Feasibility Assessment of ‘Alae ‘Ula (Hawaiian Common Gallinule; *Gallinula galeata sandvicensis*) Reintroduction to a Third Island

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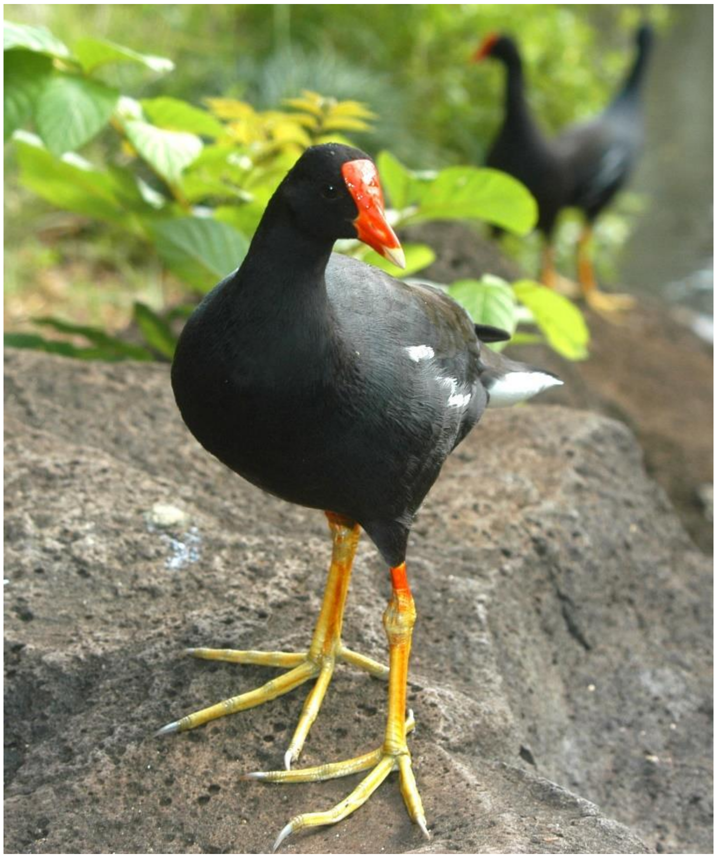

‘Alae ‘Ula at Waimea Falls, O‘ahu. Photo by Eric VanderWerf

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DLNR = Department of Land and Natural Resources
DOFAW= Division of Forestry and Wildlife
DHHL = Department of Hawaiian Homelands
ESA = Endangered Species Act
NPS = National Park Service
PPT = Parts per Thousand (a measure of salinity)
PRC = Pacific Rim Conservation
USACE = U.S. Army Corps of Engineers
USFWS = U.S. Fish and Wildlife Service

EXECUTIVE SUMMARY

The ‘Alae ‘Ula or Hawaiian Common Gallinule (*Gallinula galeata sandvicensis*) is a subspecies of the Common Gallinule that is endemic to the Hawaiian Islands. The English name previously was Hawaiian Common Moorhen, and it is listed as endangered under the U.S. Endangered Species Act and by the State of Hawai‘i by that name. The ‘Alae ‘Ula formerly was common on all five of the largest Hawaiian Islands but it was extirpated from Moloka‘i, Maui, and Hawai‘i and currently occurs only on O‘ahu and Kaua‘i. The primary threats to the ‘Alae ‘Ula are loss or degradation of freshwater habitat and predation by invasive alien species.

The most recent population estimate is 927 birds (95% CI 678-1235), including 746 (95% CI 571-960) on Kaua‘i and 190 (95% CI 62-425) on O‘ahu, based on a 5-year average of survey data from 2012-2016. The actual population size is likely to be somewhat higher than this because the species occurs in dense vegetation and is sometimes shy and difficult to detect during surveys. They are most numerous at several large wetlands that are considered the “core” wetlands for species recovery.

‘Alae ‘Ula use a variety of primarily freshwater wetland habitats, including natural ponds, marshes, streams, springs, lagoons, wet meadows, taro and lotus fields, aquaculture ponds, reservoirs, and drainage ditches. ‘Alae ‘Ula are known to prefer fresh water but their exact salinity tolerance is not well known. Increasing salinization of coastal wetlands caused by sea level rise and increasing storm surge associated with global climate change is a serious long-term threat. They are opportunistic feeders and have a varied diet that may differ among sites, and includes plants, aquatic insects and other invertebrates, and mollusks.

Previous efforts to re-establish ‘Alae ‘Ula populations on Maui, Moloka‘i, and Hawai‘i in the 1950s through 1980s were unsuccessful but the methods and outcomes of those efforts are useful for planning future reintroduction efforts. The causes of failure in previous reintroductions were thought to be inadequate or discontinued control of non-native predators, poaching, and decline of habitat quality. Similar reintroduction projects with other rail species around the world also are useful for informing ‘Alae ‘Ula reintroduction efforts.

In selecting sources of ‘Alae ‘Ula for translocation, it would be advisable to include birds from both Kaua‘i and O‘ahu to adequately represent existing genetic variation and to spread out any impacts of removal on the source populations. Based on an expert analysis of seven potential sources using six criteria, the best sources of birds for translocation are Hōkūala Resort and Hanalei NWR on Kaua‘i and James Campbell NWR on O‘ahu.

