HAWAI'I AUDUBON SOCIETY

'ELEPAIO

VOLUME 86, NUMBER 1 *Journal of the Hawai'i Audubon Society* **JANUARY / FEBURARY 2026**

Kiwikiu (Maui Parrotbill, *Pseudonestor xanthophrys*) in a high-elevation forest on Maui. © Maui Forest Bird Recovery Project

Holding the Mosquito Line: Maui's Fight to Save Its Honeycreepers

By Laura Doucette

The helicopter steadily rises, its rotors scattering a light mist above the upper canopy of ʻōhiʻa lehua (*Metrosideros polymorpha*) and koa (*Acacia koa*). Below, technicians move along a narrow ridge trail with CO_2 tanks and batteries, the forest still wet from overnight rain. Somewhere in this landscape, avian malaria-carrying mosquitoes now occupy elevations once considered safe for Maui's native birds.

Across Hawai'i, warming temperatures have pushed the mosquito "line" upslope, eroding the last disease-free refuges for species such as kiwikiu (Maui Parrotbill, *Pseudonestor xanthophrys*) and ʻākohekohe (Crested Honeycreeper, *Palmeria dolei*). Maui now offers a close look at how the Incompatible Insect Technique (IIT) is being adapted to wildlife conservation in steep, remote forests where access often depends on helicopters and, increasingly, drones.

Along a GPS-guided flight line, biodegradable paper-pulp pods fall through gaps in the canopy, each carrying about a thousand incompatible male mosquitoes. The Maui landscape-scale effort to combat avian malaria began November 2023, while Kauaʻi started their releases in February 2025.

Here, we offer an updated look at Maui's landscape and one turning point in the broader effort to reduce mosquito-borne disease in Hawai'i's forests.

Remote, steep forest terrain in a high-elevation landscape on Maui.
© Maui Forest Bird Recovery Project

A High-Elevation Turning Point

For decades, Hawai'i's high elevation forests served as the final refuge for native honeycreepers. Avian malaria (*Plasmodium relictum*) is most prevalent in warm, low-elevation areas and becomes less common upslope as temperatures drop—a pattern that historically limited both mosquito activity and parasite development (Samuel et al., 2015). These conditions allowed species such as kiwikiu, 'ākohekohe, and 'i'iwi (Scarlet Honeycreeper, *Drepanis coccinea*) to persist long after disappearing from much of their former range.

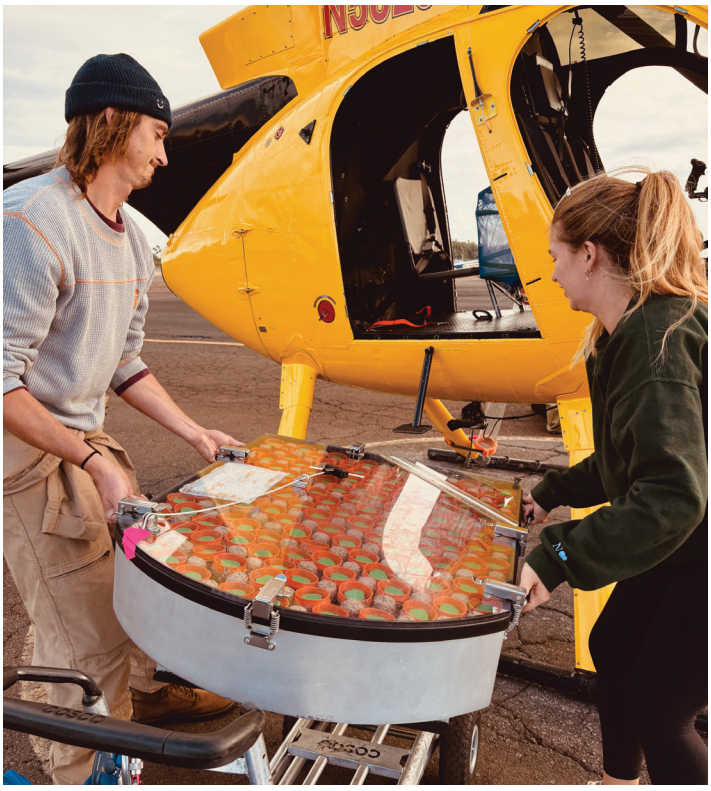
On Maui, that refuge once included Nakula Natural Area Reserve on the leeward slopes of Haleakalā. Beginning in 2013, Maui Forest Bird Recovery Project (MFBRP) and partners restored this degraded landscape through fencing, ungulate removal, and native outplantings designed to rebuild former bird habitat.

By 2019, MFBRP initiated a carefully planned translocation of kiwikiu into Nakula. For a brief time, the forest held the species' calls again. But within weeks, birds showed severe illness or disappeared. Necropsies confirmed avian malaria. Despite Nakula's elevation, mosquito densities and infection rates were far higher than anticipated. The losses echoed what climate-driven disease models had warned: rising temperatures would push malaria transmission into elevations once considered safe (Liao et al., 2017). Nakula highlighted the urgency of mosquito control. The question was no longer whether action was needed, but how quickly it could begin.

