U.S. Fish & Wildlife Service

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

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

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

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

Date: 10/3/08

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

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Guam Micronesian Kingfisher Recovery Committee

Fred Amidon, U.S. Fish and Wildlife Service

Beth Bahner, Philadelphia Zoo

Aliza Baltz, Philadelphia Zoo

Anne Brooke, U.S. Navy

Tina De Cruz, formerly of Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife

Scott Derrickson, Conservation and Research Center, National Zoological Park

Joanne Earnhardt, Lincoln Park Zoo

Sue Haig, U.S. Geological Survey, Biological Resources Discipline

Dylan Kesler, University of Missouri

Mike McElligot, U.S. Air Force

Suzanne Medina, Guam Division of Aquatic and Wildlife Resources

Paul Radley, Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife

Gordon Rodda, U.S. Geological Survey, Biological Resources Discipline

Dan Vice, U.S. Department of Agriculture, Wildlife Services

Jonathan Wald, U.S. Air Force

Jeffrey Walters, Virginia Polytechnic Institute and State University

Robert Wescom, U.S. Navy

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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 (U.S. 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 May 2008 the population consisted of 60 males, 36 females, and 4 unsexed chicks distributed among 17 captive propagation institutions in the mainland United States and Guam. The sihek has a recovery priority number of 6 on a scale of 1 (highest) to 18 (lowest), reflecting a high degree of threat, relatively low 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 sihek reproductive activities. The sihek is a cavity nester and apparently requires large, standing dead trees (nest trees were reported as averaging 43 centimeters (17 inches) in diameter) in which to excavate 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 components of suitable habitat.

Habitat degradation and loss, human persecution, contaminants, and introduced species such as disease organisms, cats (*Felis catus*), 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 were not considered a major threat due to the availability of suitable forest on Guam. However, this threat is increasing and may limit recovery 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 and 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 the sihek into the wild on Guam. Establishing a captive breeding program on Guam may alleviate some of the problems that have been encountered with efforts to increase the captive population in the continental United States. At the same time, the ongoing efforts to increase reproductive success and decrease mortality in the captive population in the continental United States must also continue. Controlling brown treesnakes includes development of new control techniques and implementation and testing of existing techniques in the field. Required habitat protection and enhancement include: protecting sufficient areas from development; controlling ungulates, weeds, and fires; and replanting native plants in degraded areas, as needed. Reintroducing the sihek to Guam is essential to the recovery of the species, and will require developing appropriate techniques, selecting and managing suitable release sites, and releasing sihek to the wild. Recovery will require the establishment of at least two subpopulations of sihek 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 sihek 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 population growth rate (λ, or lambda) of greater 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 population growth rate (λ, or lambda) of greater 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.

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 continuing to establish a captive propagation program for the subspecies on Guam (Recovery Action 2.2), increasing reproductive success of the captive population, and decreasing juvenile and adult mortality in the captive population (Recovery Action 2.3). Once the captive population is of a sufficient size (Recovery Action 2.1) 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 3.1 – 3.8).

(3) Manage factors affecting population viability;

Extensive predator control efforts are needed, especially brown treesnake control (Recovery Action 4.1). Once sihek have been reestablished in the wild, monitoring for additional threats to the subspecies (Recovery Action 4.2-4.6) 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 $145,830,000 over an estimated 50-year period that may be required to recover sihek. Approximately $39,200,000 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 $132,550,000 of the total cost is expected to contribute to the recovery of the threatened Mariana fruit bat or fanihi (*Pteropus mariannus mariannus*) and the endangered 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: $2,950,000+
b. 5 Years: $580,000+

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.

a. 50 Years: $133,430,000+
b. 5 Years: $36,830,000+

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

a. 50 Years: $9,450,000+
b. 5 Years: $1,790,000+

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* [also referred to as *Todiramphus cinnamominus cinnamominus*]), 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 under the Endangered Species Act (16 United States Code [USC] 1531 *et seq*.) (U.S. 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 94 individuals in 16 zoological institutions in the continental United States and 6 individuals at the Guam Division of Aquatic and Wildlife Resources facility on Guam (B. Bahner, pers. comm. 2008). Predation by the introduced brown treesnake (*Boiga irregularis*) appears to have been the principal cause of the wild population's decline and extirpation (Savidge 1987). Other factors that may have hastened the decline include habitat degradation and loss, competition with the introduced black drongo (*Dicrurus macrocercus*), pesticides, and avian disease. Factors that continue to limit the recovery of the species include difficulties with 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 6 on a scale of 1 (highest) to 18 (lowest; see Appendix A). This priority ranking reflects that the prospects for recovery are relatively low, the degree of threats 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 upward to priority 5.

The sihek has been federally listed as an endangered species since 1984 (USFWS 1984). A recovery plan for the sihek, which also addressed the 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 recovery plan serves as a revision of the 1990 recovery plan for the sihek. A revised recovery plan is currently being prepared for the Mariana crow. The Guam broadbill was removed from the federal list of threatened and endangered species due to extinction on February 23, 2004 (USFWS 2004a). The Guam bridled white-eye is also presumed to be extinct.

B. Guam

Guam is the largest and southernmost island in the Mariana archipelago (Figure 1). Guam is approximately 49 kilometers (30 miles) long and 7 to 15 kilometers (4 to 9 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 to 15 centimeters (3 to 6 inches) per month.

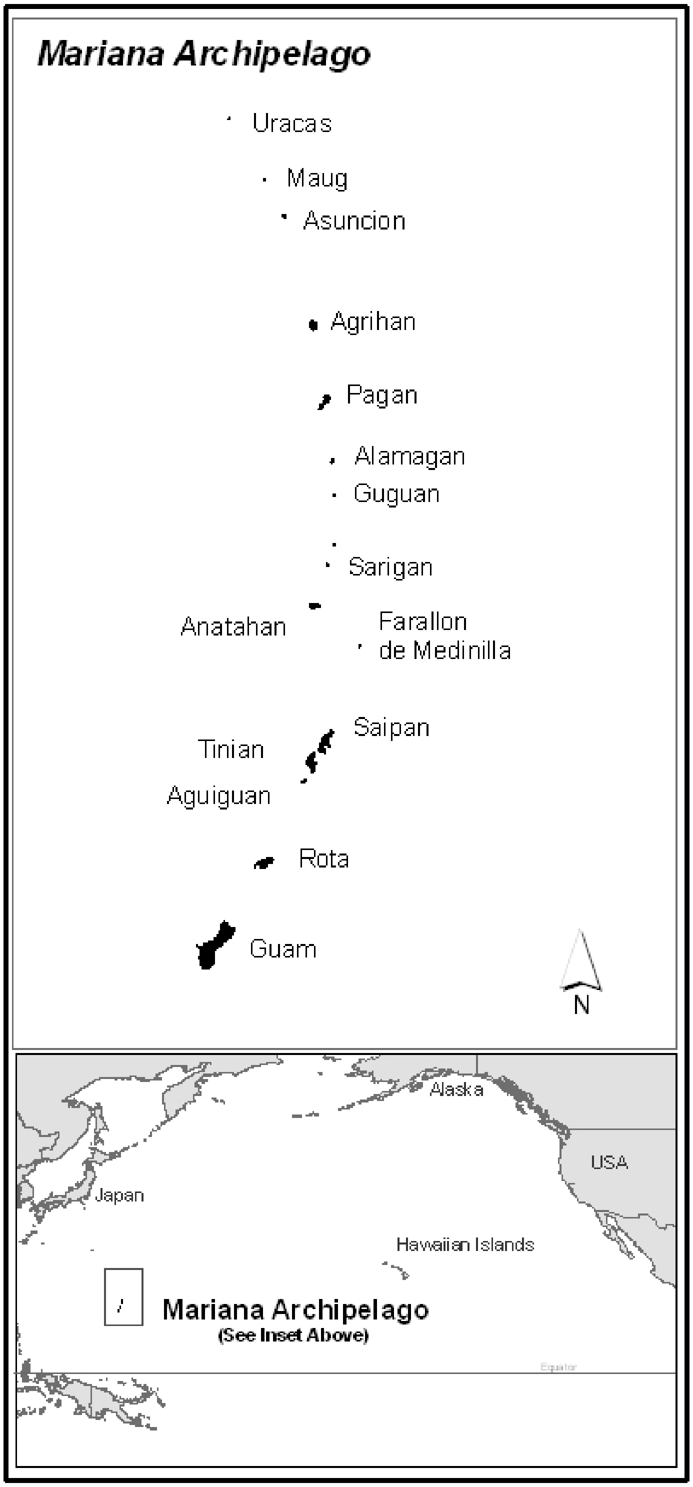

Figure 1. Location and composition of the Mariana archipelago.

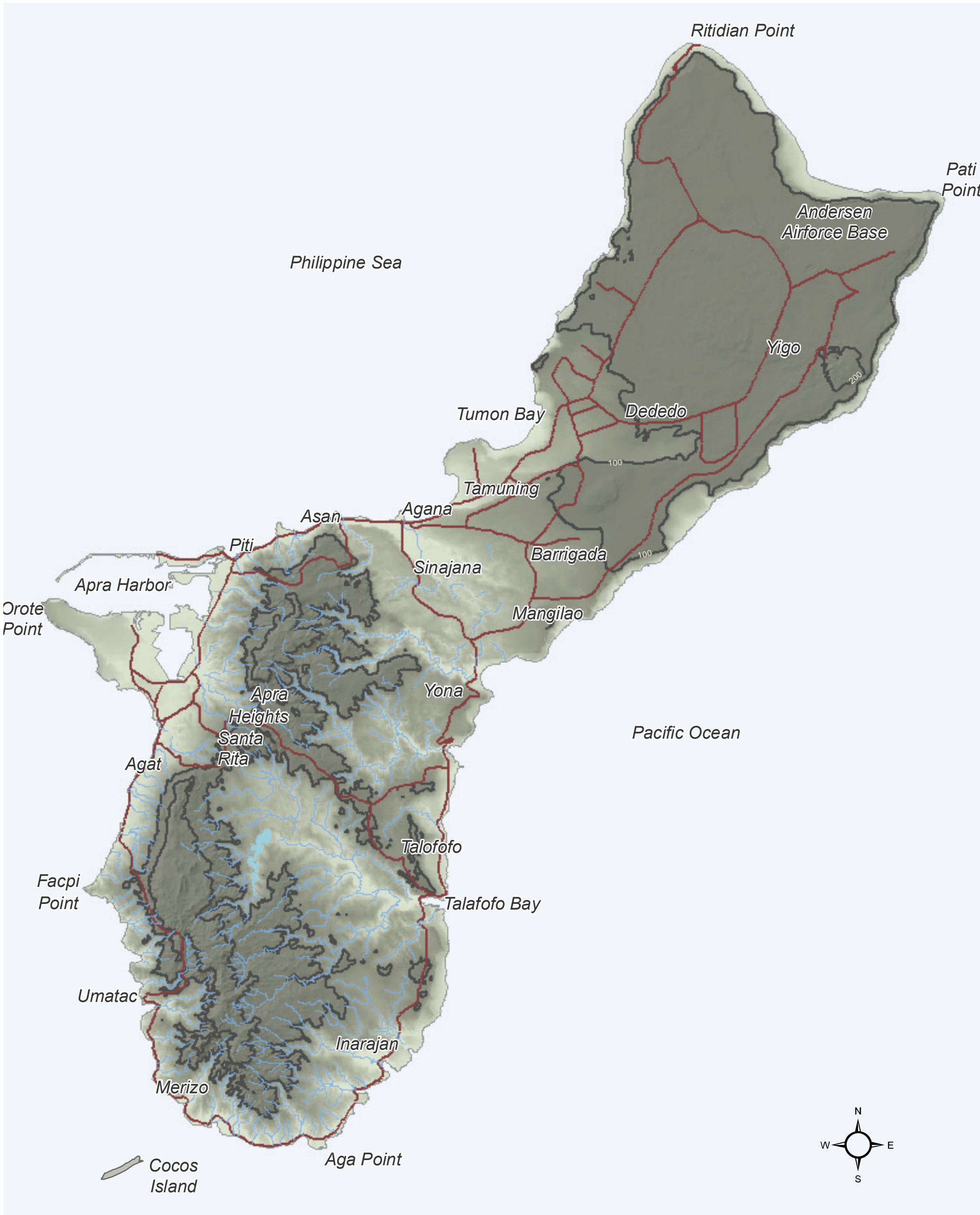

Figure 2. Territory of Guam

In 2002, Donnegan *et al.* (2004) completed a forest inventory and analysis for Guam. They estimated that approximately 48 percent (25,833 hectares, 63,833 acres) of the island was forested (Figure 3). Of the forested area, approximately (17,970 hectares, 44,404 acres) were classified as limestone forest, the majority of which was located in northern Guam, and approximately 7,741 hectares (19,129 acres) were classified as volcanic forest, primarily found in southern Guam. Of the remaining lands on Guam (29,068 hectares, 71,827 acres), 33 percent (17,991 hectares, 44,455 acres) was classified as savanna or fernland, 18 percent (9,695 hectares, 23,956 acres) was classified as urban, and the remaining 1 percent of the island was either classified as barren lands or water or unclassified. For more detailed information about the vegetation on Guam, the reader is directed to Fosberg (1960), Stone (1970), and Mueller-Dombois and Fosberg (1998).

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 (back of the neck) 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 except 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 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 buff-white in the immature male, but may be paler in the female.

Figure 3. General vegetation of Guam

The sihek is in the subfamily Daceloninae (tree kingfishers) within the family Alcedinidae (kingfishers), order Coraciiformes. It 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. pelewensis* -- 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 DNA suggest that each of these subspecies is distinct genetically, perhaps sufficiently so as to merit separate species status (S. Haig, pers. comm. 2002). However, further genetic analyses are needed.

