U.S. Department of the Interior Strategy for Preventing the Extinction of Hawaiian Forest Birds

ʻAkekeʻe (*Loxops caeruleirostris*), one of the four Hawaiian forest bird species at imminent risk of extinction due to avian malaria, overlooking the Alakaʻi Forest on the island of Kauaʻi. Photo credit L. Behnke.

Note: This is a "living document" that will be updated annually to reflect new information on technologies and budgets. This version is dated May 28. 2025 and was developed and has been approved for sharing by the National Park Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, and Office of Native Hawaiian Relations. This document identifies potential investment opportunities that will help to inform the Federal budget development process, but it is not a budget document and does not imply approval of any specific action or investment. All activities and recommendations included in the document are subject to resource constraints and weighing of priorities as part of the annual budget formulation process, as well as the availability of appropriations provided by Congress.

An Opportunity to Prevent an Imminent Extinction Crisis and Biocultural Loss

Iconic, endemic Hawaiian forest birds are facing an extinction crisis accelerated by the effects of environmental change. Hawaiian forest birds are now found only at high, cooler elevations, where they persist in habitats outside the range of invasive mosquitoes and the transmission of avian malaria, the primary driver of bird declines. Increased air temperatures due to increasingly variable climate conditions have progressively allowed for the spread of mosquito-borne disease into these isolated, high-elevation refugia. With already small population sizes and little to no resistance to avian malaria, imminent extinctions of these birds are probable without significant management actions. Four forest bird species (Hawaiian honeycreepers) on Kauaʻi (ʻAkekeʻe [*Loxops caeruleirostris*] and ʻAkikiki [*Oreomsytis bairdi*]) and Maui (Kiwikiu [*Pseudonestor xanthophrys*] and ʻĀkohekohe [*Palmeria dolei*]) are in danger of extinction in as little as 1-2 years and eight additional forest bird species are at risk of extinction in the near future.

In the Native Hawaiian culture, the cosmogony, as told through the Kumulipo (creation chant), speaks to the creation of all things in Hawaiʻi. The Kumulipo has been passed down from generation to generation and describes the genealogical and geophysical context that gave rise to and shaped the Hawaiian Archipelago. This creates an inherent connectivity and relationship between members of the Native Hawaiian Community and all indigenous and endemic flora and fauna, as well as the places they inhabit and the natural forces that act upon them. Endemic forest birds are thus recognized by the Native Hawaiians as ʻohana (family), kūpuna (ancestors), and ʻaumākua (familial gods), and their unique habitats are revered as sacred places for the cultural ecological services they provide. This centuries-old interdependent and reciprocal relationship has developed into a body of traditional biocultural knowledge and practice that is now at risk of being lost due to bird extinctions.

Extinction of bird species and loss of sacred relationships are not foregone conclusions—opportunity exists to save these species to maintain biodiversity and ecosystem function in Hawaiʻi, and to preserve the familial relationship with the Native Hawaiian Community and the continuity of biocultural knowledge and practice.

This strategy provides a comprehensive approach to prevent the extinction of Hawaiian forest birds that uses the best available science, conservation techniques, and Native Hawaiian biocultural knowledge and practices. It includes the planning and implementation of innovative landscape-level mosquito control, translocation of birds to higher elevation islands, establishment of captive populations of at-risk birds, and development of next generation tools that increase the scope or efficacy of these actions in a culturally appropriate and integrated approach.

The innovative, landscape-scale tools we propose to suppress mosquito populations have been safely and effectively used worldwide to combat mosquito-borne diseases affecting human health. However, these methods have not yet been applied in a conservation context. Developing such a tool presents a promising opportunity—not only to suppress, but potentially eliminate mosquitoes—thereby breaking the cycle of mosquito-borne diseases. This approach can serve as a model for other islands facing similar challenges and will help build capacity and enhance public health tools across the Pacific Region.

Among the U.S. Department of the Interior (DOI) bureaus and offices in Hawaiʻi, the National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), and Office of Native Hawaiian Relations (ONHR) are committed and positioned to meaningfully engage the State of

Hawai‘i, the Native Hawaiian Community, and local and national partners to successfully leverage resources for Hawaiian forest bird conservation and mosquito control development and implementation.

Purpose for Developing this Strategy

- Outline a multi-year plan of crosscutting DOI bureau and office actions to avoid extinction of native Hawaiian forest birds imperiled by the spread of mosquitoes carrying avian malaria.
- Increase ongoing coordination between national, regional, and field level representatives of the NPS, USFWS, USGS, and ONHR to achieve the goal and objectives of the strategy.
- Describe specific rate limiting steps where bureau headquarters or DOI-level assistance is needed for high-complexity elements.
- Estimate funding requirements to support the unified goal and objectives.
- Develop a unified DOI strategy to share with and cultivate collaborative approaches with the State of Hawai‘i, the Native Hawaiian Community, and other partners.

Goal

Prevent the extinction of Hawaiian forest birds through the implementation of conservation strategies, integration of Native Hawaiian biocultural knowledge and practices, and the development of innovative technologies.

