improved and updated based on controlled experimentation. The keeper training program should also continue and be updated as needed.

2.2 Reintroduce sihek to Guam

2.2.1 Develop and test reintroduction strategies to increase likelihood of successful releases

2.2.1.1 Review other reintroduction programs

A database is being developed by the Lincoln Park Zoo's Department of Conservation and Science that will contain information on the methods used in reintroductions and the results of these reintroduction efforts. This information could provide preliminary guidance for developing a reintroduction plan for the sihek.

2.2.1.2 Develop and test reintroduction methods on collared kingfishers

Due to the limited number of sihek and poor success rate of reintroduction programs (Griffin *et al.* 1989), a surrogate species such as the collared kingfisher should be used to develop and test reintroduction methods for use on sihek. Single sex birds (to prevent the establishment of a breeding population) should be radio-tagged, released, and monitored to determine best methods of release, effective release sizes, and number of releases. These birds will be retrieved or sacrificed prior to the release of sihek.

2.2.2 Determine potential release sites on Guam

Appropriate release sites are important to the success of the reintroduction program. These sites should contain the year-round requirements of the kingfisher, allow for predator control and post-release monitoring, and be protected for the long-term conservation of the sihek. To help determine an appropriate location, a database containing information from recovery actions 2.2.2.1 – 2.2.2.4 below should be developed.

2.2.2.1 Assess habitat characteristics and potential territory distribution

The quality and quantity of habitat at the release site will determine whether the reintroduction goal for that location will be achieved. The habitat requirements of the species also play an important role.

2.2.2.1.1 Obtain/construct Geographic Information System database of landscape/vegetation characteristics

Information about the location and availability of landscape resources in Guam is required to design a reintroduction plan and to manage reintroduced populations. To address this need, a Geographic Information System (GIS) database of landscape features, habitat resources, and vegetation coverage will be constructed.

2.2.2.1.2 Evaluate habitat suitability of potential reintroduction sites

Resource use and movement models developed for Pohnpei Micronesian kingfishers can be used to estimate the suitability of proposed reintroduction areas using the Geographic Information Systems database described in recovery action 2.2.2.1.1. This analysis will provide information about the potential number and distribution of sihek territories that might be expected on reintroduction areas.

2.2.2.2 Assess historical distribution of sihek

Information about the distribution of sihek prior to their extirpation from the wild should be used to help determine appropriate locations for reintroduction. Published and unpublished records and reports, and other resources should be searched for information on historical sihek sightings. This information should be incorporated into the Geographic Information Systems database of landscape/vegetation characteristics (see recovery action 2.2.2.1.1).

2.2.2.3 Assess brown treesnake densities

The density of brown treesnakes should be determined for a particular reintroduction site. Initially this information can be obtained from general estimates for different habitat types. Site-specific density estimates should be obtained once the number of potential sites has been reduced to two or three locations. This information can then be used to assess the level of snake control needed at the site.

2.2.2.4 Assess management potential of release site

Terrain, road access, and land ownership all affect the feasibility of managing a release site for kingfisher reintroduction. For example, establishing and maintaining brown treesnake trap lines through rough terrain is more difficult than along established roads and trails. This information should be incorporated in the reintroduction site database and used for release planning.

2.2.3 Evaluate kingfisher dispersal, movement, and habitat use

Success of the reintroduction program will rely heavily on management efforts such as brown treesnake control at the release site. Kingfisher distribution, movement, and dispersal after the release will determine the amount of area and types of habitats requiring management. Thus, dispersal, habitat use, and territoriality in Micronesian kingfishers should be estimated prior to release using data obtained from Pohnpei Micronesian kingfishers, and obtained from sihek after release.

2.2.3.1 Complete Pohnpei Micronesian kingfisher mark-relocate and telemetry studies

Data is currently being obtained on dispersal, habitat use, and territoriality in Pohnpei Micronesian kingfishers. These data should be analyzed and used to help plan for reintroduction efforts of the Guam subspecies.

2.2.3.2 Expand mark-relocate and telemetry studies to reintroduced sihek

As reintroductions occur, data should be obtained on sihek dispersal, habitat use, and territoriality. These data would be gathered during short-term and long-term monitoring efforts described under recovery action 2.2.8 below, and then used in spatially explicit population modeling (recovery actions 2.2.4 and 2.2.8.2.1) and other planning efforts.

2.2.4 <u>Develop a population model</u>

Population models are useful for evaluating parameters such as intrinsic growth rate (lambda) and for gaining insight into how a population might respond to proposed management actions. A spatially explicit model will be created and maintained to provide a tool for planning a sihek release, and to address the need for population information in a reintroduced population. The model will first be based on demographic data from Pohnpei Micronesian kingfishers, and later on spatially explicit demographic data from Guam.

2.2.5 <u>Determine number of kingfishers needed for successful release</u>

Other reintroduction programs should be reviewed to help determine the optimum number of kingfishers to release. This information could be obtained in the reintroduction database described under recovery action 2.2.1.1. In addition, because the subspecies is currently extinct in the wild, reintroduction will rely on releasing birds from the captive population. Therefore, the number of kingfishers needed to sustain the captive population must be maintained before determining the number of kingfishers to release.

2.2.6 <u>Develop reintroduction plan for sihek</u>

After the preliminary reintroduction work has been completed (recovery actions 2.2.1-2.2.5), a reintroduction plan for sihek should be developed based on the completed preliminary work. This plan should delineate programmatic goals, transport and release methodologies, monitoring and reporting schedules, and evaluation measures. All releases should be set up as experiments to test and refine release techniques and the relevant aspects of each release (*e.g.*, hard vs. soft; microhabitat, dimensions, and location of hacking aviary; and location and positioning of supplemental food stations, etc.) must be rigorously documented.

2.2.7 Reintroduce sihek to the wild

Recovery of the sihek requires the reestablishment of a self-sustaining population of kingfishers in the wild. Due to stochastic events such as storms and disease outbreaks, at least two subpopulations should be established on Guam to prevent extinction and support recovery. The locations of reintroduction sites in these regions of Guam will be determined by completing recovery action 2.2.2.

2.2.7.1 Establish a subpopulation in northern Guam

Prior to their extinction in the wild, the last sihek were found in northern Guam. This part of Guam still contains some excellent sihek habitat and is currently being managed for the Mariana crow and Guam rail reintroduction efforts.

2.2.7.2 Establish a subpopulation in southern Guam

Sihek were reported in southern Guam as late as the 1960's. Southern Guam currently contains some excellent kingfisher habitat and is large enough to support a subpopulation of kingfishers.

2.2.8 Monitor sihek in the wild

2.2.8.1 Gather data on post-release survival of kingfishers for refining release strategies

Released kingfishers should be individually marked prior to release and intensively monitored after release to determine survival. Monitoring efforts should consist of band resighting efforts and radio tagging a sample of released birds. Length and intensity of the post-release monitoring effort should be based on information collected in other release efforts throughout the world and modified to meet the needs of the kingfisher recovery program. All data gathered during post-release monitoring should be analyzed prior to the next release to refine and modify the release strategy.

2.2.8.2 <u>Provide long-term monitoring of the sihek population</u>

The ultimate success of the reintroduction program will depend on whether a viable self-sustaining population of sihek is established. A long-term monitoring program, which includes demographic studies and surveys, will provide the data needed to reach this goal effectively and efficiently.