Another kingfisher, the mangrove or collared kingfisher (*H. chloris*), also occurs on some of the islands north of Guam in the Mariana archipelago (Rota, Aguiguan, Tinian, and Saipan) and 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. pelewensis*.

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 sihek 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 1970s (Drahos 1977, 2002). During this decline in southern Guam, sihek were still found over much of northern Guam into the late 1970s (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).

Similar patterns of decline were also observed for many of the other native forest birds of Guam (Savidge 1987, Wiles *et al.* 2003). The white-throated ground-dove (*Gallicolumba xanthonura*), Mariana fruit dove (*Ptilinopus roseicapilla*), rufous fantail (*Rhipidura rufifrons*), Guam broadbill, Guam bridled white-eye, and Micronesian honeyeater (*Myzomela rubrata*) are now extinct on Guam. The Mariana crow, Mariana swiftlet (*Aerodramus bartschi*), and Micronesian starling (*Aplonis opaca*) are still found on Guam but at very low numbers (Aguon *et al.* 2004). The brown treesnake is believed to have been a factor in the population decline of each of these species.

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 sihek 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 4). However, high mortality rates and poor reproduction reduced the total annual population size to as low as 50 birds in 1992 (B. Bahner, Philadelphia Zoo, pers. comm. 2001). For the next several years the population hovered between 50 and 55 birds (Figure 4) 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. 17, for details). In 2001, the population grew to 65 individuals and through 2004, fluctuated between 57 and 73 birds (B. Bahner, pers. comm., 2004).

As of May 2008, the population consisted of 60 males, 37 females, and 4 unsexed chicks distributed among 17 captive propagation institutions in the mainland United States and Guam (B. Bahner, pers. comm. 2008). 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

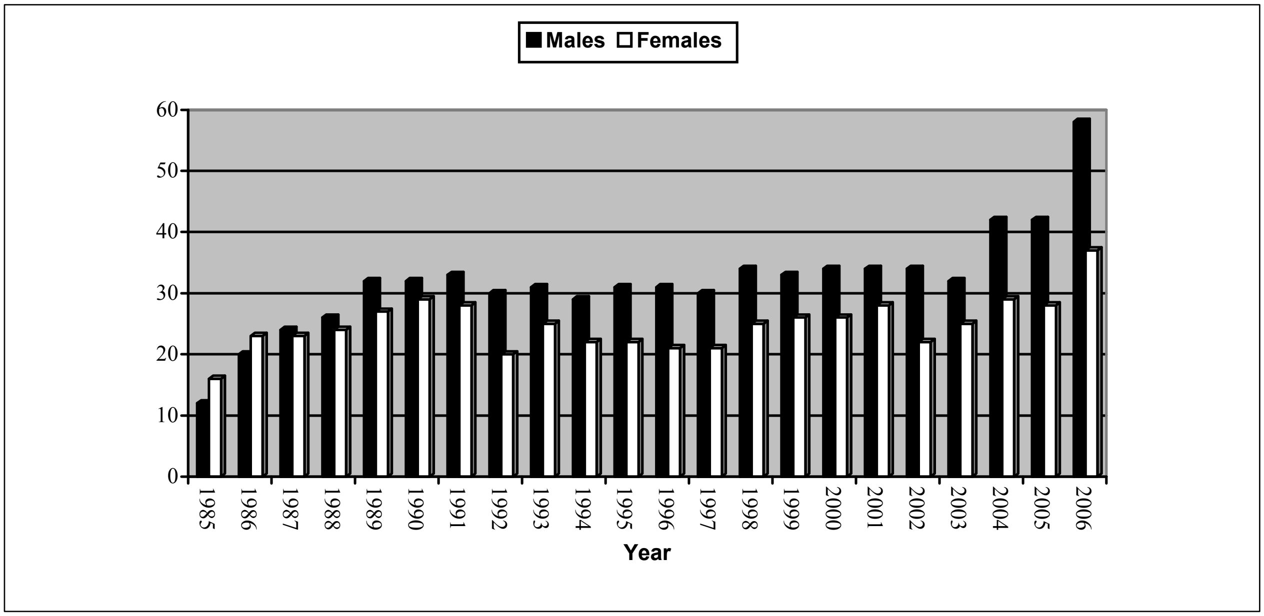

Figure 4. Annual number of male and female sihek held in captivity (Bahner 1998; B. Bahner, pers. comm. 2005; Bahner and Bier 2007).

Gardens; St. Louis Zoological Park; Philadelphia Zoological Gardens; Houston Zoological Gardens; Milwaukee County Zoological Gardens; Bronx Zoo, and the Guam Division of Aquatic and Wildlife Resources.

E. Life History

1. Behavior

Sihek make several vocalizations and have often been 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 2007a). 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 2007a). 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 (Emlen 1982). 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 (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 (same species) intrusions. Territories vary in size with location and cover type, but average approximately 10 hectares (25 acres) in the mid-elevation zones. During their 6-year study, Kesler and Haig (2007a) 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.]), or arboreal fern root masses, or may also utilize available natural cavities such as broken tree limbs (Jenkins 1983, Marshall 1989). Jenkins (1983) observed that some excavated cavities were never used 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 (Marshall 1989), and on Pohnpei copulations have been observed only following bouts of nest excavation (D. Kesler, Oregon State University, pers. comm. 2002). Excavation behaviors have also been observed on Pohnpei in association with males courting new females (Kesler and Haig 2007a). Courtship feeding and vocal duetting (simultaneous calling between members of a pair) are common, and presumably function in both pair-bond maintenance and territorial maintenance.

Pohnpei Micronesian kingfishers have been observed to excavate nest cavities only 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 and Haig 2005a). Kesler and Haig (2005a) found that termitaria used for nesting are higher from the ground and larger in volume than unused termitaria. They also found no apparent association between nest locations and 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 (Kesler 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 multiple months and years (Kesler 2002, Kesler and Haig 2007a).

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 rats (presumably Polynesian rats [*Rattus exulans*]) and various invertebrates as well as chasing and killing chicken chicks (D. Kesler, pers. comm. 2002, 2004).

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, secondary growth, and, to a lesser degree, in scrub limestone 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 sihek nest sites in the wild, but in one study in northern Guam 16 nest sites were correlated with closed canopy cover and dense understory vegetation. In this study, 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). Research on the Pohnpei Micronesian kingfisher indicates an area of approximately 8 hectares (20 acres) of such habitat may be needed to support at least one pair of kingfishers (Kesler and Haig 2007a). However, it should be noted that sihek territories may differ from Pohnpei Micronesian kingfisher territories due to differences in forest structure on Guam and Pohnpei (Mueller-Dombois and Fosberg 1998).

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 (2007b) 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 2007b) 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). These differences 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

Critical habitat is defined in section 3 of the Endangered Species Act as--(i) the specific areas within the geographic area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographic area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. "Conservation" means the use of all methods and procedures that are necessary to bring an endangered or a threatened species to the point at which listing under the Endangered Species Act is no longer necessary.

Critical habitat receives protection under section 7 of the Endangered Species Act through the prohibition against destruction or adverse modification of critical habitat with regard to actions carried out, funded, or authorized by a Federal agency. Section 7 requires consultation on Federal actions that may adversely affect critical habitat.

On October 28, 2004, the U.S. Fish and Wildlife Service designated 152 hectares (376 acres) of land as critical habitat for the sihek and two other endangered species (the Mariana crow and Mariana fruit bat [*Pteropus mariannus mariannus*]) on the fee simple portion of the Guam National Wildlife Refuge in northern Guam (Figure 5; USFWS 2004b). Excluded from this designation were 4,386 hectares (10,838 acres) of Air Force lands, 3,228 hectares (7,977 acres) of Navy lands, 1,210 hectares (2,989 acres) of Government of Guam lands, and 785 hectares (1,941 acres) of private lands in northern and southern Guam that were proposed as critical habitat on October 15, 2002 (USFWS 2002). Air Force lands were excluded under Section 4(a)(3) of the Endangered Species Act, as amended

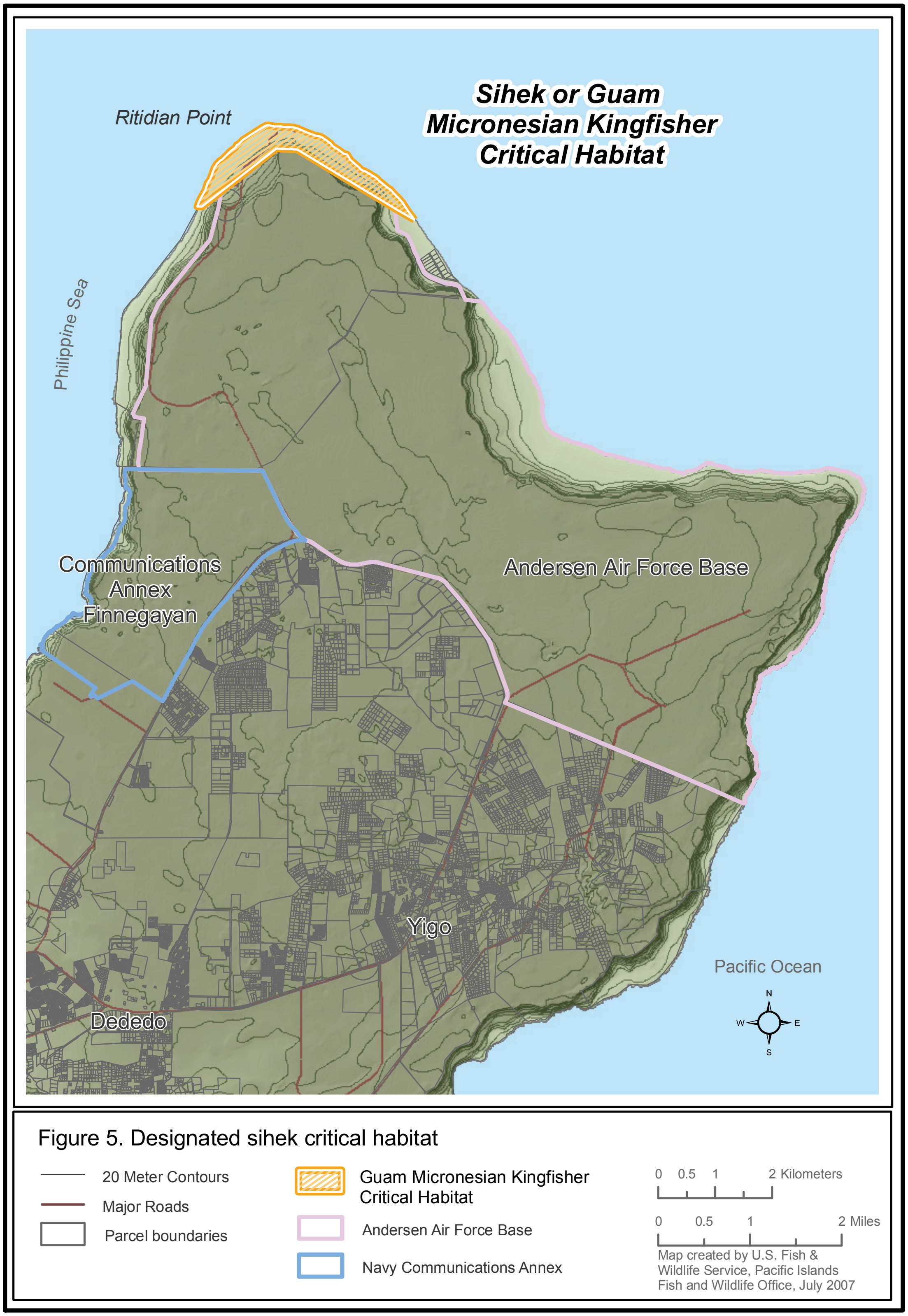

Figure 5. Designated sihek critical habitat

by Section 318 of the fiscal year 2004 National Defense Authorization Act, based on the Air Force's Integrated Natural Resource Management Plan for Andersen Air Force Base. Navy lands were excluded under Section 4(b)(2) because the benefits of excluding these lands, including benefits to national security and existing management plans and conservation efforts, outweighed the benefits of designating these lands as critical habitat. Government of Guam lands were excluded under Section 4(b)(2) because the benefits of excluding these lands, including continued and improved cooperation between Guam and the Service and Guam's natural resource plan, outweigh the benefits of designating these lands as critical habitat. Although these lands were excluded from designation as critical habitat, they are still considered essential to the conservation of the sihek.

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, 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; and
(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), disease (factor C), introduced predators such as cats (*Felis catus*), rats (*Rattus* spp.), monitor lizards (*Varanus indicus*), and brown treesnakes (factor C), human persecution (factor E), contaminants (factor E), and competition with and harassment by black drongos (factor E) (USFWS 1984, 1990). Of these threats, predation by the brown treesnake is believed to have been the overriding cause of the sihek'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 are unknown. 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) do not appear adequate. The sihek is currently listed as endangered by the governments of both the United States and Guam. However, the sihek is extirpated in the wild and the habitat identified to be essential to its conservation has not been fully protected (see Critical Habitat above).

