NIHOA MILLERBIRD (*Acrocephalus familiaris kingi*)

TRANSLOCATION PROTOCOLS

FINAL

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1. EXECUTIVE SUMMARY

The Nihoa Millerbird (*Acrocephalus familiaris kingi*) is a critically endangered passerine found only on the small island of Nihoa in the Northwestern Hawaiian Islands. This species is at a high risk of extinction from biological and catastrophic factors. Translocation of this species to another of the Northwestern Hawaiian Islands has been recommended for over 30 years to reduce the risks of extinction. Laysan Island was selected as the most suitable release site because Millerbirds were present on this island until extirpated by 1923. The island has been undergoing restoration, and assessment of the current vegetation and associated arthropod fauna determined the habitat is sufficient to support Millerbirds. Laysan also has no mammalian predators, mosquitoes, avian malaria or pox, but does have the infrastructure to support a release.

The plan is to conduct the first translocation of Nihoa Millerbirds to Laysan in September 2011. The complete timeline for this project is presented in Appendix I. The first translocation cohort will be 24 birds, and subsequent releases will be conducted to achieve a founding population of 50 Millerbirds on Laysan. This plan outlines the relevant natural history of the birds and islands, our proposed translocation and post-release monitoring methods, and benchmarks for evaluating success and determining the need and timing for subsequent translocations. The final report in December 2012 will evaluate the effectiveness of our methods, and will provide a preliminary assessment of the success of the translocation and the need, timing, and procedures for additional translocations. Our evaluation will be based upon: 1) survival of birds for one year post-release, 2) successful reproduction in the first year, and 3) implications of habitat use, territoriality, and movement patterns for the long-term persistence of Millerbirds on Laysan. This evaluation is a necessary preliminary benchmark, but determining the longer term success and creation of a self-sustaining Millerbird population will require monitoring for at least 5 years.

2. BACKGROUND

Located at the northern edge of the tropical Pacific, 4,000 km from the nearest continent and 3,000 km from the nearest high volcanic islands, the Hawaiian Islands are the most isolated archipelago on Earth. This volcanic island chain includes eight large, high islands in the southeast (the Main Hawaiian Islands) and a string of increasingly older islands extending northwest, including several volcanic fragments, coralline islands, and true atolls (the Northwestern Hawaiian Islands, hereafter NWHI, Figure 1; Carson and Clague 1995).

2.1 MANAGEMENT STATUS

Nihoa (23°03′ N, 161°55′ W) and Laysan (25°46′ N, 171°44′ W) islands lie in the NWHI and are part of the Papahānaumokuākea Marine National Monument (PMNM) established in 2006. PMNM is jointly administered by the Secretary of Commerce through the National Oceanic and Atmospheric Association (NOAA), the Secretary of Interior through the U.S. Fish and Wildlife Service (USFWS), and the State of Hawaiʻi. Both islands are only accessible by sea, and access to the islands is strictly controlled by the Monument's permitting process.

2.2 STUDY SITES

Nihoa is a 63 ha remnant of a volcanic cone, with steep cliffs that rise 277 m above sea level (asl) and well-developed interior valleys. Nihoa is arguably the most pristine island in the entire archipelago. The vegetation consists principally of low shrubs such as ʻāweoweo (*Chenopodium oahuense*), pōpolo (*Solanum nelsonii*), and ʻilima (*Sida fallax*), and bunch grass (kāwelu;

Eragrostis variabilis), with stands of native fan-palms (*Pritchardia remota*) in two of the valleys (Conant 1983, 1985). The vegetation of the island is subject to seasonal changes from amount and distribution of rainfall, which probably affects Millerbird reproduction and survivorship (Conant 1983, 1985).

In contrast, Laysan Island is a relatively flat (maximum elevation is 15 m asl) 414 ha sand island, with a ring of vegetation encircling a large, shallow, hypersaline lake in the island's interior. In the late 19th and early 20th centuries, Laysan's native habitats were profoundly altered as a result of a guano mining operation and an attempt to farm rabbits. This resulted in the devegetation of Laysan and the extinction of several endemic birds, including the Laysan Millerbird in 1923, and possibly as early as 1916 (Ely and Clapp 1973, Sincock and Kridler 1977).

In the 20th century, several invasive alien plants became established on Laysan (notably *Cenchrus echinatus* and *Pluchea indica*), leading to intensive restoration work that began in the early 1990s. The distribution of the plant communities today is similar to the vegetation documented in the 1890s, but the species composition is different (Morin et al. 1997).

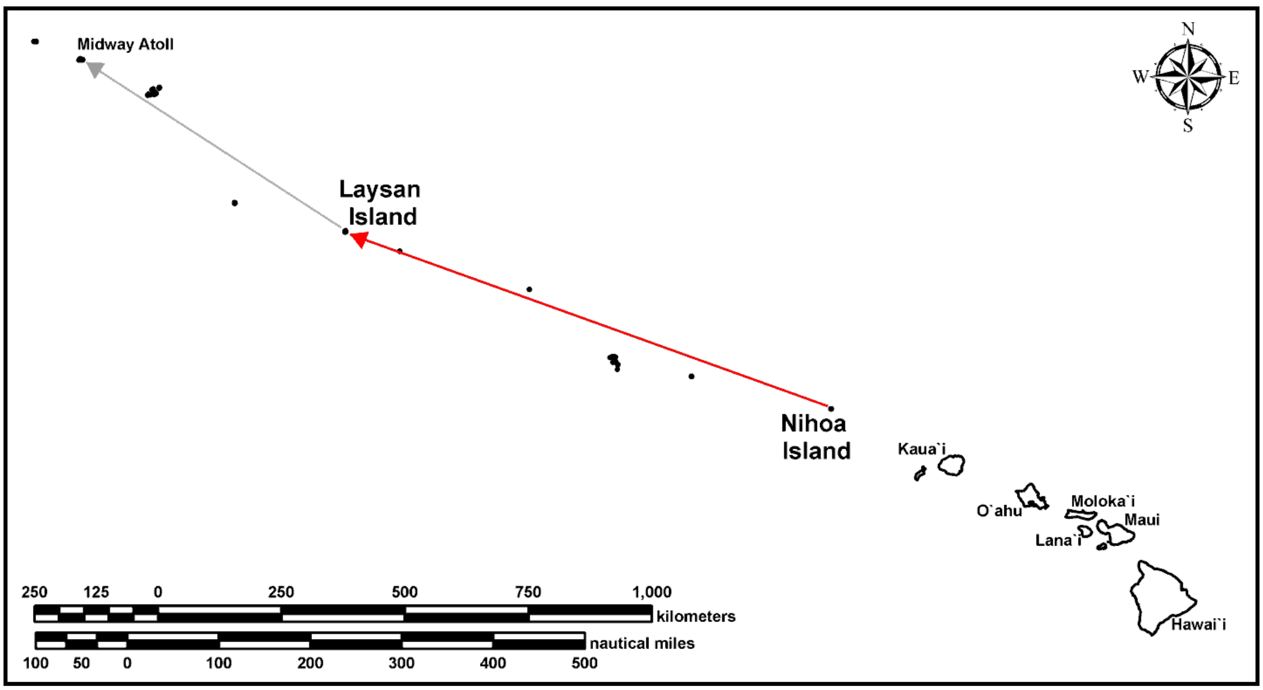

Figure 1. Hawaiian archipelago. Nihoa Millerbirds will be translocated 1,047 km from Nihoa to Laysan (red line). The translocations of Laysan Ducks (*Anas laysanensis*) from Laysan to Midway in 2004 and 2005 (622 km; see below) are shown in gray.

2.3 Avian Extinctions in Hawai'i

Hawaiian birds have suffered terrible losses since the arrival of humans approximately 1,200 years ago. At least 50 species of birds became extinct between the arrival of the Polynesians and the Europeans, and another 26 species have been extirpated since the Europeans arrived in 1778 (Olson and James 1982, Pratt 2009). Many of the remaining species persist only on a small subset of the islands they once inhabited or otherwise have dramatically reduced distributions. The evolution of the Hawaiian flora and fauna in isolation for approximately 6.4 million years left them extremely vulnerable to nonnative predators, diseases, parasites, and habitat disturbance (Fleischer and McIntosh 2001, Pratt 2009). Habitat loss and the impacts of introduced species have been the primary causes of extinctions in Hawai‘i. Humans introduced new plants and animal species such as rats, pigs, mongooses, and mosquitoes which took a heavy toll on native birds and vegetation. The introduction of new diseases such as avian malaria and avian pox to which native birds have little resistance has been devastating (Atkinson and LaPointe 2009).

As observed on islands throughout the world, the NWHI have been negatively affected by the presence of humans and the introduction of non-native species particularly. Laysan was degraded by guano collectors and feather hunters (Ely and Clapp 1973). These impacts, combined with the devegetation caused by introduced rabbits, resulted in the extinction of the Laysan Rail (*Porzanula palmeri*), Laysan Honeycreeper (*Himatione sanguinea freethii*), and Laysan Millerbird (*Acrocephalus familiaris familiaris*) (Sincock and Kridler 1977). Only four endemic bird species remain in the NWHI, all of which are endangered: Laysan Finch (*Telespiza cantans*), Laysan Duck (*Anas laysanensis*), Nihoa Finch (*Telespiza ultima*), and Nihoa Millerbird.

2.4 Ecology of the Nihoa Millerbird

The Millerbird (Passeriformes: Sylviidae) of the NWHI is the only known Old World warbler to colonize the Hawaiian Archipelago (Morin et al. 1997). The Millerbird consisted of two island-specific subspecies, one from Laysan Island (*A. f. familiaris*) and one from Nihoa (*A. f. kingi*) (Fleischer et al. 2007). The Millerbird is listed as endangered by the State of Hawai‘i and United States, and is considered critically endangered by the International Union for Conservation of Nature (IUCN), due to its very small range and significant fluctuation in population size (USFWS 1967, Mitchell et al. 2005, Birdlife International 2009).

The Nihoa Millerbird is a generalist insectivore, which gleans both native and non-native insects from shrubs and other plants. It also forages in leaf litter, on the soil surface, and has been observed eating insects from bird carcasses (Morin et al. 1997). Morin et al. (1997) found that Millerbird fecal samples contained arthropods from families in eight orders: Coleoptera, Hymenoptera, Orthoptera, Araneae, Diptera, Hemiptera, Pseudoscorpionida, and Hempitera. Captive feeding trials and associated husbandry conducted on Nihoa in 2009 and 2010 (Appendices II, III, IV) indicate that Millerbird will consume any suitably sized arthropods (<4 cm length), including flies, moths, beetles, and cockroaches.

Morin et al. (1997) found Millerbird territories centered on dense, low-lying cover near the ground, especially *C. oahuense* and *Sida falax* (Morin et al. 1997). However, *C. oahuense* used to be the most abundant plant on Nihoa (Conant 1983, 1985), but more recent work has found this species to be rare or absent from much of the island, and it is now found primarily on ridges and cliffs (Kohley et al. 2009, Kohley et al. 2010, MacDonald 2011, Rowland et al. 2007). It was not listed as one of the four most common plant on Nihoa by Kropidlowski et al. (2008), and MacDonald (2011) found it mostly localized in the northwestern corner of the island (Miller's Plateau). MacDonald (2008, 2011) found that most Millerbird territories were composed of *Sida* *fallax* and *Solanum nelsonii*. Both MacDonald (2008, 2011) and Morin et al. (1997) found that pairs of birds hold and defend territories, with sizes ranging from 0.19–0.40 ha, and show a high degree of year-to-year territory fidelity (Morin et al. 1997).

The Millerbird breeding season can extend from January through September; occurrence and timing of breeding are likely dependent on rainfall (Morin et al. 1977). In some years breeding was not detected during the summer and fall, and based upon molt and remnant nests, the peak was likely during the winter months (MacDonald 2008, *pers. comm.*). Nests are built in the available dense shrubs, such as *Solanum nelsonii, Sida falax,* and *C. oahuense*, but the birds do not seem to show a preference for a particular species (Morin et al. 1977). Clutch size is usually two eggs and both sexes incubate, brood chicks, and provision nestlings and juveniles. Hatching success, fledgling success, and survival to reproductive age are unknown (Morin et al. 1997).

2.4.1 Population Monitoring and Fluctuations

When the Nihoa Millerbird was first discovered in 1923, the population was estimated to number about 100 birds (Wetmore 1924). The USFWS Wildlife Refuges has opportunistically monitored Millerbirds (as well as Nihoa Finches) over the past several decades. They have used a series of transects, and extrapolated the density estimate to estimate the population of the entire island (see Conant et al. 1981, Kropidlowski et al. 2008 for a description of methods). Between 1967 and 2010, population estimates from these surveys have fluctuated widely, from as few as 31 birds to as many as 814, with an associated high level of variability (Figure 2; Morin et al. 1997, Kohley et al. 2010). Trips to the island have not taken place every year, and access to the island is limited by weather and seas to a window between roughly March and September. Irregular visits, combined with the difficulty and danger of landing on Nihoa have resulted in numerous gaps in the time-series of survey data. The impact of seasonal and other environmental variables on the Millerbird population has not been a focus of study. In addition, the methods used to date have yielded coarse-scale data that do not permit accurate estimation of population size or trend (see Figure 2). Even with the uncertainties in this data, it is clear that overall species abundance is very low (<1200), and has been so for a long period of time; and secondly that the abundance fluctuates dramatically through time. Both of these factors make Millerbirds highly susceptible to extinction (see below). USGS-BRD and USFWS are currently researching ways to improve the survey methods, minimize sampling error, and reduce variability in population estimates.

Genetic variation in the Millerbird is extremely low (Fleischer et al. 2007, Addison and Diamond 2011). Addison and Diamond (2011) determined that the Millerbird is among the most genetically depauperate avian species, and has lost alleles over the last 15 years. The low genetic variation is not surprising given the founder effect inherent in the original colonization, the small population that has persisted for many years, and the genetic bottlenecks experienced through time due to the population fluctuations (Figure 2; Nei et al. 1975). Conant and Morin (2001) used population viability analysis to show that the probability of extinction for this species is very high; but they viewed it as unlikely that its carrying capacity on Nihoa could be increased through management actions. The most effective way to increase the population size and decrease the risk of extinction is establishing additional populations.

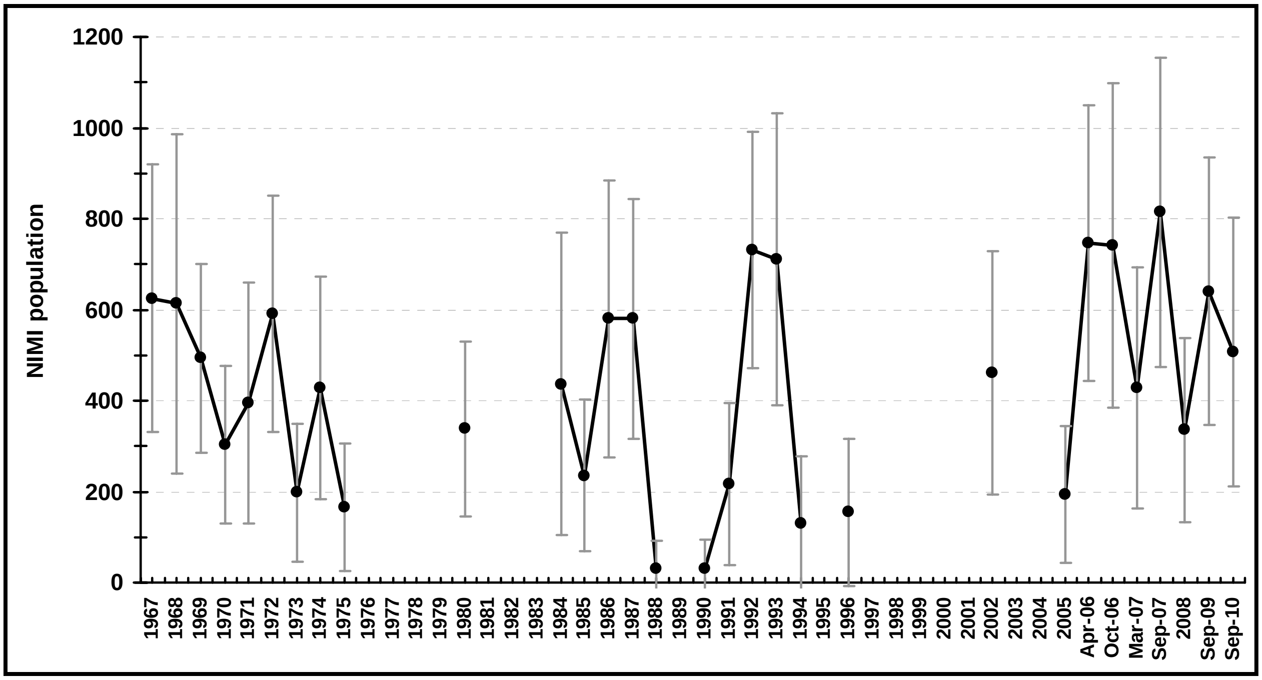

Figure 2. Population estimates of Nihoa Millerbirds (95% confidence intervals) from 1967 to 2010.

2.4.2 Threats to the Population

The Northwestern Hawaiian Island Passerine Recovery Plan describes the risks to the Nihoa Millerbird from accidental introduction of alien plants and animals and environmental catastrophes, e.g., hurricanes, severe drought, or fire (USFWS 1984). Alien species such as rats or mosquitoes could be accidentally introduced by ships or shipwrecks, such as occurred on Laysan in 1969, and cause extinction or extirpation of Nihoa's birds. An example of such an alien species that has had profound effects on Nihoa is the non-native, gray bird grasshopper (*Schistocerca nitens*) which was first detected on the island in 1977 (Beardsley 1980). Expeditions in 2002 and 2004 (Wegmann et al. 2002, Culliney 2004; *cited in* Latchininsky 2008) both estimated that 90% of the island's vegetation was denuded, which likely would have negatively impacted the availability of arthropod food resources for Millerbirds.

Translocation of Millerbirds to Laysan is a necessary initial action to reduce the threat of extinction, but is insufficient by itself to ensure the species' long-term persistence. Laysan, and the other NWHI, will be vulnerable to an increased frequency and severity of catastrophic weather events associated with global climate change (Mimura et al. 2007), supporting the need to create an insurance population of Millerbirds on a second island. Climate change will also cause a rise in sea level, increased shoreline erosion, and storm surges (IPCC 2007, Mimura et al. 2007).

The variability and complicated interactions in climate change models lead to great uncertainty in projected effects at a local scale. Baker et al.'s (2006) preliminary projections suggested Lisianski could lose up to 5% of its area by 2100 depending on the amount of sea level rise, and they believed Laysan would show a comparable loss of area. Although the exact measurements are imprecise, Laysan is higher (15 m) and larger (414 ha) than Lisianski (12.1 m and 162 ha respectively; PMNM 2008), so the loss of area at Laysan might be less. The maximum sea level rise Baker et al. (2006) considered was 0.88 m, which exceeds the bounds of the Intergovernmental Panel on Climate Change's more recent estimates (IPCC 2007, Mimura et al. 2007), but other research suggests that sea level could rise more than 2 m (Pfeffer et al. 2008). All these projections were limited to passive, "bathtub" models of sea level rise, but including active processes such as erosion, channelization, and run-up could lead to very different conclusions and effects. Laysan's coastline could be reduced, the interior inundated and the lagoon shore expanded, leading to greatly increased stress on the island's plants and animals, including the translocated Millerbird population. Additionally, Webb and Kench (2010) showed that although all the southern Pacific islands they studied experienced gross morphological changes during the recent (19–61 years before present) rise in sea level, the net area for the majority of the islands was stable (43% of islands examined) or increased (43%). Thus, there is not a direct, linear relationship between changes in island area and sea level change, and projecting the impacts are further complicated because Rooney et al. (2008) have found that the rate of sea level rise in the NWHI has been increasing over the last few decades. However, Grossman and Fletcher (1998) found that sea level was 2 m higher in the main Hawaiian Islands approximately 3,500 years ago, and the Laysan avifauna was able to survive this previous reduction in island size.

Exactly how this combination of climate change factors and interactions will affect Laysan, and its communities is unclear. Thus, creating a second population of Millerbirds on Laysan is a short-term solution in the longer-term recovery strategy for this species, and multiple translocations to other, higher islands will be necessary (Morin and Conant 2007). The high island sites recommended as long-term objectives in Morin and Conant (2007) were Kaho‘olawe, Lehua, Lāna‘i, and Ni‘ihau. At present none of these (or any other high island in Hawai‘i) are suitable due to the combination of mosquitoes and avian disease, exotic mammalian predators, and socio-political considerations. Numerous, additional actions are urgently needed to address these concerns, but designing the long-term protection and recovery strategy for Millerbirds is beyond the scope of these protocols.

2.5 Goals of Translocation

The establishment of a self-sustaining population of Millerbirds on Laysan will achieve three important objectives: (1) increase the abundance and distribution of Millerbirds and thus reduce the threat of extinction (Sincock 1979, USFWS 1984, Morin et al. 1997); (2) implementing translocation is explicitly stated within PMNM's Management Plan (Activity TES-6.2; 2008) as an action necessary to safeguard and recover the Monument's endangered animals; and (3) restore or recreate functionality within the native ecosystem of Laysan (Morin and Conant 1998, PMNM 2008).

Bryan (1912) was the first to recommend translocation of endemic NWHI birds when, after observing the devastation of Laysan by the plume hunters, rabbits and guinea pigs, he predicted the extinction of the island's unique avifauna if action was not taken. The suggestion to return Millerbirds to Laysan has been recommended repeatedly (Sincock and Kridler 1977, Sincock 1979, Morin et al. 1997, Conant and Morin 2001, PMNM 2008), including in the USFWS Northwestern Hawaiian Islands Passerine Recovery Plan (USFWS 1984), and the Laysan

Restoration Plan (Morin and Conant 1998). Extinction should not prevent restoration when replacement with a closely related species or subspecies is possible (Atkinson 1988, Seddon and Soorae 1999, Parker et al. 2010). Replacement of lost species can fulfill the goals of establishing an additional population of a threatened species, restoring some of the trophic process formerly present, and restoring lost evolutionary potential. The PMNM Management Plan considers the translocation of Nihoa Millerbirds an important restoration activity (TES-6.2; PMNM 2008). Accomplishing these goals requires the establishment of a self-sustaining population of Millerbirds on Laysan.

2.6 Site Selection

Morin and Conant (2007) led a site-ranking exercise in which 18 experts evaluated potential translocation sites for Millerbirds in the NWHI. The assessment identified Laysan as the first choice overall for Millerbirds, because it previously supported an ecologically equivalent subspecies and had no additional risk factors. The consensus was the species would not have a negative influence on the current ecosystem because Laysan once supported Millerbirds (Morin and Conant 1998). This recommendation was accepted by PMNM, and their management plan states that Laysan is the top choice for the initial translocation of Millerbirds (pp. 35–36, PMNM 2008). Other advantages of Laysan include the absence of avian diseases (e.g., pox, malaria), mammalian predators, and introduced avian species, as well as vegetation structure and composition suitable for Millerbirds.