2.2.8.2.1 <u>Update population model (see recovery action 2.2.4) with results from sihek reintroduction efforts</u>

Updating the population model created in recovery action 2.2.4 with Guam-specific information will improve its accuracy and usefulness as a management tool. Information gathered based on the populations established in recovery actions 2.2.7.1 and 2.2.7.2 will be used to update the model.

2.2.8.2.2 <u>Develop efficient and effective methods for surveying the population</u>

As the wild population increases, the difficulties of monitoring of individual kingfishers will increase. Survey techniques that accurately estimate the population size should be developed and applied consistently throughout the remainder of the recovery program.

2.3 Assess the need for wild back-up populations outside Guam

It may be necessary to establish a wild sihek population outside of Guam to prevent the extinction of the species. Other potential sites could include other islands in the Mariana Archipelago. The appropriateness of these alternate sites should be assessed utilizing an approach similar to that outlined in recovery action 2.2.2. However, additional information may be necessary to evaluate the appropriateness of alternate locations, such as the presence of collared kingfishers.

3. Manage factors affecting wild population viability

3.1 Control and eradicate predators

3.1.1 Control and eradicate brown treesnakes

Controlling brown treesnakes is an important factor in the recovery of the sihek. Success will depend either on achieving the complete eradication of snakes, or on reducing snake densities to levels at which kingfishers can maintain viable self-sustaining populations.

3.1.1.1 Delineate snake-threshold densities using surrogate native species

Reintroduction efforts would be facilitated by determining the optimum level of brown treesnake control needed to reduce mortality prior to release. This level of control could be determined by reestablishing several common native forest bird species as surrogates for the kingfisher. Appropriate surrogates should be determined based on what is logistically feasible and which species' life history most closely resembles the kingfisher. Estimation of the necessary level of brown treesnake control should be determined from the results of well-designed field studies and experiments.

3.1.1.2 Refine snake-threshold density estimates for sihek

When kingfishers become established the level of brown treesnake control should be modified to best fit the needs of the sihek.

3.1.1.3 Improve existing brown treesnake control measures

Existing control measures have several drawbacks that limit their efficacy. Efforts to improve existing techniques should continue.

3.1.1.3.1 Develop effective artificial attractants

Currently, live mice are the most effective attractant for luring snakes into snake traps. In addition, dead neonatal mice are used as a bait to deliver toxicants to snakes. However, small snakes do not normally prey on living small mammals until they are larger. In addition, it is unknown to what extent small snakes feed on dead neonatal mice. The cost for maintaining and caring for the live mice is also expensive. Similarly, getting a constant source of dead mice for toxicant use may be a concern. Therefore, artificial attractants that attract a wide range of snakes would be beneficial to control efforts.

3.1.1.3.2 Improve trap designs to increase snake capture rate

Current trap designs do not capture all snakes found in the population. Therefore, new designs that capture a wider range of snake sizes and reduce the number of untrappable snakes are needed.

3.1.1.3.3 Develop methods for sequentially controlling or eliminating brown treesnakes from large areas inside and outside snake exclosures

Brown treesnake exclosures around large areas can help reduce the immigration of snakes into these areas. However, to reduce the densities of snakes within these areas large-scale trapping is currently needed. Trapping over large areas can be very expensive. Therefore, methods of sequentially controlling or eliminating snakes from a site need to be developed. Also, because snake exclosures may not be feasible for all areas of Guam, methods for efficiently controlling brown treesnake populations over large areas outside exclosures are also needed.

3.1.1.3.4 <u>Develop “kingfisher safe” acetaminophen bait stations</u>

Environmental Protection Agency registration of acetaminophen as a brown treesnake control measure is complete. However, acetaminophen bait station designs need to be developed and studied that would minimize the take of bait by sihek.

3.1.1.3.5 <u>Determine what, if any, non-target risk exists for kingfishers by the aerial broadcast of snake toxicants</u>

The aerial broadcast of snake toxicants inside and outside of exclosure sites will likely be the most cost-effective method to reduce snake populations for kingfisher conservation efforts. The risk and benefits of this technique to kingfishers must be known.

3.1.1.3.6 Develop methods for accurately quantifying brown treesnake densities in snake-reduced areas

Brown treesnake densities are normally determined using snake traps. However, as snake densities decrease, prey densities increase and reduce the probability that brown treesnakes will enter traps. Low capture rates limit the ability of existing techniques to provide data for obtaining adequately precise population estimates. Therefore, alternative methods of quantifying densities in snake-reduced areas are needed to assess the effectiveness of control efforts.

3.1.1.3.7 Develop and test brown treesnake barrier designs

Current barrier designs are expensive or are impractical for use in some areas of Guam. Research should continue on new barrier designs to improve existing barriers and develop less costly, but effective, designs.

3.1.1.4 Continue to fund research to develop new brown treesnake control techniques

The development of new control measures should continue to assist with conservation efforts on Guam. These control measures include biocontrol, toxicants, and traps.

3.1.2 Control rats if necessary

The impact of rat predation on sihek is unknown at this time. However, as snake populations are reduced, rat populations will increase, and rats may become a significant source of kingfisher egg and nestling mortality.

3.1.2.1 Monitor impact of rat predation on sihek to determine the need for rat control

3.1.2.2 Continue efforts to register an aerial broadcast rodenticide for use on Guam

3.1.3 Assess impact of other sihek predators

Little is known about the impact of other introduced predators on kingfisher populations. The level of mortality associated with monitor lizards, cats, and other potential predators should be assessed and monitored to determine if control efforts are necessary.

3.1.4 Prevent accidental or intentional introduction of new predators to Guam

Efforts should be made to prevent the introduction of other potential kingfisher predators to Guam through effective interdiction measures. This includes developing tough importation laws and increasing other efforts to prevent introduction of alien species.

3.2 Assess the need for black drongo control

Harassment by and competition with the introduced black drongo could affect sihek recovery efforts. If black drongos are found to be a limiting factor, black drongo control measures should be developed and implemented.

3.3 Reduce potential impacts of avian disease on sihek populations

Avian disease was not found to be a factor in the decline of the sihek. However, disease could still affect recovery efforts and should be monitored and controlled. This includes preventing the introduction of exotic diseases and pathogens (*e.g.*, West Nile virus).

3.4 Translocate individuals from north or south subpopulations if necessary

Genetic diversity is maintained through the movement of individuals among subpopulations. To maintain genetic diversity in the two reintroduced sihek subpopulations, at least five individuals should be captured and moved from north to south, and from south to north biannually. These translocations may cease once there is evidence that the birds are naturally dispersing between the two subpopulations.

4. <u>Implement a habitat protection and management program</u>

4.1 <u>Maintain and/or protect reserve habitat on Guam</u>

Some Federal and Government of Guam lands are already designated conservation areas. However, some areas that contain good habitat are not included in these protected areas and may be important to the conservation of the sihek. In addition, the level of protection among conservation areas varies greatly. Adequately protected conservation areas need to be managed for the long-term conservation of the sihek. Some extant conservation areas and other lands also need to be protected and actively managed to assist recovery of the sihek.

