5-YEAR REVIEW

Short Form Summary

Species Reviewed: Palila (*Loxioides bailleui*)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2018. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 156 species in Oregon, Hawaii, Guam, and the Northern Mariana Islands. Federal Register 83(88):20088-20092.

Lead Region/Field Office:

Region 12, Portland Regional Office/ Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawaii

Name of Reviewer(s):

Eldridge Naboa, Fish and Wildlife Biologist, PIFWO
John Vetter, Animal Recovery Coordinator, PIFWO
Megan Laut, Conservation and Restoration Team Manager, PIFWO

Methodology used to complete this 5-year review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (USFWS), beginning on July 22, 2020. The review was based on a review of current, available information since the last 5-year review for the palila (USFWS 2015), as well as information from the Revised Recovery Plan for Hawaiian Forest Birds (USFWS 2006) and updates obtained from partners and researchers currently working on this species. The evaluation by Eldridge Naboa, Fish and Wildlife Biologist, was reviewed by Animal Recovery Coordinator, John Vetter. It was subsequently reviewed and approved by Megan Laut, Conservation and Restoration Team Manager.

Background:

For information regarding the species listing history and other facts, please refer to the Fish and Wildlife Service's Environmental Conservation On-line System (ECOS) database for threatened and endangered species (http://ecos.fws.gov/tess_public).

Review Analysis:

Please refer to the Revised Recovery Plan for Hawaiian Forest Birds (USFWS 2006) and the previous 5-year review for the palila, published on August 25, 2015 (available at http://ecos.fws.gov/docs/five_year_review/doc2542.pdf) for a complete review of the species' status, threats, and management efforts. No new information regarding the species biological status have come to light since listing to warrant a change in the Federal listing status of the palila as endangered.

New status information:

Palila currently occur only on the island of Hawai‘i, in one core population in subalpine, dry forest habitat on the southwestern slope of Mauna Kea (Banko and Farmer 2014). The palila population has been surveyed annually from 1998 to 2020 to determine abundance, population trends, and spatial distribution. The 2019 and 2020 count data has not yet been analyzed, so the most recent analysis in 2018 is included here.

Within the core survey area, the number of palila detected decreased by 22% between 2016 and 2017 (319 in 2016 and 248 in 2017), and a further 60% decrease in palila detections occurred between 2017 and 2018 (248 in 2017 and 99 in 2018) (Genz et al. 2018). These observations corresponded to population estimates of 1,861 in 2016, 1,461 in 2017, and 1,051 in 2018 (Genz et al. 2018, Table 1). In addition to the population in the core, palila were also detected below the core in the Ka‘ohe Restoration Area in 2017 and 2018, and on the north slope of Mauna Kea in 2017 (Genz et al. 2018). These sightings indicate that the population is either expanding into newly restored areas or that some birds are transient outside of the core.

Table 1. Palila Population Estimates (Genz et al. 2018)

Year	Estimated Abundance in the Core Survey Area	Lower Limit	Upper Limit
2015	1,076	839	1,380
2016	1,861	1500	2,309
2017	1,461	1,177	1,813
2018	1,051	778	1,420

Between 1998 and 2003, palila numbers have fluctuated annually and after a peak in 2003, palila populations declined steadily through 2011 (Genz et al. 2018). From 2011-2018, population estimates fluctuated at about the 2011 level with a peak in 2012 (Genz et al. 2018). Overall, the average rate of decline during the 20-year monitoring period (1998-2018) has been around 168 birds per year, equating to a 76% decline in the palila population (Genz et al. 2018, Figure 1).