An expert analysis of 16 potential release sites on Maui, Moloka‘i, and Hawai‘i using 19 criteria indicated that the best release sites based on current conditions were ‘Aimakapā Pond on Hawai‘i, and Kanahā Pond, Kealia Pond, Nu‘u, and Waihe‘e on Maui. The site on Moloka‘i with the highest score was Punalau Pond, which ranked seventh overall. There was considerable variation in expert opinion about which potential release sites were best. The only potential release site that currently has suitable habitat is ‘Aimakapā Pond, but there is some doubt about the long-term climate security and potential for increasing salinity at that site. At all other potential reintroduction sites extensive restoration will be required to improve habitat before birds can be reintroduced. Restoration is already underway at the Waihe‘e Refuge, and restoration is planned at Punalau Pond, and those efforts are expected to dramatically improve the habitat, but the efficacy of the restoration work remains to be seen.

Translocation of ‘Alae ‘Ula is feasible using existing knowledge and techniques, but some additional information would be useful in making decisions about release sites, including:

1) more precise data on salinity tolerance of ‘Alae ‘Ula; 2) climate security of certain sites; and 3) territory size of ‘Alae ‘Ula in different habitat types and expected and carrying capacity at different potential release sites. It is recommended that translocations be done over a period of at least two years. If adults are moved, translocations would be best done in the winter months from January to March when habitat quality is likely to be best and prior to the usual breeding season. If juveniles are moved to reduce impacts on the source populations, translocations could be done at any time when young have reached independence. ‘Alae ‘Ula are known to be stressed in captivity, so capture, transport, and release should be done as quickly as possible to avoid mortality. Translocation cohort size is recommended to be no more than 10 birds per year per site, including pairs if possible, to allow rapid capture and release and minimize effects on the source population. A pre-translocation study to identify the gender of birds and breeding pairs is advisable to ensure an equal sex ratio and facilitate rapid capture and translocation of the desired cohort. Factors that will be important to ensuring success are effective long-term habitat management, effective long-term predator control or a predator exclusion fence at the release site, and community engagement and involvement to gain community support.

1. BACKGROUND

1.1. Species Description. The ‘Alae ‘Ula or Hawaiian Common Gallinule (*Gallinula galeata sandvicensis*) is a subspecies of the Common Gallinule that is endemic to the Hawaiian Islands (Bannor and Kiviat 2002, USFWS 2011, van Rees et al. 2021). The taxonomy of this bird has changed several times and the English name previously was Hawaiian Common Moorhen (*Gallinula chloropus sandvicensis*). It was listed under the U.S. Endangered Species Act under that name and is referred to by that name in the recovery plan for the species (USFWS 2011), and it is considered endangered by the State of Hawai’i. The common and scientific names were changed to the current names when the American Ornithologists’ Union split the Common Gallinule, which occurs in North and South America and the Caribbean, from the Common Moorhen, which occurs in Eurasia (Chesser et al. 2011).

‘Alae ‘Ula are superficially similar to the ‘Alae Ke’oke’o or Hawaiian Coot (*Fulica alai*) and often share the same habitats, but they have a red and yellow bill, red frontal shield, white streaks on the flanks, yellow and red legs, and very long toes without lobes (Figure 1). The Hawaiian Common Gallinule differs from continental subspecies of the Common Gallinule in having a shorter wing chord, longer culmen, longer tarsi, and slightly larger body mass (van Rees et al. 2021), and also has been reported to have more reddish color on the front of the legs and a larger red frontal shield on the head (Figure 1). Males and females look similar but males are a little bigger (Bannor and Kiviat 2002). Immature ‘Alae ‘Ula are grayish brown with a pale yellow or brown bill and yellowish legs (Figure 1).

Hawaiian Common Gallinules presumably are descended from individuals that arrived from North or Central America by accident. The lack of genetic differentiation in the Hawaiian Common Gallinule from other subspecies indicates they arrived relatively recently, or that continued immigration has inhibited divergence. Coincidentally, an immature North American Common Gallinule was present on Midway Atoll during the winter of 2022-2023. It is possible that more North American Common Gallinules reach the main Hawaiian Islands but are not noticed among the Hawaiian Common Gallinules.

The Hawaiian name ‘Alae is used for both species of large rails that occur in Hawaii (the coot and the gallinule) and ‘ula means “red” or “to make red” (Pukui and Elbert 1986). Thus ‘Alae ‘Ula means “red rail” or “burnt rail.” The ‘Alae ‘Ula has an important place in Hawaiian mythology and was the keeper of fire for the gods. According to legend, ‘Alae ‘Ula took pity on humans and brought them fire for cooking and warmth, burning its head red in the process (Dibben-Young 2009).

Figure 1. Photographs of adult (left) and immature (center) ‘Alae ‘Ula and ‘Alae Ke‘o Ke‘o (right).

