TECHNICAL NOTE

USDA NATURAL RESOURCES CONSERVATION SERVICE PACIFIC ISLANDS AREA

Biology Technical Note No. 20

Bats of the U.S. Pacific Islands

Photo Honolulu Zoo

Hawaiian hoary bat
ʻŌpeʻapeʻa

Photo © M. D. Tuttle, BCI

Mariana fruit bat
Fanihi

Photo A. Brooke

Samoan flying fox
Peʻa vao

Purpose. To provide an introduction to the habitat requirements of bats in Hawaiʻi, American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI) and general guidance on conservation practices to enhance and manage bat habitats.

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ACKNOWLEDGEMENTS

Written by Kimberly Uyehara and Gary Wiles for the USDA, Natural Resources Conservation Service, Pacific Islands Area. Improved by comments from Sandra Banack, Julia Boland, Frank Bonaccorso, Anne Brooke, Joy Browning, Mark Defley, Jacqueline Flores, Kathleen Friday, Dustin Janeke, Wallace Jennings, Gregory Koob, Ann Marshall, Theresa Menard, Thomas O'Shea, Athena Pratt, Joseph Ruak, P. Quentin Tomich, and Joseph Tuquero. Photos provided courtesy of Bat Conservation International, Honolulu Zoo, U.S. Geological Survey, Art Whistler, and many others credited below.

HAWAIIAN HOARY BAT*

Federal – Endangered
State – Endangered

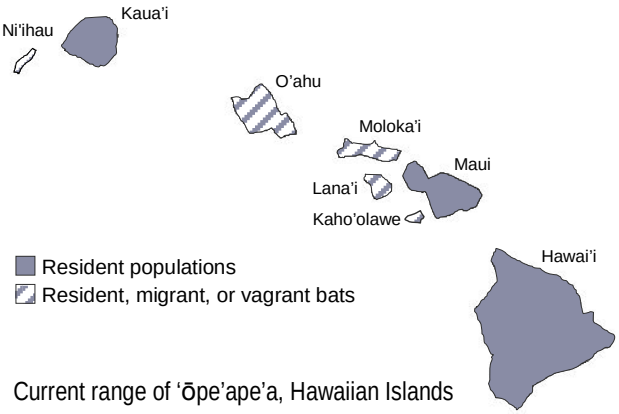
Photo Honolulu Zoo

Species Profile
Hawaiian hoary bat, **ʻōpeʻ**apeʻa

Scientific name: *Lasiurus cinereus semotus*
Habit: Solitary, nocturnal
Average wingspan: 10.5 - 13.5 inches (26.9 - 34.6 cm)
Weight: male 0.5 oz (14.2 g); female 0.6 oz (17.9 g)
Range: main Hawaiian Islands
Approximate breeding period: April - December
No. of pups per year: 2 (twins)
Roosting habitat: Trees with dense foliage
Foraging habitat: Open and wooded landscapes and linear habitats such as windbreaks and riparian corridors
Food habits: Aerial insectivore - eats night-flying insects primarily moths, beetles, and termites
Population estimate: unknown

INTRODUCTION

The Hawaiian hoary bat or ʻōpeʻapeʻa is a medium-sized member of the vesper bat family (Vespertillionidae) which consists of nocturnal, mostly insect-eating bats. It is an endemic subspecies of the North American hoary bat, a solitary tree-roosting species (does not use bat boxes). ʻŌpeʻapeʻa has frosted brown and gray fur which gives it a hoary appearance. Fur color, frosted or reddish, may be related to location or age. The best time to observe Hawaii's only native land mammal is at sunset when it comes out to feed. It's a major predator of night-flying insects such as moths, beetles, and termites. Insectivorous bats play an important role in regulating insect populations of natural and agricultural ecosystems.



Current range of ʻōpeʻapeʻa, Hawaiian Islands

STATUS & DISTRIBUTION

Although the number of bats is unknown, resident populations occur on Kauaʻi, Maui, and Hawaiʻi and possibly other main islands, with the largest numbers on Kauaʻi and Hawaiʻi. Bats occur at all elevations, with the majority of sightings below 7500 ft (2286 m) on Hawaiʻi and in lowlands on Kauaʻi. Local occurrence is influenced by insect prey abundance (*1*). It is a Federal and State endangered subspecies, but many have questioned whether the subspecies is truly endangered with so little known about its status. In 2002, the Hawaiian Hoary Bat

* **This information was taken primarily from the USFWS Recovery Plan and the current research of Dr. Frank Bonaccorso of USGS.**

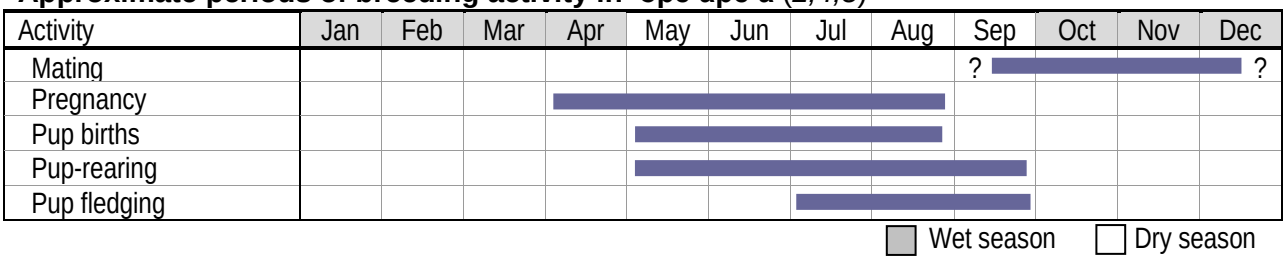
Research Cooperative was formed to overcome the challenges of recovering Hawaii's elusive ʻōpeʻapeʻa. The cooperative includes over 25 entities representing wildlife conservationists, foresters, agriculturalists, land managers, and researchers working toward sustainable conservation and development.

Photo Honolulu Zoo

REPRODUCTIVE CYCLE

ʻŌpeʻapeʻa appear to make altitudinal migrations between lowland breeding and highland wintering grounds, at least in windward Hawaiʻi, spending about May-November in lowlands and January-April in highlands (>5250 ft [1600 m]) (*2,3*). Although a fall mating period has been suggested (*4*), the mating period is unknown. Pregnant females have been observed April to August. A 2-3 month gestation (pregnancy) is followed by about a 2-3 month nursing period (*5*). Females are believed to give birth to twins between May and August and rear pups between May and September. Pups fledge (take first flights) from about July-September, which is a critical time in the reproductive cycle. Although unknown for the Hawaiian subspecies, hoary bat pups in Canada fledge within 4-5 weeks and are weaned at about 7 weeks of age (*6*).

Approximate periods of breeding activity in ʻōpeʻapeʻa (*2,4,5*)



HABITAT REQUIREMENTS

ʻŌpeʻapeʻa occur in nearly every habitat within their range including native, nonnative, agricultural, and developed landscapes. Habitat examples:

- **Barren land**. Volcano craters and lava fields for **foraging**
- **Cropland**. Macadamia nut farms with tall windbreaks and other orchards for **foraging and roosting**
- **Developed land**. Golf courses, urban areas, suburban yards, rural roads, and farmsteads for **foraging and roosting**
- **Forest land**. Eucalyptus plantations, albizia-dominant forest, ʻōhiʻa-dominant forest, koa-dominant forest, and māmane-naio forest for **foraging and roosting**
- **Other rural land**. Rural yards and windbreaks for **foraging and roosting**
- **Pastureland**. Grazed lands with a forest component for **foraging**
- **Rangeland**. Fallow fields near forest for **foraging**
- **Water areas**. Reservoirs, wetlands, river corridors, and coastal waters for **foraging**

Food. ʻŌpeʻapeʻa forage on moths, beetles, termites, leafhoppers, flies, bugs, and other night-flying insects (*7*). Prey is located using an advanced technique known as echolocation (bats detect size, distance, and shape of prey by emitting and interpreting sound pulses that bounce

off objects). In open habitats, medium-sized moths (0.6-0.8 inches [16-20 mm] long) are preferred over large moths (>0.8 inches [20 mm]) and small moths and flies (<0.4 [10 mm]) (*8*). In forested habitats, bats feed on a variety of small insects (*9*).

A North American hoary bat echolocates and captures moth prey (Photos © Merlin D. Tuttle, Bat Conservation International).

Cover (foraging). ʻŌpeʻapeʻa forage in open, wooded, and linear habitats. Vegetation varies widely. On Hawaiʻi, bats fed 65-165 ft (20-50 m) above an ʻōhiʻa forest-pasture patchwork and >50 ft (15 m) above māmane-naio forest (*10*). Bats also forage regularly below the forest canopy down to within 2 ft (0.5 m) of ground (*11*), along forest edges and gaps (e.g., eucalyptus plantations adjacent to fallow fields), and in croplands with structural diversity (e.g., macadamia nut farms with tall windbreaks) (*5*).

Cover (roosting). Vegetation cover and structure appear to be more important than tree species, as bats readily use both native and nonnative trees such as eucalyptus, mango, lychee, avocado, albizia, ʻōhiʻa, and pandanus (*12*). On Hawaiʻi, roosts are located in dense canopy foliage (or subcanopy when canopy is sparse) with open access for launching into flight. Bats generally roost below 15 ft (5 m) in macadamia and Cook pine and above 15 ft (5 m) in eucalyptus (*13*). There are a few records of bats occurring in lava tubes and other cavities (*14,15*).

Bats are attracted to flying insects attracted to macadamia flowers, and also feed along the edges of tall windbreaks (*11*) (Photo K. Uyehara).

Water. Foods presumably meet water requirements. ʻŌpeʻapeʻa are not known to drink from water bodies, but are regularly observed foraging over streams, reservoirs, wetlands, stream mouths and out to about 330 ft (100 m) offshore (*10*). Bats may be attracted to insects of lush riparian vegetation or insects emerging from water, as many flying insects have aquatic larval stages (*11*).

Interspersion of habitat components. Suitable foraging and roosting habitat near one another is preferable. Although the optimal interspersion (mix of habitat types) is unknown, varied habitat structure near riparian corridors or other insect-rich habitats appears beneficial.

Minimum habitat area. ʻŌpeʻapeʻa are capable of both high altitude and interisland flight. They require large areas that may encompass multiple landowners. For example, home range (area a bat normally uses for foraging and roosting) for males on a macadamia nut farm averages 124 ac (50 ha), but bats can also commute >7 miles (11 km) from roosts to foraging areas. Home range size varies with habitat type and territories may overlap (*5*).