A New Tool for a Changing Forest

Conservation strategies for Hawaiian honeycreepers have long included habitat restoration, predator management, and translocations to safer locations (Samuel et al., 2015). These tools remain essential, but none were designed to counter a rapidly expanding disease front.

The Incompatible Insect Technique (IIT) offers a new option. Male mosquitoes are reared with a specific *Wolbachia* strain, a naturally occurring bacteria; when they mate with wild females carrying a different or no strain, their eggs fail to hatch. Only non-biting males are released, and no genetic modification is involved. Repeated releases can suppress wild mosquito populations (U.S. Fish and Wildlife Service [USFWS], 2023a; McClure, 2020).



MFBRP staff prepare a helicopter for deployment of pods containing male mosquitoes as part of mosquito suppression efforts on Maui.
© Maui Forest Bird Recovery Project

A pod containing *Wolbachia*-infected male mosquitoes drops from a helicopter's release chute during aerial mosquito suppression efforts on Maui. © Maui Forest Bird Recovery Project

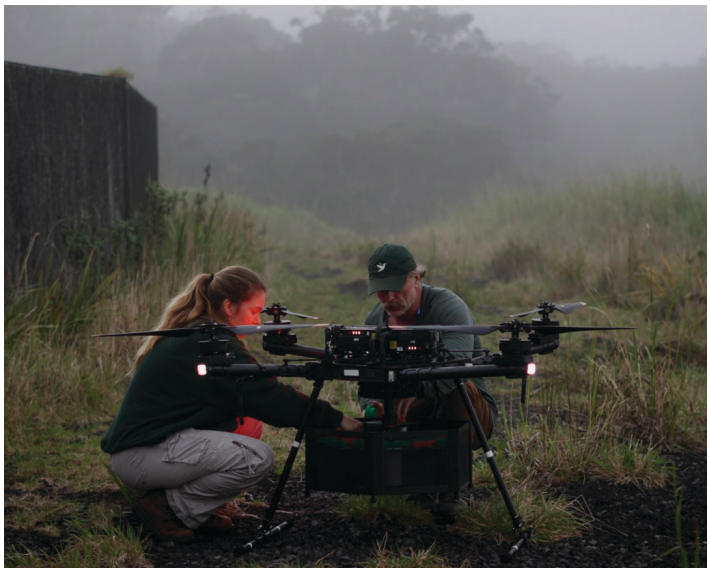
IIT has been successfully used internationally to reduce mosquito-borne diseases in humans. In Hawai'i, the method is being adapted not for urban neighborhoods, but for steep, cloud-covered native forests where access requires aircraft. Kaua'i and Maui are central to this work because they are home to the most imperiled native forest bird populations. In 2023, following similar environmental review and public consultation processes, state and federal agencies approved IIT for both islands — including tens of thousands of acres of East Maui forest and portions of Haleakalā National Park (USFWS, 2023b).

Releasing Millions in a Moving Cloudbelt

In November 2023, MFBRP and partners began the first landscape-scale IIT deployments on Maui, using twice-weekly helicopter flights to distribute incompatible male mosquitoes across approximately 3,000 acres of middle-elevation forest. These aircraft remain the backbone of the program, capable of covering steep, cloud-draped terrain. Aboard the helicopter, two technicians work closely—one drops the pods loaded with *Wolbachia*-infected males through a custom-designed chute, while the other calls out the timing for each drop.

Beneath the canopy lies a patchwork of microhabitats—bogs, tree-fern cavities, and puddled stream margins—that support breeding for the southern house mosquito (*Culex quinquefasciatus*) (LaPointe, 2024). Release points are distributed to apply approximately ten incompatible males for every wild male per acre across the landscape, increasing the likelihood that female mosquitoes encounter and mate with an incompatible male.

While helicopters remain essential, supplemental drone-based releases have expanded the release window when helicopters aren't available. As technology advances, drones are expected to play a larger role.



Under misty, low-visibility conditions, MFBRP team members prepare a drone for mosquito pod deployment, extending release operations beyond helicopter availability. © Maui Forest Bird Recovery Project

Implementing IIT in Maui's forests requires constant adaptation to shifting weather, complex winds, shipment schedules, and narrow flight windows. During the first year, more than 25 million incompatible males were released. Maui's and Kaua'i's field experiences are now informing statewide protocols and demonstrating how IIT can be scaled to other islands.

Currently, all incompatible males used in Hawai'i are reared on the mainland and shipped weekly. This system enabled early implementation but is vulnerable to transport delays and cannot support statewide expansion. Conservation partners are evaluating the development of on-island rearing

facilities to stabilize supply and support long-term mosquito suppression.

The goal is simple in concept and demanding in practice: release enough incompatible males, for long enough, that the invasive mosquito population—and thus avian malaria—declines. Because IIT cannot treat all parts of the islands, and fertile mosquitoes can fly in from non-treated areas, IIT releases need to be maintained indefinitely to reliably protect native birds.

Making the Invisible Visible: Monitoring IIT in the Forest

To evaluate whether IIT is working, MFBRP maintains monitoring stations across treated and comparable non-treated areas, building on more than a decade of research into mosquito abundance and disease transmission in Hawaiian forests (Ahumada et al. 2024).