The IUCN (1998) recommends that before a translocation is initiated, the cause of the population reduction or extirpation be identified and eliminated, and if the release site has suffered substantial degradation caused by human activity, a habitat restoration program should be initiated before any release occurs. Rabbits were eliminated, and after two decades of active restoration, Laysan's plant communities have recovered significantly from the devastation in the early part of 20th century (Lamoureux 1963, Ely and Clapp 1973, Morin et al. 1997, Morin and Conant 2007). Although restoration is an ongoing process, with native species being outplanted and non-natives controlled (Morin and Conant 1998, PMNM 2008), there are currently large habitat patches that will likely provide sufficient nesting and feeding resources for an insectivorous passerine.

The restored plant communities on Laysan are similar to the original 1890's distribution, but the species composition is different (Morin and Conant 1997). It is unknown what arthropod species were lost when the island was devegetated, and how the current fauna compares with the historical one (which supported Millerbirds and other Laysan avifauna), but the majority of recorded arthropod species are non-native (Morin and Conant 1998). MacDonald (2011) found that overall, Laysan's arthropod community has approximately the same number of individuals, but lower species richness and fewer grams of arthropods per unit area than Nihoa; however, due to its much larger size Laysan should provide sufficient food resources for released Millerbirds. At a finer scale, the densities of arthropods per unit area in Laysan's primary habitat types are within the range found at areas used by Millerbirds on Nihoa. MacDonald surveyed both islands in July–September 2007, so could not detect any seasonal trends. Reynolds' (2002) study did detect strong seasonal patterns in the monthly abundance of arthropods on the vegetation and in the soil on Laysan, but Millerbirds have survived presumably similar seasonal changes on Nihoa.

Historically, Laysan Millerbirds utilized most of the vegetated area on Laysan, including grassland, shrubs, and the wetlands around the hypersaline lake (Fisher 1903, Munro 1945). Three notable differences between vegetation on Laysan and Nihoa are the absence of *Sesbania tomentosa*, the near-absence of *Sida fallax*, and the limited distribution of *C. oahuense* on Laysan. The first two are common on Nihoa, while the latter has become uncommon in recent decades (see above). *C. oahuense* is being outplanted on Laysan, and efforts are underway to propagate *Sida fallax* there as well. *Sesbania tomentosa* has not been recorded from Laysan, and at this time is not being outplanted on the island. Another significant difference between Laysan and Nihoa is the large patches of naupaka (*Scaevola taccada*) on Laysan, a species which is not present on Nihoa. The structure and growth form of naupaka appear similar to what Millerbirds use on Nihoa, so we believe that there are large areas of Laysan's vegetation that will provide habitat for Millerbirds. In support of this, *A. sechellensis* used all available habitat roughly in proportion to its abundance in the Seychelles, including *Scaevola taccada*, where it is a dense shrub or tree up to 2.5 m; Diamond *unpubl. data*). The restoration efforts by PMNM will continue to improve the island's habitat for Millerbirds through providing additional species and structural diversity. Armstrong and McLean (1995) present examples of many differences in habitat preferences versus requirements, the potential for current distribution of endangered species to be misleading about habitat uses, and species behavioral flexibility. These reasons, combined with the conspecific's prior presence, suggest that the Nihoa Millerbird will be able to successfully utilize the available habitats on Laysan.

3. TRANSLOCATION

The IUCN defines translocation as "the movement of living organisms from one area with free release in another", with the Millerbird actions being further classified as a reintroduction, or "the intentional movement of an organism into a part of its native range from which it has disappeared or become extirpated in historic times as a result of human activities or natural catastrophe" (IUCN 1987). Many interconnected factors make translocating Millerbirds to Laysan unique, and result in a complex mix of biological, logistical, and fiscal challenges:

1. The small source population magnifies the importance of every individual.
2. To protect the PMNM, all translocation activities must minimize the disturbance to native species, including the large numbers of breeding seabirds, and follow the PMNM Quarantine Protocol to prevent introduction of alien species to the islands (Appendix V).
3. Holding small, energetic insectivorous birds in captivity is difficult, as is transitioning them to novel, non-live food (Appendices II, III, IV).
4. The distance between Nihoa and Laysan, approximately 1,047 kilometers, will require many days of captivity and care on a ship.
5. The difficulty and danger of landing at Nihoa and Laysan during rough seas or inclement weather limits the time frame for moving birds to the period between June and September. However, the calmer seas during this period should minimize the disturbance to the Millerbirds during the journey to Laysan. This time frame is further narrowed by the constraints of the Millerbird breeding season (see below).

6. Because of the remote location of the NWHI, vessel charters and other logistics are expensive, ships need to meet several different inspection protocols, materials are required to meet separate quarantine requirements for each island, and individual trips must be well planned and adequately funded to maximize the chance of success.

The potential impacts of translocation activities to endangered and other native species and to habitats on Laysan and Nihoa, and of establishing Millerbirds on Laysan, will be evaluated through compliance with Federal laws and regulations (e.g., NEPA, ESA, NHPA). Every effort will be exercised to avoid and minimize impacts to these other species during the monitoring of the Millerbirds.

Translocation has been used as a conservation strategy across the world to prevent extinction by providing insurance populations and increasing overall population size for species with restricted distributions and low abundances (Franklin and Steadman 1991, Witteman et al. 1991). Translocations have been used as a conservation tool in the NWHI and have been a successful conservation strategy for the congeneric Seychelles Warbler (*Acrocephalus sechellensis*, Komdeur 1994a; Reynolds et al. 2008). The latest successful translocation in the NWHI was moving the Laysan Duck to Midway in 2004 and 2005 to establish a second, population (Figure 1; Reynolds et al. 2008). Midway presented the Laysan Duck with novel habitat and food resources. Post-translocation monitoring found that the ducks reproduced more quickly on Midway than on Laysan, suggesting that low reproductive rates on Laysan may have been a result of food limitation, some other component of habitat quality, or possibly density dependent effects. The translocated individuals also used a wide variety of vegetation types, absent on Laysan, for nesting and foraging (Reynolds et al. 2008). The Laysan Duck is very different from the Millerbird, but the success of this translocation demonstrates that habitat use and other ecological and life history traits may be more plastic than observed on the island of origin.

The only *Acrocephalus* to be translocated is the Seychelles Warbler (*A. sechellensis*), whose global population was once reduced to less than 30 individuals on Cousin Island in the Seychelles. The first translocation occurred in 1988, when 29 individuals, from a source population of approximately 320 birds, were moved from Cousin to Aride Island with a 45 min boat trip (Komdeur 1994a). A second translocation in 1990 moved 29 birds to Cousine Island with a 15 min boat trip. In both translocations, experienced breeding pairs were captured and held separately in cardboard transfer cages with an average time in captivity of just over 3 hours. All birds survived the translocation and started feeding and drinking immediately after release. Successful nesting occurred a few weeks later. A 2004 translocation of *A. sechellensis* from Cousin to Denis Island held and transported (by helicopter) birds for an unstated time, but at least some were held overnight (Richardson et al. 2006). All 58 warblers survived and there were no complications mentioned. Nest building began within 3 days after release. The global population had grown to approximately 2,100 birds across the four islands as of 2002, and Komdeur and Richardson believed that the birds saturated the available habitat and reached their carrying capacity (Komdeur 2003, Richardson et al. 2006). The successful translocations of a congener is encouraging, but Nihoa Millerbird translocation will involve additional logistical hurdles, including a much longer holding time (≤9 days).

3.1 TIMING OF TRANSLOCATION

The schedule and timing for the various stages of this project are shown in Appendix I. All steps and actions have been closely coordinated with USFWS Wildlife Refuges' staff. Vessel charters must be organized months in advance to ensure that trips take place during the season that offers the best chance of success. Nihoa is a steep, rocky island that requires a challenging landing, and July–September offer the best opportunity to get safely ashore. Millerbirds may nest in any month from January–September, with the normal peak breeding activity between March and June (Morin et al. 1997), but in some years there is no peak or else it occurs in the winter months (MacDonald 2008, *pers. comm.*). Conducting the translocation in September will minimize the chances of removing Millerbirds with dependent young. No brood patches and only one cloacal protuberance have been detected in recent banding during September (USFWS *unpubl. data*) . During September seabird breeding activity is nearing its annual low, and translocation-related disturbance of seabirds with eggs or nestlings on both islands will be minimized. The 2011 translocation will occur in September, but future translocations and expeditions will examine the feasibility of an August trip to further minimize the dangers from high seas and rough weather.

Logistical and financial constraints prevented a thorough survey of Nihoa before initiation of translocation. An aerial survey was conducted on 7 July 2011, and the island appeared green and lush, suggesting that the rainfall had been sufficient for vegetation development, and presumably for arthropod production and Millerbird breeding. Although difficult to correlate aerial and ground viewpoints, D. Tsukayama believed the island was greener and more heavily vegetated in 2011 than when he was on the island in July 2007 (MacDonald 2008).

3.2 CAPTURE

3.2.1 Numerical Targets

Our goal is to establish a self-sustaining population of Millerbirds on Laysan. Twenty-four birds will be moved in the first translocation and at least one subsequent translocation is planned to achieve the target of 50 Millerbird founders released on Laysan. Millerbirds are highly territorial and sedentary, so 50 founders should provide a sufficient selection of mates for successful breeding. These numbers are a compromise among several factors: maximizing their long-term persistence on Laysan, minimizing the impact to the source population on Nihoa, maximizing the amount of the Millerbirds' limited genetic diversity translocated to Laysan, maximizing the chances of reproduction on Laysan, and operating within the project's resource and logistical constraints. If our post-release monitoring results show that birds are surviving, but not breeding, this would indicate that additional founders are needed. Conversely, if the initial release cohort successfully breeds in the first winter, then the need for subsequent translocations will be reconsidered (see below, and Section 4.1 Additional Translocations).

Comparison of translocation successes and failures reveals a strong positive relationship between the total number of animals released at a new site and the likelihood of translocation success. Conversely, small founding populations were highly sensitive to stochastic demographic and environmental events and were unlikely to persist (Griffith et al. 1989, Wolf et al. 1998, Fischer and Lindenmayer 2000). However, these results are not uniform, and a survey of 31 translocations using small numbers of saddlebacks (*Philesturnus carunculatus*) and New Zealand robins (*Petroica australis*) found most of the releases succeeded, and that there was no relationship with the number of birds released (Taylor et al. 2005). Similarly, Armstrong and

Ewen (2001) used population viability analysis to determine that a second translocation, which had already occurred, has been unnecessary and these resources might have been more productively used to research the source population. Therefore, although we are proceeding on the assumption that two translocations will be necessary, we will assess the need and timing for subsequent translocations based upon the initial results (see below).

The impact to the Nihoa Millerbird source population will be minimized by conducting the translocations over a period of at least two years. The 2010 population estimate was 507 Millerbirds, so removing 24 birds (4.7% of the population) should have minimal, acceptable impacts to the source population. The three translocations of *A. sechellensis* moved from 8–17% of the source population, which quickly recovered each time (Komdeur 1994a, Richardson et al. 2006). Added benefits of multiple translocations include the opportunity to adapt and improve our translocation methods and to adjust the sex ratio of subsequent cohorts to address any bias arising from mortalities (e.g., Armstrong and Ewen 2001). Adequate founders at the outset and rapid population growth together minimize the loss of genetic diversity and the risk of inbreeding depression. Multiple translocations of genetically depauperate species, such as Nihoa Millerbirds, can aid in establishing new populations by capturing the full range of the limited genetic variation (Addison and Diamond 2011, Jamieson 2011). Taylor and Jamieson's (2008) simulations of saddlebacks showed that loss of genetic variation was related to the carrying capacity of the new island, and not to the size of the founder population, suggesting that the newly created Millerbird population on Laysan (vegetated area is over three times larger than Nihoa) might not have an inbreeding problem. Although focused on sequential translocations, Taylor and Jamieson's (2008) results parallel the repeated bottlenecks Millerbirds have experienced, and they found that "genetically depauperate threatened species may be less sensitive to further losses of genetic variation during translocation/bottlenecks events than more genetically diverse species".

Based on captive feeding trials conducted on Nihoa (Appendices III, IV), we believe 24 birds are the maximum that can be cared for safely through all the steps of the translocation. Monitoring and management of small, active insectivorous birds in captivity is labor-intensive, and Millerbirds may be caged for as long as 9 days between capture on Nihoa and release on Laysan. After the first translocation, we will evaluate our avicultural capabilities and adjust the cohort size of subsequent translocations accordingly.

3.2.2 Age and Sex Targets

We plan to move an even sex ratio (12 females, 12 males) of those birds that have best acclimated to captivity. Birds that have brood patches, cloacal protuberances, dependent juveniles, or other indications of breeding will not be brought into captivity. We will use two methods to sex the birds, a discriminant function analysis (DFA) using wing and tail measurements (MacDonald et al. 2010) and a portable polymerase chain reaction (PCR) lab on the ship that can process samples overnight. The DFA will allow us to sex birds immediately upon capture and adjust our capture effort to obtain an even sex ratio. The DFA is 87.7% accurate, however 20% of the Millerbirds captured in 2010 had abraded tail feathers or were molting, so the technique cannot be successfully sex all birds. The results from PCR are more reliable, but will take longer to process and be more logistically challenging. Employing both methods will ensure we can determine the gender of all captured birds and chose the correct sex ratio for the translocation cohort. The feather samples from the founder population will be archived for later analysis, when resources permit. If we do not have an even sex ratio available for translocation, we will still move a full cohort of 24 birds. These birds will be selected based upon their condition and adjustment to captivity.

The effect of age on the success of translocations depends on the species and system. Most projects have moved adults (Komdeur 1994a, Armstrong 1995, Groombridge et al. 2004, Richardson et al. 2006), but a mixture of age classes (Armstrong and Craig 1995, Work et al. 1999, Banko et al. 2009) or juveniles/sub-adults have also been translocated (Reynolds et al. 2008). Morin and Conant (2007) recommended taking thermoregulating nestlings or fledglings to minimize the impact to the breeding population on Nihoa, but safely caring for these individuals during the translocation is infeasible, finding nests and collecting a sufficient number of birds would require the translocation team to be on Nihoa longer than permitted by PMNM, , and once released on Laysan these birds would have no normal, wild birds to serve as social tutors. Juvenile birds are potentially more plastic in their behavior and might more easily adjust to their new environment (Armstrong and McLean 1995). Adult birds have a proven ability to survive environmental and food stress relative to untested juvenile, fledgling, or nestling birds. Adults also have more social experience, and are more likely to have bred than juvenile birds. Adult birds singing and attempting to breed on Laysan could also facilitate breeding by younger, inexperienced birds. Paired, territorial birds are easier to catch using playback methods, and because of their familiarity might breed more quickly upon release (e.g., Komdeur 1994a). Armstrong and McLean (1995) provided many examples from New Zealand where there was little value in translocating pairs, so we will not limit the cohort to only including intact pairs of adult birds. All these factors favor moving at least some adult birds to maximize the likelihood of Millerbirds breeding on Laysan.

The first translocation will take Millerbirds of mixed ages, or at least mixed breeding experience. We will capture territorial pairs, presumably older birds, and also attempt to capture non-territorial birds, which may be younger or juvenile birds. In some years, the habitat on Nihoa seems to be saturated, and when Millerbirds were captured in 2009, presumptive floaters quickly filled territories made available during the captive-feeding trials (USFWS *unpubl. data*). This suggests that removing adult, territorial birds would not have a significant impact on the source population in some years. Non-territorial birds are also much more difficult to capture (USFWS *unpubl. data*). Millerbirds cannot be reliably aged in the hand, so aging non-territorial birds is not possible at this time. Attempts to use skull pneumatization and plumage characteristics to age the species have been inconclusive (Appendix IV, MacDonald *pers. comm.*). We will continue to explore reliable methods for aging Millerbirds during monitoring and other ongoing work on Nihoa.

3.2.3 Capture Techniques

The birds targeted for translocation will be captured and managed by at least four teams, three capture teams and one aviculture team. The capture teams will be deployed to different areas of the island to maximize the number of candidate birds collected, while minimizing the likelihood that captured birds are related, local impacts to the territorial breeders, and the transport time to the base camp. The aviculture team will remain at base camp to receive and care for the birds. The primary goal during capture and transfer to base camp will be to minimize stress on the birds. Mist-netting will take place only during the morning and late afternoon when temperatures are cool. In the evening, capture will halt once there is no longer time for the birds to acclimate to captivity before nightfall. The birds will be captured using the mist-netting method developed by MacDonald (2008), which uses a modified net with three trammels that is shortened to 3 m in length. The poles are only as high as the vegetation, and the shortened length facilitates quick set-up and movement in dense shrubs. The net poles are modified telescoping fishing poles, which may be anchored to the ground if substrate permits. Millerbirds will be attracted using call playback and flushed into the net by capture team members. Non-territorial and female Millerbirds do not respond as readily to playback, but can be captured with a combination of flushing, playback, and patience. Birds will be weighed, measured, banded with a USGS aluminum and unique color band combination, and sexed using DFA; breast feathers will be collected for genetic sexing in the shipboard PCR lab, and archived for later genetic analysis.

3.3 HOLDING

Millerbirds will be held for 2–5 days on Nihoa, 3 days on the boat, and 1 day prior to release on Laysan, so that the total holding time could be as long as 9 days. We will hold the birds on Nihoa following procedures developed in 2009 and 2010 (Appendices II, III, IV). The birds will be monitored for several days on Nihoa prior to departure while we capture the full cohort for translocation and conduct the PCR sexing. Individuals that do not acclimate based upon their behavior (Appendix II), will be released where they were captured. This pre-departure monitoring is important to ensure the birds can tolerate the time in captivity and the necessary handling until their release on Laysan. Once the target number is reached and acclimated to captivity, the cohort will be transported to the ship (see below). The Nihoa holding cages (four connected cells; shown in Appendices III and IV) will be transferred to the transport ship for the majority of the journey. The morning of the disembarkation at Laysan the birds will be transferred to the Laysan holding cages; during this process the birds will be inspected to make sure no arthropod food items are transferred to Laysan. The Laysan holding cages are duplicates of the Nihoa holding cages, but this transfer is required due to PMNM quarantine protocols (Appendix V). The Laysan holding cages will be transported to a secluded, quiet area of Laysan, and the birds health and stress level assessed. If the birds are stable and appear healthy, they will be transferred to the release cages, which are smaller, lighter weight, single-celled and have an easy opening release mechanism, and then hand-carried to the release site (below). We will do everything possible to minimize both the handling and holding times throughout the process.

All holding and transporting of birds will be supervised by an aviculturist and supported by a veterinarian and additional biologists. Each Millerbird will be held and fed using techniques developed during captive feeding trials on Nihoa in 2009 and 2010 (Appendices II, III, IV). These birds were acclimated to a captive diet using a combination of non-live food supplemented with locally-caught live food (primarily Diptera). External live food is not an option on either island due to PMNM quarantine protocols (Appendix V), but while on the boat the birds will be fed live mealworms and waxworms in addition to the non-live food. Millerbirds readily consumed the frozen and dried food provided (Appendices III, IV). The birds showed an initial loss of up to 9% of their capture weight, but by the end of the holding period had regained most of their weight, such that the mean relative loss in both 2009 and 2010 was 2% (Figure 3). A bird's morning weight after the first night in captivity can be closer to its normative weight, i.e., a better indicator of a bird's healthy weight, than its capture weight. After day seven of the feeding trials, the overall mean weight of the captive Millerbirds exceeded their first morning's weight in captivity (Figure 3).

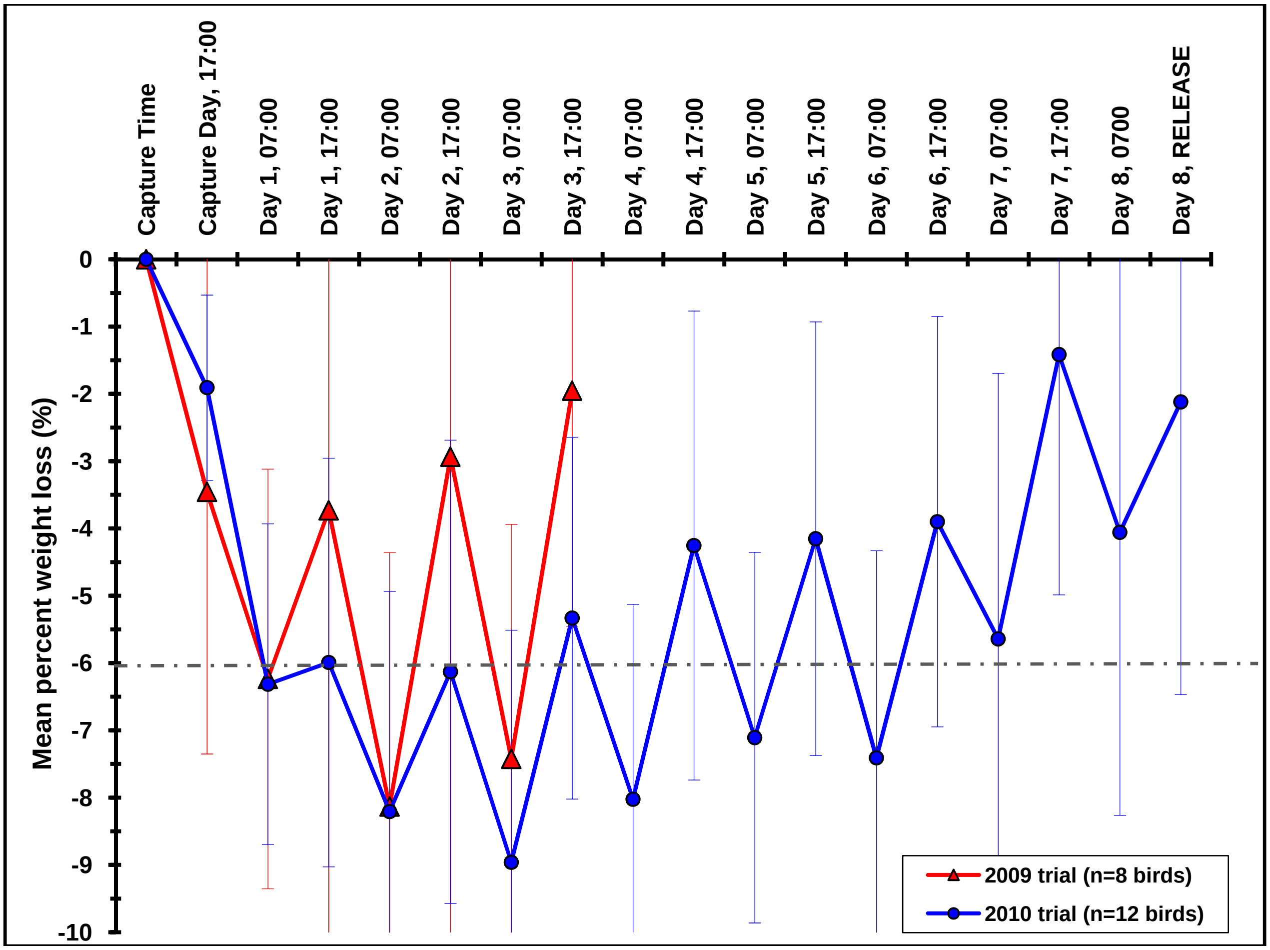

Figure 3. Mean relative weight loss (% ± SD) for Nihoa Millerbirds during the 2009 and 2010 captive feeding trials (Appendices III, IV; Kohley et al. 2009, Kohley et al. 2010). The bird's weight on the first morning in captivity, i.e., the normative weight is shown by the dashed gray line, and is the benchmark for assessing the health of birds while in captivity.

