PETITION TO LIST THE `I`IWI (*VESTIARIA COCCINEA*) AS THREATENED OR ENDANGERED UNDER THE U.S. ENDANGERED SPECIES ACT

August 24, 2010

Center for Biological Diversity

`I`IWI (*VESTIARIA COCCINEA*)
Photo source: Wikipedia

August 24, 2010

Ken Salazar, Secretary of the Interior
U.S. Department of the Interior
1849 C Street N.W.
Washington, DC 20240

Robyn Thorson, Regional Director
U.S. Fish & Wildlife Service
Pacific Region
911 NE 11th Ave
Portland, Oregon 97232

Dear Secretary Salazar,

The Center for Biological Diversity, Noah Greenwald, and Dr. Tony Povilitis formally petition to list the `I`iwi (*Vestiaria coccinea*) as a threatened or endangered species pursuant to the Endangered Species Act (ESA), 16 U.S.C. §1531 et seq. This petition is filed under 5 U.S.C. 553(e) and 50 CFR 424.14 (1990), which grant interested parties the right to petition for issuance of a rule from the Secretary of Interior.

Under the ESA, a threatened species includes "any species which is likely to become an endangered species within the foreseeable future throughout all or a signification portion of its range." An "endangered species" is one that is in danger of extinction.

The `I`iwi warrants listing because it is imperiled by climate change and disease in combination with other factors, is declining in population size and range, and is not adequately protected by existing regulatory mechanisms. With climate change forcing the spread of avian malaria and avian pox, the `I`iwi is in danger of near term extinction in the western portion of its range (the islands of Kauai, Oahu, and Molokai, and on west Maui), and severe population declines with risk of extinction within the foreseeable future across its eastern range (east Maui and the island of Hawaii).

Petitioners also request that critical habitat be designated concurrent with the listing, pursuant to 50 CFR 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. 553).

For the petitioners,

/s/

Tony Povilitis, PhD
Director
Life Net
6423 S. Bascom Trail
Willcox, AZ 85643
406-600-4803

Noah Greenwald
Endangered Species Program Director
Center for Biological Diversity
P.O. Box 11374
Portland, OR 97211
503-484-7495

Executive Summary

The `I`iwi, an icon of surviving native forests of Hawaii, is recognized by its bright scarlet and black plumage and long curved beak. Once widespread, the species now occurs only in upper elevation areas where avian disease is infrequent or absent. Increasing ambient temperature, driven by global climate change, is facilitating the spread of deadly avian malaria to remaining occupied habitat. The species is in danger of immediate or near term extinction across the entire western portion of its geographic range, namely, on the lower elevation islands of Kauai, Oahu, Molokai, and west Maui. The `I`iwi also faces extinction within the foreseeable future in higher elevation terrain on east Maui and the island of Hawaii as mosquito-borne avian malaria advances upslope.

`I`iwi populations are severely reduced on Kauai, Oahu, Molokai, and west Maui and have declined on all islands. Relatively large populations still occur above 1250 m elevation on east Maui and the island of Hawaii, where disease incidence is currently low or absent. Climate change is projected to greatly diminish or eliminate disease free areas for `I`iwi.

We petition to list the `I`iwi as threatened or endangered under the U.S. Endangered Species Act (ESA). The species qualifies for ESA protection as per four statutory factors used by the Secretary of Interior to determine if listing is warranted:

Present or threatened destruction, modification, or curtailment of habitat or range – `I`iwi habitat throughout Hawaii is adversely impacted by invasive, non-native animals and plants, and, on the island of Hawaii, by land development.

Disease or predation – The best available data indicate that the ongoing spread of avian malaria and avian pox endangers the smaller `I`iwi populations on Kauai, Oahu, Molokai, and West Maui, and threatens the larger ones on East Maui and Hawaii Island. Population-level resistance or tolerance to these deadly diseases is lacking. Climate modeling based on a conservative estimate of a 2° C increase in ambient temperature projects avian malaria to reach elevations up to or beyond 1900 m, affecting most if not all presently occupied `I`iwi habitat. Hawaii is experiencing a long-term increase in temperature and an accelerated rate of increase over the past few decades consistent with global climatic trends. Parasitism by bird lice and predation by alien rats, mongoose, and feral cats may accelerate the decline of `I`iwi populations subject to higher disease incidence.

Inadequacy of existing regulatory mechanisms – Under current national and international policies on greenhouse gas emissions, there is virtually no chance of limiting global heating to 2° C even with full policy implementation. Moreover, regulatory mechanisms are lacking to protect and restore forest habitat needed to expand 'I'iwi populations at highest elevations, as a means to reduce their vulnerability to avian diseases and fragmentation. State and private lands, which include most existing and potential upper elevation habitat for 'I'iwi, are generally not managed for forest bird recovery.