Objective 1: Develop and deploy Insect Incompatibility Technique (IIT) to reduce the mosquito vector of avian malaria by 2026.
Objective 2: Establish captive care programs for bird species most at risk of imminent extinction by 2026.
Objective 3: Identify species that are appropriate for translocation and implement translocations to higher elevation refugia on Hawai‘i Island by 2030.
Objective 4: Develop and deploy next-generation tools by 2032.
Objective 5: Develop and implement conservation strategies informed with Native Hawaiian biocultural knowledge and deployed with appropriate protocols and cultural practices (immediately and throughout strategy implementation).

Objectives are further described below. Objectives 1-4 involve the implementation of a distinct set of actions aimed at achieving specific outcomes. The fifth objective is a crosscutting objective and is incorporated throughout this strategy. These include actions involving Native Hawaiian biocultural knowledge, protocols, and practices that are integrated in each of the other four objectives.

Concurrent Approaches Needed

Saving Hawaiian forest birds will require full engagement of local NPS, USFWS, USGS, and ONHR capacity, fully integrating resources and expertise, and prioritizing this issue among bureaus at local, regional, and national levels to enhance existing capacity. The State of Hawai‘i, The Nature Conservancy (TNC), and American Bird Conservancy (ABC) along with other Federal and other non-federal entities are technical and financial partners supporting the prevention of Hawaiian forest bird extinctions. Close coordination among all entities is ongoing and necessary to implement identified objectives concurrently.

Persistence of Hawai‘i’s forest birds in the wild will require landscape-level control of invasive mosquitoes (*Culex quinquefasciatus*). DOI bureaus and partners are investing in the development and implementation of incompatible insect technology (IIT) that will use the naturally-occuring bacteria

Wolbachia to suppress mosquito reproduction and population size in forest bird habitats. However, this technology may not be deployed at a scale and degree of efficacy in time to prevent the extinction of several forest bird species. Therefore, this strategy also relies on implementation of short-term extinction-prevention efforts, such as captive care and translocations to sites on other islands that are higher elevation and currently free of malaria. These efforts may be able to prevent extinction of some species until *Wolbachia* IIT can provide mosquito-free habitat. While *Wolbachia* IIT is the best chance to control mosquitoes with available technology, DOI and partners continue to evaluate new technologies that would ultimately eradicate mosquitoes that vector avian malaria.

Native Hawaiians, through their cosmological and familial relationships, have a kuleana (right and responsibility) towards the conservation and continued stewardship of Hawaiian forest birds. Further, Native Hawaiian biocultural knowledge, practices, and protocols are integral components of the management actions contemplated in this strategy and promote the prevention of species extinction. For example, Native Hawaiian cultural practitioners were engaged in 2010 to apply their knowledge in the naming of one of the forest bird species involved in this conservation strategy – the Kiwikiu. Its original name was lost over time and through the work of Native Hawaiians, this biocultural connection has been re-established and led to the creation of chants and traditional dances (hula) to preserve the cultural significance of the bird and to assist in implementation of conservation actions.

With the current levels of partner engagement, and their willingness to provide additional funding and resources to undertake this challenge, now is an opportune time for USFWS, NPS, USGS, and ONHR to take coordinated, targeted actions. Efficient deployment of landscape-level mosquito control tools, translocation, and captive breeding may prevent extinction events, but will require near-term progress across multiple priorities.

The first four objectives are described below along with an associated timeline; each section summarizes the steps required for implementation and integrates the crosscutting fifth objective. Appendix A (Implementation Timelines for DOI Strategic Objectives and Actions) graphically summarizes this information.

Objective 1: Develop and deploy Insect Incompatibility Technique (IIT) to reduce the mosquito vector of avian malaria by 2026.

DOI bureaus and partners formed the "Birds, Not Mosquitoes" Working Group in 2017. Together, Birds Not Mosquitoes is collaborating on the development and implementation of *Wolbachia* IIT. Deploying this technique in time to save imperiled birds will require simultaneous pursuit of compliance and permitting elements, technical capacity, and physical infrastructure. The first implementation of the technique is proposed for: (1) Haleakalā National Park and the surrounding habitat on East Maui, and (2) Alakaʻi Preserve on the island of Kauaʻi. Additional proposed locations for deploying *Wolbachia* IIT, including Hakalau Forest National Wildlife Refuge and Hawaiʻi Volcanoes National Park, will follow in subsequent years.