2. CURRENT STATUS

2.1. Historical Distribution and Abundance. ‘Alae ‘Ula were formerly common on all five of the largest Hawaiian Islands (Kaua‘i, O‘ahu, Moloka‘i, Maui, and Hawai‘i) in the 1890s (Munro 1944, Shallenberger 1977, Banko 1987). They apparently were absent from Lāna‘i and Ni‘ihau (Berger 1982), presumably due to the lack of freshwater wetlands on those islands. They disappeared from Hawai`i Island in the 1880s, where they were last reported from Hilo and Ka‘ena (Puna) in 1887 (USFWS 2011). The populations on several islands declined rapidly in the early 1900s, and by 1947 their status was considered precarious on O‘ahu, Maui, and Moloka‘i (Schwartz and Schwartz 1949). ‘Alae ‘Ula disappeared from Maui after the late 1940s and were last observed on Moloka‘i in the late 1950s (Dibben-Young 2009). The total population was reported to have dropped to a low of about 57 individuals, all on Kaua‘i and O‘ahu, in the early 1960s, though that was the number actually observed and it is likely there were more that were undetected (Engilis and Pratt 1993).

2.2. Current Distribution, Abundance, and Population Trend. ‘Alae ‘Ula currently occur only on O‘ahu and Kaua‘i (USFWS 2011, Paxton et al. 2022). Efforts to re-establish ‘Alae ‘Ula populations on Maui, Moloka‘i, and Hawai‘i in the 1950s through 1980s were unsuccessful (for more details see section on previous reintroductions below).

The primary tool used to estimate abundance of waterbirds in Hawai‘i is the Biannual Waterbird Survey, which has been conducted in January and August of each year since 1986 (USFWS 2011, Paxton et al. 2022). The most recent ‘Alae ‘Ula population estimate is 927 birds (95% CI 678-1235), based on a 5-year average of survey data from 2012-2016, including 746 (95% CI 571-960) on Kaua‘i and 190 (95% CI 62-425) on O‘ahu (Paxton et al. 2022). The wide confidence intervals for the population estimates stem from the difficulty in detecting this species during surveys (DesRocher et al. 2008, Paxton et al. 2022). The long-term population trend from 1986-2016 was strongly increasing, with an average annual growth rate of 6.2%, including 9.4% on Kaua‘i and 5.0% on O‘ahu (Paxton et al. 2022). The short-term trend from 2006-2016 showed more modest population growth of 1.0% per year, including 1.6% annual growth on Kaua‘i and 0.4% annual decline on O‘ahu (Paxton et al. 2022).

‘Alae ‘Ula are broadly distributed on Kaua‘i and O‘ahu and occur in many coastal wetlands as well as in lo‘i kalo, rivers, streams, ditches and other freshwater aquatic habitat. They are most numerous at several large wetlands on each island, which are considered the “core” wetlands that are most important for species recovery (Figure 2; USFWS 2011). The core wetlands accounted for almost half (46% in summer and 45% in winter) of all ‘Alae ‘Ula counted during Biannual Waterbird Surveys, and total counts of ‘Alae ‘Ula at all sites were closely correlated with counts at core wetlands ($r = 0.99$ in winter and $r = 0.97$ in summer; Paxton et al. 2022). The core wetlands include Hanalei NWR, Hulē’ia NWR, Lumaha‘i Valley, and Mānā Plains on Kaua‘i, and James Campbell NWR, Pearl Harbor NWR Honouliuli and Waiawa Units, Kawainui Marsh, Marine Corps Base Hawai‘i, and Pouhala Marsh Waterbird Sanctuary on O‘ahu (USFWS 2011).

