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A brief review of Hawaii’s only native owl, the pueo

by Afsheen Siddiqi, State Seabird and Waterbird Coordinator
State of Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife

Although first described in the literature by Bloxham in 1826 (Konig and Weick 2008), the Pueo or Hawaiian short-eared owl (*Asio flammeus sandwichensis*) has long been chronicled throughout Hawaiian folklore and been revered highly to the people of the islands. In Hawaiian mythology, Pueo were worshipped as gods and are still honored as ancestral guardian spirits, or ‘aumakua, by Hawaiians today. Hawaiians believe that after the death of one’s ancestor, the spirit can still protect and influence the remaining family acting through a body such as that of an owl, shark, or turtle. Each species channeled by the ancestor held unique strengths and the Pueo is described as a special protector in battle or danger (Beckwith 1940). The Pueo is one of the most widely recognized of the Hawaiian ‘aumakua.

Pueo on Saddle Road, Aug 2005
Photo: Eric VanderWerf

The Pueo is one of only two owl species found in the Hawaiian Archipelago, the other being the non-native Barn owl (*Tyto alba*). Pueo are considered endemic to Hawai‘i and are one of nine subspecies of the North American short-eared owl found throughout the world (Pratt et al. 2009). Pueo are widely distributed across the main Hawaiian Islands, and have likely been established since the Polynesians arrived in the islands, but short-eared owls were probably semi-regularly visitors long before that time (Olson and James 1982, Pratt et al. 2009). Additionally, short-eared owl sightings in the Northwestern Hawaiian Islands and Johnston Atoll have been documented but are likely migrant owls from North America or Asia rather than the Hawaiian sub-species (Mostello 1994).

Found from sea level to 8,000-foot elevations, Pueo tolerate a wide variety of climatic conditions, ranging from open grasslands, shrublands, montane habitats, and agricultural areas to rain forests and urban settings (Pratt et al. 2009, Hawai‘i DLNR 2015). As suggested, Pueo may not have established until Polynesians discovered the Hawaiian Islands, linking their residence to the anthropogenic changes to a more open habitat and mammalian prey introduction such as rats (Pratt et al. 2009). Pueo diets consist primarily of rodents, but they are also known to eat birds and insects (Snetsinger et al. 1994).

Once widely distributed on all the main islands, Pueo were observed to be declining in the early 1900’s with declines attributed to the increase of cultivated land and partly because they were being shot as they were thought to be killing young chickens (Hershaw 1902, Perkins 1903). Although population numbers for Pueo have not been estimated, data from the Hawai‘i Audubon Society’s Christmas Bird Count indicate a decline since the 1960’s and decreases on other islands since counts were started in the 1970’s (Mostello 1994). Fewer and fewer sightings of the owls have led many to believe that the species is in decline which led the State of Hawai‘i listing the Pueo as an endangered species on the island of O‘ahu in 1982 (Hawai‘i Administrative Rules Chapter 13-124, Exhibit 2). The species is not currently listed by the Federal Endangered Species Act, but is still afforded Federal protections under the Migratory Bird Treaty Act.

Currently, extensive loss of habitat owing to development, and conversion of large tracts of undeveloped pasture land to agricultural, residential, and recreational uses are thought to be contributing to population declines (Hawai‘i DLNR 2015). In addition to habitat destruction, the introduction of mammalian predators including cats, dogs, pigs, and mongoose are considerable threats to the species. As ground nesting species, young owlets are particularly vulnerable to predation threats. Trauma due to vehicle collisions also threatens the survival of the Pueo (Aye 1994, Work and Hale 1996).