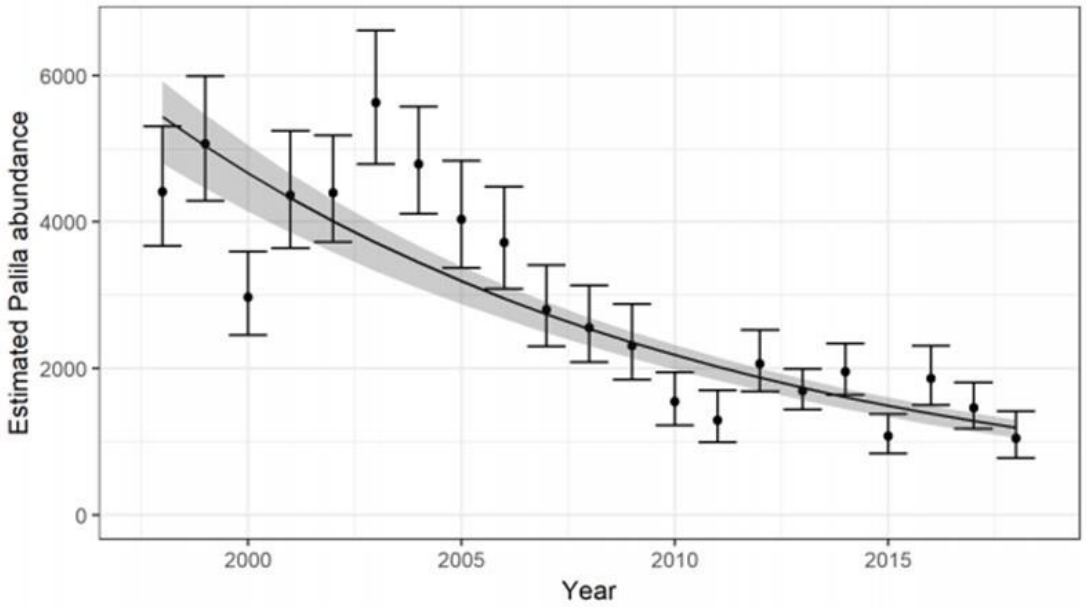

Figure 1. Estimated palila abundance from Genz et al. 2018.

- Captive Populations: The San Diego Zoo Global manages a population of palila at its facilities in Hawai‘i. As of August 2020, the Keauhou Bird Conservation Center (KBCC) on Hawai‘i Island held 10 birds and Maui Bird Conservation Center (MBCC) held 8 birds. The current captive flock has low genetic diversity primarily due to the limited breeding success of the palila founders (SDZG pers. comm. 2020).

New and ongoing threats:

- Drought conditions on Mauna Kea occurred during 74 percent of the months from 2000 to 2010, with drought recorded in all but two months from 2006 to 2010 (Banko et al. 2013). Drought conditions on Mauna Kea as of July 28, 2020 fall into the D1 category, or moderate drought intensity, based on the U.S. Drought Monitor (Heim 2020). Drought leads to tree death and also increases fire risk.

- *Myoporum sandwicense* (naio) is an important tree species in the Mauna Kea dry forests, and is especially prevalent in the lower elevations of palila core habitat. Naio thrips, *Klambothrips myopori*, is a recently established insect pest which infests *M. sandwicense* in Hawaii, and was first found on the island of Hawai‘i in December 2008. High infestation by the thrips causes branch die-back, and can eventually result in tree death. Damage from naio thrips has been observed on Mauna Kea, and has the potential to substantially reduce the number of *M. sandwicense* in palila critical habitat and leave large stands of dead trees that are prone to fire.

- Climate change degradation of habitat – Hawaiian honeycreepers are known to be highly susceptible to introduced avian disease, particularly avian malaria (*Plasmodium relictum*) (Atkinson et al. 1995; Atkinson et al. 2000; Yorinks and Atkinson 2000; Banko and Banko 2009). According to some climate change projections, temperature increases could present an additional threat specific to Hawaiian forest birds by causing an increase in the elevation below which regular transmission of avian malaria occurs, potentially reducing the remaining suitable habitat for these species. In Hawai‘i, the threshold temperature for transmission of avian malaria has been estimated to be 13 degrees Celsius (55 degrees Fahrenheit), whereas peak *P. relictum* prevalence in wild mosquitoes occurs in mid-elevation forest where the mean ambient summer temperature is 17 degrees Celsius (64 degrees Fahrenheit) (Benning et al. 2002). Lia et al. (2015) assessed how global climate change will affect future malaria risk for native Hawaiian bird populations and expect high elevation areas to remain mosquito free only to mid- century due to combined factors of increased rainfall and increasing temperatures. If climate change were to reduce the remaining suitable habitat for palila, it would likely contribute to the extinction of this species over time.