Other natural or manmade factors affecting its continued existence – Global warming threatens `I`iwi by increasing the elevation at which regular transmission of avian malaria and avian pox virus occurs. Moreover, evidence suggests that epizootics could in the near term eliminate the small `I`iwi populations on Kauai, Oahu, and Molokai, and diminish and fragment larger populations on East Maui and Hawaii Island. Hurricanes, likely to intensify in a warmer climate, and volcanism may further reduce 'I'iwi habitat. Small `I`iwi populations are at heightened risk of extinction from random demographic fluctuations, localized catastrophes (severe storms, wild fire, disease outbreaks, volcanism, etc.), inbreeding depression, and genetic drift.

This petition includes a request for critical habitat designation for the `I`iwi at the time of listing. Critical habitat should include areas of sufficient forest habitat for viable or potentially viable `I`iwi populations on Kauai, Oahu, Molokai, Maui, and Hawaii Island, as each island represents a significant portion of the species' natural range. Designation would require that federal actions promote conservation of essential `I`iwi habitat, and help resolve conflicts that undermine its protection and restoration. It would provide added impetus to re-establish native trees, remove ungulates, reduce depredation by rats and other introduced predators, control invasive plants, and otherwise manage vital habitat to improve prospects for 'I'iwi survival in a climatically challenged environment.

In conclusion, the spread of avian disease driven by climate change, severe range curtailment, ongoing loss of suitable habitat, and the history of forest bird extinctions on Hawaii are compelling reasons to list the `I`iwi as a threatened or endangered species.

I. Introduction

The `I`iwi is one of 17 surviving Hawaiian honeycreepers (Fringillidae: Drepanidinae) of 37 species known historically and 55 extant prior to human arrival on Hawaii (Pratt 2009). Its closest relative is the extinct Hawaii Mamo (*Drepanis pacifica*) (Pratt 2005). Disease and habitat loss are primary reasons for the decline of Hawaiian honeycreepers and other native forest birds. Extinctions continue to this day, with the most recent being the Poo-uli (*Melamprosops phaeosoma*) in 2004.

The `I`iwi, a scarlet bird with black wings and tail, and a long curved, salmon-colored bill. It is generally placed in the monotypic genus *Vestiaria*. It is a largely nectarivorous species that occurs commonly in closed canopy, high-stature native forests above 1500 m elevation (Fancy and Ralph 1998). `I`iwi breed and winter primarily in mesic and wet forests dominated by native 'ōhi'a (*Metrosideros polymorpha*) and koa (*Acacia koa*) trees (Scott et al. 1986). They often travel widely in search of ‘ōhi‘a flowers and are important ‘ōhi‘a pollinators (Mitchel et al. 2005). The birds respond to seasonal flowering patterns, often moving to lower elevations where they are exposed to deadly disease (Pratt 2005). The `I`iwi uses its long bill to extract nectar from decurved corollas of Hawaiian lobelioids, which have become far less common on Hawaii over the past century (Smith et al. 1995).

Female `I`iwi typically lay two eggs, and they alone are thought to incubate eggs and brood young (Mitchel et al. 2005). Males provision females with food off the nest. Breeding takes place predominantly from February to June, and is usually associated with peak flowering of 'ōhi'a (Fancy and Ralph 1998).

For native Hawaiians, the `I`iwi and other forest birds have a spiritual nexus. Feathered objects represented gods, ancestors, and divine lineage (Amante-Helweg and Conant 2009). Red feathers of clothing, such as cloaks, capes, and helmets, were predominantly from `I`iwi. Once a familiar sight on all main Hawaiian Islands, the `I`iwi remains an icon of Hawaii's native forests.

Today `I`iwi occur in higher elevation habitats largely free of avian disease, to which the species is highly susceptible. With climate change, these safe refugia may be lost entirely as pathogens and vectors advance upslope in response to higher ambient temperatures.

This petition reflects the needs for swift remedial action under the U.S. Endangered Species Act to prevent the `I`iwi from joining the tragically long list of extinct or feared extinct Hawaiian birds (Banko and Banko 2009). It explains how climate change, disease, and other factors threaten the survival of the `I`iwi.

II. Population Status

Distribution, abundance, and trends

The `I`iwi occurs on the Hawaiian islands of Kauai, Oahu, Maui, Molokai, and Hawaii (Gorresen et al. 2009). Once widely distributed in native forests on all major Hawaiian Islands, the species is now mostly restricted to elevations above 1250 m because of avian diseases and habitat loss elsewhere (Warner 1968, Scott et al. 1986, Fancy and Ralph 1998, Pratt 2005). `I`iwi are declining everywhere in Hawaii except at high elevation on East Maui and northeast Hawaii Island (Gorresen et al. 2009) (Table 1). `I`iwi population extinctions are impending throughout Hawaii (Banko and Banko 2009).

Oahu, Molokai, and the isolated western area of Maui have small remnant `I`iwi populations at high risk of extinction (Gorresen et al. 2009). `I`iwi are gone from nearby Lanai. These four areas comprise the central portion of the species' geographic range and are therefore significant.

On Kauai, in the western portion of the species' range, the `I`iwi has declined sharply (Table 1). Risk of extirpation from the island is of immediate concern because of severely diminished disease-free habitat.