Comprehensive statewide surveys designed to derive population estimates, specifically for Pueo, are needed and may require significant effort to obtain accurate results. As with many of the endemic bird species of Hawai‘i, research and data are invaluable to inform best management decisions. Pueo in particular are one of the least-studied endemic species and necessitates long-term studies to begin to understand their life history traits, abundance and demographics. The few studies that have been attempted to address the Pueo’s

biology, ecology, and life history have proved challenging due to the scarcity of the species and current methodologies, as gathering such information requires capturing animals to tag them in order to monitor them closely. A 1994 study conducted on Pueo was successful in observing only one nest and resulted in a brood size of three (Mostello 1994). This one observation is in line with information from short-eared owls in other regions of the world that lay between two and seven eggs (Aye 1994). If Pueo are similar to other short-eared owls, nesting is dependent on food supplies, hatching is asynchronous, incubation of eggs is about 26 days, and chicks leave the nest between 12 to 17 days (Aye 1994).

There is much to learn about our resident short-eared owl and an upcoming project collaboration between the U.S. Fish and Wildlife Service, the Department of Land and Natural Resources Division of Forestry and Wildlife (Division) Maui Nui Seabird Recovery Project through the University of Hawai‘i Pacific Cooperative Studies Unit, Kaho‘olawe Island Reserve Commission, and the U.S. Department of Agriculture Wildlife Services is expected to start at the end of 2016. The results of this study are expected to enhance capture and marking techniques of Pueo that will lead to further research on the status, range per island, and management needs of the species.

Additionally, the Division has received funds from two wind farms owned by SunEdison, LLC: Kaheawa Wind Power II on Maui and Kahuku Wind Power on O‘ahu to mitigate the impacts to Pueo associated with these wind farms. The Division is currently working with the University of Hawai‘i at Mānoa to initiate a Pueo research study with these funds. The work which is anticipated to begin early 2017 is expected to provide information on the Pueo population for the island of O‘ahu. Specifically, the Division is seeking to improve survey methodology for the species, model Pueo distribution and abundance, understand habitat utilization, estimate population size on O‘ahu, and engage a citizen science project.

The Division anticipates that these projects will provide useful information to better manage and ensure the survival of the Pueo. The Division further hopes that the citizen science project will excite the public to become engaged with research and data acquisition for conservation. Effective citizen science relies on good outreach. In the case of Pueo, this relies on the proper identification of our native species. The Pueo is often times confused with the more common non-native invasive Barn owl. Both species are active during crepuscular periods, but Barn owls are mainly nocturnal while the Pueo is most often observed during the daytime. Some key attributes that differ between these species is size, color, and nest/roost site. Pueo are darker in color, smaller, and nest on the ground where as Barn owls will use trees and structures for nests. The public can help accelerate our knowledge on Pueo distribution throughout the islands and citizen science allows data to be collected on a scale that would otherwise be impossible to gather.

Afsheen Siddiqi is a Wildlife Biologist with the Department of Land and Natural Resources Division of Forestry and Wildlife. She is the State Seabird and Waterbird Coordinator and previously held the Conservation Initiatives Coordinator position working on endangered species issues. Afsheen has been with the State for over 5 years.

Note the white, heart-shaped face of the larger Barn Owl, *Tyto alba.*
Photo: Airwolfhound, Flickr, https://flic.kr/p/eixyfR, creative commons license.

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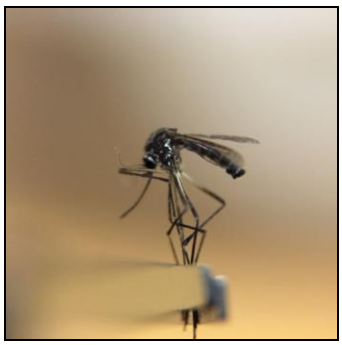
Position Announcement: Post Doctoral Fellow Hawaiian Short-eared Owl

Postdoctoral fellowship available for a Hawaiian Short-eared Owl distribution modeling project on O‘ahu. Research will include estimating population size on O‘ahu and relative abundance in various habitat types. Data collection may be conducted on both lowland and mountainous sites in rough or uneven terrain and variable weather conditions. Contact Dr. Melissa Price, UH-CTAHR Dept. of Natural Resources and Environmental Management for additional information, email: pricemel@hawaii.edu.