MFBRP tracks three primary indicators:

1. Adult mosquito trapping
CO_2-baited traps collect mostly wild females and some males, allowing researchers to estimate mosquito density, sex ratios, and the proportion of released IIT males relative to wild males.

MFBRP team members check mosquito traps as part of ongoing monitoring to inform mosquito suppression efforts.
© Maui Forest Bird Recovery Project

2. Egg raft sampling
Basins filled with fermented hay-water attract gravid females. Egg rafts are collected and hatched in the lab; a high proportion of unhatched eggs indicates successful incompatible matings.

3. Larval surveys
Teams inspect standing water across streams, feral pig wallows, and natural containers such as tree-fern cavities to document changes in larval abundance over time and identify larval breeding habitats.

An MFBRP team member collects streamside samples during larval surveys used to identify mosquito breeding habitats and monitor changes in larval abundance over time. © Maui Forest Bird Recovery Project

Mosquito populations fluctuate with rainfall and temperature; single sampling events therefore provide only limited inference. Multi-year datasets are essential to distinguish short-term variability from sustained suppression. Bird population responses lag even further: slow-reproducing honeycreepers such as kiwikiu and ʻākohekohe may take years to show measurable demographic improvement once malaria pressure declines.

Kuleana to Birds Most People Will Never See

Most residents and visitors on Maui and the Hawaiian Islands will never see kiwikiu or ʻākohekohe. Yet decisions made today—in boardrooms, labs, and

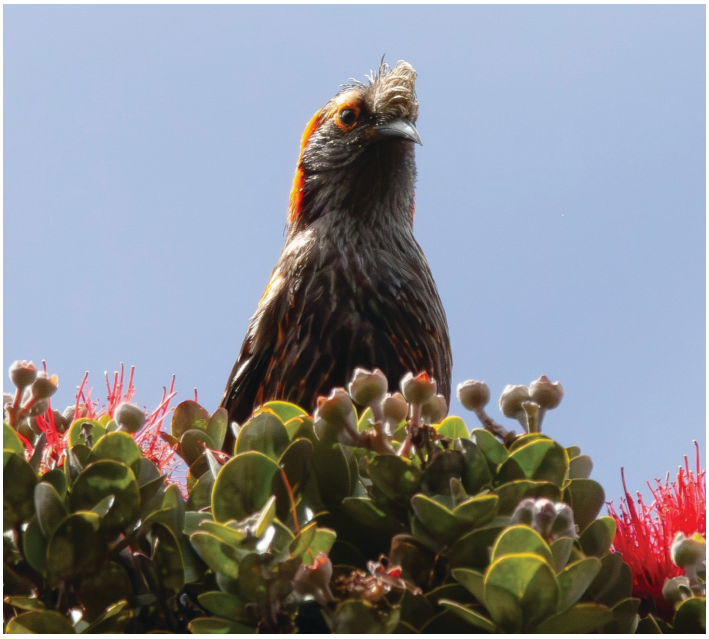
helicopter staging areas—will determine their future.

Native forest birds anchor both the ecological and cultural integrity of Hawai‘i. Ecologically, their feeding, pollination, and seed dispersal sustain native plant communities and the health of the forest canopy. Culturally, these birds carry stories that stretch back to creation, appearing in the Kumulipo and traditional mele and oli as embodiments of place, ancestry, and guidance. Their loss would erode not only the forests themselves but the cultural knowledge and relationships connected to them. Protecting them is part of honoring the reciprocal responsibilities—kuleana—that tie people to the ‘āina.

Research documenting climate-driven disease expansion and rapid avian population decline has been sobering (Paxton et al., 2016; Howard, 2017; Liao et al., 2017). IIT offers a landscape-scale tool that did not exist a generation ago: a way to reduce mosquito populations without genetic modification or broad-spectrum pesticides (USFWS, 2023a; McClure, 2020).
IIT alone cannot secure the long-term survival of Hawaiian forest birds. It must operate alongside habitat protection, predator control, and continued development of additional tools. On Maui, IIT serves as a critical bridge—an effort to hold the line against extinction while broader strategies advance (LaPointe, 2024; USFWS, 2023a).

If successful, establishing an on-island mosquito-rearing facility and sustaining IIT at landscape scale would represent one of the most significant conservation achievements in Hawai‘i’s history—an example of a One Health approach, in which reducing vector populations, safeguarding native forest birds, and sustaining healthy ecosystems also contributes to the well-being of the human communities connected to them. Continued investment in this work will determine whether Kaua‘i’s and Maui’s honeycreepers persist in the decades ahead.

As evening settles and the helicopter’s rotor noise fades, a CO_2 trap runs quietly in the understory. Inside the trap’s catch bag, the day’s pattern becomes visible: fewer wild females—small signals that, over time, the mosquito line may begin to shift downslope.



‘Ākohekohe (*Palmeria dolei*), an endemic Maui honeycreeper whose survival depends on continued protection of Hawai‘i’s remaining native forests. © Maui Forest Bird Recovery Project

What happens next will determine whether future generations on Maui know kiwikiu and ‘ākohekohe as living birds or only as photographs and museum specimens. For now, the work is still unfolding—one flight, one trap, and one egg raft at a time.