PACIFIC SHEATH-TAILED BAT

Federal – Candidate
Guam – Endangered
CNMI – Threatened/Endangered
American Samoa – Protected

INTRODUCTION

The Pacific sheath-tailed bat is a member of the sheath-tailed, sac-winged, and ghost bat family (Emballonuridae), which consists of mainly nocturnal, colonial, cavity-dwelling, insect-eaters. Its name comes from the sheath (little tube) around the tail formed by the uropatagium (skin connecting the tail and hind legs). The sheath allows the bat to adjust the length of its uropagatium in flight and skillfully maneuver the forest understory. The Pacific sheath-tailed bat is a small bat, often mistaken for a swiftlet with which it commonly roosts in caves. Little is known about this rapidly declining species.

STATUS & DISTRIBUTION

Pacific sheath-tailed bats occur in the islands of the Marianas, the Carolines, Vanuatu, Fiji, Tonga, and Samoa (4 subspecies). They are common in Palau and Pohnpei in the Carolines, but have greatly declined or disappeared in many other parts of their range in recent decades. One subspecies is known only from the Mariana Islands. The only population of this subspecies contains about 400-500 bats on Aguiguan in the CNMI (*16*). Bats are now extirpated (locally extinct) on Guam and possibly American Samoa (*17-19*). They are protected locally in Guam, the CNMI, and American Samoa and are a candidate for Federal listing under the Endangered Species Act.

REPRODUCTIVE CYCLE

Almost nothing is known about their breeding biology. A pregnant female with one embryo was collected on Aguiguan in the month of June (*17*).

Species Profile
Pacific sheath-tailed bat
fanihin liyang, fanihen toyu, payesyes (Guam)
liyang, payesyes, pai'scheei (CNMI)
pe'ape'a vai (American Samoa)

Photo E. Valdez, USGS

Scientific name: *Emballonura semicaudata*
Habit: Colonial, nocturnal
Total length: 2.4 - 2.9 inches (60 - 74 mm)
Weight: male 0.19 oz (5.5 g); female 0.25 oz (7.2 g)
Range: Micronesia, Melanesia, Polynesia
Breeding period: Unknown
No. of pups per year: Probably 1
Roosting habitat: Caves, crevices, and other cavities
Foraging habitat: Mainly forests
Food habits: Aerial insectivore - eats small night-flying insects
Population estimate: 400 - 500 (Aguiguan, CNMI); extirpated (Guam); possibly extirpated (American Samoa)

HABITAT REQUIREMENTS

Although information is lacking on habitat requirements, research on the Aguiguan population and general observations from other islands shed light. Pacific sheath-tailed bats generally roost in caves, but large tree hollows are also occupied in Pohnpei. Detailed studies on their echolocation sounds at night show that on Aguiguan they feed mainly in native limestone forest (*16*). General observations elsewhere suggest that they can also use other native, nonnative, agricultural, and developed landscapes. Habitat examples:

- **Barren land**. Caves, crevices, and other cavities for **roosting**
- **Cropland**. Coconut groves for **foraging**
- **Developed land**. Rural roads, windbreaks, rural yards for **foraging**
- **Forest land**. Native forest, secondary forest, agroforest for **foraging**; tree hollows and other cavities for **roosting**
- **Rangeland**. Shrublands or fallow fields near forest for **foraging**

Aguiguan is a 1779-acre (720 ha) limestone island located 5.6 miles (9 km) southwest of the Island of Tinian, CNMI. Here, Pacific sheath-tailed bat habitats include caves along sea cliffs and native forest (Photos P.M. Gorresen, USGS).

Food. Pacific sheath-tailed bats forage on small night-flying insects. Prey is located by echolocation (bats detect size, distance, and shape of prey by emitting and interpreting sound pulses that bounce off objects).

Cover (foraging). Bats forage in native and nonnative forested landscapes. On Aguiguan, bats emerge from their caves around the time of sunset to begin foraging. Bats feed on insects in the understory down to <3 ft (1 m) above ground, but also in and above the upper forest canopy and around tall ironwood trees (*16,20*). On Pohnpei, bats were observed during the day in dense native forest, presumably foraging (*21*).

Cover (roosting). Bats roost in caves, but also crevices, lava tubes, rock depressions, overhanging cliffs, hollows of large trees (*22*), rock falls, and even under bridges (*19*). On Aguiguan, bats roost in large to medium-sized caves ranging from 13-82 ft [4-25 m] tall, 3-148 ft [1-45 m] wide, and 30-165 ft [9-50 m] long on cave ceilings and upper walls in areas of darkness or dim ambient light (*23*).

Water. Foods presumably meet water requirements. Like other insectivorous bats, they probably forage in insect-rich mangrove swamps and riparian zones when available.

Interspersion of habitat components. Suitable roosting habitat near insect-rich foraging habitats is favorable.

Minimum habitat area. Home range is unknown. On Aguiguan, 400-500 bats rely on 741-988 ac (300-400 ha) of native limestone forest (*16*). On Palau, some bats fly ≥3 miles (5 km) to forage (*24*).

POTENTIAL THREATS – Insectivorous bats

USGS research biologists and associates collect data to assess the status of Pacific sheath-tailed bats on Aguiguan, the site of the last known population in the Mariana Islands (Photo E. Valdez, USGS).

Descriptions of threats to **Hawaiian hoary bats** and **Pacific sheath-tailed bats** are mostly speculative. Thus, for Hawaiian hoary bats we address potential threats to help prevent these factors from becoming a problem in the future. For Pacific sheath-tailed bats we address suspected threats because populations are disappearing before threats can be identified.

Roost disturbance. Roost disturbance is a common threat to bats worldwide. For **Hawaiian hoary bats**, this may include: (a) clearing trees that bats roost in, (b) loud unpredictable activities such as building a structure near a bat roosting site, or (c) other human activities that alter normal feeding and breeding patterns or cause direct mortality, which would be violations of Federal and State endangered species laws. Roost disturbance when juvenile hoary bats are fledging (Jul-Sep) has the highest potential for negative impacts (*11*). Hawaiian hoary bats don't seem to have high roost site fidelity (may return to the same area but not necessarily the same tree), use roosts seasonally, and are adaptive to human-modified landscapes (*5*). **Pacific sheath-tailed bats** readily flush from caves during the day when disturbed. On Aguiguan, some remaining colonies are found in large cliff-side caves inaccessible to humans and feral ungulates (*20*), suggesting that these bats are sensitive to noise caused during cave intrusions.

Loss of habitat. Loss of native forests from agricultural conversions, other types of development, and/or WWII destruction historically contributed to **Hawaiian hoary bat** and **Pacific sheath-tailed bat** habitat loss. Although secondary forests and plantations have replaced some native forests, invasive plants and animals such as feral ungulates continue to contribute to **Pacific sheath-tailed bat** habitat loss and degradation (*16*). Cave destruction, especially during WWII, eliminated some **Pacific sheath-tailed bat** roosting habitat in the Marianas and perhaps elsewhere.

Pacific sheath-tailed bat habitat on Aguiguan, note over-browsing by feral goats (Photo P.M. Gorresen, USGS)

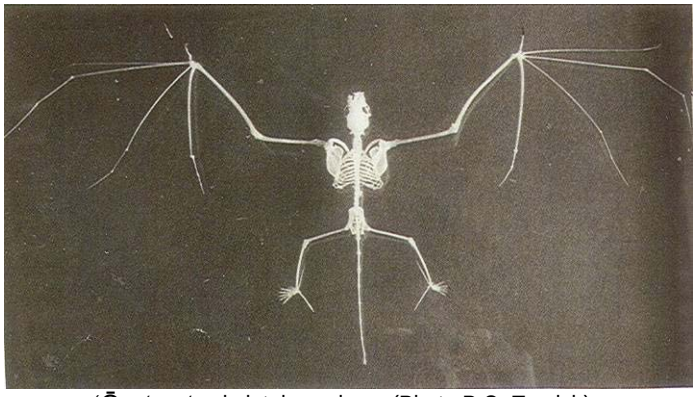
Obstacles to flight. Obstacles during flight are a major source of mortality for some continental species, particularly during mass migrations. Major sources of mortality include windfarms for migratory tree-roosting bats like the North American hoary bat (*25*) and barbed wire fences for some migratory bats in Australia (*26*). **Hawaiian hoary bats** are not known to migrate in large aggregations. Nevertheless, a small number of individuals have been documented colliding with obstacles (e.g., wall, vehicle, windmill, barbed wire fence), presumably while foraging (*2*).

Dr. Ben Okimoto monitors the health of a Hawaiian hoary bat with an injured wing (Photo Honolulu Zoo).

Introduced predators. Young **Hawaiian hoary bats** may be vulnerable to cats, rats, and other predators during rearing and fledging periods. On Aguiguan, rats and monitor lizards are potential predators of **Pacific sheath-tailed bats**, and brown tree snakes would be a threat if they reached the island (*20*).

Pesticides. Insecticides can affect the abundance of insect prey available to **Hawaiian hoary bats** and **Pacific sheath-tailed bats** through reduction in insect populations or insect habitat, and may cause bats to fly further in search of food or feed in unfamiliar landscapes. Some insecticides can also affect bats through bioaccumulation of chemicals through the food chain. Herbicides can alter vegetation structure and community composition in foraging habitats, likely influencing the availability of insect prey.

Natural phenomena. Natural phenomena can become a factor in species decline for populations already in danger of local extinction. In Guam, CNMI, and American Samoa, typhoons/hurricanes can cause flooding of seaside caves and potentially damage food resources of **Pacific sheath-tailed bats**. Although storms typically last only a day, storm surges, flooding, tree defoliation, and insect depletions associated with severe storms have longer term effects (*22*). In American Samoa, coastal caves are small, shallow, and vulnerable to tidal surges (*19*).



ʻŌpeʻapeʻa skeletal specimen (Photo P.Q. Tomich).