On east Maui and the Island of Hawaii, forming the eastern part of the species' range, `I`iwi populations are restricted to high elevations (Table 1). While some populations are still large, they are at risk of fragmentation and decimation resulting from the spread of avian disease driven by climate warming (Pratt et al. 2009). Scott et al. (1986) estimated the population of 'I'iwi in high elevation areas of the Island of Hawaii may be as large as 340,000 birds, suggesting that in this area they remain abundant. This estimate, however, is more than two decades old, the species has been declining, and even within the portion of range, which represents a fraction of the species' historic range, the 'I'iwi is threatened by upslope movement of mosquitoes with climate change.

Declines in `I`iwi abundance corresponding with reduced lower elevation range since the early 1970s are consistent with anticipated impacts of mosquito borne disease (Foster et al. 2004).

The population trend is downward on all islands, with some stability in high elevation areas (Pratt et al. 2009). Climate change is now setting the stage for widespread disease transmission at the highest elevations on Maui and Hawaii Island (Benning et al. 2002; LaPointe et al. 2005).

Reproduction and Survivorship

`I`iwi pairs are reported to produce on average only 1.33 chicks per year, reflecting low productivity characteristic of Hawaiian forest birds in general (Woodworth and Pratt 2009). However, the `I`iwi has the lowest annual survivorship reported (55% ± 12 SE for adults and 9% ± 5 for juveniles) for any extant species of honeycreeper, reflecting the impact of malaria and avian pox and/or low re-sighting probabilities (Fancy and Ralph 1998; Pratt 2005).

Table 1. `I`iwi population estimates for Hawaiian islands.

Kauai -- `I`iwi numbers decreased by 62%, from 26,000 ± 3,000 to 9,985 ± 960, between the 1970s and 2000 (Foster et al. 2004, Gorresen et al. 2009);. `I`iwi range contracted from 140 to 110 sq km, consistent with a shift in its low elevation boundary from ~900 m to >1,100 m.

Oahu – Few, if any, birds remain; 8 individuals dispersed in 3 isolated locations were reported in 1994-1996 (VanderWerf and Rohrer 1996).

Molokai -- Few birds (1-3) were detected from 1988-2004 (Reynolds and Snetsinger 2001, Gorresen et al. 2009), contrasting with 12 in 1979 (Scott et al. 1986).

Maui -- About 19,000 ± 2,000 individuals occurred in restricted upper elevation habitats of east Maui (Scott et al. 1986); ~ 180 ± 150 birds were reported in isolated west Maui prior to 1980 (Scott et al. 1986); the west Maui population persists today at a very low number (Gorresen et al. 2009).

Hawaii Island – 340,000 ± 12,000 birds were estimated in higher elevation range; ~1,000 birds in lower elevation Kohala and Puna areas (Scott et al. 1986). These estimates, however, are over two decades old and there have been overall downward trends in recent decades (Camp et al. 2009a, Gorresen et al. 2009); of 10 study locations, `I`iwi appear now absent at one, declining at 5, stable at 3, with no estimate for 1 (Gorresen et al. 2009).

Regional breakout of data for Hawaii Island:

Northeast area: For the Hakalau Forest National Wildlife Refuge (Hakalau Unit; 1,500-2,000 m elevation) population trend data vary from stable (over a 21-year period) to declining (during a recent 9-year period), except for increasing numbers in limited newly restored upper elevation habitat (Camp et al. 2009a). Recent `I`iwi numbers were estimated at ~61,000 birds.

Central windward area: `I`iwi frequency decreased 54% between late 1970s and 1986-2000 periods in National Park and Hamakua areas, with specific study area declines and evidence of upward range contraction (Gorresen et al. 2005, Camp et al. 2009b);`I`iwi showed pronounced decline at lower elevations (East Rift, <1,000 m elev., and `Ōla`a, ~1,200-1,400 m, 1977-1994 data); modest declines (Kūlani-Keauhou, 1,500-2,000 m, 1977-2003 data) or stability (Mauna Loa Strip, ~1,500-2,000 m, 1977-1994 data) at higher elevations.

Southeast area: Lower `I`iwi density in the Ka`û area (2002 and 2005 data) than previously (1976 and 1993 data) (Gorresen et al. 2009); recent estimate of ~ 78,000 bird, with 60% occurring above 1,500 m (Gorresen et al. 2007).

Leeward (western) area: `I`iwi densities have dramatically declined in the Hualâlai and Kona regions (1997-2000); they are decreasing at lower elevations (<1,500 m; Kona Forest Unit, Hakalau Forest National Wildlife Refuge); stable only at upper elevations (Gorresen et al. 2009); `I`iwi range is contracting upslope, with few occurrences below 1,100 m during the breeding season (Camp et al. 2002).

III. Five-Factor Analysis

Under the ESA, 16 U.S.C. § 1533(a)(1), The U.S. Fish and Wildlife Service (USFWS) is required to list an organism for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range. In making such a determination, USFWS must analyze the `I`iwi's status in light of five statutory listing factors:
(A) the present or threatened destruction, modification, or curtailment of its habitat or range;
(B) overutilization for commercial, recreational, scientific, or educational purposes;
(C) disease or predation;
(D) the inadequacy of existing regulatory mechanisms; and,
(E) other natural or manmade factors affecting its continued existence.

