EAST MAUI ʻALALĀ RELEASE PLAN

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Contents

Chapter 1 Introduction

OVERVIEW

The purpose of this plan is to provide direction for the implementation of the ʻalalā (*Corvus hawaiiensis*) releases (also known as translocations) on east Maui. This plan focuses on the goal and purpose of various activities that will occur as part of the release process, including pre- and post-release activities. This plan has intentionally been written to not be too prescriptive and detailed regarding how the release will be conducted, to allow for on-the-ground adjustments and decisions to be made as needed and in a timely manner. This plan aligns with existing permits and compliance, as well as decisions made by government agencies.

BACKGROUND

ʻAlalā (*Corvus hawaiiensis*) is an endangered corvid endemic to Hawaiʻi and Maui and currently extinct in the wild, but with a robust population of birds in human care. Two previous release efforts were carried out on Hawaiʻi Island: 1993-1999 in the Kona region and 2016-2020 in the Kūlani region. For the 2016-2020 releases, birds were released annually from 2016-2019, and remaining birds were recaptured in 2020. Previous recovery documents and release plans for Hawaiʻi Island provide detailed information on ʻalalā biology, cultural significance, decline in the wild, presumed threats, and previous recovery efforts (USFWS 2009 Ch. I; VanderWerf et al. 2013 pp. 10-27; AWG 2019). Thus with brevity in mind, readers unfamiliar with the species are encouraged to review those documents. This plan builds upon previous ʻalalā documents and is adapted for east Maui.

GOAL OF ʻALALĀ TRANSLOCATION ON EAST MAUI

The east Maui forest where birds will be released is wetter than on Hawai'i Island, however habitat on east Maui is free of ʻio, or Hawaiian hawk (*Buteo solitarius*). Depredation by ʻio on ʻalala was a major factor surviving birds released on Hawai'i ultimately had to be recaptured and returned to human care.

The goal of the east Maui translocation effort detailed in this plan is to determine whether ʻalalā can survive and breed in wet/mesic forest on east Maui, in the absence of ʻio. Lessons learned from these releases will support a larger effort to develop methods for preventing the extinction of ʻalalā. In the long term, these methods are intended to help establish wild populations that fulfill their ecological roles and that are supported ideally by the minimum amount of conservation management. The east Maui translocation effort will be evaluated after five years, and periodically throughout this period. Methods implemented during the east Maui translocation will allow recapture and removal of released ʻalalā should this be determined necessary.

Release of birds into the wild is now appropriate because the target population size prescribed by the ʻAlalā Recovery Plan (USFWS 2009) for preserving maximal genetic diversity (75 birds) has been reached, and because the reproductive rate is at a level that will provide a sustainable source of birds for release.

PROJECT STRUCTURE

An ʻAlalā Working Group was formed in 2010, as recommended by the ʻAlalā Recovery Plan (USFWS 2009), to plan and provide guidance for the upcoming ʻalalā releases at Kulani on Hawaiʻi island. The ʻAlalā Working Group consisted of representatives from the U.S. Fish and Wildlife Service (USFWS), Hawaiʻi Division of Forestry and Wildlife (DOFAW), Three Mountain Alliance, San Diego Zoo Global (since renamed San Diego Zoo Wildlife Alliance [SDZWA]), and Kamehameha Schools.

The organizational chart below (Figure 1) illustrates the overall structure and relationships of the various components of the current ʻAlalā Working Group, including a wider Hui that serves in an advisory capacity and sub-groups that are in charge of decision making and implementation, depending on their designation. This organization is intended to operate throughout the entire release effort, with minor adaptations if needed.

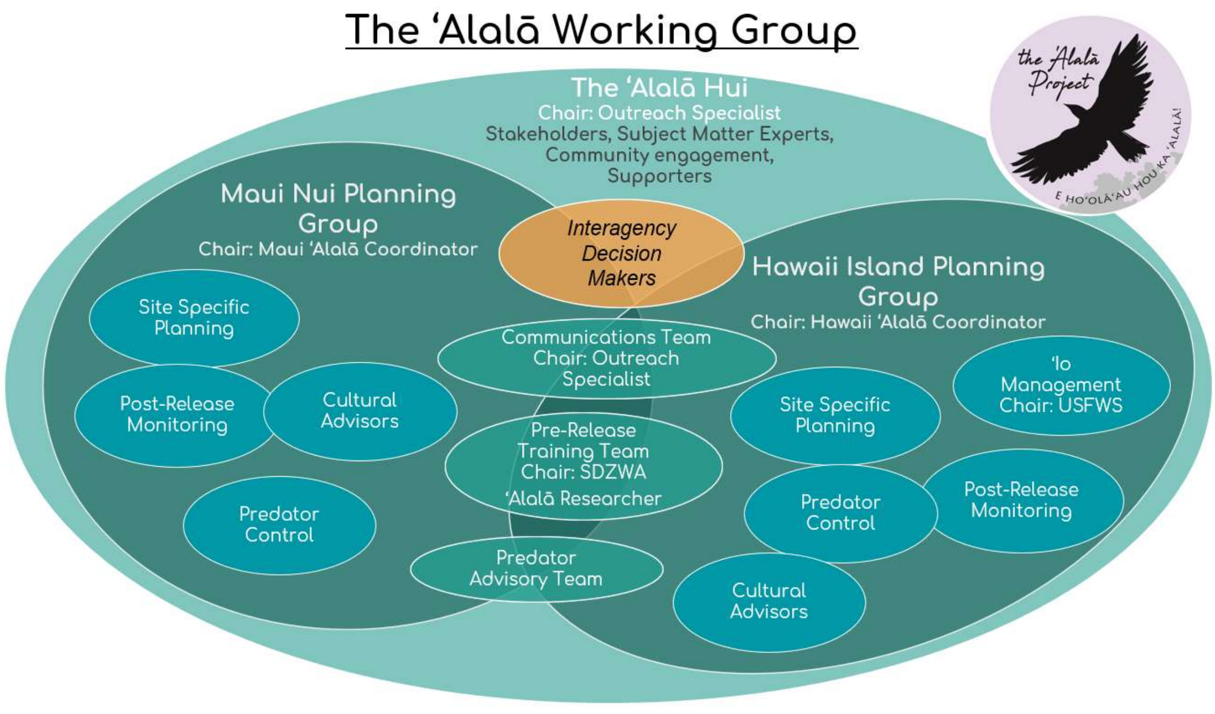

Figure 1. Organizational chart of the ʻalalā translocation team a.k.a. ʻAlalā Working Group. Only the teams overlapping with the Maui Nui Planning Group will be directly involved in implementing this plan.

Composition of each sub-group with their roles and responsibilities are listed below.

- The Maui Nui Planning Group consists of representatives from DOFAW, USFWS, SDZWA, land managers of the specific release areas, and one representative from the cultural advisor‘s subgroup. This group meets monthly and is responsible for selecting Reserves for release, approving the release plan, and adaptively managing ‘alalā during release efforts.

- Cultural Advisors include respected kupuna, traditional practitioners, and additional community members representing a breadth of *kanaka maoli* (native Hawaiians) who live in or have an interest in the recovery landscape. This group meets tri-annually and advises on site-selection, outreach, social issues, and cultural protocols.
- Within each island's planning group, there are smaller teams. These teams can form and dissolve as dictated by the current phase of the project, but include predator control, pre-release training, site-specific logistics, and post-release care and monitoring. These groups draft the appropriate components of the release plan, identify necessary permits, and communicate regularly as needed. ‘Alalā Project staff conduct outreach are also included in this category and are further described in Table 1 below.
- DOFAW and USFWS administrative staff meet as an interagency decision makers group representing their agencies‘ line officers to make higher level decisions about recovery for the species, allocation of funds, and compliance.
- An ‘Alalā Research and Recovery Coordinator coordinates and supervises all aspects of the ‘alalā reintroduction, including releases and monitoring, predator control, habitat management, private land access, and public outreach oversees all components of the project. The coordinator is encouraged to have discussions with outside experts and landowners outside of the Hui, planning, and implementation teams, and to provide relevant information to the teams.
- Outside experts who have participated in designing or implementing successful restoration projects focused on endangered birds (including methods for release or predator control) are used in an advisory capacity and may be consulted by the Planning Group or the project coordinator to provide input at any time and to review documents, such as this ‘Alalā Maui Nui Release Plan.

SUMMARY OF RECENT RELEASE ATTEMPTS

Birds in the 2016-2020 reintroduction survived in the wild from 3 days to nearly 3 years. Although a conclusive immediate cause of death was difficult to determine in a majority of cases, ‘io predation was suspected in as many as 9 of 25 deaths, however the number could have been higher, given that an additional 6 birds were never recovered. Poor physical condition was the second leading cause of mortality. Release methods were continually adapted to incorporate information gained from previous release cohorts. The Hawai‘i Island Planning Group met in June 2020 to assess efforts and identify key lessons learned. The following bullet points were the result of that effort and are an interpretation of data available at that time. The results of that assessment are listed here for the sake of continuity within ‘alalā release teams, however these conclusions should be treated with caution because they were not drawn from an experimental design, and were from a small sample of birds.

2016 Release Cohort

- Birds had low survival without adequate anti-predator training (for ʻio).
- Social structure and cohesion should be considered when identifying juvenile cohorts, because the cohort failed to stick together.
- The release aviary size was not large enough to hold a cohort for the desired acclimation period.
- Juvenile birds released in groups should be fully socialized to maximize the likelihood of anchoring to the release site. Birds have additional challenges to survival when released during the coldest and wettest months.

2017-2019 Release Cohorts

- Birds can be depredated by ʻio despite anti-predator training, despite also exhibiting proper anti-predator responses and achieving high shorter term post-release survival.
- When juveniles are released, conspecific aggression increasingly occurs in the proximity of supplemental feeders as birds mature.
- Cohorts continue to interact when release sites are 1.4 km apart, although cohorts did not immediately discover each other after release.
- Supplemental feeder location and vegetation structure could be used to reduce risk of predation by ʻio. Moving hoppers frequently may reduce predictability for predators.
- Increasing the number of supplemental feeders can reduce aggression if they are not clustered too closely.
- Juvenile birds need to be in the same pre-breeding social stage to be cohesive in a cohort.
- While most social bonds in human care are stable, post-release, they are not guaranteed to prevent dispersal.
- Quantitative site selection was a helpful decision making tool for selecting microsites (SWOT, Strengths, Weaknesses, Opportunities, Threats).
- Monitoring via VHF transmitters is very time and resource intensive; there is a strong need for remote monitoring technology (satellite GPS tags) to reduce effort.
- Late Fall and Winter are not optimal times to release because they are the coldest and wettest months.
- Rain storm events appear to be a hazard, as three birds perished following a three-day rain event in January 2020, with necropsies determining poor condition (indicated by low fat reserves and reduced muscle mass) as the cause of death.
- The weaning strategy containing preferred food items was not successful. Future efforts could use a strategy of weaning that removes preferred food items first, in sequence, and then reduces the overall percentage of food over time.
- Providing native fruit cuttings near hoppers leading up to and after the removal of fruit from the diet may reinforce native fruit recognition and foraging.
- Suppression of small mammalian predators at hoppers can be achieved by use of hopper stand modifications, flashing on trees, and trail cameras to monitor predators' presence and method of approach, as well as predator control.

PUBLIC EDUCATION AND OUTREACH

The long-term success of the ʻalalā reintroduction program depends in large part on public support so that the project receives adequate funding and connected actions, such as habitat restoration, are maintained. Education and outreach therefore are an important component of ʻalalā restoration efforts. The goal of education and outreach efforts are to establish, build, and maintain learning opportunities and working relationships for community members and stakeholders. These efforts are intended to create a community that is aware of the status of ʻalalā, who understand and appreciate its cultural and biological importance, who know what must be done to save the species, and who are empowered to take appropriate actions to support its recovery.

Future outreach and education activities should focus on producing deliverable outcomes that support project goals. Table 1 identifies target audiences with explanations of why each group is relevant to the project‘s success and specific methods for engagement.