SUMMARY OF HABITAT COMPONENTS – Insectivorous bats

Habitat component	Habitat characteristics	
	☐ Hawaiian hoary bat	☐ Pacific sheath-tailed bat
Food	▪ Moths, beetles, termites, leafhoppers, flies, bugs and other night-flying insects	▪ Small night-flying insects
Cover (foraging)	▪ Open, wooded, and linear habitats ▪ Forest edges and gaps, croplands with structural diversity ▪ All elevations	▪ Native and nonnative forests ▪ Forages in forest understory, also in and above upper canopy
Cover (roosting)	▪ Trees with dense foliage ▪ Human activity is minimal ▪ All elevations to treeline	▪ Roosts in caves and other cavities ▪ Human and ungulate disturbance minimal
Water	▪ Foods presumably provide adequate water in diet ▪ Forage over wetland, riparian, and coastal-marine habitats	▪ Foods presumably provide adequate water in diet
Interspersion	▪ Suitable roosting habitat near insect-rich foraging habitats	▪ Suitable roosting habitat near insect-rich foraging habitats.
Minimum habitat area	▪ Wide ranging species ▪ Average home range is 124 ac (50 ha) for males on a macadamia nut farm, varies by habitat type, territories may overlap	▪ Home range unknown
Potential threats	▪ Roost disturbance ▪ Loss of habitat ▪ Obstacles to flight ▪ Introduced predators ▪ Pesticides ▪ Natural phenomena (e.g., severe storms)	▪ Roost disturbance ▪ Loss of habitat ▪ Obstacles to flight ▪ Introduced predators ▪ Pesticides ▪ Natural phenomena (e.g., severe storms, tidal surges)

ASSESSMENT OF LIMITING FACTORS – Insectivorous bats

Using the habitat characteristics above, subjectively rate the (a) availability and quality of bat habitat and (b) presence or absence of potential threats within a planning area. Habitat components rated “low” or “absent” or potential threats rated “present” could be limiting habitat quality.

(a) Habitat component	Quality / Availability			
	High	Medium	Low	Absent
Food				
Cover (foraging)				
Cover (roosting)				
Water				
Interspersion				
Minimum habitat area				

(b) Potential threat	Present	Absent
Roost disturbance		
Loss of habitat		
Obstacles to flight		
Introduced predators		
Pesticides		
Natural phenomena		

MANAGEMENT RECOMMENDATIONS – Insectivorous bats

Management treatments should address the habitat components and potential threats that appear to limit habitat potential for bats. Specific management options are lacking for both species. Thus, general advice for insectivorous bats is given below that may increase the quality or availability of each habitat component. NRCS Conservation Practices and various programs that may provide financial or technical assistance to carry out practices are also listed.

Habitat component	General management options for increasing habitat quality or availability	Conservation Practices
Food	▪ Minimize adverse effects of pesticides on non-target species (i.e., reduction in prey and prey habitat) by developing an integrated pest management plan; include role of bats and other native species in reducing pest outbreaks	595, 645
Cover (foraging) *If insectivorous bats are known or suspected to be foraging in area:*	▪ In native forest, protect and enhance habitat especially mature trees and understory; restore new forest patches ▪ Restore forest community structure and function to benefit multiple species of native birds and bats ▪ Consult with NRCS Biologist, Forest Ecologist, or Plant Materials Center for best plant sources, spacing, care, and maintenance (See Appendix A for native plants used by Hawaiian hoary bat) ▪ For Island of Hawai‘i, see NRCS Ecological Site Descriptions for your planning area: http://esis.sc.egov.usda.gov/	314, 382, 550, 612, 643, 645
	▪ In orchards, increase horizontal and vertical vegetative structure by enhancing windbreaks; plant multi-species, tree-shrub windbreaks with varied leaf forms; use native species when feasible	380, 612, 645, 650
	▪ In tree plantations, avoid extensive clearcuts; integrate selective harvest techniques that leave young trees and snags; create gaps, bays, or irregular forest edges	645, 666
	▪ Leave snags (dead or dying trees) and downed wood; old trees and decomposing woody debris provide good habitat for insects and other organisms eaten by bats	643, 645
	▪ Exclude feral ungulates through fencing or control feral ungulate populations through trapping or hunting	382, 645
Cover (roosting) *If insectivorous bats are known or suspected to be roosting in area:*	▪ Protect roost sites and surrounding habitat by excluding areas from or minimizing activities related to resource extraction, grazing, or vehicular traffic Hawaiian hoary bat: ▪ Minimize chances of negatively impacting roosting bats by conducting activities such as vegetation clearing or timber harvesting when bats are not or not likely to be present ▪ In windward Hawai‘i, bats are not likely to be present Jan-Apr in	382, 472, 528, 595, 645

Habitat component	General management options for increasing habitat quality or availability	Conservation Practices
	lowlands and Jun-Nov in highlands (>5250 ft [1600 m] elevation) Pacific sheath-tailed bat: ▪ Control feral ungulate access to caves through fencing, gating, trapping, or hunting ▪ Control human access to caves through gating and signage	
	▪ Protect roost sites and surrounding habitat from potential predators Hawaiian hoary bat: ▪ Keep cats and dogs restrained and away from bat roost sites, particularly during breeding ▪ Hawaiian hoary bats bear young May-Aug and fledge pups Jul-Sep which is the most critical time (see pg. 3) Pacific sheath-tailed bat: ▪ If rats or monitor lizards are suspected predators, control them through trapping or other wildlife agency approved methods	382, 595, 645
Water *General advice to conserve and enhance insect diversity for bats*	▪ If river bank management (e.g., dredging) is necessary, restrict management to small areas or one bank at a time; protect habitat by retaining natural meanders, shallow pools and riffles, and bankside trees and shrubs	391, 395
	▪ Establish riparian buffer zones through fencing, managing roads, runoff, feral ungulates, livestock, and vegetation (for large properties, conduct a watershed analysis to identify and halt or control activities contributing to habitat degradation)	382, 390, 391, 395, 528, 560, 578, 614
	▪ Protect and enhance wetlands; including small temporary pool complexes with varied depths, aquatic vegetation, and high insect diversity	644, 646, 659
	▪ Avoid introducing nonnative fish to water bodies; fish can deplete aquatic insect communities and degrade water quality	644, 646
Interspersion and minimum habitat area	▪ Consider relationship of planning area to habitat components on property or neighboring lands. Landowners can manage for bats if one of more of the habitat components is present on their property and adjacent lands provide other habitat components.	645
Fencing considerations	Options to prevent potential bat entanglement in barbed wire fences: ▪ Replace top 2 strands with smooth high-tensile wire ▪ Omit barbed wire atop hogwire fences ▪ Install a 6-ft (1.8-m) high hogwire fence without barbed wire on top ▪ Remove fence if old or no longer needed	382, 645

NRCS Conservation Practices: 314 Brush Management, **380** Windbreak/Shelterbelt Establishment, **382** Fence, **390** Riparian Herbaceous Cover, **391** Riparian Forest Buffer, **395** Stream Habitat Improvement and Management, **472** Access Control, **528** Prescribed Grazing, **550** Range Planting, **560** Access Road, **578** Stream Crossing, **595** Pest Management, **612** Tree/Shrub Establishment, **614** Watering Facility, **643** Restoration and Management of Rare or Declining Habitats, **644** Wetland Wildlife Habitat Management, **645** Upland Wildlife Habitat Management, **646** Shallow Water Management for Wildlife, **659** Wetland Enhancement, **650** Windbreak/Shelterbelt Renovation, **666** Forest Stand Improvement (More info: http://www.nrcs.usda.gov/technical/efotg/).

NRCS Conservation Programs that apply: CREP Conservation Reserve Enhancement Program (Hawai'i only - administered by Farm Service Agency); **CSP** Conservation Stewardship Program; **EQIP** Environmental Quality Incentives Program; **WHIP** Wildlife Habitat Incentives Program; **WRP** Wetlands Reserve Program (More info: http://www.pia.nrcs.usda.gov/).

MARIANA FRUIT BAT*

Federal – Threatened
Guam – Endangered
CNMI – Threatened/Endangered

INTRODUCTION

The Mariana fruit bat or fanihi is a medium-sized member of the ecologically important old world fruit bat family (Pteropodidae), which consists of bats that forage primarily on fruit, flowers, nectar, and pollen. It is a striking dark brown to black bat with a golden "cape" around its neck and back. On islands, fruit bats (also known as flying foxes) are often important seed dispersers, playing a critical role in plant reproduction, diversity, and distribution, including post-typhoon plant regeneration (*27-29*).

Species Profile
Mariana fruit bat, fanihi, pai'scheei

Photo © Merlin D. Tuttle, Bat Conservation International

Scientific name: *Pteropus mariannus*
Habit: Colonial, nocturnal
Wingspan: 34 - 43 inches (86 -108.5 cm)
Weight: 0.73 - 1.37 lbs (330 - 620 g)
Range: Micronesia, formerly Ryukyu Islands
Breeding period: Year-round
No. of pups per year: Usually 1
Roosting habitat: Primarily native forests
Foraging habitat: Forests, farmlands, and coastal strand
Food habits: Frugivorous - eats primarily fruit, also nectar, pollen, flowers, and leaves
Population estimate: 5000 (Marianas)

STATUS & DISTRIBUTION

The species is known from the Caroline (Palau, Ulithi, Yap, Kosrae), Mariana, and formerly Ryukyu islands (6 subspecies). In the Marianas, it was once a common sight. On Guam, fanihi became less common in the 1930s-1940s, then plunged from about 3000 in the 1950s to <50 bats twenty years later. Today, there are an estimated 5000 bats in the CNMI and <100 on Guam (*22*). Overall, bat numbers in the southern and some northern islands in the chain are in decline, while numbers on some northern islands appear stable (*30*). Few fanihi survive on Saipan or Tinian. Colonies are believed to move infrequently between islands, probably in response to severe food limitations or colony disturbance (e.g., typhoons followed by poaching), which may explain sudden increases or decreases in bat numbers on individual islands (*31*). Historically, fanihi coexisted on Guam with little Mariana fruit bats, which are now extinct.

Fanihi are a traditional food source of the people in the Marianas. However, overhunting is a major cause in the bats' decline, both in the past and presently. Fanihi are Federally-protected as a Threatened species throughout the Mariana Islands. Hunting is prohibited by law until fanihi populations can be restored to larger levels that may allow for sustainable harvests.

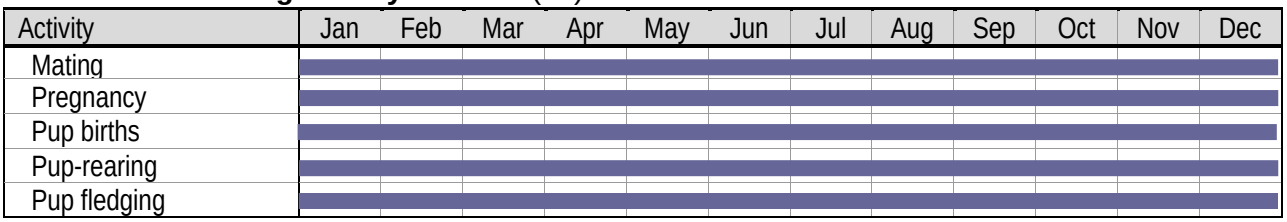
* **This information was taken primarily from the USFWS Recovery Plan.**

Recent studies linking regular consumption of fanihi to a disease of the nervous system (known as lytico-bodig) in people on Guam suggest this practice may have negative health effects (*32*).