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Continued progress depends on sustained funding and community support. To learn more about the Maui Forest Bird Recovery Project, the Kaua‘i Forest Bird Recovery Project, Birds, Not Mosquitoes, and how to contribute to mosquito suppression and forest bird recovery in Hawai‘i, visit:

https://www.mauiforestbirds.org/
https://kauaiforestbirds.org/
https://www.birdsnotmosquitoes.org/

Acknowledgments

The author thanks the Maui Forest Bird Recovery Project team, particularly Jessica Eden and Christa Seidl, for sharing data and operational details, and for reviewing the manuscript for scientific and project accuracy.

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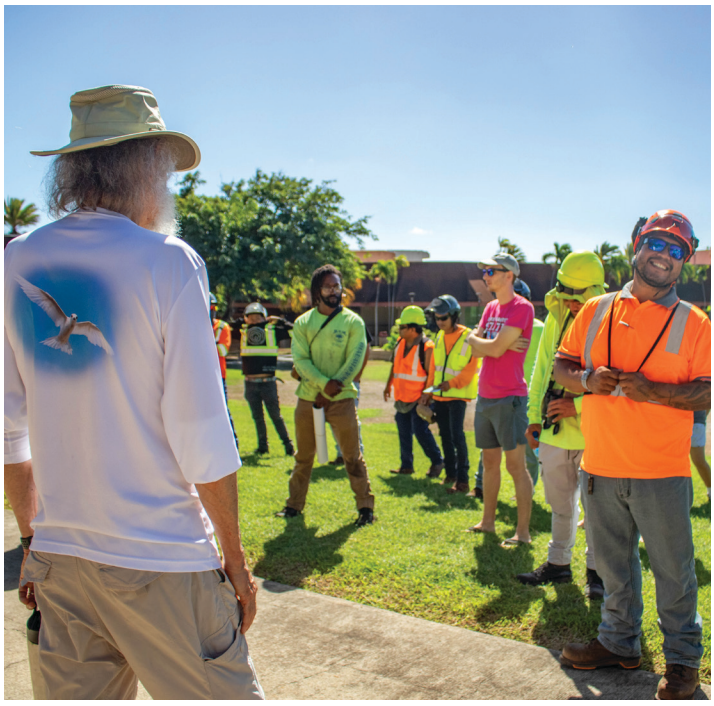


Rich Downs engages with arborists during the morning session of the *Arborists Guide: Protecting Manu o Kū During Tree Work* workshop at Kapi'olani Community College. © Laura Doucette

Sharing the Canopy: Building Skills to Protect Honolulu's White Terns

By Laura Doucette

Honolulu's urban canopy supports one of the city's most distinctive seabirds: the Blue-billed White-Tern (*Gygis candida*), or manu o Kū, the official bird of the City and County of Honolulu. Unlike most birds, manu o Kū place their eggs directly on open branches without constructing a nest, making their breeding success closely tied to the care and management of the trees they depend on.

In Honolulu, this responsibility often falls to arborists, grounds crews, and tree care professionals working at the front lines of the urban forest. Their daily decisions—how and when to trim, where to climb, when to pause work—play a critical role in protecting manu o Kū while also maintaining public safety and healthy trees. The continued presence of this seabird in the city demonstrates that coexistence between people and native wildlife is not only possible, but already occurring through informed, careful tree care.

Addressing a Growing Need Through the Kaulunani Grant Program

In recent years, Hawai'i Audubon Society (HAS) and its partners observed recurring challenges: inconsistent trimming practices near breeding sites, uncertainty among crews about identifying active tern use, and limited training opportunities focused on urban wildlife considerations. These concerns coincided with growing interest in both urban forest care and manu o Kū conservation, creating an opportunity to link the two.

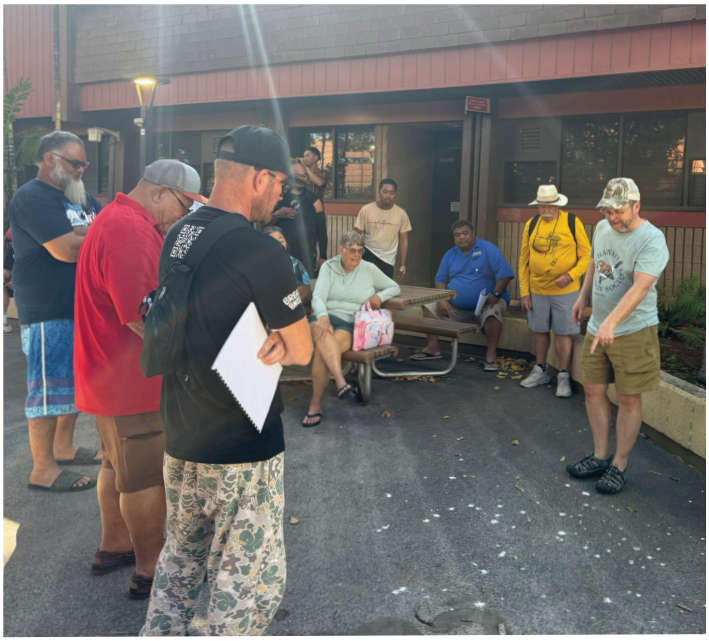
To help meet this need, HAS applied for a Kaulunani Urban & Community Forestry Program grant under the statewide "Year of Our Community Forests 2025" initiative. Kaulunani, administered by the Hawai'i Department of Land and Natural Resources Division of Forestry and Wildlife in partnership with the USDA Forest Service, supports projects that strengthen community forestry through education, outreach, and practical demonstration.

