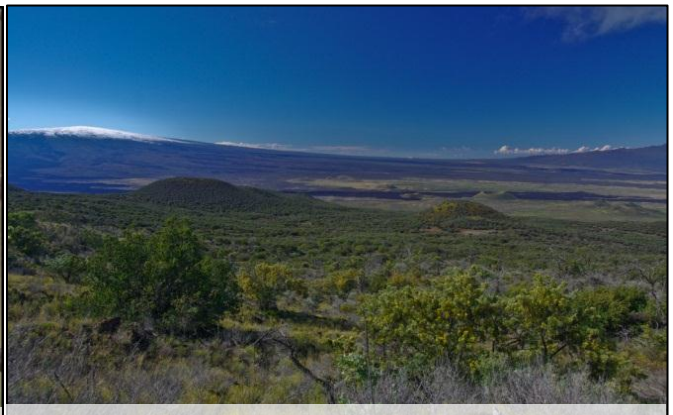
Focal Species: Palila (*Loxioides bailleui*)

Synopsis: The Palila is a specialized Hawaiian honeycreeper with a population of only 1,263 birds that are restricted to 45 km^2 of remnant high elevation māmane forest on Mauna Kea. Palila numbers have declined annually since 2003 because of long-term drought and habitat degradation by feral sheep introduced for hunting. Lawsuits resulted in Federal court orders in 1979, 1987, and 1998 that mandated removal of feral ungulates from Palila Critical Habitat, but a substantial number of feral sheep remain. Following a settlement agreement in 2009, fencing efforts are underway and sheep eradication is expected to follow, but natural forest regeneration and active restoration will take time. Greater public and local government support are needed.

Adult male Palila. Photo Eric VanderWerf.