Novel technologies for addressing avian malaria in Hawai‘i

by Joshua Fisher, Invasive Species Biologist, Pacific Islands Fish and Wildlife Office



Aedes albopictus collection sample
Photo: Adam Vorsino USFWS

Dengue, chikungunya, and now Zika, have captured the public's attention in the last year. These mosquito-borne diseases are making headlines around the world because of their potential to infect tens of millions of people. The Bill and Melinda Gates Foundation considers mosquitoes the world's most deadly animal, attributing an estimated 725,000 deaths annually to diseases vectored by mosquitoes (Gates 2016). While this issue is at the forefront of popular media, Hawai'i's native birds have been suffering from mosquito-borne diseases since the early 1900s (Walther 2016).

Prior to human contact, there were more than 57 species of Hawaiian honeycreeper in the Hawaiian Islands. Only 17 of these species remain today, and some are at critically low numbers (Banco et al. 2001). Factors such as over exploitation, habitat loss, and competition and predation from invasive species have contributed to the decline of honeycreepers (Pratt et al. 2010). Tools to manage most of these threats to the birds are currently available. At present, however, no tools are available to manage what is arguably the greatest threat to honeycreeper survival: mosquitoes and the diseases they transmit.

Two diseases can be transmitted to Hawaiian birds by mosquitoes. The most dangerous of these is avian malaria, a disease caused by the parasite *Plasmodium relictum* for which most Hawaiian honeycreepers have no immunity. Like human malaria, this disease causes the infected organism's red blood cells to rupture, weakening and ultimately killing them. Of the five biting mosquitoes introduced to Hawai‘i, only one species, *Culex quinquefasciatus*, transmits avian malaria to the birds (Pratt 2010). Avian malaria restricts most honeycreeper populations to upper elevations where average temperatures are too cold for the mosquitoes and *P. relictum* to complete its development cycle. Climate change will increase the attitudinal gradient at which mosquitoes will be able to persist (Fortini et al. 2015). This compounds the potential impacts of the disease and increases the urgency to address the problem of honeycreeper decline.

Recent modeling efforts indicate that the geographic range of honeycreepers will continue to contract (Fortini et al. 2015). Overall, suitable disease-free habitat per species is expected to decline from a median of 86 ha to 17 ha in the next century. Ten species will be restricted to less than 50% of their current range by 2100. The situation is even more dire for some species. Three species will have greater than 90% range loss, while three other species will go extinct due to complete loss of habitat. In fact, the recent detection of mosquitoes as well as low population numbers of ‘Akeke‘e (*Loxops caeruleirostris*) and ‘Akikiki (*Oreomystis bairdi*) (Figs. 1, 2) in Kaua‘i's high elevation habitat have prompted wildlife agencies to implement captive propagation for these two species as a measure to prevent their extinction (Paxton et al. 2016). Unfortunately, captive propagation is not a panacea. It is expensive and will not solve the threat to the wild populations. To preserve the remaining honeycreepers of Hawai‘i, mosquitoes must be managed at a landscape scale.

Municipalities commonly control mosquito populations for public health purposes using classical forms of mosquito control (e.g., chemical spraying, habitat modification). A primary focus is on source reduction to reduce breeding grounds for mosquitoes as well as focusing directly on adult mosquitoes through ground-based and/or aerial applications of residual chemical insecticides (AMCA 2014). These classical forms of mosquito control are not an option for conservation purposes in Hawai‘i. Because of the complexity of the islands' forested landscapes, applications of these methods with insecticides would not be effective. Furthermore, the majority of the native fauna would be vulnerable to the insecticides used to control mosquitoes. The need for better management solutions to address the issue of mosquito borne diseases is imperative.