Table 1. ʻAlalā Project Outreach Target Audiences

Audience	Purpose	Methods
Rural Landowners	1. Assuage fears of infringement on private property rights. 2. Accomplish more habitat restoration over a broad scale by engaging people in activities on their own lands. 3. Facilitate access for monitoring or release activities. 4. Reduce likelihood of intentional harm to the species.	1. Personal phone calls to landowners adjacent to new release sites. 2. Addition of representatives to the Hui. 3. Present to rural landowner groups. 4. Revise "ʻAlalā in my backyard" brochure.
Hawaiian community	1. Build trust between indigenous population and western-style conservation groups/DLNR. 2. Access Traditional Ecological Knowledge that could benefit species restoration. 3. Gain support to leverage in outreach to other sectors of	1. Include broad swath of Hawaiians in cultural advisors group and Hui and incorporate their suggestions into planning. 2. Present to Maui Nui Island Council (Aha Moku) during project development. 3. Attend local Maui Nui community government

	community.	meetings seeking meaningful feedback. 4. Present to Maui Nui Hula Halaus and immersion schools. 5. Make personal contacts with other leaders and ask they publicly support project. 6. Work with cultural advisor group on translation of historical documents and oral history to draft summary document of ʻalalā TEK and disseminate results.
Hunters and other outdoor recreationists	1. Reduce likelihood of harm to the species. 2. Reduce likelihood of damage to conservation fencing. 3. Increase likelihood of citizen science inputs of observations.	1. Present to local hunting and recreation groups (Kahikinui hunting ohana, and others). 2. Provide information or training to outdoor gear store owners and guides. 3. Submit articles (or pitch topic to authors) to Hawaiian hunting and outdoor recreation periodicals, blogs, and DOFAW Go Hunt newsletter. 4. Pitch ʻalalā project to be featured on popular Maui youtube channels, conventional video media outlets, or local podcasts.
General Population	1. Gain public support for ʻalalā and other endangered species conservation that translates into legislative or private funding. 2. Gain public support for ʻalalā and other endangered species conservation that results in legislative actions to restore native forest to	1. Support ʻalalā ambassador program in zoos. 2. Support KBCC and MBCC interpretation programs. 3. Develop and distribute ʻalalā merchandise. 4. Encourage ʻalalā public art. 5. Identify and utilize local “celebrity” spokespersons.

	support ʻalalā,	6. Produce and distribute press releases with project updates. 7. Update Maui Forest Bird Recovery Project (MFBRP) webpage with ʻalalā species and ʻalalā research and recovery pages. 8. Update ʻalalā project webpage to reflect current status of project. 9. Produce regular and digestible social media postings (maximum 2-3 sentences each). 10. Produce and distribute an ʻalalā newsletter with project updates.

RELEASE SITE

Corvids were once present on most of the major Hawaiian islands, with ʻalalā or a similar species found on Maui (Fleischer et al. 2003, James and Olson 1991). If the factors that caused the decline of the original wild population are not corrected, translocated birds will face the same threats and the restoration program is unlikely to succeed. Previous ʻalalā releases in the 1990s and from 2016-2020 were successful in the short-term, but they failed to result in the establishment of a wild breeding population. Restoring the density of understory and canopy vegetation, where ʻalalā primarily forage for fruit, arthropods, and bird nests is believed to be a crucial component of ʻalalā recovery (Banko 2009).

In addition, previous ʻalalā releases in the 1990s and from 2016-2020 were unsuccessful partly from high predation by ʻio and infection by toxoplasma gondii (for the 1990's at least; Work et al 2000). Maui does not contain any resident populations of ʻio, nor are there other birds filling the unique role that ʻalalā have in Hawaiʻi (i.e., contributing to a healthy functioning ecosystem). Therefore if releases on Maui are successfully carried out in suitable habitat, long-term success is predicted by the Hui, since Maui does not have ʻio.

Site Selection

The sites for release of initial translocation of ʻalalā onto Maui have been selected through a rigorous, SWOT-like decision-making process by the Maui Nui ʻAlalā Planning Group; composed of the US Fish and Wildlife Service Pacific Islands Fish and Wildlife Office (PIFWO), Hawaiʻi Department of Land and Natural Resources Division of Forestry and Wildlife (DOFAW), San Diego Zoo Wildlife Alliance (SDZWA), National Park Service

(Haleakalā National Park; NPS), The Nature Conservancy (TNC) and a representative from the Maui Nui ʻAlalā Cultural Advisor Group. The Maui Nui Planning Group completed a systematic process to identify and evaluate habitat characteristics of reserves on Maui and Molokaʻi that would be suitable for a release and will be evaluated in the Environmental Assessment. The Maui Nui Planning Group extensively evaluated island-wide conditions of habitat, including vegetation, food resources, climate, topography, accessibility, and other resources, including field reconnaissance verification and input from a cultural advisory team on Maui. The cultural advisory team was generally supportive of the project, and their input and site-specific recommendations were fully incorporated into the release site selection process.

The final sites selected for the initial releases of captive birds covered in this plan are the Koʻolau Forest Reserve in the Koʻolau Gap and the Healani Section of Kīpahulu Forest Reserve (Figure 2). These two sites are located on the windward and the leeward side of the contiguous native forest of east Maui. Both release sites present a continuum of habitat and resource features (e.g., gradients of intact native forest and precipitation) which allows a hypothesis-based release strategy for assessing the habitat factors that are most important to the success of ʻalalā. The order of sites used for releases will depend upon the outcome of the larger National Environmental Policy Act (NEPA) process, for which an environmental assessment (EA) is currently being drafted. Much remains unknown about specific ʻalalā life history requirements and necessary release strategies; therefore, we are adopting an adaptive management approach as a key component of this release.

The decision-making process evaluated several candidate sites that contain the highest quality remaining mature upland native forest habitat on Maui and Molokaʻi Islands (Table 2). In-person visits by the entire Maui Nui Planning Group were made unrealistic by COVID-19 restrictions and travel cost and logistics to helicopter access-only field sites. Thus, a diverse subset of the Maui Nui Planning Group conducted release site field visits based on discussions that were informed both by TNC and DOFAW land manager presentations. In selecting release sites, the group considered many factors including year-round food availability, total area of connected habitat, forest structure, habitat protection status, support from land managers, suitable nest trees, ability for staff to navigate, potential release aviary sites, cell phone coverage (relevant to communication and ability to use remote tracking technology), and more. Although the two TNC sites were advantageous for a number of those indicators, the group recognized that releasing birds on State-owned properties would be the most efficient at this time and decided to carry forth with releasing only on State-owned properties for this phase.

Release infrastructure and initial support activities will occur on State-managed land, with the intention that birds will disperse to other ownerships if they establish territories and increase in numbers.

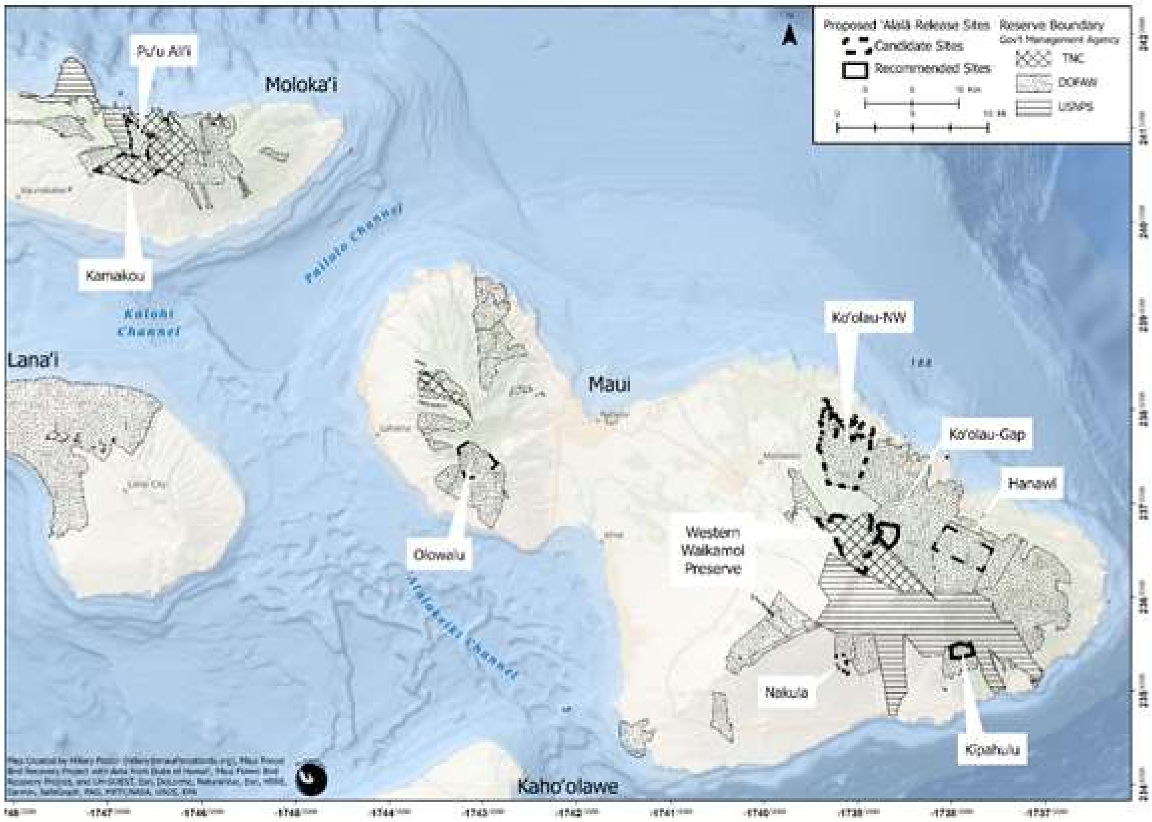

Figure 2. Candidate and recommended release sites.

Table 2. Summary of Maui Nui candidate ʻalalā release sites.

Candidate Site	Primary advantages	Primary disadvantages
Lower Hanawī Natural Area Reserve	Quality native and diverse forest, connected to large contiguous native forest, great existing infrastructure	Most divergent from historical ʻalalā climatic conditions (very wet)

Pu‘u Ali‘i Natural Area Reserve (Moloka‘i)	Quality native and diverse forest, some existing infrastructure, cell phone coverage	No on-island captive facility, helicopter company, or MFBRP office, extreme terrain makes monitoring difficult, few stores for materials on-island, limited suitable aviary locations
TNC Western Waikomoi Preserve	Quality native and diverse forest, connected to large contiguous native forest, good existing infrastructure, resembles historical climatic conditions	State is not landowner, presenting potential for additional logistic complexity
TNC Kamakou Preserve (Moloka‘i)	Native forest in moderate condition, some existing infrastructure, drive-up access available	No on-island captive facility, helicopter company, or MFBRP office, extreme terrain makes monitoring difficult, few stores for materials on-island, State is not landowner
Olowalu Forest Reserve	Native forest in moderate condition, approaching historical climatic conditions	Extreme terrain makes monitoring difficult, smaller area of contiguous native forest, no existing infrastructure, limited suitable aviary locations

Kīpahulu Forest Reserve RECOMMENDED SITE	Native forest in moderate condition, connected to large contiguous native forest, approaching historical climatic conditions, cell phone coverage, many suitable aviary locations, easy to navigate off-trail for monitoring	Invasive plant species prevalent in some areas, limited existing infrastructure and ungulates
Koʻolau Forest Reserve RECOMMENDED SITE	Native forest in moderate condition, connected to large contiguous native forest, management flexible to clearing for aviaries, quality existing infrastructure	Invasive plant species prevalent in some areas (NW section not carried forward as lacks suitable nesting trees), higher precipitation compared to historical range
Nakula Natural Area Reserve	Existing infrastructure, easy to navigate off-trail for monitoring, within historical climatic conditions, cell phone coverage	Invasive plant species prevalent throughout, low canopy cover of preferred nest tree species, low forest structure, site is smaller than one hypothesized ʻalalā breeding territory, isolated from other forest habitat

Type of release
The soft-release technique used during the 2016-2020 releases will continue to be utilized

for the release of ʻalalā on Maui. This soft-release process involves holding animals at the release site for a period of time prior to release (Parker et al. 2012). During the 2016-2020 releases, ʻalalā were held in the release aviary for one to two weeks prior to release. Additionally, in 2017-2019 birds were released in stages; the release of the first group was soon followed by the acclimatization period of the second to help with anchoring near the aviary. In general, a soft-release technique should be utilized for birds originating from human care to increase post-release survival, reduce stress, acclimate individuals to the wild by increasing the likelihood of recognition and utilization of supplemental feeders (Mitchell et al. 2011, Ryckman et al. 2010, Jones and Merton 2012), and anchor birds to a site after release (Swaisgood and Ruiz-Miranda 2018). Although the initial outcome of the 2016 release was poor, these methods were generally successful during the 2017-2019 releases.