- As of August 2020, six palila hatched at the conservation breeding centers; two had fledged but none survived (all of the six hatches came from one palila pair at MBCC). Necropsy showed the parasite *Isopora coccidia*; a parasite rarely seen before at the centers. It is unknown how the palila got the parasite (SDZG pers. comm. 2020)

New and on-going management actions:

- In an effort to establish a second population of palila at the Pu‘u Mali Restoration Area on the north slope of Mauna Kea, a total of eight captive birds were released in 2019. Prior to release, preparations included building a new release aviary and rebuilding previously established release aviaries, controlling introduced mammalian predators, and assessing *Sophora chrysophylla* (māmane) flowers and seedpods in and around the release area. Palila were also prepared for release by being paired at KBCC and MBCC, before being transferred to the Pu‘u Mali Restoration Area, where they were temporarily held in release aviaries to allow for acclimation. The palila dispersed widely after release and most died from predation or disappeared within one week. However, one of the palila pairs settled near the release site and the birds were observed foraging and interacting together for nearly three months after release. Unfortunately, the female then died, appearing to be depredated by a raptor, either ‘io (*Buteo solitarius*) or pueo (*Asio flammeus sandwichensis*). The male palila was observed foraging at the feeders for a short period after the female disappeared before he then disappeared as well (last observed on September 26, 2019).

- The Palila Hui, a group of biologists from state, federal, and non-profit entities began a demography study in 2020. The objectives were to: (1) determine nest survival (or nest success) rates and adult fecundity, and identify major causes of nest failure, (2) determine adult and juvenile

survival rates, adult sex ratio, habitat use, dispersal and juvenile recruitment rate to estimate spatial abundance, (3) determine the disease prevalence in the wild palila population, (4) measure nest site characteristics and compare with historical data), and (5) quantify avian mammalian predator prevalence within core breeding habitat (Palila Demography Plan unpublished 2020). The Hawai‘i Division of Forestry and Wildlife (DOFAW), Natural Area Reserves (NAR), and the Mauna Kea Forest Restoration Project (MKRFP) banded a total of 26 palila in 2020 and observed four palila nests (NARS pers. comm. 2020).

- Habitat restoration and management – The MKFRP conducts weed control, forest restoration, forest monitoring, fence monitoring and maintenance, community outreach, volunteer trips, and ungulate control at Ka‘ohe and Pu‘u Mali Restoration Areas and in the core palila habitat within Mauna Kea Forest Reserve. From 2015 to 2019, an average of 15,000 to 20,000 plants have been outplanted per year by volunteer groups (approximately 200-300 volunteers per year). There is a 70% overall success rate of outplantings (MKRFP pers. comm. 2019).

- Predator control – The MKFRP and DOFAW continue to conduct predator trapping on the west (Ka‘ohe) and north (Pu‘u Mali) slopes of Mauna Kea. In August of 2018, a total of 210 traps were placed in a grid system at Pu‘u Mali and 20 cats, 11 mongoose, and 6 rats were captured. At Ka‘ohe, a total of 250 traps captured 11 cats, 8 mongoose, and 8 rats in 2018 (MKRFP pers. comm. 2019).

- Ungulate control (sheep) – DOFAW conducts quarterly control efforts for mouflon sheep (*Ovis orientalis orientalis*) on Mauna Kea, mostly focused on the core palila area. The number of sheep remaining on Mauna Kea is estimated at between 100 to 200 individuals. A total of 25-27 mouflon sheep have been radio-collared on the mountain since February 2019. Currently, three to four of these collared sheep are together which supports the low population estimate. Mauna Kea is also open year-round for hunting and hunters removed 38 animals over a six-month period in 2019 (DOFAW pers. comm. 2019).

- Ungulate control (pigs) – Pigs (*Sus scrofa*) have been controlled in Ka‘ohe Restoration Area with 36 pigs caught in 2018 and 60 pigs in 2019 (MKRFP pers. comm. 2019).

- Fencing – To date, there are 62.5 miles (100 kilometers) of fencing around palila critical habitat and around the Ka‘ohe and Pu‘u Mali restoration areas. Currently, 5.9 miles (9.5 kilometers) are left to be contracted and replaced using Capital Improvement Program funding (DOFAW pers. comm. 2019). The MKFRP currently maintains these fences on Mauna Kea (MKRFP pers. comm. 2019).

- Fire management – Approximately 16 miles (26 kilometers) of fire/fuel breaks are in place at Ka‘ohe, which are maintained by DOFAW.