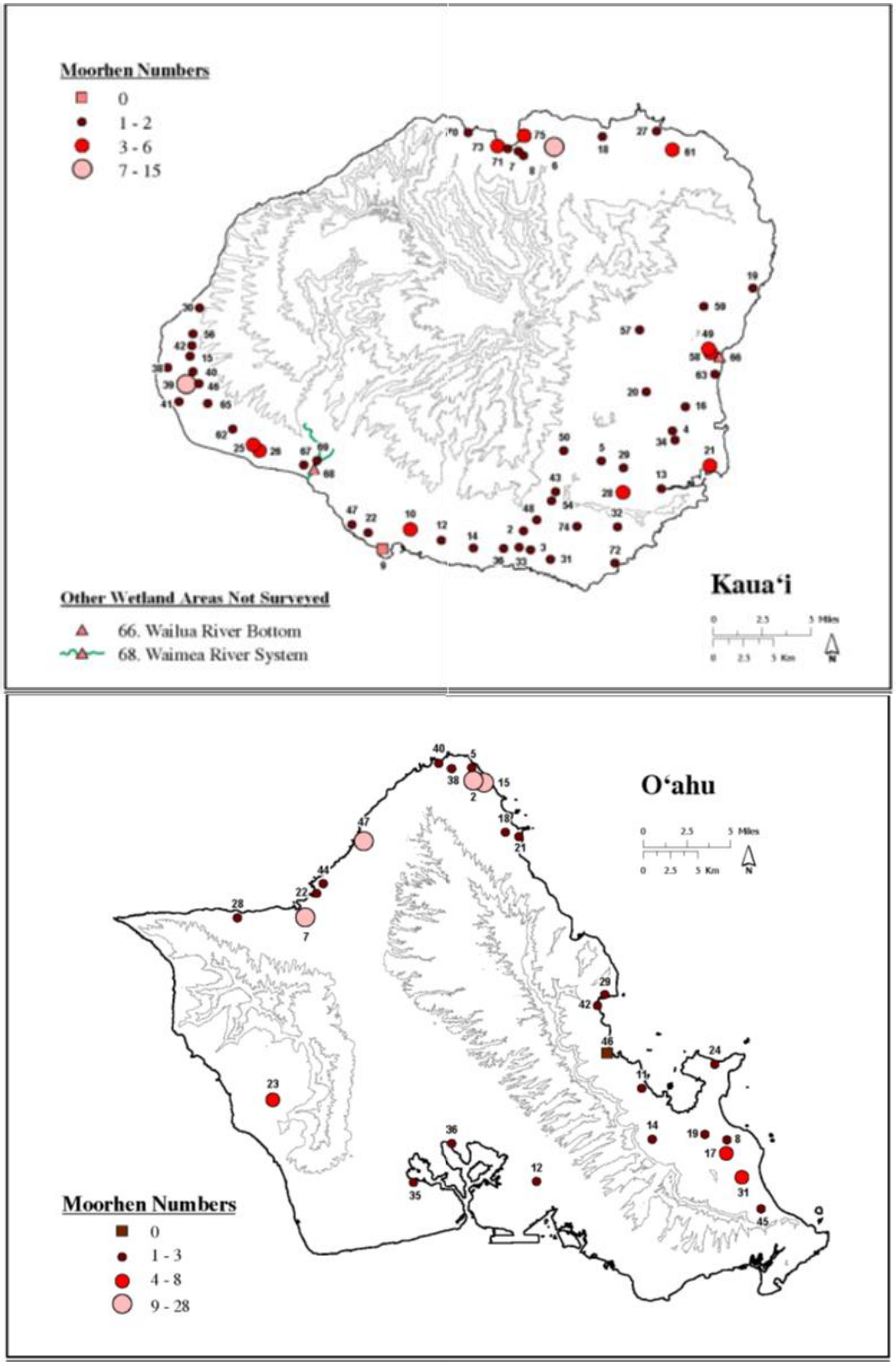


Figure 2. Maps showing abundance and distribution of ʻAlae ʻUla on Kauaʻi and Oʻahu based on counts from 1999-2003. Copied from USFWS (2011). Numbers next to wetlands are sites listed in USFWS (2011).

2.3. Population Genetics.

Van Rees et al. (2018b) found moderately high genetic population structure in the ‘Alae ‘Ula at small geographic scales on O‘ahu, indicating dispersal among subpopulations is limited. They also found asymmetrical gene flow among subpopulations, indicating there probably were only two or three refugia where the species persisted during population bottlenecks, with subsequent expansion into additional sites during the recent recovery period. Sonsthagen et al. (2017, 2018) found that historically there was genetic exchange between Kaua‘i and O‘ahu, but that more recently genetic exchange between the islands has been restricted.

2.4. Ecology.

2.4.1. Foraging Behavior and Diet. ‘Alae ‘Ula usually forage in shallow water with dense emergent vegetation. They are generally shy and often forage while concealed among vegetation, but they are good swimmers and readily cross open water to reach foraging sites. They are thought to be opportunistic feeders and to have a broad and varied diet that may vary among sites, and includes plants, aquatic insects and other invertebrates, and mollusks (Schwartz and Schwartz 1949, Shallenberger 1977). Telfer (unpubl. data, in litt. USFWS 2011) found remains of snails, guava seeds, algae, and other plant material in stomachs of road-killed Hawaiian common moorhens on Kaua`i.

2.4.2. Habitat Use, Preference, and Territory Size. ‘Alae ‘Ula use a variety of primarily freshwater wetland habitats, including natural ponds, marshes, streams, springs or seeps, lagoons, wet meadows, taro and lotus fields, aquaculture ponds, reservoirs, sedimentation basins, sewage ponds, and drainage ditches (Bannor and Kiviat 2002, Banko 1987a; Shallenberger 1977, Nagata 1983; USFWS 2011, van Rees and Reed 2018). According to USFWS (2011), “the key features of habitat…are: 1) dense stands of robust emergent vegetation near open water, 2) floating or barely emergent mats of vegetation, 3) water depth less than 1 meter (3.3 feet), and 4) fresh water (as opposed to saline or brackish water).” In addition, interspersion of emergent vegetation and open water is important for Common Gallinules on the mainland, and presumably is for the Hawaiian subspecies too, with a 50:50 ratio of emergent vegetation and open water being optimal (Weller and Frederickson 1973). ‘Alae ‘Ula are conservation reliant, and continued management of wetlands is necessary to maintain their preferred habitat conditions (Reed et al. 2012).

‘Alae ‘Ula are known to prefer fresh water and rarely use brackish water, but their exact salinity tolerance is not well known. At the Kawai‘ele Sanctuary on Kaua‘i, the number of birds declined from an average of 24 individuals to an average of 10 when the salinity rose to about 20 ppt, and in another instance when the number dropped to just 5 individuals when average salinity rose to about 22 ppt (Jason Vercelli, pers. comm). Similarly, at Hāmākua Marsh State Wildlife Sanctuary, the number of ‘Alae ‘Ula present declined when salinity of the ponds increased (Works 2021, Aaron Works unpubl. data).