1. 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 (see Figure 3), some of these areas may be further fragmented and degraded by development activities and road building in the coming years (*e.g.*, the Air Force's proposed munitions storage igloo, northwest field beddown, and intelligence, surveillance, reconnaissance, and strike capability projects and the Department of Defense's proposal to move an Marine Expeditionary Force to

Guam). Much of the remaining forest has also been severely degraded by introduced Philippine deer (*Cervus mariannus*), feral pigs (*Sus scrofa*), and feral Asiatic water buffalo (*Bubalus bubalis*), which were introduced to Guam in the 1600s and 1700s (Conry 1988a, Wiles *et al.* 1999). 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.* 1999, Wiles 2005). Philippine deer and feral pigs are found throughout Guam. On Andersen Air Force Base, densities of Philippine deer and feral pigs were estimated at 1.8 deer per hectare (0.8 deer per acre) and 0.4 pigs per hectare (0.2 pigs per acre), which are some of the highest densities recorded in the world (Knutson and Vogt, unpubl. manuscript 2003). Feral Asiatic water buffalo are found predominantly on the Ordnance Annex and surrounding non-Navy lands in southern Guam, where the population is estimated to be at least 50-60 animals (A. Brooke, U.S. Navy, pers. comm. 2007).

Typhoons, a common natural occurrence on Guam (Figure 6), have also contributed to the degradation of native forest on Guam. Typhoons can cause defoliation (loss of leaves), uprooting of trees, and breakage of stems, branches, and trunks of trees depending on the severity and duration of the storm and its point of impact (Brokaw and Walker 1991). Donnegan *et al.* (2004) estimated 20 percent of the individual trees on Guam have been damaged and that typhoons were the primary source of damage for 36 percent of the damaged individuals. The impact of typhoons on native forests along with the impacts of feral ungulates on regeneration of native species and the spread of invasive plants can work in conjunction to further degrade the remaining forests on Guam.

Sihek may be able to withstand some degree of habitat alteration. Because they require open understory forests and forest edges for foraging (Jenkins 1983), fragmented and somewhat degraded habitats may provide useful resources for 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

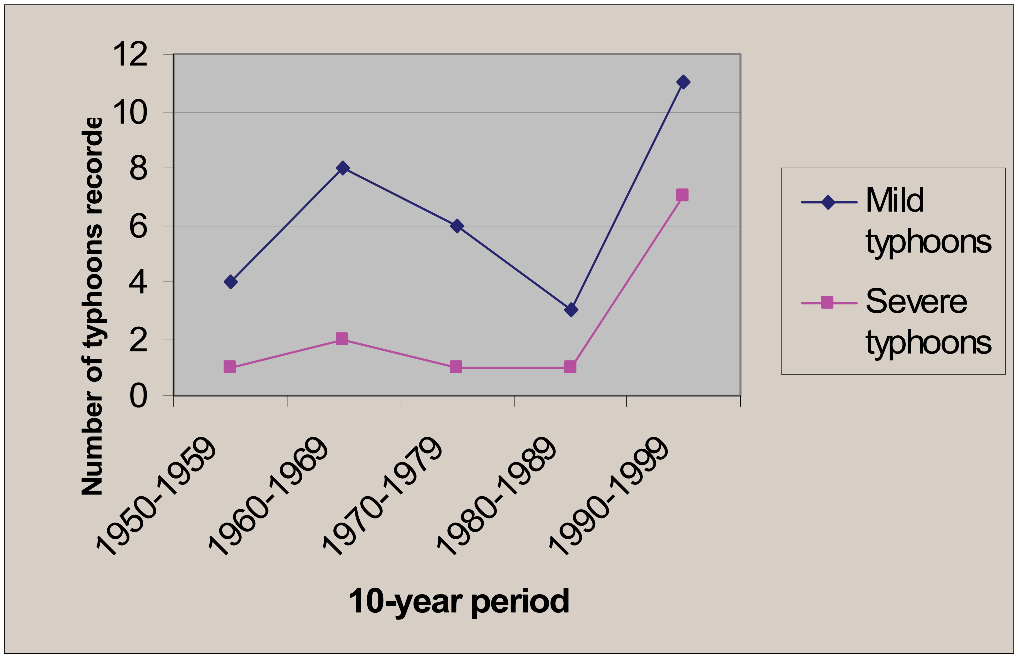

Figure 6. Mild and severe typhoons recorded within 10-year increments at the U.S. Navy Joint Typhoon Warning Center for Guam from 1950 to 1999. Mild typhoons are defined as typhoons with estimated gusts between 80 kph (50 mph) and 160 kph (100 mph). Severe typhoons are defined as typhoons with estimated gusts above 160 kph (100 mph).

grasses and herbs facilitates the detection of terrestrial skinks (Kesler and Haig 2007b). Nonetheless, Pohnpei Micronesian kingfishers were found in the highest densities in areas without human impacts, such as mangrove forests.

2. 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 affect the recovery of the sihek. Avian mycobacteriosis, 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 mycobacteriosis. 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 native and introduced bird species on Guam.

Newly emerging diseases, such as West Nile virus and the highly pathogenic strain of avian influenza, H5N1, may pose a significant risk to sihek in the continental United States and on Guam if it reaches the Pacific rim. As of July 2007, H5N1 has not been reported in the western hemisphere or the Mariana Islands (National Wildlife Health Center 2007). However, as of May 2007, West Nile virus has been detected in 284 bird species, including the related belted kingfisher (*Ceryle alcyon*), from 48 states and the District of Columbia (CDC 2007). West Nile virus was detected in one sihek that died at the National Zoological Park (B. Bahner, pers. comm. 2003); as a result, three sihek at the Park were vaccinated (R. Junge, Saint Louis Zoo, pers. comm. 2002). As of May 2007, RNA (ribonucleic acid) of West Nile virus, the West Nile antigen, or the isolated virus had been detected in 62 mosquito species from 10 genera (*Aedes*, *Anopheles*, *Coquillettidia*, *Culiseta*, *Culex*, *Deinocerites*, *Ochlerotatus*, *Orthopodomyia*, *Psorophora*, and *Uranotaenia*) in the United States. 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 and avian influenza to the island, Guam's Department of Agriculture implemented new testing and quarantine requirements for all avian importations (J. Burgett, USFWS, pers. comm. 2007).

3. 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 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 (23 to 39 inches) snout-vent length (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 Manus, an island near New Guinea, following World War II (Savidge 1987, Rodda *et al.* 1992). Available evidence suggests that brown treesnakes first colonized the Santa Rita/Ordnance Annex 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 (*Ramphotyphlops 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 two of Guam's native bird species (the yellow bittern [*Ixobrychus sinensis*] and Mariana swiftlet) have shown patterns of decline coinciding with the expansion of the snake's range across the island. These patterns of decline indicated an inverse relationship between populations of snakes and birds (Savidge 1987), presumably due to nest predation by brown treesnakes. Conry (1988b) 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, 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-1980s and have since declined, but remain at levels that threaten efforts to reestablish wild populations of sihek on Guam. Without efforts to control brown treesnakes on Guam the recovery of the sihek will not be possible. Current evidence suggests that snake populations in tangantangan (*Leucaena leucocephala*) forest 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). 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 limited food availability that resulted from the decimation of nearly all native fauna on the island by the brown treesnake (Rodda *et al.* 1992, 1999a; Fritts and Rodda 1998). However, high densities of treesnakes persist on Guam due 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).

The persistence of high densities of brown treesnakes on Guam continues to hamper efforts to reestablish sihek populations in the wild. Reestablishing sihek on Guam requires successful reproduction in the wild. However, the level of brown treesnake predation on sihek eggs and nestlings is expected to be high if brown treesnake densities remain high. Therefore, large scale control and/or eradication of brown treesnakes on Guam are essential for sihek recovery in the wild.

4. Other Introduced Predators (Factor C)

In addition to the brown treesnake, other potential sihek predators found on Guam include feral cats, Polynesian rats, roof rats (*Rattus rattus*), Norway rats (*R. 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 sihek from these sources as rat and monitor lizard populations would undoubtedly increase in response to lower treesnake populations. 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 Pohnpei 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, young apparently fledged from every nest observed during the study (n = 35; Kesler and Haig 2007a). This extremely high nest success suggests that sihek may not be very susceptible to predators other than brown treesnakes. However, the impacts of rats, cats, and other introduced predators on sihek have not been determined; therefore, their impacts will need to be monitored and managed, if necessary.

5. Human Exploitation and Persecution (Factor E)

There are no historical 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). 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 fowl.

6. 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 1970s, 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, 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 1980s 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 because pesticides, such as DDT and malathion, are no longer aerially broadcast on Guam.

7. 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). They were first noted on Guam in February 1960 and may have dispersed on their own from Rota (Jenkins 1983) or been displaced from Rota by a storm (Drahos 2002). 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. In 2005, black drongos were also observed harassing a nesting pair of Mariana crows and an individual

Mariana crow that was recently introduced into the wild in northern Guam (B. Dicke, DAWR, pers. comm. 2005). Therefore, harassment by black drongos and competition with this introduced bird species could affect sihek recovery, especially during the initial stages of the process to reestablish wild populations on Guam.

8. Limited Population Growth in Captivity (Factor E)

Initial efforts to breed sihek in captivity were successful. However, high embryonic, chick, 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 1980s due to higher levels of female mortality (see Figure 4). Poor egg viability and infanticide have also been identified as problems. Of the 778 eggs produced under captive conditions up to 1997, only 39 percent (301 eggs) were fertile; 20 percent (159 eggs) were broken, and 41 percent (318 eggs) were infertile. 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, either due to cannibalism by the parents or other causes. In addition to avian mycobacteriosis (22.5 percent of deaths; see Disease, above), other factors that have contributed to adult mortality in the captive population include stress, pair aggression, and nutritional deficiencies (Hutchins *et al.* 1996, Bahner *et al.* 1998).

As long as the captive population size remains small, loss of genetic diversity will be accelerated. This loss can reduce fitness and evolutionary flexibility, and increase the 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 is 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 29.5 and the estimated mean inbreeding coefficient (F) is currently 0.023 (Bahner and Bier 2007). 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 89.8 percent and is projected to drop to 67 percent gene diversity in 100 years if the population does not exceed 100 individuals (Bahner and Bier 2007).

I. Conservation Efforts

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

(1) develop a captive breeding program;
(2) reduce avian mortality in the field;
(3) provide maximum legal protection for sihek habitat;
(4) conduct additional research and surveys;
(5) develop methods for reintroduction; and
(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 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 48 birds in 1992 and subsequently hovered around 60 birds with adult mortalities balanced by juvenile recruitment (Bahner 1993; Hutchins *et al.* 1996; B. Bahner, pers. comm. 2004); populations have increased from 2004 to the present.

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). Studbooks, which provide pedigree data used for demographic and genetic analysis, have been published since 1988 (Bahner 1988-1996, 1998, 1999, 2001). Formal master planning for the population occurred in 1989, 1993, 2001, and 2003 to help in long-term planning for the captive population (Bahner 1993, Bahner and Lynch 2003). 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 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, research has been conducted on increasing the captive population and maintaining genetic diversity. Marshall (1989) completed research on the basic life history of the wild population of sihek which was applied to improve captive breeding efforts. Because the sihek is extirpated from the wild, research on the breeding biology and life history of Micronesian kingfishers has also been undertaken with the Pohnpei subspecies (Kesler 2002; Kesler and Haig 2004, 2005a, 2005b, 2007a, 2007b). Haig and Ballou (1995) studied the genetic diversity of the captive population and Haig *et al.* (1995) studied the genetic relationship among the founders of the captive population. Research on the behavioral (Baltz 1998) and hormonal aspects (Fowler and McGill 2002) of sihek pairs was undertaken. Finally, research continues on the adequacy of sihek diets, pathology, and behavior (B. 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 sihek's native Guam, as well as the lack of appropriate nesting logs or natural foods (Hutchins *et al.* 1996; Kesler and Haig 2004, 2005b). Breeding sihek on Guam in their native climate, with natural nesting substrates and foods available at a facility dedicated to sihek 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 facilities 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 were transferred to the island. In April 2004, an additional male and a female sihek were transported to facilities on Guam to begin captive breeding efforts on the island. In 2005, a total of three clutches were produced resulting in one female and two male chicks (S. Medina, pers. comm. 2005). As of February 2007, the captive population of sihek on Guam includes four adult males and one male and one female juvenile sihek (Bahner and Bier 2007). Two adult female and two adult male sihek are scheduled to be transferred to the facility on Guam in late 2007.

2. Reduce Avian Mortality in the Field

Brown treesnake control has been the focus of efforts to reduce avian mortality in the field. However, research has also been conducted on the potential impacts to wild populations of avian disease (Savidge *et al.* 1992, Silva-Krott *et al.* 1998), contaminants (Drahos 1975, Grue 1985), and black drongo competition (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. Agencies that have committed resources to this research include the Department of Interior's Office of Insular Affairs, the Department of Defense, U.S. Department of Agriculture, U.S. Fish and Wildlife Service, U.S. Geological Survey, and Guam Division of Aquatic and Wildlife Resources. 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. 17). 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 Resources Discipline 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 compartment within the trap to motivate snakes to enter (Linnell *et al.* 1998, Rodda *et al.* 1999c). 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. Attempts to protect Mariana crow nests from predation using some type of barrier (*e.g.*, Tanglefoot and galvanized steel bands) were first attempted in 1988 (Aguon *et al.* 2002). Of the techniques, an electrical barrier was found to be the most effective at protecting nests from predation (Aguon *et al.* 2002) and 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), and only the bulge barrier (fencing constructed with an overhang to discourage climbing) has been used for endangered species conservation efforts. In 1998 a bulge barrier was retrofitted around a cyclone fence around Area 50, a 24-hectare limestone forest area in Northwest Field on Andersen Air Force Base. 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 (Searle and Anderson 1998). 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. The construction of a test masonry snake barrier around Area 50 and around the Munitions Storage Area was also proposed. The results of these experiments should determine if trapping and/or toxicant use in conjunction with snake barriers is an effective conservation technique. However, the status of these two proposed projects is uncertain due to Air Force concerns about the barriers being constructed in the blast zone of the Munitions Storage Area on Andersen Air Force Base (E. Campbell, U.S. Fish and Wildlife Service, pers. comm. 2004). As of September 2008, plans were underway to construct a barrier around an alternate site near Potts Junction on Andersen Air Force Base (K. Buermeyer, USFWS, PIFWO, pers. comm. 2008). This area was proposed as a mitigation area for the Air Force's Northwest Field Beddown Project (U.S. Air Force 2006a)

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 either in 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 vertical bait station design; tests of the design (smaller PVC tubes open only on one end and hung vertically with the open end down) have shown that they deter non-target bird species but may also exclude smaller snakes (D. Vice, USDA, Wildlife Services, pers. comm. 2008). Therefore, work on alternate designs is being undertaken.