For each factor, we provide the following analysis in support of our petition:

A. The present or threatened destruction, modification, or curtailment of habitat or range.

Climate change facilitating the spread of avian disease threatens severe curtailment of the `I`iwi's current range (see discussion under C below).

Most of the `I`iwi's original forest habitat has been cleared for food crops, livestock grazing, tree plantations, and land development, with habitat losses since human settlement ranging from 52% on Hawaii Island to 85% on O'ahu (Fancy and Ralph 1998). The amount of habitat available to the 'I'iwi and other forest birds has declined over the past few decades as many areas become dominated by invasive non-native species (Price et al. 2009). On the island of Hawaii, additional forest habitat loss results from land development, logging, and conversion to livestock pasture.

`I`iwi habitat across Hawaii is primarily threatened by destruction and adverse modification by feral pigs and other exotic ungulates (goats, sheep, mouflon, deer, cattle) (USFWS 2006, Pratt et al. 2009). Alien animals destroy forest understory vegetation, eliminate food plants for birds, create mosquito breeding sites through ground disturbances, provide openings on the forest floor for weeds, transport weed seeds to native forests, cause soil erosion, disrupt seedling regeneration of native plants, and girdle young trees (Fancy and Ralph 1998; Pratt 2005; USFWS 2006). Spread of exotic ungulates that are especially difficult to contain (i.e., axis deer on Maui and Molokai, black-tailed deer on Kauai, and mouflon sheep on Hawaii Island) represent a growing threat to `I`iwi habitat as these high-jumping species invade areas even with fencing designed to exclude feral pigs and goats (Price et al. 2009). Browsing and soil compaction by feral pigs, goats, and deer in Molokai has reduced 'ōhi'a forest to grassy scrubland (Hess 2008).

Hawaiian forests are severely modified by invasive alien plant species that displace native plants used by foraging and nesting birds (Scott et al. 1986; Foster et al. 2004) and increase the frequency of forest fires (Pratt et al. 2009). Herbivory by the introduced black rat on the flowers and fruits of native plants may also reduce food resources for native birds and impact regeneration of native plants (Banko and Banko 1976). Introduced predatory insects also may reduce or eliminate specialized native insects that are needed for pollination of plants important to `I`iwi.

Habitat degradation by non-native mammals, plants, and invertebrates will likely continue to result in loss, modification, and curtailment of `I`iwi habitat and range.

B. Overutilization for commercial, recreational, scientific, or educational purposes.

Not considered a threat at this time.

C. Disease or predation.

Disease

The `I`iwi survives in habitat largely free of avian malaria (*Plasmodium reluctum*) and bird pox (*Aviapoxvirus*). Such habitat is currently limited to 22 acres on Kauai, 6,500 acres on Maui, and 16,000 acres on Hawaii Island (with virtually none on Oahu and Molokai) (Pratt et al. 2009). The best available data indicate that the elevational advance of these pathogens driven by climate change endangers the smaller `I`iwi populations on Kauai, Oahu, Molokai, and west Maui, and threatens the larger ones on east Maui and Hawaii Island.

`I`iwi is highly vulnerable to disease

Avian disease is a primary reason for the decline of I`iwi and other Hawaiian honeycreepers (Pratt 2005, Atkinson and LaPointe 2009). Warner (1968) demonstrated high susceptibility of honeycreepers that died from avian malaria and bird pox after experimental exposure to mosquito infested lower elevations where the birds were absent. Van Ripper et al. (1986) also provided experimental evidence of high susceptibility of I`iwi to avian malaria. More recently, Atkinson et al. (1995) experimentally exposed several species of honeycreepers to a single bite of a malaria infected mosquito and found that effects were most severe in `I`iwi with significantly higher mortality and clear manifestations of malaria disease at death. `I`iwi were infected by either single (low-dose) or multiple (high-dose) mosquito bites. Mortality in both groups was significantly higher than in uninfected controls, reaching 100% of high-dose birds and 90% (9 of 10) in low-dose birds.

While some individual I`iwi are known to have at least temporarily survived malaria, we find no evidence of population level tolerance or resistance to the disease. Atkinson et al. (1995) found that the one `I`iwi that survived malaria after a single experimental bite from an infected mosquito did not develop new parasitemia after multiple bites from infected mosquitoes. This indicated that `I`iwi are capable of an immunological response at least to the administered strain of malaria. Freed et al. (2005) discovered tolerance to malaria in two wild `I`iwi that successfully bred 2-years post infection. However, broken head feathers in these birds suggested physiological costs of malarial tolerance that could reduce survivorship of wild birds. Studies of experimentally infected birds indicate that tolerant birds likely retain chronic infection for life (Atkinson et al. 2001, Valkiunas 2005). Challenges to the immune system by stress or excessive energy expenditure can result in recrudescence of a chronic infection to higher parasitemia levels (Freed et al. 2005). Infected birds lose weight and suffer malaria related pathologies (Atkinson et al. 2001), and would be expected to be more susceptible than healthy birds to predation, competition, avian pox, unfavorable weather, and other stressors. A comparison of infection incidence in `I`iwi and other Hawaii forest birds suggests that few `I`iwi survive exposure in the wild (Atkinson et al. 2005).