3.4 Transport

Safely transferring birds from Nihoa to the transport ship will be challenging. The birds will be transferred from Nihoa to the transport ship in custom-built, ventilated boxes (see above) using a Zodiac. All the boxes will be transferred at one time to the ship as soon as light permits to avoid overheating. Sea conditions typically are calmest at this time of day. The boxes containing the birds will be transferred from shore to the Zodiac by hand. The distance from shore to the transport ship will be dependent on ocean conditions.

Once the birds have been transferred to the ship they will be held in a cabin designated and equipped for this purpose. Only the aviculturist and veterinarian will enter the cabin to feed, monitor, and provide care for the birds (Appendix II). The transit time from Nihoa to Laysan is dependent on vessel speed and ocean conditions, but will be approximately three days. A dedicated vessel suitable has been secured for translocation in 2011 (Appendix I).

Experienced Zodiac operators familiar with Nihoa and Laysan have been identified and will be hired to ensure birds are safely transported off of Nihoa and onto Laysan. The landing on Laysan is a broad sandy beach and, barring rough weather, much less technical than the Nihoa landing. The birds will be transported in the Laysan holding boxes (see above). We have incorporated several flex days into the vessel schedule, which when combined with constant weather monitoring, will allow us to adjust the schedule and maximize the ability to safely transport birds onto Laysan. If poor weather prevents landing, we can hold the birds at anchor during the flex days. Although time in captivity will be minimized in all ways possible, the results from the captive feeding trials (Figure 3) suggest that if absolutely necessary, Millerbirds could be safely held for additional days.

Once the release cohort has arrived on Laysan, their holding boxes will be placed under a temporary awning (see pictures in Appendices III, IV), out of the direct sun and wind, and away from human activity; but still near the current PMNM camp. In case of an extreme weather event, the camp's hurricane shelter will be used which provides better protection, but less isolation and less exposure to a natural environment. The birds will not be released until the extreme event passes, or if one is predicted to occur within the next few days. Birds will be under significant stress during transit. Thus, the aviculturist and veterinarian will evaluate any changes in body condition and behavior while birds are held in this staging area. Birds within 5% of the weight recorded on their first morning in captivity and exhibiting normal behavior will be released as soon as conditions permit (Figure 3). Individuals with greater weight loss or abnormal behaviors will be held in in captivity until they recover.

Radio transmitters will be attached to half of the birds (n = 12) using the glue-on method the morning of the release (Johnson et al. 1992, Fancy et al. 1993, Paxton et al. 2003). A small piece of cloth will be attached to the bottom of the transmitter to increase the contact area. The feathers on the bird's interscapular region will be trimmed from an area slightly larger than the transmitter and the feathers cleaned with acetone. SkinBond® adhesive will be applied to both the transmitter and feathers, and then the transmitter gently, but firmly, held on the back until secure (2–5 min). Attachment will be checked with a gentle pull, the feathers arranged to cover the transmitter, and the birds transported to the release site.

Millerbirds are small birds, with a mass of approximately 18 g, and a minimum of 15 g (Morin et al. 1997, MacDonald 2008). Although radio-transmitters can negatively impact birds, transmitters ≤3% of a bird's mass minimize potential adverse impacts to the bird (Millspaugh and Marzluff 2001, Davis et al. 2008, Anich et al. 2009). Therefore, transmitters must be ≤0.54 g for the average bird, and ≤0.45 g for a light-weight bird. Transmitters of this mass (Holohil LB-2N) that included temperature sensor to provide a proxy for mortality data have a 21 day nominal battery life.

3.5 Release

The area on Laysan chosen for the first release of Millerbirds is located in the middle of the southern edge of a large *Scaevola taccada* patch which is protected by a berm to the north (Area A–B, Figure 4). This site will expose the released Millerbirds to a large, homogenous area of S. *taccada* to the north, and a high level of species and structural diversity to the south (Appendix VI), providing the birds a wide variety of options for establishing territories. This area is surrounded by *Eragrostis* (the dominant habitat on Laysan) and contains nearly every habitat type on Laysan, so the birds will be able to disperse, sample, and settle into whichever habitat is preferred. There are several patches of the exotic *Pluchea indica* to the south of the release site (along the northern edge of the lagoon; Figure 4) that are targeted for removal and subsequent restoration (Morin and Conant 1998, Kristof et al. 2011). Recent control efforts by USFWS staff have substantially reduced the distribution of *P. indica* along the lagoon's northern shore compared to Figure 4, and the 2011 winter floods caused additional mortality that has not been fully assessed (Kristof et al. 2011). Although Millerbirds might use *P. indica* for nesting or foraging, the translocation team fully supports its continued removal according to the current USFWS best management practices that minimize the impacts to nesting avian species, e.g., Laysan Finch, Red-footed Booby, and Greater Frigatebirds, (Kristof et al. 2011).

Any habitat preferences exhibited by the Millerbirds will be used to adaptively modify future release area selections. The release area is large enough to support numerous territories. Because the species composition of Laysan is different than Nihoa, predicting how many territories could be established is difficult, but conservative estimates suggest at least 80. This area also is close to the camp, thus reducing travel time for moving and monitoring the birds, all of which must be accomplished on foot. The habitat evaluation and site selection process on Laysan are detailed in Appendix VI.

Birds will be transferred the short distance from the staging area to the release site early the morning of release (Figure 4). The release cages will be designed and positioned so that the bird can be observed and released from a distance. Once the release cages have been placed in the habitat, the Millerbirds behavior will be monitored using binoculars. When the bird has settled down in the release cages and its behavior appears normal, the trapdoor will be opened. The cage will be oriented so that the bird exits directly into dense suitable habitat. The full cohort will be released in small sub-groups (six birds each, four sub-groups total) over the course of one morning, with the release cages arrayed in the selected release site (below). The releases will begin in the early morning (06:00 HST), with subsequent subgroups staggered by 30–60 min to allow for monitoring the birds' behavior and dispersal, as well as transport of the next sub-group to the release area. Supplemental food stations will be distributed throughout the release area prior to release, and once the birds are released the stations' locations will be adjusted so that no territory has more than one. We will resupply the stations at least twice daily (morning and evening), and monitor the Millerbirds' visitation and food consumption to assist in determining survival, habitat use, and potentially nest locations (see below; Armstrong and Ewen 2001). These stations will contain both a small sampling of fruit enclosed by mesh, and food items in a

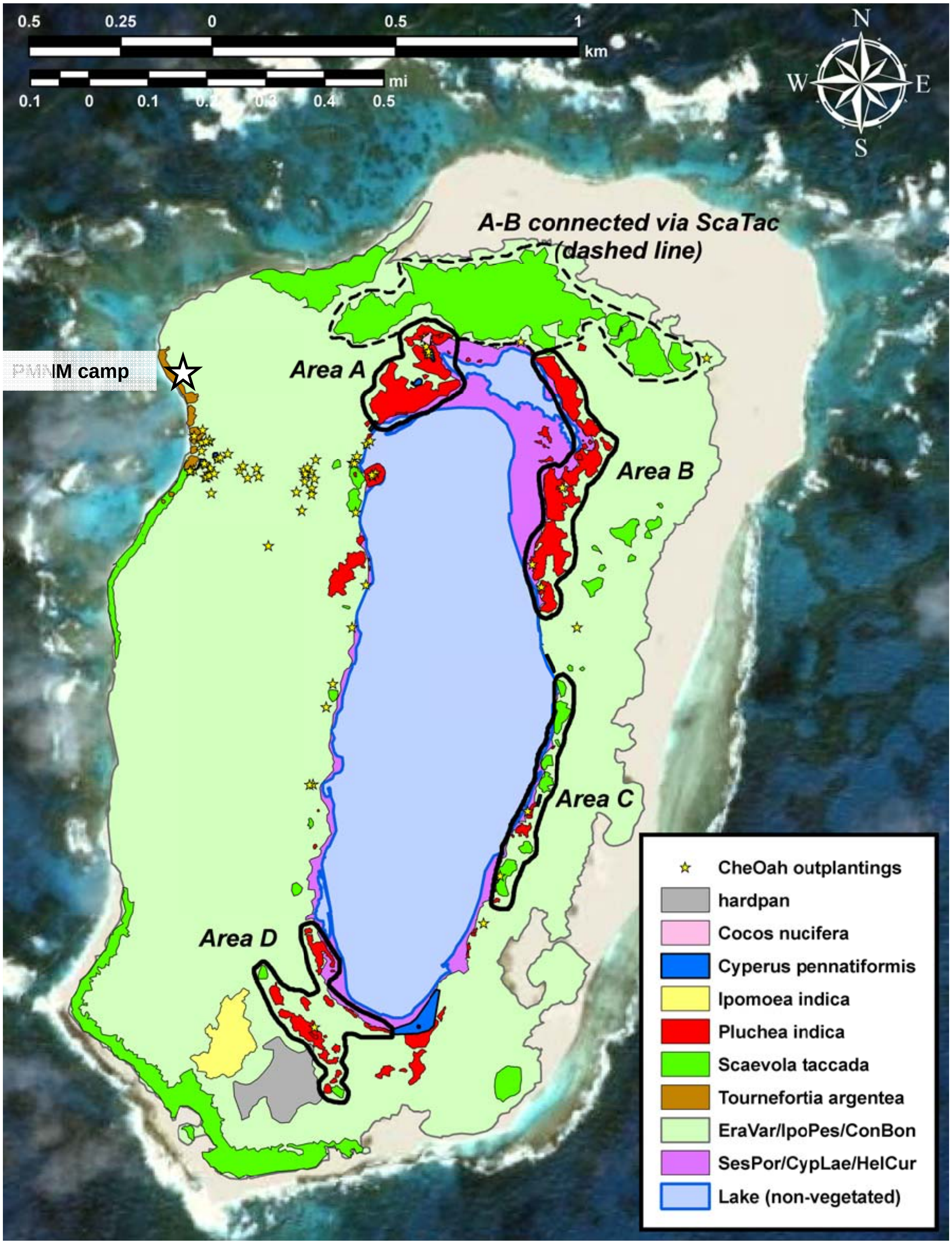

Figure 4. Vegetation types on Laysan, 2009. The four potential release areas (A–D) surveyed are shown above. The map is based upon PMNM staff (M. Stelmach) walking the boundaries of all habitat types in Summer 2009. The vegetation codes are: *Chenopodium oahuense* (CheOah), *Conyza bonariensis* (ConBon), *Cyperus laevigatus* (CypLae), *Eragrostis variabilis* (EraVar), *Heliotropium curassavicum* (HelCur), *Ipomoea pes-caprae* (IpoPes), and *Sesuvium portulacastrum* (SesPor).

similar food dish to those provided while in captivity to facilitate detection and use by the released birds. The mesh-enclosed fruit will attract flying insects (e.g., Diptera), while protecting the supplemental food from Laysan Finches. During the captive trials on Nihoa, Millerbirds were observed gleaning insects from the fly traps in camp (USFWS *unpubl. data*), suggesting they can recognize and utilize such a created, stationary food source. The open food dishes will provide a more complete diet that the birds will recognize from captivity, however Laysan Finches will likely consume and quickly exhaust the food offering. We will monitor the visitations, and if Millerbirds are not consuming the open food, it will be discontinued.

3.6. Post-release Monitoring

Long-term post-release monitoring is critical to provide the data on the status and fates of released birds (Sarrazin and Barbault 1996, Hein 1997, IUCN 1998, Fischer and Lindenmayer 2000, Reynolds et al. 2008). The data collected will allow the managers and scientists to understand the underlying causes of success or failure of the translocation, and suggest how future releases should be modified (e.g., Scott and Carpenter 1987, Danks 1997, Seddon 1999, Clarke et al. 2003). As the project progresses through its first year, monitoring will allow us to assess the different stages in the establishment of a Millerbird population on Laysan, and adapt our methods to improve future translocations (Section 4.1 Additional Translocations; Sarrazin and Barbault 1996, Hein 1997, IUCN 1998, Fischer and Lindenmayer 2000, Reynolds et al. 2008).

Radio transmitters will operate for approximately 21 days post-release, but due to battery variability and capture difficulty, maintaining active transmitters would require a recapture effort roughly every 14 days following release. Such frequent recapture efforts would involve substantial stress to the birds themselves, and a high level of disturbance to other nesting bird species and vegetation. In our view, the costs of this stress and disturbance outweigh the potential benefits of continual replacement of transmitters on Millerbirds. Once the transmitter batteries die, collecting high-quality data for assessment of the translocation will require making repeated, reliable observations of color bands.

Resight surveys will be further complicated by the need to minimize disturbance to the millions of seabirds that breed on the island. The abundant Procellariid burrows throughout the island greatly increase the difficulty of monitoring Millerbirds. Traversing the area, whether for visual or telemetry detections, has the potential to collapse burrows, crush eggs and chicks, and entomb adult birds. In addition to the burrowing seabirds, other seabirds nest on the ground and in the vegetation across the island. The federally endangered Laysan Finch and Laysan Duck breed in low-lying vegetation, mostly within *E. variabilis* (Moulton and Marshall 1996, Morin and Conant 2002, Reynolds 2002). Several low-impact routes have been established on the island with a low density of nesting, but are insufficient to collect all the necessary monitoring data. These routes circumnavigate the release area and will be used for telemetry data collection, and resight surveys when possible. These routes traverse the vegetation-dune border to the north, the vegetation-lake border to the south, and the west and east paths between the interior and exterior of the island.

After release, the Millerbirds may disperse among the different vegetation types available, and possibly across the entire island (Figure 4). Laysan's remoteness and the need to minimize human impacts mean there are limited infrastructure and personnel for monitoring, further complicating the monitoring framework. Taken together, these factors render a rigid set of monitoring protocols impractical. Instead, a flexible approach will allow the field supervisor to select the most appropriate set of methods to collect the highest quality data possible while minimizing impacts.

3.6.1. Data Collection

The data types needed to assess the success of this translocation form a hierarchy of importance and utility. The data in categories 1–4 below are necessary to evaluate the first translocation, adapt methods for subsequent translocations, and determine whether the biological goals for establishing the population are met (Table 1). The remainder (categories 5–7) will be valuable for the long-term (>1 year) assessment of the translocation. The data collection methods and schedule for data types are presented below for the short term (<21 days; Table 2) and extended term (>21 days; Table 3). The monitoring team will attempt to collect all the following data, but these protocols are intended as dynamic guidelines, and the field crew leader will modify or limit the data collected as necessary to minimize impacts on Millerbirds, other species and habitats. If collecting a particular type of data is determined to be excessively intrusive or impractical given the logistical and field conditions on Laysan, the frequency and/or intensity of field efforts will be decreased to what can be accomplished with minimal disruption to Laysan's biota.

1) Survival. Determining the length of survival for each of the translocated Millerbirds is critical and can be collected by checking the mortality sensors while transmitters are operating (<21 days). Once the transmitters cease to operate, survival data will be collected by regularly resighting the birds.

2) Reproduction. Breeding by multiple individuals across multiple years is necessary for population growth and establishment. Documenting breeding behavior is critically important, and information about the number of individuals breeding, nest success and the rate of population growth can provide important predictors of population persistence and the potential need for additional founders. The vegetation composition of Laysan is different from Nihoa, so determining the habitat preferred for breeding is crucial for assessing the long-term prospects for establishing Millerbirds on Laysan, and informing future habitat restoration. Because of individual behaviors and mate preferences, the breeding population is likely to be lower than the total number of released Millerbirds, and determining the breeding status of all birds will help evaluate the need for a second translocation. The translocated birds are unlikely to begin breeding before the transmitter batteries have expired. Therefore, all reproductive data will be collected from resights and behavioral observations.

3) Causes of mortality. Addressing and attempting to avoid future mortalities requires finding carcasses quickly and determining the cause of death. Unfortunately, necropsies might not be possible or sufficient to determine the cause of death.

4) Coarse-scale movement and habitat use. Movement and habitat-use data are necessary to characterize habitat selection. These data will be used to estimate the long-term population size and persistence of Millerbirds on Laysan, which will in turn help to inform habitat restoration efforts on the island. Based upon their behavior on Nihoa, we expect the birds to be relatively sedentary once they establish territories. However,

given the differences in habitat between the two islands, we will monitor movement patterns including any dispersal from the release site, and commuting among different vegetation types. Radio telemetry triangulation will be used to estimate locations on the island. Due to habitat heterogeneity and imprecision in triangulation, behavioral observations are necessary to determine habitat use and foraging behavior.

5) Foraging behavior. Millerbirds are generalist insectivores (Morin et al. 1997). Arthropod surveys of Laysan (see above; MacDonald 2011) suggest there will be sufficient food resources for Millerbirds on Laysan. However, foraging observations that include identification of prey items will be necessary to determine how and what the birds actually eat on Laysan. Obtaining these data will require behavioral observations which will be collected concurrently with other data, and fecal samples which will be collected opportunistically.

6) Territory size. The habitat and nesting substrates available on Laysan are substantially different from those on Nihoa, and as a result territory sizes may be different. Estimating average territory size will help us estimate the total area available for territories on the island, which will allow estimation of the potential size of the breeding population and the island's carrying capacity.

7) Behavioral interactions. Observations of interactions and conflicts between Millerbirds and any of the Laysan biota will be carefully detailed when encountered.

3.6.2. Monitoring Procedures

The first stage of monitoring includes all responses and mortalities that occur during capture and transport, hereafter termed pre-release. The birds will be faced with multiple stressors during capture and transport. The long transit time from Nihoa to Laysan means that this will be one of the most physiologically challenging passerine translocations ever attempted, and unfortunately mortalities or stress-induced behaviors could possibly occur prior to release on Laysan.

Post-release monitoring will include three methods: (1) remote mortality sensing, (2) telemetry triangulation, and (3) resight observations and spot mapping (Table 2). These methods are ranked by increasing quality of data and increasing adverse impacts on Millerbirds and other species. Half of the birds will have transmitters' with temperature sensors that will provide survival data from the lake shore, and possibly at further distances, with negligible impact on Laysan's other bird species. Triangulation can provide a location estimate, and using the low-impact routes will minimize impacts on other species. Due to some location uncertainty, habitat heterogeneity, and small territory size, this technique will provide only coarse-scale data. Resight observations will be required to determine the survival and movement of half the birds initially (those without transmitters), and all of the birds after approximately 21 days. Such direct observations will be the most reliable way to collect precise locations and the high quality information about habitat selection and behavior necessary to evaluate the long-term suitability of Laysan to support Millerbirds.

Table 1. Monitoring data to be collected from released Millerbirds and targets we hope to achieve for each dataset. These targets are based upon previous Millerbird research (Morin and Conant 1983, 1997, 1998, and 2001), Komdeur and collaborators (1992, 1994a, 1994b, 1995), the translocation teams experience with other translocations, and general passerine ecology. The actions resulting from not achieving these targets are detailed in Section 3.8 Translocation Assessment.

Data	Biological Targets
Pre-release	
survival	≥50% survival
health	≥85% capture weight
Initial (<21 days)	
survival	≥50% survival
Extended term (21 days–1 year)	
survival, through Sept 2012	≥70% survival
breeding, any relevant behavior	≥75% individuals
breeding, nest building	≥50% individuals
breeding, egg-laying	≥50% females
breeding, nestlings	≥33% female
breeding, fledglings	≥25% females
breeding, independent juveniles	≥25% females
habitat use	birds using multiple vegetation types
movement	>1 individual detected outside of Areas A, B, and A–B

There will be a short-term monitoring period 0–21 days post-release, when half the birds will have radio transmitters and half will not. This period will provide the most comprehensive and reliable data. The survival of the birds with transmitters will be determined via mortality sensors early in the morning (<07:00 HST) to determine overnight survival, and again in late afternoon (~17:00 HST) to determine daytime survival (Table 2). The timing of the afternoon check will allow carcass recovery in daylight, thereby minimizing disturbance to other species roosting during evenings. Carcasses will be recovered as soon as a mortality signal is detected, if possible to do without adversely affecting other species. This will increase the likelihood of a productive necropsy that ascertains the cause of death (e.g., Armstrong et al. 2002), potentially allowing reduction of mortalities from this source in the future. If time permits, there will be additional, remote mortality checks throughout the day. Resights will be required to determine the survival of the birds without transmitters.

The extended monitoring period will last from 22 days to 1 year. During this period, we will use resight and behavioral data to document the survival of Millerbirds through the winter and any breeding behaviors in the first complete year. Continued monitoring beyond the first year will be dependent upon the outcome of the first translocation and post-release survival (see below).

Table 2. Short-term monitoring of Millerbirds with radio-transmitters (battery life <21 days), and those without transmitters. Mortality, necropsy, location and resight data will be used to evaluate the translocation of Millerbirds from Nihoa to Laysan (see Section 3.6.1 for details).

Activity/frequency	data collected
TRANSMITTERS (n = 12 birds)	
mortality check, 2/day	survival rate
recovery of corpse (*if necessary*)	cause of mortality
triangulated location, 1/day	coarse-scale movement
resights, 3/week (*rotated through three daily periods*)	reproductive behavior
	habitat usage
	foraging behavior
	territory location and size
	intra- and interspecific interactions
NO TRANSMITTERS (n = 12 birds)	
resights, daily (*rotated through three daily periods*)	reproductive behavior
	habitat usage
	foraging behavior
	territory location and size
	intra- and interspecific interactions
recovery of corpse (*if possible*)	cause of mortality

Radio-tagged Millerbirds will be located by triangulation using the low-impact routes whenever possible. The entire island will be searched if necessary, and the position of all 12 birds will be determined daily. This method will determine the approximate dispersal distance from the release site, the approximate area used by the Millerbirds, and detect coarse-scale movement patterns. The locations of transmittered birds will be estimated by triangulation initially, then the field personnel will resight these individuals and observe their behavior.

The monitoring team will attempt to resight the other half of the release cohort (without transmitters) daily, including island-wide surveys if necessary to locate the birds. The observation times for each bird will be rotated through the morning (06:00–10:00 HST), midday (10:00–14:00 HST), and afternoon (14:00–18:00 HST) periods to ensure each bird's daily pattern is monitored over several days (Table 2). Once detected, the focal bird's behavior will be observed for at least 15 min, and data collected on intra- and interspecific interactions, habitat used, foraging observations, and location(s). These observations will be used to examine habitat use and territory size, and eventually calculate carrying capacity and the ability of Millerbirds to persist on Laysan (see below). Because of the substantial differences in vegetation and arthropods between the two islands collection of basic natural history data is critical in assessing the potential success and long-term prognosis of Millerbird translocation. Playback equipment will be used sparingly on Laysan, and only as a supplemental technique to locate a birds. We will avoid using playback if at all possible, so that the individuals do not become acclimated to it, and that the birds establish territories and breeding pairs with minimal disturbance. Before and after the supplemental feeding stations are resupplied, field personnel will monitor the behavior of any Millerbird in the vicinity. Laysan Finches will likely use these as well, and potentially consume the food in the open containers before the Millerbirds can access it, but the arthropods attracted to the mesh-enclosed fruit should provide valuable observation opportunities. Focal observations cannot be limited to birds visible from the external, low-impact route, because birds utilizing these edge habitats may have different behaviors from birds occupying interior habitats. Careful observations and spot-mapping along natural breaks in the vegetation will allow detections and data collection of these birds, however disturbance to the Millerbirds and other species will be minimized at all times. Additional observation time will be spent with each individual as time permits.

