Focal Species: Hawaiian Hoary Bat or Ōpeaʻapeʻa. (*Lasiurus cinereus semotus*)

Synopsis: The Hawaiian Hoary Bat is the only land mammal native to Hawai'i. It is considered a subspecies of the North American hoary bat, but additional research would help to confirm this status. Unlike many bats, it roosts solitarily in large trees rather than in caves. Recent research has begun to shed light on its ecology, behavior, and movements, but it still relatively little-known and more information is needed. It is found on most of the larger islands, but its population size and trend are unknown because of the difficulty in detecting this nocturnal species. Important conservation actions are to minimize lethal collisions with wind turbines, barbed wire fences, and other structures.

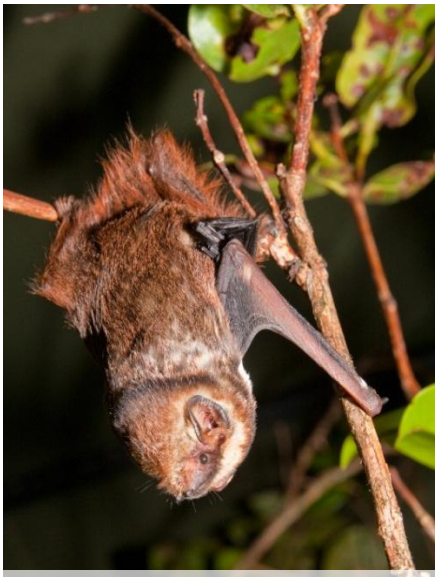

Photo David Leonard

Geographic region: Island of Hawai'i
Group: Bats
Federal Status: Endangered
State status: Endangered
Watch List 2007 Score: NA
Climate Change Vulnerability: High

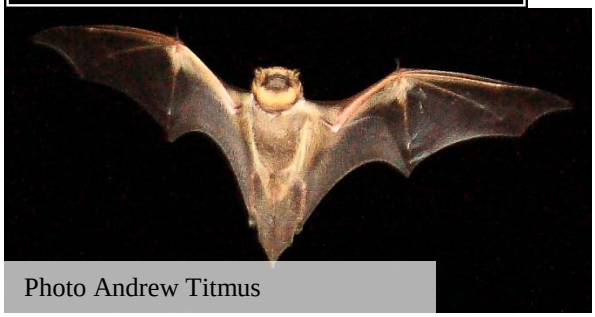

Photo Andrew Titmus

Population Size and Trend: Unknown, however there are substantial populations on Hawai'i Island, Maui, and Kaua'i (Bonaccorso 2010). Infrequent sightings occur on Oahu, Moloka'i, Lana'i, and Kaho'olawe (Tomich 1986), and bats have been detected on O'ahu using ultrasonic "bat detectors" to record their vocalizations.

Range: Hawaiian hoary bats occur throughout the main Hawaiian Islands and are found from sea level to the highest volcanic peaks (approaching 4,270 m [14,000 ft]). While prime habitats include native moist and rain forests up to at least 1,830 m (6,000 ft), bats also use native xeric and disturbed habitats as well as wet to moist non-native habitats and urban areas (Bonaccorso 2010).

Essential Biology:
The Hawaiian hoary bat is Hawaii's only native terrestrial mammal, although fossil evidence indicates that at least one other bat species formerly occurred in Hawai'i. Males and females have a wingspan of approximately 4.7 cm (12 in) and weigh between 12.4-20 g (0.4-0.7 oz); females are typically larger than males. Hawaiian individuals are about 30% smaller than their North American relatives (Jacobs 1996). Both sexes have a coat of brown to gray fur and individual hairs are tipped or frosted with white; "hoary" means frosted. The Hawaiian name refers to a half taro leaf or canoe sail shape which is somewhat similar to the bat's shape in

flight. Hawaiian hoary bats roost in native and non-native vegetation and rarely in lava tubes, cracks in rocks, or man-made structures. While roosting during the day, bats are solitary, although mothers and their pups roost together. On Hawai'i, bats appear to move to higher elevations during January through April, potentially because the cooler temperatures allow them to achieve a lower metabolic rate while roosting.

Individuals begin foraging either just before or after sunset depending on the time of year; altitude also may affect activity patterns. Similar to other insectivorous bats, echolocation is used to locate a variety of native and non-native night-flying insects, including moths, beetles, crickets, mosquitoes, and termites (Belwood and Fullard 1984, Bernard 2011, Bonaccorso et al. 2012, Jacobs 1999, Whitaker and Tomich 1983). Water courses and edges (e.g., coastlines and forest/pasture boundaries) are important foraging areas and the species also is attracted to insects that congregate near artificial lights.