Figure 1: ‘Akekek‘e, Robby Kohley

Fortunately, in the last decade there have been significant advances in mosquito control (TDR 2010). These new technologies can address mosquitoes at a landscape scale and eliminate the risks of non-target impacts. The most promising of these new tools forego chemicals as a means of lethal control and directly manipulate the viability (or fitness) of the mosquitoes and can be grouped into two broad categories: the Sterile Insect Technique (SIT) and the Population Replacement Technique (PRT). These tools have positive attributes that set them apart from traditional mosquito control options. These new approaches have the potential to achieve landscape-scale control, are species-specific, and are more effective against dispersed, cryptic, and hard-to-reach targets such as *Culex* in the Hawaiian forests (Alphey et al. 2010).

The SIT approach floods a system with sterile-male mosquitoes, which unsuccessfully mate with wild females resulting in a suppression of the population (Knipling 1955). The ability to render them sterile has been achieved via three methods: irradiation, direct genetic modification, and the introduction of microbes, such as *Wolbachia* (Alphey et al. 2010). All three of these methods are self-limiting, so would require repeated releases of sterile-males. Irradiation has been used successfully multiple times in addressing agricultural pests in the United States. For some time, radiation of mosquitoes was problematic due to fitness reductions that rendered the sterilized males less successful when competing with wild males (Helinski et al. 2009). However, the International Atomic Energy Agency, the leader in developing and using this technology, has developed new methods to address this problem. Inducing sterility can also be achieved via a self-limiting genetic construct. A male mosquito is engineered with a dominant lethal gene that causes sterility. This technique has been deployed in four countries and initial data show a 90-99% reduction of mosquitoes (Oxitec 2016). Oxitec, a company working with the local mosquito control management district, is implementing the first U.S. application of this self-limiting construct in Florida to address dengue and Zika.

Figure 2: ʻAkikiki, Robby Kohley

They have received necessary regulatory approvals at the federal and state levels and local community approval is the final step needed prior to implementation. *Wolbachia*, a symbiotic bacterium naturally found in insects, can cause infertility and prevent the mosquitoes from reproducing (Atyame et al. 2015). In this approach, the bacterium is passed on by the mother to offspring and when male mosquitoes are trans-infected with a strain, it can result in their inability to successfully reproduce with a wild female that does not have the same strain of *Wolbachia*. Initial field trials for public health are under way in several localities, including a small trial in Fresno County, California, a first for the United States (Wired 2016).

PRT, another form of potentially effective mosquito control, incorporates a modified (e.g., genetically engineered) mosquito that is released into the environment. It differs from SIT, in that it uses a gene drive that enables a desired trait to spread through a population in successive generations. The uses of PRT are numerous: for population suppression and elimination, or the delivery of a novel trait, such as disease inhibition (Burt 2003). Unlike SIT where it is necessary to continually re-release sterile mosquitoes into the environment to maintain control, some forms of PRT require a single input of modified males. PRT is unproven outside the lab and genetic safeguards, regulatory oversight, and public inclusion must be established prior to any proposed release to help foster public support of the control mechanism (NASEM 2016).

These novel mosquito control techniques offer a new level of optimism towards the recovery of imperiled honeycreepers of Hawaiʻi. However, to implement these tools in Hawaiʻi for use on *Culex*, there are challenges to overcome. For one, these tools have been used in public health applications that differ from how they would potentially be used in Hawaiʻi. Deployments have been in urban centers, where there are road networks from which modified mosquitoes can easily be released from trucks. For the inaccessible areas and steep mountainous terrain of Hawaiʻi, an aerial deployment capability would be required. There are groups working on aerial deployment methods, but more attention and focus needs to be directed to this area for a Hawaiʻi application to be feasible (Potterton 2015). These are new tools for conservation. No matter what locality, all of the various SIT strategies have taken time to garner enough public support for their implementation. Hawaiʻi will be no exception. Vector control capacity in Hawaiʻi was significantly diminished in the 2008 economic down turn (Terrell 2016). It would take some time to raise the public's awareness about the need for proactive vector control as well as developing an informed understanding of these novel approaches towards mosquito control.