4.1.1 <u>Guam National Wildlife Refuge</u>

4.1.1.1 <u>Ritidian Point</u>

This area is owned by the U.S. Fish and Wildlife Service and is currently protected as part of the refuge proper. However, very little management occurs on these lands. Active programs to manage this land for endangered species such as the sihek should be implemented. These types of programs would include fencing and ungulate removal, reforestation, predator control, and other habitat management.

4.1.1.2 <u>Overlay refuge</u>

We manage the Guam National Wildlife Refuge overlay lands but they are owned by the U.S. Navy and U.S. Air Force. Some management is occurring on these lands but more is needed for kingfisher recovery. An active management program involving both the U.S. Fish and Wildlife Service and the Department of Defense is needed.

4.1.2 <u>Government of Guam Conservation Areas</u>

Government of Guam conservation areas include the Anao and Y-Pigua Conservation areas in northern Guam and Cotal and Bolanos Conservation areas in southern Guam.

These lands should be designated as permanent conservation areas, and actively managed for kingfisher recovery with reforestation, ungulate control, and predator control.

4.2 Improve and manage habitat on Guam

4.2.1 Assess suitability of habitat on Guam

The quality of potential sihek habitat needs to be assessed to determine if vegetation management is necessary. The assessment should include feral ungulate damage, availability of important foraging and breeding resources for sihek, invasive non-native vegetation, and other habitat components important to sihek.

4.2.2 Develop a kingfisher habitat management plan

After the suitability of habitat has been assessed, a habitat management plan should be developed to assist private, Government of Guam, and Federal land managers with managing their lands for kingfisher recovery. This management plan should prioritize areas requiring management and provide suggestions for appropriate habitat management techniques. Examples of habitat management techniques include feral ungulate and invasive plant control and reforestation with native plant species.

4.2.3 Implement the kingfisher habitat management plan

Areas identified in the habitat management plan should be managed to improve the quality of habitat for sihek. The management plan could be used by us and other Federal agencies for developing land management agreements with private landowners and the local government.

5. Develop a public awareness program for sihek

Provide information to the general public and lawmakers about Guam's native and endemic species, and their habitats, to create an island-wide conservation ethic and to build alliances for conservation on Guam. Public information and education play an important role in all recovery programs. With public and lawmaker support, the time, costs, and controversy associated with recovery actions would be reduced. This support can even persuade lawmakers to support changes necessary to preserve and protect endangered species and their habitats.

5.1 Fund, support, and promote programs that inform teachers, and that educate students, lawmakers, local public and visitors

Raising the level of awareness on endangered species issues at the community level is key to the success of the recovery of the sihek. Informed teachers will aid in educating the community and lawmakers, and with public backing, will support habitat protection and endangered species recovery.

5.1.1 Fund and support teacher education programs that promote native species conservation

Teachers provide the basis for educating a large segment of the population; therefore educating teachers about endangered species issues should be paramount. Providing teachers with interesting, appropriate and up-to-date teaching materials for classroom use is also an important part of this education program.

5.1.1.1 Institute core curriculum programs at the University of Guam and community colleges that emphasize native species and ecosystem conservation for elementary and high school teacher education programs

5.1.1.2 Develop and distribute educational materials that provide teachers with "student friendly" information about native species and ecosystems

5.1.1.2.1 Work with local teachers to develop lessons on native species and ecosystems for use in the classroom

Effective education programs require the input of educators who will be implementing these programs and understand the needs of their students. Contests or other means of obtaining the ideas and input of local teachers should be pursued.

5.1.1.2.2 Make educational materials easily available

Education materials will not be used if they are not easily available. One method of making materials obtainable and easy to update is to make them available for downloading from a website (see recovery action 5.1.2). Compact disks containing education materials could also be cheaply produced and easy distributed among educators.

5.1.1.2.3 Update and revise materials

Seek feedback and input from educators using the education materials to improve the materials. New materials should also be produced and old lessons updated annually to keep them interesting and fresh. This could be facilitated with the internet (see recovery action 5.1.2) and contests to develop new lessons (see recovery action 5.1.1.2.1).

5.1.2 Create a clearinghouse, such as a website, for information and education materials about Guam's native species

Teachers, students, lawmakers, businesses, conservation groups, and the general public should have the most up-to-date information available to them. This information can be obtained from Federal and territory biologists and the Micronesian Kingfisher Species Survival Plan.

5.1.3 Continue to provide information and promote awareness of the harmful effects of alien species, such as the brown treesnake, to native species and ecosystems

The brown treesnake is believed to be the leading cause of the extinction and endangerment of Guam's native forest birds. However, habitat degradation caused by alien ungulates and weeds, predation by introduced rats, and competition and harassment by black drongos may have also factored into the decline. In addition, new species may be introduced that may impact the recovery of Guam's native species.

5.2 <u>Use a professional marketing agency and business marketing techniques (television, radio, internet, newspaper and magazine articles and advertising) to promote awareness of the uniqueness of Guam's native species and gain local support for endangered species and related conservation issues</u>

Radio, television, contests, and promotions featuring local entertainers, celebrities and heroes to promote public education and awareness of environmental issues and other mass marketing techniques are effective and should be used to increase the public's awareness of native and endangered species and their associated problems.

5.2.1 <u>Conduct market research on the public's knowledge of native species and attitudes towards conservation to provide the information to develop the most direct ways to inform the public and gain support for native species</u>

5.2.2 <u>Promote and fund the development of public service announcements for television and radio about native species and their habitat</u>

5.2.2.1 <u>Assist in the development of public service announcements about native species by providing local television stations with footage of native species with natural sounds and suggest their use as background visuals or sounds during credits for local or other programming</u>

5.2.2.2 <u>Use local "heroes," entertainers, sports figures, or other role models, to promote local pride in native species</u>

5.2.2.3 <u>Promote the use of prize-winning contests with sponsors on local radio, television stations and newspapers to promote native species awareness</u>

Contests might include a native species essay contest or a song writing contest in which the song is used as a theme song for a locally produced nature program (see recovery action 5.2.2.4).

5.2.2.4 Fund weekly or monthly programs in newspapers or on radio or television stations that provide a short informative environmental education story

5.2.3 Promote private business use of native species likenesses, images and names on old and new products and use them in advertising and logos

5.3 Promote the creation of and support for "Friends" groups, partnerships, environmental outreach programs and other support groups to provide support for conservation of the sihek and other species endemic to Guam

Funding and manpower support for environmental education is often in short supply. The establishment of "Friends" groups and partnerships helps to fill the short falls and need by supplying volunteers and funds to maintain these important programs. Many refuges and parks greatly rely on these resources to champion new programs and maintain old ones at little or no cost.

5.3.1 Recruit, train and support volunteer community leaders to organize outreach, native species educational and awareness programs at the community level

5.3.1.1 Support conservation outreach organizations to promote conservation at a "grassroots" level

5.3.1.2 Develop a "mentor" program where natural science professionals provide field opportunities for young people to learn about Guam's native species

5.3.1.3 Support the use of volunteers in projects that will contribute to the enhancement of native habitat and increase the level of awareness and pride in native species within the local populace

5.3.2 Develop and support partnerships with other conservation agencies, local interest groups and private landowners

Protection and rehabilitation of native ecosystems are common goals shared among a wide variety of groups and individuals in the Mariana Islands. Partnering with other groups and individuals to support efforts like reforestation and habitat protection benefits the sihek as well as the coral reef ecosystem and the tourist industry.