Chapter 2 Pre-release

RELEASE MECHANICS

A variety of release cohorts will be utilized during the east Maui release. Both juvenile cohorts, and adult bonded pairs without young-of-the-year will be prioritized over the 5 year period of this plan, but the release of solo birds may be considered in some cases. Decisions on releasing juveniles versus adult bonded pairs will be made closer to the onset of releases based on the availability of release candidates, the time of year, and the demographics of existing ʻalala on the landscape (after the initial release), among other factors.

Juvenile cohorts were released in both the 1990s and 2016-2020 releases, and generally resulted in high survival immediately after release, but lower and declining survival after one year post-release, and ultimately the failure for released individuals to establish a population. No more than six juveniles are planned to be held in a release aviary at one time because constraints on the aviary size (See Release aviaries construction section, below) suggest that more than six juveniles may be likely to exhibit stress or aggressive behaviors due to crowding. The age at release of juvenile birds could range anywhere from 3 to 20 months old. Juvenile cohorts will be composed of similarly aged birds within approximately three months of one another in age.

Releasing bonded pairs in addition to juvenile cohorts will provide the potential for breeding to begin as early as the same year of release, accelerating the project timeline and reducing crowding in the breeding centers so that new younger birds can continue to be produced.

Solo birds may be released to augment the sex-ratio of the population, or to learn about site suitability or release techniques. For instance, solo birds may be released if unpaired birds are already present on the landscape, if higher post-release mortalities occur with one sex over another, or if the sex ratio is skewed. Female ʻalalā in captivity and post-release have demonstrated a high degree of choosiness in mate selection (SDZWA unpublished data), and we expect this behavior to also be an important factor in the wild. Unpaired individuals will still provide ecosystem services to the release landscape and useful information on space use and foraging behavior to inform future project design.

Releasing family groups (pairs with their young-of-the-year) will not be utilized. This was considered as another technique to kickstart breeding and to anchor birds to the release site either by placing a pair in a release aviary in advance of the breeding season hoping they would nest within the aviary or transferring the pair with young after fledging. However, that option was not selected for several reasons:

1. Disruption at the critical developmental stage may reduce fitness of offspring
2. A single fledgling is unlikely to find other juveniles for socialization in the wild when the number of birds on the landscape is very small
3. Each parent-reared fledgling was considered too valuable to the conservation

breeding program to use to test new release methods at that life stage
4. The logistics required to construct a release aviary and the months-long intensive care required to maintain birds breeding in a release aviary was unrealistic given the remoteness of the release sites

Timing of releases

The timing of releases will be planned to avoid the coldest and wettest months (December, January, February) for all cohorts and the breeding period (April-July) for adult pairs. The following factors contribute to ʻalalā condition and will be considered when choosing a release date, based on the age category of the release cohort. .

- Adult pairs could be released at any time outside of active breeding activity or the coldest and wettest months of the year at each site. Effectively, this limits releases to late summer and fall, or early spring, but the specific month of release for a given pair would depend on success or failure of that year's breeding attempt. If an adult pair has a failed nesting attempt or is otherwise not caring for young or in the process of nesting in the release year, they may be released during the breeding period.

- Solo birds could be released at any time outside of the coldest and wettest months at the release site.

- Juvenile birds could be released as soon as they are able to independently and proficiently find food items and have adequate mobility. In addition, juvenile birds could be released at any time outside of the coldest months of the year.

Holding birds in release aviaries

Birds will be held in the release aviary prior to release. The exact number of days that birds will be held in the release aviary prior to release will be decided at the time of release, depending on numerous factors such as, if excessive stress-related behavior is observed, as well as the status of progress of achieving the three objectives described below. If more than 6 juveniles are released, the cohort will be split into subgroups, and held in quick succession to help with anchoring. The objective of holding birds in the release aviary prior to release is for the birds to 1) recognize and reinforce the location where supplemental food is being presented, 2) familiarize the birds with the release area and habitat to limit post-release dispersal, 3) acclimate birds to the release area to reduce stress prior to release.

Holding birds in the release aviary prior to release has the following benefits:

1) Improved health. Protocols developed from previous husbandry of ʻalalā require 10 days of prophylactic antifungal medication immediately after moving birds between facilities. This 10-day period is required because ʻalalā are known to have a weakened immune system due to stress resulting from moving to a new location. Following the 10-day prophylactic treatment period, birds will require additional time to improve and enhance body condition for improved likelihood of high survival after release, as measured by weight prior to release. Release weight is a particularly important variable in cases when a bird disperses from supplemental food locations, as a bird in better condition will have more time to find alternative food resources prior to starvation.

2) Familiarization with the release site. The habitat type and climatic conditions at the release sites are different from the habitat types surrounding Maui Bird Conservation Center (MBCC) and Keauhou Bird Conservation Center (KBCC) where the birds are cared for. MBCC is situated in a non-native pine (*Pinus spp.*) and eucalyptus (*Eucalyptus spp.*) forest and while KBCC is located within a recovering native forest, it is on a different island (Hawai'i). The release site will have different plant species represented and structural complexity in addition to different weather patterns and soundscape than what the birds are familiar with at either breeding center. Therefore, acclimatizing birds to the specific site in an aviary prior to release will ease the transition and reduce stress for the birds once liberated. Prior to release into an existing wild population in the 1990s, ʻalalā were held at the release site for a mean of 73.0 days (SE=4.0 days) which resulted in high short-term survival and site fidelity (USFWS unpublished data). However, two weeks in the release aviary, in combination with provisioning of supplemental food, proved a sufficient amount of time to anchor most birds to the site in the 2016-2020 releases (SDZWA unpublished data).

Release aviaries construction

Release aviaries will be constructed at the release site being used that year with materials that allow for ease of transport via external helicopter load to the site, on-site construction, and full dismantling and removal. The aviaries are planned to be constructed directly on the ground (no deck) and wire mesh skirting will be attached around the perimeter to limit ingress by introduced mammalian predators. In addition, rodent control will be conducted around the release aviary to reduce the likelihood of ingress under the mesh skirting, as well as via the aviary roof. A roof will be added to a portion of the top of the release aviary to provide shade and protection from the elements which will offer birds a variety of shelter options throughout the day, but also provide opportunities for sunning and to develop self-preserving behaviors such as seeking shelter during rain events. Branches, native browse, and native fruits will be provided in the release aviary to reduce stress and further help birds adjust to the surrounding plant community.

Release aviaries will be approximately 40'L x 20'W x 12'H at a maximum. These dimensions were used for the 2017-2019 release aviaries, which were larger than the 2016 release aviary, to maintain flight conditioning and competency throughout the two-week holding period before release, and to reduce social stress. Dimensions of the release aviary may be altered due to unique site conditions, individual bird dynamics, or if a smaller aviary is deemed suitable for a pair or single bird.

As with releases at Puʻu Makaʻala in 2017-2019, it is desirable to reserve an option to observe birds without the influence of human presence to assess health and relevant behavior of release cohorts. Thus, either an attached observation compartment, or nearby hunting blind will be incorporated into the design. Finally, to facilitate recapture immediately following release, each aviary will be outfitted with a door to allow for capture if necessary.

INITIAL ELIGIBILITY FOR RELEASE

Eligibility for release will be determined based on demographic, physical condition, and behavioral criteria. An initial pool of candidates will be identified via demographic criteria that prioritizes retaining maximal genetic diversity within the conservation breeding population as identified in the ʻAlalā Restoration Plan (VanderWerf et al. 2013). These guidelines will remain flexible to accommodate various situations, with the goal of balancing sex ratio and genetic representation in the wild population with that of the conservation breeding flock. The list below are considerations to determine eligibility of individuals for release.

1) Inbreeding coefficient. Individuals with very low inbreeding coefficients are valuable for maintaining the genetic health of the conservation breeding flock and too valuable to risk losing in a release. Birds with high inbreeding coefficients are not appropriate for release, because this could result in the wild population being initiated with inbred individuals. Inbreeding has been shown to drastically reduce fitness in the ʻalalā conservation breeding population (Hoeck et al. 2015, Flanagan et al. 2021).

2) Founder representation. All potential candidates will be evaluated regarding their lineage, and release candidates will be balanced across lineages as much as possible to maximize genetic diversity in the founding population. This will be balanced against the same needs to balance the conservation breeding population across founding lineages.

3) Sex ratio. The ultimate target at the population level is 1:1 in the field over subsequent years. However, given observations of the 2016-2019 releases, we should not assume that a 1:1 release cohort will pair equally, because ʻalalā appear to be selective in mate choice. Even if an equal number of males and females are initially released, loss of individuals is likely to result in a skewed sex ratio in the initially small population by chance. Therefore, a mix of males and females will be released over time with the understanding that a 1:1 ratio is unlikely to be achieved early on, but efforts will be made to balance the ratio as best possible.

4) Age. Age of birds at release may be one of many factors affecting survival of birds. During 1993-1998, ʻalalā were first released at ages ranging from 3 to 7.5 months old (USFWS, 2009). Birds released between 3 and 5 months had higher survival. In the 2016-2019 releases, ʻalalā were first released at ages ranging from 6.5 to 29 months old. In that effort, birds released between the ages of 16 and 17 months had the highest survival, however the age of release was not tested in a systematic manner (SDZWA, unpublished data). For example, the majority of birds released 2016-2019 were 16-17 months old, and none were released at 9-15 or 18-25 months old.

Clearly there is more to be learned from outcomes of releasing birds at additional ages, as well as confounding factors in addition to release age, but for juveniles it appears that there are benefits from releasing either very young birds (3-5 months) or juveniles nearing natural stage of separation from parents (16-17 months) (i.e. natal site departure; see Masuda and Jamieson 2012). Thus, age at first release will not be strictly identified in this plan but will be determined in an adaptive framework that considers constraints such as climate, weather, staffing resources, while balancing a need for evaluating success at different ages of release. Furthermore, the absence of ʻio on Maui may also provide additional information on how birds of different ages survive without the potential of predation from ʻio. During the Maui releases, juvenile ʻalalā could be released at ages ranging from 3 to 20 months.

Adult considerations: Up to this point, no attempts have been made to release adult ʻalalā, so optimal strategies for full adults (age 3+) in pairs or as single males have not been assessed. Adults in captivity may have more trouble transitioning to the wild, particularly in predator recognition. Releasing pairs on Maui, where ʻio are not present, allows us to assess the ability of these birds to adapt and may provide key insights for conducting these releases in other areas in the future. Release of single birds may be considered if additional males or females are needed to even out the breeding potential of a surviving cohort.

6) **Rearing method.** Either parent- or hand-reared birds will be released, depending on what birds are available. Parent-reared birds are presumed to be better adapted to life in the wild as their early and direct socialization with their parents would more closely mimic natural conditions and species-specific behaviors. However, as the number of ʻalalā fledged by parent-rearing has thus far been lower than by hand-rearing methods in the conservation breeding program, hand-rearing may be used to meet the needs of the program. During the 2016-2019 releases, there were no differences in mortalities of parent- versus hand-reared birds, although the sample sizes, particularly of parent-reared birds, were small. Additionally, the adult pairs selected for other reasons as good release candidates may be of an age when hand-rearing was the most common method. Thus, released birds are likely to represent a combination of both rearing methods over time.