‘Alae ‘Ula are territorial; territory size of nesting pairs at Hāmākua Marsh on O`ahu ranged from 853 to 2,416 square meters (9,182 to 26,006 square feet; Smith and Polhemus 2003), but territory size may vary depending on habitat structure and quality and consequent food availability.

2.4.3. Breeding Ecology. Van Rees et al. (2018b) reviewed all that was known about reproduction of the ‘Alae ‘Ula based 252 individual nests monitored from 1979 to 2014 at eight locations on Kaua‘i and O‘ahu where there was active predator control (Nagata 1983, Chang 1990, Gee 2007, Silbernagle unpubl data). Summary data on reproductive rates also were reported by Byrd and Zeillemaker (1981).

Nesting may occur year-round, but most activity occurs from March-August and can be influenced by water levels and vegetation growth, and thus breeding phenology may vary among years (Shallenberger 1977, Byrd and Zeillemaker 1981, Chang 1990, Works 2021). ‘Alae ‘Ula generally nest in areas with shallow freshwater less than 60 centimeters (24 inches) deep, and most nests are concealed within dense emergent vegetation over water (USFWS 2011). The emergent vegetation is folded over into a platform nest (Shallenberger 1977). Where emergent aquatic vegetation is sparse, nests may be placed on the ground, but most nests have tall cover nearby.

Clutch size averaged 5.10 eggs (SD=0.75, range 4.18-6.30) at eight sites and was slightly higher on Kaua‘i than on O‘ahu (Van Rees et al. 2018b). Hatching rate of eggs averaged 52% (SD=12%, range 34%-65%) and did not differ between islands (Van Rees et al. 2018b). The incubation period was reported to range from 19 to 22 days by Byrd and Zeillemaker (1981), while Webber (2022) reported the incubation period to be 25 days. Nest success averaged 66% (SD=11%, range 42%-77%) at six sites combined, with an average of 3.86 chicks per successful nest (SD=0.83, range 2.25-4.51; Van Rees et al. 2018b). Works (2021) reported that fledging success averaged 73% from 2007-2021 (range 13%-96%) and that the number of fledglings per brood averaged 1.5 from 2019 to 2021 (range 0.6 to 2.2). Webber (2022) found daily nest survival probability of 0.979 (95% CI 0.972-0.984) and nest success was 59% at Hanalei NWR. The most common causes of nest failure in eight studies combined were predation (59%), abandonment (33%), and flooding (8%; Van Rees et al. 2018b). Webber (2022) found that at Hanalei NWR predation accounted for only 6% of failures, while flooding caused 21%, and abandonment for unknown reasons was the cause in 73% of failures.

Chicks are semi-precocial and hatch covered with down and able to walk but are dependent on their parents for food for several weeks. Brood sizes have been observed to range from 2 to 7 chicks (mean of 4.4 chicks per brood) at Hāmākua Marsh, O`ahu (Smith and Polhemus 2003). Renesting and multiple broods during one season have been observed (Byrd and Zeillemaker 1981). Nagata (1983) observed that pairs raise two or three broods per year, and Van Rees et al. (2018b) observed one pair that raised four broods in one year.

2.4.4. Survival and Dispersal. Annual adult survival was estimated to be 0.66 (95% CI 0.55-0.76; van Rees et al. 2018b). Van Rees et al. (2018b) reported that survival from hatching to fledging was 42% at JCNWR (Chang 1990) and 37% at Hanalei NWR (Gee 2007). The oldest known Hawaiian Gallinule was 7 years and 8 months (van Rees et al. 2018b). Webber (2022) reported that chick survival was 0.18 ± 0.08 from hatch to 40 days, and that chick survival was lower in the first half of the 40-day, pre-fledging period (0.78 ± 0.05 per 4-day interval) than the second half (0.88 ± 0.09). There is little information on causes of mortality, but Webber (2022) documented 4 barn owl (*Tyto alba*) attacks on chicks and adults in nests within 7 days post-hatch when broods were roosting at night, and one depredation of a chick by a Black-crowned Night-heron (*Nycticorax nycticorax*).

‘Alae ‘Ula are generally sedentary but they may disperse in spring, presumably to breed (Nagata 1983). Dispersal also may occur in relation to dry and wet periods (Engilis and Pratt 1993). The presence of ‘Alae ‘Ula on multiple islands indicates they must have moved among islands in the past. Van Rees et al. (2018b) found zero dispersal by 423 banded birds from O‘ahu to Kaua‘i from 2004-2017, and only three instances of dispersal among wetlands on O‘ahu, with distances moved ranging from 10-47km. Paxton et al. (2022) detected no movement among wetlands on O‘ahu. In the Mariana Common Moorhen (*Gallinula chloropus guami*), site fidelity was lower during dry periods with lower water levels and dispersal among islands occurred following creation of new habitat by heavy rains (Takano and Haig 2004).