Lethal effects of avian poxvirus have also been experimentally demonstrated in Hawaiian honeycreepers (Jarvi et al. 2008). Freed et al. (2005) found a dead `I`iwi in the field with massive poxvirus sores on its ankles. The bird also tested positive for malaria. A significantly high proportion of Hawaiian forest birds with avian pox also had chronic malaria, suggesting interaction between the two diseases (Atkinson et al. 2005).

The downward trajectory of `I`iwi populations (Table 1) indicates a pattern of decline similar to ESA-listed Hawaiian forest birds vulnerable to disease, and dissimilar to populations of the unlisted Amakihi (*Hemignathus* spp.) (Shehata et al. 2001, Woodworth et al. 2005) and Apapane (Atkinson et al. 2005) which have shown some disease resistance and population persistence at lower elevations.

Among the most endangered Hawaiian bird species, the `Ō`ū, (*Psittirostra psittacea*), like the `I`iwi, was widespread on all main islands across a wide range of habitats a century ago (USFWS 2006). However, Ō`ū primarily inhabited the lower to mid-elevation forests where the impact of introduced mosquito-borne diseases was first manifested. Today, the `Ō`ū is probably extinct. Similar widespread exposure of `I`iwi to avian diseases can be expected in coming decades as a consequence of climate change.

Disease will spread over `I`iwi range as ambient temperatures rise

Avian malaria in Hawaii has been mostly confined to elevations below 1500 m (van Riper et al. 1986) where cool temperatures limit mosquito presence and development of the malaria parasite (LaPointe 2000). Recent climate modeling, however, has projected avian malaria to reach elevations up to or beyond 1900 m within this century, affecting most if not all remaining forest bird habitat (Benning et al. 2002).

Benning et al. (2002) modeled changes in malaria prevalence for Hawaiian honeycreepers at high quality habitat sites, assuming a 2° Celsius (C) increase in regional temperatures (based on International Panel on Climate Change 2007 projections; see Meehl et al. 2007). Current low-risk habitat diminished by 57% (665 to 285 ha) at the Hanawi Natural Area Reserve, Maui. Low-risk habitat at the Hakalau National Wildlife Refuge on Hawaii Island declined by 96% (3,120 to

130 ha). On Kauai (the Alakai Swamp), currently with little or no malaria free habitat, a 2° C warming placed most habitat (84%) at highest risk for malaria infection in native birds. Current mean ambient temperatures are believed to already allow limited disease transmission throughout Kauai as all `I`iwi habitat occurs below 1600 m elevation (LaPointe et al. 2005).

The effects of a 2° C warming would almost certainly eliminate the small `I`iwi populations from the lower-elevation islands of Kauai, Molokai, and Oahu, and from West Maui. Larger populations on East Maui and Hawaii Island would be expected to decline severely in a manner corresponding to decreases (~60-96%) in high elevation, disease-free refuges (Atkinson and LaPointe 2009).

The prognosis for `I`iwi and many other native forest birds appears worse than indicated by the Benning et al. (2002) model. The model assumed an increase of 2° C above current temperature, corresponding to ~2.7° C increase above pre-industrial levels. However, recent analysis of global heating indicates that temperature increases in Hawaii and elsewhere are unlikely to be limited to 2° C in this century. Increases in global temperature are currently on a trajectory to reach 2° C (above pre-industrial levels) by mid-century and about 5° C by 2100 (Meinshausen et al. 2009, Sokolov et al. 2009). Global greenhouse gas emissions would need to be halved by 2050 (from 1990 levels) to keep near the 2° C level with a high probability (55-88%) (Meinshausen et al. 2009). Unfortunately, under current multi-national policies regarding greenhouse gas emissions, there is virtually no chance of limiting heating to 2° C even with full policy implementation (Rogelj et al. 2009). For Hawaii, only a low global emissions scenario would likely keep temperature increases to 2° C (Karl et al. 2009).

An added concern is the risk of abrupt increases in global temperature unaccounted for in most modeled climate projections (Lovelock 2009). For example, a global climate model used by Sokolov et al. (2009) did not fully incorporate positive feedbacks that may occur, for example, if increased temperatures cause a large-scale melting of permafrost in arctic regions and subsequently release large quantities of methane, a very potent greenhouse gas (Rice 2009). If these positive feedback loops should occur, and evidence in mounting that they will (McCarthy 2010), temperatures are likely to increase to an even greater degree in Hawaii.