IV. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows lists and prioritizes the actions and estimated costs for the recovery of the sihek. It is a guide for meeting the recovery goals outlined in this plan. Recovery actions in the Implementation Schedule have been prioritized in a two-tiered ranking system. First, each action was assigned a "priority number" from 1 (highest priority) to 3 (lowest priority; see definitions below). Second, within each priority number, actions were further subdivided and ranked into "priority tiers" from 1 (highest priority) to 3 (lowest priority). For example, an action with a priority number of 1 and a priority tier of 1 has higher priority than an action with a priority number of 1 and a priority tier of 2. The numbers in the Action Number column correspond to the descriptions of recovery actions in the Narrative Outline of Recovery Actions (p. 40).

Parties with 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 has agreed to implement the action(s) or to 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 sihek. 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:

- **Continuous:** An action that will be implemented on a routine basis once begun for the period of time estimated to recovery (in this case, 50 years).
- **Ongoing:** An action that is currently being implemented and will continue until the time estimated to recovery. 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;
(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 creating two viable, stable subpopulations on Guam, predator control, and management of habitat needed for recovery (see Recovery Criteria section). The majority of the recovery actions in this plan address the brown treesnake threat (factor C), habitat loss (factor A), and limited population growth (factor E). The overutilization of sihek for commercial, recreational, scientific, or educational purposes (factor B) is not a significant threat. Existing regulatory mechanisms (factor D) appear adequate, as the sihek 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 statutory responsibility for implementing this recovery plan. Only Federal agencies are mandated to take part in the effort. However, species recovery will require the involvement of the full range of Federal, territorial, private, and local interests. The expertise and contributions of additional agencies and interested parties will be needed to implement recovery actions and to accomplish education 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:

- **BRD:** United States Geological Survey, Biological Research Division
- **DAWR:** Guam Division of Aquatic and Wildlife Resources
- **GNWR:** Guam National Wildlife Refuge
- **MKRC:** Guam Micronesian Kingfisher Recovery Committee
- **SSP:** American Zoo and Aquarium Association's Species Survival Plan
- **USAF:** United States Air Force
- **USFWS:** United States Fish and Wildlife Service
- **USN:** United States Navy
- **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 for the 50-year period that may be required to fully recover the sihek (Total Costs column).

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
1	1	2.1.1.1	E	Build and maintain kingfisher breeding pens on Guam	Continuous	DAWR	50	10	1	1	10	1	23
1	1	2.1.1.2	E	Complete staffing of Guam facility	20 years	DAWR	120	6	6	6	6	6	30
1	1	2.1.1.3.1	E	Transfer two or three genetically well-represented male siheks to Guam	1 year	SSP*, DAWR	1	1	-	-	-	-	1
1	1	2.1.1.3.2	E	Transfer established breeding pair of sihek to Guam	1 year	SSP*, DAWR	1	1	-	-	-	-	1
1	1	2.1.1.3.3	E	Plan transfers of additional kingfishers to Guam	15 years	SSP*, DAWR	15	1	1	1	1	1	5
1	1	2.1.2.1.1.1	E	Evaluate environmental enrichment and reproductive success	2 years	SSP	10	5	5	-	-	-	10

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
1	1	2.1.2.1.1.2	E	Evaluate climate, photoperiod, and reproductive success	2 years	SSP	10	5	5	-	-	-	10
1	1	2.1.2.1.1.3	E	Evaluate nest logs and reproductive success	2 years	SSP*, DAWR	10	5	5	-	-	-	10
1	1	2.1.2.1.2	E	Assess effects of adult weight on reproductive success	2 years	SSP	10	5	5	-	-	-	10
1	1	2.1.2.1.3	E	Assess effects of age on reproductive success	2 years	SSP	10	5	5	-	-	-	10
1	1	2.1.2.1.4	E	Assess effects of hand-rearing on reproductive success	2 years	SSP	10	5	5	-	-	-	10
1	1	2.1.2.1.5	E	Develop methods to establish pairs	Ongoing; 5 years	SSP*, DAWR	15	3	3	3	3	3	15
1	1	2.1.2.1.6	E	Review artificial incubation techniques	2 years	SSP	10	5	5	-	-	-	10
1	1	2.1.2.1.7	E	Study cannibalism	2 years	SSP	10	5	5	-	-	-	10

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
1	1	2.2.1.8	E	Continue stress hormone research	2 years	SSP	10	5	5	-	-	-	10
1	2	2.1.2.2.1	E	Collect and analyze pathology data	5 years	SSP	10	2	2	2	2	2	10
1	2	2.1.2.2.2	E	Prevent disease in captive population	15 years	SSP	15	1	1	1	1	1	5
1	2	2.1.2.2.3	E	Standardize husbandry techniques . . .	15 years	SSP	15	1	1	1	1	1	5
1	2	3.1.1	C	Control and eradicate brown treesnakes	22 years	WS, DAWR	11,000	500	500	500	500	500	2,500
1	2	3.1.1.3.3	C	Develop methods for controlling or eliminating brown treesnakes inside & outside exclosures	2 years	BRD, WS	40	20	20	-	-	-	40
1	2	3.1.1.3.4	C	Develop “kingfisher safe” acetaminophen bait stations	2 years	WS	20	10	10	-	-	-	20
1	2	3.1.1.3.5	C,E	Determine risk of aerial broadcast . . .	2 years	WS	20	10	10	-	-	-	20

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
1	3	2.2.1.1	E	Review other reintroduction programs	1 year	USFWS, DAWR*	3	3	-	-	-	-	3
1	3	2.2.1.2	E	Develop and test reintroduction methods on collared kingfishers	2 years	USFWS	40	20	20	-	-	-	40
1	3	2.2.2	E	Determine locations of potential release sites on Guam	1 year	USFWS, DAWR*, MKRC	1	1	-	-	-	-	1
1	3	2.2.2.1.1	E	Obtain/construct GIS of Guam landscape/vegetation characteristics	1 year	USFWS	5	5	-	-	-	-	5
1	3	2.2.2.1.2	E	Evaluate suitability of potential reintroduction sites	1 year	USFWS*, BRD	20	20	-	-	-	-	20
1	3	2.2.2.2	E	Assess historical distribution of sihek	1 year	USFWS	1	1	-	-	-	-	1
1	3	2.2.2.3	C	Assess brown treesnake densities	1 year	USFWS*, DAWR, BRD	20	20	-	-	-	-	20

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

							Cost Estimate (in $10,000 units)						
Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
1	3	2.2.2.4	C,E	Assess management potential of release site	1 year	USFWS*, DAWR, WS, MKRC	2	2	-	-	-	-	2
1	3	2.2.3.1	C,E	Complete Pohnpei Micronesian kingfisher mark-relocate and telemetry studies to assess dispersal, movement, and habitat use	1 year	BRD	20	20	-	-	-	-	20
1	3	2.2.4	C,E	Develop a population model	1 year	USFWS	10	10	-	-	-	-	10
1	3	2.2.5	C,E	Determine number of kingfishers needed for successful release	1 year	USFWS, DAWR*	5	5	-	-	-	-	5
1	3	2.2.6	E	Develop reintroduction plan for sihek	1 year	USFWS, DAWR*	5	-	-	-	-	5	5