HAS's proposal focused on expanding professional and community knowledge of tern-sensitive tree work, producing educational materials that translate technical guidance into accessible practices, and hosting a live case-study tree-trimming event to demonstrate safe, ecologically informed techniques. The grant provided the foundation for the 2025 workshop and related outreach efforts, supporting planning, equipment needs, training materials, student engagement, and coordination among arborists, biologists, and educators.

Collaborative Planning Grounded in Experience

Following the award, HAS convened partners from the Aloha Arborist Association, Western Chapter International Society of Arboriculture, Donahue Arborist, Tree Solutions Hawaii, U.S. Fish and Wildlife Service, Hawai'i DLNR, Pacific Rim Conservation, Delphi Cinema, Hui Manu o Kū, and Kapi'olani Community College (KCC). Planning meetings throughout the year focused on adapting the 2019 Best Management Practices (BMP) document into a practical training curriculum and identifying areas where arborists frequently encounter uncertainty—such as interpreting adult bird behavior, recognizing potential nesting surfaces, and adjusting work approaches in tern habitat.

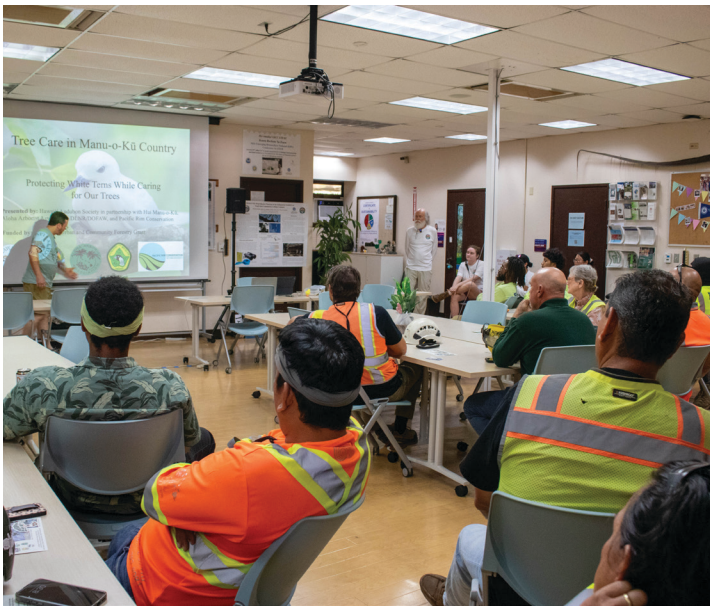
KCC was selected as the workshop site through the longstanding collaboration between HAS and two of its board members—Dr. Wendy Kuntz, Ecology Professor at Kapi'olani Community College, and Rich Downs of Pacific Rim Conservation and the Hui Manu o Kū. The campus provided a setting that supported both classroom instruction and outdoor demonstrations. KCC grounds staff worked closely with the team to designate appropriate trees and ensure the site could safely accommodate a large group, strengthening the partnership between HAS and KCC.



Keith Swindle identifies manu o Kū guano, or white wash, on the ground at the Kapi'olani Community College Campus for afternoon workshop participants, indicating the likely location of an active nesting site overhead. © Wendy Kuntz, PhD.

A Training Designed for Professional Arborists, Homeowners and Students

The workshop was originally planned as a two-track event: arborists in the morning and homeowners and students in the afternoon. Once registration opened, the audience shaped itself. Arborists working daily across Honolulu's urban core filled the roster quickly, while homeowner enrollment remained low and a small group of KCC students



Keith Swindle and Rich Downs lead the morning session for arborists on manu o Kū breeding biology, behavior, and applicable migratory bird protections. © Laura Doucette

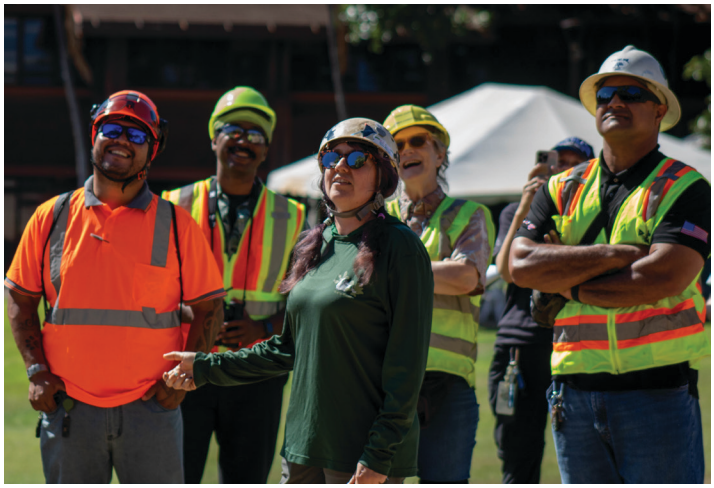
registered to assist and attend. Because the strongest demand came from those responsible for tree care on a daily basis—commercial crews, municipal contractors, and city grounds staff—HAS adjusted the schedule and offered the full professional session twice.