1. Development of IIT tool
    a. IIT mosquito development (2019-2023)
    b. Monitoring techniques (2021-2023)
    c. Deployment technology development (2021-2024)
    d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and protocol (2019-2024)
    e. Public outreach, communications, and human dimensions (2019-2024)

2. Pre-Implementation Permitting for IIT Tool
    a. National Environmental Policy Act (NEPA) / Hawai‘i Environmental Policy Act (HEPA) compliance (2020-2025)
    b. State import permit (2020-2025)
    c. Federal Environmental Protection Agency (EPA) registration/permit (2022-2025)

3. Implementation of IIT Tool
    a. Mass production of IIT mosquitoes for application/deployment (2023-2026+)
    b. Application/deployment in forest bird habitat for conservation purposes (2023-2026+)
    c. IIT efficacy and integrity monitoring (2023-2026+)
    d. Coordination with Native Hawaiian cultural practitioners for appropriate actions (2021-2026+)

4. Post-Implementation of IIT Tool
    a. Adaptive management and planning after field trials to increase efficacy at landscape scales (2023-2026+)
    b. After action reporting, public communication, and engagement with Native Hawaiian cultural practitioners, as appropriate, to address unforeseen direct and collateral effects (2023-2026+)
    c. Production and transport enhancement (2023-2026+)
    d. Monitoring and periodic reporting to stakeholders (2022-2026+)

Objective 2: Establish captive care programs for bird species most at risk of imminent extinction by 2026.

Species that are at imminent risk of extinction may need to be protected from the threat of disease by bringing them into captivity. Under this objective, some species will either be: (1) held in captivity temporarily while *Wolbachia* IIT is deployed and translocation planning is completed, or (2) held in captivity long-term as a source to supplement or establish wild populations. There are two existing captive care facilities in Hawai‘i, both operated by the San Diego Zoo. However, both facilities are already at maximum capacity and would require additional aviary space and skilled personnel to house additional species. Additional zoos and partners outside of Hawai‘i have offered assistance; establishing captive populations at these facilities would require movement of individual birds to the continental United States and additional permitting, compliance, and public engagement. Additionally, many Native Hawaiians consider moving forest birds to the continent to damage biocultural connections. Therefore, this objective focuses on building capacity for captive care within Hawai‘i, while recognizing that, under narrow circumstances, captive care may temporarily be needed at facilities in the continental United States.

1. Planning and compliance for captive care program
    a. Structured decision making for species needs (2021-2022)
    b. Development of species-specific captive care plans (2019-2024)
    c. NEPA/HEPA compliance (2022)
    d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and protocol (2021-2023)
    e. Public outreach, communications, and human dimensions (2017-2023)

2. Facility capacity and readiness of captive care program
    a. New or amended captive care facility agreements and recovery permits (2022-2023)
    b. Aviary build-out and retrofit (2022-2026)
    c. Captive care staffing (2022-2026+)

3. Implementation of captive care program
    a. Field crew staffing and training (2022)
    b. Capture of wild individuals (2022-2025)
    c. Transport to captive care facility(ies) (2022-2025)
    d. Coordination with Native Hawaiian cultural practitioners for appropriate actions (2022-2025)

4. Research and adaptive management for "release-ready" individuals
    a. Adaptive management and planning to preserve wild behaviors (2021-2026+)
    b. Research and development of additional tools (2022-2026+)
    c. Coordination with Native Hawaiian cultural practitioners for appropriate actions (2022-2026+)
    d. Monitoring and periodic reporting to stakeholders (2022-2026+)

Objective 3: Identify species that are appropriate for translocation and implement translocations to higher elevation refugia on Hawai'i Island by 2030.

In addition to captive care, conservation translocations to refugia within the Hawaiian Islands where avian malaria is not yet present may be able to help in preventing extinctions. Hawai'i Island is the only island in the State with a relatively large amount of disease-free habitat. Under this strategy, some species at risk of imminent extinction on Kaua'i and Maui would be released at suitable sites on Hawai'i Island. Conservation translocations require detailed planning, consultation, communication, and compliance in the face of complex and inter-related ecological, social, cultural, and economic issues. Existing and planned research will aid in determining how long recipient sites will remain disease free. Translocation sites would require implementation of landscape-level mosquito control in future years.

1. Planning and compliance for translocations
    a. Structured decision making for species needs (2021-2022)
    b. Development of species-specific translocation plans following International Union for Conservation of Nature guidelines (2021-2025)
    c. NEPA/HEPA compliance (2022-2025)
    d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and protocol (2021-2026+)
    e. Public outreach, communications, and human dimensions (2021-2026+)

2. Pre-implementation for translocations
    a. Release site selection and baseline condition monitoring (2022-2025)
    b. Coordination with Native Hawaiian cultural practitioners for appropriate actions (2022-2025)
    c. Build-out of release infrastructure (2023-2025)
    d. Implementation of threat management measures (2023-2025)
    e. Field crew staffing and training (2023-2025)

3. Implementation of translocation
    a. Capture and transport of wild individuals or transport of captive individuals (2025-2026)
    b. Coordination with Native Hawaiian cultural practitioners for appropriate actions (2023-2026+)
    c. Release activities (2025-2026+)
    d. Post-release supplemental feeding and monitoring (2025-2026+)
    e. Continued implementation of threat management measures (2025-2026+)

4. Research and monitoring for translocation
    a. Adaptive management to increase survivorship (2025-2026+)
    b. Research and development of additional translocation methods (2025-2026+)
    c. Monitoring and periodic reporting to stakeholders (2025-2026+)

Objective 4: Develop and deploy next-generation tools by 2032.