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Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
1	3	2.2.7.1	C,E	Reintroduce sihek to northern Guam	10 years	USFWS, DAWR*	200	-	-	-	-	20	20
1	3	2.2.8.1	A,C,E	Gather data on post-release survival of kingfishers	4 years	USFWS, DAWR*	40	-	-	-	-	10	10
1	3	3.1.1.1	C	Delineate snake-threshold densities using surrogate native species	4 years	USFWS*, BRD	100	30	30	20	20	-	100
1	3	3.1.1.2	C	Refine snake-threshold density estimates for sihek	4 years	USFWS, BRD*	40	-	-	-	-	10	10
2	1	3.1.1.3.1	C	Develop effective artificial attractants	2 years	BRD, WS*	20	10	10	-	-	-	20
2	1	3.1.1.3.2	C	Improve trap designs to increase snake capture rate	2 years	BRD*, WS	20	10	10	-	-	-	20
2	1	3.1.1.3.6	C	Develop methods for quantifying brown treesnake densities in snake-reduced areas	2 years	BRD	40	20	20	-	-	-	40

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							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
2	1	3.1.1.3.7	C	Develop and test snake barrier designs	3 years	BRD	30	10	10	10	-	-	30
2	1	3.1.1.4	C	Continue to fund research to develop new control techniques	10 years	USFWS*, USAF, USN	100	10	10	10	10	10	50
2	1	3.3	C	Reduce potential impacts of avian disease on sihek populations	Continuous	USFWS*, DAWR, WS	50	1	1	1	1	1	5
2	2	2.2.3.2	C,E	Expand mark-relocate and telemetry studies to reintroduced sihek	4 years, minimum	USFWS*, DAWR	40	-	-	-	-	10	10
2	2	2.2.7.2	C,E	Reintroduce kingfishers to establish a subpopulation in southern Guam	Unknown	USFWS, DAWR*	200	-	-	-	-	-	0
2	2	2.2.8.2.2	A,B,C, D,E	Develop efficient survey methods	1 year	USFWS, DAWR*	10	-	-	-	-	10	10

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
2	2	2.3	E	Monitor need for backup populations	5 years	USFWS*, MKRC	5	-	-	-	-	1	1
2	3	2.2.8.2.1	A,B,C, D,E	Update population model (see 2.2.4) with results from sihek reintroduction	4 years	USFWS*, DAWR	40	-	-	-	-	10	10
2	3	3.1.2.1	C	Monitor impact of rat predation on sihek to determine the need for rat control	2 years, minimum	USFWS, DAWR*	20	-	-	-	-	10	10
2	3	3.1.2.2	C	Continue efforts to register an aerial broadcast rodenticide	2 years	USFWS*, DAWR	20	10	10	-	-	-	20
2	3	3.1.3	C	Assess impact of other sihek predators	2 years, minimum	USFWS, DAWR*	20	-	-	-	-	10	10
2	3	3.1.4	C	Prevent accidental or intentional introduction of new avian predators to Guam	Continuous	USFWS, WS	50	1	1	1	1	1	5

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Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
2	3	3.2	E	Assess the need for black drongo control	2 years, minimum	USFWS, DAWR*	20	-	-	-	-	10	10
2	3	4.1.1	A	Manage Guam National Wildlife Refuge fee simple and overlay lands	10 years	USFWS*, USAF, USN	500	50	50	50	50	50	250
2	3	4.1.2	A	Manage and protect Government of Guam Conservation Areas	10 years	DAWR	500	50	50	50	50	50	250
3	1	1.1	NA	Maintain an active Recovery Committee	Ongoing	USFWS	50	1	1	1	1	1	5
3	1	1.1.1	NA	Coordinate recovery actions with other conservation efforts	Ongoing	USFWS	50	1	1	1	1	1	5
3	1	1.1.2	NA	Develop 5-year recovery milestones	Continuous, as needed	USFWS*, MKRC	10	1	-	-	-	-	1
3	1	1.1.3.1	NA	Review recovery efforts annually	Continuous	USFWS*, MKRC	50	1	1	1	1	1	5
3	1	1.1.3.2	NA	Update and revise recovery plan	Ongoing, as needed	USFWS	10	-	-	-	-	1	1

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Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
							Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
3	1	1.2	NA	Develop recovery subcommittees	1 year	USFWS	1	1	-	-	-	-	1
3	1	1.3	NA	Monitor recovery efforts	Ongoing	USFWS	50	1	1	1	1	1	5
3	1	4.2.1	A	Assess suitability of kingfisher habitat on Guam	2 years	USFWS*, USAF, USN, DAWR	40	20	20	-	-	-	40
3	1	4.2.2	A	Develop kingfisher habitat management plan	1 year	USFWS*, USAF, USN, DAWR	5	-	-	5	-	-	5
3	1	4.2.3	A	Implement kingfisher habitat management plan	20 years	USFWS, USAF, USN, DAWR	400	-	-	-	20	20	40
3	1	5.1.1.1	A,B,C, D,E	Institute core curriculum programs . . . for elementary & high school teacher ed. programs	10 years	USFWS*, DAWR	50	5	5	5	5	5	25

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

							Cost Estimate (in $10,000 units)						
Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
3	1	5.1.1.2.1	A,B,C, D,E	Work with local teachers to develop lessons on native species and ecosystems	Unknown	USFWS*, DAWR	50	5	-	-	-	-	5
3	1	5.1.1.2.2	A,B,C, D,E	Make educational materials easily available	Unknown; as needed	USFWS*, DAWR	25	1	-	1	-	1	3
3	1	5.1.1.2.3	A,B,C, D,E	Update and revise materials	Unknown; as needed	USFWS*, DAWR	50	5	-	-	-	-	5
3	1	5.1.2	A,B,C, D,E	Create a clearinghouse for information and education materials about Guam's native species	10 years	USFWS*, DAWR	10	1	1	1	1	1	5
3	1	5.1.3	A,B,C, D,E	Continue to provide information and promote awareness of the harmful effects of alien species . . .	Continuous	USFWS*, DAWR	50	1	1	1	1	1	5

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

							Cost Estimate (in $10,000 units)						
Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
3	1	5.2.1	A,B,C, D,E	Conduct market research on the public's knowledge of native species . . .	1 year	USFWS*, DAWR	10	10	-	-	-	-	10
3	1	5.2.2.1	A,B,C, D,E	Assist in the development of public service announcements . . .	Continuous; every 2 years	USFWS*, DAWR	125	5	-	5	-	5	15
3	1	5.2.2.2	A,B,C, D,E	Use local "heroes," entertainers, sports figures, or other role models, to promote local pride in native species	20 years	USFWS*, DAWR	20	1	1	1	1	1	5
3	1	5.2.2.3	A,B,C, D,E	Promote the use of prize-winning contests . . . to promote native species awareness	20 years	USFWS*, DAWR	20	1	1	1	1	1	5
3	1	5.2.2.4	A,B,C, D,E	Fund weekly or monthly media programs . . .	Continuous	USFWS*, DAWR	150	3	3	3	3	3	15

Implementation Schedule for the Draft Revised Recovery Plan for the Guam Micronesian Kingfisher