For Hawaii, Giambelluca et al. (2008) document a long-term increase in temperature and an accelerated rate of increase over the past few decades consistent with global trends (0.04° C C/decade over an 88-year period, and about 0.2° C/decade since 1975). Moreover, since 1975 higher elevation temperatures exceeded average warming (a 0.27° C/decade increase) with steepest increases in minimum (night time) temperature (near 0.5° C/decade), which is likely the most limiting for malaria transmission. The recent surface temperature trend in Hawaii is only slightly lower than the overall global trend. Similar surface warming has been detected elsewhere in the Pacific, and is associated with an increase in sea surface temperatures, upper ocean heat content, and sea level height (Richards and Timmermann 2008).

In Hawaii, the upper limit of mosquito presence appears to have increased substantially, from about 600 m in the late 1960s to 1100-1500 m in recent decades (Pratt 2005). Freed et al. (2005) reported that prevalence of malaria in Hawaiian forest birds at 1900 m on the island of Hawai‘i more than doubled over a decade. A highly significant increase of malaria in `I`iwi was associated with much warmer summertime air temperatures. The 13° C threshold for malaria development projected for 1900 m sites by the conservative Benning et al. (2002) model was surpassed in 2001 by a wide margin (4.4° C; Freed et al. 2005). Measured temperatures were believed to exceed model expectations because the site was strongly affected by the island's trade wind inversion layer related to tropical air circulation. The altitude of the inversion has averaged 1900 m, above which cooler, drier conditions prevail (*Atlas of Hawaii*, 3rd edition). The response of the inversion layer to climate heating is uncertain (Pounds et al. 1999, Loope and Giambelluca1998). If the inversion layer rises, disease epizootics could become commonplace at higher elevations with devastating short-term consequences for `I`iwi. If the inversion falls, and higher temperatures become associated with high-elevation drought, the effects would be very damaging to upper elevation Hawaiian forests and ultimately to surviving honeycreepers including the `I`iwi (Benning et al. 2002). Given that scenario, or if the inversion layer remains stable, high-elevation forest bird populations may be squeezed between expanding disease transmission from lower elevations and the upper limits of suitable habitat (Atkinson and LaPointe 2009).

Hawaii may see an increased frequency of heavy rain events and increased rainfall during summer months (Karl et al. 2009), conditions that, along with increased temperature, are likely to facilitate breeding of malaria-carrying mosquitoes (Ahumada et al. 2004). At the same time, overall annual precipitation for the Hawaiian Islands may decline (Chu and Chen 2005) thereby affecting habitat quality (e.g., ‘ōhi‘a forest) for the `I`iwi.

Ectoparasites, particularly chewing lice (Phthiraptera), may impact `I`iwi by increasing morbidity and reducing the ability of birds to survive environmental challenges.
Freed et al. (2008) documented an explosive increase in the prevalence of chewing lice in all bird host species at a study site on Hawaii Island. The number of major fault bars in wing and tail feathers, a sign of nutritive stress, was correlated with intensity of infection, suggesting an indirect cost to parasitized birds. Poorer body condition preceded the outbreak indicating the synergistic effect of multiple stressors on forest birds. At a minimum, chewing lice will increase food requirements of hosts. This indirect cost may be especially relevant because it can affect the ability of birds to mount a sufficient immune defense against diseases like avian malaria and pox. Chewing lice may also directly contribute to bird mortality (Freed et al. 2008).

Additional risks to `I`iwi from disease include potential introductions of West Nile virus, new avian malaria vectors (such as temperate varieties of *Culex quinquefaciatus*), or biting midges (Culicoides) that transmit avian diseases.

Predation

Introduced rats are serious predators on adults and nests of Hawaiian forest birds, and are abundant in high elevation habitats (Atkinson 1977, Scott et al. 1986, Fancy and Ralph 1998, VanderWerf and Smith 2002). Feral cats, introduced small Indian mongoose, and the native Short-eared Owl and introduced Barn Owl may also impact native Hawaiian birds (Scott et al 1986; Kowalsky et al. 2002). Predator control efforts generally have not been conducted over areas large enough to result in significant improvement in the status of imperiled forest birds

(USFWS 2006). Logistical and other obstacles to predator control can be great, especially in rugged bird habitat.

D. <u>Inadequacy of existing regulatory mechanisms</u>.

Existing international and U.S. regulatory mechanisms to reduce global greenhouse gas emissions are clearly inadequate to safeguard the `I`iwi against extinction resulting from climate change, which is expected to cause a severe shrinkage of disease free habitat for the ‘I’iwi.

United States Climate Initiatives are Ineffective

The United States is responsible for over 20% of worldwide carbon dioxide emissions (USEIA 2004), yet does not currently have adequate regulations to reduce greenhouse gas emissions. This was acknowledged by the Department of Interior in the final listing rule for the polar bear, which concluded that regulatory mechanisms in the United States are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). While existing laws including the Clean Air Act, Energy Policy and Conservation Act, Clean Water Act, Endangered Species Act, and others provide authority to executive branch agencies to require greenhouse gas emissions reductions from virtually all major sources in the U.S., these agencies are either failing to implement or only partially implementing these laws for greenhouse gases. For example, the EPA has recently issued a rulemaking regulating greenhouse gas emissions from automobiles (75 Fed. Reg. 25324, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule), but has to date failed to implement the majority of other Clean Air Act programs, such as the new source review, the new source pollution standards, or the criteria air pollutant/national ambient air quality standards programs, to address the climate crisis (See, e.g. 75 Fed. Reg. 17004, Reconsideration of Interpretation of Regulations That Determine Pollutants Covered by Clean Air Act Permitting Programs). While full implementation of these flagship environmental laws, particularly the Clean Air Act, would provide an effective and comprehensive greenhouse gas reduction strategy, due to their non-implementation, existing regulatory mechanisms must be considered inadequate to protect the ‘I’iwi from climate change.