- Habitat Assessment – To assess *Sophora chrysophylla* flowers and seed pods, phenology surveys have been conducted on a quarterly basis at Puʻu Mali and at Kaʻohe since 2019. Data analysis for this project has not been completed.

- Surveys – Annual palila surveys are coordinated by MKRFP and DOFAW staff in January or February of each year to monitor the range and abundance of palila.

Synthesis:

Downlisting and delisting objectives are provided in the Revised Recovery Plan for Hawaiian Forest Birds (USFWS 2006). The palila may be downlisted from endangered to threatened when all of the following four criteria have been met, (1) palila occur in two or more viable populations, and viable populations exist on the southwestern slope of Mauna Kea, either the northern, eastern or the southern slope of Mauna Kea, and at least one other location on Hualalai or Mauna Loa, over a 15-year period; (2) either (a) quantitative surveys show that the number of individuals in each isolated population or in the metapopulation has been stable or increasing for 15 consecutive years, or (b) demographic monitoring shows that each population or the metapopulation exhibits an average growth rate (λ or lambda) not less than 1.0 over a period of at least 15 consecutive years; and total population size is not expected to decline by more than 20 percent within the next 15 consecutive years for any reason; (3) sufficient recovery area is protected and managed to achieve criteria 1 and 2 above; and (4) the threats that were responsible for the decline of the species have been identified and controlled. The palila may be delisted when all four of the criteria above have been met for a 30-year period.

The downlisting goals for this species have not been met (Table 2), as there is only one population on the southwestern slope of Mauna Kea, the population continues to decline, palila habitat is not adequately managed, and while threats to the palila have been identified, they are not adequately controlled (Table 3). Therefore, the palila meets the definition of endangered as it remains in danger of extinction throughout its range.

Recommendations for Future Actions:

- Continue population surveys and monitoring to determine palila response to management actions and the effects of climate change.

- Habitat protection and restoration
  - Increase frequency and improve efficacy of aerial hunting to remove all mouflon sheep from palila critical habitat.
  - When ungulates are removed from critical habitat, increased habitat management should occur in palila core habitat, including grass control and forest restoration. When ungulates are removed from critical habitat, increased habitat management should occur in palila core habitat, including grass control and forest restoration.
  - Continue funding for the MKFRP for forest restoration, fence maintenance, and all other aspects of the MKFRP program.
  - Continue enhancement of habitat outside the currently occupied range of palila, including Puʻu Mali Restoration Area, Lupea on the western slope of Mauna Loa,

and Kīpuka ʻAlala in the saddle between Mauna Kea and Mauna Loa, where new populations could be established.

- Research
    - Investigate methods to reduce or control invasive grass cover on Mauna Kea. Examine experimental approaches to restore *Sophora chrysophylla* in heavily degraded areas and improve *S. chyrsophylla* tree vigor and density by applying fertilizer, giving water, and/or removing competing weeds in the less affected *S. chrysophylla* forest habitats.
    - Identify a mycologist to collaborate on *Armillaria* (fungus affecting the roots of *S. chrysophylla*) for root diagnostics; will need a plan and a research proposal.
    - Identify survey and research opportunities for *Cydia* caterpillars to determine overall function and abundance as an important food source for palila.

- Threats – disease control research – Of particular concern to the continued survival of many Hawaiian forest birds (particularly Hawaiian honeycreepers) is avian disease. Existing tools and approaches have proved largely ineffective in addressing this problem given mosquito dispersal distance and the abundance of mosquito breeding sites in most wet native forest habitats (LaPointe et al. 2009). Opportunities are emerging however based on new genetic tools as part of the fields of synthetic biology and genomic technology that have the potential to assist Hawaiian forest birds in developing genetic resistance to avian disease (LaPointe et al. 2009). In addition, recent progress has been made with the development of modified mosquitoes for disease control. Several of these techniques have achieved proof-of-principle in laboratory studies, while other transgenic insect techniques, including self-sustaining technologies to achieve long-term transmission control are anticipated to advance to field testing in the near future. We encourage continued research in development of modified mosquitoes for disease control and their field application as a conservation strategy for Hawaiian forest birds.

- Predator monitoring and control – Continue and expand predator control (particularly for cats) in all areas where palila breed, including on adjacent lands (Pōhakuloa Training Area).

- Determine the feasibility of captive propagation for reintroduction and genetic storage / reintroduction / translocation. Continue care for the palila in captivity and develop a release or translocation strategy.