Genetic analyses showed that there was historical dispersal between Kaua‘i and O‘ahu in the past, but that more recently gene flow has been restricted between the islands, presumably as a result of a recent population decline and bottleneck (Sonsthagen et al. 2018).

2.4.5. Conservation Status and Threats. The Hawaiian Common Gallinule is listed as endangered under the U.S. Endangered Species Act and by the State of Hawai‘i (USFWS 2011). The Hawaiian Common Gallinule is not considered by the IUCN because it is a subspecies of the Common Gallinule. The ‘Alae ‘Ula is regarded to be conservation reliant, meaning that its continued existence is reliant on human management, including management of water levels and vegetation to maintain its preferred habitat conditions, and control of non-native predators (Reed et al. 2012, Underwood et al. 2013).

The primary threats to the ‘Alae ‘Ula are loss or degradation of freshwater habitat and predation by invasive alien predators. Draining and degradation of wetland habitats for urban and agricultural development was common on all islands in Hawai‘i in the past. Agricultural and urban development has adversely affected the ‘Alae ‘Ula through draining and filling of wetlands, modification and channelization of waterways and shorelines, increased siltation, and altered hydrology that stabilized water levels in some areas and caused fluctuations or flooding in other areas (Berger 1981; Bannor and Kiviat 2002, USFWS 2011, van Rees and Reed 2018b). The decline of taro and rice farming is thought to have contributed to a population decline (Nagata 1983; Bannor and Kiviat 2002). Wetland loss has been higher on O‘ahu (65%) than on Kaua‘i (8%; van Rees and Reed 2014). Hunting was a major cause of decline in the past, and despite being removed from the game bird list in 1941, illegal hunting continued to be a problem for some time (Berger 1981, Nagata 1983, Bannor and Kiviat 2002).

Currently, the most serious threat is predation on eggs, chicks, and adults by non-native predators, including feral cats (*Felis sylvestris*), feral dogs (*Canis familiaris*), small Indian mongooses (*Herpestes auropunctatus*), rats (*Rattus* spp.), bullfrogs (*Rana catesbiana*), and Barn Owls (*Tyto alba*; Berger 1981; Byrd and Zeillemaker 1981; Viernes 1995, Eijzenga 2004). ‘Alae ‘Ula cannot fly for about 25 days each year when they are molting, usually from June-September, increasing their vulnerability to predation (DesRochers et al. 2009).

In the long-term, increasing salinization of coastal wetlands caused by sea level rise and increasing storm surge associated with global climate change is a threat to the ‘Alae ‘Ula, particularly for smaller subpopulations (Kane and Fletcher 2013, Underwood et al. 2013, Kane et al. 2015, van Rees and Reed 2018).

3. TRANSLOCATION FEASIBILITY AND METHODS

As part of this feasibility assessment, experts on Hawaiian waterbirds and Hawaiian wetlands were contacted to gather information about the natural history of the ‘Alae ‘Ula, what criteria should be used in selecting source and release sites, whether any selection criteria were especially important and should be given more weight, and which wetlands would be the best source sites and release sites. A total of 18 experts were interviewed, including 13 by phone and 5 who chose to provide information in writing. The questionnaire used to gather information by phone or in writing is provided as Appendix 1.

3.1. Similar Previous Projects.

3.1.1. Previous Reintroductions of ‘Alae ‘Ula. There were four previous attempts to reintroduce ‘Alae ‘Ula to Moloka‘i, Maui, and Hawai‘i through translocation during the 1950s to 1980s (Dibben-Young 2009, USFWS 2011). Although none were successful in establishing a population in the long-term, the methods and outcomes are useful for planning future reintroduction efforts. Dibben-Young (2009) provided a detailed description of what is known about the first three reintroduction efforts from 1953-1969. A fourth reintroduction effort, on Moloka‘i, was summarized by USFWS (2011). Many of the birds released on other islands were raised at the Honolulu Zoo and were the offspring of three birds collected in 1953 and 1954 at Pearl Harbor and Ka‘a‘awa, O‘ahu (Dibben-Young 2009). In general, the causes of failure in previous reintroductions were thought to be inadequate or discontinued predator control, poaching, and degradation of habitat quality, all of which likely occurred because of an overall lack of concerted project management.

On Maui, at least four releases were made at Kanahā Pond (Medeiros pers. comm. in Litt. Dibben-Young 2009), including six birds on 11 September 1956, seven on 30 January 1957, two on 19 November 1957, and an unknown number of birds in 1959 (Breese 1980). The birds were held in a temporary enclosure placed along the waterline half in the water and half on dry land. A gate on the wetland side was opened to allow their release two weeks later (L. Cambra pers. comm. in Litt. Dibben-Young 2009). Predator control was conducted four days a week and about a dozen of the released moorhens were observed on a regular basis for some time. Predator control eventually was discontinued and the birds quickly disappeared afterwards, with their disappearance attributed to predation by feral dogs (E. Andrade pers. comm. in Litt. Dibben-Young 2009).