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 vertebrate 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 “trap shy” 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 adjacent, non-treated areas). Snake barriers are relatively costly and may thus 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 (Caudell *et al.* 2002). 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, research has been conducted 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 are considered to have been major factors in the extirpation of this species from Guam (see Reasons for Decline and Current Threats, p. 17). The potential impact of predators other than brown treesnakes on sihek has not been 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 Guam 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 contain 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 (COMNAVMARIANAS [U.S. Navy]). The latter includes the Naval Computer and Telecommunications Station in northern Guam, and the Waterfront Annex (known as "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 (Figure 7).

In 1993, the U.S. Air Force, U.S. Navy, and U.S. Fish and Wildlife Service entered into a Memorandum of Understanding to create the Guam National Wildlife Refuge. As per the terms of the Memorandum of Understanding, the two military branches entered into Cooperative Agreements with the U.S. Fish and Wildlife Service in 1994 to designate Department of Defense lands as overlay units in the Guam National Wildlife Refuge. Currently the Guam National Wildlife Refuge includes 152 hectares (376 acres) of fee simple lands and 9,300 hectares (22,980 acres) of overlay lands owned by the U.S. Navy and U.S. Air Force (Figures 8 and 9). The primary use of the overlay lands is to meet the military mission of national defense and natural resource management on these lands, guided by the Integrated Natural Resource Management Plans for Andersen Air Force Base and Commander of Naval Forces in the Mariana Islands.

Within the Guam National Wildlife Refuge overlay lands, there are several areas that have been designated by the U.S. Air Force and U.S. Navy for special management consideration. Andersen Air Force Base set aside the 281-hectare (694-acre) Pati Point Natural Area in 1973 (Figure 8), an area that contains the primary roost site of the threatened Mariana fruit bat (*Pteropus mariannus mariannus*) on Guam (Wiles *et al.* 1995), and that also supported sihek

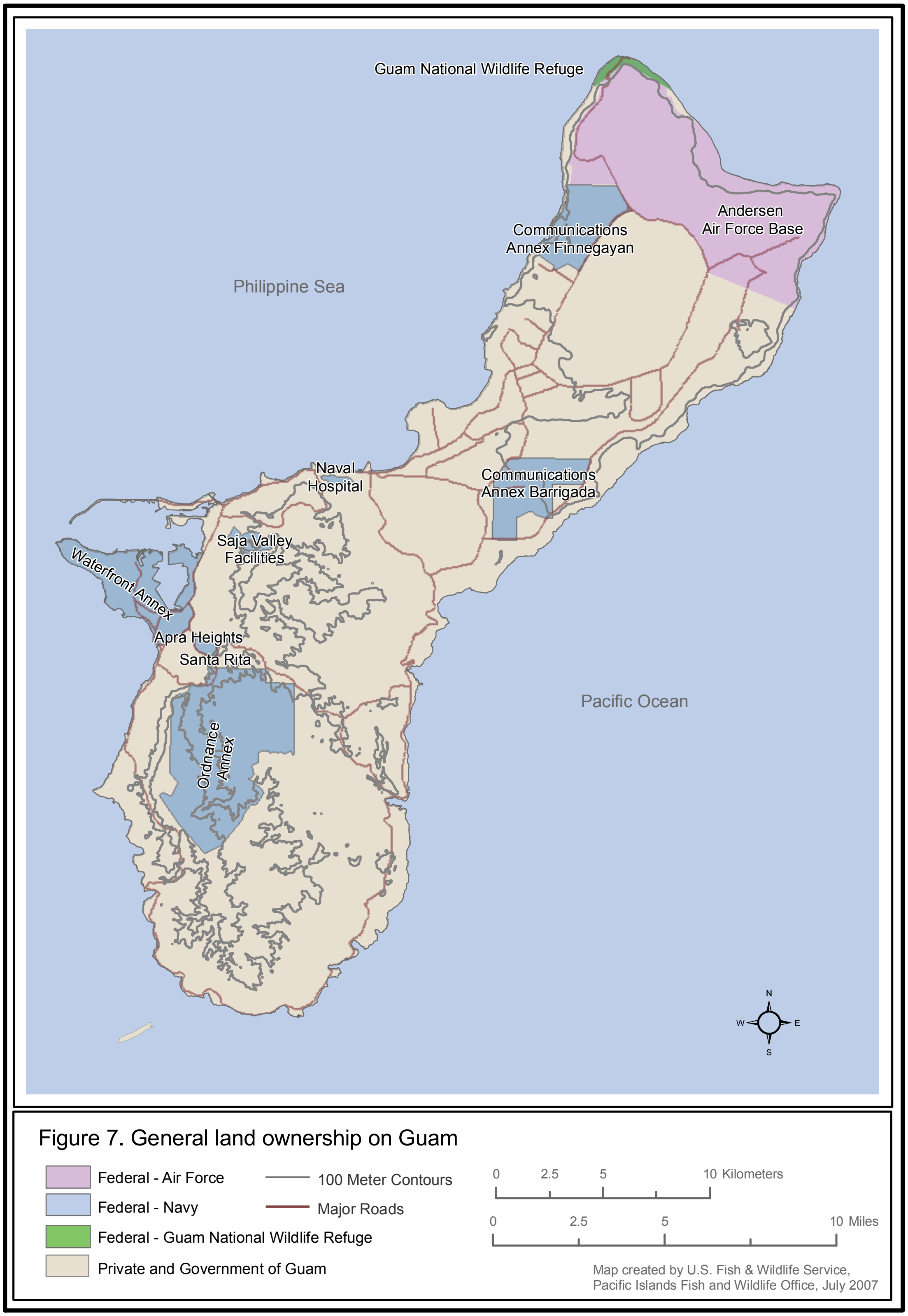

Figure 7. General land ownership on Guam

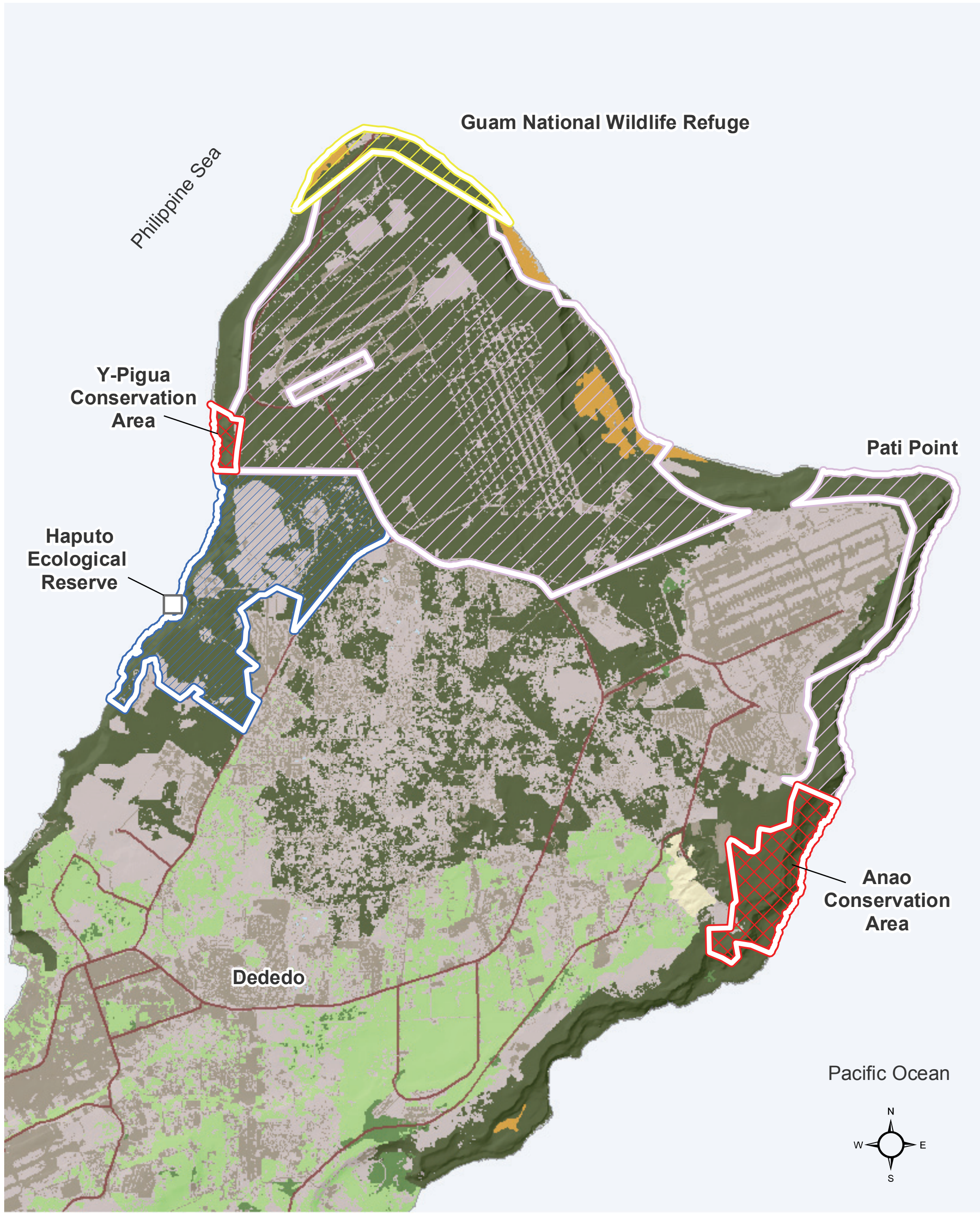

Figure 8. Conservation areas in northern Guam, with vegetation Types

Conservation Areas
- Fee Simple Refuge
- Overlay Refuge - Navy
- Overlay Refuge - Air Force
- Government of Guam

Vegetation Types
- Limestone Forest
- Limestone Scrub Forest
- Scrub Forest
- Ravine Forest
- Savanna Complex
- Plantations
- Urban
- Urban Cultivated
- Water
- Wetlands

0 0.5 1 2 Kilometers

0 0.5 1 2 Miles

Map created by U.S. Fish & Wildlife Service,
Pacific Islands Fish and Wildlife Office, July 2007

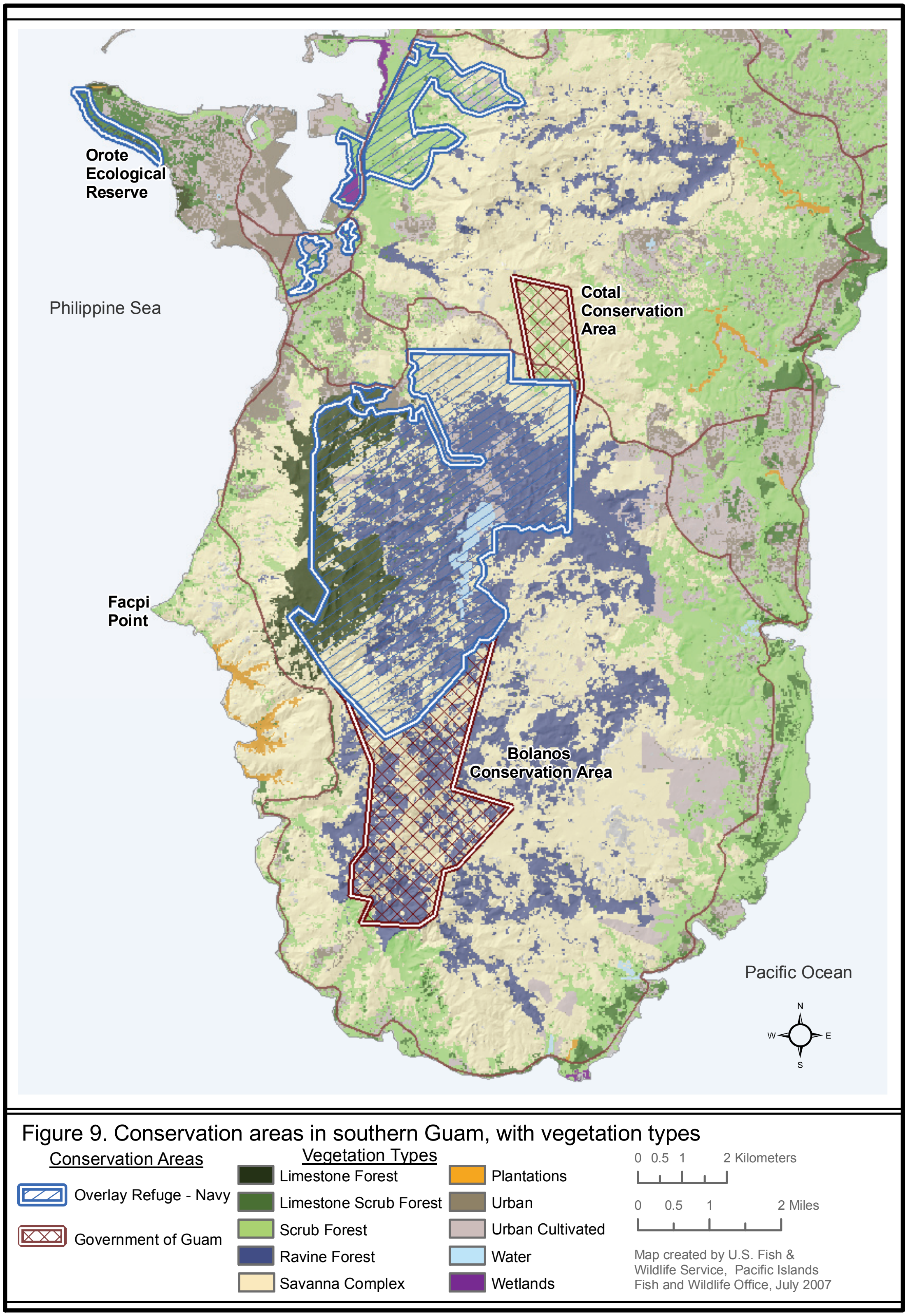

Figure 9. Conservation areas in southern Guam, with vegetation types

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 (Figure 8) and the 66-hectare (163-acre) Orote Ecological Reserve on the Waterfront Annex (Figure 9). 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 colony). These areas contain forested habitat important to the conservation of the sihek. For additional information about the U.S. Air Force and Navy lands included in the overlay refuge see the Integrated Natural Resource Management Plans for Andersen Air Force Base (U.S. Air Force 2003) and COMNAVMARIANAS (U.S. Navy 2001).