- Fire monitoring and control – Implement fire risk reduction measures by establishing green fuel breaks and improving existing roadway fire breaks; improve fire detection and response by stationing fire response resources (such as water trucks and fire spotters) on the west slope of Mauna Kea in key habitat; and conduct other improvements where necessary to allow a rapid and effective ground and aerial response to fire. Establish partnership with Parker Ranch and the possibility of placing dip tanks along fencelines between Kaʻohe and Puʻu Mali.

- Weed monitoring and control – Continue funding the MKFRP for weed control, including *Delairea odorata* (cape ivy), *Ulex europaeus* (gorse), *Cenchrus setaceum* (fountain grass), *Senecio madagascariensis* (fire weed), and *Passiflora mollisima* (banana poka) and any newly identified invasive plants.

Table 2. Status and trends of palila from listing through current 5-year review.

Date	**No. wild individuals**	**Downlisting Criteria identified in Recovery Plan**	**Downlisting Criteria Completed?**
1967 (listing)	Unknown	No recovery plan developed yet.	N/A
1977 (critical habitat designation)	Unknown	No recovery plan developed yet.	N/A
1978 (recovery plan, USFWS 1978)	1,400 individuals	1. Protect existing habitat from further degradation	Partially
		2. Improve palila habitat	Partially
		3. Monitor palila population	Yes
		4. Identify factors limiting palila population growth other than loss of habitat	Yes
		5. Develop and implement a public relations program	Partially
1986 (recovery plan, USFWS 1986)	2,269 individuals (USFWS 1986); ~2,000 individuals (Leonard et al. 2008)	1. Maintain existing palila habitat	Partially
		2. Improve palila habitat	Partially
		3. Monitor palila population	Yes
		4. Identify factors, other than deterioration of habitat, limiting palila population growth, and take corrective action as needed	Yes
		5. Develop and implement a public information program to acquaint government leaders and the public with the palila and the recovery program.	Partially
2006 (revised recovery plan, USFWS 2006)	3,958 individuals (Camp et al. 2014)	1. Palila occur in two or more viable populations or a viable metapopulation that represent the ecological, morphological, behavioral, and genetic diversity	No

		of the species, and viable populations exist on the southwestern slope of Mauna Kea, either the northern, eastern or the southern slope of Mauna Kea, and at least one other location on Hualālai or Mauna Loa, over a 15-year period.	
		2. Either (a) quantitative surveys show that the number of individuals in each isolated population or in the metapopulation has been stable or increasing for 15 consecutive years, or (b) demographic monitoring shows that each population or the metapopulation exhibits an average growth rate (λ or lambda) not less than 1.0 over a period of at least 15 consecutive years; and total population size is not expected to decline by more than 20 percent within the next 15 consecutive years for any reason.	No
		3. Sufficient recovery area is protected and managed to achieve criteria 1 and 2 above.	No
		4. The threats that were responsible for the decline of the species have been identified and controlled.	Partially (threats identified)
2009 (5-yr review)	2,518 individuals (Camp et al. 2014); 2,640 individuals (USFWS 2009)	1. Palila occur in two or more viable populations or a viable metapopulation that represent the ecological, morphological, behavioral, and genetic diversity of the species, and viable populations exist on the southwestern slope of Mauna Kea, either the northern, eastern or the southern slope of Mauna Kea, and at least one other location on Hualālai or Mauna Loa, over a 15-year period	No

		2. Either (a) quantitative surveys show that the number of individuals in each isolated population or in the metapopulation has been stable or increasing for 15 consecutive years, or	No
		(b) demographic monitoring shows that each population or the metapopulation exhibits an average growth rate (λ or lambda) not less than 1.0 over a period of at least 15 consecutive years; and total population size is not expected to decline by more than 20 percent within the next 15 consecutive years for any reason.	
		3. Sufficient recovery area is protected and managed to achieve criteria 1 and 2 above.	No
		4. The threats that were responsible for the decline of the species have been identified and controlled.	Partially (threats identified)
2015 (5-yr review)	2,070 individuals	1. Palila occur in two or more viable populations or a viable metapopulation that represent the ecological, morphological, behavioral, and genetic diversity of the species, and viable populations exist on the southwestern slope of Mauna Kea, either the northern, eastern or the southern slope of Mauna Kea, and at least one other location on Hualālai or Mauna Loa, over a 15-year period.	No