The U.S. Fish and Wildlife Service along with the Hawaiʻi Department of Land and Natural Resources are committed to working with partners and stakeholders across the state to assess the full range of options available to deal with this recovery issue. In 2015, state and federal agencies along with non-governmental organizations formed an avian malaria vector control working group. These entities have a mandate or position to address the conservation crisis caused by mosquito-borne disease. The working group will focus on identifying information gaps, developing short and long term goals, disseminating information and progress, and investigating how best to engage the public. Moving forward will require a partnership among supportive government agencies, local collaborators, and a willing public (Lavery et al 2010). If successful in these endeavors, not only will these rare birds thrive in the native forests of Hawaiʻi, but Hawaiʻi will be a global leader in conservation.

Joshua Fisher is an Invasive Species Biologist, and for the last 10 years has served in the Invasive Species Program within the Pacific Islands Fish and Wildlife Office. The program's primary focus is to help coordinate the prevention of the establishment of introduced invasive species that negatively affect or have the potential to affect the USFWS trust resources and their habitats within the Pacific Ecoregion. A current project is looking at addressing avian malaria by supporting the development and implementation of control, management, and eradication techniques for incipient and established non-native mosquito populations that vector the disease.

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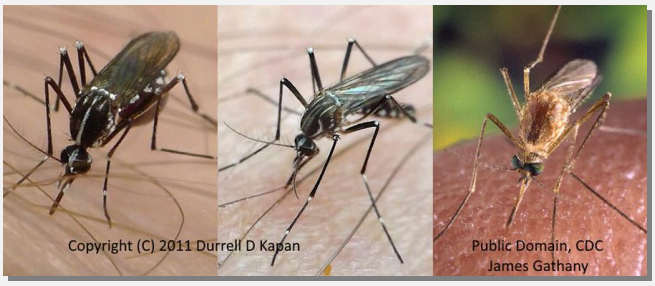
Citizen Science: In Search of Mosquitoes in Hawai'i



Asian Tiger Mosquito (*Aedes albopictus*) and Yellow Fever Mosquito (*Aedes aegypti*), carriers of dengue and zika; and Southern House Mosquito (C*ulex quinquefasciatus*), carrier of avian malaria and West Nile Virus.

A number of citizen scientists living in Hawai'i have joined a project to map the distribution of the six non-native mosquito species we have here. The project is led by Durrell Kapan, Adjunct Professor, Center for Conservation and Research Training, University of Hawaii--Mānoa and Institute for Biodiversity Science and Sustainability, California Academy of Sciences. The research will use our observations to make detailed, fine-scale predictions of where mosquitoes are likely to be found - critical information for vector control and bird conservation efforts.

You can contribute to this research! Your observations of mosquitoes can add valuable input - the project needs observations from a wide variety of locations, habitats and micro-climates. When you are out observing birds, you can also watch for mosquitoes. Learn more at the Hawai'i Audubon Society's website under the Citizen Science Section.

http://www.hawaiiaudubon.org/citizen-science

Keeping Track of Honolulu's Growing White Tern Population

Submitted by Hui Manu o Kū

Tracking their numbers

White tern (*Gygis alba*) watchers are accustomed to spending the holidays pining away for spring when Manu O Kū once again show up en masse to grace the skies over Honolulu and begin their solemn egg-sitting vigils. Not so this season, at least for what seems to be a surprising number of eggs laid in October, as witnessed or discovered by Dr. Eric VanderWerf, Rich Downs, Ian Vogel, Miriam Swann and others from the Hui Manu O Kū.

One good-sized kukui tree currently hosts no fewer than 6 pairs of terns, each with an egg or chick of their own. Dr. VanderWerf has long noticed that a few Manu O Kū can be found around town at any time of year, and that some will raise a chick in what we usually think of as the "off-season". But something special looks to be happening as the end of 2016 draws near because, if luck and vigilance, by terns and their human caretakers, continues to hold, an unusually large number of little puffball tern chicks will welcome the New Year to Honolulu.