Once the transmitters are no longer active, monitoring will occur over the same three diurnal periods (06:00–10:00, 10:00–14:00, 14:00-18:00 HST), but occur at three times per week. Each bird will be observed for at least 30 min, and the data outlined above will be collected, with additional observations as time and logistics permit (Table 3).

Table 3. Extended term monitoring of individual Nihoa Millerbirds to be conducted after radio-transmitters are no longer active (>21 days). Resight data and nest observations will be used to evaluate the translocation of Millerbirds from Nihoa to Laysan (see Section 3.6.1 for details).

Activity/frequency	data collected
resights, 3/week (*rotated through three daily periods*)	reproductive behavior habitat usage foraging behavior territory location and size intra- and interspecific interactions
resights + additional habitat surveys (*as needed* †)	mortality coarse-scale movement
nest observations, 1/day (*if breeding occurs*)	reproductive behavior

† these surveys will be triggered if the bird cannot be found for one day. Other potential Millerbird habitat will be surveyed, see text for details.

Based on the Millerbirds' small territory size (0.19–0.40 ha) and relatively sedentary nature on Nihoa, we hypothesize that birds will not change their core use area on Laysan after their initial dispersal and settlement within the short-term monitoring period (≤21 days) (Morin et al. 1997, MacDonald 2008, USFWS personnel *pers. obs.*). By the time the transmitter batteries expire, the field crew will have numerous resightings of each bird and will be able to delimit the bird's territory via spot-mapping and behavioral observations such as counter-singing. Subsequently, visual and aural cues will be used to resight, monitor, and construct maps of the birds' territories. Monitoring personnel will collect data on foraging, habitat use, breeding behavior, and intra- and interspecific interactions (Tables 1–3). Armstrong and Seddon (2008) state that, "the key factors ultimate found to determine whether reintroductions succeed have been habitat factors (e.g., food availability and exotic predators)", so collecting these data are critical. Although these intensive observations have the potential to negatively affect other species via disturbance, no better alternative exists to obtain the data necessary to evaluate the successes or problems of the Millerbird translocation. The impacts of the monitoring and data collection to the overall Laysan ecosystem will be continually assessed, and if necessary they will be scaled back to reduce any negative influences. If an individual bird is absent from its territory for two days, surveys of the entire island, especially other potential habitat (i.e., Areas C, D; Figure 4) will be conducted (Table 3). If the bird is not detected in these areas, additional searches under the bird's primary perches within its territory will be conducted in hopes of finding the carcass.

The breeding season (normally January–September, but see above; Morin et al. 1997) will occur after all the transmitter batteries have expired, but documenting reproductive attempts, successes, and failures is necessary for evaluating the overall success of the Millerbird translocation. Other *Acrocephalus* have displayed significant differences in their breeding attempts and annual production of juveniles after translocation (Komdeur 1994a, 1996a), which given the differences between Nihoa and Laysan is also a possibility for Millerbirds. The extended term monitoring framework described above should ensure detection of breeding behavior (e.g., courtship-feeding, carrying nest materials, etc.). If nesting behavior is observed, and it is possible to do without disturbing the birds, nests will be located and monitored from as far away as possible using binoculars or a spotting-scope (Table 3). If mating and pair formation behaviors are observed, but no nest is seen, the supplemental feeding stations will be re-supplied and the delivery of food items to females or nests carefully observed (this technique was used to located nests of New Zealand robins; Armstrong and Ewen 2001). Once the female commences laying, visual confirmation of eggs will be obtained using a mirror-pole, if possible to do without disturbing the surrounding vegetation. Based upon one egg found in one nest, incubation lasts 16 days; no data exist on time until fledging or parental care post-fledging (Morin et al. 1997). If possible to do so without unduly disturbing the parents, the nests will be carefully monitored to document incubation and nestling periods.

We will attempt to mist-net and band fledgling Millerbirds on Laysan ≥14 days after fledging, when the bird is using a limited area, begging is frequent, and parental care is obvious; however capture will only be attempted if it can be accomplished with minimal disturbance to both the birds and the surrounding habitat. The field crew leader will make the final decision as to whether it is prudent to attempt to capture the fledgling, based upon its flying competence, general well-being, and interactions with its parents. Banding the young is critical for evaluating the translocation, but banding nestlings was deemed too risky because the safe period between the reduction in swelling in the nestling's legs and the increased risk of older nestlings jumping from the nest is unknown for Millerbirds. Morin et al. (1997) and Sincock and Kridler (1977) provide some approximate morphological measurements, but no timelines, for banding nestlings. When Sincock banded a nestling in 1969 it actually did jump from the nest. Juvenile Seychelles Warblers can be dependent on their parents for 3–4 mo (Komdeur et al. 1995, Komdeur 1996b), so there should be sufficient time to safely capture juvenile birds. Body feathers will be collected during capture for future genetic analysis. An additional goal in 2012 is to collect sufficient breeding phenology observations so that bands can safely be placed on nestling Millerbirds. Monitoring juveniles will help us evaluate Millerbird habitat selection, release sites of future translocations, and begin to understand the species' carrying capacity on Laysan. We do not currently plan on deploying radio transmitters on the juveniles, but will use our experience monitoring and resighting the adults to follow the dispersal and behavior of the juveniles.

In translocations of the cooperative breeding Seychelles Warblers, a burst of reproductive activity occurred within weeks after release, however the habitat of the donor population was over-saturated and many younger birds were unable to secure territories (Komdeur 1994a, Richardson et al. 2006). Conversely, breeding has been delayed in other translocations, possibly due to the physical and physiological disruption (Armstrong and Ewen 2002, Armstrong et al. 2002, USGS-BRD *unpubl. data*). The predicted reproductive response of Millerbirds is unclear, so although the field team will be prepared for the first cohort of released birds to breed, the absence of breeding in 2012 should not be interpreted as a failure of the translocation.

3.7. Recovery and Necropsy Protocols

Some Millerbirds may die during the translocation process. A necropsy will be performed expeditiously on all recovered carcasses to determine cause of death. This information may allow us to minimize future mortalities (e.g., Armstrong et al. 2002). Trained veterinary staff will be available during the capture and transport phases of the translocation, and all birds will be under close observation while in captivity. Similarly, while the veterinary staff is on Laysan the radio transmitters will be active, allowing for quick recovery and a timely necropsy by qualified personnel. Once the veterinary staff departs Laysan, recovered Millerbird carcasses will be stored in formalin and transported to Honolulu on the next available boat. After transmitter batteries expire, we will rely upon the absence of detections to indicate a mortality.

3.8 Translocation Assessment

The overarching objective of this translocation project is to create a self-sustaining population of Millerbirds on Laysan. This will require multiple breeding seasons and sustained population growth, but the results from the initial release are critically important. We have limited life history information about Millerbirds to compare to data collected from released birds and their offspring on Laysan, particularly important is the absence of information on age- or sex-specific survival, proportion of males and females that breed, and the age at first breeding (which can range from 8 months to 4 years in the Seychelles Warbler; Komdeur 1992). Millerbirds produce a mean of 2.2 eggs/clutch (n = 16 clutches), and although multiple clutches have been documented within one year, the average frequency of this is unknown (Morin et al. 1997, Conant and Morin 2002). Therefore, the goals described below are based on limited information about Millerbirds, augmented by data pertaining to the natural history and translocations of the congeneric Seychelles Warbler. Based on this paucity of information we propose a conservative approach in establishing triggers for alternate actions such as additional translocations or modifications to these translocation, release, and monitoring methods. Whether the individual criteria are met or not, identifying the various difficulties will be used to improve efforts in future years.

3.8.1 Survival during Pre-release

At this stage in the Millerbird translocation process it is difficult to anticipate all eventualities, but >50% mortality from irresolvable causes in the pre-release stage seems an appropriate trigger for conducting additional research prior to attempting a second translocation (Table 1). No mortalities occurred when Seychelles Warblers were moved (three translocations, n = 116 birds total), but the distance between islands was 2–57 km, and the birds were in captivity for a very short time (Komdeur 1994a, Richardson et al. 2006). Millerbirds will be held in close captivity for as long as 9 days and transported over 1,000 km before released on Laysan – several times longer than any other passerine translocation (e.g., Komdeur 1994a, Armstrong 1995, Armstrong and Craig 1995, Fancy et al. 1997). If a high rate (>50%) of unattributable mortalities occurs during the pre-release stages (Table 1), then additional research with surrogate species (e.g., Japanese Bush-warbler, *Cettia diphone*) will be conducted before undertaking a second translocation of Millerbirds. The Seychelles Warblers were held just over 3 hours and lost 5.7–7.1% of their capture weight, although they were not fed during their captivity (Komdeur 1994a). Our objective is to release birds at ≥95% of their first morning's captivity weight, and if we cannot achieve ≥85% then additional research on captive diets will be conducted prior to another translocation (Table 1).

3.8.2 Short-term Survival Post-release (<21 days)

Our goal is to achieve >50% survival of the released Millerbirds during the 21 day monitoring period while the transmitters are active (Table 1). Initial mortalities occur in many translocations due to cumulative stress and environmental change (Armstrong and Ewen 2002). Because of the additional stress of capture and holding, we will not attempt to recapture any of the released birds. This will be the Millerbirds' first exposure to the novel environment of Laysan, and once released the birds will be immediately exposed to a combination of weather, habitat, and intraspecific interactions. The most likely cause of excessive (>50%) mortality during the first days following release is an unexpected weather event. Weather-based mortalities suggest that the timing of future releases be adjusted, but there are no modifications that can be implemented during the 2011 release.

Inability to obtain sufficient food on Laysan is a potential source of mortality that could be especially severe within the first 21 days as the birds adjust to their new environment, and which could lead to exceeding the target survival rate (Table 1). Although arthropod abundance on Nihoa and Laysan are similar, there are differences in species composition (MacDonald 2011). Foraging observations and opportunistic fecal collections will help determine if the translocated birds are successfully capturing arthropods. If the released birds appear to be dependent on the stations, the supplemental feeding period will be extended. Such behavior could indicate that the food resources and habitat of Laysan are actually not sufficient for the persistence of Millerbirds, and additional foraging observations and arthropod studies will be initiated. If the birds are not visiting the feeding stations or are not successfully capturing arthropods, the stations' locations can be adjusted and additional feeding stations can be deployed. Alternatively, if the birds are no longer visiting the feeding stations, we will halt the provisioning and incorporate these results into future releases.

Millerbirds are fiercely territorial (Morin et al. 1997, USFWS personnel *pers. obs.*), and are expected to immediately engage in territorial defense, similar to that observed in Seychelles Warblers during the post-release period (Komdeur 1994a). Any pre-existing dominance hierarchy will have been disrupted, so an increased level of intraspecific interactions is anticipated. The initial release period is expected to be the period of most intense interactions, as the birds explore the habitat and attempt to establish territories.

3.8.3 Extended term Survival Post-release (>21 days)

We set a target of an 80% survival rate of the Millerbirds present on Laysan after 21 days at the end of the first year (Table 1). The released birds will have experienced a complete cycle of seasonal variation, and the associated vegetative and arthropod phenology on Laysan by September 2012, and surviving for a year will be a significant achievement. Conversely, high levels of mortality will suggest concerns about the long-term suitability of Laysan. If the survival rate is lower than this, foraging observations, habitat use, interspecific interactions, and necropsy results will be carefully examined to determine the viability of Laysan's current ecosystem to support Millerbirds. Annual adult survival the Seychelles Warbler ranged from 80–100%, with survival rates in the translocated population significantly higher (Komdeur 1994a, Komdeur et al. 1995). The habitat at the source population of Seychelles Warbler was saturated with compact territories, and most birds bred cooperatively. The increase in survivorship observed in the translocated birds was presumed to result from a reduction in territorial interactions and a per capita increase in food resources in a novel habitat (Komdeur et al. 1995). There are some observations that in some years and seasons the habitat on Nihoa is saturated and a sizeable floater population exists (USFWS *unpubl. data*). Therefore, released Millerbirds on Laysan may experience a relaxation of density dependent factors, similar to the Seychelles Warbler system, and an associated increase in survival. However, because the translocation process will be much more challenging for Millerbirds than it was for the Seychelles Warbler, an 80% target is more realistic.

3.8.4 Breeding

Although Seychelles Warblers started breeding soon after release, many passerines show a delay in reproduction following translocation. Because of the wide range of responses, Millerbirds may require two breeding seasons to achieve the breeding benchmarks in Table 1. If after two years there has not yet been any significant reproductive effort, additional research into the breeding ecology on Nihoa is warranted. The reproductive phenology of Millerbirds is poorly known, so we used Morin et al. (1997), Conant and Morin (2001), and results from Komdeur and collaborators (1992, 1994a, 1994b, 1995) to derive these realistic, albeit semi-arbitrary, objectives (Table 1).

3.8.5 Movement and Habitat Use

Information about Millerbird dispersal and habitat use will be used to help plan future translocations (e.g., release locations), estimate Laysan's carrying capacity, and inform restoration efforts. Armstrong et al. (2002) believed that most translocations failed because of poor habitat rather than poor release strategies, and given the differences in habitats between Laysan and Nihoa this is a significant concern that habitat use data will address. Collecting these data will be easiest while the radio-transmitters are active, but determining their movements throughout the year is important. Failure to meet the targets for movement and habitat use (Table 1) has less impact on future translocation protocols, but is a significant concern in assessing the long-term viability of Millerbirds on Laysan. The birds could use all the vegetation equally, or they may exhibit preferences for certain vegetation types or structure (e.g., dense, woody shrubs). Comparing the habitat used versus that available will allow us to estimate how many Millerbird territories could be established on Laysan over the long term and the sustainability of the new population. PMNM is conducting intensive vegetation restoration on the island (PMNM 2008, Kristof et al. 2011), including removal of *Pluchea indica*, an exotic shrub, from the Millerbird release area and outplanting six native plant species. Information about their habitat use therefore will be an important contribution to integrating avian restoration with native vegetation restoration.

3.9 Impacts from Translocation

The goal of the translocation is to create a self-sustaining population of Millerbirds on Laysan while minimizing negative impacts to the source population. Removing 24 birds is approximately 5% of the mean estimated population, based on the most recent estimate [Figure 2; 2010 Millerbird population estimate = 507 ± 295 (95% CI)], and mitigating the extinction risk by creating a second population provides a significant overall benefit to the species. The 2011 aerial survey (7 July; details above) indicated that Nihoa was green, and heavily vegetated, i.e., no drought or other catastrophic events had occurred. Additionally, if breeding habitat on Nihoa is saturated, taking adult birds to Laysan would not have a significant impact on the source's breeding population in those years because sub-adult floaters are likely to move into vacant territories. Although collecting eggs or nestlings for translocation might have a lower impact to the source population, the logistical and resource constraints of adequately caring for eggs or nestlings through the entire translocation and release process render these options unrealistic. The increased disturbance from collecting eggs or nestlings, combined with a larger cohort size required by their higher mortality rate during translocation, would likely more than offset any reduced fitness impact to the source population. Spreading the removal of birds from Nihoa over the course of two or more years will further reduce impact on the source population and benefit the new population.

To minimize disturbance during capture of Millerbirds, a system must be used that is sensitive to birds in the air and underground. This is accomplished by using a netting system developed by MacDonald (2008) that minimizes ground disturbance and capture of non-target species. The capture of non-target species is further reduced by stationing a team member at the net to discourage non-target species from entering the net. This system was used during the September 2009 and September 2010 field trips in which nearly 100 Millerbirds were captured without adverse impacts to other species.

The translocation of Millerbirds to Laysan is not anticipated to have a negative impact on the Laysan ecosystem. Historically, Millerbirds shared the island with Laysan Finches, Laysan Ducks, and the extinct Laysan Honeycreepers. The Laysan Finch is primarily a granivore, eating mostly seeds, fruits, leaves, flowers, and other vegetative parts; less than 11% of its diet is invertebrates (Morin and Conant 2002). Competition with the finch may be familiar to the translocated Millerbirds because of their co-existence with the closely related Nihoa Finch. The Laysan Duck primarily consumes arthropods (e.g., Diptera, Formicidae, Lepidoptera, *Artemia sp*.), but seeds and plant fibers are also common (Moulton and Marshall 1996, Reynolds 2002). Although there might be overlap in taxa consumed, there are substantial differences in foraging habitats, behaviors, and time between Millerbirds and Laysan Ducks. Reynolds (2002) found that the ducks showed distinct diurnal movements among the four primary habitat zones on Laysan. Ducks spent 88% of the day in the upland terrestrial zones, but only ≤6% of their time was spent foraging in this zone during the morning, day, and evening; however, during the night 42% of their time was spent foraging in this zone (Reynolds 2002). Millerbirds, like most passerines, are most active in the morning, with little activity at night. The ducks main foraging habitat was the lake and wetland zone, 44% overall and ranging from 34–50% depending on the time of day (Reynolds 2002). The terrestrial zone encompasses all the habitats Millerbirds are likely to use, and based upon their avoidance of open areas on Nihoa, it seems unlikely they will use the open lake and wetland zones on Laysan. Therefore, ducks and Millerbirds do not seem to be dependent upon foraging in the same habitat at the same time. Additionally, ducks "mostly probed the substrates at the base of plants" in the terrestrial zone (55% focal observations), and also used sand dabbling (17%) (Reynolds 2002). Probing and dabbling are different from the typical Millerbird gleaning, although ducks sometimes used a "snapping" behavior (19%) that might be similar to Millerbird foraging behavior.

The maximum, initial Millerbird population on Laysan will be 24 birds. The July 2010 Laysan Finch population estimate was 8,327 ± 1,711 (95% CI; Hammond et al. 2010). There were 28–414 Laysan Ducks detected during the bi-monthly winter counts (11 August 2010–23 March 2011), with a mean of 222 birds (Kristof et al. 2011). The Millerbird population will be a tiny proportion of the finches, and likely small relative to the actual population of ducks, so it seems unlikely there will be significant, detectable effects. It is always difficult to prove competition, but the intensive behavioral and habitat use observations (see above) should allow us to detect possible, incipient interspecific conflicts. If Millerbirds cause an unacceptable negative impact to any native species on Laysan, additional consultations with PMNM and USFWS will occur. All observations will be fully presented in the preliminary and final reports.

Similar to other endemic Hawaiian birds, Millerbirds evolved in isolation and may be highly susceptible to introduced diseases (Pratt 2005). With no mosquitoes on Laysan or Nihoa to serve as disease vectors and strict quarantine protocols to prevent their introduction, the birds on Laysan and Nihoa are still protected from diseases currently affecting endemic landbirds in the main Hawaiian Islands. This sensitivity to introduced diseases means that any exposure could have a major effect on the population of endemic bird species. Laysan Finches are known to be highly susceptible to avian malaria (Warner 1968), the scourge of endemic forest birds in the main Hawaiian Islands, and we assume the Nihoa Finch is susceptible as well. No incidence of this or other mosquito-borne avian diseases has been recorded on either Laysan or Nihoa; to the best of our knowledge mosquitos are not present on either island. During the capture and handling of Millerbirds no unique parasites or diseases have been recorded. Millerbird feather mites were collected in September 2010, and identified as members of Trouessartidae, which is the family of the one species (*Trouessartia trouessarti*) known to use *A. familiaris kingi* as host (D. LaPointe, USGS-BRD, *pers. comm.*).

4. FUTURE ACTIONS

4.1 ADDITIONAL TRANSLOCATIONS

Establishing a second, self-sustaining population of Millerbirds on Laysan could require at least two, and perhaps more, translocations because the chances of successfully establishing a new population typically increase with the number of individuals released (Griffith et al. 1989, Wolf et al. 1998, Fischer and Lindenmayer 2000). The initial release may be affected by unavoidable mortalities, unsuitable mate choices (i.e., a behavioral Allee effect), and a small cohort size that will be below the minimum tested in a population viability analysis for extinction resistance (n = 20 males, 20 females; Conant and Morin 2001). Addison and Diamond (2011) recommend moving 20–40 individuals to increase the likelihood of successfully establishing a second population on Laysan. However, in some cases translocated birds and their offspring have such a high breeding rate that the population increases rapidly in the new site and additional translocations are unnecessary (Armstrong and Ewen 2001, Taylor et al. 2005).

We will build on the results of the 2011 translocation and refine our protocols for a second translocation in 2012, if needed. Many aspects of this first translocation are extremely challenging and untested. We expect unanticipated difficulties, especially during the pre-release and immediate post-release stages, and assume that, once identified, these can be avoided during subsequent translocations. If behavioral observations suggest that Laysan has insufficient food or habitat to support Millerbirds, then further translocations will have to be delayed until habitat restoration on the island has advanced. If the mortality exceeds these target levels at any stage, additional research will be needed on Nihoa to fill critical gaps in our knowledge of Millerbird biology.

4.2. Preliminary and Final Progress Reports

A preliminary progress report will be produced six months (roughly 31 March 2012) after Millerbirds are released on Laysan. This preliminary report will include all records up to that point, such as results of capture and transport, survival on Laysan, dispersal and habitat use, foraging, breeding, and other behavioral observations, interactions with other species, and any impacts of monitoring. Because fund-raising and logistical planning for a second translocation must be well underway before the end of a complete year's monitoring, the preliminary report will make an initial recommendation regarding the need for a second translocation. If an additional translocation is justified, the preliminary report will propose preliminary changes to the translocation protocols (this document) to correct problems or deficiencies. A final, comprehensive report will be produced by 31 December 2012.

4.3. Population Model of Millerbirds on Laysan

As soon as sufficient demographic data are available, a revised population model (e.g., Conant and Morin 2001) will project the population trend and estimate the numbers of individuals and timeframe for subsequent translocations, if these are determined to be necessary. Conant and Morin (2001) conducted a population viability analysis of the Millerbirds on Nihoa using VORTEX, but had to make extensive estimations of life history parameters. Their two most relevant conclusions were that with minimal supplemental translocations (five year-old females and five year-old males, 10 total birds added every 50 years) the Laysan population always persisted for greater than 1000 years (assuming a relatively constant environment), and their initial translocation was larger than logistically feasible in 2011 (the simulations used either 20 males + 20 females or 40 males + 40 females). Addison and Diamond (2011) found the effective Nihoa Millerbird breeding population was 5–13 individuals, and recommended translocating 20–40 founders over several years to account for mortalities, mate choice, reproductive variation, and other uncertainties. However, Armstrong and Ewen (2001) found that additional translocations are not always needed, even with small initial release cohorts, and instructive models can be constructed with less than a year's data. We have insufficient new data at this time to warrant another modeling exercise before conducting the first translocation. We will attempt to construct simple projections with the preliminary post-release results, but decisions about funding, logistics, permits, and personnel for a second translocation may need to be made before sufficient data are available.