REPRODUCTIVE CYCLE

Fanihi breed year-round with no apparent seasonal peak. Females bare one pup at a time. Although unknown for fanihi, other fruit bats have a gestation period (pregnancy) of 4.5-6 months, and pups reach maturity between 6-18 months of age. Historically on Guam, the species roosted in large colonies (60-800 bats) made up of harems, bachelor groups, and solitary males. Harems consisted of 1 male to 2-15 females. On Sarigan (CNMI), there are more solitary bats and smaller colonies than on some of the larger islands in the chain (*33*).

Periods of breeding activity in fanihi (*34*)



HABITAT REQUIREMENTS

Fanihi mainly forage and roost in both native limestone and volcanic forest, but also secondary native-nonnative mixed forest, forest patches, and coastal strand. Tangantangan forest, farmlands, and developed areas are used infrequently (*34*). In Palau and Yap, mangroves and agroforests are also important (*35,36*). Habitat examples:

- **Cropland**. Coconut groves for **foraging and roosting**
- **Forest land**. Native limestone and volcanic forest, secondary native-nonnative mixed forests, and mangrove forest for **foraging and roosting**; agroforests for **foraging**
- **Other rural land**. Rural yards for **foraging**
- **Rangeland**. Coastal strand and savanna with trees for **foraging and roosting**

Food. Fanihi are primarily frugivorous, feeding on fruit, nectar, and pollen and occasionally flowers and leaves. They feed on at least 39 species of plants in the Marianas. Of these, 72% are native (*37*). Bats usually begin feeding about sunset and return to roosts before sunrise, but can also be seen during the day. Fanihi have well developed sensory organs and locate food by sight and smell. Foods include fruit of pandanus, breadfruit, fig, fagot, cycad, tropical almond, and false elder and the nectar of kapok, coral tree, and coconut flowers (See Appendix B).

Cover (foraging). Fanihi forage in native forests and other forests where human activity is infrequent, but may venture into rural areas in search of food particularly after typhoons have depleted regular food sources (*38*). In Palau and Yap, bats regularly forage in mangrove forests (*35*), pandanus savanna, and agroforests (*36*).

Fanihi foraging on (left to right) a liana flower, cycad fruit, and kapok flower (Photos © Merlin D. Tuttle, Bat Conservation International).

Cover (roosting). Large emergent trees with easy access for bats, such as banyan, ironwood, breadfruit, pengua, yoga, fagot, and chopak are regularly used for roosting. On Guam, fanihi roost primarily in native limestone forest along steep cliff faces largely inaccessible to humans (*34*). On Sarigan, where there's little human disturbance, roosts are located in stands and patches of volcanic forest and isolated coconut trees in savanna (*33*). On Yap, bats regularly roost in mangroves and secondary forests (*36*). Colonies may relocate if disturbed by people, but may use favored roost sites for long periods if left undisturbed.

Fanihi roosting in a banyan tree in native limestone forest on Guam (Photo © Merlin D. Tuttle, Bat Conservation International).

Water. Moisture in ripe fruit and other foods meets water requirements. Bats also lap up rainwater from leaves.

Interspersion of habitat components. Suitable roosting habitat near suitable foraging habitat with minimal or no disturbance generally allows bats to forage efficiently and dedicate more time and energy toward successful reproduction (*36*).

Minimum habitat area. The species requires large areas that can encompass multiple landowners. Foraging distances are similar to other medium-sized, Pacific Island flying foxes. For instance, 2 of 3 radio-collared fanihi in primary and secondary forest commuted approximately 2-3 miles (4-5 km) from day roosts to night foraging areas (the third flew up to 11 miles [18 km]). Foraging areas ranged from 35-270 ac (14-110 ha), but bats spent most of their time in core areas of about 14-30 ac (6-12 ha). Foraging areas vary by habitat type and quality (*39*).

SAMOAN FLYING FOX

Federal – Species of Concern
American Samoa – Protected Species

INTRODUCTION

The Samoan flying fox or pe'a vao is one of two medium-sized members of the old world fruit bat family (Pteropodidae) in the Samoan archipelago. Its body is dusty black with russet-brown on its neck and shoulders. Its head can have yellowish or whitish patches or be grayish (*40*). While most fruit bats are nocturnal and roost in colonies, pe'a vao is unique because it roosts alone or in small family groups and is active during the day and night (*41*). The long-term survival of pe'a vao is dependent on hunting limitations and protection of primary forest tracts (*42*).

STATUS & DISTRIBUTION

The species distribution includes the islands of Samoa, Fiji (2 subspecies) and, based on the fossil record, formerly Tonga. In American Samoa, resident populations of pe'a vao occur on Tutuila, Aunu'u, and Manu'a at a wide range of elevations (*41*). The population estimate for Tutuila is currently about 1000-1500 bats (*19,42,43*), but is uncertain for other islands. Pe'a vao were able to rebound from being overhunted after hunting was banned in 1992. Overall, the American Samoa population is believed to be locally stable but in need of ongoing protection due to illegal hunting, habitat loss, and hurricanes (*19*).

REPRODUCTIVE CYCLE

Females generally bear one pup per year. Pregnancy lasts about 5 months. Most births occur April to June, however, births have been recorded March to November. Pe'a vao pups have been observed year-round, but more often between March and October. Pups fledge (begin to fly) at about 2-3 months but remain dependent on their mother's milk until 4-6 months of age or more. The final stages of pup-rearing may overlap with mating (*40-42*).

Species Profile
Samoan flying fox, pe'a vao

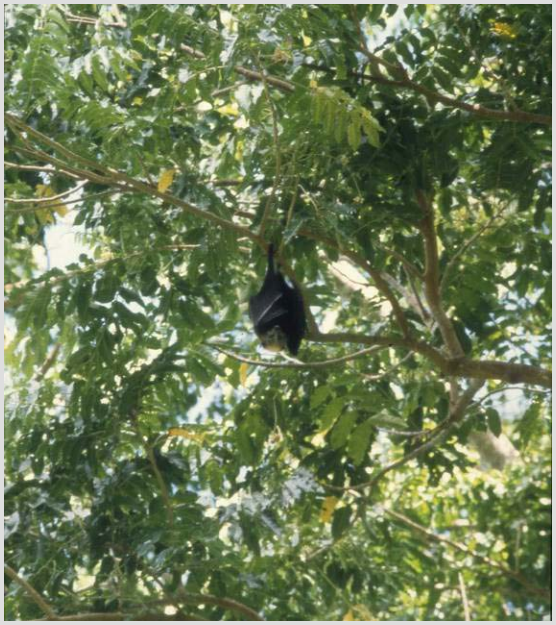


Photo A. Brooke

Scientific name: *Pteropus samoensis*
Habit: Generally solitary, diurnal and nocturnal
Average wingspan: 34 inches (86 cm)
Weight: 7.8 - 15.5 oz (220 - 440 g)
Range: Polynesia
Breeding period: Year-round
No. of pups per year: 1
Roosting habitat: Primary and secondary forests, forest edges, large trees in pasturelands
Foraging habitat: Primary and secondary forests
Food habits: Frugivorous - eats primarily fruit, also nectar, pollen, flowers, and leaves
Population estimate: 1000 - 1500 (Tutuila, American Samoa)

Periods of breeding activity in pe'a vao (*40-42*)

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mating	Off-peak							Peak	Peak	Peak	Peak	Peak
Pregnancy	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak
Pup births			Off-peak	Peak	Peak	Peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	
Pup-rearing	Off-peak	Off-peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Peak	Off-peak	Off-peak
Pup fledging	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Off-peak	Peak	Peak	Peak	Off-peak	Off-peak

Peak Off-peak

HABITAT REQUIREMENTS

Pe'a vao roost and forage in mainly primary forest, but also secondary forest and agroforest. Developed areas are used infrequently or not at all. Habitat examples:

- **Cropland**. Coconut plantations for **foraging**
- **Forest land**. Primary forest, secondary forest, and agroforest for **foraging and roosting**
- **Other rural land**. Rural yards for **foraging**
- **Rangeland**. Large trees in pasture for **roosting**

Food. Pe'a vao are primarily frugivorous, feeding on fruit and occasionally nectar, pollen, flowers, and leaves. They feed on at least 32 species of plants. Of these, 91% are found in primary forest. They typically begin to forage in late afternoon and may return to the roost as late as mid-morning (*44*). Preferred fruit include those of the māmālava, 'ala'a, tropical almond, and probably banyan. Flowers of asi, māmālava, and 'ie'ie are frequently visited. Leaves of trees such as the Polynesian chestnut, breadfruit, and fig are eaten in small amounts year-round. Leaves also serve as a post-hurricane food when regular sources are scarce (*29*).

Māmālava, *Planchonella samoensis* (Photo A. Whistler).

Tropical almond, talie, *Terminalia catappa* (Photo A. Whistler).

Plant Families Important for Pe'a (*29*)

- Sapodilla (Sapotaceae)
- Myrtle (Myrtaceae)
- Mulberry (Moraceae)
- Indian Almond (Combretaceae)
- Pea (Fabaceae)
- Soapberry (Sapindaceae)

See Appendix C for a partial list of native and Polynesian plants that could be used for habitat enhancements.

Cover (foraging). Pe'a vao rely on primary forest for foraging, but will also feed in secondary forest and agroforest.

Cover (roosting). Pe‘a vao prefer to roost in mature primary forest distant from villages, but occasionally use non-primary forest near roads and houses. Bats have high roost site fidelity, often returning to the same trees, tree, or even specific branches. Roosts are typically located in large trees with exposed branches and edible fruit or flower parts, such as the banyan, asi, and malili (*45*).

Roost characteristics (*45*)	Average
Height of roost branch above ground	*ca* 16-66 ft (5-20 m)
Slope of site	52°
Distance to nearest house	1312-2133 ft (400-650 m)
Cover of valley in fruiting trees	45%

Pe‘a vao are one of two principal pollinators of the native ‘ie‘ie, *Freycinetia reineckei*. In turn, ‘ie‘ie provides nutrient-rich pollen and famine food for pe‘a vao (*27,46*) (Photo A. Whistler).

Water. Foods meet water requirements because fruit bats live largely on a liquid diet. Fruit bats “drink” by squeezing fruit between the roof of the mouth and tongue. The juices are swallowed, and pulp is discarded.

Interspersion of habitat components. Suitable roosting habitat that doubles as or is near protected foraging areas is preferable.

Pe‘a vao can be seen soaring above the forest canopy, taking advantage of thermal updrafts and onshore breezes (Photo © Merlin D. Tuttle, Bat Conservation International).

Minimum habitat area. Pe‘a vao require large areas that encompass multiple landowners. For example, home ranges (area a bat normally uses for foraging and roosting) for 2 young male bats radio-tracked in remote primary forest were about 432 and 2021 ac (175 and 818 ha) and core areas were 49 ac (20 ha) (*42*). Home range varies by habitat type and territories may overlap.