Although IIT is considered the technique most likely to control mosquitoes using available technology, more effective tools are on the horizon that may be developed to help in the conservation of Hawaiian species. Examples of these new tools could include gene drives, precision-guided Sterile Insect Technique, and improving malaria resistance in birds. Development and application of these next generation tools may be able to achieve island-wide eradication of mosquitoes and more durable protection for Hawaiian forest birds. Furthermore, these innovations underscore the potential for this research to have far-reaching implications for public health and the management of invasive species across the U.S., offering more sustainable and cost-effective solutions than current approaches.

1. Planning and compliance for next-generation tools
    a. Identification and prioritization of next-generation tools targeted for development (2022-2026+)
    b. Development of species-specific plans for research on increasing resistance (2022-2026+)
    c. Identification of compliance and permitting challenges and solutions (2022-2026+)
    d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and protocol (2022-2026+)
    e. Public outreach, communications, and human dimensions (2022-2026+)

2. Pre-implementation for next-generation tools
    a. Improvement of genetics and animal care facilities for DOI in Hawai‘i to allow in-vitro and in-vivo tool trials (2024-2026+)
    b. Research and development for synthetic biology control tools and IIT advances (2023-2026+)
    c. Field trials of methods for improving malaria resistance in birds (2023-2026+)
    d. Coordination with Native Hawaiian cultural practitioners for appropriate actions (2023-2026+)

3. Implementation of next-generation tools
    a. Delivery of tested vaccines and probiotics to birds at priority sites (2026+)
    b. Potential release of engineered mosquitoes or similar treatment technique (post 2026)
    c. Biosecurity monitoring to prevent invasion of other mosquitoes that may vector disease (2024-2026+)

d. Coordination with Native Hawaiian cultural practitioners for appropriate actions (2023-2026+)

4. Research and monitoring for next-generation tools
    a. Validation of efficacy of control using synthetic biology tools (post 2026)
    b. Assessment of bird population recovery (2026+)
    c. Monitoring and periodic reporting to stakeholders (2026+)

Objective 5: Develop and implement conservation strategies informed with Native Hawaiian biocultural knowledge and deployed with appropriate protocols and cultural practices (immediately and throughout strategy implementation).

Native Hawaiian biocultural knowledge and practices are necessary and vital components to each of the four conservation objectives above and is therefore a crosscutting objective within this strategy. Active engagement of Native Hawaiian cultural practitioners and experts through consultation, knowledge sharing, protocol, and traditional practices at each major stage of a conservation action not only contributes to the overall forest bird recovery efforts but also sustains the Native Hawaiian Community's biocultural relationship with the forest birds. Successful implementation of Objective 5 can further serve as a model and best practice for future conservation actions regarding Hawaiian forest birds and other at-risk endemic species.

Understanding the Risks

Four species within Hawai‘i's forest bird community are at imminent risk of extinction which could damage some ecosystem functions. In considering the risk of imminent species extinction, DOI bureaus and partners also recognize inherent risks in each of the proposed actions to save Hawai‘i's forest birds. These risks – including biological, financial, technological, human capital capacity, and support from stakeholders and the public – influence the way that resource managers determine a course of action for a species. Risk management identifies risks and implements actions to reduce those risks. Risk management is, and will continue to be, an integral component during implementation of this strategy. For example, although used world-wide for human health, *Wolbachia* IIT is a novel tool for conservation purposes and its degree of efficacy in remote forest landscapes is unknown. This uncertainty is clearly defined in implementation plans, and risks are managed through robust monitoring and adaptive management using the best available science. Risks throughout the strategy are managed through continued research, monitoring, environmental compliance analyses (e.g., National Environmental Policy Act), stakeholder engagement, and other efforts.

DOI Bureau and Office Roles

To achieve the objectives of this strategy, each of the participating DOI bureaus and offices and partner organizations will leverage their collective resources and technical skillsets. Below is a summary of the roles of DOI in this effort. The State of Hawai‘i, TNC, and ABC also play significant roles in the implementation of programmatic objectives.

National Park Service: Lead for planning, compliance, implementation, and pre- and post-release implementation monitoring for all *Wolbachia* IIT project sites that occur on NPS-managed lands, including Haleakalā and Hawai‘i Volcanoes National Parks. Partner for captive care and conservation translocation projects.

U.S. Geological Survey: Lead for developing field and quantitative tools for monitoring efficacy of mosquito control tools and population response of native birds. Shares leadership of decision science and human dimensions work with USFWS. Continues genomic tool development for identifying mosquito populations and *Wolbachia* strains. Conducts biosecurity research for future IIT efforts. Lead for developmental research for next-generation control tools and methods for increasing resistance to avian malaria in forest birds.

U.S. Fish and Wildlife Service: Lead for planning, ensuring compliance with captive care and translocation regulations, and implementing related extinction prevention measures. Primary conduit of government funds that are provided to non-federal partners for captive care facilities and conservation implementation, including the State of Hawai‘i (for implementation of *Wolbachia* IIT on State lands and implementation of conservation translocations). Lead for planning, compliance, implementation, and pre- and post-release implementation monitoring for *Wolbachia* IIT project sites on National Wildlife Refuges. Shared leadership for engagement and consultation with Native Hawaiian communities with support from ONHR. Shared leadership of decision science and human dimensions work with USGS.