Each session began in KCC's Koki'o STEM Center, where participants received an overview of manu o Kū biology and the behavioral cues most relevant to tree work. Instructors Rich Downs and Keith Swindle—a former Criminal Investigator and Biologist for the U.S. Fish and Wildlife Service and current HAS Executive Director—outlined legal considerations guiding trimming around protected wildlife, including the Migratory Bird Treaty Act and applicable state regulations. They reviewed key recommendations from the BMP document and emphasized pre-work assessments: scanning trees before climbing, identifying signs of recent tern activity, and planning work sequences when wildlife may be present.

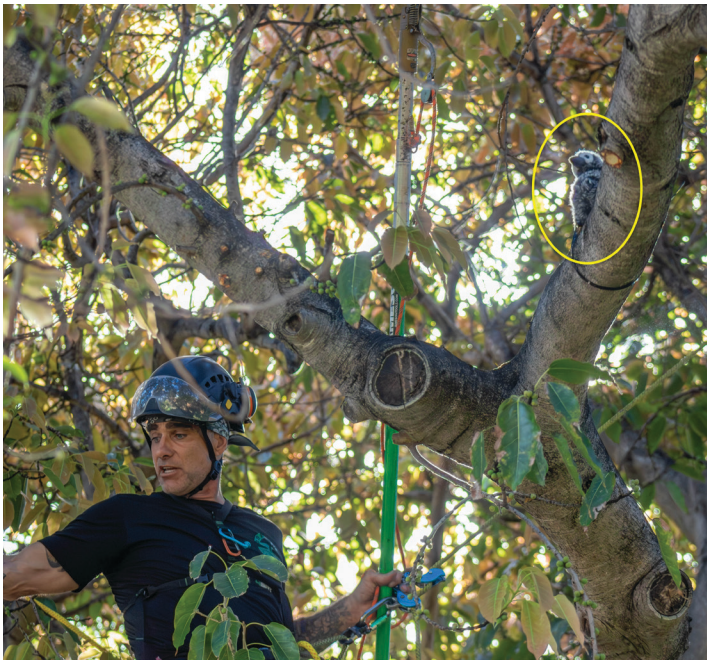
The indoor training also addressed what to do if a downed chick or adult bird is encountered during tree work. Participants were instructed to contact the Manu o Kū Hotline at (808) 379-7555, and arborists later received helmet and vehicle stickers with the number so it would be readily accessible in the field.

Outside, certified arborists Justin Donahue of Donahue Arborist and Ilana Nimz of Tree Solutions Hawaii—Nimz also a wildlife biologist—led a live trimming demonstration designed to model safe, wildlife-aware practices. Because the workshop took place after peak breeding season and no reliable chicks were present in the selected trees, trainers placed a stuffed bird decoy in the canopy, allowing participants to practice identifying likely nesting surfaces, moving around the bird while in the tree canopy, and recognizing subtle indicators of past tern use.

Participants worked through observational exercises that emphasized reading the birds themselves. Trainers highlighted behavioral cues—flushing, head turns, upright postures, or small changes in stance—that should guide decisions in real time rather than relying on fixed distance rules alone. The demonstration reinforced that careful observation and responsiveness to individual birds are central to wildlife-safe tree care.


Ilana Nimz explains wildlife-aware tree care practices to professional arborists, as Justin Donahue demonstrates climbing and trimming techniques in the tree canopy above. © Laura Doucette

The demonstration also highlighted the equipment and techniques arborists rely on in the canopy. Justin Donahue used ropes, climbing aids, hand saws, a pole saw, and an electric chainsaw to demonstrate how professional tree workers move safely through a tree and make controlled cuts while remaining attentive to nearby wildlife. KCC grounds staff collaborated with the training team to select demonstration trees, establish safe viewing areas, and assist with cleanup after each session.