PACIFIC FLYING FOX

American Samoa – Protected Species

INTRODUCTION

The Pacific flying fox or pe´a fanua is the more common and widespread of the two old world fruit bat (Pteropodidae) species in the Samoan archipelago. Pe‘a fanua differs in appearance from pe‘a vao by its darker head and body, golden “cape” around the neck and upper back, and narrower wings. It is most active at night and roosts in colonies. Pe‘a fanua is believed to be is a *keystone species*, meaning that it strongly influences the structure of forests because of its dominant role in seed dispersal (*29*).

STATUS & DISTRIBUTION

The species is widely distributed on islands off Papua New Guinea in the west to the Cook Islands in the east (3 subspecies). In American Samoa, pe´a fanua use a wide range of elevations on Tutuila, Aunu‘u, and Manu‘a with the largest numbers on Tutuila. The population for Tutuila is estimated at about 7000-8000 bats, but is uncertain for other islands. The species was able to rebound from being overhunted after hunting was banned in 1992. Overall, the American Samoa population is believed to be stable (*19*), but in need of ongoing protection from illegal hunting, habitat loss, and hurricanes.

Species Profile
Pacific flying fox, pe‘a fanua

Photo NRCS file

Scientific name: *Pteropus tonganus*
Habit: Colonial, nocturnal
Average weight: 463 g (range 314 - 590 g)
Range: Melanesia, Polynesia
Breeding period: Year-round
No. of pups per year: 1
Roosting habitat: Primary and secondary forests
Foraging habitat: Forests, agroforests, and plantations
Food habits: Frugivorous - eats primarily fruit, also nectar, pollen, and leaves
Population estimate: 7000 - 8000 (Tutuila, American Samoa)

REPRODUCTIVE CYCLE

Pe‘a fanua breed year-round with possible peaks in births in winter and summer (*40,46*). Females generally bear only one pup per year and dedicate considerable time and energy toward raising young. Pregnancy lasts 5-6 months. Pups fledge (begin to fly) at about 3 months of age when they are 50-75% adult size, but remain dependent on their mothers until about 6 months of age. Mating may overlap with pup-rearing (*47*). Colonies may be organized by breeding status, and include bachelor groups, harems (females defended by a single male), and females with young (*40*).

Periods of breeding activity in pe'a fanua (*40,47*)

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mating												
Pregnancy												
Pup births												
Pup-rearing												
Pup fledging												

Peak Off-peak

HABITAT REQUIREMENTS

Pe'a fanua mainly roost in primary forest and forage in agroforest. Primary and secondary forests and developed areas are also used for foraging (*29,48*). Habitat examples:

- **Cropland**. Coconut plantations for **foraging**
- **Forest land**. Primary forest, secondary forest, and agroforest for **foraging and roosting**
- **Other rural land**. Rural yards for **foraging**

Pacific flying fox mother and pup in King of Tonga's protected roost, Tonga (Photo © Merlin D. Tuttle, Bat Conservation International).

Food. Pe'a fanua are primarily frugivorous, feeding on fruit but also nectar, pollen, and leaves. They feed on at least 42 plant species (*29*). Bats emerge from day roosts to feed around sunset and return to roosts before sunrise (*49*). Favorite fruit include those of the māmālava, 'ala'a, tropical almond, breadfruit, and papaya. Flowers of asi, māmālava, coral tree, and banana are frequently visited. Leaves of trees such as breadfruit, sogā (*29*), and tamanu supplement diets with calcium and other minerals needed for reproduction (*50*). See Appendix C for a partial list of native and Polynesian plants that could be used for habitat enhancements.

Cultivated fruit (*48,51*)

- Fruit bats eat cultivated and wild fruit, however, in doing so they also pollinate plants, disperse seeds, and help perpetuate cultivated and wild fruit trees and the forests that sustain life
- Primary forests provide bats with a more nutritionally-balanced diet
- Bats may eat more cultivated fruit when they need an energy boost or wild-growing fruits are scarce
- By conserving native forest through protection, restoration, or agroforestry (vs. monocultures), landowners help ensure native fruits are available, may reduce the chances of wildlife crop damage, as well as maintain the watershed
- See Appendix D (FAQs about Crops and Pe'a) for more on this topic.

Cover (foraging). The species forages in primary forest, secondary forest, agroforest, and plantations. Some pe'a fanua regularly forage in primary forest (*29*), but more foraging occurs in mixed agroforests (secondary forests with cultivated fruit trees) (*48*). Pe'a fanua forages more often in agroforests than pe'a vao (*29*).

Cover (roosting). Colonies range from 10-4000 bats. Roosts are generally located on sea cliffs or steep mountainsides in areas inaccessible to people. Bats use primary and secondary, coastal

and montane forests and usually avoid agroforests for roosting. Colonies may relocate if disturbed by hurricanes or people, but may use favored roost sites for long periods if left undisturbed. Commonly-used roost trees also provide forage such as the fish-poison tree, coral tree, fetau, and maota (*45*). Typical roost trees are large and emergent and have widely-spaced branches with sparse foliage, which allows for the "free-fall' launch into flight (*47*).

Roost characteristics (45)	Average
Height of roost trees	49 ft (15 m); ranged from 13-98 ft (4-30 m)
Slope of site	46° (range 0-71°)
Distance to nearest house	2395-3868 ft (730-1179 m)
Elevation	220 ft (67 m) - coastal; 463 ft (141 m) - inland

Water. Foods meet water requirements because fruit bats live largely on a liquid diet. Fruit bats "drink" by squeezing fruit between the roof of the mouth and tongue. The juices are swallowed, and pulp is discarded.

Bat-aerobics

Pe'a fanua can carry Polynesian chestnut fruit, representing 36% of its weight, to protected foraging sites >2.5 mi (4 km) away. Mother fruit bats fly with young representing 50-66% of their weight (*49*).

Interspersion of habitat components. Suitable roosting habitat that doubles as or is near protected foraging areas is preferable.

Minimum habitat area. Pe'a fanua require large areas that may encompass an entire forest or a small oceanic island, and have been radio-tracked exploring up to 29 miles (47 km) on a single night. The distance bats travel nightly from roosting to foraging areas generally increases when food is limited (average 3-14 miles [5-23 km]) (*49*) and decreases when food is plentiful (average 0.5-3 miles [1-5 km]) (*48*).

A sustainable agroforest provides many benefits.
Flying foxes in Samoa are an important component of the agroforest ecosystem.
This unique habitat is under threat of modernization and mechanization (*52*).

Benefits:
Nutritional
Cultural/Social
Ecological
Economic

Threats:
Single-crop systems (monocropping)
"Matai" system land disputes
Improper gathering practices
Misuse of pesticides

Agroforest trees beneficial to pe'a include papaya ('esi), pandanus (fasa), coral tree (gatae), Polynesian chestnut (ifi), mango (mago), ylang-ylang (moso'oi), coconut (niu), tropical almond (talie), breadfruit ('ulu), and tava. Families important to pe'a: Sapodilla (Sapotaceae), Myrtle (Myrtaceae), Mulberry (Moraceae), Indian Almond (Combretaceae), Pea (Fabaceae), Soapberry (Sapindaceae) (*29*). For more info see Appendix C, also Traditional Tree Initiative: http://www.traditionaltree.org/.

POTENTIAL THREATS TO FRUGIVOROUS BATS

Several major threats exist for **Mariana fruit bats**, **Samoan flying foxes**, and **Pacific flying foxes**:

Illegal hunting. Although fruit bats are protected, an unknown number are illegally killed each year, primarily for human consumption. It is against Federal law to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect **Mariana fruit bats**. It is against local and international laws to hunt or export **Mariana fruit bats** and **Samoan and Pacific flying foxes**. In the 1970s and 1980s, depleted populations of fruit bats in the Mariana Islands, where bats are a delicacy, triggered a market demand for fruit bats in Samoa and other islands (*36,53*). In 1992, hunting of Samoan bats was banned when populations dipped to dangerously low numbers (e.g., <500 **Samoan flying foxes** on Tutuila) from the combined effects of overharvest and hurricanes, illustrating the unforeseen "ripple effects" of fruit bat depletions in other countries (*22*). Landowners can help by reporting illegal activities as soon as possible to the local wildlife authorities listed below.

Roost disturbance. Human presence and activity can alarm fruit bats, particularly if frequent, because bats associate humans with being hunted. Entire colonies can abandon roosts for less suitable habitat, and be exposed to unfamiliar territory and predators. **Mariana fruit bats** are very sensitive to roost disturbance and often become agitated and frightened after detecting the human scent. **Pacific flying foxes** appear more sensitive to human activity than **Samoan flying foxes**.

Habitat loss. Loss of native forest to agriculture, urbanization, military expansion, and invasive species threatens bat populations. Feral ungulates can prevent native forest regeneration, cause soil erosion, and facilitate the spread of invasive plants. On Guam, introduced Philippine deer and feral pigs suppress seeded breadfruit recruitment through browsing and seed predation (*54*). Insect pests such as the cycad aulacaspis scale and the erythrina gall wasp threaten the cycad (Guam) and coral tree (Guam and American Samoa), respectively, both important plants for fruit bats (*22*). In American Samoa, steep slopes of montane rainforest limit human activity, however, almost all the lowland rainforest of the Tafuna Plains (Tutuila) has been replaced by urban development and plantations. New roads could be sources of erosion and sedimentation and pathways for invasive species and poachers. Conversion of primary habitats could cause bats to use agroforest and plantations more frequently, which could lead to more human-bat conflicts. Human population growth is a major driver of habitat loss worldwide.

Prevent new invasions

Bats disperse seeds of native plants, but bats and birds could also disperse seeds of invasive species, if we aren't careful. Seeds of invasive trees, such as strawberry guava, can infest the landscape and be detrimental to native forests. Landowners can help by not importing, selling, or growing fruit trees known to be highly-invasive on other Pacific islands. For more info checkout:

Hawaii and Pacific Ecosystems at Risk
http://www.hear.org/

Weed Risk Assessments
http://www.hear.org/wra/

Hurricanes/typhoons. Small, fragmented populations are more vulnerable to natural catastrophes than large, stable ones. Fruit bats generally bear only one young per year, thus, recovery is a long-term process. In the early 1990s, post-storm studies showed the less

common **Samoan flying foxes** were, surprisingly, more resilient than the **Pacific flying foxes**. First of all, **Pacific flying foxes** had a pup-rearing peak that coincided with the hurricane season (Dec-Feb) and experienced high mortality; whereas, **Samoan flying foxes** had their pup-rearing season outside hurricane season. Secondly, starving **Pacific flying foxes** entered villages to feed on fallen cultivated fruit and were subject to opportunistic predation by domestic cats, dogs, and pigs and harvest by people; in contrast, **Samoan flying foxes** remained in the forest and fed primarily on leaves and the fleshy bracts of the storm-resistant, native ‘ie‘ie. Severe storms can sometimes lead to dramatic increases in bat poaching, as occurred on Tutuila (American Samoa) and Rota (CNMI) (*38,46*).