Priority Number	Priority Tier	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units) Total Costs	FY 04	FY 05	FY 06	FY 07	FY 08	5-Year Costs
3	1	5.2.3	A,B,C, D,E	Promote private business use of native species likenesses, images and names . . .	20 years	USFWS*, DAWR	20	1	1	1	1	1	5
3	1	5.3.1.1	A,B,C, D,E	Support conservation outreach organizations to promote conservation at a "grassroots" level	20 years	USFWS*, DAWR	20	1	1	1	1	1	5
3	1	5.3.1.2	A,B,C, D,E	Develop a "mentor" program . . .	10 years	USFWS*, DAWR	50	5	5	5	5	5	25
3	1	5.3.1.3	A,B,C, D,E	Support the use of volunteers . . .	Continuous	USFWS*, DAWR	50	1	1	1	1	1	5
3	1	5.3.2	A,B,C, D,E	Develop and support partnerships	20 years	USFWS*, DAWR	20	1	1	1	1	1	5
						TOTALS	14,995						4,039

V. REFERENCES

A. Literature Cited

Aguon, C. F., E. W. Campbell, III, and J. M. Morton. 2002. The efficacy of electrical barriers used to protect Mariana crow nests. Wildlife Society Bulletin 30:703-708.

Anderson, R. D. 1981. Impact of environmental contaminants on native forest bird populations. Pages 177-178, *in* Job Progress Report. Guam Division of Aquatic and Wildlife Resources Annual Report 1981. Mangilao, Guam.

Atkinson, I. A. E. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. Pages 35-81 *in* Conservation of Island Birds (P. J. Moors, editor). Tech\nical Publication No. 3, International Council for Bird Preservation, Cambridge, England.

Bahner, E. L. 1988. 1987 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1989. 1988 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1990. 1989 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1991. 1990 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1992. 1991 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1993. Micronesian kingfisher masterplan (1993) and 1992 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1994. 1993 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1995. 1994 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1996. 1995 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1998. 1996-1997 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 1999. 1999 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E. L. 2001. 2001 North American Regional Studbook for the Micronesian kingfisher. Zoological Society of Philadelphia. Philadelphia, Pennsylvania.

Bahner, E.L., and C. Lynch. 2003. Micronesian Kingfisher Species Survival Plan Complete Analysis and Breeding Plan, 16 December 2003. American Zoo and Aquarium Association Population Management Center, Chicago, Illinois. 22 pp.

Bahner, E. L., A. Baltz, and E. Diebold. 1998. Micronesian Kingfisher Species Survival Plan Husbandry Manual, First Edition. Zoological Society of Philadelphia, Philadelphia. 54 pp.

Baker, R. H. 1946. Some effects of the war on the wildlife of Micronesia. Transactions of the 11th North American Wildlife Conference 11:205-213.

Baker, R. H. 1948. Report on collections of birds made by United States Naval Medical Research Unit No. 2 in the Pacific War area. Smithsonian Miscellaneous Collections 107:1-74.

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

Baltz, A. P. 1998. The assessment of reproductive potential in Micronesian kingfisher pairs. Zoo Biology 17:425-432.

Bohart, R. M. 1956. Insects of Micronesia. Diptera: Culicidae. Voume 12. Bernice P. Bishop Museum, Honolulu, Hawaii. 85 pp.

Buden, D. W. 2000. A comparison of 1983 and 1994 bird surveys of Pohnpei, Federated States of Micronesia. Wilson Bulletin 112:403-410.

[CDC] Centers for Disease Control and Prevention. 2003. Website of the Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, available online at <http://www.cdc.gov>.

Churcher, P. B., and J. H. Lawton. 1987. Predation by domestic cat in an English village. Journal of Zoology 212:439-456.

Conry, P. J. 1988a. High nest predation by brown tree snakes on Guam. Condor 90:478-82.

Conry, P. J. 1988b. Management of feral and exotic game species on Guam. Transactions of the Western Section of the Wildlife Society 24:26-30.

Dobson, A. P., and Altizer, S. 2001. Pathogens and the conservation of island biota: modeling the biological control of invasive brown treesnakes on Guam (Cooperative Agreement No. 99HQA60024). Report submitted to the U.S. Geological Survey National Wildlife Health Center, Madison, Wisconsin.

Drahos, N. 1975. Habitat appraisal and study of exotics for Guam. Pages 77-84, *in* Job Progress Report. Guam DAWR Annual Report 1975. Mangilao, Guam.

Drahos, N. 1977. Population dynamics of Guam birds. Unpublished Report, Division of Aquatic and Wildlife Resources, Department of Agriculture, Government of Guam. 236 pp.

Drahos, N. 2002. The mysteries and histories of Guam's birds. Published by the Author, Aurora, New York. 569 pp.

Eldredge, L. G. 1983. Summary of environmental and fishing information on Guam and the Commonwealth of the Northern Mariana Islands: historical background, description of the islands, and review of the climate, oceanography, and submarine topography. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Center. 181 pp.

Engbring, J. 1992. A 1991 survey of the forest birds of the Republic of Palau. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 81 pp.

Engbring, J. and F. L. Ramsey. 1984. Distribution and abundance of the forest birds of Guam: results of a 1981 survey. U.S. Fish and Wildlife Service, FWS/OBS-84/20. 54 pp.

Engbring, J., F. L. Ramsey, and V. J. Wildman. 1986. Micronesian forest bird survey, 1982: Saipan, Tinian, Agiguan, and Rota. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 143 pp.

Engbring, J., F. L. Ramsey, and V. J. Wildman. 1990. Micronesian forest bird surveys, the federated states: Pohnpei, Kosrae, Chuuk, and Yap. U.S. Fish and Wildlife Service, Honolulu, Hawaii. 312 pp.

Fosberg, F. R. 1960. The vegetation of Micronesia. Bulletin of the American Museum of Natural History 119:4-75.

Fowler, G. S. and P. McGill. 2002. Hormonal correlates of reproduction and failure to reproduce in Guam Kingfishers. Paper presented at the 120th Meeting of the American Ornithologists' Union, New Orleans, Louisiana.

Fritts, T. H. and M. J. McCoid. 1991. Predation by the brown tree snake on poultry and other domesticated animals in Guam. The Snake 23:75-80.

Fritts, T. H. and G. H. Rodda. 1998. The role of introduced species in the degradation of island ecosystems: a case history of Guam. Annuual Review of Ecology and Systematics 29:113-140.

Fry, C. H., K. Fry, and A. Harris. 1992. Kingfishers, bee-eaters and rollers. Princeton University Press, Princeton, New Jersey. 324 pp.

Grue, C. E. 1985. Pesticides and the decline of Guam's native birds. Nature 316:301.

Griffin, B., J. M. Scott, J. W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477-480.

Haddock, R. L., R. A. Mackie, and K. Cruz. 1979. Dengue control in Guam. South Pacific Bulletin 2:16-24.

Haig, S. M., and J. D. Ballou. 1995. Genetic diversity in two avian species formerly endemic to Guam. Auk 112:445-455.

Haig, S. M., J. D. Ballou, and N. J. Casna. 1995. Genetic identification of kin in Micronesian kingfishers. Journal of Heredity 86:423-431.