International Climate Initiatives are Ineffective

The primary international regulatory mechanisms addressing greenhouse gas emissions are the United Nations Framework Convention on Climate Change and the Kyoto Protocol. As acknowledged by the Department of Interior in the final listing rule for the polar bear, these international initiatives are inadequate to effectively address climate change (73 Fed. Reg. 28287-28288). Additionally, the Kyoto Protocol’s first commitment period only sets targets for action through 2012. Importantly, there is still no international agreement governing greenhouse gas emissions in the years beyond 2012. Thus international regulatory mechanisms must be considered inadequate to protect the ‘I’iwi from climate change.

While the 2009 U.N. Climate Change Conference in Copenhagen called on countries to hold the increase in global temperature below 2 degrees Celsius, the *non-binding* “Copenhagen Accord” that emerged from the conference fails to enact binding regulations that limit emissions to reach this goal. Even if country’s did meet their pledges, a summary by the Pew Center (2010) of four analytical reviews of the Accord found that collective national pledges to cut greenhouse gas emissions are inadequate to achieve the 2° C goal, and instead suggest emission scenarios leading to a 3 to 3.9° C warming.

Regulations to protect high elevation forests that could serve as refugium for 'I'iwi are inadequate

Current regulatory mechanisms are inadequate to conserve high elevation forests needed to buffer the `I`iwi and other susceptible forest birds against the upslope advance of avian diseases driven by global heating. While some progress has been made to reforest former upper elevation habitat areas with native trees and reduce or eliminate harmful alien species from existing ones, huge tracts of land needed for forest bird conservation in Hawaii remain degraded or without native tree cover (USFWS 2009). A preponderance of lands intended for forest bird recovery are not managed conservation lands (Pratt et al. 2009). Management actions identified in existing forest bird recovery plans have not been implemented at ecologically relevant scales, and successful efforts to restore higher elevation forests must occur across tens of thousands of areas, not hundreds (Scott 2009). On the Island of Maui, for example, more than half of the lands identified for forest bird recovery remain without native forests, have only remnant forest patches, or are dominated by introduced tree species and other alien vegetation (A. Povilitis, pers. com.). Yet restoration of high elevation koa/`ōhi`a forest to protect native birds is clearly a conservation priority (Scott et al.1986, USFWS 2006)

At current rates, reforestation and forest enhancement efforts for Hawaiian forest birds will not achieve habitat conservation goals in time to build and expand populations robust enough to withstand avian malaria and other consequences of climate change. Of over 140 actions for forest bird recovery relating to reforestation and securing recovery areas (USFWS 2006), 61% have not begun, 37% are ongoing, and only 2% are complete or partially so (USFWS 2009). Likewise, of more than 160 actions designed to reduce or eliminate exotic ungulates and mammalian bird-predators, 71% are not yet underway, 27% are ongoing, and less than 2 % are complete or partially complete.

Poor political and policy decisions are responsible for the current inadequacy of regulatory mechanisms to prevent forest bird extinctions. The problem includes conflicting management goals and policies, most notably involving state forest lands (USFWS 2006, 2009), and failure to provide necessary funding (Leonard 2008).

Leonard (2009) discusses political obstacles to saving Hawaiian forest birds, including a state mandate to provide public hunting opportunities of exotic ungulates even where incompatible with conservation of native birds. Actions such as fencing and ungulate control for bird conservation may result in the loss of hunting areas, which is very controversial within his state agency (Leonard 2008). Even proposals for protecting limited forest in areas of little or no public access receive fierce opposition from local hunters (San Nicolas 2010). Native forest restoration is also hampered by agency decisions favoring exotic tree species or leasing for livestock (USFWS 2006).

The `I`iwi, like all other Hawaiian honeycreepers, is not included on the list of species protected under the Migratory Bird Treaty Act and thus receives no protection under federal law.

E. <u>Other natural or manmade factors affecting its continued existence</u>.

Climate change

Global heating threatens `I`iwi by increasing the elevation at which regular transmission of avian malaria and avian pox virus occurs (Benning et al. 2002, Harvell et al. 2002). It is the primary reason why the species merits listing under ESA at this time (review discussion under section C for details).