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 (Figure 8), and the Cotal and Bolanos Conservation areas in the south (Figure 9). 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.

b. Feral Ungulate Management and Removal

To date, there has been no large-scale control or removal of ungulates in northern Guam. Several attempts have been made to completely remove resident Philippine 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 (C. Kessler, U.S. Fish and Wildlife Service, pers. comm. 2007). The Air Force is also proposing to fence approximately 254 hectares (628 acres) to exclude pig and deer and to remove ungulates from these areas to offset impacts associated with two projects on Andersen Air Force Base (U.S. Air Force 2006a, 2006b). In southern Guam, efforts to control Asiatic water buffalo on Navy lands have been underway since 1996 and the population has been reduced from approximately 300 animals to 50-60 animals (A. Brooke, pers. comm. 2007). The Navy has also been working on developing a plan for the long-term sustained reduction of pig populations on their lands (A. Brooke, pers. comm. 2007).

4. Public Awareness

A wide variety of public education and outreach activities has been implemented by the Guam Division of Aquatic and Wildlife Resources, focusing on the conservation of native species and their biology, and the 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, occasional appearances on radio talk shows, 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 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. However, habitat loss and degradation may become a significant issue as the remaining forests on Guam undergo clearing and modification due to development, proposed military expansion, and heavy browsing pressure from feral ungulate populations. In addition, other threats such as disease, and other predators, such as rats, can also affect recovery. Therefore, recovery actions are focused on increasing the size of the captive population, controlling brown treesnakes, protecting and enhancing habitat for sihek conservation, and reintroducing the sihek 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 implementing and improving existing control techniques in the field and development of new techniques, as necessary. Habitat protection and enhancement includes protecting sufficient areas of habitat for recovery 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 them 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 sihek 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. Sihek breeding and holding pens have been constructed on Guam, and five birds were transferred there in 2003 and 2004 to start a new captive breeding program on the island. Releases of birds into the wild will commence when brown treesnake numbers are controlled in suitable habitats. Ideally, sihek releases will occur after the captive population has increased and optimal numbers of individuals are available for release in order to keep the captive population viable. However, if efforts to either increase the captive population or control brown treesnakes are not successful, it may be necessary to reevaluate the recovery strategy for the sihek. Temporary or permanent introduction of a sihek population on another island outside the native range of the species, without brown treesnakes, may be appropriate to establish a self-sustaining wild population with a behavioral repertoire that might be better suited for ultimate reintroduction to Guam than that of captive-bred birds. After the sihek becomes 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 sihek 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.

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 sihek population on Guam, and establishing and maintaining two wild, self-sustaining subpopulations of sihek on Guam.

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 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); (3) information available on the biology of Micronesian kingfishers on Guam and Pohnpei; and (4) vegetation assessments for Guam (Donnegan et al. 2004). We estimate that the island of Guam could support a population of between 3,600 and 6,800 sihek based on available density estimates from Guam and Pohnpei (Engbring and Ramsey 1981, Engbring *et al.* 1990), territory sizes on Pohnpei (Kesler 2007a), and the availability of potential habitat on Guam (Donnegan *et al*. 2004). However, these population estimates may not be necessary to consider the species for delisting. An assessment of populations of collared kingfishers, a common species that receives no federal or local protection, in the Mariana archipelago indicates that apparently isolated populations of 1,300 (*e.g.*, the island of Rota; *Todiramphus chloris orii*) to 2,300 (*e.g.*, the closely situated islands of Aguiguan, Tinian, and Saipan combined; *T. chloris albicilla*) collared kingfishers can persist for the foreseeable future without being threatened with extinction (Engbring *et al.* 1986). Therefore, we selected 1,000 adults in northern and southern Guam (2,000 adults total) as a minimum population goal for a delisting criterion, in conjunction with efforts to control and remove threats to the species, to ensure the population was not likely to become in danger of going extinction in the near future. A minimum population of 500 adults in northern and southern Guam (1,000 adults total) was selected as a downlisting criterion, in conjunction with efforts to control and remove threats to the species, to ensure that the species was not in immediate danger of going extinct.

These goals should be reevaluated 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 at least 2 subpopulations (with at least one each in northern and 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 population growth rate (λ, or lambda) of greater 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 at least 2 subpopulations (with at least one each in northern and 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 population growth rate (λ, or lambda) of greater 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.

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 a 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, a few of the actions described below are designed to obtain data from the related 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 Review recovery efforts annually
    - 1.2 Monitor recovery efforts
2. Captive management
    - 2.1 Continue captive population management efforts in the mainland United States
    - 2.2 Continue to expand the sihek breeding program on Guam
        - 2.2.1 Continue to maintain sihek breeding and holding pens
        - 2.2.2 Maintain staffing of facility
        - 2.2.3 Plan transfer of additional sihek to Guam
    - 2.3 Increase size of the sihek captive population

- 2.3.1 Evaluate climate, photoperiod, and reproductive success
- 2.3.2 Evaluate nest logs and reproductive success
- 2.3.3 Assess effects of nutrition on reproductive success and mortality
- 2.3.4 Assess effects of age on reproductive success
- 2.3.5 Assess effects of hand-rearing on reproductive success
- 2.3.6 Develop methods to establish pairs
- 2.3.7 Review artificial incubation techniques
- 2.3.8 Study chick loss during parent-rearing
- 2.3.9 Continue stress hormone research
- 2.3.10 Continue to collect and analyze pathology data
- 2.3.11 Continue to prevent disease in captive population
- 2.3.12 Continue to standardize husbandry techniques and increase training

3. Reintroduce sihek to Guam
    - 3.1 Develop and test reintroduction strategies to increase likelihood of successful releases
        - 3.1.1 Review other reintroduction programs
        - 3.1.2 Develop and test reintroduction methods on collared kingfishers
    - 3.2 Determine potential release sites on Guam
        - 3.2.1 Assess habitat characteristics and potential territory distribution
            - 3.2.1.1 Obtain/construct Geographic Information System (GIS) database of landscape/vegetation characteristics
            - 3.2.1.2 Evaluate habitat suitability of potential reintroduction sites
        - 3.2.2 Assess historical distribution of sihek
        - 3.2.3 Assess brown treesnake densities
        - 3.2.4 Assess food availability
        - 3.2.5 Assess management potential of release site
    - 3.3 Work with landowners to develop agreements for sihek release and reestablishment
    - 3.4 Evaluate sihek dispersal, movement, and habitat use
    - 3.5 Develop a sihek population model
    - 3.6 Determine number of sihek needed for successful release

- 3.7 Develop reintroduction plan for sihek
- 3.8 Reintroduce sihek to the wild
  - 3.8.1 Establish a subpopulation in northern Guam
  - 3.8.2 Establish a subpopulation in southern Guam
- 3.9 Assess the need for wild back-up populations outside Guam and establish populations as needed.
- 3.10 Monitor sihek in the wild
  - 3.10.1 Gather data on post-release survival of sihek for refining release strategies
  - 3.10.2 Provide long-term monitoring of the sihek population
    - 3.10.2.1 Update population model (see recovery action 3.5) with results from sihek reintroduction efforts
    - 3.10.2.2 Develop efficient and effective methods for monitoring the population

4. Manage factors affecting wild population viability
   - 4.1 Control and eradicate brown treesnakes
     - 4.1.1 Continue and expand brown treesnake control efforts at potential reintroduction sites
     - 4.1.2 Delineate snake-threshold densities using surrogate native species
     - 4.1.3 Refine snake-threshold density estimates for sihek
     - 4.1.4 Improve existing brown treesnake control measures
       - 4.1.4.1 Develop effective artificial attractants
       - 4.1.4.2 Improve trap designs to increase snake capture rate
       - 4.1.4.3 Develop methods for sequentially controlling or eliminating brown treesnakes from large areas inside and outside snake exclosures
       - 4.1.4.4 Develop “kingfisher-safe” acetaminophen bait stations
       - 4.1.4.5 Develop methods for accurately quantifying brown treesnake densities in snake-reduced areas
       - 4.1.4.6 Develop and test brown treesnake new barrier designs
     - 4.1.5 Continue to fund research to develop new brown treesnake control techniques
   - 4.2 Monitor direct and indirect impacts of rats on sihek to determine the need for rat control

4.3 Assess impact of other sihek predators

4.4 Prevent accidental or intentional introduction of new predators to Guam

4.5 Assess the need for black drongo control

4.6 Reduce potential impacts of avian disease on sihek populations

4.7 Translocate individuals from northern or southern Guam subpopulations if necessary

4.8 Maintain and/or protect reserve habitat on Guam

4.8.1 Manage the Guam National Wildlife Refuge fee simple and overlay refuge lands for sihek conservation

4.8.2 Manage Government of Guam conservation areas for sihek conservation

4.9 Improve and manage habitat on Guam

4.9.1 Assess suitability of habitat on Guam

4.9.2 Develop and implement a sihek 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 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

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

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

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

5.2.1.3 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

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

B. Narrative Outline of Recovery Actions

1. <u>Coordinate and monitor recovery efforts</u>

Due to the complexity of issues associated with sihek recovery, a coordinated recovery effort is needed. Successful recovery will only be feasible through a strategy of adaptive management which combines the close cooperation and coordination of stakeholders, careful monitoring and evaluations of recovery actions, and the prompt resolution of new situations as they arise.

1.1 <u>Maintain an active Recovery Committee</u>

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. As defined here, the recovery committee would serve a broader function and differs from a recovery team. The committee should include members with relevant 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, avian captive management, and endangered species reintroduction.

1.1.1 Coordinate recovery actions with other recovery and ecosystem management efforts

Due to the similarities in recovery issues for listed species on Guam and the Mariana Islands, the recovery committee should 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 Develop 5-year recovery milestones

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 prioritized, 5-year recovery milestones should be developed.

1.1.3 Review recovery efforts annually

The recovery committee should meet as necessary in order to review recovery actions, evaluate new information, establish annual research and recovery action plans and priorities, and update the 5-year recovery milestones. Important information should be disseminated via electronic means to all committee members promptly and on a routine basis between meetings.

1.2 Monitor recovery efforts

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. Captive management

Increasing the captive population to sufficient numbers to allow for reintroduction to the wild is the first step toward recovery of the sihek. When the captive population is increased to a number that is sufficient for supporting a reintroduction program, efforts to reintroduce sihek into the wild can be initiated. In order to achieve this goal, a captive propagation program, which includes both captive propagation efforts on Guam and in zoos on the continental United States, is needed.

2.1 Continue captive population management efforts in the mainland United States

The sihek captive population is managed by the Micronesian Kingfisher SSP to maintain high genetic diversity for the population by focusing on equalization of the founder representation, increasing population effective size and increasing annual population growth rates. These efforts should continue but be modified as necessary to maintain a viable captive population while managing the captive population to support a reintroduction program.

2.2 Continue to expand the sihek breeding program on Guam

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 sihek (Hutchins *et al.* 1996; Kesler and Haig 2004, 2005b). Continuing efforts to breed sihek on Guam may alleviate some of these problems and result in an increase in the size of the captive population.

2.2.1 Continue to maintain sihek breeding and holding pens

Initially, three captive breeding pens and six holding pens were built on Guam at the Division of Aquatic and Wildlife Resources' facilities. These pens were built to the specifications suggested by other captive rearing facilities and are snake-proofed and typhoon resistant. These pens should be appropriately maintained and as the captive breeding program develops, additional breeding, holding and prerelease conditioning enclosures should be built as needed.

2.2.2 Maintain staffing of facility

The captive rearing facility should be sufficiently staffed at all times to care for their captive population of sihek. This staff should include a supervisory aviculturalist, assistant aviculturalist and technicians, and have a qualified veterinarian on staff or available on island.

2.2.3 Plan transfer of additional sihek individuals to Guam

In September 2003, three genetically well-represented male sihek were transferred to Guam and in April 2004, an established pair of sihek was sent to Guam to begin captive breeding efforts on Guam. Additional sihek individuals 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.