Hutchins, M., C. Shepard, A. M. Lyles, and G. Casadei. 1995. Behavioral considerations in the captive management, propagation, and reintroduction of endangered birds. Pages 263-289 *in* Conservation of endangered species in captivity (E. F. Gibbons, Jr., B. S. Durrant, and J. Demarest, editors). State University of New York Press, Albany, New York.

Hutchins, M., E. Paul, and E. Bahner. 1996. AZA Micronesian Kingfisher Species Survival Plan Action Plan. American Zoo and Aquarium Association. Bethesda, Maryland. 31 pp.

Jenkins, J. M. 1983. The native forest birds of Guam. Ornithological Monographs 31. 61 pp.

Johnston, J. J., P. J. Savarie, T. M. Primus, J. D. Eisemann, J. C. Hurley, and D. J. Kohler. 2002. Risk Assessment of an acetaminophen baiting program for chemical control of brown tree snakes on Guam: evaluation of baits, snake residues, and potential primary and secondary hazards. Environmental Science and Technology 36:38277-3833.

Junge, R. E. 1998. Medical management and care of Micronesian kingfishers. Pages 30-40 *in* Micronesian Kingfisher Species Survival Plan Husbandry Manual (E. Bahner, A. Baltz, and E. Diebold, editors). Zoological Society of Philadelphia, Philadelphia, Pennsylvania.

Kepler, A.K. 1972. A comparative study of todies (Aves, Todidae), with emphasis on the Puerto Rican Tody, *Todus mexicanus*. Ph.D. dissertation, Cornell University, Ithaca, New York. 485 pp.

Kesler, D. C. 2002. Nest site selection in cooperatively breeding Pohnpei Micronesian kingfishers: does nest-site abundance limit reproductive opportunities? M.S. thesis, Oregon State University, Corvallis, Oregon. 86 pp.

Kesler, D.C., and S.M. Haig. In press. Thermal characteristics of wild and captive Micronesian kingfisher nesting habitats. Zoo Biology.

Kibler, L. F. 1950. Notes on the birds of Guam. Auk 67:400-403.

Kuehler, C., and J. Good. 1990. Artificial incubation of bird eggs at the Zoological Society of San Diego. International Zoo Yearbook 23:188-196.

Maben, A. F. 1980. Development of a study to determine the past and present impact of pesticides on Guam's wildlife population. Pages 326-329 *in* Job Progress Report. Guam Division of Aquatic and Wildlife Resources Annual Report 1980. Mangilao, Guam.

Maben, A. F. 1982. The feeding ecology of the black drongo (*Dicrurus macrocercus*) on Guam. M.S. thesis. California State University, Long Beach; Long Beach, California. 87 pp.

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

Marshall, S. D. 1989. Nest sites of the Micronesian Kingfisher on Guam. Wilson Bulletin 101:472-477.

Marzluff, J. M., and R. P. Balda. 1988. Pairing patterns and fitness in a free-ranging population of pinyon jays: what do they reveal about mate choice. Condor 90:201-213.

McCoid, M. J. 1997. Interactions of *Carlia* cf. *fusca* (Scincidae) with the herpetofauna of Guam. M.S. thesis, Texas A&M University, Kingsville; Kingsville, Texas.

Mueller-Dombois, D. and F. R. Fosberg. 1998. Vegetation of the tropical pacific islands. Ecological Studies, Volume 132. Springer-Verlag, New York, New York. 733 pp.

Myers, S. A., J. R. Millam, T. E. Roudybush, and C. R. Grau. 1988. Reproductive success of hand-reared vs. parent-reared cockatiels (*Nymphicus hollandicus*). Auk 105:536-542.

Nichols, D. K. 2000. Project title: Pathogenesis of *Ophidian paramyxovirus* infection in the Brown Tree Snake (*Boiga irregularis*). Final report for the Office of Insular Affairs, Department of the Interior, September 30, 2000. Unpublished report submitted to the U.S. Department of the Interior Office of Insular Affairs, Washington, D.C.

Perry, G., G. H. Rodda, T. H. Fritts, and M. W. Doles. 1996. Experimental research on snake control conducted using Legacy funding - a preliminary report on barrier technology and related work. Unpublished report prepared for Ohio State University, Columbus, Ohio.

Perry, G., E. W. Campbell, III, G. H. Rodda, and T. H. Fritts. 1998. Managing island biotas: Brown Treesnake control using barrier technology. Pages 138-143 *in* Proceedings of the 18th Vertebrate Pest Conference (R. O. Baker and A. C. Crabb, editors). University of California, Davis; Davis, California.

Perry, G., Rodda, G. H., Fritts, T. H., and Qualls, F. J. 2001. Snake control using barrier technology: a final report on studies to develop temporary and permanent barriers for blocking movement of Brown Treesnakes (*Boiga irregularis*). Unpublished report submitted to the U.S. Department of the Interior, Washington, D.C.

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

Rodda, G. H., T. H. Fritts, and P. J. Conry. 1992. Origin and population growth of the brown tree snake, *Boiga irregularis*, on Guam. Pacific Science 46:46-57.

Rodda, G. H., T. H. Fritts, M. J. McCoid, and E. W. Campbell, III. 1999a. The feasibility of controlling the brown treesnake in small plots. Pages 468-477 *in* Problem snake management: the habu and the brown treesnake (G. H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka, editors). Cornell University Press, Ithaca, New York. 534 pp.

Rodda, G. H., M. J. McCoid, T. H. Fritts, and E. W. Campbell III. 1999b. Population trends and limiting factors in *Boiga irregularis*. Pages 236-253 *in* Problem snake management: the habu and the brown treesnake (G. H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka, editors). Cornell University Press, Ithaca, New York. 534 pp.

Rodda, G. H., Y. Sawai, D. Chiszar, and H. Tanaka. 1999c. Problem snake management: the habu and the brown treesnake. Cornell University Press, Ithaca, New York. 534 pp.

Savage, H. M., C. J. Mitchell, M. Roppul, L. T. Castro, R. L. Kepple, and S. P. Flood. 1993. Mosquito faunal survey of Saipan, Mariana Islands (Diptera: Culicidae): taxonomy and larval ecology. Mosquito Systematics 25:17-24.

Savarie, P. J., and R. L. Bruggers. 1999. Candidate repellents, oral and dermal toxicants, and fumigants for brown treesnake control. Pages 417-422, *in* Problem snake management: the habu and the brown treesnake (G. H. Rodda, Y. Sawai, D. Chiszar, and H. Tanaka, editors). Cornell University Press, Ithaca, New York. 534 pp.

Savarie, P. J., D. L. York, J. C. Hurley, S. Volz, and J. E. Brooks. 2000. Testing the dermal and oral toxicity of selected chemicals to Brown Treesnakes. Pages 139-145 *in* Volume 19, Proceedings of the 19th Vertebrate Pest Conference (T. P. Salmon and A. C. Crabb, editors). University of California, Davis; Davis, California.

Savarie, P. J., J. A. Shivik, G. C. White, J. C. Hurley, and L. Clark. 2001. Use of acetaminophen for large scale control of Brown Treesnakes. Journal of Wildlife Management 65:356-365.

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

Savidge, J. A. 1988. Food habits of *Boiga irregularis*, an introduced predator on Guam. Journal of Herpetology 22:275-282.

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

Seale, A. 1901. Report of a mission to Guam. Honolulu: Occasional papers of the Bernice P. Bishop Museum 1:17-128.