4.4. Continued Monitoring of Millerbirds

> "*The ultimate objective of any reintroduction is population persistence without intervention, but this is a state, not a result, and is assessable only through long-term, post-release monitoring*" – P. J. Seddon (1999)

This plan only covers the first year in what needs to be a multi-year commitment from all partner agencies to establish a self-sustaining population of Millerbirds on Laysan. Sutherland et al. (2010) in their overview of avian reintroduction standards stated that the minimum acceptable monitoring standard are population estimates at 1 and 5 years after reintroduction. Wolf et al. (1998) caution that even a high abundance does not indicate a self-sustaining population, but rather presence of individuals beyond the maximum expected life span is necessary to indicate a self-sustaining population. The oldest Millerbird recorded was 5 years (Morin et al. 1997), while the mean Seychelles Warbler was 8.9 years and the maximum was 21 years (Diamond 1980, Komdeur and Pels 2005). Using the known Millerbird maximum lifespan, monitoring of the released Millerbirds needs to continue through at least 2016. However, more intensive monitoring will likely extend the lifespan for *A. familiaris*, so plans for extended monitoring and assessment need to be constructed and implemented. If there are insufficient funds for dedicated monitoring in 2012–2016, then the stakeholders should explore potential arrangements to use their limited resources to collect the post-release data necessary to evaluate the long-term success of the translocation and determine any modifications necessary for future translocations. For example, the Millerbird field team could assist with PMNM restoration and other tasks, and the PMNM staff could assist with monitoring Millerbird survival and habitat use. Discussions within USFWS on the most productive ways to structure the collaboration are underway. The possibilities for extended monitoring from 2013–2016 will be addressed in the preliminary report.

> "*To have a chance of success, a reintroduction project, whether a wild-to-wild translocation or a release of captive-bred animals, needs careful planning and long-term commitment of resources.*" – P. J. Seddon and P. S. Soorae (1999)

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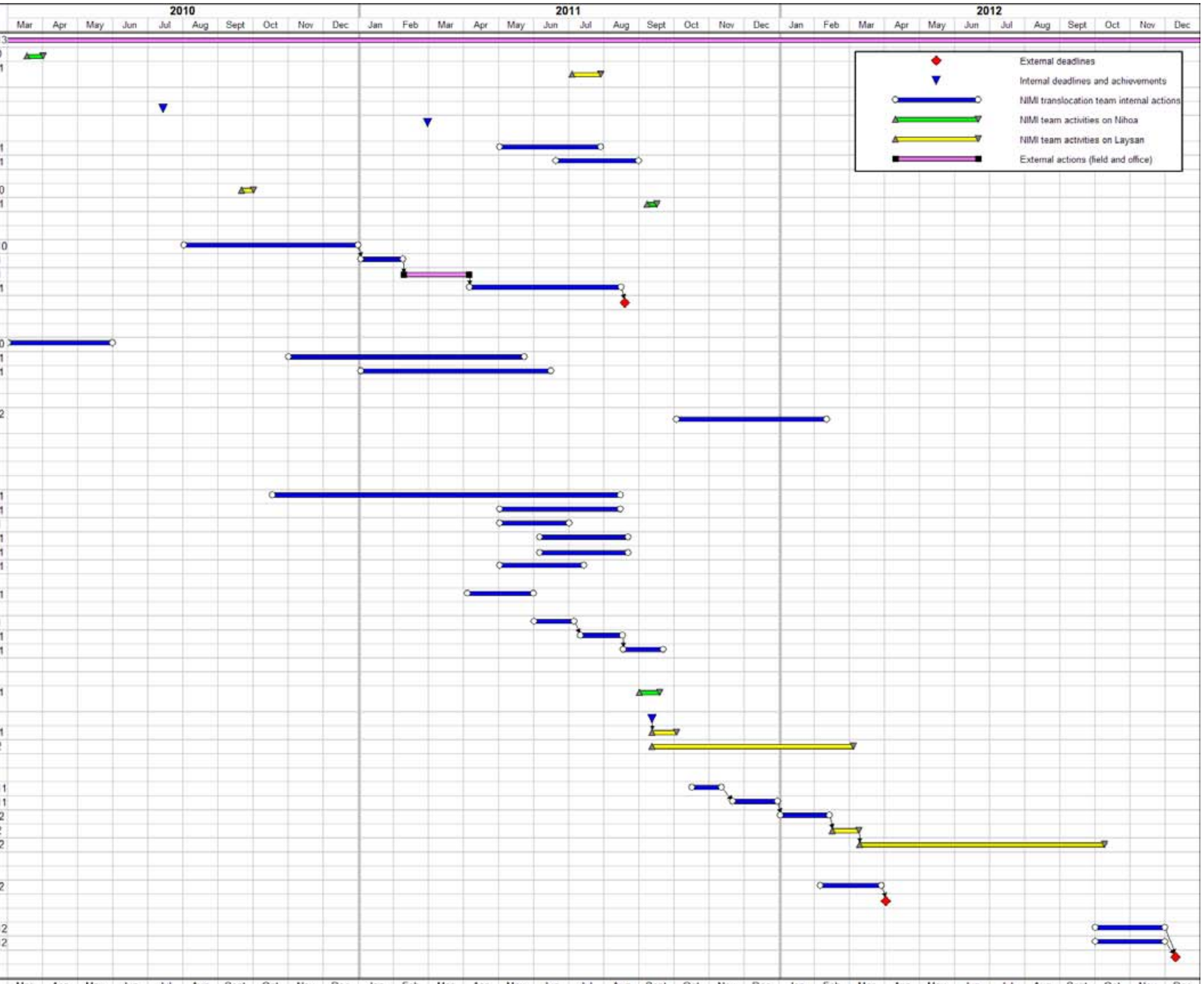
7. APPENDIX I: Millerbird Translocation Timeline, 2010–2012

Actions	Start Date	Finish Date
PMNM staff working on Laysan habitat restoration	1/1/08	12/31/13
habitat assessment for NIMI translocation on Laysan	3/18/10	4/1/10
inspect Laysan restoration, final decision on release location, construct release infrastructure	7/4/11	7/29/11
secure vessel for Nihoa surveys	7/14/10	
secure vessels for 2011 Translocation (Searcher, Kahana)	2/28/11	
coordinate logistics, berths, storage space	5/2/11	7/29/11
coordinate departure and arrival schedules	6/20/11	8/31/11
extended captive feeding trials on Nihoa	9/21/10	10/1/10
Nihoa population surveys	9/8/11	9/16/11
NIMI Translocation protocols		
translocation protocols, draft final	8/2/10	12/31/10
translocation protocols, USFWS review	1/3/11	2/8/11
translocation protocols, draft final, peer review	2/9/11	4/5/11
translocation protocols, revise draft final	4/6/11	8/16/11
translocation protocols, final version released	8/19/11	
apply and secure funding for 2011 translocation		
NFWF (secured)	3/1/10	5/31/10
FWS-PIFWO FY11	11/1/10	5/23/11
FWS State of the Birds	1/3/11	6/15/11
Other FWS		
non-federal		
apply and secure funding for 2012 monitoring and translocation	10/3/11	2/11/12
Other FWS		
non-federal (ABC, National Geographic)		
permits		
NHPA s106 consultation	10/18/10	8/15/11
PMNM permit	5/2/11	8/15/11
banding permit amendment	5/2/11	7/1/11
endangered species permit (Section 7)	6/6/11	8/22/11
endangered species permit (Section 10)	6/6/11	8/22/11
NEPA	5/2/11	7/14/11
coordinate schedules of NIMI team for translocation	4/4/11	5/31/11
hire NIMI 2011 translocation & monitoring staff (crew #1)		
advertise positions	6/1/11	7/5/11
interview, offer positions	7/11/11	8/17/11
hire, orientation, paperwork, etc	8/18/11	9/21/11
TRANSLOCATION 2011		
voyage to HNL-Nihoa-Laysan-HNL (capture, transport NIMI)	9/1/11	9/18/11
release of NIMI on Laysan	9/12/11	
monitoring NIMI on Laysan (with telemetry)	9/12/11	10/3/11
monitoring NIMI on Laysan (without telemetry)	9/12/11	3/4/12
hire NIMI 2011-2012 monitoring staff (crew #2)		
advertise positions	10/17/11	11/11/11
interview, offer positions	11/21/11	12/30/11
hire, orientation, paperwork, etc	1/2/12	2/13/12
crew-change and swap	2/16/12	3/9/12
monitoring NIMI on Laysan (without telemetry)	3/10/12	10/9/12
preliminary report		
analysis of initial data	2/6/12	3/29/12
preliminary report due	4/2/12	
final report		
analysis of 1 yr data	10/1/12	11/30/12
modify & update population viability analysis	10/1/12	11/30/12
final 2011 Translocation report due	12/10/12	



8. APPENDIX II: Nihoa Millerbird Husbandry Protocol

DIET PER FEEDING:

Food Item:	Quantity
Freeze dried house fly pupae and larvae	1 Tablespoon
Frozen insects (moths, cockroaches)	3 grams
Frozen crickets (4–6 wk old)	3 grams
Frozen waxworms	3 grams
Common house fly (live)	when available
Frozen bee larvae	when available
Nekton I (undiluted concentrate)†	sprinkle over food
Kaytee Exact® hand feeding formula	sprinkle over food

†*when additional caloric intake is needed waxworms can be soaked in Nekton I dilution*

HUSBANDRY ROUTINE

Each captured bird will be banded, weighed and then transported to the holding cages in a standard bird bag. The latitude and longitude of the capture site will be recorded, allowing us to release any birds that do not acclimate to captivity at their original capture site.

The team will be divided into at least four crews, three netting and one husbandry crew. As soon as a netting crew has caught a bird in a net, the husbandry crew will be notified by radio so they can finalize preparations for the new bird. The husbandry crew will place fresh paper on the cage floor, a full food dish in the center of cage, and water placed in the water dish. When the bird arrives it will be placed into the cage and left alone for at least two hours. On the initial day of capture, each bird will be weighed every three hours (08:00, 11:00, 14:00, and 17:00 HST), until 17:00. On subsequent days, birds will be weighed at 07:00 and 17:00.

Morning Feeding

Feeding will commence once all the morning weights have been taken. The food bowls for all birds in captivity will be prepared at one time. Once the food and water bowls are prepared, we will remove the floor trays and replace the bowls (for cage design, see Appendices III, IV). For monitoring purposes, the food dishes will be inspected and recorded for review of food consumption and preferences. The paper lining the cage bottom will also be removed and the fecal remains reviewed to determine the relative quality of feces and health of the bird. We will then replace the paper, water, and food; sliding them in on the trays to minimize the chances of birds escaping.

Lunch Feeding

Food consumption will be examined and based on quality of remaining food and individual bird's weight and additional food will be added if necessary.

Evening Feeding

The same procedure will be followed as for the morning feeding.

MONITORING BIRDS

We will monitor the food consumption and qualitatively rank how much food is consumed by each bird. Food trays will be weighed before being offered to the birds and after removal from the cages, and total consumption recorded as: trace, 25, 50, 75, and 100%. Our goal will be to identify how much and what food items individual birds are eating so that diets can be adjusted to assure each bird is maintaining their weight.

CRITERIA FOR RELEASE

The goal of these criteria is to return any bird not acclimating to captivity to the wild before its health is compromised. If a bird displays the conditions below, it will be released.

1. If a bird has lost > 20% of its initial capture weight. This will be the main criterion for evaluating the birds.
2. If a bird is not eating any food items.
3. If the fecal samples have a high urate concentration and low solids, indicating low food consumption.
4. If the bird is over-active or lethargic.

9. APPENDIX III: Nihoa Island trip report for September 6–18, 2009

The following is an abbreviated version of the trip report from September 2009 containing the relevant data concerning the captive feeding trials on Nihoa. The summary graph of weight loss is shown in the main text, Figure 3.

Citation: Kohley R., P. Luscomb, M. MacDonald, and D. Tsukayama. 2009. Nihoa Millerbird Pre-translocation and Nihoa Biological Monitoring Expedition, September 6-18, 2009. Nihoa Island, Northwest Hawaiian Islands, Papahānaumokuākea Marine National Monument, U.S. Fish and Wildlife Service, Honolulu, Hawaii. All photographs © Robby Kohley/USFWS 2009

Personnel:
Robby Kohley: USFWS Contractor
Peter Luscomb: General Curator, Honolulu Zoo
Mark MacDonald: Graduate student, University of New Brunswick, Canada
Daniel Tsukayama: Field Assistant (USFWS ES Contractor)

NIHOA MILLERBIRD CAPTIVE FEEDING TRIALS

Photographs 1 and 2. Nihoa Millerbird (*Acrocephalus familiaris*).

Base Camp Setup

***Location*:** A site in the stream bed was chosen that was situated away from the staff tents (sleeping) area and the food preparation and eating area. The chosen area was located just above the first waterfall on the stream bed about 30 m mauka of the food preparation area.

Photograph 3. Base camp location and shelter arrangement.

***Shelter*:** A combination of an MSR Outfitter Wing, measuring 15 x18 ft, and a tarp were used to provide shelter. The set-up worked well in the chosen location. The island can be very windy, especially when the wind is channeled up the valleys; during our September stay the wind was estimated at 25-30 m.p.h. Due to high winds it was critical that the tarps be securely tied down. On one night, one of the tarp support lines did give way and had to be quickly repaired, as the tarp was flapping against the bird boxes and could have knocked them to the ground. To avoid this situation in the future we will explore using an anchor system that allows us to attach anchor points directly to the rock which can be removed at the end of the trip. The shelter system provided sufficient protection from the sun. During feeding trials average temperatures under the shelter were documented for various times of the day: 07:00 HST = 82°F, 09:30 HST = 88°F, 11:00 HST = 91°F, 1700 hrs = 84°F. In comparison, midday temperatures outside the shelter in the stream bed exceeded 110°F. The high temperature in the area could be attributed to the fact that it was primarily solid rock and retained heat. A temperature reading taken inside the vegetation where the Millerbirds are found during midday was 93°F; during future trips more temperature data should be collected in such microhabitats. Because of the high temperatures, we decided to maximize the air flow through the cages. Originally, to provide the birds with privacy, a solid cloth was used to cover the back wall of the cages. However, to increase the air flow, strips of the cloth were cut out of the covering. On future trips, we may consider using camouflage coverings similar to what the military uses. At no time during the captive trials did the birds show any indication of heat stress.

***Shelving*:** A system using tent corner brackets was used to make a portable shelf system. This shelf system worked well and was able to adjust to the uneven ground. The shelf was originally designed so it had three shelves to accommodate six bird holding boxes (24 birds). Because of the high winds and concerns that the shelf could be blown over, it was decided to remove the top two shelves and work with only one shelf level. In order to avoid the shelf falling over in high winds, we will need to develop a better method to anchor the shelf to the ground. One problem with the shelf system was that there was no way to secure the boxes to the shelf. This was a concern because high winds could possibly blow the boxes off the shelf. During the trip, we tried duct tape to secure the boxes to the shelf. However, this technique had limited success as the tape kept coming loose and had to be reapplied. We also used parachute cord to tie the boxes to the shelf. One solution would be to place two strips of wood on the bottom of the bird boxes that would fit between the support bars and prevent the boxes from sliding off the shelf.

***Ant Barrier*:** We were able to develop an ant barrier for the shelf system by taping paper around the shelf legs and then spraying Terro ant spray onto the paper. This system worked well for keeping ants off the shelf. We did have a problem when we tied the bird boxes to the shelf with parachute cord and, during the night, the end of the cord fell off of the box and onto the ground. When we checked the boxes in the morning, ants had already found their way up the cord to the bird boxes.

Avian Husbandry

***Food Preparation*:** Food was prepared at the base camp food area. It was placed into four-inch dishes, which were then placed onto a plastic food tray. The food tray easily allowed eight food dishes, eight water bowls, and eight fly containers to be carried simultaneously. We will need three food trays to handle all of the food and water dishes for 24 birds.

***Weighing Birds*:** Before taking weights, the status of all the birds was quickly assessed by looking through the rear viewing window. To weigh a bird, we would lift the plywood platform attached to the perch and place the scale under the platform. Once the scale was centered, we would then place a hand on the far side of the cage and touch the screen window. The bird would then generally fly onto the perch connected to the scale. Getting the weights usually took less than a minute for each bird. We did have some trouble with the wind as it often prevented the scale from stabilizing. We may have to develop a wind block for the scale and perch system.

Photographs 4 and 5. Weighing system and fresh food tray.

***Feeding and Cleaning*:** The actual feeding of the birds and cleaning of the cages went well. When we started to feed and clean the cages, we would first place the fresh food and water on the top of the cages; this practice allowed us to use the food tray to hold the old food bowls as they were removed from the cages. The cage doors were lifted just enough to allow the cage floor tray to be pulled out. Once the cage floor tray was out of the cage, we took the water bowl and threw out the water before placing it on the food tray. We would then remove the old food dish and fly container, and place them on to the food tray as well. The dirty paper was then removed from the cage floor tray and placed on the food tray and replaced with precut paper. A magic marker was used to number each paper as it was placed into the cage. Once the fresh paper was down, we were able to place new food and water dishes onto the cage floor tray. The tray was then placed back into the cage.

Photographs 6 and 7. Peter Luscomb servicing cages; used paper and food dish.

***Cage System*:** The basic system we had for managing birds worked well. The cage system allowed us to easily feed the birds and clean the cages. It was possible to weigh the birds with minimal disturbance and also easily monitor the birds visually to ensure their health. The cages had a trap system that allowed us to extract the bird from the cage without having to place a hand in the cage and seize them. This system greatly reduced the potential stress and injury to the birds.

Food Storage

***Frozen Food*:** We purchased two Yeti coolers, 35 qt and 65 qt, in the hopes that these coolers would keep our bird food frozen. Prior to bringing the coolers to Nihoa, they were placed within a large walk-in freezer and filled with water to at least 1/3 capacity. When the water was frozen, the frozen food items were then placed in the cooler and topped with frozen ice cubes. When the coolers were taken to the boat, dry ice was placed on the top of the ice in the coolers. The coolers were then placed into the ship's freezers. The coolers were brought ashore to Nihoa on 6 Sept. The largest cooler was placed under a rock overhang (out of direct sunlight) just up the trail from the landing site. It was our intent to use this cooler to keep the bulk of the bird food. The plan was to open this cooler only once a day, early in the morning prior to the sun coming up and taking only what we needed for the day. The food taken from the large cooler was then placed into the smaller cooler, which was stored under the tarp at the food preparation area. This cooler would be opened off and on throughout the day when the birds were fed. The larger cooler was only able to keep the bird food frozen for three days. On the morning of 9 Sept., the waxworm cubes were completely thawed. The cooler did keep the contents cold but is was still above freezing and after day one everything started to thaw. There was remaining ice in the coolers for at least two weeks. If additional captive trials on Nihoa are planned, we will have to look at purchasing a propane freezer to ensure that the insects are kept frozen during the whole trip. Frozen food consisted of waxworms frozen in pedialyte in ice cube trays, as well as frozen two-week-old crickets. The crickets were quick frozen in their large rearing cage. Once they were frozen they were placed into Ziploc bags, with each bag holding approximately 150 grams of crickets.

Live Food Acquisition

One goal of the trip was to test and refine techniques to collect and propagate live insects for use as a local and familiar prey source for captive Millerbirds.

Flies**:** P. Luscomb brought two Ridmax fly traps to collect adult flies. The trap system worked very well. With two traps that were baited properly, we could easily collect enough flies to feed the eight birds we housed. When fresh fish was used as a bait source we were able to collect a lot of flies quickly. The one problem was that, in such a hot and dry environment, the fish bait would dry out quickly, becoming less attractive to the flies, and the capture rate would decrease. This problem required that the fly bait be replaced daily. In the future, we will probably need a large enough supply of frozen fish so fly bait can be replaced daily. Once we ran out of fresh fish, we tried fruit cocktail, which also attracted flies in good numbers. The area was so dry that anything with moisture was attractive to the flies. Once the flies were collected in the trap we found we needed to provide the flies with moisture to keep them alive. P. Luscomb had originally planned on using Jello placed on top of the trap to provide the flies with moisture, but because of the temperature the Jello did not solidify and was never used. We did use canned fruit placed on top of the trap, the flies would then fly up to the fruit and eat it through the screen. We also tried to use a piece of sponge dampened with water. However, with the heavy winds, the sponge usually got blown away as soon as it dried. One thing that should be done when feeding out any food item on the top of the trap would be to place a cover over the food source. This step should be taken, so that the trapped flies' food source does not compete with the baited traps in attracting wild flies. We discovered that if the bait was placed elevated on a rock up in the cone of the trap, the trap was more effective in collecting flies. P. Luscomb developed a good system for transferring the flies from the trap to a small container that could be placed into the bird cage. He used a plastic petri dish with a small hole (1 cm) burned into the lid. To transfer the flies from the trap, he turned the trap over and inverted the trap cone. The flies then proceeded to fly to the top of the trap cone and exit the small hole on the top of the cone. If he aligned the hole in the petri dish over the hole in the top of the cone, the flies would exit the cone directly into the petri dish. Once the petri dish was full of flies, he would put the petri dish down on the feed tray so the hole was now on the bottom. The process was then repeated with the next petri dish until the majority of the flies were transferred to petri dishes. The only problem with the petri dish system in managing flies is if a petri dish with flies was allowed to be in direct sun light for any length of time, the flies would die. On one occasion, by the time he have finished filling all of the petri dishes with flies,(approximately eight minutes), the flies in the first six containers were all dead. It is important to make sure that the petri dishes, filled with flies, are put in the shade after the flies are collected.

Maggots**:** In an attempt to raise maggots using fish carcasses, two mullets were placed into an aluminum pan on top of bran. The sides of the mullet were cut to expose the muscle and body cavity to the flies. This technique did generate a few maggots, but not at a level that would have been sufficient to feed the Millerbirds. There were two apparent problems with the maggot set up. Firstly, the fish were placed out in direct sun light and that seemed to dry out the fish very quickly and secondly, there were a lot of carrion beetles in the bran. When P. Luscomb first tried this system on Tinian, he had a fish that was approximately 20 pounds and it was kept under a tree in the shade. The carcass of this fish seemed to be very moist and the whole body was engulfed with maggots. The fish used on Nihoa was a frozen mullet that weighed approximately two pounds. The fish was placed in the direct sun light and dried up quickly and was only able to support a few maggots. The few maggots that were produced fell into bran that was inundated with carrion beetles. It is unclear if the beetles would have eaten the maggots, but it is a concern that will need to be looked into. In the future, P. Luscomb is considering using a rearing formula for flies that utilizes a cereal based diet. This process can be experimented with and techniques can be refined at the zoo before returning to Nihoa.


Photographs 8 and 9. Baited Ridmax fly trap and pit fall trap.