7) **Breeding history.** Adult breeding pairs will be prioritized for release if they show promise for successful breeding in the wild. Indicators of success include, strong pair bonds and history of successful nest building, incubation, and/or fledging offspring. The tradeoff between older birds being more likely to have successfully fledged young and the presumed reduction in breeding years remaining will need to be considered while selecting suitable pairs. The loss of successful breeding pairs to the conservation breeding population will also be considered, but will be balanced against the potential negative effects on the genetics of the entire flock.

PRE-RELEASE TRAINING

A pool of initial release candidates will be selected based on the demographic, genetic, and behavioral factors described above. All of the short-listed birds will undergo pre-release training and additional final assessments before being deemed a candidate for release. Pre-release training is intended to help release candidates recover or maintain wild-type behaviors that are commonly lost while in human care (Shier 2016, Alberts 2007). Specifically, training will focus on promoting predatory wariness towards aerial and mammalian predators (model species: barn owl and cat), identification and consumption of native fruits, successful foraging for live insects, social cohesion within the release cohort, training for recall, adequate physical condition, and agility in flight.

The competency of each individual with each type of training will be measured and considered when selecting final release cohorts (See Table 3 for pre-release markers/competency standards). How individuals will be chosen for release and the different types of training and monitoring they will undergo is explained in detail in the sections below. Each section is written with the release of juvenile cohorts, adult pairs, and single adults in mind and specified for each where training will differ.

Table 3. Pre-release behavioral training. All training of candidate birds prior to release will be for the purpose of increasing behaviors that likely contribute to higher likelihood of survival post-release or recall for necessary care.

Behavior	Training	Purpose	Pre-release Marker	Preferred Outcome	Wild Marker
Respond to alarm and distress calls	Present aerial and ground predators in combination with mentor birds or vocal recordings.	Ensure recognition and communication of threats to companions through auditory pathways.	Displays reactions such as alarm calling, freezing, and scanning behavior.	Effectively communicate and respond to alarm and distress calls.	Observation when ʻalalā naturally alarm call.
Anti-predator response	Present aerial and ground predators in combination with mentor birds or vocal recordings.	Increase wariness of potential predators.	Displays fear-related behaviors in the presence of predator (e.g. alarm calling or hyper-vigilant behaviors such as “sky scanning”)	Reduce likelihood of predation post-release.	Few to no mortalities due to aerial and ground predators.
Consume native fruits	Provide native fruits to release candidates. If individuals do not consume native fruits, provide opportunities to observe other birds who do consume these fruits or alter ratio of domestic to native fruits.	Ensure released birds will locate and consume adequate fruit post-release.	Incorporate native food into diet	Consumption of full range of fruits available at the release site.	Foraging on wild fruits from several species.
Locate and consume bird nest contents	Present eggs of smaller non-native species in a natural nest.	Ensure released birds will locate and consume important protein source found in eggs and nestlings of small birds.	Demonstrate interest in and consume eggs.	Consumption of eggs and nestlings.	Foraging on nest contents.
Locate and consume live insects	Present a variety of live insects to candidates in natural settings such as, decaying stumps and logs,	Ensure released birds will locate and consume adequate insects post-release.	Foraging for insects on multiple delivery systems.	Consumption of a wide range of insects. Locate and	Foraging for insects in multiple mediums.

	forest debris, and on fruits or branches.			manipulate insects in an efficient manner.	
Eat from food supplemental feeder	Identical food delivery systems to those used in the wild post-release will be placed in aviaries once birds are in the release pool. Tactics will be used to encourage feeding from the supplemental feeders, such as placing food near it, and propping it open.	To ensure adequate food resources can be successfully obtained during critical transition period to the wild.	Each individual needs to show competency with accessing food via the supplemental feeder without assistance from other birds.	Independently identify, manipulate, and consume supplemental food.	This behavior is not wild behavior but will provide a stop-gap measure to transition birds to a wild diet and provide opportunities for monitoring released birds.
Return to staff via cue	Perform a cue prior to food delivery.	Allow for efficient recapture of sick or injured birds. Improve ability to monitor condition of birds post-release.	Demonstrate alertness after cue and fly towards direction of cue.	Recognize cue as indicator of food delivery and fly to location of cue command when within range.	This behavior is not adaptive, solely for the purpose of recapturing released birds. In order to be effective, behavior should be retained for several months after training discontinued.
Flight competency	Attach backpack with unit that mimics radio transmitter packages, with additional weight prior to attachment of actual units in use.	Provide conditions for birds to gain muscle mass and ability to fly prior to release with actual units affixed so that flight is not encumbered.	Full flight across aviary while carrying dummy transmitter.	Unencumbered flight in forest and no reduction in physical condition due to units.	Unencumbered flight (e.g. agility within forest structure)
Social Cohesion	Co-house birds with remainder of release cohort.	Reduce likelihood of separation and post-release dispersal.	Social network analysis revealing multiple affiliates per bird.	Strong bonds exhibited by breeding pairs or connected to one or more other	Continued association with release cohort post-release. Minimize aggression within cohort.

				birds in juvenile cohort.	

Anti-predator training

Anti-predator training helps animals identify and respond to predators, a set of behaviors that often fail to develop in human care where there is little exposure to predatory danger (Griffin et al. 2000). While a breeding population of ʻio is not present on Maui, general wariness of predators will likely increase resilience of released birds should they encounter aerial predators, such as barn owls or terrestrial predators, such as cats.

Antipredator training towards ʻio threats was conducted prior to release. These methods were adapted from previous iterations of ʻalalā antipredator training (VanderWerf et al. 2013), using best practice recommendations of antipredator literature (Shier 2016), and were deployed at Puʻu Makaʻala after a series of pilot trials at KBCC that helped identify relevant training stimuli (Greggor et al. 2021). The general premise of training involves presenting birds with a realistic set of predator cues alongside conspecific signals of danger, allowing the birds to form a quick association between them. Birds' responses to the predatory cue(s) are also briefly assessed prior to and after the training event to help monitor learning outcomes. An additional training can then occur if behavior exhibited is deemed insufficient. For the 2017-2019 releases, this assessment-training-assessment structure took place over three days, but data suggest a longer period between the training and final assessment may be warranted (Greggor et al., 2022). Depending on the year, either a live ʻio or a hand-help ʻio puppet was used for the assessments. For all years, training involved a simulated predation event with the live ʻio, alongside playbacks of ʻio calls, a flying taxidermy ʻio, and playbacks of multiple ʻalalā alarm and distress calls. Data were collected via live observer and video camera, from multiple locations around the aviary to help track birds' responses.

Training for Maui birds will follow similar principles, structure, and methods as those deployed for the 2017-2019 releases, but the predatory cues will need to be adjusted to target different predators. Specifically, two types of anti-predator training will be developed and conducted: training towards a general avian predator (to help aid responses towards barn owls and ʻio), and training towards cats. A flyover model and predatory bird puppet (which moves to make a flapping motion) can be used for the general aerial training, both of which have been trialed previously with ʻalalā (Greggor et al. 2021, Greggor et al. 2022). For the cat training, ideally a live cat on a leash would serve as the predator. Mongoose training may also be considered.

If a live cat is not available for use, alternative predator stimuli will be explored. For instance, we will explore the use of a robotic taxidermy cat, which may take some time for development, but would likely be more convincing than a static taxidermy mount. Additionally, we will explore the use of video playback, keeping in mind that several aspects of the video setup and relevant predatory clip would need to be trialed on other ʻalalā first (see Choiunard-Thuly et al. 2017 for detailed considerations). Specifically, we would first need to ensure that the ʻalalā attend to the predator in the video clip, and not some other detail of video or the playback setup, including making sure the clip coloration matches the visual sensitivities of corvid eyesight (since ʻalalā can see in the UV spectrum). Second, we would need to ensure the clip realistically matches the background and setup of the aviary, including the lighting, scale, and screen presentation, to increase the likelihood that the birds would respond as if the clip were occurring near their aviary.

For the aerial and terrestrial training types, both the predatory and conspecific cues will aim to be as ecologically relevant as possible, for instance, the cat would be viewable on the ground or walking along a log. No direct contact will occur between the ʻalalā and any of the predatory stimuli. Finally, if a potential mentor bird that shows high anti-predator responses becomes available for the release cohort(s), they may be incorporated into the training, so long as they can have adequate space, and safe housing.

To help track training progress and outcomes, we will collect data on baseline, training, and post-training responses to both types of predatory stimuli, using fear appropriate behavior as a response variable (Appendix 2). These data will then be used to determine if additional training is warranted and can be incorporated into the behavioral competency standards prior to release. Since there is less certainty that training is essential for survival on Maui, we will focus on birds' responses to conspecific danger cues in defining competency standards, ensuring that birds respond fearfully or with vigilance when conspecific alarm and distress calls are played. While most adult ʻalalā housed at KBCC readily respond to such cues, there is considerable individual variation, which could lead to birds being less prepared to respond to these survival-relevant signals post-release (Sabol et al., 2022).

Adult training: Follow-up work on anti-predator training at KBCC identified that adult birds were responsive to a similar training setup as used in Pu'u Maka'ala (Greggor et al. 2022). Therefore, the same protocols can be used for juvenile and adult cohorts.

Food training

As a generalist forager (Sakai et al. 1986), wild ʻalalā need to recognize and forage on a variety of fruit and insects. However, even in generalist species, the extent of their foraging breadth can be influenced by experience and can be limited by human care if inadequate opportunities for wild-type foraging are given.

As part of general husbandry and care, all ʻalala are offered native fruits but fruit availability/labor are not sufficient to provide them in high abundances for all birds. Therefore, between seven and twelve different native fruits were repeatedly provided to release candidate ʻalalā throughout the rearing and conditioning process for the 2016-2019 releases. Additionally, for the 2017-2019 releases birds in the flight conditioning aviary were provided with native fruits and their consumption was assessed. All individuals passed the competency tests and were observed foraging on wild foods after release. For the Maui releases we will make sure that release candidates are exposed to a similar breadth of native fruits, prioritizing species found at the release site and Maui island where possible. We will collect data on native fruit consumption when it is first provided and over multiple exposures, but responses to true novelty per se will not be the focus since adults and juveniles may have different fruit exposure histories, especially if birds are sourced from both MBCC and KBCC where fruit supply differs. All birds will ideally consume multiple types of native fruits to be considered releasable.

ʻAlalā consume a wide breadth of insects in the wild (Sakai et al. 1986), however exposing birds to each taxa that may be important post-release is not realistic given logistical constraints on accessing sufficient insect families as well as incomplete knowledge of which specific insects are most important to their diet, found at each specific release site, and how specific insects are found within specific substrates. Thus, conditioning will focus not on recognition of insects but rather development of foraging skills. Insects such as isopods and crickets will be presented in leaf litter. Natural foraging substrates, such as rotting logs, snags, and terminal branches with foliage, will also be placed in aviaries with the assumption that insects will be present in these materials.

To reduce the association of all humans with positive reinforcement (food), a clothing marker will be introduced prior to movement to the release aviary. From that time forward, birds will only be fed from staff wearing the marker (eg. colorful hat, mosquito head net that obscures the face). To facilitate recapture to replace monitoring equipment or care for compromised birds, an audio cue will also be introduced prior to movement to the release aviary. The audio cue, such as a whistle, will be played immediately prior to food delivery by staff wearing the clothing marker, with the intention of ʻalalā associating positive outcomes from the direction of the audio cue.

Supplemental food will be provided post-release and will require proficiency by the birds with using the feeder prior to release. Supplemental feeders are described in greater detail in Chapter 4: Supplemental Feeding, but here we recognize the importance of early exposure to feeders and evidence of their independent use.