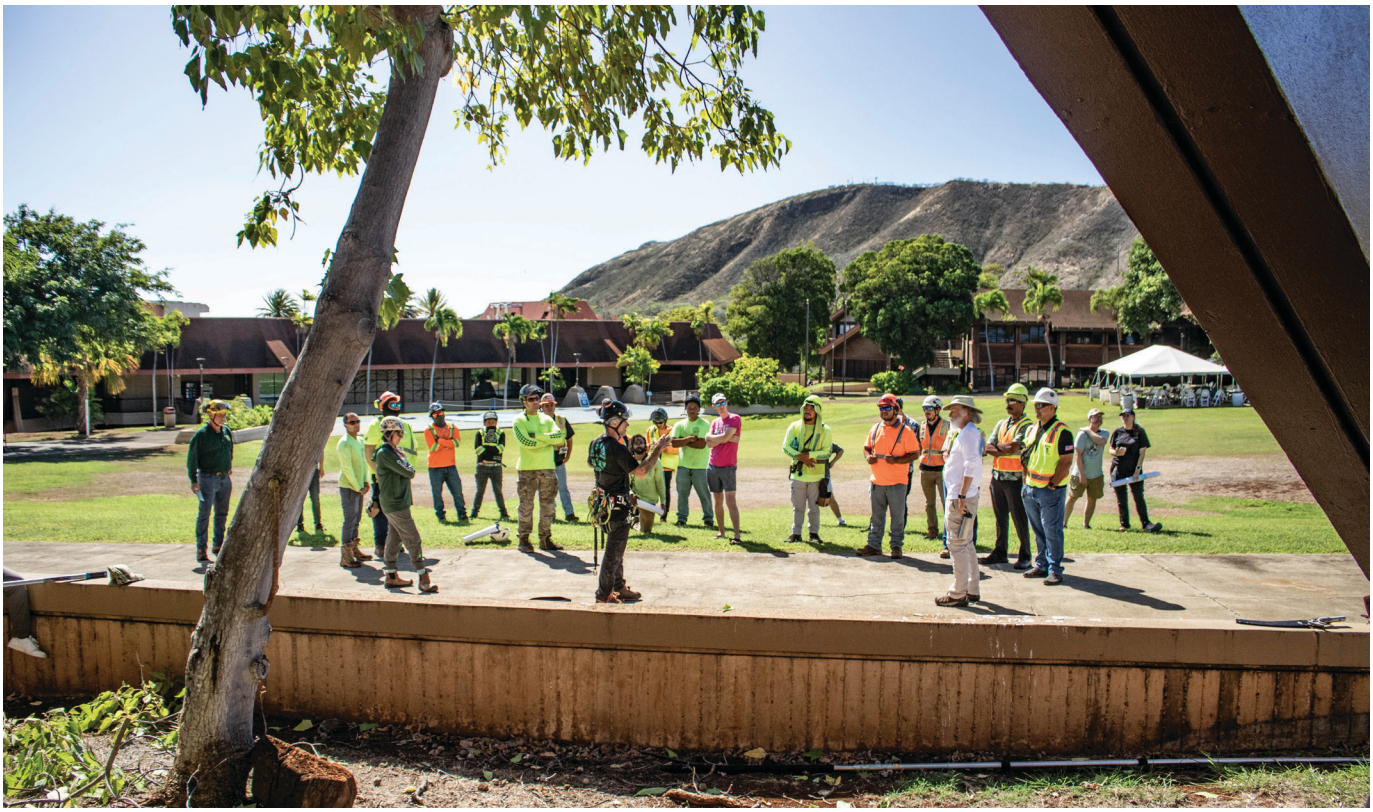
Justin Donahue works in the tree canopy during a live demonstration, using climbing aids and a pole saw around a stuffed bird decoy (circled) to model wildlife-aware movement and cutting techniques. © Laura Doucette

Across both sessions, more than 40 attendees—from commercial tree companies, municipal crews, campus operations, conservation organizations, state agencies, students, and community members—observed how practical trimming techniques intersect with careful, real-time assessment of manu o Kū behavior in an active urban environment.

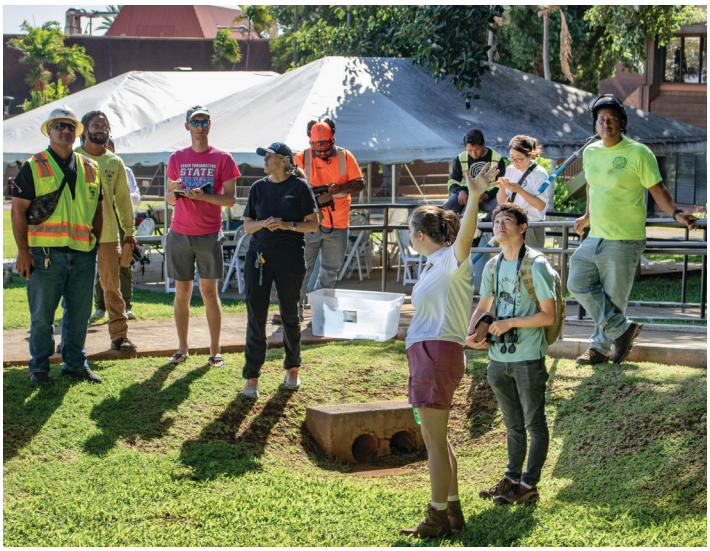
Developing Educational Video Resources

Another major component of the Kaulunani project is the development of video-based educational materials designed to extend the reach of the workshop beyond in-person training. Hawai'i Audubon Society contracted with Delphi Cinema to produce a video that reinforces the core concepts presented during indoor instruction and applies them to real tree work.

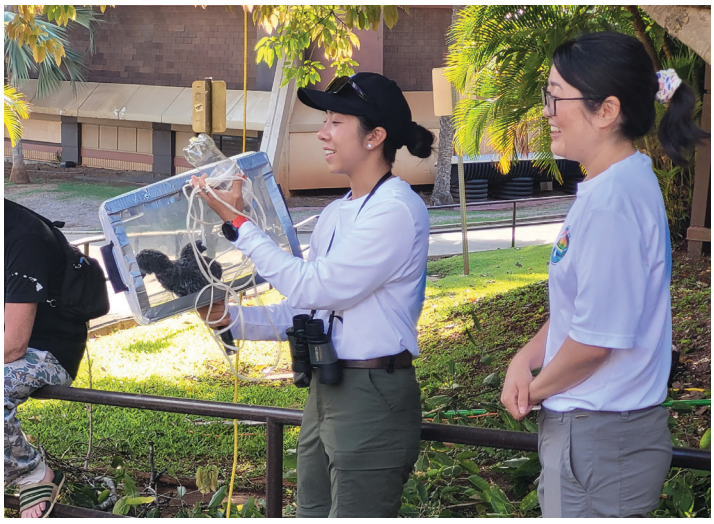
The video centers on a key message of the grant: arborists are frontline stewards of Honolulu's urban canopy, and their daily work plays a critical role in protecting manu o Kū. Footage of Justin Donahue working in a tree provides visual context for applying wildlife-sensitive practices when birds are present. Once completed, the video will serve as an accessible training resource for arborists, students, and community members unable to attend in-person sessions.