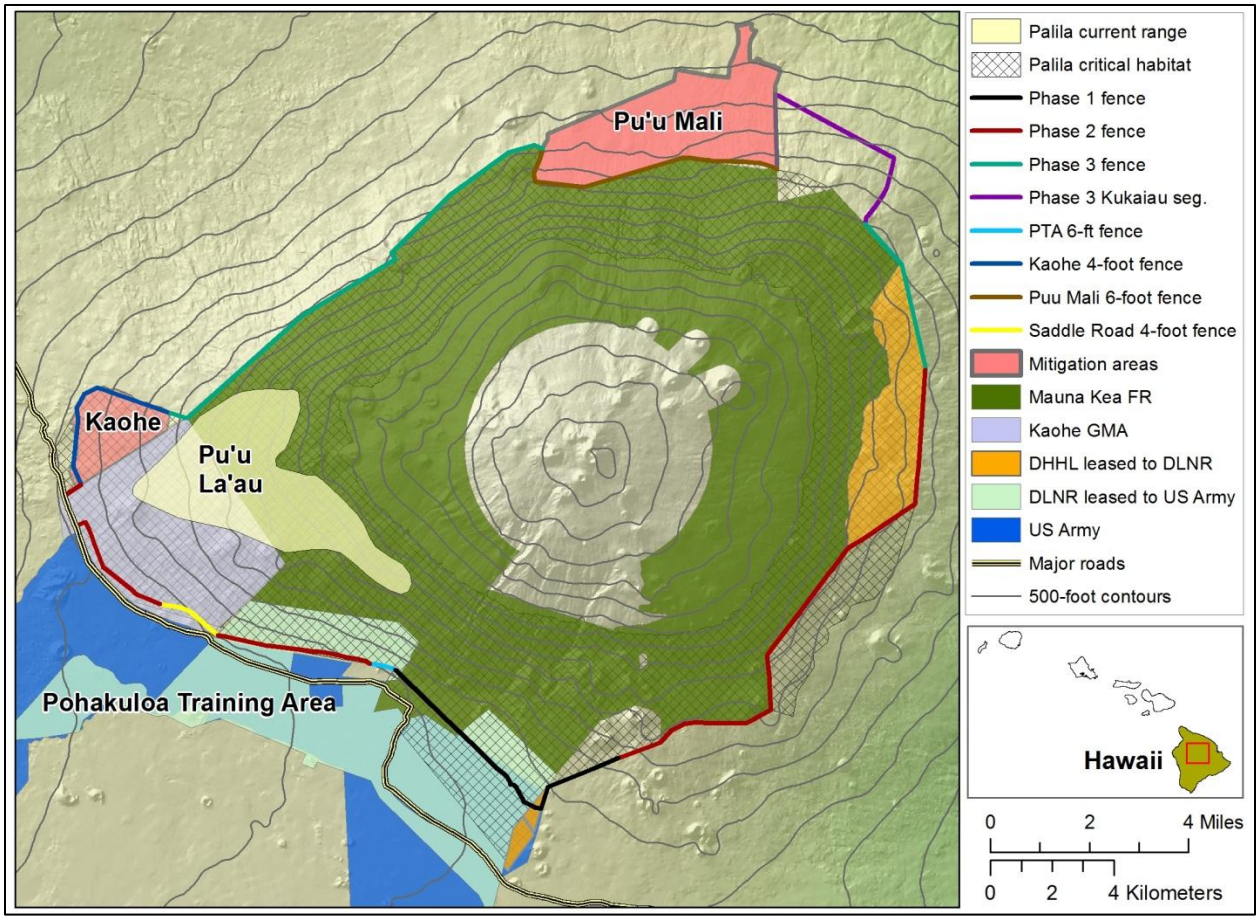


Māmane forest, Mauna Kea. Photo David Leonard.

Geographic region: Hawaiian Islands
Group: Forest Birds
Federal Status: Endangered
State status: Endangered
IUCN status: Critically endangered
Conservation score, rank: 20/20, At-risk
Watch List 2007 Score: Red
Climate Change Vulnerability: High

Population Size and Trend: Range-wide population surveys have been conducted annually since 1980 (Johnson et al. 2006, Leonard et al. 2008, Banko et al. in press). Population estimates fluctuated between 2,000 and 7,000 birds from 1980 to 2004, but no statistically significant trends were detected (Johnson et al. 2006). However, Leonard et al. (2008) documented a significant decline beginning in 2003 that has continued through 2011. From 2003 to 2011, population estimates declined each year by an average of 586 ± 106 birds for a mean annual loss of 17% ± 3.5 or 79% overall (Banko et al. in press). The 2011 population estimate was 1,263 individuals.

Range: Palila occurred in lowland habitats on Kaua'i and O'ahu when Polynesians arrived in Hawai'i less than 800 years ago (Olson and James 1991). When Europeans arrived in 1778, Palila had been extirpated from Kaua'i and O'ahu but were still found over about 1,300 km^2 of Hawai'i Island. Over the last 60 years, the species' range on Hawai'i has been dramatically reduced. The last individuals were seen on Mauna Loa in 1950 (Banko 1986). Today, all of the breeding population occurs in <45 km^2 on the southwestern slope of Mauna Kea, about 1% of their historical range Scott et al. 1984, Pratt et al. 1997, Banko et al. in press.



Essential Biology: The Palila is a finch-billed Hawaiian honeycreeper whose life history and survival are linked to māmane (*Sophora chrysophylla*), an endemic dry-forest tree in the legume family. Palila have a yellow head and breast, greenish wings and tail, a gray back, and white underparts. Males have a black mask, and females have less yellow on the head and a gray mask. Juveniles have wing bars. Song and calls consist of bubbly, canary-like warbles (Banko et al. 2002). Adults aggregate in small flocks prior to the breeding season, and fledglings often join flocks after nesting.