2.3 Increase size of the sihek captive population

Recovery of the sihek requires that the captive population be increased to sufficient numbers to allow for eventual reintroduction to the wild (see Recovery Actions 2.1 and 3.7). Unfortunately, reproductive success in the captive population has been limited by difficulty forming breeding pairs, infertile eggs, embryonic death, and loss of parent-reared chicks shortly after hatching. Mortality in young adult and adult sihek has also been high and has been linked to avian disease (*e.g.*, avian mycobacteriosis) and may be linked to stress and inadequate nutrition. The factors associated with poor reproductive success and mortality should be assessed so that propagation techniques can be developed or improved to increase reproductive success and decrease mortality.

2.3.1 Evaluate climate, photoperiod, and reproductive success

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

2.3.2 Evaluate nest logs and reproductive success

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.

2.3.3 Assess effects of nutrition on reproductive success and mortality

Captive Micronesian kingfishers have a tendency to become obese, which may affect their ability to reproduce (Hutchins *et al.* 1996). In addition, mortality in young adult and adult sihek may be related to inadequate nutrition. Data should be collected on body weights on all pairs and analyzed to help identify the relationship between weight and reproductive success. Kingfisher diets in captivity and the wild should also be evaluated to determine if the diets used for the captive population are sufficient. This information could then be used to help optimize sihek diets in captivity.

2.3.4 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.

2.3.5 Assess effects of hand-rearing on reproductive success

Hand-rearing of sihek was initiated to help improve chick survival. However, hand-rearing may affect 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.

2.3.6 Develop methods to establish pairs

Historically, fewer 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 sihek 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 2.3.9).

2.3.7 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 needed to determine the most appropriate incubation techniques and parameters.

2.3.8 Study chick loss during parent-rearing

Of the chicks parent-reared since 1997, about 74 percent disappeared from the nest. Possible explanations include parental cannibalism; however, that behavior has never been observed its potential frequency and the conditions under which it may occur are unknown. Time-lapse video studies should be used to investigate parental behavior and nestling mortality.

2.3.9 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.

2.3.10 Continue to 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.

2.3.11 Continue to prevent disease in captive population

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.

2.3.12 Continue to 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 (see Recovery Actions 2.3.1 to 2.3.9). The keeper training program should also continue and be updated as needed.

3. Reintroduce sihek to Guam

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

3.1.1 Review other reintroduction programs

A database has been developed by the Lincoln Park Zoo's Department of Conservation and Science that contains information on the methods used in avian reintroductions and the results of these reintroduction efforts. This information may provide preliminary guidance for developing a reintroduction plan for the sihek.

3.1.2 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. A coordinated plan should be developed that includes the release of radio-tagged single sex birds (to prevent the establishment of a breeding population) and monitoring to determine best methods of release, effective release sizes, and number of releases. This plan should also include the requirement that all released collared kingfishers will be retrieved or sacrificed prior to the release of sihek.

3.2 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 sihek, 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 3.2.1 – 3.2.4 below should be developed.

3.2.1 Assess habitat characteristics and potential territory distribution

In addition to basic habitat requirements, the quality and quantity of habitat at the release site will help predict whether the reintroduction goal for that location is achievable.

3.2.1.1 Obtain/construct Geographic Information System (GIS) 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 GIS database of landscape features, habitat resources, and vegetation coverage will be constructed.

3.2.1.2 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 GIS database described in recovery action 3.2.1.1. This analysis will provide information about the potential number and distribution of sihek territories that might be expected on reintroduction areas.

3.2.2 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 GIS database of landscape/vegetation characteristics (see recovery action 3.2.1.1).

3.2.3 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.

3.2.4 Assess food availability

The availability of potential food items for sihek should be evaluated at potential reintroduction sites prior to release. The relative numbers of lizards, small mammals, and invertebrates should be assessed at sites on Guam and compared to other Micronesian islands that support kingfisher populations, like Pohnpei or Rota.

3.2.5 Assess management potential of release site

Terrain, road access, and land ownership all affect the feasibility of managing a release site for sihek 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.

3.3 Work with landowners to develop agreements for sihek release and reestablishment

Prior to the release of sihek, agreements (e.g., Memorandum of Agreement, Safe Harbor Agreement, and Cooperative Agreement) should be developed with landowners for the release and eventual reestablishment of sihek on their land.

3.4 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. Sihek 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. 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 3.9 below, and then used in spatially explicit population modeling (recovery actions 3.5 and 3.9.2.1) and other planning efforts.

3.5 Develop a sihek population model

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.

3.6 Determine number of sihek individuals needed for successful release

Other reintroduction programs should be reviewed to help determine the optimum number of sihek individuals to release. This information could be obtained in the reintroduction database described under Recovery Action 3.1.1. 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 sihek needed to sustain the captive population must be maintained before determining the number of sihek to release (see Recovery Action 2.1).

3.7 Develop reintroduction plan for sihek

After the preliminary reintroduction work has been completed (recovery actions 3.1-3.5), 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.

3.8 Reintroduce sihek to the wild

Recovery of the sihek requires the reestablishment of a self-sustaining population 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 3.2. In addition, brown treesnakes will be controlled at the reintroduction sites through recovery action 4.1.

3.8.1 Establish a subpopulation in northern Guam

Prior to their extirpation from 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 reintroduction efforts.

3.8.2 Establish a subpopulation in southern Guam

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

3.9 <u>Assess the need for wild back-up populations outside Guam and establish populations as needed.</u>

It may be necessary to introduce a wild sihek population outside of Guam. Such a population might be more viable than one reintroduced directly from captivity to Guam because it could be established in habitat that has not been compromised by brown treesnakes. It could also hedge against the risk of the captive population being lost to disease or catastrophe. Moreover, a successful free-living population should minimize the progressive loss of behavioral or genetic traits (related to, for example, foraging, nesting, and predator avoidance) suited to survival in a wild as opposed to captive environment, and could thus ultimately improve the likelihood of successful reintroduction to Guam.

Because the sihek is endemic to Guam and all of its native range on Guam is now occupied by brown treesnakes, any such introduction of back-up populations outside of Guam would be outside the historic range of the species. Introduction may be done as an experimental population under section 10(j) of the Endangered Species Act, which typically is restricted to a species' probable historic range but can be extended beyond this range if "the primary habitat of the species has been unsuitably and irreversibly altered or destroyed" [50 CFR 17.81(a)]. Determination of experimental population status for the sihek would parallel that used for the population of Guam rail (*Rallus owstonii*) that was introduced on Rota after the species was extirpated on Guam by brown treesnake predation (USFWS 1989).

The appropriateness of the various potential introduction sites outside Guam should be evaluated using an approach similar to that outlined in recovery action 3.2. The extent and apparent suitability of available habitat at each site, as well as the presence of potentially competing collared kingfishers, should be considered. The major Mariana Islands such as Rota, Saipan, and Tinian have larger areas of habitat, but they support substantial human populations, collared kingfishers, and some introduced predators, and are either at some risk of accidental brown treesnake introduction or already support an incipient snake population. Some remote northern islands in the Mariana archipelago are uninhabited or sparsely inhabited, reducing the likelihood of conflict with other uses as well as accidental brown treesnake introduction; however, many of these islands have collared kingfisher populations and are small or volcanically active, and the logistical difficulties of introduction and monitoring activities may be substantial. Cooperative opportunities for introduction in the Federated States of Micronesia or elsewhere outside United States jurisdiction may also be worth considering.

If an island is determined to be appropriate as an alternate release site, the preliminary work and implementation of the introduction plan should be completed in a similar manner to that described for Guam reintroductions in recovery actions 3.3 through 3.8 above.

3.10 Monitor sihek in the wild

3.10.1 Gather data on post-release survival of sihek for refining release strategies

Released sihek 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 sihek recovery program. All data gathered during post-release monitoring should be analyzed prior to the next release to refine and modify the release strategy.

3.10.2 Provide long-term monitoring of the sihek population

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.

3.10.2.1 Update population model (see recovery action 3.4) with results from sihek reintroduction efforts

Updating the population model created in recovery action 3.5 with Guam-specific information will improve its accuracy and usefulness as a management tool. Information gathered based on the populations established in recovery action 3.8 will be used to update the model.

3.10.2.2 Develop efficient and effective methods for surveying the population

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

4. Manage factors affecting wild population viability

4.1 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 sihek can maintain viable self-sustaining populations.

4.1.1 Continue and expand brown treesnake control efforts at potential reintroduction sites

Brown treesnake control measures are currently being undertaken at the Munitions Storage Area. These control efforts should continue and be expanded to include larger areas that may serve as potential sihek reintroduction sites. Techniques that may be utilized include snake trapping, acetaminophen bait stations, and aerial broadcast of snake toxicants. Due to concerns about the potential ingestion of toxicants by sihek, toxicants found harmful to sihek should be aerially broadcast prior to reintroduction and bait stations should be tested prior to reintroduction (see Recovery Task 4.1.4.4).

4.1.2 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, such as the Micronesian starling (*Aplonis opaca*), as surrogates for the sihek. Appropriate surrogates should be determined based on what is logistically feasible and which species' life history most closely resembles the sihek. Estimation of the necessary level of brown treesnake control should be determined from the results of well-designed field studies and experiments.

4.1.3 Refine snake-threshold density estimates for sihek

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

4.1.4 Improve existing brown treesnake control measures

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

4.1.4.1 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 costs of maintaining and caring for the live mice are also relatively high. Similarly, securing a constant source of dead mice for toxicant use may be difficult. Therefore, artificial attractants that attract a wide range of snakes would be beneficial for control efforts.

4.1.4.2 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.

4.1.4.3 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, large-scale trapping is currently the only method available to reduce the densities of snakes within these areas. Trapping over large areas can be very expensive. Therefore, more efficient methods of controlling or eliminating snakes from a site also 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.

4.1.4.4 Develop "kingfisher-safe" acetaminophen bait stations

The Environmental Protection Agency has registered the use of acetaminophen for brown treesnake control. However, existing acetaminophen bait station designs need to be tested and, if necessary, new designs need to be developed that would minimize the take of bait by sihek.

4.1.4.5 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, such as bait take, are needed to assess the effectiveness of control efforts.

4.1.4.6 Develop and test brown treesnake new 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.

4.1.5 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.

4.2 Monitor direct and indirect impacts of rats on sihek to determine the need for rat control

The impact of rat predation on sihek is unknown at this time. As snake populations are reduced, rat populations will increase. Rats may negatively affect sihek directly (i.e., egg and nestling mortality) or indirectly (i.e., reductions in food resources). Therefore, rat impacts on sihek should be monitored to determine if rat control will be necessary.

4.3 Assess impact of other sihek predators

Little is known about the impact of other introduced predators on sihek 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.

4.4 Prevent accidental or intentional introduction of new predators to Guam

Efforts should be made to prevent the introduction of other potential sihek predators to Guam through effective interdiction measures; measures may include strengthening the enforcement of importation laws.

4.5 Assess the need for black drongo control

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

4.6 Reduce potential impacts of avian disease on sihek populations

While disease was not found to be a factor in the decline of the sihek, diseases represent a serious threat that could adversely affect recovery efforts. Appropriate regulatory measures and procedures should be adopted to minimize the potential for the introduction of diseases and pathogens (*e.g.*, West Nile virus and avian influenza). Disease monitoring and control measures should also be initiated as appropriate and necessary.

4.7 Translocate individuals from northern or southern Guam 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.

4.8 Maintain and/or protect reserve habitat on Guam

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.

4.8.1 Manage the Guam National Wildlife Refuge fee simple and overlay refuge lands for sihek conservation

A Comprehensive Conservation Plan will be developed for the Guam National Wildlife Refuge. This plan should include programs to manage land on the refuge for the sihek and other endangered species. These programs might include fencing and ungulate removal, reforestation, predator control, and other habitat management. In addition to the refuge conservation plan, the overlay refuge is managed through the Integrated Natural Resource Management Plans for Air Force and Navy lands. These management plans should include programs that will benefit the conservation of the sihek on overlay lands, including reestablishment of sihek by captive release.

4.8.2 Manage Government of Guam conservation areas for sihek conservation

Government of Guam conservation areas include the Anao and Y-Pigua Conservation areas in northern Guam (see Figure 8) and Cotal and Bolanos Conservation areas in southern Guam (see Figure 9). These lands should be designated as permanent conservation areas, and actively managed for sihek recovery with reforestation, ungulate control, and predator control.

4.9 Improve and manage habitat on Guam

4.9.1 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 (e.g., *Pisonia* sp. trees) resources for sihek, invasive non-native vegetation, and other habitat components important to sihek.

4.9.2 Develop and implement a sihek 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 sihek 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.

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 implement these programs and who understand the needs of their students. Contests or other means of obtaining ideas and input from 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 easily 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 Guam 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 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 shortfalls and need by supplying volunteers and funds to maintain these important programs. Many refuges and parks rely on these resources to champion new programs and maintain old ones at little or no cost.

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

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

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

5.2.1.3 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

5.2.2 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 can benefit the sihek as well as, for example, 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. 48).

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).