Why this apparent phenomenon of a high number of "late" nesters is coming to pass is a bit of a mystery. Intensive city-wide tern watching is a new phenomenon in its own right. Consequently, we can't say for sure whether the percentage of pairs laying eggs in late 2016 is an anomaly or just the enigmatic terns doing their thing. There appear to be more terns nesting this fall than in previous years, but is that part of a long term trend or just a difference between two years? One consequence of this year's extended breeding season is that anyone trimming trees this fall will need to be on the lookout for white tern eggs and chicks.

What we do know, thanks to Dr. VanderWerf and other more casual watchers, is that Honolulu's population of white terns has continued to grow each year since 1961 when the first pair began to nest on O'ahu, in recent times at least, starting an apparent natural recolonization of O'ahu. By 2003, there were about 250 nesting pairs. Early results from ongoing surveys indicate that Honolulu's white tern breeding population has substantially grown over the last 13 years.

We also know that white terns lay only one egg when they "nest" if y
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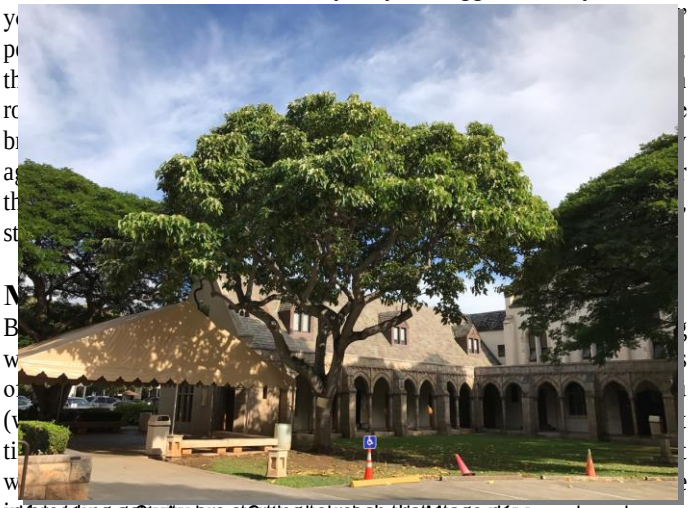
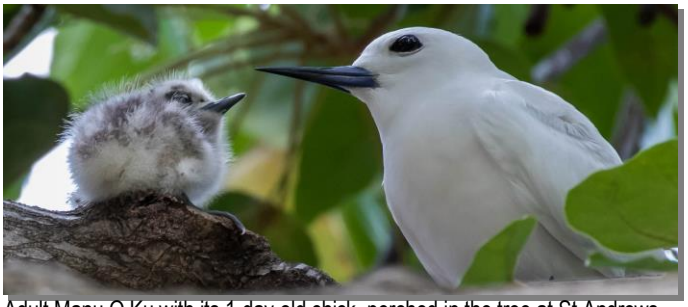


Kukui tree at St. Andrews Cathedral where six Manu o Ku eggs have been laid since September. Photo: R. Downs



Adult Manu O Ku with its 1-day old chick, perched in the tree at St Andrews Cathedral. Photo: R. Downs

In early December, with help from Eric VanderWerf and Lake Gibby, the Hui Manu o Kū banded four chicks. Lake is a professional arborist who is lending his ability to adroitly climb trees to reach and retrieve nesting chicks. Eric, who is a certified bander, attaches a silver colored metal band with a unique identifying number to one of the chick's legs. This band will allow anyone who finds the bird in the future to learn where and when it was banded. Colored bands are also being attached to the birds to help anyone studying white tern behavior to differentiate one bird from another.

Earlier this year a white tern incubating an egg in a tree in front of the central post office in downtown Honolulu was discovered to be banded. We sent the number recovered from the band to the Bird Banding Laboratory at the Patuxent Wildlife Research Center and learned that this white tern had been banded in 1981 near Diamond Head. At 35 years of age this bird had lived twice the average lifespan for a white tern… and was still laying eggs! Who knows what the Manu o Ku we band now will help citizen scientists and other researchers learn about these amazing birds in the future.