Palila are found in dry subalpine forest from 2,000-3,000 m in elevation dominated by māmane and naio (*Myoporum sandwicense*) trees (Banko et al. 2002), as well as ʻilahi (*Santalum paniculatum*) ʻakoko (*Chamaesyce olowaluana*), and pilo (*Coprosma montana*). Important understory shrubs include ʻa'aliʻi (*Dodonaea viscosa*), pūkiawe (*Styphelia tameiameiae*), na'ena'e (*Dubautia arborea*), and ʻakala (*Rubus hawaiensis*). Green māmane seeds make up most of the diet of adults and nestlings, but māmane flowers, buds, and leaves, and naio berries also are consumed, especially when māmane seeds are scarce. Density of Palila is strongly related to māmane pod availability (Scott et al. 1984, 1986; Hess et al. 2001, Banko et al. 2002). Caterpillars and other insects are frequently fed to nestlings and also are eaten by adults. Māmane seeds contain secondary compounds that are toxic to most vertebrates (Banko et al. 2002). Palila appear to be immune to these compounds, but their concentration may vary among trees, causing Palila to prefer certain trees. Consequently, more trees are needed to support Palila than would be predicted based on the number of pods harvested during a day (Banko et al. 2009). In addition, māmane flowers asynchronously at different elevations and trees distributed

across an elevational gradient increase the availability of māmane seeds to Palila. The elevational distribution of māmane is the most important predictor of suitable Palila habitat (Scott et al. 1984) and Palila are restricted to the largest remaining expanse of māmane forest on Mauna Kea (Scott et al. 1984, Jacobi et al. 1996, Johnson et al. 2006, Leonard et al. 2008, Banko et al. in press). The availability of green māmane seeds strongly influences adult survival and the number of nesting attempts in a given year; in poor years, not all pairs will attempt to nest.

Palila form long-term pair bonds and males perform low advertisement flights. Females build nests, usually in large, mature māmane trees, and males defend a small territory around the nest tree. Females incubate the eggs, brood the nestlings, and feed young with food delivered by males, but males feed nestlings directly later in the nesting cycle. First-year males sometimes help a pair by defending the nest and feeding the female and nestlings, and usually are related to the female or male. Fledglings are dependent on their parents for three to four months. Although pairs often renest after nest failure and they sometimes renest after fledging a brood, Palila typically have a low reproductive capacity and thus are slow to recover from perturbations.

Primary Threats:

- Non-native Ungulates/Habitat Degradation. Non-native ungulates have degraded Palila habitat for 200 years and are the most important threat to Palila. Low elevation māmane forest was converted to pasture for cattle ranching, and feral goats (*Capra hircus*), feral sheep (*Ovis aries*), and mouflon (*O. musimon*) have degraded high elevation habitat by browsing and stripping bark off māmane trees and suppressing regeneration (Bryan 1937, Scowcroft and Giffin 1983, Scott et al. 1984), although periodic reductions in sheep can result in recovery of māmane in some areas (Hess et al. 1999).
- Climate Change. Drought reduces māmane seed production and likely contributes to the mortality of mature trees (Juvik et al. 1993), especially those stressed by browsing (Banko et al in press), pathogens (Gardner and Trujillo 2001), and competition from invasive grasses and weeds (Banko et al. 2009). Drought conditions have persisted on Mauna Kea since 2000 but have been most severe since 2006 (Banko et al. in press). The Palila's dry, subalpine habitat is expected to become even drier (Chu and Chen 2005, Cao et al. 2007, Giambelluca and Luke 2007, Chu et al. 2010).
- Non-native Predators. Introduced predators, primarily feral cats (*Felis catus*) but also black rats (*Rattus rattus*), depredate approximately 11% of Palila nests and will take incubating and brooding females (Amarasekare 1993, Laut et al. 2003).
- Invasive species. Introduced grasses and other weeds compete for resources with māmane trees, suppress seedlings, and increase fire risks. An invasive fungus, *Armillaria mellea*, may be killing māmane trees (Gardner and Trujillo 2001). Alien wasps parasitize caterpillars that Palila feed to their nestlings.
- Wild Fires. Fire risk is high in this dry forest habitat. In August 2010, a fire destroyed about 500 ha of degraded Critical Habitat. The recent invasion of alien fireweed (*Senecio madagascariensis*) has increased fire threat, sometimes filling in areas that are only patchily covered by invasive grasses.
- Human Conflict. A small but vocal minority, primarily hunters, has opposed ungulate control in Palila Critical Habitat. This opposition has slowed and complicated effective management. Local government officials have resisted eradication efforts.