***Cockroaches*:** Eight pit fall traps were set up in an attempt to collect cockroaches. A fermented mixture of water, barley, hops, and yeast was used as an attractant. Plastic 8 oz. Dixie cups were buried in the soil so the lip of the cup was at ground level. The cups were placed around the camp site, typically in or under the vegetation. A rock was placed on the bottom of each cup and the liquid attractant poured into the cup so as not to cover the rock. A plastic cover was elevated over the top of the cups by approximately ½ inch. This cover was used to keep birds from falling into the cup and getting trapped. The cups were checked every morning. This technique did not collect many roaches, with two large cockroaches typically caught each night. This technique was stopped after two nights, because of the low capture rate.

Results

***Bird Acclimation*:** The eight birds collected acclimatized to a captive diet smoothly. Though, birds did not eat much on the first day in captivity, with an average weight loss from the capture weight to the next morning weight of 6%, birds were observed consuming flies and showing some interest in the crickets and waxworms on the first day. The greatest weight loss for most birds was seen on the morning of day three; the total average maximum weight loss of all birds was 9% (Figure 4). By the afternoon of day three, the birds were beginning to aggressively eat waxworms and starting to gain weight. On day four, when the birds were released in the evening, their total average weight change from their capture weight was -2%. (Table 5). If birds had to be held on island for a greater length of time, it would require a more dependable method of keeping waxworms frozen to be assured that they remained in good condition. Also, six-week-old crickets would provide the birds with greater nutrition, and bee larvae would be another food source worth considering.

Table 5. Nihoa Millerbird weight changes during captive feeding trials, lower weight limit represents -20% wt loss. (weights in grams).

			Day One					Day Two		Day Three		Day Four	
Band #	**Date captured**	**Time captured**	**Cap. Wt**	**Lower Wt limit**	**1100**	**1400**	**1700**	**0700**	**1700**	**0700**	**1700**	**0700**	**1700**
81601	8-Sep-09	10:05	17.9	14.32	17.4	17.5	17	16.8	16.2	15.7	16.5	16.1	16.9
81704	8-Sep-09	10:05	19.1	15.28	18.7	18.7	18.4	17.3	17.9	17.0	17.9	17.1	17.8
81705	8-Sep-09	11:00	16.8	13.44		16.5	17.7	16.2	17.5	15.8	16.8	16.4	17.4
81706	8-Sep-09	12:00	18.2	14.56		17.6	17.1	17.0	17.1	16.3	17.1	16.7	17.8
81707	9-Sep-09	8:10	18.5	14.8	17.5	19.6	18.1	17.6	17.9	17.6	18.4	17.3	18.2
81708	9-Sep-09	8:30	16.2	12.96	16.5	15.6	15.4	15.0	16.7	15.6	16.4	15.4	16.1
81709	9-Sep-09	8:45	17.6	14.08	16.7	16.4	16.3	15.7	15.2	15.4	16.0	15.4	16.9
81710	9-Sep-09	10:20	18.6	14.88	18.3	17.9	17.9	18.4	18.9	17.8	20.6	17.8	18.9

10. APPENDIX IV: Nihoa Island trip report, September 6–October 5, 2010

The following is an abbreviated version of the trip report from September 2010 containing the relevant data concerning the captive feeding trials on Nihoa. The summary graph of weight loss, Figure 3 from this trip report, is also Figure 3 in the main text.

To: Trip Report File, U.S. Fish & Wildlife Service, Hawaiian Islands National Wildlife Refuge, Honolulu, Hawai'i.

From: Robby Kohley, Chris Farmer, Daniel Tsukayama, Ruby Hammond, and Walterbea Aldeguer.

Citation: Kohley R., C. Farmer, D. Tsukayama, R. Hammond, and W. Aldeguer. Nihoa Millerbird captive-feeding trials and Nihoa biological monitoring expedition, September 19–October 5, 2010. Nihoa Island, Northwest Hawaiian Islands, Papahānaumokuākea Marine National Monument, USFWS, Honolulu, Hawai'i. All photographs © Robby Kohley/USFWS 2010

Personnel:
Walterbea Aldeguer: Office of Hawaiian Affairs/Papahānaumokuākea Marine National Monument cultural monitor (USFWS volunteer)
Chris Farmer: American Bird Conservancy biologist
Holly Freifeld: USFWS biologist
Ruby Hammond: USFWS biologist
Robby Kohley: USFWS contractor
Sheldon Plentovich: USFWS biologist
Daniel Tsukayama: American Bird Conservancy contractor
George Wallace: American Bird Conservancy biologist

NIHOA MILLERBIRD BANDING

Background and Methods: Mist-netting, banding, and morphometric data collection were carried out using techniques established by MacDonald (2008). Wallace led the biologists in examining the ossification, or pneumatization, of the birds' skull as a possible aging technique. Wallace has extensive experience with using this technique on North American passerines (e.g., Collier and Wallace 1989). Pyle et al. (2008) state that the Nightingale Reed-warbler, another *Acrocephalus* species found on Saipan, can be aged based upon the shape of the primaries and rectrices. Therefore, digital pictures were taken of the spread tail and right wing to examine the ability of plumage characteristics to discriminate between juvenile and adult Millerbirds. The initial goal of capture was to secure individuals for the captive feeding trials (detailed below). Subsequent mist-netting and banding efforts were conducted to increase the overall number of marked individuals in the population. The majority of the banding occurred between the western slope of Camp Ravine (also known as Miller's Valley) and the eastern slope of Middle Valley (USFWS 1984, pg. 19).

Results: A total of 33 Nihoa Millerbirds were captured, comprised of 28 new individuals and 5 recaptures, including two Millerbirds used for the 2009 feeding trials. The preliminary results of using skull pneumatization, feather growth bars, and feather shape to discriminate between juvenile (HY) and adult (AHY) birds were discouraging. Any differences in these features are subtle and will require more intensive study of additional birds captured across multiple years. Mites on the primary feathers were detected on 84% (21/25) of the birds. Representative samples from 17 individuals were collected, stored in isopropyl alcohol, and returned for identification. Dennis LaPointe (USGS-BRD) is working on the identification and taxonomy of these specimens as of 18 October 2010. Fecal samples were collected from 7 individuals, and breast feathers for DNA analysis were collected from 29 individuals.

NIHOA MILLERBIRD CAPTIVE FEEDING TRIALS

Background: The location, infrastructure, and avian husbandry protocols for the 2010 feeding trials were based upon the techniques and knowledge gained during the 2009 feeding trials (Kohley et al. 2009). The goals for the 2010 feeding trials were to hold a larger cohort of Nihoa Millerbirds in captivity for eight full days to more accurately simulate the holding time necessary for a translocation from Nihoa to Laysan. The duration of captivity during the 2009 trials was severely limited because of the inability to maintain frozen food. Acclimating wild caught birds, particularly insectivores, to a diet of non-live food requires providing high-quality frozen food items to the birds. This obstacle was surmounted in 2010 through purchasing a small, portable freezer that was powered through the camp's solar panel array.

Results: The 12 birds collected on 22–23 September were able to successfully transition to a captive diet and were held for the full eight days. The birds did not eat much on the first day in captivity, with a mean relative weight loss of 6.3% from their capture weight (Figure 3). However, the birds were observed consuming live flies and eating small amounts of frozen crickets and waxworms during their first day. Generally, birds had lost the most weight by the morning of day three, with a cumulative mean relative weight loss of 9%. By late morning of day three, the birds were beginning to aggressively eat waxworms and crickets and starting to regain weight. When the birds were released on day eight at their time and place of capture, the overall mean weight change from their capture weight was -2%. Each individual's weight graph is presented below in Figures 1–12.

Photo 1. The holding cages and shelter arrangement for the Nihoa Millerbird captive feeding trials.

An encouraging difference from the 2009 feeding trials was the birds' willingness to take larger, four week old crickets and their consumption of freeze-dried house fly pupae and larvae. Nihoa Millerbirds also showed a willingness to take a wide variety of large prey items when offered opportunistically, e.g., moths, beetles, and cockroaches. This result combined with their consumption of three varieties of non-live food indicates they are true generalists and will consume most appropriately sized food items. The captive diet could be improved by offering more crickets (4–6 weeks old) that have been gut-loaded on a high protein diet; crickets quickly became the captive birds' favorite food, often taken before the waxworms. Additional frozen insect species should be added to the diet to increase the diversity of food items. The birds were not observed eating the dried Avico® Bugs-n-Berries, a commonly used insectivore diet item. Replacement of Avico® Bugs-n-Berries with Kaytee Exact® hand feeding formula, which can be sprinkled on the insects and increase the Millerbirds' caloric intake through secondary consumption, could help minimize weight loss. The success of the 2009 and 2010 feeding trials demonstrates the Millerbirds' elasticity in behavior and diet, and confirms our ability to support the birds for the time necessary to translocate them from Nihoa to Laysan. The diet necessary to maintain the birds in captivity conforms to PMNM's bioquarantine protocols.

These 12 graphs show the actual weight change (grams) for each individual Nihoa Millerbird. The numbered black line is each bird's USGS band number, the green line is the capture weight, and the red line is 20% of the capture weight and indicates the "caution weight". Any bird reaching its caution weight would have been released, but none of the birds did so in 2010 (or 2009; Kohley et al. 2009).

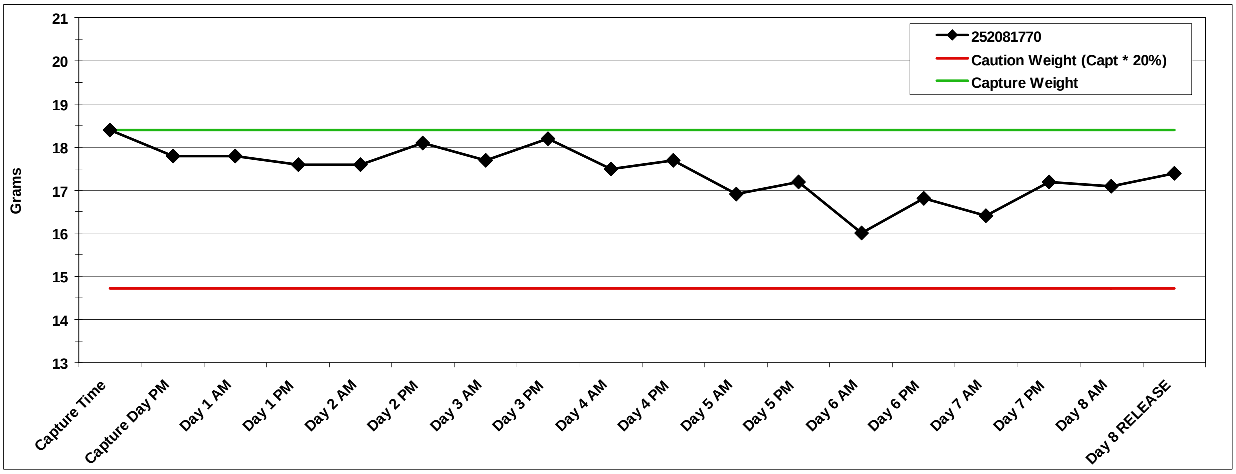


Figure 1. Bird 1 (2520-81770), captured at 10:14 on 22 September 2010.

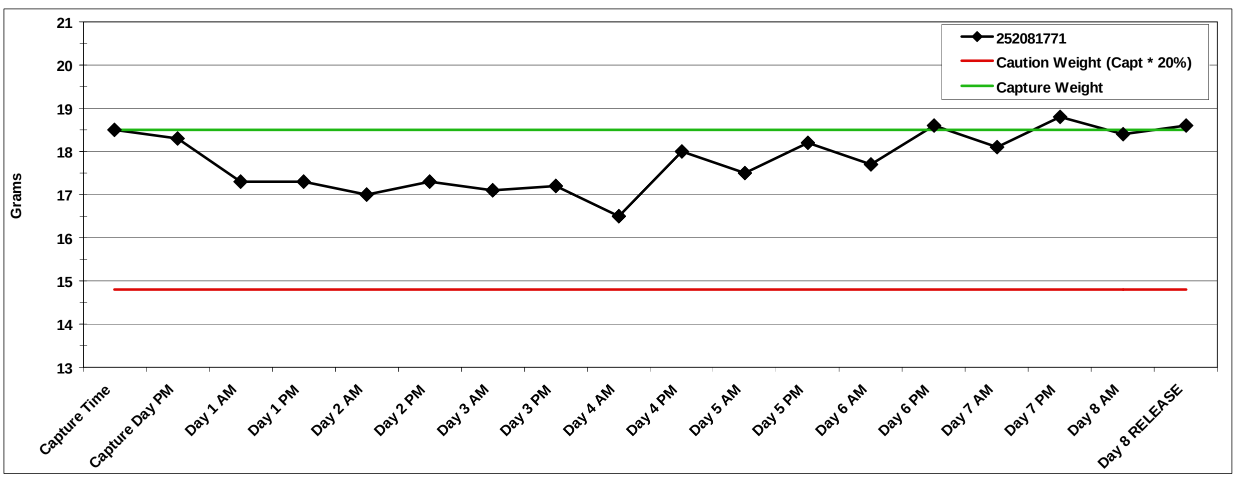


Figure 2. Bird 2 (2520-81771), captured at 11:11 on 22 September 2010.

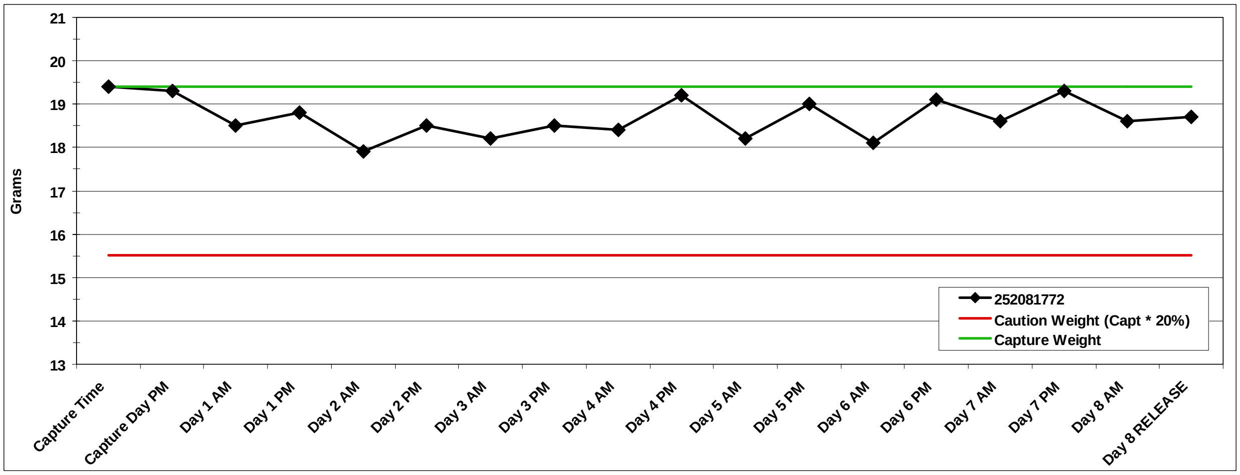


Figure 3. Bird 3 (2520-81772), captured at 11:37 on 22 September 2010.

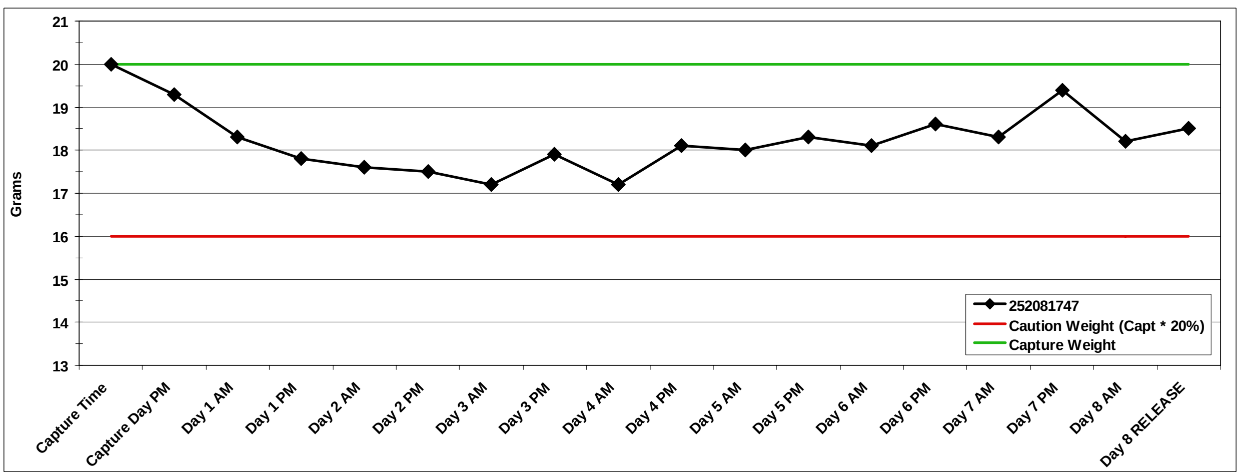


Figure 4. Bird 4 (2520-81747), captured at 12:16 on 22 September 2010.

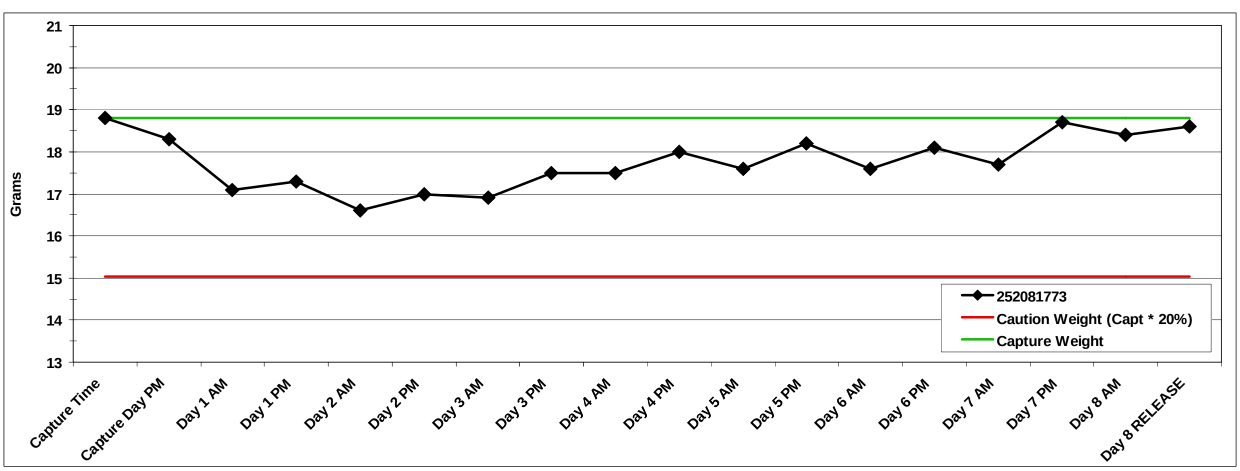


Figure 5. Bird 5 (2520-81773), captured at 13:34 on 22 September 2010.

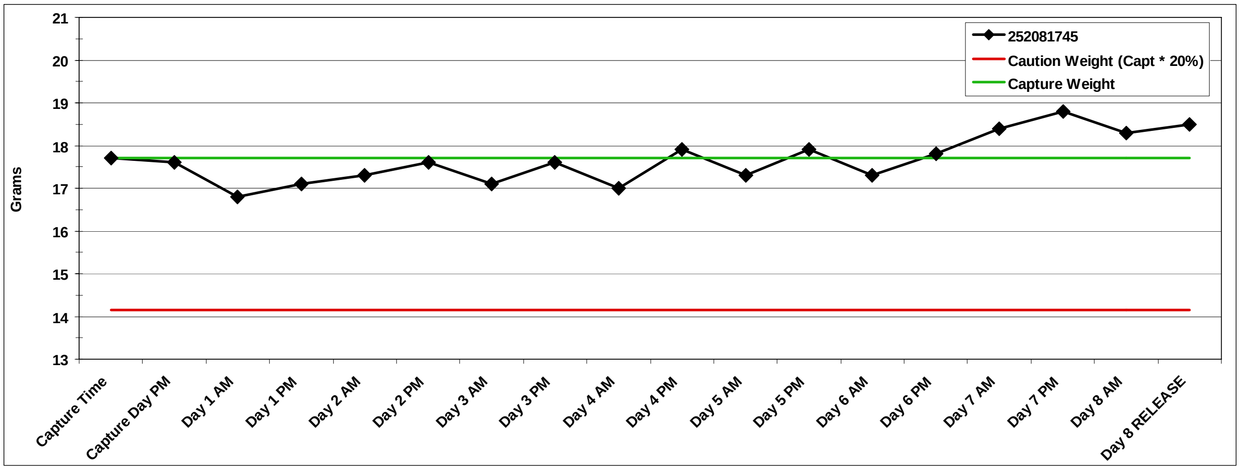


Figure 6. Bird 6 (2520-81745), captured at 09:29 on 23 September 2010.

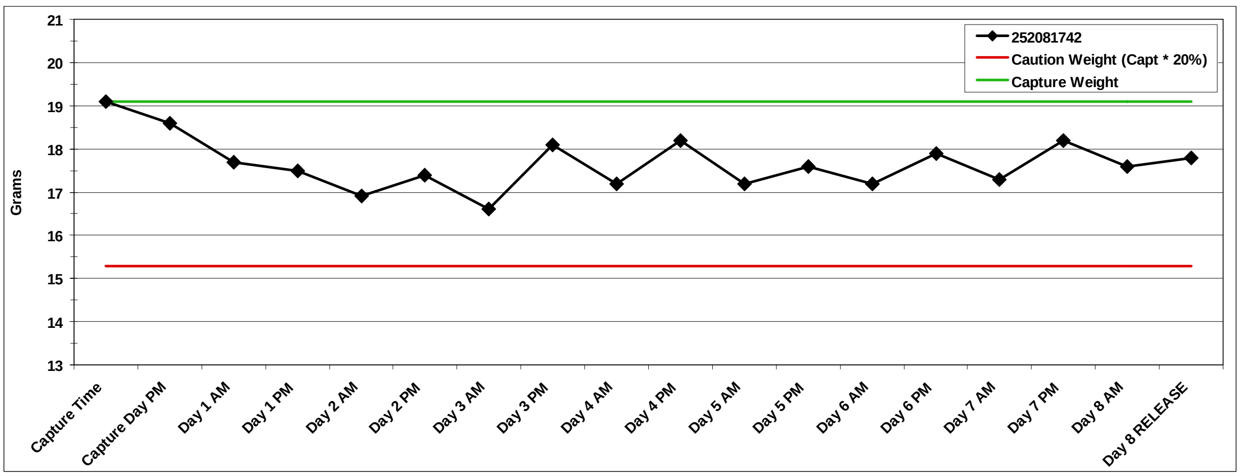


Figure 7. Bird 7 (2520-81742), captured at 10:25 on 23 September 2010.