Catastrophic events

Epizootics involving avian malaria or other pathogens could eliminate remaining `I`iwi from the lower elevation islands of Kauai, Oahu, and Molokai, and from west Maui in the near term, and could diminish and fragment 'I'iwi populations on higher elevation east Maui and Hawaii Island. There is currently no habitat on Kauai, Oahu, and Molokai where mean ambient temperature entirely restrict malaria development (Benning et al. 2002). These islands are vulnerable to avian malaria at all elevations on a more or less ongoing basis. A recent avian malaria outbreak on Hawaii Island was associated with increases in summertime temperatures related to tropical inversion layer conditions (Freed et al. 2005). Outbreaks of malaria can be triggered by warm periods linked to inversion layer dynamics or El Niño events, and will likely intensify and persist longer with ongoing climate change.

Hurricanes are known for their devastating effects on island birds (Foster et al. 2004). They reduce habitat by blowing down trees and by creating forest openings that facilitate the spread of invasive alien plants. The `I`iwi decline on Kauai after a 1992 hurricane may have partially resulted from the birds seeking substitute nectar resources at lower elevations where risk of malaria transmission is highest (Foster et al. 2004).

Hurricanes are likely to intensify in a warmer climate (Meehl et al. 2007) in terms of wind speeds and precipitation, though the number of storms may be fewer (Bengtsson et al. 2007). Infectious mosquitoes can be carried upslope in strong winds, a probable factor in malaria outbreaks on Hawaii above 1900 m elevation (Freed et al. 2005).

On Hawaii Island, volcanism presents a potential threat to substantial acreage of forest bird habitat. For example, a large portion of the Upper Waiākea Forest Reserve, location of some of the last observations of `Ō`ū and considered prime habitat for the species, was inundated by the 1984 Mauna Loa lava flow which destroyed thousands of acres of forest and created a treeless corridor over 1 km wide (USFWS 2006).

Introduced Competitors

Introduced species of insects and birds can compete with native birds for food and other resources. `I`iwi may face competition from Japanese White-eye (*Zosterops japonicas*) (Mountainspring and Scott 1985), a malaria resistant species, whose numbers have increased at least on Kauai over the past 30 years (Foster et al. 2004). Negative correlations between `I`iwi and Japanese White-eye densities may stem from competition for limited nectar resources (Fancy and Ralph 1998). There are no current efforts to control competing species within the recovery areas of endangered forest birds (USFWS 2006).

Population fragmentation and isolation

'I'iwi populations have suffered from fragmentation as well as reduced size and range. Small population units are at risk of extinction from random demographic fluctuations, localized catastrophes (severe storms, wild fire, disease outbreaks, volcanism, etc.), inbreeding depression, and genetic drift (Primack 2006).

IV. Request for Critical Habitat

When the USFWS lists a species as endangered or threatened under ESA it must concurrently designate critical habitat for that species "to the maximum extent prudent and determinable." The ESA defines the term "critical habitat" to mean: i. the specific areas within the geographical area occupied by the species, at the time it is listed . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and ii. specific areas outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary [of Interior] that such areas are essential for the conservation of the species.

Critical habitat for `I`iwi is needed to ensure that federal actions avoid jeopardizing the species and help promote its conservation. Designation would help inform federal and state governments and private landowners on conservation planning, habitat management, and other actions needed to secure habitat, and help address conflicts that undermine its protection and restoration.

To reduce the climate change/disease threat, `I`iwi habitat requires special management including reforestation and forest protection adequate to sustain the species. Specific measures include elimination or control of alien species inimical to the survival of `I`iwi, and special measures to monitor and reduce (or eliminate) occurrence of avian malaria vectors. Programs to re-establish native forests, reduce rat depredation, control weeds, and fence out and remove ungulates are essential for forest bird recovery in high elevation habitats that serve as native bird refugia (Gorresen et al. 2005). Reducing mortality, such as that caused by rodent predation, may lessen the threat from disease by improving survival and reproduction of any birds with disease tolerance or natural immunity (VanderWerf and Smith 2002). The evolutionary acceleration of disease resistance through rodent control is possible (USFWS 2006).

Critical habitat should include all areas needed to provide sufficient forested habitat to support viable or potentially viable `I`iwi populations on Kauai, Oahu, Molokai, Maui, and Hawaii Island, as each island represents a significant portion of the species' natural range. This should include areas on Maui and Hawaii Island above the current limit of tree growth to accommodate any forest expansion resulting from climate change.

Critical habitat designation for `I`iwi will extend habitat protection to other listed endangered Hawaiian birds, where ranges overlap. Unfortunately, most currently listed forest birds do not have critical habitat designations.

V. Conclusion

The best available science indicates that global warming will allow avian diseases to spread throughout most or all of the `I`iwi's geographic range. The `I`iwi is highly vulnerable to avian diseases and cannot sustain itself where disease prevails.

`I`iwi in the central portion of the species' range (Oahu, Molokai, and west Maui) are critically endangered because of small population sizes and exposure to malaria. Those to the west (on Kauai) are severely threatened as disease free habitat is fast disappearing. `I`iwi in the eastern portion of the range (east Maui and Hawaii Island) face further population declines and eventual extinction with ongoing climate change.

The `I`iwi warrants listing under the US Endangered Species Act with concurrent designation of critical habitat.

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