Shivik, J. A., P. J. Savarie, and L. Clark. 2002. Aerial delivery of baits to brown treesnakes. Wildlife Society Bulletin 30:1062-1067.

Silva-Krott, I., M. K. Brock, and R. E. Junge. 1998. Determination of the presence of *Mycobacterium avium* on Guam as precursor to reintroduction of indigenous bird species. Pacific Conservation Biology 4:227-231.

Stacey, P. B., and W. D. Koenig. 1990. Cooperative breeding in birds. Cambridge University Press, Cambridge, Great Britain.

Stone, B. C. 1970. The flora of Guam. Micronesica 6:1-659.

Stophlet, J. J. 1946. Birds of Guam. Auk 63:534-541.

Swezey, O. H. 1942. Insects of Guam – 1. Culicidae of Guam. Bernice P. Bishop Museum Bulletin 172:199-200.

Tubb, H. A. 1966. Notes on birds of Guam. Natural History Bulletin of the Siam Society 21:135-138.

U.S. Census Bureau. 2003. Website of the U.S. Census Bureau, available online at <http://www.census.gov>.

[USFWS] U.S. Fish and Wildlife Service. 1983a. Endangered and threatened species listing and recovery priority guidance. Federal Register 48:43098-43105.

[USFWS] U.S. Fish and Wildlife Service. 1983b. Endangered and threatened species listing and recovery priority guidelines correction. Federal Register 48:51985

[USFWS] U.S. Fish and Wildlife Service. 1984. Endangered and threatened wildlife and plants; Determination of endangered species status for seven birds and two bats of Guam and the Northern Mariana Islands. Federal Register 49:33881-33885.

[USFWS] U.S. Fish and Wildlife Service. 1990. Native forest birds of Guam and Rota of the Commonwealth of the Northern Mariana Islands Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 86pp.

[USFWS] U.S. Fish and Wildlife Service. 2002. Endangered and threatened wildlife and plants; Determinations of prudency for two mammal and four bird species in Guam and the Commonwealth of the Northern Mariana Islands and proposed designations of critical habitat for one mammal and two bird species; proposed rule. Federal Register 67:63738-63772.

U. S. Navy. 2001. COMNAVMARIANAS final integrated natural resources management plan for Navy lands, Guam. U.S. Department of the Navy, Pacific Division, Naval Facilities Engineering Command, Pearl Harbor, Hawaii.

Van Riper, C., III, S. G. Van Riper, M. L. Goff, and M. Laird. 1986. The epizootiology and ecological significance of malaria in Hawaiian land birds. Ecological Monographs 56:327-344.

Warner, R. E. 1968. The role of introduced diseases in the extinction of the endemic Hawaiian avifauna. Condor 70:101-120.

Wiles, G. J., C. F. Aguon, G. W. Davis, and D. J. Grout. 1995. The status and distribution of endangered animals and plants in northern Guam. Micronesica 28:31-49.

Wiles, G. J., I. H. Schreiner, D. Nafus, L. K. Jurgensen, and J. C. Manglona. 1996. The status, biology, and conservation of *Serianthes nelsonii* (Fabaceae), an endangered Micronesian tree. Biological Conservation 76:229-239.

Wiles, G.J., J. Bart, R.E. Beck, Jr., and C.F. Aguon. 2003. Impacts of the brown tree snake: patterns of decline and species persistence in Guam's avifauna. Conservation Biology 17:1350-1360.

Yamamoto, J. T., K. M. Shields, J. R. Millam, T. E. Roudybush, and C. R. Grau. 1989. Reproductive activity of force-paired cockatiels (*Nymphicus hollandicus*). Auk 106:86-93.

B. Personal Communications and Other References

Bahner, Elizabeth L. 2001, 2002, 2003. Philadelphia Zoo, Philadelphia, Pennsylvania. Personal communication.

Beck, Robert E., Jr. 1985. Guam Division of Aquatic and Wildlife Resources, Mangilao, Guam. Unpublished data.

Haig, Susan. 2001, 2002. U.S. Geological Survey, Oregon State University, Corvallis, Oregon. Personal communication.

Junge, Randy. 2002. Saint Louis Zoo, Saint Louis, Missouri. Personal communication.

Kesler, Dylan. 2002, 2003, 2004. Oregon State University, Corvallis, Oregon. Personal communication.

Kesler, Dylan., and Susan Haig. 2004. Oregon State University, Corvallis, Oregon and U.S. Geological Survey, Oregon State University, Corvallis, Oregon. Manuscript in preparation.

Knutson, Kelly, and Scott Vogt. 2003. U.S. Air Force, Anderson Air Force Base, Guam and U.S. Navy, Pearl Harbor, Hawaii. Unpublished manuscript.

Marshall, Joe T., Jr., and Robert E. Beck, Jr. 1985. New York Zoological Society, Bronx, New York and Guam Division of Aquatic and Wildlife Resources, Mangilao, Guam. Unpublished data.

Qualls, Fiona, and Carl Qualls. 2001. U.S. Geological Survey, Colorado State University, Fort Collins, Colorado. Personal communication.

Vice, Diane. 2002. Guam Division of Aquatic and Wildlife Resources, Mangilao, Guam. Personal communication.

Vogt, Scott. 2003. U.S. Navy, Pearl Harbor, Hawaii. Personal communication.

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

allele	Alternative forms of a gene that code for the same trait. Alleles usually occur in pairs, one at the same genetic locus on each of a pair of chromosomes. For example, in humans there are multiple alleles for blood type: O, A and B. If both of the alleles on each chromosome carry the same allele (*e.g.*, AA), the individual is said to be *homozygous* at that locus. If the alleles are different (*e.g.*, AB), the individual is *heterozygous*.
arboreal	Living or placed in trees; adapted for life in trees.
avifauna	The bird life or bird community of an area.
coverts	The small feathers on top of the wings (wing coverts), over the tail feathers (upper tail coverts), or under the tail (undertail coverts, or crissum).
effective population size	The functional size of a population, from a genetic perspective, based on the number of breeding individuals (often abbreviated N_e). The effective population size is generally smaller than the census population size (*i.e.*, there may be numerous individuals in the total population that are not contributing genes to future generations, such as juveniles or senescent adults).
heterozygosity	A measure of the degree of genetic diversity in a population, as measured by the proportion of heterozygous loci across individuals (see *allele*, above).

inbreeding coefficient (F)	The probability that two alleles at a genetic locus are identical by descent from a common ancestor to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in the observed heterozygosity relative to the expected heterozygosity of a founder population.
interspecific	Between different species; between individuals or populations of different species.
intraspecific	Within a species; between individuals or populations of the same species.
mitochondrial DNA	The mitochondria are organelles responsible for energy production within the cells. DNA is found in the mitochondria in addition to the DNA within the cell nucleus, but unlike nuclear DNA, mitochondrial DNA is inherited only through the mother. The high levels of variability in mitochondrial DNA and uniquely maternal inheritance are two of the characteristics that make analysis of mitochondrial DNA a common tool for investigating factors such as the degree of divergence between lineages.
N_e	see *effective population size*, above.
snout-vent length (SVL)	A standard measurement of body length for reptiles. The measurement is from the tip of the nose (snout) to the opening of the cloaca (vent), and excludes the tail.
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).