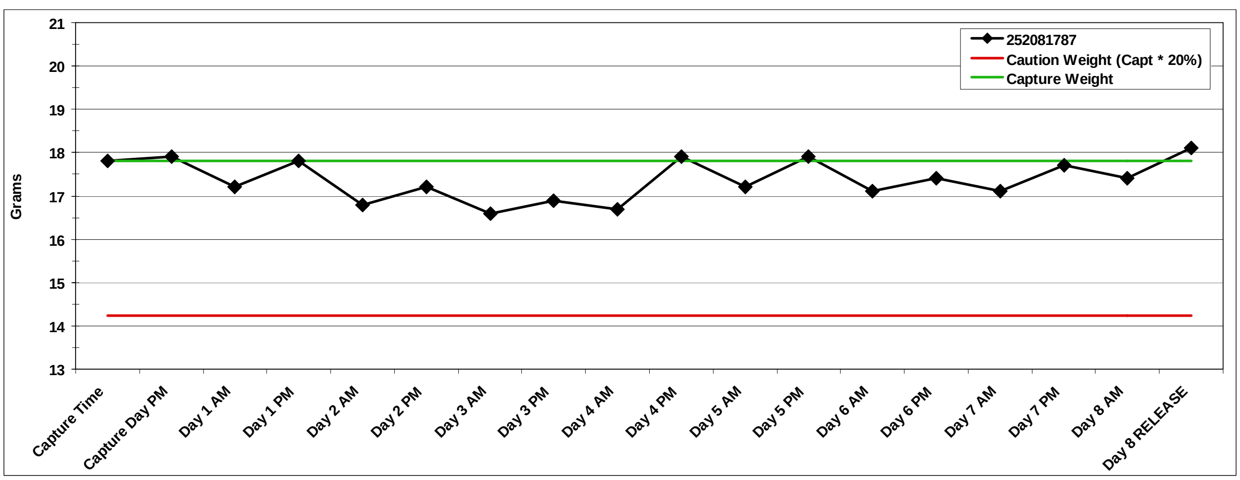


Figure 8. Bird 8 (2520-81787), captured at 11:26 on 23 September 2010.

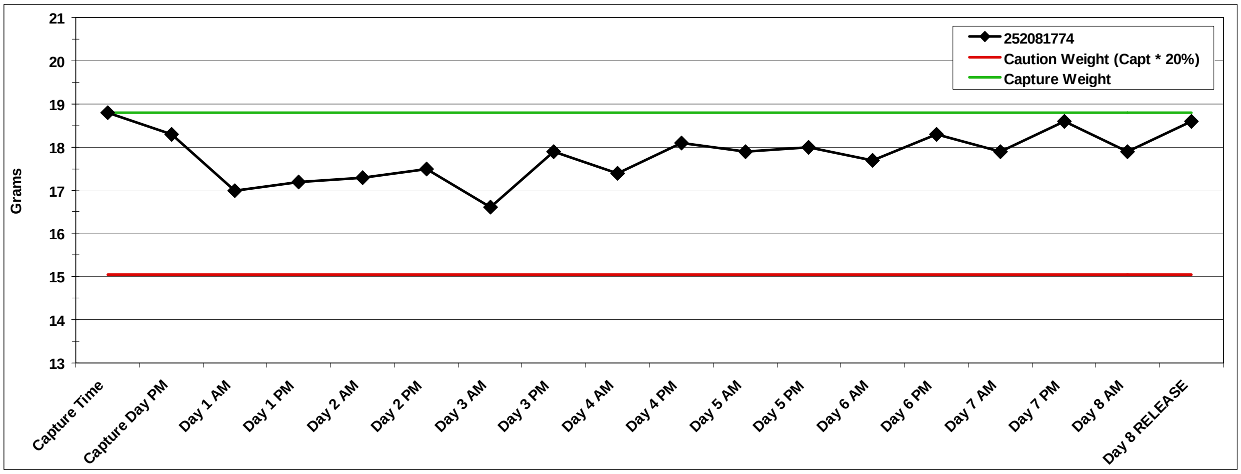


Figure 9. Bird 9 (2520-81774), captured at 11:30 on 23 September 2010.

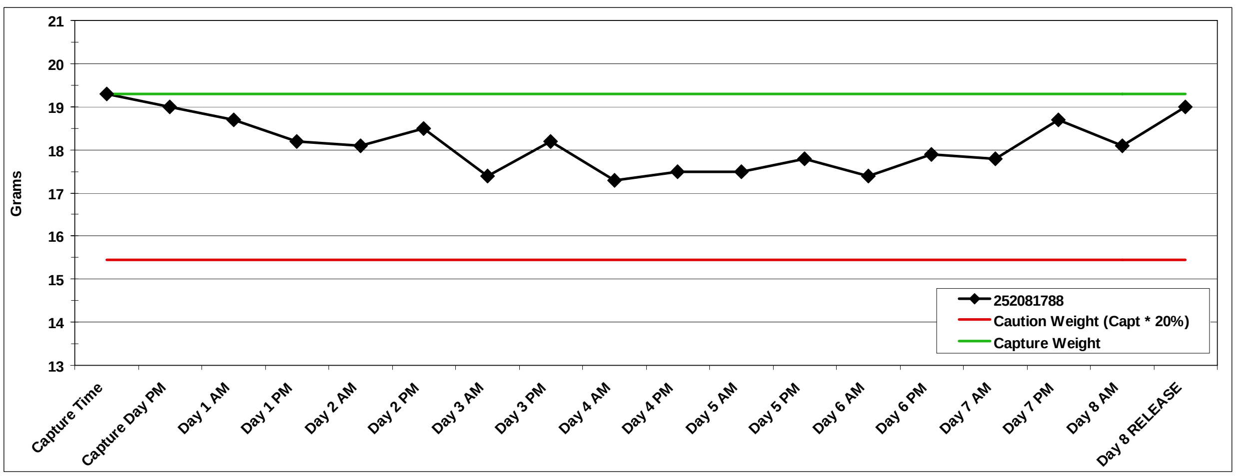


Figure 10. Bird 10 (2520-81788), captured at 12:20 on 23 September 2010.

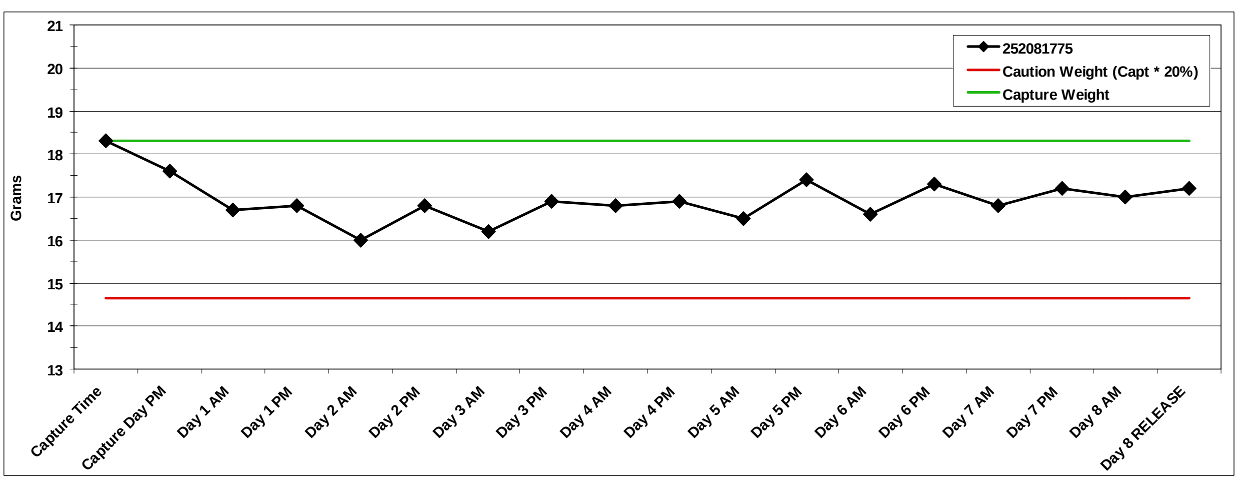


Figure 11. Bird 11 (2520-81775), captured at 12:24 on 23 September 2010.

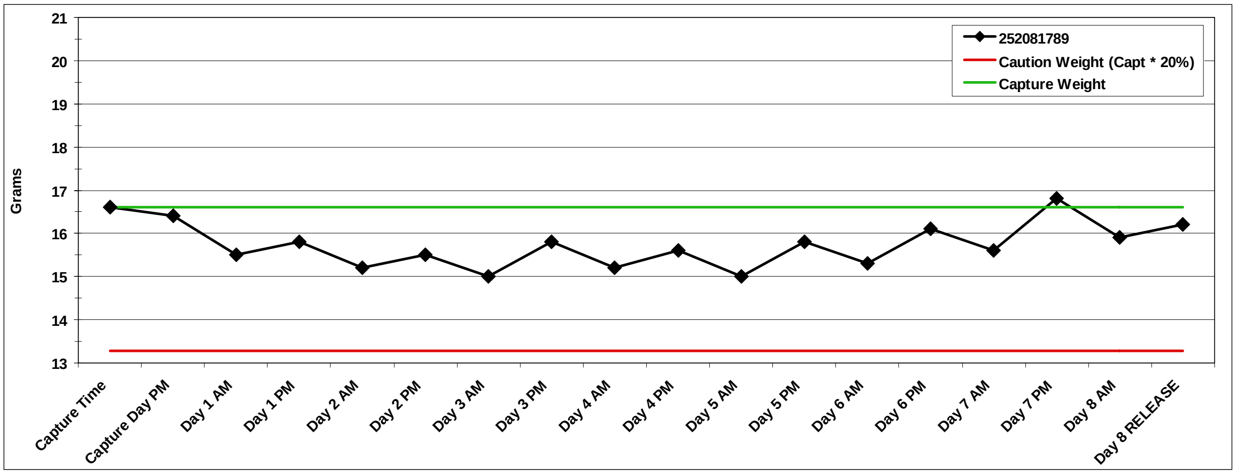


Figure 12. Bird 12 (2520-81789), captured at 12:40 on 23 September 2010.

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11. APPENDIX V: Papahānaumokuākea Marine National Monument Quarantine Protocol

**PAPAHĀNAUMOKUĀKEA MARINE NATIONAL MONUMENT
SPECIAL CONDITIONS AND RULES FOR
MOVING BETWEEN ISLANDS AND ATOLLS
AND PACKING FOR FIELD CAMPS**

June 2007

The islands and atolls of the Papahānaumokuākea Marine National Monument (Monument) and the Hawaiian Islands National Wildlife Refuge are special places providing habitat for many rare, endemic plants and animals. Many of these species are formally listed as Endangered under the Endangered Species Act. Endemic plants and insects, and the predators they support, are especially vulnerable to the introduction of competing or consuming species. Such introductions may cause the extinction of island and reef endemics, or even the destruction of entire island or reef ecological communities. Notable local examples include: the introduction of rabbits to Laysan Island in 1902 which caused the extinction of numerous plant and insect species, and 3 endemic landbird species; the introduction of rats to many Pacific Islands causing the elimination of many burrowing seabird colonies; the introduction of the annual grass, sandbur, to Laysan Island where it has crowded out native bunch grass thus, eliminating nesting habitat for the Endangered Laysan finch; and, the introduction and proliferation of numerous ant species throughout the Pacific Islands to the widespread detriment of endemic plant and insect species.

Several of the islands within the Monument are especially pristine, and as a result are rich in rare and special plants and animals. Nihoa Island has at least 17 endemic and rare insect species, 5 Endangered plants and 2 Endangered birds. Necker Island has Endangered plants and 11 endemic insects. Laysan Island has Endangered plants, 9 endemic arthropods and the Endangered Laysan finch and Laysan duck. Other islands in the Monument such as Lisianski, and islets in Atolls such as Pearl and Hermes Reef and French Frigate Shoals provide homes for a variety of endemic and/or endangered species and require special protection from alien species.

Other Pacific Island such as Kure and the "high islands" (O'ahu, Hawai'i, Maui, Kaua'i, etc.) as well as, certain islands within Midway Atoll, Pearl and Hermes Reef and French Frigate Shoals have plants and/or animals that are of high risk for introduction to the relatively pristine islands discussed above. Of special concerns are snakes, rats, cats, dogs, ants and a variety of other insect and plant species. Harmful plant species of highest concern that we know of are *Verbesina encelioides, Cenchrus echinatus,* and *Setaria verticillata.*

The Co-trustees are responsible for the management and protection of the islands, reefs and wildlife of the Monument. No one is permitted to set foot within the Monument without the express permission of the Co-trustees through the permitting process. Because of the above concerns, the following restrictions on the movement of personnel and materials throughout the Monument exist.

The Following Conditions and Rules apply to the all islands within the Monument with the exception of those at French Frigate Shoals and Midway Atoll:

DEFINITIONS:

"**new**" means off the shelf and never used anywhere but the island in question.
"**clothing**" is all apparel , shoes, socks, over and under garments.
"**soft gear**" is all gear such as daypacks, fannypacks, packing foam or similar material, camera bags, camera/binocular straps, microphone covers, nets, holding or weighing bags, bedding, tents, luggage, or any fabric, fiber, paper or material capable of harboring seeds or insects.

1. Any personnel who will be landing boats, and staying within the boats, at any island should have clean clothes and shoes.

2. Any personnel going ashore at any island and moving inshore from the immediate area in which waves are breaking, or beyond the intertidal area, at the time of landing must have new footwear, new or island specific clothes and new or island specific soft gear. All must be frozen for at least 48 hours prior to landing.

3. Any personnel entering any vegetated area, regardless of how sparse the vegetation, must have new footwear, new clothes and new soft gear all frozen for at least 48 hours prior to landing.

4. To avoid transport of seeds from within small boats the following protocol should be followed. For islands with safe or sandy landing conditions, one should keep quarantine shoes/socks inside quarantine containers until the island is reached. One should go ashore bare foot, and then don the quarantine shoes. Non quarantine shoes should be removed in the small boat, put into a bucket or some kind of sealed container, and left enclosed in that container until the person departs the island. The sealed container, if clean on the outside, may go ashore, but should not be opened ashore. For landings which are rocky, rough, and relatively unsafe (such as Necker and Nihoa) for safety reasons, quarantine shoes should be donned when inside the small boats, but care should be taken to look for seeds and insects which may be in the small boat.

5. Soft gear may not be moved between islands. Hard gear must be thoroughly cleaned and frozen for at least 48 hours between islands.

6. During transit, clothing and gear coming off Kure, Midway, or any islet of French Frigate Shoals must be carefully sequestered to avoid contamination of gear bound for cleaner islands. Special care must be taken to avoid contaminating gear storage areas and quarters aboard transporting vessels with seeds or insects from these islands.

7. Regardless of origin or destination, inspect and clean all equipment, supplies, etc., just prior to any trip to the Monument. Carefully clean all clothing, footwear and softgear following use to minimize risk of cross contamination of materials between islands.

8. Pack supplies in plastic buckets with fitted lids or other sealable metal or plastic containers since they can be thoroughly cleaned inside and out. **Cardboard is not permitted on islands.** Cardboard boxes disintegrate in a short time and harbor seeds, animals, etc., which cannot be easily found or removed. **Wood is not permitted unless sealed (painted or varnished) on all surfaces and frozen for 48 hours.**

   Wooden boxes can also harbor insects and seeds and therefore are only allowed if well constructed (tight fitting seams are required). All wood must be treated, and inside and outside surfaces must be painted or varnished to provide a smooth, cleanable finish that seals all holes.

9. Freeze or tarp and fumigate then seal all equipment (clothes, books, tents, everything) just prior to departure. Food and cooking items need not be fumigated but should be cleaned and frozen, if freezable. Cameras, binoculars, radios, and other electronic equipment must be thoroughly cleaned, including internal inspection whenever possible, but do not need to be frozen or fumigated. Such equipment can only be packed in wooden crates if treated as in #2 above. Any containers must contain new, clean packing materials and be frozen or fumigated.

10. At present, Tern Island is the singular exception to the above rule, having less stringent rules due to the large number of previously established alien species. Careful inspection of all materials and containers is still required. However, it is acceptable to use wooden and cardboard containers for transporting supplies to Tem Island. Also, there is no requirement for freezing or fumigating items disembarked at Tem. Although requirements for Tem Island are more lax, the Refuge is still concerned about the possibilities of new introductions. Do not wear clothing to Tern Island that has been worn at Pearl and Hermes, Midway Atoll or Kure Atoll.

ADDITIONAL SPECIAL CONDITIONS FOR TRAVEL TO NIHOA AND NECKER (MOKUMANAMANA) ISLANDS:

Nihoa and Necker are the most pristine locations in the Monument. Nihoa is home to the highest number of federally listed endangered species in the Monument. Many areas of these small rugged islands are inaccessible. Introduction of any alien species could have disastrous results in a very short time. It would be almost impossible to mount any kind of control or eradication program on these islands should an alien species become established. Because of these reasons, access to Nihoa and Necker are strictly limited, and rules governing entry are more stringent.

1. Access to Nihoa and Necker by permittees will only be allowed under the accompaniment and supervision of a U.S. Fish and Wildlife Service (USFWS) Representative. The representative, who shall be appointed by the U.S. Fish and Wildlife Service Monument Manager will work with permittees to assure careful compliance with all rules for inspection, handling and preparation of equipment. The USFWS Representative will have the authority to control and limit access to various parts of the island to protect animals, plants and archaeological sites, especially endangered species. The USFWS Representative will have the authority to disallow access to the island, or order an immediate departure from the island if conditions for working on the island are not met or are violated in some way.

2. All field equipment made out of fabric material or wood must be new, and never previously used in the Northwestern or main Hawaiian Islands. Equipment previously purchased or made for use on Nihoa and Necker that has been carefully sealed and stored while away from Nihoa and Necker, and not used elsewhere, may also be brought onto the island. Rules for freezing and/or fumigating are as described for other sites in the Monument (see above).

3. Clothing, footwear (shoes, slippers, socks, etc.), daypacks (soft gear) must be new, unused, or previously only used on Nihoa (or Necker) and carefully sealed and stored while off of the island. Hard gear such as camera, and equipment must be thoroughly cleaned and inspected.

ADDITIONAL SPECIAL CONDITIONS FOR TRAVEL WITHIN PEARL AND HERMES ATOLL:

In recent years *Verbesina encelioides* has been introduced to Southeast Island within Pearl and Hermes Atoll. This noxious weed has taken over a large portion of the island. To prevent the further spread of this weed to the other islets within this atoll the following precaution must be taken:

1. Every person should have one set of quarantine gear and clothing for Southeast Island and one set of quarantine gear and clothing for all other islets in the atoll. For instance the same clothing, and if needed camping gear, may be used at north and seal kittery, but anything used at southeast needs to stay off all other islets in the atoll. Do not use the outer islet clothing and gear on Southeast Island.

2. Carefully inspect small boats and their associated equipment when traveling between islets at Pearl and Hermes Atoll. Since folks likely take one anchor ashore and put one anchor in the water there is potential for seed dispersal on anchor lines as well as from within the small boats. This needs to be watched very carefully.

ADDITIONAL SPECIAL CONDITIONS FOR FOOD:

Fresh foods such as fruits, vegetables, leafy vegetables and tubers are not permitted on quarantine enforced islands (Necker, Nihoa, Laysan, Garner Pinnacles, Lisianski and Pearl and Hermes Reef). Concern is not only that certain species such as tomatoes could easily become established but that decomposing organic waste can also harbor microbes and insects and can act as an introduction vector. Soil can contain many seeds, eggs, larvae, etc., and cannot be transported to or between islands.

All other food that can be safely frozen (this does not apply to food in cans or glass jars) must be packaged in air tight containers just as all other gear and frozen for 48 hours.

12. APPENDIX VI: Laysan Island trip report for March 18–April 1, 2010

The following is an abbreviated version of the trip report from March 2010 containing the relevant data concerning the habitat evaluation of Laysan. The vegetation map of Laysan (designated Figure 1 in this trip report) is Figure 4 in the main text.

Citation: Kohley R., C. Farmer, H. Freifeld, and P. Luscomb. 2010. Nihoa Millerbird Pre-translocation Reconnaissance Expedition to Laysan, March 18-April 1, 2010. Laysan Island, Northwest Hawaiian Islands, Papahānaumokuākea Marine National Monument, U.S. Fish and Wildlife Service, Honolulu, Hawai‘i.

Personnel
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GOALS OF LAYSAN TRIP FOR THE NIHOA MILLERBIRD PROJECT

The first goal was to gain first-hand, practical information from the PMNM staff working on Laysan about the process and logistics for initiating and completing a long-term restoration project on Laysan, and begin coordinating translocation of Nihoa Millerbirds (*Acrocephalus familiaris kingi*; NIMI) with current restoration project and the conservation goals of the PMNM.

The second main goal was to learn first-hand about the ecology and landscape of Laysan, particularly facets of the habitat and biota pertinent to planning translocation of Millerbirds to the island. Additionally, we sought to gain knowledge of the logistical constraints to conducting work on Laysan. This information will be used to:

- Determine the personnel and infrastructure necessary to safely transport the birds onto Laysan, and then to the release site.
- Evaluate what resources are available or needed to care for birds while in captivity and for post-release support.
- Determine possible release locations, infrastructure to support holding-cages, and (temporary) footprint needed or available for release cages.
- Determine practical methods for monitoring a released population of NIMI that will yield high-quality information about survival, reproduction, and population establishment and persistence.
- Explore possible positive and negative interactions with the resident biota, and detail possible management responses for all reasonable interactions in the translocation plan.
- Evaluate possible adverse impacts to NIMI of habitat restoration work, infrastructure maintenance, and refuge management activities and suggest possible measures to avoid and minimize these.
- Determine the staffing and logistical needs for monitoring the translocated population.

BACKGROUND

The Nihoa Millerbird is a critically endangered passerine endemic to the island of Nihoa. The NIMI is listed as critically endangered due to its very small range and significant fluctuations in population size (Birdlife International 2009). The non-native grasshopper (*Schistocerca nitens*) undergoes periodic irruptions on Nihoa and has the potential to significantly alter the vegetation, and subsequently the food resources, on which NIMI depend, and thus adding additional impetus for moving NIMI. The island of Laysan had a closely related, endemic Millerbird, *A. f. familiaris*, that was extirpated between 1916 and 1923 when introduced rabbits destroyed the island's vegetation. Morin et al. (1997) provide additional natural history of *Acrocephalus familiaris* in the Northwestern Hawaiian Islands.

The restoration of Laysan is ongoing, with several native plants being outplanted while non-natives are controlled or eradicated according to the strategic plan (Morin and Conant 1998, Papahānaumokuākea Marine National Monument 2008). Although restoration is incomplete, there are currently large areas of vegetation that provide habitat for an insectivorous passerine. In addition to creating a second, insurance population of Nihoa Millerbirds on Laysan, this project will contribute to the restoration of Laysan's ecosystem by translocating *Acrocephalus familiaris* to the island. The translocation of the Nihoa Millerbird is an activity in the PMNM Management Plan (TES-6.2; Papahānaumokuākea Marine National Monument 2008).