Breeding has been documented only on Hawai'i and Kaua'i. Mating most likely occurs during the late fall and females are suspected of storing sperm until they return to warmer, coastal areas (i.e., April). Females give birth to twins during late June or early July and pups remain with their mothers for about two months. While the timing of gestation, birth, and fledging is somewhat understood, the species' requirements during the winter/spring, when most of the population moves to elevations above 1,525 m (5,000 ft), is little known. Nothing is known about annual survival or longevity.

Primary Threats:

- Collisions. Hawaiian hoary bats are injured and killed from collisions with man-made structures including barbed wire fences, wind turbines, and communication towers. Snagging on barbed wire is the most significant source of reported mortality (Zimpfer and Bonaccorso 2010). Most individuals are snagged at the tail membrane probably while maneuvering to catch insects or when prey is transferred to the mouth; echolocation is shut down for a few seconds while prey is eaten.

  To date, relatively few instances of bat striking wind turbines have been reported in Hawai'i. However, methods used to evaluate bat mortality associated with wind turbines are inadequate. The State of Hawai'i has mandated that renewable energy will provide 70% of the state's energy by 2030 and there are strong incentives to fast-track alternative energy projects. Given the high rate of bat mortality associated with wind turbines on the mainland, expansion of wind energy production in Hawai'i is a cause for concern. Currently, proposals are in place to double the number of facilities in the state.
- Lack of information. The primary criterion for delisting the Hawaiian hoary bat (USFWS 1998) is that populations on Hawai'i, Kaua'i, and Maui must be well distributed, naturally reproducing, and stable or increasing for at least five consecutive years. This information is currently being collected. The recovery plan further states that the majority of the species' genetic diversity should be maintained. Currently, the Hawaiian hoary bat is recognized as an endemic subspecies of the hoary bat found throughout North America, however genetic analyses of Hawaiian individuals has not been conducted. Some experts have suggested that the Hawaiian hoary bat is a distinct species (N. Simmons, pers. comm.) or that multiple subspecies or species occur across the main Hawaiian archipelago. Genetic data would provide information needed to manage potentially distinct populations, however a lack of funding has prevented genetic analyses to date. Finally, because relatively little is known about the species'

life history and threats, designing effective recovery and mitigation actions is difficult.

- Pesticides. The effect of pesticides on bats in Hawai'i is poorly understood and the use of pesticides by agro-industry should be investigated.
- Disease. A disease called "white-nose syndrome" that is caused by the fungus *Geomyces destructans* has resulted in serious declines in populations of multiple species of bats in North America (Blehert et al. 2009, 2011). Although this disease has not been detected in Hawaii and appears to primarily affect cave-dwelling bats that roost in groups, the arrival of this or a similar disease could affect the Hawaiian hoary bat.
- Habitat changes. Past clearing of forested lands for pastures, pineapple, and sugar cane likely reduced foraging and roosting habitat, however, coffee, macadamia nuts, and fruit orchards provide important habitat. The replacement of native trees with alien horticultural species in rural, suburban, and smaller urban areas is not detrimental as the Hawaiian hoary bat is a habitat generalist.
- Predation. Introduced mammalian and avian predators appear to take few bats. The species' low population density as well as its solitary and cryptic roosting behavior likely contributes to low predation rates.

Conservation Actions to Date:

The Hawaiian hoary bat was listed as endangered under the Endangered Species Act in 1970. In 2003 the Hawaiian Hoary Bat Research Cooperative (HHBRC) was formed to prioritize and fund research, members include the Hawai'i Division of Forestry and Wildlife, U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service, U.S. Forest Service, Research Corporation University of Hawai'i at Hilo, non-government organizations, and private businesses. Since 2003, HHBRC partners have provided more than $1,000,000 to collect life history information and to evaluate the species' status. Ongoing studies on Hawai'i by USGS have documented daily movement patterns, home range size, roost tree selection, foraging patterns, insect prey, seasonal use of habitats, and population trends. These data have been collected using a variety of methods including automated bat detectors, mist-netting, and radio-telemetry. Acoustic monitoring on western Kaua'i was completed in 2011 and indicated that bats had a widespread distribution. The HHBRC and its technical committees meet at least once a year to plan and evaluate progress.

Planning/Research Needs:

- Determine genetic diversity and population structure.
- Develop effective monitoring protocols of bat activity near wind turbines as well as mortality associated with wind turbines. An effective, replicable, economical, comparative, and quantitative methodology is urgently needed.
- Determine the risk of the fungus that causes White-nose Syndrome being transported to lava tubes by mainland spelunkers.
- Determine the effects of pesticides on Hawaiian hoary bats.