Predation by brown tree snake. On Guam, the brown tree snake is the main suspect in the ongoing disappearance of **Mariana fruit bat** pups. It’s believed that pups, too large to be carried by their mothers but too young to fly, left at the roost while mothers forage at night are falling victim to brown tree snakes (*22,55*). Currently, no pups are known to survive to maturity (*23*).

Pacific flying fox (Photo © Merlin D. Tuttle, Bat Conservation International).

SUMMARY OF HABITAT COMPONENTS – Frugivorous bats

Habitat component	Habitat characteristics		
	☐ Mariana fruit bat	☐ Samoan flying fox	☐ Pacific flying fox
Food	▪ Mainly fruit, also nectar, pollen, flowers, and leaves	▪ Mainly fruit, also nectar, pollen, flowers, and leaves	▪ Mainly fruit, also nectar, pollen, and leaves
Cover (foraging)	▪ Native limestone forest ▪ Native volcanic forest ▪ Secondary forest ▪ Coastal strand ▪ Savanna	▪ Primary forest ▪ Secondary forest ▪ Agroforest	▪ Primary forest ▪ Secondary forest ▪ Agroforest
Cover (roosting)	▪ Native limestone forest and forest patches ▪ Volcanic forest ▪ Minimal human activity	▪ Mature primary forest ≥1312-2133 ft (400-650 m) from nearest house ▪ Cover ≥45% fruiting trees ▪ Minimal human activity	▪ Primary or secondary forest ≥2395-3868 ft (730-1139 m) from nearest house ▪ Tree height averages ~50 ft (15 m) ▪ Minimal human activity
Water	▪ Foods provide adequate moisture ▪ Drinks rainwater from leaves	▪ Foods meet water requirements	▪ Foods meet water requirements
Interspersion	▪ Roosting habitat that doubles as or is near foraging areas	▪ Roosting habitat that doubles as or is near foraging areas	▪ Roosting habitat that doubles as or is near foraging areas
Minimum habitat area	▪ Wide ranging species ▪ Foraging areas of 3 bats ranged from 35-270 ac (14-110 ha) in primary and secondary forest, varies by habitat type and quality	▪ Wide ranging species ▪ Home ranges for 2 young males were 432 and 2021 ac (175 and 818 ha) in primary forest, varies by habitat type, territories may overlap	▪ Wide ranging species ▪ Foraging distance averages 0.5-14 miles (1-23 km), varies by habitat type and food availability
Threats	▪ Illegal hunting ▪ Roost disturbance ▪ Habitat loss ▪ Severe typhoons ▪ Predation by brown tree snake	▪ Illegal hunting ▪ Roost disturbance ▪ Habitat loss ▪ Severe hurricanes	▪ Illegal hunting ▪ Roost disturbance ▪ Habitat loss ▪ Severe hurricanes

ASSESSMENT OF LIMITING FACTORS – Frugivorous bats

Using the habitat characteristics above, subjectively rate the (a) availability and quality of bat habitat and (b) presence or absence of potential threats within a planning area. Habitat components rated "low" or "absent" or potential threats rated "present" could be limiting habitat quality.

(a) Habitat component	Quality / Availability			
	High	Medium	Low	Absent
Food				
Cover (foraging)				
Cover (roosting)				
Water				
Interspersion				
Minimum habitat area				
(b) Threat	Present		Absent	
Illegal hunting				
Roost disturbance				
Habitat loss				
Hurricanes/typhoons				
Brown tree snake				

MANAGEMENT RECOMMENDATIONS – Frugivorous bats

Management treatments should address the habitat components that appear to limit habitat potential for bats. Specific management options are lacking for the species. Thus, general advice for frugivorous bats is given below that may increase the quality or availability of each habitat component. NRCS Conservation Practices and various programs that may provide financial or technical assistance to carry out practices are also listed.

Habitat component	General management options for increasing habitat quality or availability	Conservation Practices
Food	▪ Minimize adverse effects of pesticides on non-target species by developing an integrated pest management plan; include role of native plants and animals in reducing pest outbreaks	595, 645
Cover (foraging and roosting) *Emphasize protection, enhancement, and restoration of mature native forests to benefit multiple species of native birds and bats*	▪ In native forest, protect, enhance, and restore community structure and function ▪ In agroforest, enhance native forest canopy; e.g., retain or plant large trees to improve watershed functions, protect farm, and maintain habitat ▪ Consult with NRCS Biologist, Forest Ecologist, or Plant Materials Center for best plant sources, spacing, care, and maintenance (See Appendices B-C for native plants associated with bats)	314, 472, 595, 612, 643, 645
	▪ Control invasive plants that threaten the continued existence of native forests and may be spread by bats and birds; also incipient weed populations (e.g., inkberry) ▪ Consider removing highly-invasive cultivated fruit trees, maintain as few as possible, or make plants bird/bat-inaccessible (e.g., netting) ▪ Plant threats to Pacific islands: http://www.hear.org/Pier/	382, 472, 528, 643, 645

Habitat component	General management options for increasing habitat quality or availability	Conservation Practices
	▪ Control insect pests that threaten the continued existence of native forests (e.g., cycad scale, erythrina gall wasp); consult with local Cooperative Extension Service for wildlife-friendly pest control methods	
	▪ Control feral ungulates through fencing, trapping, or hunting	382, 595, 643
	▪ Control domestic ungulates through fencing, prescribed grazing	382, 528, 645
Cover (roosting) *If fruit bats are known or suspected to be roosting in area:*	▪ Protect and enhance roosting areas and surrounding habitat by excluding areas from or minimizing activities related to resource extraction, grazing, or traffic	382, 472, 528, 643, 645
	Mariana fruit bat (Guam): ▪ Control brown tree snakes in and around roosting areas; contact DAWR, USFWS, or USDA-APHIS-Wildlife Services for best methods	595, 643, 645
Interspersion and minimum habitat area	▪ Consider relationship of planning area to habitat components on property or neighboring lands. ▪ For large-scale multi-landowner habitat planning, areas near protected lands and sheltered areas such as valleys (vs. areas regularly damaged by typhoons/hurricanes) are preferred.	391, 645
Human environment	▪ Minimize damage to cultivated fruit by harvesting or bagging fruit before they ripen; bats prefer ripe fruit	314, 595

NRCS Conservation Practices: 314 Brush Management, **379** Multi-story cropping, **382** Fence, **391** Riparian Forest Buffer, **472** Access Control, **528** Prescribed Grazing, **595** Pest Management, **612** Tree/Shrub Establishment, **643** Restoration and Management of Rare or Declining Habitats, **645** Upland Wildlife Habitat Management (More info: http://www.nrcs.usda.gov/technical/efotg/).

NRCS Conservation Programs that apply: CSP Conservation Stewardship Program; **EQIP** Environmental Quality Incentives Program; **WHIP** Wildlife Habitat Incentives Program; **WRP** Wetlands Reserve Program (More info: http://www.pia.nrcs.usda.gov/).

What to do with a sick or injured (or dead) bat?

1. Note the bat's condition, behavior, and exact location
2. Call the your local wildlife office as soon as possible for guidance

Contacts for more info on bats and other wildlife:

Guam	**NRCS** (671) 472-7490 Mongmong	**Division of Aquatic & Wildlife Resources** (671) 735-3955 Mangilao
CNMI	**NRCS** (670) 236-0888 Garapan, Saipan	**Division of Fish & Wildlife** (670) 664-6000/04 Lower Base, Saipan (670) 433-1404/01 San Jose, Tinian (670) 532-6000 Songsong, Rota
American Samoa	**NRCS** (684) 633-1031 Pago Pago, Tutuila	**Dept. of Marine & Wildlife Resources** (684) 633-4456 Pago Pago, Tutuila
Hawai'i	**NRCS Biologist** (808) 541-2600 Honolulu, O'ahu **U.S. Fish & Wildlife Service** (808) 792-9400 Honolulu, O'ahu	**Division of Forestry & Wildlife** (808) 274-3433 Lihue, Kaua'i (808) 587-0166 Honolulu, O'ahu (808) 984-8100 Wailuku, Maui (808) 887-6061 Waimea, Hawai'i (808) 974-4229 Hilo, Hawai'i

Common and scientific names of animals and plants in text

Animals

Brown tree snake (*Boiga irregularis*)
Cat (*Felis catus*)
Dog (*Canis familiaris*)
Cycad aulacaspis scale (*Aulacaspis yasumatsui*)
Erythrina gall wasp (*Quadrastichus erythrinae*)
Goat (*Capra hircus*)
Little Mariana fruit bat (*Pteropus tokudae*)
Monitor lizard (*Varanus indicus*)
North American hoary bat (*Lasiurus cinereus*)
Philippine deer (*Rusa marianna*)
Pig (*Sus scrofa*)
Rat (*Rattus* spp.)
Roof rat (*Rattus rattus*)
Swiftlet (*Aerodramus* spp.)