Hui Manu-o-Kū
http://www.whiteterns.org/

Volunteer with Hui Manu-o-Kū
http://www.whiteterns.org/citizenscience.html

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VOLUNTEER OPPORTUNITIES

Freeman Seabird Preserve 2017 Fieldwork Season

Seeking Volunteers for Habitat Restoration!

9 am to Noon, Every Saturday morning JAN through MAR 2017

In November and early December, Wedge-tailed Shearwater adult birds and chicks leave the Freeman Seabird Preserve at Black Point to forage at sea for several months before returning in the latter part of March to nest.

Volunteers are needed for fieldwork at the site on Saturday mornings from 9 am to noon beginning January 7th. Activities will include maintenance of native plants and man-made landscape features, along with removal of invasive plants, trash and debris. Other dates and times can be arranged for groups wishing to contribute their time in an effort to preserve rare Hawaiian coastal vegetation and seabird nesting habitat.

Contact the Hawai‘i Audubon Society office by phone at (808) 528-1432 or e-mail at hiaudsoc@pixi.com in advance if you would like to participate. We will meet each Saturday at Triangle Park near Diamond Head at 8:45am to carpool to the site. Plan on bringing drinking water, sun and rain protection, gloves, weeding tools, clippers and loppers.

Aloha Hawai‘i Audubon Society Leadership

The Society wishes to gratefully acknowledge the efforts of outgoing Board members **Dr. Donald Drake** and **Thorne Abbott** who have completed their terms of service to the HAS Board for the past two years. Mahalo nui loa for your leadership and insights.

Continuing to serve for yet another two years are Board members **Alice Roberts** and **Dr. Phil Bruner**. Mahalo nui loa for your ongoing efforts.

E komo mai and Welcome to our two newest Board members, **Dr. Wendy Kuntz** and **Rich Downs**, who will be serving one year terms.

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Help prevent the O‘ahu ‘Elepaio from going Extinct

Eric VanderWerf
Pacific Rim Conservation

There are less than 1,200 O‘ahu ‘Elepaio left, an endangered forest bird found only on O‘ahu, and their numbers are declining. Rats climb trees that ‘Elepaio nest in, eat eggs, chicks, and sometimes even the mother as she tends her nest. When rats are trapped, twice as many ‘Elepaio pairs successfully raise a chick, fewer females are eaten, ‘Elepaio increase in number and can expand their range.

Male and female ‘Elepaio share most aspects of nesting and raising the young, but only the female incubates the eggs at night. Because rats are active mostly at night, female ‘Elepaio are especially vulnerable to predation. In some areas of O‘ahu where ‘Elepaio have declined most seriously, there are only males left; all the females have been eaten by rats or died before raising any young. The last males may hang on for years, singing each year to attract a mate, but there are none left. This is why it is so important to protect O‘ahu ‘Elepaio nests- to stop females from being eaten and to allow them to reproduce.

To help fund predator removal from O’ahu ‘Elepaio nesting areas, go to http://www.elepaio.org/help-elepaio.html, or contact Pacific Rim Conservation, PO Box 61827, Honolulu, HI, 96839.

Learn more about O’ahu ‘elepaio at http://www.elepaio.org/

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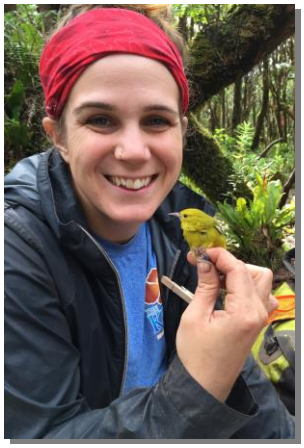

Congratulations
Fall 2016
Hawai‘i Audubon Society
Student Research Grant Winner

Maria Costantini
Department of Biology
University of Hawai‘i at Mānoa

Describing ‘Akikiki diet through DNA barcoding of fecal samples