On Hawai‘i Island, four to six birds from the Honolulu Zoo were shipped to Hilo on 7 April 1959 and were released on Wailoa Stream in Waipi‘o Valley. The number of birds released differed among sources (Dibben-Young 2009). D. Woodside (pers. comm. in Litt. Dibben-Young) reported that “the four ‘alae ‘ula were extremely alert and wary” when released, and that about a year later only one or two were present, and he speculated that taro farmers or other residents or visitors had killed them for food (Breese 1980). M. Matsunami reported on 22 September 1966 that “some survived four or five years but did not nest successfully” (Banko 1987).

On Moloka‘i, four releases were made by Division of Fish and Game Warden Noah Pekelo, Jr., at three sites: Kalua‘apuhi Pond, Kakahai‘a Pond, and ‘Ipukai‘ole Pond on Kainalu Ranch (Dibben-Young 2009). The exact numbers of birds released at each site and the timing of the releases apparently was not recorded, but Dibben-Young (2009) deduced that two birds from the Honolulu Zoo were shipped to Moloka‘i on 18 November 1960 and released shortly thereafter, followed by six birds released in 1961, 11 in 1962, and 12 on 9 August 1969.

Reproduction occurred following the first three releases, and nineteen gallinules were observed on Molokaʻi in January 1963 and 17 in January 1964 by Pekelo (1964), who reported that gallinules were common but localized in brackish fishponds at ʻŌʻōʻia, Kaluaʻapuhi, and Honomuni ponds. By January 1967, only three moorhens were observed on Molokaʻi, reflecting a hiatus in the release program and also mortality from poaching (Dibben-Young 2009). The numbers declined, and the last observation following those releases was in 1973 (Pekelo pers. comm. to R. Walker; in Litt. Dibben-Young 2009). Six marked birds were released by USFWS staff at Kakahaiʻa National Wildlife Refuge in June 1983. At least two birds were present in January 1984, but there have been no confirmed sightings since 1985 (USFWS 2011).

3.1.2. *Previous Translocations of Related Species*. There have been several previous translocations involving various rail species around the world, and the methods and outcomes of these efforts also are useful in designing the reintroduction strategy for the ʻAlae ʻUla.

In the flightless Aldabra Rail (*Dryolimnas aldabranus*), 20 adults were moved to a cat-free island to create a new population using a soft release approach. Two of the 20 birds died in captivity, but the remaining 18 birds survived and eight breeding pairs formed and bred successfully within two months of release, producing at least 13 chicks (Wanless et al. 2002). The soft release approach was thought to have been important to the success of the project by allowing the birds to acclimate and build up energetic reserves and for monitoring the health of individual birds before release into the wild (Wanless et al. 2002). Aldabra Rails were captured for translocation during the prebreeding period when pair-bonding was occurring but no breeding activity had begun. All the birds were taken from a single island to avoid mixing of possibly distinct populations among islands, and half the birds were taken from the eastern and western ends of the island to increase the chance of representing the genetic variation present. Pairs of rails were usually trapped together and they were held in a holding crate 75x40x45 cm until they could be transported to the release island. Pairs were placed in individual 30 square-meter enclosures and were fed twice daily and weighed opportunistically to help assess their condition. They were released after 6-14 days, when they were judged to have become acclimated and were in good health. All birds were released at a higher body weight than when they were captured. The two birds that died in captivity were thought to have been a pair, but necropsy revealed that both were males and it was suspected that they died from exhaustion caused by fighting (Wanless et al. 2002).

In the Buff Weka (*Gallirallus australis hectori*), reintroduction to a predator-free island resulted in successful establishment of a robust population, but all reintroduction attempts to unfenced main island sites have failed, and predation was suspected as the main cause of failure (Watts et al. 2017). In 2011, 19 individuals comprising 18 subadults and 1 adult were moved. Birds were transported in cat carriers partitioned to accommodate two birds per carrier, with birds held in the carriers for an average of 13 hours (range 2-25 hours; Watts et al. 2017). They were held in a 1-ha enclosure from which predators were excluded by a fence for six weeks to allow them to develop site attachment. Intensive monitoring showed that no birds dispersed away from the release site but that, despite predator control, 12 individuals had been killed by predators within four months after release.

In the Cocos Buff-banded Rail (*Gallirallus philippensis andrewsi*), 39 individuals of unknown sex were moved to a predator-free island in April 2013, which resulted in successful establishment of a new population (Woinarski et al. 2016). Birds were held in cardboard holding boxes for about 2.5 hours during capture and transport, then immediately released upon arrival at the new island because of logistical constraints. At least 30 birds were observed post-release, with an average post-release survival length of 5.1 months and a maximum of 18 months. The presence of unbanded individuals four months after translocation indicated there was reproduction, with the proportion of unbanded individuals increasing over time and about 121 individuals present after two years (Woinarski et al. 2016).

In reintroduction efforts for the Crested Coot (*Fulica cristata*), Tavecchia et al. (2009) examined survival and reproduction of birds raised in captivity by their parents and soft-released 2-12 months after hatching, which revealed that one-third of post-release mortality occurred within the first month after release, likely due to inexperience of captive-bred birds and difficulty in adapting to the wild environment. In addition, birds released during the late winter (February-March) had a greater probability of surviving and reproducing compared to birds released later in the year, which could have been related to better habitat conditions in those months that encouraged birds to stay at the release site and breed instead of dispersing to areas where hazards like hunting, predators, and vehicle collisions were more likely (Tavecchia et al. 2009).