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 under section 7(a)(1) of the Act (16 USC 1531 *et seq*.). 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 Discipline
- **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 Revised Recovery Plan for the Guam Micronesian Kingfisher

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
1	2.1	E	Continue captive population management efforts	15 years	SSP*, DAWR	15	1	1	1	1	1	5
1	2.2.1	E	Continue to maintain sihek breeding and holding pens on Guam	Continuous	DAWR	50	10	1	1	10	1	23
1	2.3.3	E	Plan transfers of additional sihek to Guam	15 years	SSP*, DAWR	15	1	1	1	1	1	5
1	2.3.11	E	Continue to prevent disease in captive population	15 years	SSP	15	1	1	1	1	1	5
1	3.8.1	C,E	Reintroduce sihek to northern Guam	10 years	USFWS, DAWR*	200	-	-	-	-	20	20
2	4.1.1	C	Continue and expand efforts to reduce snake populations at reintroduction sites	Ongoing	WS*, DAWR	11,000	500	500	500	500	500	2,500

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
2	2.2.2	E	Maintain staffing of Guam facility	20 years	DAWR	120	6	6	6	6	6	30
2	2.3.1	E	Evaluate climate, photoperiod, and reproductive success and modify captive management, as appropriate	2 years	SSP	10	5	5	-	-	-	10
2	2.3.2	E	Evaluate nest logs and reproductive success and modify captive management, as appropriate	2 years	SSP*, DAWR	10	5	5	-	-	-	10
2	2.3.3	E	Assess effects of nutrition on reproductive success and modify captive management as appropriate	2 years	SSP	10	5	5	-	-	-	10

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
2	2.3.4	E	Assess effects of age on reproductive success and modify captive management, as appropriate	2 years	SSP	10	5	5	-	-	-	10
2	2.3.5	E	Assess effects of hand-rearing on reproductive success, and modify management, as appropriate	2 years	SSP	10	5	5	-	-	-	10
2	2.3.6	E	Develop methods to establish pairs and implement, as appropriate	Ongoing; 5 years	SSP*, DAWR	15	3	3	3	3	3	15
2	2.3.7	E	Review artificial incubation techniques and modify management, as appropriate	2 years	SSP	10	5	5	-	-	-	10

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
2	2.3.8	E	Study chick loss during parent-rearing and modify management, as appropriate	2 years	SSP	10	5	5	-	-	-	10
2	2.3.9	E	Continue stress hormone research and incorporate results in management, as appropriate	2 years	SSP	10	5	5	-	-	-	10
2	2.3.10	E	Collect and analyze pathology data and modify management, as appropriate	5 years	SSP	10	2	2	2	2	2	10
2	2.3.12	E	Continue to standardize husbandry techniques and training	15 years	SSP	15	1	1	1	1	1	5

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
2	4.1.4.3	C	Develop methods for controlling or eliminating brown treesnakes inside & outside exclosures to support reintroduction	2 years	BRD, WS	40	20	20	-	-	-	40
2	4.1.4.4	C	Develop "kingfisher safe" acetaminophen bait stations to support snake control efforts	2 years	WS	20	10	10	-	-	-	20
2	3.1.1	E	Review other reintroduction programs	1 year	USFWS, DAWR*	3	3	-	-	-	-	3
2	3.1.2	E	Develop and test reintroduction methods on collared kingfishers	2 years	USFWS	40	20	20	-	-	-	40
2	3.2	E	Determine locations of potential release sites on Guam	1 year	USFWS, DAWR*	1	1	-	-	-	-	1

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
2	3.2.1.1	E	Obtain/construct GIS of Guam landscape/vegetation characteristics to support reintroduction planning	1 year	USFWS	5	5	-	-	-	-	5
2	3.2.1.2	E	Evaluate suitability of potential reintroduction sites	1 year	USFWS*, BRD	20	20	-	-	-	-	20
2	3.2.2	E	Assess historical distribution of sihek to support reintroduction planning	1 year	USFWS	1	1	-	-	-	-	1
2	3.2.3	C	Assess brown treesnake densities to support reintroduction planning	1 year	USFWS*, DAWR, BRD	20	20	-	-	-	-	20
2	3.2.4	A,C	Assess food availability to support reintroduction planning	1 year	USFWS*, DAWR	2	2	-	-	-	-	2

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units) Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
2	3.2.5	C,E	Assess management potential of release site	1 year	USFWS*, DAWR, WS	2	2	-	-	-	-	2
2	3.3	E	Work with landowners to develop agreements for sihek release and reestablishment	2 years	USFWS	4	2	2	-	-	-	4
2	3.6	C,E	Determine number of sihek needed for successful release	1 year	USFWS, DAWR*	5	5	-	-	-	-	5
2	3.7	E	Develop reintroduction plan for sihek	1 year	USFWS, DAWR*	5	-	-	-	-	5	5
2	3.9	C, E	Assess the need for wild backup populations outside Guam and establish populations as needed	TBD	USFWS, DAWR*	TBD						
2	3.10.1	A,C,E	Gather data on post-release survival of sihek	4 years	USFWS, DAWR*	40	-	-	-	-	10	10

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
2	4.1.2	C	Delineate snake-threshold densities using surrogate native species	4 years	USFWS*, BRD	100	30	30	20	20	-	100
2	4.1.3	C	Refine snake-threshold density estimates for sihek	4 years	USFWS, BRD*	40	-	-	-	-	10	10
2	4.1.4.1	C	Develop effective artificial attractants for snakes to support reintroduction efforts	2 years	BRD, WS*	20	10	10	-	-	-	20
2	4.1.4.2	C	Improve trap designs to increase snake capture rate to support reintroduction efforts	2 years	BRD*, WS	20	10	10	-	-	-	20
2	4.1.4.5	C	Develop methods for quantifying brown treesnake densities in snake-reduced areas	2 years	BRD	40	20	20	-	-	-	40
2	4.1.4.6	C	Develop and test new snake barrier designs	3 years	BRD	30	10	10	10	-	-	30
2	4.1.5	C	Continue to fund	10 years	USFWS*,	100	10	10	10	10	10	50

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
			research to develop new snake control techniques		USAF, USN							
2	4.6	C	Reduce potential impacts of avian disease on sihek populations	Continuous	USFWS*, DAWR, WS	50	1	1	1	1	1	5
2	4.4	C	Prevent accidental or intentional introduction of new avian predators to Guam	Continuous	DAWR*, USFWS	50	1	1	1	1	1	5
2	4.8.1	A	Manage the Guam National Wildlife Refuge fee simple and overlay lands for sihek conservation	Ongoing	USFWS*, USAF, USN	500	50	50	50	50	50	250
2	4.8.2	A	Manage and protect Government of Guam Conservation Areas for sihek conservation	10 years	DAWR	500	50	50	50	50	50	250
2	4.9.1	A	Assess suitability of	2 years	USFWS*,	40	20	20	-	-	-	40

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
			sihek habitat on Guam		USAF, USN, DAWR							
2	4.9.2	A	Develop and implement habitat management plan	20 years	USFWS*, USAF, USN, DAWR	405	-	-	5	20	20	45
3	1.1	NA	Maintain an active Recovery Committee	Ongoing	USFWS	50	1	1	1	1	1	5
3	1.1.1	NA	Coordinate recovery actions with other conservation efforts	Ongoing	USFWS	50	1	1	1	1	1	5
3	1.1.2	NA	Develop 5-year recovery milestones	Continuous, as needed	USFWS*, MKRC	10	1	-	-	-	-	1
3	1.1.3	NA	Review recovery efforts annually	Continuous	USFWS*, MKRC	50	1	1	1	1	1	5
3	1.2	NA	Monitor recovery efforts	Ongoing	USFWS	50	1	1	1	1	1	5
3	3.4	C,E	Evaluate sihek dispersal, movement and habitat use	4 years, minimum	USFWS*, DAWR	40	-	-	-	-	10	10
3	3.5	C,E	Develop a population model	1 year	USFWS	10	10	-	-	-	-	10

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units) Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
3	3.8.2	C,E	Reintroduce sihek to establish a subpopulation in southern Guam	20 years	USFWS, DAWR*	200	-	-	-	-	-	0
3	3.10.2.2	A,B,C, D,E	Develop efficient survey methods	1 year	USFWS, DAWR*	10	-	-	-	-	10	10
3	3.10.2.1	A,B,C, D,E	Update population model (see 3.4) with results from sihek reintroduction	4 years	USFWS*, DAWR	40	-	-	-	-	10	10
3	4.2	C	Monitor direct and indirect impacts of rats on sihek to determine the need for rat control	2 years, minimum	USFWS, DAWR*	20	-	-	-	-	10	10
3	4.3	C	Assess impact of other sihek predators	2 years, Minimum	USFWS, DAWR*	20	-	-	-	-	10	10
3	4.5	E	Assess the need for black drongo control	2 years, minimum	USFWS, DAWR*	20	-	-	-	-	10	10

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
3	5.1.1.1	A,B,C, D,E	Institute curriculum programs for elementary & high school teachers	10 years	USFWS*, DAWR	50	5	5	5	5	5	25
3	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	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	5.1.1.2.3	A,B,C, D,E	Update and revise materials	Unknown; as needed	USFWS*, DAWR	50	5	-	-	-	-	5
3	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

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

Priority Number	Action Number	Listing Factor	Action Description	Action Duration	Responsible Parties	Cost Estimate (in $10,000 units)						
						Total Costs	FY 08	FY 09	FY 10	FY 11	FY 12	5-Year Costs
3	5.1.3	A,B,C, D,E	Continue to provide information and promote awareness of the harmful effects of alien species to native species and ecosystems	Continuous	USFWS*, DAWR	50	1	1	1	1	1	5
3	5.2.1.1	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	5.2.1.2	A,B,C, D,E	Develop a "mentor" program . . .	10 years	USFWS*, DAWR	50	5	5	5	5	5	25
3	5.2.1.3	A,B,C, D,E	Support the use of volunteers . . .	Continuous	USFWS*, DAWR	50	1	1	1	1	1	5
3	5.2.2	A,B,C, D,E	Develop and support partnerships	20 years	USFWS*, DAWR	20	1	1	1	1	1	5
					TOTALS	14,583						3,920

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VI. APPENDICES

APPENDIX A

Endangered and Threatened Species Recovery Priority Guidelines

(adapted from USFWS 1983a,b).

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic genus	1	1C
				1
		Species	2	2C
				2
		Subspecies	3	3C
				3
	Low	Monotypic genus	4	4C
				4
		Species	5	5C
				5
		Subspecies	6	6C
				6
Moderate	High	Monotypic genus	7	7C
				7
		Species	8	8C
				8
		Subspecies	9	9C
				9
	Low	Monotypic genus	10	10C
				10
		Species	11	11C
				11
		Subspecies	12	12C
				12
Low	High	Monotypic genus	13	13C
				13
		Species	14	14C
				14
		Subspecies	15	15C
				15
	Low	Monotypic genus	16	16C
				16
		Species	17	17C
				17
		Subspecies	18	18C
				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).
extant	Still existing, not extinct.
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	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).

APPENDIX C

Summary of the Agency and Public Comment on the Draft Revised Recovery Plan for the Sihek or Guam Micronesian Kingfisher (*Halcyon cinnamomina cinnamomina*)

In April 2004, the U.S. Fish and Wildlife Service (Service) released the Draft Revised Recovery Plan for the Sihek or Guam Micronesian Kingfisher (Halcyon cinnamomina cinnamomina) for review and comment by Federal agencies, the Government of Guam, and members of the public. The public comment period was announced in the Federal Register (U.S. Fish and Wildlife Service 2004c) on April 28, 2004 and closed on June 28, 2004. Over 50 copies of the draft plan were sent out for review during the comment period. In addition, the draft revised plan was distributed to scientific peer reviewers for comment prior to finalization and publication of this final revised plan. We received comments from four peer reviewers.

Sixteen letters/comments were received during the comment period. Comments were received from two Federal agencies, one Territory agency, four peer reviewers, and nine private organizations or individuals. Since the comment period closed, additional information and updates to the plan have also been received by the Service. All comments received have been considered and incorporated into the approved recovery plan, as appropriate. A summary of the all of the major comments received and the Service's response follow.

Summary of Comments and Service Responses

Issue 1: Life History of the Sihek

Comment: The recovery plan's discussion of kingfisher habitat requirements are inconsistent and it is inappropriate to relate Pohnpei kingfisher habitat requirements with those of the Guam kingfisher because the climate, soil, and plant community on Pohnpei is very different from Guam.

Response: We agree that the habitat requirements of the Pohnpei Micronesian kingfisher may differ from the habitat requirements of the sihek. However, we believe that including information on the habitat requirements of Pohnpei kingfisher provides information about the potential needs of the sihek and may help facilitate conservation planning for sihek. Therefore, we have kept all of the discussion regarding Pohnpei kingfisher habitat needs. However, we have added additional language to qualify that the Pohnpei kingfisher and sihek may have different habitat requirements.

Comment: One commenter suggested that additional research on the life history of the sihek is not needed.

Response: We disagree that enough is known about the life history to make it unnecessary to do additional research on its life history. We believe that very little is known about the life history of the sihek and that additional research would greatly aid efforts to recover the species. For example, the research being done on the Pohnpei Micronesian kingfisher is being used to improve the captive breeding program for the sihek.

Issue 2: Brown Treesnake Control

Comment: One commenter suggested that brown treesnake control efforts be placed higher in the step-down outline to emphasize their importance.

Response: The step-down outline does not rank the importance of specific recovery tasks. The step-down outline simply categorizes the recovery tasks and lists them to show how they relate to one another. The recovery tasks are ranked using a three-tiered priority ranking system in the Implementation Schedule. Currently, brown treesnake control is one of the highest priority tasks in the recovery plan.

Comment: One commenter suggested we develop a plan for ridding the island of Guam of brown treesnakes.

Response: In 1996, as an effort separate from, and in addition to, recovery planning for the sihek, a brown treesnake control plan was developed with the purpose of controlling snakes on Guam and preventing their spread to other islands. This plan was developed with input from the Departments of Interior, Defense, and Agriculture; Government of Guam; and other parties. Currently, it is being revised based on input from an advisory committee.

Comment: One commenter suggests that the island of Guam be sprayed with a snake-specific spray to rid the island of brown treesnakes.

Response: We are not aware of a registered spray that specifically controls brown treesnakes, nor are we aware of efforts to develop such a spray.