Plants

'Ala'a (*Planchonella* spp.)
Albizia (*Falcataria moluccana*)
Asi (*Syzygium inophylloides*)
Avocado (*Persea americana*)
Banana, fa'i (*Musa* spp.)
Banyan, āoa, (*Ficus prolixa*)
Breadfruit, 'ulu (*Artocarpus altilus*)
Chopak (*Mammea odorata*)
Coconut palm, niu (*Cocos nucifera*)
Cook pine (*Araucaria columnaris*)
Coral tree, gatae (*Erythrina variegata*)
Cycad (*Cycas micronesica*)
Eucalyptus (*Eucalyptus* spp.)
Fagot (*Neisosperma oppositifolia*)
False elder (*Premna obtusifolia*)
Fetau (*Calophyllum inophyllum*)
Fig, mati (*Ficus* spp.)
Fish-poison tree, futu (*Barringtonia asiatica*)
'Ie'ie (*Freycinetia reineckei*) (*Freycinetia* spp.)
Inkberry (*Cestrum diurnum*)
Ironwood (*Casuarina equisetifolia*)
Kapok (*Ceiba pentandra*)
Koa (*Acacia koa*)
Lychee (*Litchi chinensis*)
Macadamia (*Macadamia integrifolia*)
Malili (*Terminalia richii*)
Māmālava (*Planchonella samoensis*)
Māmane (*Sophora chrysophylla*)
Mango, mago (*Mangifera indica*)
Mangrove (Rhizophoraceae)
Maota (*Dysoxylum maota*)
Naio (*Myoporum sandwicense*)
'Ōhi'a (*Metrosideros polymorpha*)
Pandanus, fasa (*Pandanus* spp.)
Papaya, 'esi (*Carica papaya*)
Pengua (*Macaranga thompsonii*)
Polynesian chestnut, ifi (*Inocarpus fagifer*)
Seeded breadfruit (*Artocarpus mariannensis*)
Sogā (*Pipturus argenteus*)
Strawberry guava, ku'ava (*Psidium cattleianum*)
Tamanu (*Calophyllum neo-ebudicum*)
Tangantangan (*Leucaena leucocephala*)
Tava (*Pometia pinnata*)
Tropical almond, talie (*Terminalia catappa*)
Ylang-ylang, moso'oi, (*Cananga odorata*)
Yoga (*Elaeocarpus joga*)

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Web Resources

American Samoa Digital Library: http://www.nps.gov/npsa/naturescience/digitallibr.htm
Bat Conservation International: http://www.batcon.org/
Comprehensive Wildlife Conservation Strategy-CNMI: http://www.wildlifeactionplans.org/n_marianas.html
Comprehensive Wildlife Conservation Strategy-Guam: http://www.guamdawr.org/Conservation/gcwcs2/
Comprehensive Wildlife Conservation Strategy-Hawai'i: http://www.state.hi.us/dlnr/dofaw/cwcs/index.html
Habitat Management for Bats (UK): http://www.jncc.gov.uk/page-2138
Integrated Pest Management & Wildlife: ftp://ftp-fc.sc.egov.usda.gov/WHMI/WEB/pdf/IPM_Wildlife.pdf
Microchiropteran Bats, IUCN Conservation Plan: http://data.iucn.org/dbtw-wpd/
Old World Fruit Bats, IUCN Conservation Plan: http://data.iucn.org/dbtw-wpd/
USFWS Hawaiian hoary bat: http://ecos.fws.gov/speciesProfile/SpeciesReport.do?spcode=A03W
USFWS Mariana fruit bat: http://ecos.fws.gov/speciesProfile/SpeciesReport.do?spcode=A07X

Appendices

A. Native plants and communities used by Hawaiian hoary bat
B. Native plants commonly used by Mariana fruit bat
C. Native and Polynesian plants associated with Samoan and Pacific flying foxes
D. FAQs about crops and pe'a
E. Summary of habitat components and range map for Guam and CNMI
F. Summary of habitat components and range map for American Samoa

Appendix A. Native plants and communities used by Hawaiian hoary bat.

Family	Common name (scientific name)	Foraging cover (*1,8*)	Roosting cover (*15*)	Roosts in (*4,12*)	Elevation - ft (m)[†]	Habitat[†,‡]
Epacridaceae (Epacris)	Pūkiawe (*Styphelia tameiameiae*)			✓	50-10600 (15-3230)	Mesic to wet shrublands and forest
Fabaceae (Pea)	Koa (*Acacia koa*)	✓			195-6760 (60-2060)	Dry to wet forest
Fabaceae – Myoporaceae (Pea - Myoporum)	Māmane-naio (*Sophora chrysophylla-Myoporum sandwicense*)	✓			3000-9800 (900-3000)	Dry to mesic forest
Myrtaceae (Myrtle)	ʻŌhiʻa (*Metrosideros polymorpha*)	✓		✓	0-7220 (2200)	Dry to wet shrublands, mesic to wet forest
Myrtaceae – Ebenaceae (Ebony)	ʻŌhiʻa-lama (*Metrosideros polymorpha-Diospyros sandwicensis*)		✓		15-4000 (5-1220)	Dry to mesic forest
Pandanaceae (Screw pine)	Hala (*Pandanus tectorius*)			✓	0-2000 (610)	Mesic valley slopes and coastal sites

[†]W. L. Wagner, D. R. Herbst, S. H. Sohmer, *Manual of the Flowering Plants of Hawai`i* (Univ. of Hawai'i Press, Honolulu, HI, ed. 2, 1999).
[‡]Dry: <50 inches (1200 mm) annual rainfall, where evaporation exceeds rainfall; Mesic: 50-100 inches (1200-2500 mm) annual rainfall, where evaporation and rainfall are approximately equal; Wet: >100 inches (2500 mm) annual rainfall, where rainfall exceeds evaporation.

Appendix B. Native plants used by Mariana fruit bat (*37*).

Family name	Common name (scientific name)	Forages on (*33.39.56-58*)	Roosts in (*23.33.34.57*)	Habitat[†,‡]
Apocynaceae (Dogbane)	Fagot, fago (*Neisosperma oppositifolia*)	✓	✓	Strand, limestone forest, volcanic forest
	Lipstick tree, langiti, lengit (*Ochrosia mariannensis*)	✓		Limestone forest, volcanic forest
Arecaceae (Palm)	Coconut palm, niyog, nihok, luu (*Cocos nucifera*)	✓	✓	Strand, volcanic forest
Casuarinaceae (She-oak)	Ironwood, Australian pine, gagu, gago, weighu (*Casuarina equisetifolia*)	✓	✓	Strand, savanna, limestone forest, volcanic forest
Clusiaceae (Mangosteen)	Palomaria, mastwood, da'ok, da'og, raghisch (*Calophyllum inophyllum*)	✓		Strand, savanna
	Chopak, chopag, lifeis (*Mammea odorata*)	✓	✓	Limestone forest
Combretaceae (Indian Almond)	Tropical almond, talisai, talisei (*Terminalia catappa*)	✓		Strand, volcanic forest
Cycadaceae (Cycad)	Cycad, fandang, fadan, federico (*Cycas micronesica*)	✓		Strand, limestone forest, volcanic forest
Euphorbiaceae (Spurge)	Pengua, bwengwa (*Macaranga thompsonii*)		✓	Limestone forest, savanna
Fabaceae (Pea)*	Gulos (*Cynometra ramiflora*)	✓		Limestone forest, volcanic forest
	Coral tree, catclaw tree, gaogao (*Erythrina variegata*)	✓		Limestone forest, volcanic forest
	Seabean, bayogo dikike, gayetan (*Mucuna gigantean*)	✓		Strand
Gentianaceae (Gentian)	Wengu (*Fagraea berteriana*)	✓		Limestone forest
Hernandiaceae (Hernandia)	Nonak, nonag, oschal (*Hernandia sonora*)	✓		Strand, limestone forest
Icacinaceae (Icacina)	Faniok (*Merrilliodendron megacarpum*)	✓		Limestone forest, strand
Lecythidaceae (Brazil-nut)	Fish-kill tree, puting, ghuul (*Barringtonia asiatica*)	✓		Strand, limestone forest, volcanic forest
Meliaceae (Mahogany)	Mapunyao, mapunao, fischil liyoos (*Aglaia mariannensis*)	✓	✓	Limestone forest, volcanic forest
Moraceae (Mulberry)*	Seeded breadfruit, dogduk, dukduk, meiyas (*Artocarpus mariannensis*)	✓	✓	Limestone forest, volcanic forest
	Fig, banyan, nunu, ghiliau (*Ficus* spp.)	✓	✓	Strand, limestone forest, volcanic forest
Pandanaceae (Screw pine)*	Liana (*Freycinetia reineckei*)	✓		Limestone forest, volcanic forest
	Pandanus, kafu, fatsao, fashil wal (*Pandanus tectorius*)	✓		Strand, limestone forest, volcanic forest, savanna
Rubiaceae (Coffee)	Zebrawood, panao, mwesor (*Guettarda speciosa*)	✓	✓	Limestone forest, strand
Sapindaceae (Soapberry)	Faniok, fanog, faia (*Tristiropsis obtusangula*)	✓		Limestone forest
Tiliaceae (Linden)	Yoga, joga, ghumar (*Elaeocarpus joga*)	✓	✓	Limestone forest, volcanic forest, savanna
Urticaceae (Nettle)	(*Dendrocnide latifolia*)	✓		Limestone forest, volcanic forest
	Silvery pipturus, amahadyan, ghasooso (*Pipturus argenteus*)	✓		Strand, limestone forest
Verbenaceae (Verbena)	False elder, ahgao, yoor (*Premna obtusifolia*)	✓		Limestone forest, volcanic forest, strand, savanna

*Important families (*37*)

[†]L. Raulerson, A. Rinehart, *Trees and Shrubs of the Northern Mariana Islands* (Coastal Resources Management, Saipan, CNMI, 1991).

[‡]S. Vogt, L. L. Williams, *Common Flora and Fauna of the Mariana Islands* (Self published, Saipan, CNMI, 2004).

Appendix C. Native and Polynesian plants associated with Samoan and Pacific flying foxes (*For more info see references 29,45*).

Family name	Common name (scientific name)	Forages on (*29*)	Roosts in (*45*)	Elevation - ft (m)[†,‡]	Habitat[†,‡]
Clusiaceae (Mangosteen)	Fetau (*Calophyllum inophyllum*)	✓	✓	3-330 (1-100)	Littoral strand, lowland forest
Combretaceae (Indian Almond)*	Tropical almond, talie (*Terminalia catappa*)	✓		3-920 (1-280)	Littoral strand, lowland forest
	Malili (*Terminalia richii*)	✓	✓	3-2720 (1-830)	Lowland forest, montane forest
Fabaceae (Pea)*	Polynesian chestnut, ifi (*Inocarpus fagifer*)*	✓		3-2460 (1-750)	Lowland forest
	Coral tree, gatae (*Erythrina variegata*)	✓	✓	3-410 (1-125)	Littoral strand, lowland forest
Lecythidaceae (Brazil nut)	Fish-poison tree, futu (*Barringtonia asiatica*)	✓	✓	3-655 (1-200)	Littoral strand, lowland forest
Meliaceae (Mahogany)	Maota (*Dysoxylum maota*)	✓	✓	3-1475 (1-450)	Lowland, montane forest
Moraceae (Mulberry)*	Breadfruit ʻulu (*Artocarpus altilus*)*	✓		3-2160 (1-650)	Lowland forest
	Banyan, āoa (*Ficus obliqua*)	✓	✓	100-2300 (30-700)	Lowland forest, montane forest
	Banyan, āoa (*Ficus prolixa*)	✓	✓	3-490 (1-150)	Lowland forest
Myrtaceae (Myrtle)*	Asi, asi toa, asi malo (*Syzygium inophylloides*)*	✓	✓	3-3675 (1-1120)	Lowland forest, montane forest
Pandanaceae (Screw pine)	ʻIeʻie (*Freycinetia reinecki*)	✓		590-3935 (180-1200)	Lowland forest, montane forest
	Pandanus, fasa (*Pandanus tectorius*)	✓		3-330 (1-100)	Littoral strand. lowland forest
Sapindaceae (Soapberry)*	Tava (*Pometia pinnata*)	✓		3-1640 (1-500)	Lowland forest
Sapotaceae (Sapodilla)*	Gasu (*Palaquium stehlinii*)*	✓		490-2460 (150-750)	Lowland forest, montane forest
	ʻAlaʻa (*Planchonella garberi*)	✓		3-1640 (1-500)	Lowland forest
	ʻAlaʻa (*Planchonella grayana*)	✓		3-605 (1-185)	Littoral strand, lowland forest
	Māmālava (*Planchonella samoensis*)*	✓		3-3545 (1-1080)	Lowland forest, montane forest

*Important families and species (*29*)

[†]W. A. Whistler, *The Samoan Rainforest* (Isle Botanica, Honolulu, HI, 2002).