Social cohesion

Both the density of birds in an aviary and the combination of individual temperament traits within the group can influence group cohesion. During the 2017-2019 releases, behavioral observations were taken of the release cohorts a few times a week to monitor the social structure of the group and pinpoint potential stress, welfare concerns, or issues which could compromise the releases. In addition to helping separate birds into release groups from the main cohort, these observations can be used to diagnose issues such as aggression.

As in the 2017-2019 releases, measures of social bonding and dominance will be recorded for Maui releases via in-person observation while birds are held in aviaries with other release candidates. Social interactions will be documented using an ethogram and any decisions about changes to release cohort composition in groups will be made using social network metrics and visualized through network plots (Farine and Whitehead 2005). The sampling method and associated ethogram that was used in 2017-2019 is adapted from previous studies that measured sociality and dominance across several corvid species (Jolles et al. 2013; Logan et al. 2013), and from measures developed for ʻalalā monitoring in 2016 (see Appendix 2).

Adult training: Although adults may only be released in a pair of two birds, or alone, the social dynamics of the pair will also need to be monitored. While social network metrics wouldn't be necessary for assessing the cohesion of the pair, the relative number of pair bonding behaviors in comparison to the rest of the population would still be important for making decisions about the likelihood of their suitability for release.

Physical conditioning and agility

ʻAlalā must be able to proficiently fly, perch, and land in a dynamic forest environment, including moving to and from supplemental feeders, and within forest vegetation. Pre-release physical conditioning for this post-release environment will be accomplished in the conservation breeding aviaries, by providing an environment in human care that mimics the forest as much as possible.

For example, aviaries will be furnished with dynamic perches, to ensure ʻalalā gain experience landing on and taking off from perches that move and respond to their body weight, as terminal branches do in the wild. Dynamic perches move and flex and vary in shape and size, unlike static perches that may be completely horizontal, of the same length and thickness, and do not move about. Perches will also be strategically located throughout the aviaries to discourage short hops and encourage long flight. Conditioning for release candidates will occur in the larger aviaries. Lastly, aviaries will be outfitted with free-standing supplemental feeders to familiarize birds with the design and provide opportunities for them to manipulate supplemental feeders to successfully obtain food.

To help condition birds to the rigors of wild flight and help them build muscle mass suitable for carrying telemetry backpacks, all birds were fitted with dummy transmitters 1-6 months prior to the 2017-2019 releases. The same procedures will be applied for upcoming Maui releases, aiming to have birds wear dummy transmitters for 2-3 months. The dummy transmitters will be attached with the same backpack harness type as the functional transmitters, made with Spectra© material (Bally Ribbon Mills). The dummy transmitters will weigh approximately 10% more than the functional VHF or GPS transmitters, but less than 5% of the bird's body weight (White and Abreu-Gonzalez 2007). The functional transmitter will be attached approximately 14-21 days before the birds are released allowing time for birds to acclimate to the new units and ensure functionality and proper fitting prior to release.

Adult training: No aspect of the physical conditioning or physical competency standards will be adjusted for adult birds.

General Enriched Experiences

In addition to the training and behavioral observations of the release cohort, an enriched experiences and health monitoring regime will help ensure the birds are healthy, occupied, and maintain a neutral relationship with people. Staff will keep voices quiet as much as possible around release candidate birds. Additionally, to help foster neutrality prior to release, the birds will be given occasional exposure to observers walking quietly outside the aviary, carrying backpacks and gear. This gentle and occasional exposure will reduce stress experienced by birds when they encounter observers post-release, without leading to any associations, positive or negative with people other than those wearing the marker and playing the audio cue.

Adult considerations: Adult release birds would receive similar enriched experiences and husbandry throughout their lives, however entry into pairs' aviaries during the breeding season will be reduced to avoid interruption of breeding activities.

FINAL ASSESSMENTS

Assessing eligibility of release candidates will be an iterative process with regular feedback from the training program as described above. Behavioral observations of birds during release preparations will help identify potential problems relating to training, housing, or social interactions (see Appendix 2). If release candidates pass the behavioral training assessments as described in Table 3, they will receive a final veterinary exam to prove their fitness for release.

The veterinary checks will take place within one month of the release date. At that time birds need to show no signs of significant disease or physical injury to the joints, eyes, beak, wings, legs, or feet, and need to have a body score of 4 out of 9 on the scale commonly used by SDZWA veterinarians to assess ʻalalā condition (>3 is emaciated, 5 is peak condition, >7 is obese). Birds need to have mostly intact flight and tail feathers, with no signs of serious breakage or wear beyond what is seasonally appropriate given the current molt cycle. Older juveniles and adults must also be within the post-fledging weight range observed for the individual's life prior to release preparations. Extended records for younger juveniles' weight range will not be available for comparison. At the time of the vet checks, a blood sample and series of swabs will be taken to determine the health of the bird pre-release and serve as a baseline for future disease or health investigations that may come about post-release. Finally, upon transfer to the release aviary, each bird needs to be observed navigating the release enclosure with species-appropriate take off, obstacle navigation, and landing.

Maintaining a record of weights for each bird pre-release will be important to assess changes that may be cause for concern post-release. Weights will be collected at the breeding centers opportunistically when birds are in hand for other reasons and remotely via scales incorporated into food delivery devices leading up to releases.

Chapter 3 Post-release

POST-RELEASE MONITORING

ʻAlalā will be monitored post-release in a hypothesis-testing framework to inform adaptive management actions during this and subsequent releases. The overarching goal of monitoring is to collect data to inform the reintroduction strategy.

Meaningful monitoring of individual birds on the landscape is critical to assessing project success and gaining valuable information to support adaptive management both to help individual birds thrive in real-time as well as improving project activities for future releases. However, as resources are finite, not all monitoring items that are important to the project may be feasible to accomplish. There is also a tradeoff between implementation and monitoring, whereas a high intensity of monitoring may mean that fewer cohorts could be released and reduced extent of predator control or other habitat restoration activities could occur. Clear identification of monitoring priorities ensures staff time and other resources are applied in a deliberate manner that has the greatest potential for direct application to improving methodology and reaching project objectives.

Table 4 captures the results of an assessment of the 18 most important monitoring items across three phases post-release: active supplemental feeder use, weaning, and post-feeder use. For each item and phase, planners ranked the "*importance to adaptive management*" as that which would directly inform decisions during concurrent or future releases, "*feasibility of accomplishing*" considering the difficult logistics of operating in roadless areas with challenging terrain for navigability, and a "*monitoring priority*" that takes the other two factors into consideration.

Under this scheme, it is possible for an item to have a relatively high importance to adaptive management, but medium or low monitoring priority if the feasibility for accomplishing it is low. For example, there is great value at all phases from recovering carcasses soon after death to perform a quality necropsy and learn the major causes of death so that they may be mitigated, however by Phase 3, we anticipate many birds will have dispersed to remote locations away from project activities and the challenges faced by immediate detection of a mortality, mobilization, and recovery within a timely manner are low. So despite an importance value of 5, the monitoring priority in Phase 3 was medium because the feasibility of accomplishing the task was 1. This assessment recognizes there may be some cases where the expense or resource cost to other components of the project are not justified given the extreme effort required to accomplish.

Monitoring Item	PHASE 1: ACTIVE FEEDER USE			PHASE 2: WEANING			PHASE 3: POST-FEEDER USE		
	Importance	Feasibility	Priority	Importance	Feasibility	Priority	Importance	Feasibility	Priority
Survival	5	5	H	5	4	H	5	3	H
Cause of death	5	2	H	5	1	M	5	1	M
Weight	4	4	H	5	2	M	4	0	L
Molt status	2	4	L	3	2	L	3	1	L
Pox lesions	4	4	H	4	2	M	4	1	M
Breeding activity and status/outcome	5	4	H	5	4	H	5	3	H
Categories of wild diet items used	3	4	M	5	3	M	5	2	M
Supplemental food consumption	4	5	H	4	5	H	NA	NA	NA
Dispersal	5	5	H	5	4	H	5	3	H
Foraging and perching substrate	2	3	M	3	3	M	3	2	M
Intraspecific aggression	4	2	M	5	2	H	4	0	L
Social affiliations	2	4	M	3	4	H	3	3	M

Mode of foraging (canopy height)	1	3	L	2	3	L	2	2	L
Elevation	3	5	M	3	4	M	4	3	M
Forest/Habitat type	1	5	L	3	4	M	4	3	H
Condition (BAR, feather condition)	5	4	H	5	3	H	4	1	M
Monitoring equipment status	5	5	H	5	5	H	2	5	H
Auxiliary markers	5	5	H	5	4	H	5	4	H
Interspecies interactions	2	1	L	2	1	L	2	1	L

Table 4. Monitoring Goals. Importance to adaptive management (Importance), feasibility of accomplishing (Feasibility), and monitoring priority (Priority) were assessed for three phases of ʻalalā post-release monitoring on a scale of 1(low) to 5(high) and low (L), medium (M), and high (M).

The highest ecological monitoring priorities across all three phases are survival, breeding activity and outcome, and dispersal, since success of the project will be measured by longevity of released birds and maintaining birds in quality habitat. Two priorities focused on ensuring proper function of equipment ranked high for all three phases as well. Monitoring equipment status (e.g., camera traps, RFID readers) and auxiliary markers (eg. telemetry units, color bands) are both important to ensure adequate data collection.

The lowest priorities across all three phases are molt status, height in canopy of foraging activities, and interspecies interactions. Molt status was ranked low because it is somewhat redundant as one of multiple ways to infer both condition and breeding status, however other methods (condition, direct observations of breeding via nests and behavior) will be easier to obtain unless birds are recaptured. Height in canopy can provide information for future site selection, however to obtain these data, direct observations are required, and other factors obtained through remote sensing (eg. forest habitat type, elevation) will also inform site selection and are less likely to be biased by uncontrolled responses to observer presence or ease of viewing birds in varying forest conditions. Assessing the frequency of nest depredation and encounters with predators (interspecies interactions) would be difficult to achieve without daily observations and recovery of many fecals and casts. Emphasis on the remainder of the monitoring items will shift over time.

Methods

Monitoring items were selected if they directly contribute to improving the recovery program. The purpose of collecting these data are outlined in Table 5 along with general methodology. A Maui ʻAlalā Monitoring Protocol will be developed to provide more details. General methods of data collection may include:

1) Transmitters affixed by a backpack to each released ʻalalā. Transmitters will utilize both the ARGOS (or similar) satellite system (due to the lack of GSM cellular signal at the release sites) allowing for automatic remote data transfer once daily and a UHF signal that allows for tracking on the ground using a hand-held receiver and antenna. These units will be outfitted with a mortality switch so that the condition of deceased birds can be detected within 24 hours of death. Satellite tags will need to be durable towards ʻalalā beak damage and have sufficient ability to pick up sunlight in the forest canopy to recharge their solar battery or have another suitable lightweight battery that meets weight requirements. The same harness design will be used, regardless of the transmitter type that is chosen. This harness design (Figure 3) was successfully used on released ʻalalā from 2017-2020 and used a lightweight Spectra © material (Bally Ribbon Mills).
2) Remote trail cameras deployed at supplemental feeders and active nests to monitor individual's health, social associates, condition of auxiliary markers, and breeding status.

3) Scales will be integrated into supplemental feeders to capture bird weight.
4) Standard measuring cups will assess volume of food consumed.
5) Radio Frequency Identification (RFID) units affixed to ʻalalā bands and RFID readers integrated into supplemental feeders may be used to provide an additional measure of survival should telemetry units malfunction. They could also provide information on social affiliations and, to a lesser degree, dispersal. They may be used to trigger supplemental feeder opening if desired.
6) Recapture will occur using release aviaries, mist-net, bow-net, noose carpet, or other capture methods in the event of intervention for birds' welfare or to replace auxiliary markers.
7) A unique combination of colored leg bands and aluminum alloy bands engraved with unique numbers from the USGS Bird Banding Lab will be placed on each bird.
8) Direct visual and audio observation from 10 m away, where possible, either in a blind near feeders or at a remote location in the forest to assess survival, condition, and behavior.
9) Opportunistic collection of fecals and casts, particularly from supplemental feeders, for diet analyses.
10) Collection of carcasses from deceased birds for necropsy in a certified lab.
11) Additional GIS vegetation, elevation, and other environmental data to overlay with location data for each bird or pair.