Comment: One commenter suggested that aerial drops of acetaminophen be conducted several years before reintroduction of the sihek because sihek may consume broadcast baits.

Response: We agree that sihek consumption of aerial drop baits with acetaminophen is a concern and have added language to Recovery Task # 4.1.1, p. 61, to that effect.

Comment: One commenter suggested that the majority of funding be used for operational control and to maximize effectiveness of existing brown treesnake control techniques. Developing additional snake control techniques should be conducted last.

Response: We agree that on-the-ground brown treesnake control (Recovery Task # 4.1.1) and improving existing snake control techniques (Recovery Task # 4.1.4.2) are a higher priority than developing additional techniques (Recovery Task # 4.1.5). We have prioritized them accordingly in the Implementation Schedule.

Comment: One commenter stated that including the estimated cost of predator control efforts is inappropriate until effective control techniques have been developed and implemented.

Response: Under the Endangered Species Act, we are required to include estimated costs of recovery actions needed to recover the sihek. Based on currently available information, we estimated the cost to control brown treesnakes for recovery of the sihek using existing technology. These are only estimated costs and may change as new technology is developed and existing techniques are improved.

Comment: One commenter state that the plan concludes that predators other than the brown treesnake are not expected to be a major threat to recovery yet the plan states that $900,000 is needed to address this issue. This is not consistent.

Response: The recovery plan includes monitoring the potential impacts of rats and other predators on sihek as recovery tasks. We believe that these tasks are necessary because no predators studies were ever done on sihek prior to its extinction in the wild. The available information does not indicate that they will necessarily impact sihek recovery, however, when sihek are reintroduced to Guam and their populations are small, it may be possible that these predators may threaten the success of the program. This is especially true if rat populations increase after brown treesnakes are controlled.

Issue 3: Captive Management

Comment: One commenter stated that the Guam Micronesian Kingfisher is one of the most thoroughly managed captive populations and it seems unlikely that any additional resources can be applied to the list of actions outlined in the plan.

Response: The recovery plan is intended to list the management actions that may be necessary to recover the species. As resources are limited, we believe that the allocation of these resources will need to be determined to best fulfill the needs of the species. In the Implementation Schedule, we prioritized each recovery task using a three-tiered system to help focus resources to the higher priority tasks. For those tasks with similar priority rankings, the parties involved in implementing these tasks will need to determine how best allocate funds.

Comment: One commenter suggested that the irregular breeding of sihek appears to be due to density-related stress. They suggested that most of the sihek be moved to Guam or to other cages to reduce density of sihek under current conditions.

Response: Sihek are housed in separate cages, except during breeding. In addition all breeding pairs are housed in separate cages away from other sihek. Therefore, we have no reason to believe that poor reproductive success is due to density-related stress. We do, however, agree that moving additional sihek to Guam would be beneficial, if captive propagation efforts there are found to be successful.

Issue 4: Reintroduction

Comment: One commenter stated that sihek should only be reintroduced when captive breeding facilities can ensure both a sustainable captive population and excess birds for release.

Response: We agree that releasing sihek into the wild before a viable long-term captive population is established is not an appropriate course of action at this time. However, if efforts to increase the captive population are not successful it may be necessary to evaluate other courses of action to help recover the species. At that time, we will seek the input of experts outside the Service on an appropriate course of action. However, because we have no reason to believe that a long-term viable population of sihek cannot be established, alternative courses of action are not included in the recovery plan.

Comment: One commenter asked how large the captive population needs to be before reintroductions can occur.

Response: This will need to be determined by the Guam Micronesian Kingfisher SSP which manages the captive population (see Recovery Task # 2.1). The number needed will be based on founder representation, the effective size of the population, and the annual population growth rate.

Comment: One commenter stated that the plan contains no discussion on how sihek will be introduced to Guam.

Response: Recovery tasks 3.1-3.6 describe the reintroduction planning process that will occur prior to a reintroduction of sihek. Because the planning process is not complete, a detailed discussion of how sihek will be introduced is not available at this time. The reintroduction plan (see Recovery Task # 3.7) will provide details on how sihek should be reintroduced into the wild when it is completed.

Comment: One commenter suggested that the plan overlooks whether there is adequate food for sihek on Guam and asked if there have been any efforts to ascertain whether adequate food is available and are there any plans to re-stock Guam's lizard populations.

Response: Currently, there have been no formal efforts to evaluate whether there is adequate food for sihek on Guam and there are no plans to re-stock lizard populations. The availability of food will be evaluated prior to the reintroduction as part of the reintroduction planning process (see Recovery Task # 3.2.4) and the appropriate management measures will be implemented.

Comment: One commenter asked whether we believe that snake numbers are low enough to start reintroducing sihek to Guam.

Response: We do not believe that brown treesnakes are controlled at sufficient levels to allow for reintroduction. The captive population is also not large enough for a release on Guam. Both of these goals will need to be attained prior to a reintroduction on Guam.

Comment: One commenter asked whether we were considering introducing sihek to Rota.

Response: The recovery plan includes a task to evaluate other islands in the Mariana archipelago as potential release sites. While Rota's potential as a release site could be evaluated under this task, we have no specific plans to introduce sihek to Rota at this time.

Comment: One commenter suggested that sihek be released in other areas than Guam because the current level of brown treesnake control is not adequate and it does not appear that adequate control will even be possible. In addition, they suggested a healthy wild population on another island would be preferred over a stagnant captive population or a doomed release on Guam.

Response: We have added additional discussion of this option in the recovery plan. Because we have no evidence at this time that sihek were ever found on any of the other islands in the Mariana archipelago, we believe Guam is ultimately the most appropriate location for reestablishing a wild population of sihek if brown treesnakes can be adequately controlled. We also believe it is premature to conclude that adequate snake control on Guam will not be possible. However, pending availability of suitable snake-free habitat on Guam, releasing genetically well-represented sihek on another island in the Mariana archipelago could be considered as a backup for the captive population and as a method for introducing captive-reared sihek to free-living conditions in a relatively safe context. Any potential sites for such an introduction would be carefully evaluated for their relative risks and benefits in comparison with retaining individuals in captivity or releasing them on Guam.

Comment: One commenter suggested that effective snake control techniques should be developed and implemented before considering the release of kingfishers into the wild.

Response: We agree that brown treesnakes should be effectively controlled prior to reestablishing sihek to Guam. Snake control at reintroduction sites (Recovery Task # 4.1.1) and improving existing control techniques (Recovery Task # 4.1.4.2) are both high priority recovery tasks. The Recovery Strategy (p. 38) also states that effective brown treesnake control is needed prior to reintroduction of sihek.

Issue 5: Habitat Protection and Management

Comment: One commenter asked why the plan suggests that Government of Guam conservation lands be given to the Service for management.

Response: The recovery plan does not suggest that the Government of Guam conservation lands be given to the Service for management. The recovery plan does suggest that additional management be conducted on these lands (see Recovery task # 4.8.2) but does not suggest this management be conducted by the Service or that the Service should control these lands.

Comment: One commenter suggested that there probably is not enough suitable habitat on Guam to reach the recovery goals outlined in the plan.

Response: Little is known about the habitat requirements of sihek on Guam (see Habitat Requirements, p. 12, for additional information). However, based on available information we believe that there may be adequate habitat available on Guam to reach the recovery goals of this species. However, we also believe that management of this habitat may be needed to improve its quality (Recovery Task # 4.9).

Comment: One commenter suggested that introduced deer and pigs are not a threat to the recovery of the sihek because the forests on Guam have not changed over the last couple of decades and an ungulate eradication and habitat improvement program is not necessary. In contrast, another commenter suggested that browsing by high numbers of introduced ungulates has severely degraded native forests on Guam and habitat loss and degradation is a major concern for recovery of the sihek on Guam.

Response: We agree that feral ungulates have been negatively impacting the native forests on Guam and that this will impact the recovery of the sihek. However, we believe that extent of this impact needs to be further evaluated to determine how best to manage for the recovery of the sihek. Although some research has been completed, we believe that the quality of existing sihek habitat should be assessed (Recovery Task # 4.9.1) and that the management of this habitat would benefit from a management plan (Recovery Task # 4.9.2).

Issue 6: Competition and Harassment by Black Drongos

Comment: Several commenters suggested that black drongos are not a threat to the sihek and that evaluating their impact on sihek is not necessary.

Response: We agree that the available information does not indicate that black drongos are a major threat to the recovery of the sihek. However, Maben (1982) did report harassment of sihek by black drongos in her study. This harassment could be problematic when sihek are first reintroduced to Guam and the sihek population is still small. Therefore, we believe it is necessary to monitor black drongo impacts on sihek and determine if drongo control efforts are needed (Recovery Task # 4.5).

Issue 7: Southern Guam Population of Sihek

Comment: One commenter suggested that the establishment of a sihek population in southern Guam is probably not possible and would be a waste of time and money under current circumstances.

Response: We agree that establishing a sihek population in southern Guam is probably not an appropriate initial course of action, as much of the effort to control predators has been implemented in northern Guam. However, we believe that reestablishing a second population of sihek on Guam is vital to the recovery of the species. Southern Guam is an appropriate location for establishing this second population and as efforts to recover the species continue, it will be appropriate to begin efforts to establish sihek there.

Issue 8: Public Outreach

Comment: One commenter suggested that many of the outreach tasks are a waste of money and that the Guam public understands the brown treesnake and recovery situation.

Response: We agree that much of the public on Guam is aware of the brown treesnake and recovery situation. However, this level of awareness was in large part due to previous public outreach efforts by local and Federal agencies. In order to maintain and increase this level of awareness, we believe additional outreach is needed as recovery efforts continue and progress. Public support and interest is vital to the success of the recovery program.

Issue 9: Funding

Comment: One commenter stated that the plan requires a sizable amount of funding to be implemented and it is unlikely these funds will be available. Without these funds the kingfisher will likely be functionally extinct. The commenter then suggested that the Service consider alternate uses of funding, such as reducing the spread of brown treesnakes to additional islands, that will benefit multiple species in the region.

Response: We agree that implementing the plan will require a sizable amount of funding and that other species in the region could benefit if the available funding for sihek recovery was used elsewhere. However, we are required under the Endangered Species Act to conserve all threatened and endangered species despite their status and their likelihood of recovery. Therefore, we cannot give up our efforts to recover the species. We can, however, place a higher priority on recovery tasks that benefit sihek and other listed species in the Mariana Islands. The final recovery plan does include a large number of high priority recovery tasks, like brown treesnake control, that would benefit other listed species on Guam and in the Mariana Islands.

Comment: One commenter stated that the plan is needlessly expensive and many of the tasks can be paid for by other federal entities like the Air Force and Navy.

Response: We agree that implementing all of the recovery tasks contained within the recovery plan will be expensive. However, section 4(f)(1)(B) of the Act requires the recovery plan to include a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; and estimates of time and the cost to carry out those measures needed to achieve intermediate steps toward this goal. We have strived to include a description of all the management actions that may be necessary to recover the sihek based on the best available information and we have prioritized these tasks (see Implementation Schedule) to focus funding on higher priority tasks. As recovery tasks are completed and the species begins to recover, some of the lower priority tasks may become unnecessary.

Comment: One commenter asked what happens when such a large estimated cost for recovery of a species is presented. Does it affect whether any progress is made on recovery efforts for that species?

Response: Obtaining the total funding required to implement the recovery plan may be difficult and some of the more expensive tasks may take additional time to implement if all of the funding is not available. For the sihek, the most expensive recovery task is brown treesnake control. Unfortunately, with current technology, control of large areas is very labor-intensive and costly. However, brown treesnake control is also a high priority recovery task for the endangered Mariana crow, Guam rail, and Mariana fruit bat. Therefore, the costs estimates provided in this plan also cover tasks that would benefit other listed species. Because this recovery task benefits multiple species, it receives a higher priority for funding and in fact has already received a significant amount of funding.

Issue 10: General Recovery Plan Format and Content Issues

Comment: One commenter asked why the Service is writing a new recovery plan when nothing has changed since the 1990 recovery plan.

Response: Prior to revising the recovery plan, we evaluated the 1990 plan to determine if it was still appropriate for the conservation needs of the sihek. We determined that the primary focus of the 1990 plan, brown treesnake control and sihek captive propagation, had not changed but the recovery efforts needed for the species, especially captive propagation, had become more focused. We also found that many of the recovery tasks outlined in the 1990 recovery plan for the sihek were completed (see Conservation Efforts, p. 25, for a description of tasks completed). Based on this evaluation we determined that the recovery effort for the sihek would benefit from a revised recovery plan that was dedicated to this species.

Comment: One commenter asked what was meant by the statement "Only federal agencies are mandated to take part in the effort," in the implementation section.

Response: Section 7(1)(a) of the Act states that all Federal agencies shall utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of threatened and endangered species. State and local agencies are not required, under the Act, to carry out these programs.

Comment: One commenter suggested that the implementation schedule includes numerous activities (e.g., research on rat predation, registering rodenticides, black drongo control, management of the Guam National Wildlife Refuge and Guam's conservation areas, instituting core curriculum, etc.) that are not specific to the recovery effort and are inappropriate for a recovery plan. These activities distract from the plan and appear to be a massive research, public relations, and employment effort rather than a rigorous scientific-based and plausible recovery effort for the sihek.

Response: We are required to provide a description of all management actions in the recovery plan that may be necessary to recover the sihek. Recovery of the species will require a wide range of actions from multiple parties. We have strived to be as comprehensive as possible in including recovery tasks that we believe are necessary to recover the species. We reevaluated the recovery tasks and removed several that were in the draft revised plan because we believe they may not be necessary for recovery. However, the majority of the recovery tasks included in the draft revised plan were also included in the final revised plan.