Office of Native Hawaiian Relations: Lead for providing guidance and support to NPS, USGS, and USFWS on integration of Native Hawaiian knowledge, practices, protocol, and engagement processes throughout the development of action plans and implementation of strategy components, monitoring, and reporting. Shared leadership for engagement and consultation with the Native Hawaiian Community with USFWS.

Immediate Rate Limiting Steps

Human capital: NPS, USFWS, and USGS have technical specialists working on avian malaria, bird ecology, and mosquito control tools but these personnel are not working solely on these issues. ONHR currently has limited staff capacity to fully implement the actions necessary under Objective 5 and, in the near term, will need to rely upon external partnership agreements with Native Hawaiian organizations. Dedicating personnel primarily to this effort and identifying additional personnel from across DOI could hasten progress and enable consistent implementation of the goal and objectives.

Coordination: Due to the complexity and immediacy of this conservation challenge, enhanced coordination is needed to leverage DOI and partner resources and expedite actions efficiently and cost-effectively. New models for private and public partnerships would support novel technology deployment and implementation, with consideration for intellectual property rights.

Product registration: *Wolbachia* IIT tools require EPA product registration, which can be a lengthy and complex process. Close coordination is required among industry, Federal, State, and non-governmental partners to ensure registration and permitting are completed in a timely manner. USGS hired a Regulatory Affairs Coordinator in Fiscal Year (FY) 2022 who is assisting with this process. EPA leaders are already aware of DOI bureau needs.

Native Hawaiian Community engagement, public outreach, communications, and human dimensions: Given the cultural importance of the forest birds and their habitat, increased capacity and engagement by Native Hawaiian cultural practitioners, communication specialists, and human-dimensions experts are needed to meaningfully consult with the Native Hawaiian Community and broader public and incorporate their input into planning, implementation, monitoring, and reporting. The Birds, Not Mosquitoes working group, DOI bureaus, and the State of Hawai‘i are implementing initial outreach plans to support specific actions and determining requirements for sustained statewide engagement.

Infrastructure to hold birds in captivity: Currently, there is space for only 31 additional captive Hawaiian forest birds at the San Diego Zoo Wildlife Alliance facilities on Maui and the island of Hawai‘i, so additional infrastructure aviary space is needed. Some aviary capacity at facilities in the continental United States may be necessary to address immediate needs, although this is not a preferred option due to cultural concerns. Therefore, USFWS, in coordination with the State of Hawai‘i, has estimated that space for at least an additional 80 birds is needed in Hawai‘i.

Tool development and production: Due to the urgency of the issue, time required to develop the *Wolbachia* IIT tools could result in further decline in Hawaiian honeycreeper populations and potential loss of expertise and support systems for research and mosquito production. Haleakalā National Park may be able to begin *Wolbachia* IIT deployment within two years contingent on the availability of funding.

Bureau and Partner Investments

DOI bureaus, the State of Hawai‘i, and multiple non-governmental partners and landowners have made major contributions to the conservation and recovery of Hawaiian forest birds for more than 30 years. These efforts have included forest conservation and restoration, control of invasive ungulates and predators, systematic monitoring of native birds and mosquitoes, public engagement, and, for some species, captive care. Funding for these actions has been allocated via each entity’s funding streams (actual expenditures may differ). The most significant sources of existing Federal funding derive from the State of the Birds congressional allocation, Endangered Species Act Cooperative Endangered Species Conservation Fund (Section 6), State Wildlife Grants administered by USFWS, and most recently through the Bipartisan Infrastructure Law.

Implementation of this strategy will require dedicated allocation of existing appropriations and identification of resources above current levels that continue in the future. Non-governmental partners have expressed an interest in supporting components of this strategy to assure it can be implemented as expeditiously as possible.

Objective 1: Develop and deploy Insect Incompatibility Technique (IIT) to reduce the mosquito vector of avian malaria by 2026.

- Between FY17 and early FY22, the State of Hawai‘i allocated $503,000 of State funds, $948,000 of USFWS-awarded Federal funds, and State employee staff time toward development of *Wolbachia* IIT development and planning/compliance for future implementation.
- Between FY17 and early FY22, the USFWS allocated $545,000 and staff time toward the development of *Wolbachia* IIT (in addition to the $948,000 of funds awarded to the State of Hawai‘i through State of the Birds, State Wildlife Grants, and section 6).
- NPS invested $1.2 million into planning, compliance, deployment methods, and research for implementation of *Wolbachia* IIT at Haleakalā National Park and surrounding State of Hawai‘i and TNC lands. In addition, NPS has invested $6 million in FY22 into standing up an interagency field deployment team for Maui and development and initial production of *Wolbachia* IIT.
- TNC committed to collecting and providing some of the initial costs to deploy *Wolbachia* IIT for the first site in Hawai‘i through a contract with Verily Life Sciences, a subsidiary of Google.
- ABC provided funding for coordination and public outreach. In 2022, they provided $500,000 to TNC toward the contract with Verily and committed a total of $1 million toward this effort.
- Between FY17 and FY21, USGS invested approximately $7.05 million in research on Hawaiian forest birds, invasive mosquitoes, and avian malaria.