Conservation Actions to Date: The Palila was recognized as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1967 and by the State of Hawai'i in 1982, with critical habitat designated in 1977 (USFWS 2006). Federal court rulings in 1979, 1987, and 1998 mandated the removal of all ungulates from Critical Habitat. The Division of Forestry and Wildlife has conducted periodic sheep removal via aerial shooting since 1987 and maintains a liberal hunting policy in Palila Critical Habitat, but the number of sheep removed has increased over time and the current strategy is not effective at reducing sheep numbers. In 2009, EarthJustice filed a motion to enforce the previous ungulate eradication orders, which resulted in a settlement decree under which the State of Hawaii is currently pursuing fencing and ungulate eradication.

Research has been conducted since 1996 to identify limiting factors and threats to the Palila and develop recovery techniques (Banko et al. 2001, 2009). Habitat restoration began in 2008. Federal mitigation for realigning Saddle Road through a portion of critical habitat called for: (1) re-establishing a Palila population on the northern slope of Mauna Kea; (2) removing cattle from former māmane woodland on the northern and western slopes of Mauna Kea; (3) rehabilitating habitat on Mauna Loa in Pōhakuloa Training Area (U.S. Army) for eventual re-establishment of Palila; (4) controlling predators in portions of Critical Habitat; (5) and investigating fire ecology in Palila habitat to develop a fire-management plan. Saddle Road mitigation also funded studies of alien insects that may threaten Palila food resources and limited monitoring of non-native animals and plants on Mauna Kea.

Two mitigation parcels totaling 2,648 ha have been fenced and are nearly free of sheep, goats, and cattle. Active habitat restoration is ongoing at both sites and as of 2011, over 35,000 māmane and other native seedlings have been outplanted and techniques are being developed to increase the rate of restoration. The Army has fenced and removed feral ungulates from over 2,000 ha of māmane habitat on Mauna Loa. Predator control was conducted by USGS from 1998-2005 and by DOFAW since January 2008; 133 cats and 59 mongooses have been removed since 2008. A fire ecology study was completed (Thaxton and Jacobi 2009) and funds to build water tanks have been provided by the USFWS. The State has initiated construction of 67 km of fence that will protect 91% of Palila Critical Habitat with funds provided by the USFWS. The State is attempting to control fountain grass, cape ivy, and banana poka (*Passiflora tarminiana*) and monitor for the presence of incipient populations of the most pernicious weeds (e.g., gorse [*Ulex europaeus*]). A plan to eradicate sheep, goats, and cattle was drafted by DOFAW in October 2011. The Three Mountain Alliance recently fenced almost 2,500 ha of māmane habitat on Mauna Loa that may eventually be able to support Palila.

Palila have been bred in captivity by the Zoological Society of San Diego, although to date, captive production has been insufficient to contribute to recovery. Attempts have been made to re-establish Palila on Mauna Kea's northern slope using translocation and captive-releases (Banko et al. 2009). Translocations were conducted in 1997, 1998, 2004-2006, and captive-bred birds were released in 2003-2005 and 2009. A few pairs nested in the area but most birds did not persist, though a few were still present in March 2011.

Planning/Research Needs:

- Develop effective methods for rapidly eradicating sheep and monitoring their abundance and progress toward eradication.
- Develop a plan for monitoring habitat response to sheep eradication, evaluating Palila habitat carrying capacity, and the spread of new invasive weed species.

- Ensure that the capacity exists for long-term restoration efforts and to monitor the demographic response of Palila to management activities.
- Develop techniques to expand and improve māmane restoration (e.g., with vs. without irrigation, stocking densities, "companion" plant species, removing grass and weed cover).
- Develop methods to effectively combat invasive weeds that compete with māmane and increase fire threats, and to mitigate the impacts of diseases of māmane.
- Investigate factors that limit māmane distribution, productivity, and survival (e.g., what determines tree line, given that plantings at 10,000 ft. elevation are thriving; how will māmane respond to increasing drought; does grass and weed removal result in increased productivity?).
- Investigate climate trends and develop models for understanding how patterns of drought are likely to change and how the vegetation may respond.
- Develop programs for involving the public in forest restoration and for providing educational outreach.