COLLABORATION WITH PMNM STAFF AND RESTORATION PROGRAM

We experienced excellent communication and involvement by PMNM staff throughout all stages of this trip. The frequent discussions with staff on-island were particularly fruitful. Laysan Island biological technicians and volunteers staff conducted an introductory tour of all the interior habitats on 23 March for new staff and the NIMI translocation team which provided the structure and context for our Laysan visit. The discussions focused on three topics: distribution and abundance of the present Laysan flora and fauna; the protocols, future plans, and effectiveness of habitat restoration; and camp and island-wide infrastructure. The NIMI translocation team and PMNM staff met at the preferred release area on 26 March and discussed the potential for collaboration and integration of Millerbird releases with other restoration projects on the island. We anticipate continuing this communication and further developing this partnership as this project continues.

SUMMARY OF HABITAT EVALUATION

Area A

This and Area B were the two highest ranked areas based upon our selection criteria (Figure 2). Area A was dominated by *Pluchea indica* overlain with a heavy coating of *Sicyos maximowiczii* vines, and scattered patches of *E. variabilis*. Overall it was a large contiguous patch of apparently suitable habitat. This area has received aggressive *P. indica* removal combined with *C. oahuense* outplantings. The coconut trees (*Cocos nucifera*) adjoin this area, providing a radically different structure than anything else on the island. This area is also close to the camp, thus reducing travel time for moving and monitoring NIMI.

As we circled Area A and Area B, we discovered that a large patch of *Scaevola taccada* connected both areas, such that these were in fact one Area (Figure 3). Hereafter, we combined the two areas into one, A-B. The combination provides a tremendous amount of species and structural diversity, allowing for the released NIMI to select from a wide variety of options. Area A-B contains nearly every habitat type on Laysan, so we will use any preferences expressed by the NIMI to adaptively modify future release area selections. The area is large enough to support numerous NIMI territories, so hopefully the entire founding cohort will remain in this area.

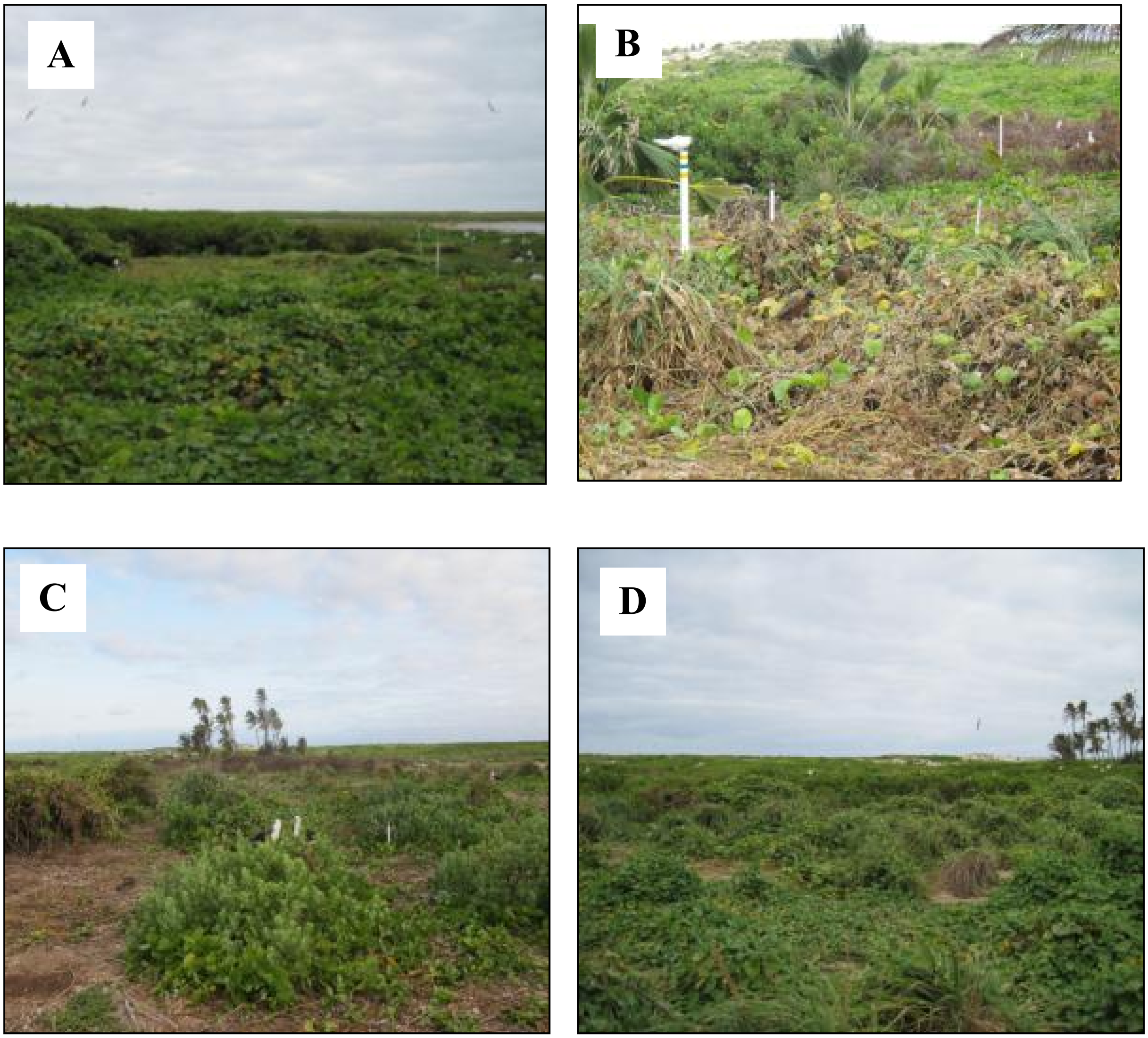

Figure 2A–D. Habitat types in Area A. 2A. Southeastern corner of Area A looking west; *C. oahuense* outplantings in foreground with *S. maximowiczii* covered *P. indica* in the background. **2B.** Northeastern corner of Area A looking northwest; dying *S. maximowiczii* vines and scattered *E. variabilis* in foreground with *P. indica*, *S. taccada*, and a few *C. nucifera* in the background. **2C.** Southwestern corner of Area A looking northeast; view dominated by *S. maximowiczii* and *P. indica.* **2D.** Southwestern corner of Area A looking north; *S. maximowiczii* covered *P. indica* with scattered *E. variabilis.*

Figure 3. Large patch of *S. taccada* that connects Area A and B. The picture is taken from the northern edge of the patch, between area A and B, looking east.

Area B

This area was similar to Area A, but the *P. indica* was more linear and sparser (Figure 1), and there was far less *S. maximowiczii* (Figure 4). Overall Area B was smaller than A, but, as noted above, our evaluation determined this area should be combined with Area A.

Figure 4. Area B. The *S. taccada* patch in the background connecting it to Area A is shown in the background.

Area C

This area was composed of scattered *S. taccada* patches, with limited *P. indica* and *E. variabilis*, and lots of bare ground. It was not selected due to its limited species diversity and structural composition, and overall small size with no connectivity to other suitable habitats (Figure 5).

Figure 5. Area C. This area was nearly all *S. taccada* and was isolated from other types of vegetation so had limited habitat and structural diversity.

Area D

Although this was a large area, it was mostly small *E. variabilis* patches covered in *S. maximowiczii*, with lots of openings in the habitat (Figure 6). Sicyos is a seasonal plant which dies back during fall and winter. NIMI do not use *E. variabilis* on Nihoa, so we did not weigh the presence of this grass heavily in our evaluation. However, the extinct Laysan Millerbird used *E. variabilis* for nesting (Morin et al. 1997). This area was also the furthest from camp (Figure 1).

Figure 6. **Area D.** The patchy *E. variabilis* covered by *S. maximowiczii* that was common in Area D.

PLUCHEA INDICA REMOVAL AND *CHENOPODIUM OAHUENSE* REVEGETATION EFFORTS

PMNM staff and volunteers are removing the invasive *P. indica* in accordance with the PMNM General Management Plan (Activity HMC-4.3; Papahānaumokuākea Marine National Monument 2008). The density and structure of *P. indica* make it a plant that would likely be utilized by NIMI, but due to the aggressive timeline of the PMNM for *P. indica* removal it is unlikely to be abundant during the NIMI translocation (tentatively scheduled for September 2011). The current Laysan restoration timeline aims to have all the *P. indica* removed from Area A-B by September 2011. However the dead *P. indica* biomass is collected into brushpiles, providing excellent arthropod habitat and potential NIMI habitat. We attempted to incorporate this change in the island's habitat, and thus discounted the presence of *P. indica* at an area. We believe that Area A–B still contains enough species diversity and connectivity without including *P. indica* to support a population of released NIMI. The PMNM is replanting the removal areas with six key plant species: anaunau (*Lepidium bidentatum),*lou‘lu palm *(Pritchardia remota), S. fallax,* koali awa *(Ipomoea indica),* Laysan sedge *(Cyperus pennatiformis),* and *C. oahuense. C. oahuense* is currently used by NIMI on Nihoa, is one of the favored breeding sites, and would provide familiar habitat for NIMI on Laysan. The staff on-island felt that one of the major limitations to their revegetation effort is the number of seedlings they can propagate and outplant. *C. oahuense* propagation is limited by shade-house space and water, which could be addressed with minimal infrastructure investment. The NIMI project is providing materials to erect a water catchment system and new shade-house near the *Cocos* grove in the northern interior (Figure 1), which is in proximity to the current *P. indica* removal and revegetation site, and in the middle of Area A-B.

Propagation and outplanting of *S. fallax* on Laysan has not been successful to date. The seeds used are from Nihoa, where the species is an upright, tall shrub growing in soil derived from basalt; Laysan substrate is derived from coralline rock. The *S. fallax* propagation on Laysan may switch to using seeds from O'ahu, where this plant is prostrate and low-lying, but soil type are similar to Laysan. Establishing S. *fallax* on Laysan would increase species diversity on the island, but we do not view it as a prerequisite for translocating NIMI.

13. APPENDIX VII: AUTHORS' RESPONSE TO EXTERNAL REVIEW, 15 AUGUST 2011.

The Nihoa Millerbird (*Acrocephalus familiaris kingi*) is a critically endangered passerine found only on Nihoa Island in the Northwestern Hawaiian Islands, part of Papahānaumokuākea Marine National Monument (PMNM). Biologists and managers have recommended translocating this species to another of the Northwestern Hawaiian Islands for over 30 years to reduce its risk of extinction. PMNM (2008) and U.S. Fish and Wildlife Service (1984) had determined that translocation of this species was an important recovery and restoration activity for three reasons: (1) increase the abundance and distribution of Millerbirds, and thus reduce the threat of extinction (Sincock 1979, USFWS 1984, Morin et al. 1997); (2) achieving one of the activities explicitly stated within PMNM Management Plan (2008) to safeguard and recover the Monument's endangered animals; (3) restore or recreate functionality within the native ecosystem of Laysan (Morin and Conant 1998, PMNM 2008). The USFWS sponsored scoping and site evaluation overwhelming selected Laysan as the most suitable release site for Millerbirds (Morin and Conant 2007).

The Nihoa Millerbird Translocation Protocols were written as a blueprint for how USFWS could implement and accomplish the translocation of Millerbirds using the best biological practices possible. The Protocols were intentionally limited to the procedures for the translocation, transport, release, and monitoring in the first year of establishing a Millerbird population on Laysan. Several reviewers suggested addressing larger scale issues (e.g., climate change), and although the treatment of such issues was expanded in the final version, a comprehensive consideration of actions and effects beyond the one year timeframe was beyond the scope of the Protocols. The authors recognize that the Protocols' activities are just the initial steps in creating an additional self-sustaining population, and that actual long-term monitoring on Laysan and a more active, realistic, and comprehensive conservation strategy for Millerbirds are urgently needed. The actions described by these Protocols provide the opportunity to learn how to translocate Millerbirds and establish an additional population under circumstances uncomplicated by the presence of alien predators or pathogens, and in an environment where this species previously occurred. The techniques and solutions gained in the 2011 translocation will serve as a critical foundation of knowledge and experience when we take on more challenging translocation scenarios in the future.

We received responses from 17 reviewers from four countries that served to greatly improve the final version. The authors' general responses to reviewers' concerns are detailed below. The reviewers' suggestions concerning clarity and technical editing were accepted and incorporated without further comment.

Pre-translocation Millerbird population assessment. Several reviewers inquired if there was going to be a population survey before the translocation began. The USFWS Refuges' present population monitoring system has high levels of variability, with the 2010 estimate ranging from 212–802 Millerbirds on Nihoa (Figure 2, pp. 4–5). Previous annual surveys have had similar or greater relative uncertainty, making the utility of a single point-estimate very low, and detection of trends between years nearly impossible. Therefore, the translocation team decided the information provided by a complete, pre-translocation transect survey did not justify the additional impacts to Nihoa's biological and cultural resources, or the substantial additional costs. A qualitative habitat reconnaissance flight was conducted 7 July 2011, indicating the island was covered in green and apparently healthy vegetation, presumably favoring arthropod production and Millerbird breeding.

One reviewer suggested that the current population monitoring was inadequate and needed to be more scientifically rigorous. The authors agree, but the current USFWS Refuges' data is the best available (pp. 4–5). In collaboration with USFWS, USGS-BRD is addressing these concerns and examining ways to improve the survey methods, but results of this work are unavailable for management decisions at this time.

Timing and scheduling. Two reviewers suggested conducting the translocation in August, and not September. That was not logistically and financially possible in 2011, but will be considered in the future (p. 10).

Two reviewers with knowledge of recent Millerbird breeding phenology stated that the species' breeding effort seems to be inconsistent among years and there might not be a peak of activity between March and June, as described in the Birds of North America account (Morin et al. 1997). This modification was included in the final Protocols (pp. 4, 24), but does not significantly alter the timing and methods for translocation.

We have been in close and constant communication with National Wildlife Refuge and PMNM staff since the Millerbird translocation became a serious proposal. This has ensured that the timing of translocation does not hinder the restoration of Laysan or the Refuge's numerous other critical tasks. Because the Refuge's and PMNM's concerns were already incorporated, no additional changes to the timeline were necessary.

We have secured sufficient funding and logistical flexibility to have 3–4 buffer days during the translocation process. These buffer days could occur at Nihoa and/or Laysan, and combined with intensive weather monitoring, will maximize our chances of encountering acceptable weather and swell conditions at both islands.

Reduction in distribution and abundance of *Chenopoidum oahuense* on Nihoa. One reviewer provided results and observations indicating that *C. oahuense* is no longer one of the most common plants on Nihoa. These data were incorporated into the Protocols (pp. 3–4, 9).

Impacts of climate change. Several reviewers suggested including a discussion of how climate change will affect Millerbirds, particularly the created population on Laysan. USFWS and PMNM are actively discussing and planning a climate change strategy for all the biota of the Northwestern Hawaiian Islands. A comprehensive treatment of the impacts of climate change and the long-term viability of the Northwestern Hawaiian Islands avifauna is beyond the scope of the Protocols, but a brief overview of possible effects was included (pp. 5–6). Generally, applying the Intergovernmental Panel on Climate Change predictions to Laysan suggests it will lose less than 5% of its area by 2100 (Baker et al. 2006). Translocation will help ensure the survival of the species for the near future (<100 years) through minimizing the risk from catastrophic events or demographic stochasticity. The authors acknowledge that although an important tactic in the species' overall conservation strategy, as an isolated action translocation to Laysan is not sufficient to ensure the long-term persistence of the species. Other additional efforts such as translocation to higher islands will need to be considered (p. 6). The 2011 translocation will provide the time necessary for additional management actions to be planned and enacted to help address the local and regional effects of global climate change.

Translocation cohort composition. The reviewers had a mixed response to the number and age targets, some supporting and some dissenting. The biological rationale was expanded and clarified (pp. 10–13), particularly that 24 was the maximum that the authors believed could be safely transported in the first translocation. Building upon our experiences in 2011, this number might be safely increased in subsequent years, but we did not want to challenge biological and logistical constraints the first year. One reviewer suggested moving fledglings or first-year birds, but this was viewed as biologically infeasible, and the justification expanded and clarified (p. 12). Additionally, we have been unable to develop a reliable method of aging post-fledgling birds, so detecting and capturing sufficient juveniles for translocation would require an extensive field effort prior to translocation to detect and follow the fledglings to independence.

Minimizing handling and cage transfers. Many reviewers were concerned about the number of times the Millerbirds were handled and transferred among cages. Minimizing handling time and transfers would inarguably be less stressful for the birds, but the current plan is the minimum possible while adhering to the PMNM's quarantine guidelines. Additional text (p. 13) was added to clarify some reviewers' questions about handling and time in captivity. One reviewer suggested monitoring the stress level via hormone assay. As the reviewer states, and the authors agree, the birds will be highly stressed during the entire process. Although scientifically interesting, hormone assays would require drawing blood from the birds multiple times. We are attempting to minimize handling time and stress, so decided that subjecting birds to repeated blood collection was not justified by the possible benefits to the birds.

Remote PCR analysis. Several reviewers were concerned about the practicality and reliability of conducting PCR on Nihoa (p. 11), but one member of the translocation team has extensive experience in this technique. She has used the exact lab set-up we will use during translocation to successfully sex Millerbirds using feathers collected in 2010. The authors clarified that both the morphometric-based discriminate function analysis and the PCR will be used to sex the captured Millerbirds (pp. 12–13).

Radio transmitter attachment. In response to the many reviewer comments and concerns, we changed the radio-telemetry methods (p. 15). The transmitters will be attached the morning of release, not the night before, providing less time for the antennas to become entangled in the cage. Additionally, only half the release cohort will have transmitters, not the full cohort as initially proposed. This will allow us to better assess the utility and need for future transmitters on Laysan, and also to minimize the stress and impact on the released Millerbirds. Lastly, we no longer plan to place transmitters on fledglings (pp. 24–25), but will rely upon resights to monitor juvenile dispersal, and use behaviors and genetics to determine pedigree.

Release site and habitat. Several reviewers expressed concern about the amount of *Pluchea indica*, an exotic species targeted for removal by USFWS Refuges, in the release area. We clarified that the actual release site for the cages will be located in *Scaevola taccada* in the northern berm on Laysan (p. 16). We also incorporated text from the USFWS Biological Opinion and current Laysan Finch Best Management Practices that state the *Pluchea* removal will continue. The presence of an additional endangered species will not significantly delay the habitat restoration on Laysan (p. 16). The Refuge's control efforts have substantially reduced the distribution of *Pluchea* in the proposed Millerbird release area (Figure 1, Kristoff et al. 2011). One reviewer was concerned that the effects of the March 2011 tsunami could have negatively impacted the proposed release site. The initial report shows limited inundation of the release area (Figure 92, Kristoff et al. 2011), and that the immersion following a February storm appeared to kill many of the *Pluchea* shrubs in the area (Kristoff et al. 2011).

Millerbird conflicts with Laysan Finch and Ducks.
There was some concern about possible interspecific competition between Millerbirds and Laysan's two resident landbirds, Laysan Finch and Laysan Duck. This concern was reviewed under Section 7 of the Endangered Species Act, and the reasons the competition seems unlikely were greatly expanded here as well (pp. 28–29), focusing on differences in diet, niches, and population sizes. Proving the negative results of competition is difficult under optimal circumstances, but the monitoring team will collect behavioral and habitat use data that should detect qualitative patterns about interactions, behavior, and habitat conflicts. These initial observations will provide the data necessary for USFWS and PMNM to decide if additional translocations are warranted, or an alternative response is more appropriate. If the translocation of the Millerbird results in unacceptable impacts to Laysan's landbirds, there will be additional consultations with PMNM and USFWS to determine the appropriate actions.

Supplemental feeding stations. All reviewers experienced with Laysan suggested that Laysan Finches would empty the feeding stations before Millerbirds could access them. The supplemental feeding stations were redesigned and a novel design will be deployed that will create a localized, high concentration of arthropods such that the finches can neither become trapped nor exhaust the food before Millerbirds access the stations (pp. 16–18). Millerbirds were observed to use an analogous system on Nihoa, the live fly traps shown in Appendix III (photograph 8).

Post-release monitoring. The reviewers provided many helpful comments about various aspects of the post-release monitoring, with some viewing our framework as too intrusive, while others thought it appropriate. We reduced the resighting frequency for the radio-transmittered birds to three times per week, but for those birds with no transmitters kept it at once per week. The reviewers provided a mixed response concerning dispersal and detectability, with some stating that Millerbirds are not cryptic, while others were concerned about finding the birds once they dispersed from the release site. The combination of the telemetry, a relatively small and open island, and two full-time monitoring staff, encourages us that all birds will eventually be detected post-release. However, we did clarify that the entire island will be searched if necessary (p. 22). The monitoring team will also have the equipment to occasionally conduct playbacks if absolutely necessary, but we did not accept the suggestion from several reviewers to use this as a regular part of the monitoring (pp. 22–23). Routine playbacks could disrupt territorial formation and maintenance, and possibly breeding. There is also the chance that birds could become habituated to playbacks over time, and we want to reserve the ability to use this technique when it is absolutely necessary.

There was a mixed response to the targets in Table 1 (p. 21), with some viewing them as too high, too low, or realistic. These estimates were calculated based upon data from other *Acrocephalus* (Millerbirds and Seychelles Warbler), other translocations, and the translocation team's experience with similar projects. However, the translocation process, duration, and physiological stress for the birds will be unique, making it difficult to provide definitive benchmarks based upon previous research. The value and how the results will be used in future actions for the various data types was clarified (pp. 19–25), and possible actions and alternatives if the benchmarks are not met were included (pp. 25–28). We expanded the justification and value of determining the initiation and success of the stages in the breeding cycle (pp. 19, 24–25). Determining the Millerbirds' habitat use and behavior were singled out as potentially unimportant and invasive, but these data are required to determine carrying capacity on Laysan (and eventual construction of a new PVA) and interspecific conflicts with Laysan's other avifauna.

Reviewers were justifiably concerned that one year is insufficient to truly assess the translocation outcome, and does not constitute long-term monitoring. The authors agree, and intend to ensure that monitoring continues, but as stated above, the Protocols are focused on techniques and procedures for the first year. This limitation was clarified (pp. 25–28), and the need for true long-term monitoring (≥5 years) to assess the success of translocation was emphasized (p. 31). Discussions among all the stakeholders continue as of August 2011 about how to fund and implement the necessary actions in subsequent years.

All of our monitoring will be conducted to minimize the impact on all of Laysan's species, but several reviewers mentioned the statements of caution in monitoring and minimizing the impacts on other species were repetitious, so some were removed. However, this in no way lessens our concern for the resources on Laysan and need for caution. This is especially true regarding nest monitoring – there is invaluable data that can only be collected from nest observations, but the monitoring team will always minimize disturbance and avoid jeopardizing nest success. The 2011 monitoring crew leader (R. Kohley) has extensive experience with nest monitoring of numerous species, has worked in delicate island ecosystems (including both Laysan and Nihoa), and is one of the primary authors of the Protocols.

Additional literature review. There were some suggestions to include a more comprehensive review of translocation science and history. These Protocols were intended as a set of working guidelines for the Millerbird translocation with sufficient historical and literature support to inform the development and explanation of the proposed actions. If the additional references were relevant to understanding or assessing the proposed actions, they were included, but the authors decided not to expand this document into a more general review of translocation literature.

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