[‡]W. A. Whistler, "Botanical inventory of the proposed Tutuila and Ofu Units of the National Park of American Samoa" (Tech. Rep. 87, Cooperative National Park Resources Studies Unit, Univ. of Hawaii, Honolulu, HI, 1994).

Appendix D
FAQs about Crops and Pe‘a

How to prevent pe‘a from eating crops? Harvest fruit before they ripen. Pe‘a eat cultivated fruit such as papaya or breadfruit, but not until fruit are ripe or over-ripe. Since most fruit grown for the market are harvested before they ripen, there should be little or no conflict. If fruit must be tree-ripened, protect fruit through bagging or other means. Growers in Asia shine bright lamps below fruit a few days before harvest to keep bats away.

Do pe‘a eat green fruit? Pe‘a sometimes eat green (un-ripened) fruit when ripe fruits are scarce, such as after a hurricane or during a drought, but they normally like ripe fruit. Therefore, if it’s not ripe and not hanging from a tree, shrub, or vine, there’s a good chance another animal is involved. Rats, birds, and pigs eat green and ripe fruit. In Hawaii, Red-vented Bulbuls and Indian Mynahs eat cultivated fruit.

Who’s eating my fruit? It’s important to understand a problem (who, where, when, why, how) before trying to fix it. Look carefully to figure out the best solution. Most birds eat during the day, roof rats eat at night, and pe‘a eat day or night. For pe‘a vao, look for triangular-shaped tooth marks and discarded fruit pulp under the tree. If you hear bats in coconut groves, they are usually feeding on flowers not fruit. Roof rats can be heard at night in trees. Look for roof rat signs such as (a) hole in skin with fruit hollowed out, (b) rat nests in trees, or (c) black banana-shaped droppings about ¼ - ½ inch long (1 cm). For birds, observe the site to see which birds are present. Keep in mind that many different animals could be eating the fruit. For example, birds may be eating insects on fruit previously damaged by rats. So if you see a bird, it doesn’t necessarily mean the bird is causing the damage. Keep track of what you see.

Bats are beneficial. Farmers generally accept a small percentage of crop damage, especially if it’s infrequent. Pe‘a help the forest in many, many ways. They pollinate flowers and transport seeds around which helps with forest re-growth. Timely harvest is one of the keys to an environmentally sustainable farm.

Recommended reading

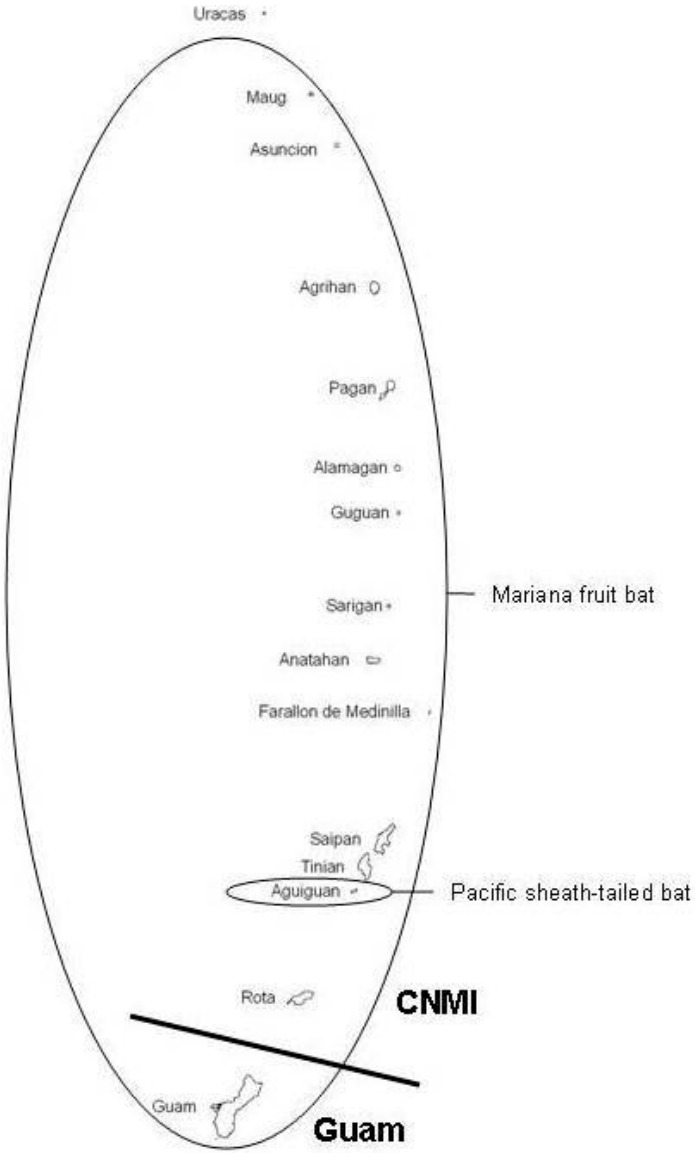
M. S. Fujita, M. D. Tuttle, Flying foxes (Chiroptera: Pteropodidae): threatened animals of key ecological and economic importance, *Cons. Biol*. **5**, 455-463 (1991).

W. H. Kern, “Control of roof rats in fruit trees” (Tech. Rep. No. SS-WEC-120, Univ. of Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, 1997; http://polkhort.ifas.ufl.edu/documents/publications/Rat%20Control%20in%20Fruit%20Trees.pdf).

Appendix E. Summary of habitat components and range map for Guam and CNMI.

Habitat component	Habitat characteristics	
	☐ Pacific sheath-tailed bat	☐ Mariana fruit bat
Food	▪ Small night-flying insects	▪ Mainly fruit, also nectar, pollen, flowers, and leaves
Cover (foraging)	▪ Native and nonnative forests ▪ Forages in forest understory, also in and above upper canopy	▪ Native limestone forest ▪ Native volcanic forest ▪ Secondary forest ▪ Coastal strand ▪ Savanna
Cover (roosting)	▪ Roosts in caves and other cavities ▪ Human and ungulate disturbance minimal	▪ Native limestone forest and forest patches ▪ Volcanic forest ▪ Minimal human activity
Water	▪ Foods presumably provide adequate water in diet	▪ Foods provide adequate moisture ▪ Drinks rainwater from leaves
Interspersion	▪ Suitable roosting habitat near multiple insect-rich foraging habitats.	▪ Roosting habitat that doubles as or is near foraging areas
Minimum habitat area	▪ Home range unknown	▪ Wide ranging species ▪ Foraging areas of 3 bats ranged from 35-270 ac (14-110 ha) in primary and secondary forest, varies by habitat type and quality
Threats*	▪ Roost disturbance ▪ Loss of habitat ▪ Obstacles to flight ▪ Introduced predators ▪ Pesticides ▪ Natural phenomena (e.g., severe storms, tidal surges)	▪ Illegal hunting ▪ Roost disturbance ▪ Habitat loss ▪ Severe typhoons ▪ Predation by brown tree snake

*Potential threats for Pacific sheath-tailed bat

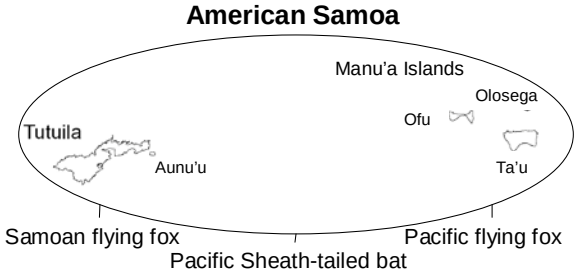


Current range for bats in Guam and CNMI.

Appendix F. Summary of habitat components and range map for American Samoa.

Habitat component	Habitat characteristics		
	☐ Pacific sheath-tailed bat	☐ Samoan flying fox	☐ Pacific flying fox
Food	▪ Small night-flying insects	▪ Mainly fruit, also nectar, pollen, flowers, and leaves	▪ Mainly fruit, also nectar, pollen, and leaves
Cover (foraging)	▪ Native and nonnative forests ▪ Forages in forest understory, also in and above upper canopy	▪ Primary forest ▪ Secondary forest ▪ Agroforest	▪ Primary forest ▪ Secondary forest ▪ Agroforest
Cover (roosting)	▪ Roosts in caves and crevices, and other natural and manmade cavities ▪ Human and ungulate disturbance minimal	▪ Mature primary forest ≥1312-2133 ft (400-650 m) from nearest house ▪ Cover ≥45% fruiting trees ▪ Minimal human activity	▪ Primary or secondary forest ≥2395-3868 ft (730-1139 m) from nearest house ▪ Tree height averages ~50 ft (15 m) ▪ Minimal human activity
Water	▪ Foods presumably provide adequate water in diet	▪ Foods meet water requirements	▪ Foods meet water requirements
Interspersion	▪ Suitable roosting habitat near multiple insect-rich foraging habitats.	▪ Roosting habitat that doubles as or is near foraging areas	▪ Roosting habitat that doubles as or is near foraging areas
Minimum habitat area	▪ Home range unknown	▪ Wide ranging species ▪ Home ranges for 2 young males were 432 and 2021 ac (175 and 818 ha) in primary forest, varies by habitat type, territories may overlap	▪ Wide ranging species ▪ Foraging distance averages 0.5-14 miles (1-23 km), varies by habitat type and food availability
Threats*	▪ Roost disturbance ▪ Loss of habitat ▪ Obstacles to flight ▪ Introduced predators ▪ Pesticides ▪ Natural phenomena (e.g., severe storms, tidal surges)	▪ Illegal hunting ▪ Roost disturbance ▪ Habitat loss ▪ Severe hurricanes	▪ Illegal hunting ▪ Roost disturbance ▪ Habitat loss ▪ Severe hurricanes

*Potential threats for Pacific sheath-tailed bat



Current range for bats in American Samoa.