5-Year Conservation Goals:

- Increase public support for Palila conservation and resolve conflicts with hunters and local government over hunting.
- Protect and restore Palila Critical Habitat by fencing, ungulate eradication, native forest restoration, and invasive alien plant control.
- Control feral cats in the area supporting the highest density of Palila and where Palila reintroduction is planned or natural expansion is to be encouraged.
- Evaluate, select, and begin restoring a site to support a second Palila population.

Conservation Actions:

- Habitat Restoration. DOFAW's Mauna Kea Forest Restoration Project conducts forest restoration, weed control, predator control, and some fence inspection and maintenance. This project does not have a dedicated funding source.
    - Complete 67 km of new ungulate-proof fence around the lower perimeter of Palila Critical Habitat to protect 22,165 ha of māmane forest, which is 91% of Palila Critical Habitat. About 27 km of this fence is completed, 31 km will be completed in the next 24 months, and funds are in hand to build the remaining 26 km of fence. After construction, this fence must be inspected and repaired in perpetuity.
    - An ungulate eradication plan has been drafted. Eradication of feral sheep will cost an estimated $361,000 and require two years. Monitoring for ingress of ungulates must be conducted in perpetuity.
    - Continue and expand forest restoration by out-planting and experimenting with other restoration techniques in the Puu Mali Mitigation Area and other sites, focusing on areas that will maximize the elevational range of māmane.
- Predator Control. Continue and increase feral cat trapping efforts on the western slope of Mauna Kea, especially during April-July, when most Palila nesting occurs.
- Invasive Plants. Increase efforts to control invasive alien plants in Palila habitat, especially fountain grass (*Pennisetum setaceum*) and fireweed. Continue to survey for and control incipient populations of other invasive plants such as gorse.

- Wild Fire. Complete construction of fire control and suppression infrastructure. Implement a forest ranger or surveillance program to help prevent fires and suppress them quickly when they occur. Initial funding from USFWS but more may be needed.
- Public Education. Conduct outreach to increase the public's understanding of the need to eradicate ungulates to prevent extinction of the Palila. Continue to build ties with the community by providing opportunities to volunteer and by showcasing successes.
- Captive Propagation/Reintroduction. Continue refining propagation and release techniques. Evaluate potential sites for the establishment of a second population and draft plans outlining the management actions necessary for establishing a viable population via translocation and the release of captive birds.

Summary and Estimated Costs of Conservation Actions, 2013-2017:

Conservation Action	Year(s)	Annual cost	Total Cost
Mauna Kea Forest Restoration Project (habitat restoration, fence maintenance, predator control, weed control)	1-5	$400,000	$2,000,000
Ungulate eradication	1-2	na	$361,000
Fence inspection and monitoring ungulate ingress	2-5	$75,000	$300,000
Public outreach	1-5	$50,000	$250,000
Re-introduction site evaluation and selection	1-2	$50,000	100,000
Re-introduction site restoration	2-5	$150,000	$600,000

Potential Partners: Hawaii Division of Forestry and Wildlife, U.S. Fish and Wildlife Service, U.S. Geological Survey Pacific Island Ecosystems Research Center, Department of Hawaiian Homelands, Mauna Kea Watershed Alliance, Three Mountain Alliance, Zoological Society of San Diego, American Bird Conservancy.

Ancillary Species: Ungulate eradication, habitat restoration, and control of alien predators would benefit all native bird species that use māmane forests, including the ʻIo or Hawaiian Hawk (*Buteo solitarius*), Hawai'i ʻElepaio (*Chasiempis sandwichensis*), ʻIʻiwi (*Vestiaria coccinea*), ʻApapane (*Himatione sanguinea*), and Hawai'i ʻAmakihi (*Hemignathus virens*). The endangered ʻAkiapōlāʻau (*Hemignathus munroi*) and Hawaiʻi Creeper (*Oreomystis mana*), which formerly occurred in the area, could be re-introduced to restored forests on Mauna Kea. The ʻUaʻu (*Pterodroma sandwichensis*) also could be reintroduced in areas where predators are controlled.

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