Participants engage in a closing group discussion during the professional arborist training, with instructors Justin Donahue and Ilana Nimz responding to questions following the live demonstration. © Laura Doucette



Kapiʻolani Community College students Charlotte Bender and James Lee discuss campus-based manu o Kū monitoring and research projects with arborists during the workshop. © Laura Doucette



Hui Manu o Kū rescuers Sora Gallo (left) and Kelly Furuya (right) demonstrate chick rescue techniques, explaining assessment methods, handling protocols, and the specialized tools used to safely return fallen chicks to their nesting trees. © Elena Arinaga

Strengthening Urban Forest Stewardship Through Partnership

Beyond the technical training, the workshop created opportunities for arborists, biologists, campus staff, and students to compare experiences and discuss the realities of working in Honolulu's urban canopy. These exchanges helped bridge gaps between wildlife conservation, day-to-day tree care operations, and campus-based monitoring efforts.

KCC students shared details from ongoing projects documenting manu o Kū activity on campus, including mapping sightings, noting breeding behavior, and tracking frequently used trees. Their observations illustrated how student-led monitoring can complement professional tree care and conservation work. Hui Manu o Kū rescuers also offered a hands-on demonstration, explaining how fallen manu o Kū chicks are assessed, safely handled, and returned to their specific nesting trees using established rescue methods and tools.

The impact of the training became evident soon after the workshop. Within a week, an arborist who attended contacted the manu o Kū hotline to report what is believed to be the first documented case of manu o Kū nesting at the National Memorial Cemetery of the Pacific (Punchbowl). The arborist noticed fresh droppings beneath a shower tree, looked up, and identified a chick—applying the same observational cues emphasized during the training.

The Kaulunani grant project underscored the close connection between Honolulu's trees and the wildlife that depend on them, reinforcing practices that allow arborists to protect wildlife while continuing their essential work. Thoughtful tree care—grounded in science and supported by collaborative training—is central to protecting manu o Kū and maintaining a resilient urban forest. HAS and its partners intend to build on the success of the 2025 workshop through continued outreach, educational materials, and future training opportunities that strengthen shared stewardship of the city's canopy.

This project was supported by the Kaulunani Urban & Community Forestry Program of the Hawaiʻi Department of Land and Natural Resources Division of Forestry and Wildlife and the USDA Forest Service as part of the Year of Our Community Forests 2025 initiative. Mahalo to all our project partners and collaborators, and to our volunteers for their expertise, time, and commitment to making this project a resounding success.

Editorial note: Bird naming conventions continue to evolve. The names used here reflect current standardized usage at the time of publication.

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Events

January 10: Bird Tour at Kapi‘olani Park (O‘ahu)

January 11: Ka‘ena Point Bird Tour (O‘ahu)

January 16: E Ola Kākou 2026: HIDOE Health Education Symposium (O‘ahu)

February 16: World Wetlands Day at Keawāwa Wetland (O‘ahu)

For more details, event additions, and updates visit:
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‘Elepaio ISSN 0013-6069
Managing Editor: Laura Doucette
Scientific Editor: Eric VanderWerf, PhD

The *‘Elepaio* is printed on recycled paper and published six times per year.

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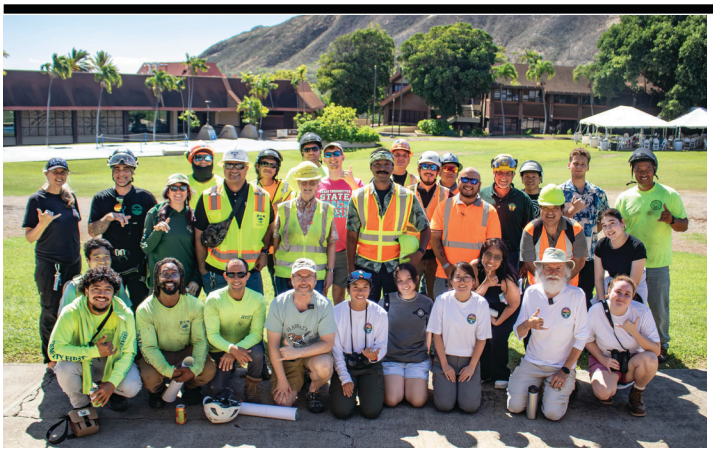

Participants in the *Arborists Guide: Protecting Manu o Kū During Tree Work* workshop at Kapiʻolani Community College. © Laura Doucette

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Table of Contents

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