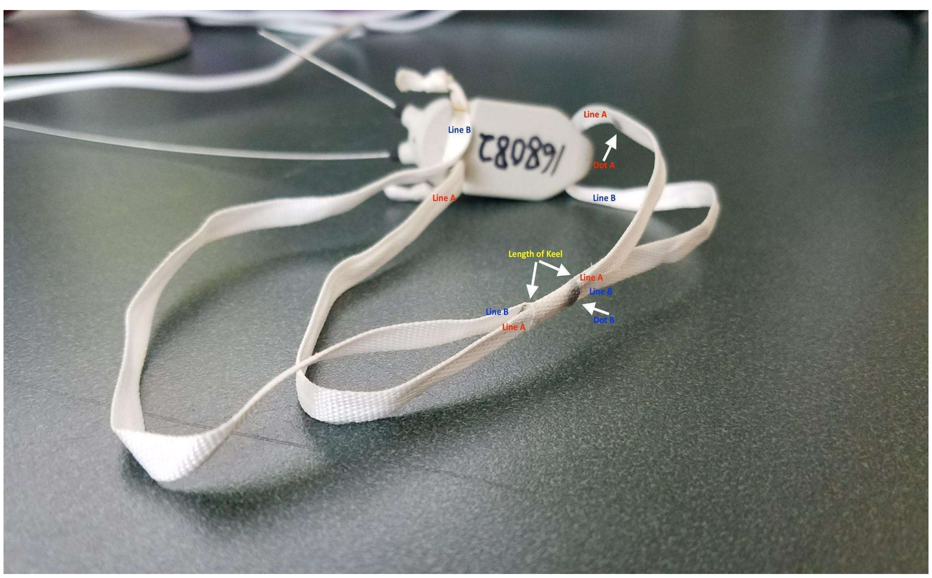

Figure 3. Harness design used on ʻAlalā for carrying VHF radio-transmitter during 2017-2019 releases (only some birds in 2017), and all subsequent reharnessing. The harness straps are made of Spectra ©, a light-weight, teflon-type material. Design adapted from model used on burrowing owls (pictured here). Photo credit: David Johnson.

Table 5. ʻAlalā Monitoring Methods.

Monitoring Item	**Purpose of Monitoring Item**	**Method of Monitoring**
Survival	Calculate survival rate	Visual and satellite tag (mortality sensor)
Cause of death	To identify primary causes to reduce mortality in future releases	Carcass collection and necropsy, visual observation of event, timing/correlation/behavior
Weight	To assess whether birds are thriving or not, detect issues in real time to address through treatment/recapture for rehabilitation, inform weaning decisions	Scale at feeder with remote camera, recapture
Molt status	Breeding status because not molting during breeding and to inform interpretation of space use/activity because do not move as much during molting	Recapture, direct observation, possibly with remote cameras
Pox lesions	Assess bird health, suitability of release site (proximity to chicken farms, elevation, and moisture are contributing factors)	Recapture, direct observation, possibly with remote cameras
Breeding activity and status/outcome	Assess project overarching goal	Telemetry to see if birds are localizing or associated with a mate, direct observation/nest searches, possibly remote camera
Categories of wild diet items used	Assess habitat suitability for both this release area and to identify new ones, assess impacts to other species, influence supplemental diet or breeding center diet	Visual observation, fecals and casts using DNA barcoding
Supplemental food consumption	To inform the weaning process, combine info with weight to assess bird health, to reduce food being wasted/help reduce rat activity	Volume of food before/after delivery

Dispersal	Understand birds' use of landscape to explore for wild food sources, estimate home range size and pair dynamics, inform minimum distance of cohorts released in future releases, inform decisions and communication regarding land ownership and threats to reduce conflict in future releases. Components include daily space use but also maximum dispersal distance to establish a territory post-supplemental feeding, dispersal immediately post-release.	Satellite tags, hand-tracking, audio, public reporting/partners
Foraging and perching substrate	Assess habitat suitability to inform future site selection	Visual observation
Intraspecific aggression	Determine cause of death, assess supplemental food provisioning and weaning and influence movements, inform age of release cohorts and spacing of release cohorts, inform habitat quality, indicator of breeding territory establishment, indicator of social hierarchy to inform future cohort composition or correlations with survival	Visual or audio observation and remote cameras
Social affiliations	To inform cohort selection and flock persistence, early indicator of breeding activity	Visual observation, satellite tags, remote cameras
Mode of foraging (canopy height)	To inform site suitability, assess potential for predation based on which canopy level and species they spend a lot of time	Visual observation
Elevation	To inform future site selection (mosquitoes, fruit phenology, response to seasonal temperature changes)	GIS, location data via satellite tags and hand-tracking
Forest/Habitat type	To inform future site selection on a larger scale	GIS, location data via satellite tags and hand-tracking
Condition (BAR, feather condition)	Assess whether birds are thriving or not, detect issues in real time to address through treatment/recapture for rehab	Visual observation, remote cameras
Monitoring equipment status	To ensure adequate data collection	Regular checks via direct observation and remote monitoring

Auxiliary markers	To identify issues with the markers themselves (injury to birds/impeding movement), to ensure adequate data collection	Direct observation, remote cameras, satellite data, recapture
Interspecies interactions	To determine degree of nest predation on other declining birds to address public comments.	Direct observation, fecals/casts

All field data and documented observations will be recorded on mobile electronic devices using ESRI ArcGIS Survey123 or similar spatial-referenced data collection software. This method will allow users the ability to enter data directly to an electronic format in the field and upload it to ArcGIS Online once cellular or wifi service is available, making it available for rapid dissemination and reports. This process will also eliminate the need for time-intensive data entry and facilitate map generation and other documentation that are dependent on spatial data.

Phases of release actions

ʻAlalā releases on east Maui may consist of several cohorts of birds over multiple years. Since time and other resources are limited, and the release sites are located in a remote landscape without easy (or any) access by road and hiking, monitoring each cohort will be most intense during the initial release period and settlement and be reduced thereafter. Subsequent monitoring efforts will rely primarily on remote monitoring methods (satellite telemetry) as resources shift towards support and intensive monitoring of the next cohort in a new release area, which will be far enough away to prevent daily spatial overlap between cohorts. The following portion of the plan is broken into four sections titled *Monitoring Preparations, Phase 1: Active Supplemental Feeder Use, Phase 2: Weaning,* and *Phase 3: Post-feeder Use*. According to the generalized weaning schedule identified in Chapter 4: Supplemental Feeding, Phase 3 may be reached within two years of each cohortʻs release.

Monitoring preparations

Activities to prepare for active monitoring will be focused on testing equipment, training staff, and gaining access to adjacent ownerships as needed. Early in project planning, the project coordinator and outreach specialist will engage adjacent landowners in an effort to obtain permission to access land for monitoring purposes if released birds disperse to neighboring ownership. The coordinator will work with state land managers at the actual release site and adjacent land owners, to ensure monitoring methods and frequency of access is designed to mitigate impacts to native ecosystems or competing land uses.

In the months leading up to the release, project staff will test equipment in the release area under varying weather conditions and topographical terrain to ensure reliability. Field staff will install, or improve existing trails to facilitate monitoring. Staff will also be trained on equipment use, methods for data collection, and methods for performing visual health assessments prior to birds' transfer to release aviaries.

Phase 1: Active supplemental feeder use

Ten monitoring items are ranked as high priority during Phase 1 (Table 4) and the majority of monitoring staff time will be spent in activities supporting the collection of these data.

The emphasis during this phase is to ultimately understand the amount of supplemental and wild food needed to maintain a bird or pair, which will in turn inform habitat restoration efforts and guide future releases. The supplemental feeder visitation rates, bird weight, and behavioral observations will inform the team about individuals' foraging competence and preferences. Additionally, once it is established how best to attract birds and maintain them in areas that seem most suitable or desirable for establishing a territory, data from feeding locations could direct predator management, habitat restoration, and optimal feeding locations, while providing a basis for understanding how many ʻalalā could be supported in a given region. Some of these items will be ongoing and easy to plan for, however others only occur during discrete periods of time, such as locating deceased birds to determine the cause of death, and during those times other activities will be suspended to prioritize carcass retrieval.

Many of the activities performed to support these monitoring items will be aided by the fact that birds should be localized around supplemental feeders, based on how birds responded during earlier release efforts. Staff will monitor birds through live visual observation and review images from remote cameras at supplemental feeders. Considerable data on condition of birds and auxiliary markers, molt status, pox lesions, some behaviors and association with conspecifics, and weight of bird is expected to be available through review of camera images. Scales will be incorporated into supplemental feeder design, and cameras positioned in view of supplemental feeders, so that weight can be obtained in absence of observers.

Phase 2: Weaning

Nine monitoring items are ranked as high priority during Phase 2 (Table 4). The primary changes from the previous phase to this will be an increased emphasis on assessing relations with conspecifics for early intervention if aggression arises after a reduction in food and a decreased emphasis on obtaining weights and determining cause of death since obtaining those data will be less feasible as birds visit feeders infrequently and begin to disperse. Consumption of supplemental food will continue to be important, and factor into minor modifications of weaning methods and timeline if needed.

Phase 3: Post-feeder use

Fewer high priority monitoring items remain by Phase 3 (Table 4) since visual observation will become increasingly difficult as birds disperse away from centralized supplemental food and resources shift towards the next release cohort. However, forest/habitat type will increase in priority as ʻalalā use of the landscape should better represent actual habitat choice as previous locations of supplemental food should have minimal effect on territory establishment over time. Monitoring activities will increasingly rely on remote sensing during this final phase. Satellite tags will allow for remote monitoring to track survival, space use, and infer breeding. Similar to other monitoring phases, if a mortality signal is detected, staff will attempt to recover the carcass as soon as possible in an attempt to determine cause of death. Overlapping territories and seasonal localization of recorded bird points will be used to infer breeding activity, with visits by field staff to observe birds and protect nests as logistics allow. Remotely monitored bird locations will be used to learn about ʻalalā dispersal, establishment of territories, and habitat selection using GIS data.

Monitoring intensity

The monitoring frequency and intensity will change based on the time elapsed since release to help collect data that will be best suited to the management needs at the time. For the first month post-release, we will attempt to visually locate all birds twice a week. After the first month, remote monitoring methods will be increasingly relied upon. The ultimate monitoring schedule will be adapted as needed, depending on real-time information about the status of the cohort, their health, dispersal, and acclimation to wild food sources.

Daily monitoring of birds by field personnel will occur from the time birds enter a release aviary until 30 days post-release or for the duration of time birds are being fed fresh food daily. After supplemental feeding switches to automated feeders and up to 6 months post-release, birds will be monitored in the field for two weeks each month. From 1 year to up to 3 years, attempts will be made to observe birds in person once every 2-3 months to determine the monitoring items described in Table 4. Remote monitoring via satellite telemetry will occur for at least 3 years or until equipment fails. In the event that monitoring indicates an ʻalalā would benefit from recapture and release, (e.g. transmitter failure), monitoring may need to be more intensive to facilitate recapture efforts.

Monitoring team structure, roles, and communication

The monitoring team will be structured to best facilitate communication and data collection within the team and outwards to the ʻAlalā Project Coordinator and Planning Group. Daily field activities will be managed by senior ʻalalā staff such as the ʻAlalā Senior Logistics Technician and ʻAlalā Project Coordinator. In cases of urgent matters (e.g., death or illness of a bird), information will be conveyed immediately to the Project Coordinator, who will disseminate information to project partners to make rapid decisions as necessary. In the event that a rapid decision must be made without time for consensus, the post-release monitoring team will use best judgment and implement actions to resolve the situation.