- The National Fish and Wildlife Foundation (NFWF) identified the need for landscape-level mosquito control to prevent Hawaiian forest bird extinction in their Hawai‘i Conservation Business Plan and is providing grant funds through ABC and TNC for *Wolbachia* IIT coordination, outreach, monitoring, and on-the-ground management. NFWF provided $627,000 for *Wolbachia* related projects between 2019 and 2021, in addition to $1.1 million for other Hawaiian forest bird extinction prevention efforts during the same time period.
- In FY22, ONHR provided in-kind services and support to engage with Native Hawaiian Community members on the biocultural considerations for the planning and implementation of *Wolbachia* IIT. ONHR also synthesized such considerations into an implementation strategy following a palliative care model to bridge understanding between the Native Hawaiian Community members and the Federal, State, and private entity decision makers.

Objective 2: Establish captive care programs for bird species most at risk of imminent extinction by 2026.

- USFWS currently allocates $700,000 per year to two captive care facilities in Hawai‘i, both of which are operated by the San Diego Zoo.
- The State of Hawai‘i currently allocates $500,000 per year to the two captive care facilities through their USFWS-awarded section 6 funds.
- The San Diego Zoo contributes $600,000-$800,000 per year in in-kind services, staffing, veterinary care, and administrative support in the operation of the two Hawai‘i facilities.
- In FY22, ONHR provided in-kind services and support to engage with Native Hawaiian Community members on the biocultural considerations for the planning and implementation of captive care.

Objective 3: Identify species that are appropriate for translocation and implement translocations to higher elevation refugia on Hawai'i Island by 2030.

- There are no current commitments of funding or resources to implement translocations; however, funding was allocated in FY22 for planning. Previous conservation translocations of forest birds have been funded by USFWS (through State of the Birds, Recovery, and Coastal Program funds, section 6, and State Wildlife Grant funds) and the State of Hawai‘i, with supporting funding provided by ABC, NFWF, and the San Diego Zoo.
- In FY22, ONHR provided in-kind services and support to engage with Native Hawaiian Community members on the biocultural considerations for the planning and implementation of conservation translocations.

Objective 4: Develop and deploy next-generation tools by 2032.

- USFWS provided $60,000 to the Akbari Laboratory (University of California, San Diego) to explore the development of next generation precision-guided Sterile Insect Technique (pgSIT) mosquito control tools.

Objective 5: Develop and implement conservation strategies informed with Native Hawaiian biocultural knowledge and deployed with appropriate protocols and cultural practices (immediately and throughout strategy implementation).

- In FY22, ONHR provided in-kind services and support to engage with Native Hawaiian Community members on the biocultural considerations for the development and publication of forest bird assessment report and towards the development of appropriate conservation strategies.

Investments and Projected Costs

DOI is investing in research and development of mitigation techniques while on-the-ground conservation efforts continue. In the latter part of FY22, DOI invested an additional $15,511,066 in conservation and recovery efforts for Hawaiian forest birds utilizing a variety of appropriated funding sources including the Infrastructure Investment and Jobs Act (IIJA). This section provides an overview of recent investments and projected funding estimates for each of the objectives.

Table 1. DOI investments in FY22 and total estimated need for subsequent years for DOI to successfully implement each objective. These estimates do not include current and projected non-DOI partner investments that could contribute to these estimates.

Objectives	DOI Investments in FY22	Year 1	Year 2	Year 3	Year 4	Total Projection
Insect Incompatibility Technique	$9,305,200	$8,851,000	$7,421,000	$6,319,000	$13,234,000	$45,130,200
Captive Care	$5,963,786	$5,840,000	$1,420,000	$890,000	$530,000	$14,643,786
Translocation	$100,000	$1,437,000	$2,091,000	$1,582,000	$1,026,000	$6,236,000
Next Generation Tools	$142,080	$1,053,000	$1,280,000	$1,210,000	$1,258,000	$4,943,080
Total	$15,511,066	$17,181,000	$12,212,000	$10,001,000	$16,048,000	$70,953,066

Funding is illustrative. Additional resources would be required through the budget process to undertake this work.

Below are specific FY22 investments listed by objective:

- Insect Incompatibility Technique
  - NPS - $6,000,000 in DOI IIJA funds
  - NPS - $450,000 in internal national-level competitive Natural Resource funding
  - USFWS pass-thru funds to the State of Hawai‘i - $1,500,000 in DOI IIJA funds
  - USFWS - $1,000,000 in DOI IIJA funds, $50,000 of these funds were invested with ONHR to support the initial development of a biocultural strategy
  - USGS - $355,200 in DOI IIJA funds

- Captive Care
  - USFWS pass thru to the State of Hawaii - $5,000,000 in DOI IIJA funds
  - USFWS - $963,786 in State of the Birds funds

- Translocation
  - USGS - $100,000 in Biological Threats Program funds

- Next Generation Tools
  - USGS - $142,080 in DOI IIJA funds

Description of Objective Costs

Below is a brief description of objective cost components.