5-Year Conservation Goal:

- Develop guidelines to minimize mortality risk associated with barbed wire.
- Refine monitoring methods to evaluate bat activity near, and take associated with, wind energy facilities to guide mitigation and minimize risks.
- Continue research on Kaua'i and Oahu and initiate work on Maui.

- Analyze tissue samples to determine the genetic diversity of the Hawaiian hoary bat across their range.

Conservation Actions:

- Collisions. Wherever possible smooth wire should be used instead of barbed wire. If having barbed wire is critical, using or replacing the top strand of barbed wire with smooth wire is beneficial. Investigate the use of visual and noise generating materials hung from fences to reduce the chances of bats getting snagged on barbed wire. Use infra-red videography to monitor bat behavior near fences to develop strategies to minimize strikes. Develop automated near infra-red videography to monitor behavior near wind turbines and to evaluate strikes and near-strikes.
- Lack of information. Continue life history studies to determine winter/spring habitat requirements as well as survival rates. Conduct genetic analyses of the species using samples that have already been collected. Determine the feasibility of testing for White-nose Syndrome.

Summary of 5-year Actions, 2013-2017:

Conservation Action	Year(s)	Annual cost	Total Cost
Monitor barbed wire for take	1-2	$50,000	$100,000
Develop methods to reduce barbed wire mortality	1-3	$100,000	$300,000
Develop methods to monitor turbine mortality	1-3	$200,000	$600,000
Conduct genetic analysis	1	$50,000	$50,000
Continue life history monitoring	1-4	$250,000	$1,000,000
TOTAL		$650,000	$2,050,000

Potential Partners: U. S. Geological Survey, U. S. Fish & Wildlife Service, U. S. Forest Service, U. S. Department of Agriculture, Hawai'i Department Forestry & Wildlife, Research Corporation University of Hawai'i at Hilo, First Wind (wind energy production company), The Nature Conservancy, Three Mountain Alliance, Kamehameha Schools.

Ancillary Species: Wind energy facilities in Hawai'i are a threat to seabirds that travel to their nesting colonies at night, including the Hawaiian Petrel, (*Pterodroma sandwichensis*), Newell's Shearwater, (*Puffinus newelli*), and Band-rumped Storm-petrel, (*Oceanodroma castro)*. The videographic tools and methods required to monitor bats likely will have the ability to document nocturnal seabird activity. Habitat improvements for bats (e.g., riparian forest buffers, integrated pest management) are likely to benefit the Hawaiian hawk (*Buteo solitarius*) and other native forest and open-country birds.

References:

Belwood, J. J. and J. H. Fullard. 1984. Echolocation and foraging behavior in the Hawaiian hoary bat, *Lasiurus cinereus semotus*. Canadian Journal of Zoology 62:2113-2120.

Blehert, D.S., J.M. Lorch, A.E. Ballmann, P.M. Cryan, and C.U. Meteyer. 2011. Bat White-Nose Syndrome in North America. Microbe 6(6): 267-273.

Blehert, D. S., A. C. Hicks, M. Behr., et al. 2009. Bat white-nose syndrome: an emerging fungal pathogen? Science 323:227.

Bernard, R. 2011. Dietary overlap: does the invasive frog (*Eleutherodactylus coqui*) have the potential to compete with the endemic Hawaiian hoary bat (*Lasiurus cinereus semotus*) on the island of Hawaii. Master's Thesis, University of Hawaii at Hilo.

Bonaccorso, F. J. 2010. Ope'ape'a: understanding the puzzles of Hawaii's only bat. Bats 28:10-12.

Bonaccorso, F. J., R. Bernard, C. Todd, C. Pinzari, and T. Zinn. 2012. Food habits of the Hawaiian hoary bat (*Lasiurus cinereus semotus*) along a gradient of elevation. Pacific Science: in press.

Jacobs, D. S. 1996. Morphological divergence in an insular bat, *Lasiurus cinereus semotus*. Functional Ecology 10:622-630.

Jacobs, D. S. 1999. The diet of the insectivorous Hawaiian hoary bat (*Lasiurus cinereus semotus*). Canadian Journal of Zoology 77:1603-1607.

Tomich, P. Q. 1986. Mammals in Hawaii. Bishop Museum Sepcial Publication 76, Bishop Museum Press, Honolulu.

Whitaker, J. O., Jr. and P. Q. Tomich. 1983. Food habits of the hoary bat, *Lasiurus cinereus semotus*, from Hawaii. Journal of Mammalogy 64:151-152.

Zimpfer, J. and F. Bonaccorso. 2010. Barbed wire fences and Hawaiian hoary bats: what we know. Hawaii Conservation Conference abstract.