There will be daily communication between field and office staff with a minimum of daily safety checks via radio or cell phone with the ability to transmit other project information from the field to the office at that time. Important location or status information obtained from daily satellite monitoring of birds from the office will be transmitted to the field during those daily safety checks as well, or sooner if critical. Weekly updates containing summaries of mortalities, changes in supplemental feeding, observations of breeding activity, dispersal or presumed territory establishment, and other relevant behaviors such as aggression will be provided via email to Maui Nui Planning Group for the first month post-release, and monthly thereafter (or immediately in the case of mortalities or suspected illness). Summaries of predator control will be provided quarterly to the Maui Nui Planning Group. Content from the email summaries will also be presented in abbreviated form in monthly Maui Nui Planning Group and quarterly Hui ʻAlalā meetings.

Data responsibility

Partners active in the Maui Nui ʻAlalā Planning Group will have access to data summaries such as through an online dashboard. Real time data may not be possible due to field logistics and the remoteness of the release sites but the project will strive for timely and efficient transparency to all such data. All research publications related to ʻalalā post-release will offer authorship to at least one representative of each of the major partners of the Maui Nui ʻAlalā Planning Group for all studies where they directly contribute.

Monitoring team accommodation

To maximize efficiency of field efforts and limit impacts to the release area, a semi-permanent base camp will be established within reasonable hiking distance to each release aviary. Preferred camps will be located at existing facilities within reserves, but new camps with a weatherport, sanitation facilities, and water collection system may be established with land manager approval. Access will in most cases be via helicopter and crews will adhere to biosecurity and phytosanitation Standard Operating Procedures. For safety reasons, two or more individuals will stay overnight at a time. Any food prepared there for the birds will be contained and prepared in a sanitary environment.

Chapter 4 Supplemental Feeding

SUPPLEMENTAL FEEDING

Supplemental feeding is regularly employed with the soft release strategy for conservation translocations (Brightsmith et al. 2005, White et al. 2012). Supplemental feeding can increase post-release survival and minimize dispersal immediately after release. Similar to previous ʻalalā releases (VanderWerf et al. 2013), the duration of supplemental feeding will be adjusted adaptively depending on ʻalalā feeding patterns, their reliance on offered foods, and project goals to establish fully wild birds. In general, supplemental food will be provided as a tool for helping birds establish and maintain territories in protected areas, survive short-term extreme weather or other environmental events, prolonged droughts (and other long-term environmental stressors), and breed successfully. Supplemental feeding will occur in three stages: search image development and anchoring, initial release support feeding, and weaning transition.

The type, location and aims of supplemental feeding will change throughout the period. However, the overarching plan for supplemental feeding is to encourage the use of the supplemental feeders in the early post-release months but transition to encouraging food independence similar to the approach used in 1993-1998 (Marzluff et al. 1993).

Supplemental Feeder Design

The highest priorities for the supplemental feeder are to 1) provide released alala with supplemental food, 2) obtain body weights on individual birds to determine the health status of each bird, 3) prevent rodents from directly accessing the supplemental feeder, and 4) minimize mold developing on the supplemental food within the feeder. For more details regarding post-release data collection, see Table 4, Monitoring Goals. Supplemental feeders may be outfitted with a scale to obtain body weights, camera to capture scale weights, and an RFID reader to establish the identity of visiting birds, by scanning RFID tags integrated into their leg bands. These RFID tags are scanned instantaneously each time they pass the RFID reader, and each scan will record a timestamp. The body weights may be obtained by staff multiple days after being captured by the camera, as there may be a delay if the physical retrieval of the SD card to download the weights is required. Food will not be weighed. Although the supplemental feeder design will prevent wild rodents from having direct access to food within the supplemental feeder, rodents will inevitably have access to residual food falling on the ground especially when supplemental feeders are checked infrequently by staff and are automated. Active predator control with ʻalalā excluders will occur in the direct vicinity of each supplemental feeder. To become proficient and comfortable with using the supplemental feeder, the released birds will be introduced to the supplemental feeder design approximately 2-3 months prior to release.

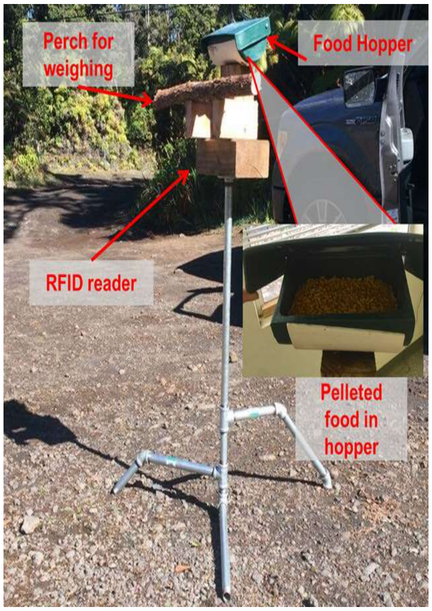

Figure 4. Supplemental feeder utilized during the ʿalalā reintroduction from 2016-2020. This figure is an example of what may be used during future releases, although the future design will likely change from this picture.

Figure 5. Supplemental feeder utilized during the ʿalalā reintroduction from 2016-2020 with a trail camera to record weights of birds while feeding.

Figure 6. Trail camera view of feeder from 2017-2019 releases. An RFID antenna is integrated into the perch, and the bird's orange leg band contains the RFID tag. Trail cameras were used for monitoring weight, survival, and social interactions. Photo from Greggor et al., in review.

Spatial Extent

Prior to release two to four supplemental feeders will be placed within ~20m from the release aviary and in view of the birds held within the aviary (similar distances to Kuehler et al. 1995, and what was used in the 2017-2019 releases). An additional feeder may be placed within the aviary to facilitate recapture if desired. After several weeks (timing used in 2017-2019 releases) of offering food in the close vicinity of the release aviary (20m), supplemental feeders may be moved out into the forest, to facilitate wider space use and reduce aggression within release cohorts.

Efforts will be made to encourage birds to establish home ranges in optimal habitat through guided dispersal away from the release aviary to leave open options for future releases there. To achieve this, several weeks post-release supplemental feeders may be moved to adjacent areas away from the release aviary to maximize feeding opportunities, based on the birds’ movement patterns. These moves may also help foster the establishment of territories, since the abundance of high-quality food is a known marker of territory quality in many bird species, especially if occurring adjacent to successful conspecifics (Muller et al. 1997). If one or more birds disperse away from the release site within the active supplemental feeder use phase, a supplemental feeder may be placed in the new location if logistics allow.

In all cases, new supplemental feeder locations will be placed in areas of suitable habitat for ‘alalā that avoid areas impacted by human activities. Based on birds’ responses to supplemental feeder movement at Pu’u Maka’ala (Greggor et al. in review), movements of up to 150m of full supplemental feeders are easily located by ‘alalā, with preference for feeders located in areas of high canopy cover instead of open habitat. The exact distance of the move will depend on post-release behavior, dispersal, and movements.

Diet Composition

Food provided in supplemental feeders will change over time. In the release aviaries and for the first 1-2 months immediately following releases, a diet resembling that provided in human care will be provided. The amount of fresh food will be removed gradually, while dry pellets will continue to be available. This dietary change will allow automated delivery by supplemental feeders and, in dry pellets being less desirable to ‘alalā, encourage foraging for wild foods. All food provided to ‘alalā will be subject to strict bio-control measures to limit the likelihood of non-native plant establishment due to project activities.

Temporal Period

Individual release cohorts are intended to be transitioned from supplemental food to wild food within two years. If birds are still using supplemental feeders 2 years after release, then a variety of options will be assessed. The implementation of providing supplemental food will be adaptively managed by considering the condition and movements of birds post-release. Adult pairs actively breeding may also be fed within their territory to increase survival of offspring to fledgling stage as long as ‘alalā are on the landscape pending project resources, access, and perceived need.

Weaning Process

After approximately four months or once all birds have been seen foraging on wild foods and are maintaining normal weight, weaning will begin. Weaning is the process of removing regularly provided supplemented food to transition released birds to a wild diet so that they can fully integrate into the natural ecosystem. The weaning process will involve incremental reduction of food items, starting with the most desireable fresh food from the supplemental feeders (within a few weeks post-release) and then reducing dry pelleted food amounts over time. Weaning may be halted for various, to be determined reasons.

Chapter 5 Predator Control

PREDATOR CONTROL

Successful translocations of ʻalalā to Maui will be determined by a combination of placing birds in locations with favorable food, climate, and nesting conditions, as well as mitigating risks on the landscape. Non-native mammalian predators are the presumed cause of nearly 70% of avian extinctions on Pacific islands (Griffin et al. 1989). Non-native rats (*Rattus rattus, R. exulans,* and to a lesser extent *R. norvegicus*), cats (*Felis catus*), and small Indian mongooses (*Urva auropunctatus*) all pose risks to released ʻalalā.

All three species prey on a variety of Hawaiian forest bird eggs and nestlings (Lindsey et al. 2009) and would presumably do the same for ʻalalā. Mongooses have always been thought to be weak climbers, and thus would pose little threat to nesting ʻalalā. However, they have been observed near the proposed release sites at the tops of the canopy and this risk could be evolving. They also pose a persistent threat when birds forage near the ground (reviewed in Lindsey et al. 2009; MFBRP pers. comms.). Mongooses killed two wild ʻalalā fledglings in previous studies (Giffin 1983, Temple and Jenkins 1981). Since juvenile ʻalalā spend considerable amounts of time on the ground immediately after fledging, mongoose predation is a significant risk to young birds and possibly to adult ʻalalā as they forage on the forest floor.

As proficient tree climbers and the most abundant rat species in most Hawaiian wet forests, black rat depredation of ʻalalā nests is a risk (Lindsey et al. 2009).

Fatal diseases spread by invasive small mammals present additional challenges to ʻalalā recovery. Feral cats likely pose the most significant threat to ʻalalā on islands lacking ʻio both for their documented depredation of Hawaiian avifauna, and as the definitive host for *Toxoplasmosis gondii* (Hutchison et al. 1971, Wallace 1969), a protozoan parasite that caused fatal infection in multiple ʻalalā during 1993-1999 releases (Work et al. 2000). Consumption or manipulation of cat feces is a presumed risk for transmission of *T. gondii* to ʻalalā. Rats and mongooses can be intermediate hosts and reservoirs of infection for *T. gondii* (Wallace 1973, Choudhary et al. 2013) so there is potential for wild ʻalalā to become infected if they consume infected rat or mongoose carcasses as well. Additional diseases caused by bacterium *Pasteurella multocida* (transmitted by cats) and *Erysipelothris rhusiopathiae* (found in rat carcasses) are also concerning, with *E. rhusiopathiae* implicated in the death of one ʻalalā during the 1990s releases (Lindsey et al. 2009). *Escherichia coli* was also implicated in the death of one ʻalalā in 2020 (SDZWA unpublished data), although results of the necropsy were inconclusive, and a source was not identified.

Rats and mongooses will likely be attracted to supplemental feeding stations either in supplemental feeders post release or within release aviaries. Trails created by field staff may positively influence cat travel patterns. We will mitigate risk from these introduced predators in the areas most heavily used by ʻalalā through lethal trapping. Lethal predator control will target rats, cats, and mongooses to support the ʻalalā release program. Like other components of the Maui ʻalalā conservation translocation, predator control will take an adaptive approach. The program as outlined here is likely to be modified as conditions or available resources change, we learn more about successful removal tactics, location and number of birds on the landscape varies, and other factors.

Goals of Predator Control

1. The goal of rodent control is to reduce possible interactions with adult birds while they are confined in release aviaries and while utilizing feeding stations, and to prevent loss of eggs during nesting, by reducing and eliminating rodents in the immediate vicinity of these areas.
2. The goal of mongoose and cat control is to remove cats and mongooses on a larger scale around the immediate release area in order to reduce the chances of depredation of ʻalalā and reduce pathogen pollution of release habitat with T. gondii oocysts.

Operational Constraints

Maui release sites (at least initially) will be located in areas away from roads, with limited trail infrastructure, steep terrain, and thick understory vegetation. These characteristics of the field sites will limit the ability of field staff to travel safely and efficiently over large areas. Field sites will be accessible primarily by helicopter. The ability to successfully deploy traps and monitor trap success will be constrained by both access and tradeoffs between staff time devoted to trapping versus other project needs such as direct care for and monitoring behavior and condition of released ʻalalā.