Objective 1: Develop and deploy Insect Incompatibility Technique (IIT) to reduce the mosquito vector of avian malaria by 2026.

The goal of this objective is to implement *Wolbachia* IIT technology at high-elevation sites in East Maui and Kauaʻi during the next five years and complete the planning and regulatory requirements to support the implementation of this technology at one or two sites on the Hawaiʻi Island (e.g., Hakalau Forest National Wildlife Refuge and Hawaiʻi Volcanoes National Park). NPS would be the lead for *Wolbachia* IIT implementation on NPS lands on Maui at Haleakalā National Park and Hawaiʻi Island at Hawaiʻi Volcanoes National Park, while USFWS would be the lead for implementation on Kauaʻi (State land) and at Hakalau Forest National Wildlife Refuge, Hawaiʻi Island.

Implementation of this technology would require repeat treatment of sites using *Wolbachia* IIT. The cost of implementation of *Wolbachia* IIT is currently high (estimated at >$1 million/site/year) as this technology is in a developmental stage. Costs may drop after the technology is optimized. Revised cost estimates may enable more accurate projections for the cost of concurrent implementation at multiple sites.

Objective 2: Establish captive care programs for bird species most at-risk of imminent extinction by 2026.

The costs for this objective can broadly be broken down into two components: (1) Federal and State human capital requirements, and (2) construction of new aviary space.

As of the writing of this document, USFWS supports the maintenance and operation of two captive care facilities in the Hawaiian Islands with funding from the State of the Birds congressional appropriation. The State of Hawaiʻi also provides funding to these facilities. The San Diego Zoo, who operates the two facilities, donates staff time and additional resources. However, to accommodate the four additional species, aviary space for at least an additional 80 individual birds is required within Hawaiʻi.

Objective 3: Identify species that are appropriate for translocation and implement translocations to higher elevation refugia on Hawaiʻi Island by 2030.

The costs for this objective can be broken down into two broad categories: (1) activities to be conducted before translocations would be implemented and (2) activities that would be implemented following translocation. Initial efforts to develop techniques for Kiwikiu (Maui parrotbill) translocation have already occurred.

Objective 4: Develop and deploy next-generation tools by 2032.

The previous three objectives represent complementary options for reducing or reversing the declines of four species of native forest birds over the next decade. However, a total of 12 species are at risk of extinction over a somewhat longer time period due to climate-facilitated expansion of mosquitoes. Synthetic biology may offer the most promising tool for island-wide eradication of mosquitoes and thus long-term persistence of the full suite of forest birds.

Objective 5: Develop and implement conservation strategies informed with Native Hawaiian biocultural knowledge and deployed with appropriate protocols and cultural practices (immediately and throughout strategy implementation).

The costs for this objective involve the engagement of Native Hawaiian Community members to coordinate, plan, and implement biocultural activities during the various stages of conservation actions described in Objectives 1 through 4. Biocultural activities may involve the conduct of appropriate protocols, monitoring, and other practices in the field, in captive care, and during translocation actions.

Next Steps

This strategy builds on fundamental partnership-based efforts to prevent the imminent extinction of Hawaiian forest birds and outlines a unified goal and objectives to inform a coordinated approach among DOI and its bird conservation partners. In addition, a key purpose of the strategy is to estimate the funding requirements to support these efforts. By doing so, DOI can better explore and leverage any current and future funding to advance these priorities, which will be necessary for full implementation. DOI bureaus cannot accomplish this effort in isolation. To be successful, these efforts will continue to be undertaken in collaboration with the State of Hawai‘i, TNC, ABC, the Native Hawaiian Community, and other partners and stakeholders. To that end, DOI bureaus and offices will continue to coordinate internally and externally to adaptively advance, implement, and refine this strategy.

Prepared By

Michelle Bogardus, U.S. Fish and Wildlife Service - Pacific Islands Fish and Wildlife Office
Earl Campbell, U.S. Fish and Wildlife Service - Pacific Islands Fish and Wildlife Office
Ryan Monello, National Park Service - Pacific Island Inventory and Monitoring Network
Robert Reed, U.S. Geological Survey - Pacific Island Ecosystems Research Center
Jennifer Sieracki, National Park Service - Biological Resources Division
Stanton Enomoto, Department of the Interior - Office of Native Hawaiian Relations
Hilary Smith, Department of the Interior - Office of Policy Analysis

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APPENDIX A – IMPLEMENTATION TIMELINE – DOI STRATEGIC OBJECTIVES & ACTIONS