		2. Either (a) quantitative surveys show that the number of individuals in each isolated population or in the metapopulation has been stable or increasing for 15 consecutive years, or (b) demographic monitoring shows that each population or the metapopulation exhibits an average growth rate (λ or lambda) not less than 1.0 over a period of at least 15 consecutive years; and total population size is not expected to decline by more than 20 percent within the next 15 consecutive years for any reason.	No
		3. Sufficient recovery area is protected and managed to achieve criteria 1 and 2 above.	No
		4. The threats that were responsible for the decline of the species have been identified and controlled.	Partially (threats identified; limited control)
2020 (5-yr review)	1,051 individuals (Genz et al. 2018)	1. Palila occur in two or more viable populations or a viable metapopulation that represent the ecological, morphological, behavioral, and genetic diversity of the species, and viable populations exist on the southwestern slope of Mauna Kea, either the northern, eastern or the southern slope of Mauna Kea, and at least one other location on Hualālai or Mauna Loa, over a 15-year period.	No
		2. Either (a) quantitative surveys show that the number of individuals in each isolated population or in the metapopulation has been	No

		stable or increasing for 15 consecutive years, or (b) demographic monitoring shows that each population or the metapopulation exhibits an average growth rate (λ or lambda) not less than 1.0 over a period of at least 15 consecutive years; and total population size is not expected to decline by more than 20 percent within the next 15 consecutive years for any reason.	
		3. Sufficient recovery area is protected and managed to achieve criteria 1 and 2 above.	No
		4. The threats that were responsible for the decline of the species have been identified and controlled.	Partially (threats identified; limited control)

Table 3. Threats to the palila and ongoing conservation efforts.

Threat	**Listing factor**	**Current Status**	**Conservation/ Management Efforts**
Ungulates – degradation of habitat and herbivory	A, C, E	Ongoing	Partial: ungulate removal from critical habitat is ongoing
Invasive introduced plants	A, E	Ongoing	Partial: MKFRP conducts weed control on Mauna Kea
Fire	A	Ongoing	Partial: maintenance of fire breaks in core habitat is ongoing
Predation	C	Ongoing	Partial: MKFRP and DOFAW conduct cat and mongoose trapping in core habitat and on the north slope is ongoing
Avian Disease	C	Ongoing	No
Stochastic events - drought	E	Ongoing	No
Stochastic events - low numbers	E	Ongoing	Partial: captive population maintained by San Diego Zoo Global
Climate change	A, E	Increasing	No

References:

See previous 5-year review for a full list of references (USFWS 2009). Only references not listed in that document are provided below.

Genz, S., Brinck, K.W., Camp, R.J., Banko, P.C. 2018. 2017-2018 Palila Abundance Estimates and Trends. Technical Report HCSU-086. Hawaii Cooperative Studies Unit, University of Hawaii at Hilo. 16 pages.

Heim, R. 2020. National Oceanic Atmospheric Administration and National Centers for Environmental Information. U.S. Drought Monitor for Hawaii. National Drought Mitigation Center 2020.Available online at: https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?HI

Palila Demography Plan. 2020. Unpublished.

Personal communications:

[MKFRP] Mauna Kea Forest Restoration Project. 2019. Palila Hui Working Group Meeting Notes, dated August 8, 2019.

[DOFAW] Division of Forestry and Wildlife. 2019. Palila Hui Working Group Meeting Notes, dated August 8, 2019.

[SDZG] San Diego Zoo Global. 2020. Palila Hui Working Group Meeting Notes, dated August 3, 2020.

[NARS] Natural Area Reserves. 2020. Email regarding palila banding dated May 6, 2020, May 8, 2020, May 14, 2020, and June 3, 2020.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Loxioides balleui*/Palila

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review Conducted By:

Eldridge Naboa, Fish and Wildlife Biologist, PIFWO
John Vetter, Animal Recovery Coordinator, PIFWO
Megan Laut, Conservation and Restoration Team Manager, PIFWO

FIELD OFFICE APPROVAL:

MEGAN LAUT Digitally signed by MEGAN LAUT Date: 2020.08.11 15:07:45 -10'00'

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for

Field Supervisor, Fish and Wildlife Service