Methods

Approaches for removing or deterring rats, cats, and mongooses will vary somewhat by species, but the emphasis will be on lethal control.

Rodenticide is not being considered for this project for use for two reasons. First, diphacinone (the preferred rodenticide for use in Hawaiʻi) requires repeated consumption over 3-7 days to kill rats (Hess et al. 2009), so would not immediately remove the risk to ʻalalā in the targeted areas. Secondly, diphacinone poses a direct risk to ʻalalā survival. Diphacinone is lethal to ʻalalā in small doses if ingested directly (Eisemann and Swift 2006) and we consider the risk to ʻalalā too great to justify its use. Additionally, as ongoing use of anticoagulants can result in target species resistance (Buckle 2013), its use may compromise future control or eradication measures if our predator control efforts in ʻalalā release sites continue over the long-term. Duron et al. (2017) found no difference in total project costs between trapping and poisoning.

Since some individual rats avoid certain types of traps (MFBRP unpublished data), they will be targeted with a combination of lethal traps which may or may not include traps such as A24 (Figure 7), D-RAT supervisor Max, Victor rat traps, DOC200, and DOC250. All traps will be modified as needed so that ʻalalā are not captured or harmed by the devices. Excluders will be used with A24s, and all hinged (snap) traps will be covered to prevent ʻalalā access (Figures 7 and 8). All trapping methods employed for predator control will be assessed by SDZWA staff to determine risk level to ʻalalā. Traps will be camouflaged to reduce interest in traps from ‘alalā. Similarly to the type of trap, preference or avoidance of certain baits has also been observed (MFBRP unpublished data). Thus traps will be baited with a rotating array of baits such as chocolate Goodnature paste, sweet fruit paste, peanut butter, and others.

Figure 7. A24 trap.

Figure 8. Trap with excluder.

Cats and Mongooses

Cats and mongooses will be targeted with body grip traps such as Conibear (#160), Bridger, or Duke (Figure 9) as well as DOC250s. All traps will be fitted with a cover to exclude ‘alalā. Previous predator control on Hawai‘i Island overlapping the range of released ‘alalā from 2016-2020 demonstrated the effectiveness of ‘alalā-excluding devices placed on lethal traps (DOFAW unpublished data). To ensure bait preferences are accounted for, body grip baits will also be rotated with substances such as sardines, dry cat food mixed with oil such as fish and/or shellfish oil, or sponges with fish and shellfish oil paste.

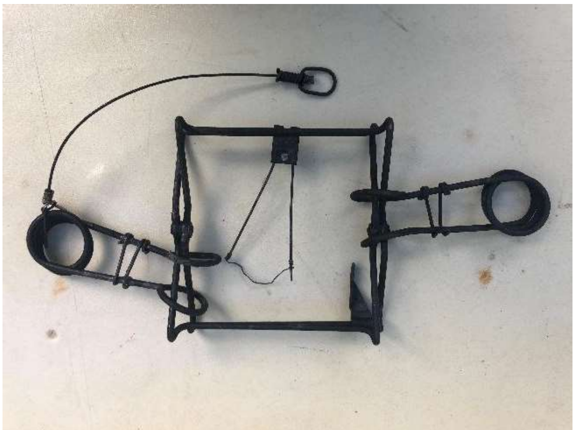

Figure 9. Body grip trap without ʻalalā excluder.

Advantages to using live traps could be to reduce lethal ʻalalā incidental capture or to collect specimens from freshly-killed animals for *Toxoplasmosis* tests. The only ʻalalā captured in predator control traps during the 2016-2020 efforts in Puʻu Makaʻala were in live traps set for cats and mongoose. We do not intend to test for *Toxoplasmosis* at Maui release sites because it is already documented to occur on Maui (Work et al. 2016) and transfer of fresh specimens to a lab within the required time frame would be prohibitively expensive given each specimen would need to be flown out via helicopter from the remote sites. Traveling a trap line large enough to be effective towards cats with large home ranges on a daily basis would not be realistic given the absence of roads or ATV trails and rough hiking terrain. Additionally, installing a large predator control grid of traps greatly increases the human disturbance, erosion, and trampling of native plants across the release area. Thus, live (leghold, cage) traps will not be used widely. Live traps may be considered directly around supplemental feeders, release aviaries, or other problem areas if lethal methods are considered ineffective and in cases where staff will be visiting a given site daily. Targeted hunting may be deployed if traps are deemed ineffective and permitted hunters are available.

Although there is a potential for ʻalalā to scavenge carcasses after removal from covered traps and a risk of disease transmission, the likelihood of ʻalalā locating carcasses in thick understory vegetation is low. Thus, to reduce negative impacts to native vegetation and spread of non-native invasive plant species, soil will not be disturbed for disposition of carcasses and they will not be buried. Carcasses removed from traps will be dispersed far enough from the traps so that ʻalalā do not associate traps with carrion. Carcasses will be thrown into areas of thick vegetation where they will not be visible to ʻalalā.

Access and Permits

All activities will be compliant with University of Hawaii Animal Care and Use Committee (IACUC) requirements. MFBRP is currently approved by UH IACUC for mammal control using all methods identified in this plan.

ʻAlalā releases will occur only on land managed by the State of Hawaii. DOFAW land managers from Maui Forestry, NEPM, and Wildlife divisions contributed to the development of this plan and all appropriate permits for conducting predator control on State-managed land will be attained. If dispersing ʻalalā nest on other ownerships, no predator control will occur on those lands unless permission is granted by the land owner or they agree to conduct predator control and monitoring on their own lands.

Temporal Extent
Predator control will begin prior to birds being placed in release aviaries so that birds will be released into an environment of reduced risks and so that a larger suite of methods can be deployed for the initial reduction efforts (control methods that pose a risk of incidental ʻalalā exposure may be utilized while birds are not present and removed prior to birdʻs transfer to the site). Predator control may continue at release sites and around nests, however, predator control post-release is to be determined and based on factors such as the risks to ʻalalā, if ʻalalā are still using the landscape, and if there are adequate financial resources. Traps will be checked and reset most intensely prior to ʻalalā release so that the density of predators will be reduced immediately prior to naive ʻalalā encountering a site for the first time. Traps at nests or feeding stations will be checked during each visit for monitoring or to replace food. Traps along trails and fencelines will be checked every 3-4 months or sooner if the trapping rate demonstrates that is necessary. As the goals are reduction and to have as many traps available at all times to capture predators, traps will also be opportunistically reset whenever they are observed to be set off during other work in the release area.

Traps may be deployed around nests on State-managed land as soon as nests are detected, as long as traps can be deployed without significant adverse disturbance to the adults. They will be maintained until either juveniles have fledged and left the area or adults have abandoned them due to nest failure. Traps will be placed no closer than 10 m from the nest tree to minimize disturbance to nesting birds. If placement of predator control causes significant changes in bird behavior, control devices will either be moved a further distance from the nest or removed completely. Carcasses will be removed from the area opportunistically to reduce the likelihood of ʻalalā locating carcasses to scavenge and to prevent attraction by other scavenging mammals during staff visits.

Spatial Extent
Rodent control will be in small targeted areas in the direct vicinity of release aviary, nests, and supplemental feeders. The goal for rodent control is not landscape scale.

Larger traps targeting cats and mongooses without excluders may be utilized only prior to release, during which they may be placed along existing trails and fencelines at a scale meaningful to ʻalalā estimated home range sizes (500 acres) dependent on the total number of birds released at a given site. Larger traps that are deemed safe for ʻalalā will continue to be run in the monitoring vicinity of released ʻalalā.

Predator control will be placed at nests only if it is not a significant disturbance to breeding pairs.

Monitoring Effectiveness
Methods for outcome monitoring, such as survival and cause of mortality for ʻalalā, are detailed in Chapter 3: Post-release Monitoring.

Triggers for Increasing or Decreasing Trapping Effort
Trap returns, proportion of total staff time spent on trapping compared to other needs, remote camera data, anecdotal observations, and ʻalalā space use and behavior will be reviewed at a minimum of 6-month intervals and the need to increase or decrease trapping effort will be assessed at that time. One cause for increasing trapping effort could be if ʻalalā begin dying from specific predators or diseases spread by a specific predator, confirmed from necropsy of carcasses or direct observation. Another cause for increasing trapping effort may be if camera traps or other signs indicate a high density of predators in a sensitive area as compared to the rest of the release site. Trapping effort may be reduced if birds disperse from an area, supplemental feeding terminates, or evidence suggests predator density is already low or not affected by our efforts. Ground trapping will be discontinued if considerable pig presence is observed, as traps elsewhere have been unable to withstand the curiosity of pigs (DOFAW unpublished data).

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Appendices

Appendix 1: Permits

Bird monitoring

All necessary federal and state permits will be obtained and/or renewed by project staff prior to the start of activities in east Maui. No landowner agreement is required for DOFAW activities since all release activities will be conducted on DOFAW-managed land. If monitoring or other project activities occur on other ownerships, a landowner agreement would be obtained and all conditions would be abided by. Due to the federal funding received by DOFAW for the project activities, all locations and methods will undergo a Section 7 compliance review and a joint USFWS-DLNR Environmental Assessment would be completed before implementation occurs.

The State of Hawaiʻi DOFAW holds a Bird Banding Laboratory permit (# 08487) that authorizes listed subpermittees to conduct the handling, recapture, banding and auxiliary marking work with ʻalalā in this project DOFAW's Threatened and Endangered Species Recovery Permit (#TE45531B-1) will be amended to authorize the release and monitoring of ʻalalā. SDZWA staff are covered under their Threatened and Endangered Species Recovery permit (#TE060179-6) and a State of Hawaiʻi Protected Wildlife Permit (#WL21-08) to hold, care for, and release ʻalalā.

Infrastructure

The area identified for the infrastructure will be chosen by the Maui Nui Planning Group and the land manager to ensure that no endangered plant species or other sensitive resources are affected by the placement of this structure.

Appendix 2: Table A1. *Example ethogram for antipredator training. All occurrences of these behaviors or contexts in which behavior occurs will be recorded during the 3-minute pre-trial, during the stimuli presentations, and during a 3-minute post-trial period.*

Behavior	Definition
Fear-related behavior	
Alarm call	Alarm vocalization, count each one given
Flight	Taking flight and moving away from stimulus
Mobbing	Aggressive approach towards the stimulus, accompanied by alarm calling

Vigilance	Visually monitoring the stimulus or sky and searching for threat
Non-fear related behavior	
Foraging	Consuming or touching any food with the beak
Begging	Wing fluttering while calling with an open beak
Approach	Moving towards the stimulus without aggression
Preening	Running the beak through the feather

Appendix 3: Table A2. *Social ethogram for behavioral observations.*

BEHAVIOR	DEFINITION
Contact sitting	2 birds sit while touching (< 5 cm apart); birds may twine necks around each other; score for both birds, non-directional
Allopreening/ Preen	One bird preens, nibbles, or rubs another with head, beak, or neck
Threaten	Threatening behavior that does not involve physical contact toward another bird; includes raising scapular feathers, head down threat, head up threat, lunges, attempts at biting, pecking, or striking with wing, foot, etc., flight buzz, successful and unsuccessful attempts to steal an object or food item (without contact being made)
Chasing	A prolonged, continuous approach by one bird towards another while the other continuously moves away
Contact aggression	One bird aggresses another and actual physical contact is made; examples include biting, pecking, striking, or landing on another bird, or feather plucking, moving another bird's head away with the aggressor's own head/beak, successful and unsuccessful attempts to steal an object or food item (with contact being made)
Displacement	One bird approaches another bird, and the other bird moves away

Steal	One bird forcefully takes food or object from another bird
Beg	Bird pumps head up and down while holding wings out and pumping them up and down
Co-feeding	Two individuals foraging while in close enough proximity that one could aggress the other

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