STRATEGIC OBJECTIVES AND ACTIONS	Fiscal Year (20**)										
1. Develop and deploy Insect Incompatibility Technique (IIT) to reduce the mosquito vector of avian malaria by 2026.	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**Post-2026**
1. Development of IIT tool											
a. IIT mosquito development											
b. Monitoring techniques											
c. Deployment technology development											
** d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and protocol											
e. Public outreach and human dimensions											
2. Pre-Implementation Permitting for IIT Tool											
a. National Environmental Policy Act (NEPA) / Hawai‘i Environmental Policy Act											
b. State import permit											
c. Federal Environmental Protection Agency (EPA) registration/permit											
3. Implementation of IIT Tool											
a. Mass production of IIT mosquitoes for application/deployment											➔➔
b. Application/deployment in forest bird habitat for conservation purposes											➔➔
c. IIT efficacy and integrity monitoring											➔➔
** d. Coordination with Native Hawaiian cultural practitioners for appropriate actions											➔➔
4. Post-Implementation of IIT Tool											
a. Adaptive management and planning after field trials to increase efficacy at landscape-scales											➔➔
** b. After action reporting, public communication, and engagement with Native Hawaiian cultural practitioners											➔➔
c. Production and Transport Enhancement											➔➔
d. Monitoring and periodic reporting to stakeholders											➔➔

2. Establish captive care programs for bird species most at risk of imminent extinction by 2026.	17	18	19	20	21	22	23	24	25	26
1. Planning and compliance for captive care program										
a. Structured decision making for species needs										
b. Development of species-specific captive care plans										
c. NEPA/HEPA compliance										
** d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and protocol										
e. Public outreach and human dimensions										
2. Facility capacity and readiness of captive care program										
a. New or amended captive care facility agreements and recovery permits										
b. Aviary build-out and retrofit										
c. Captive care staffing										
3. Implementation of captive care program										
a. Field crew staffing and training										
b. Capture of wild individuals										
c. Transport to captive care facility(ies)										
** d. Coordination with Native Hawaiian cultural practitioners for appropriate actions										
4. Research and adaptive management for "release-ready" individuals										
a. Adaptive management and planning to preserve wild behaviors										
b. Research and development of additional tools										
** c. Coordination with Native Hawaiian cultural practitioners for appropriate actions										
d. Monitoring and periodic reporting to stakeholders										

STRATEGIC OBJECTIVES AND ACTIONS	Fiscal Year (20**)										
3. Identify species that are appropriate for translocation and implement translocations to higher elevation refugia on Hawai'i Island by 2030.	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**Post-2026**
1. Planning and compliance for translocations											
a. Structured decision making for species needs											
b. Development of species-specific translocation plans following International Union for Conservation of Nature guidelines											
c. NEPA/HEPA compliance											
** d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and protocol											➔➔
e. Public outreach, communications, and human											➔➔
2. Pre-implementation for translocations											
a. Release site selection and baseline condition monitoring											
** b. Coordination with Native Hawaiian cultural practitioners for appropriate actions											
c. Build-out of release infrastructure											
d. Implementation of threat management measures											
e. Field crew staffing and training											
3. Implementation of translocation											
a. Capture and transport of wild individuals or transport of captive individuals											
** b. Coordination with Native Hawaiian cultural practitioners for appropriate actions											➔➔
c. Release activities											➔➔
d. Post-release supplemental feeding and monitoring											➔➔
e. Continued implementation of threat management measures											➔➔
4. Research and monitoring for translocation											
a. Adaptive management to increase survivorship											➔➔
b. Research and development of additional translocation methods											➔➔
c. Monitoring and periodic reporting to stakeholders											➔➔

STRATEGIC OBJECTIVES AND ACTIONS	Fiscal Year (20**)										
4. Develop and deploy next-generation tools by 2032.	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**Post-2026**
1. Planning and compliance for next-generation tools											
a. Identification and prioritization of next-generation tools targeted for development											➔➔
b. Development of species-specific plans for research on increasing resistance											➔➔
c. Identification of compliance and permitting challenges and solutions											➔➔
** d. Engagement, consultation, and integration of Native Hawaiian knowledge, practices, and											➔➔
e. Public outreach, communications, and human dimensions											➔➔
2. Pre-implementation for next-generation tools											
a. Improvement of genetics and animal care facilities for DOI in Hawai‘i to allow in-vitro and											➔➔
b. Research and development for synthetic biology control tools and IIT advances											➔➔
c. Field trials of methods for improving malaria resistance in birds											➔➔
** d. Coordination with Native Hawaiian cultural practitioners for appropriate actions											➔➔
3. Implementation of next-generation tools											
a. Delivery of vaccines and probiotics to birds at priority sites											➔➔
b. Potential release of engineered mosquitoes or similar treatment technique											➔➔
c. Biosecurity monitoring to prevent invasion of other mosquitoes that may vector disease											➔➔
** d. Coordination with Native Hawaiian cultural practitioners for appropriate actions											➔➔
4. Research and monitoring for next-generation tools											
a. Validation of efficacy of control using synthetic biology tools											➔➔
b. Assessment of bird population recovery											➔➔
c. Monitoring and periodic reporting to stakeholders											➔➔

STRATEGIC OBJECTIVES AND ACTIONS	Fiscal Year (20**)										
5: Develop and implement conservation strategies informed with Native Hawaiian biocultural knowledge and deployed with appropriate protocols and cultural practices (immediately and throughout strategy implementation).	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**Post-2026**
** Denotes crosscutting actions that are associated with various activities in Objectives 1-4 above											➔➔