Henderson Crakes (*Zapornia atra*) were cared for in captivity during an attempt to eradicate rats from the island (Oppel et al. 2016), which involved techniques similar to those used in translocations. A total of 108 crakes were captured, including 54 females, 47 males, and 7 of unknown sex, of which 22 died in captivity, 1 escaped, and two were released intentionally. Crakes that died in captivity lost 15%-47% of their body mass during an average of four days in captivity, indicating refusal to eat and starvation was the cause of mortality. The remaining 83 birds were released after 5 months, at which time their body weight did not differ from that at capture. Three breeding pairs laid eggs and raised two young each while in captivity, which were released with their parents. Detailed methods of caring for captive wild birds rarely are reported in the literature, but are extremely valuable and therefore are repeated here verbatim from Oppel et al. (2016):

"Crakes were housed in 1.5 × 3.0 × 0.8 m cages, with side walls comprising a 10 m length of 90 cm wide wire mesh dug about 10 cm into the ground. The four corners were supported by 1.2 m metal reinforcing rods hammered into the ground. Cages were roofed with bird netting sewn onto the wire sides and supported by a central wooden post. Roofs had a small opening with a sliding bolt to allow access for providing food and water. All cages were shaded by natural vegetation, or fronds from coconut (*Cocos nucifera*) trees. We placed natural vegetation inside each enclosure, including small logs and rocks, as shelters for birds. Crakes were also provided with two plastic bowls 17 cm in diameter and 3 cm deep for water and food that could be covered during heavy rain."

"Each morning, crakes were fed with 15 g of Wombaroo Insectivore Rearing Mix (Wombaroo Food Products, Glen Osmond, Australia; 52% protein, 18% carbohydrate, 12% lipid, maximum 5% fibre, 2% calcium, 500 mg/kg taurine, 500 mg/kg carotenoids; metabolisable energy 15 MJ/kg) mixed with water to form a firm paste, and combined with dried raisins; food was replenished at midday if the bowl was empty. A calcium supplement (Vetark Nutrobal, Vetark Professional, Winchester, UK) was added every 3–4 days. Crakes were provided water ad libitum, which was replenished through the day, and an avian probiotic and a critical care formula (Vetark Avipro plus, and Vetark CCF, Vetark Professional, Winchester, UK) were added to the water for the first few days of captivity to combat the effects of stress. These served to replenish vitamins and minerals, gut flora, maltodextrins and included a protein concentrate to aid birds that were reluctant to consume food. Food and water bowls were removed at night to avoid attracting rats and crabs into aviaries; water bowls were scrubbed each morning before refilling with water, and food bowls were cleaned with detergent every evening and allowed to air dry to reduce the risk of bacterial build up and contamination to food in the warm humid conditions. To ensure food recognition and acceptance in the days immediately following capture, we provided live sphingid moth caterpillars (*Gnathothlibus erotus*) or small hermit crabs with shells removed together with the Wombaroo Insectivore RearingMix until we observed crakes eating the mix directly. Similarly, we provided live prey to chicks hatched in captivity (see Results) to aid their development and assist natural instincts and prey recognition."

In situ captive breeding of the Lord Howe Woodhen (*Hypotaenidia sylvestris*) to augment the wild population also offers useful information for ʻAlae ʻUla reintroduction efforts (Portelli and Carlile 2019). In the woodhen project, three wild breeding pairs were taken into captivity, which produced 76 chicks that were released at four sites. Only 13% of released birds were resighted later and the number of birds increased at only one release site and eventually declined at all of them. The original source population from which the three breeding pairs were taken increased rapidly, despite the removal of three pairs, as a result of other management actions. A soft-release strategy was initially employed, whereby woodhen were kept in 100 m2 roofed pens at the release site for two weeks before release (Miller & Mullette 1985). Once a population was established at the first release site (Little Slope), woodhen were released directly into the wild." In 2013, to prepare for a rodent eradication attempt that would use rodenticide expected to cause mortality of woodhens, a trial was conducted to determine whether woodhens could be housed in groups for extended periods (up to 100 days; Taronga Zoo 2014). This involved housing twenty adult woodhens for three months in a single, purpose-built 15 m by 15 m enclosure within an enclosed outdoor greenhouse. All woodhens maintained their body condition on a mixed diet of natural and artificial foods and monitoring confirmed they tolerated living in a group; all were returned in good health to their original territories (Taronga Zoo 2014).

3.2. Potential Source Sites. Several factors should be considered when selecting sources of ʻAlae ʻUla for reintroduction to a third island, which are listed and discussed below. Because the ʻAlae ʻUla occurs only on Kauaʻi and Oʻahu, all potential sources are located on those islands. Because ʻAlae ʻUla on Kauaʻi and Oʻahu differ genetically (Sonsthagen et al. 2017, 2018), it is advisable to include birds from both islands in a reintroduction to adequately represent the existing genetic variation and avoid possible inbreeding depression. The ʻAlae ʻUla went through a relatively recent bottleneck because of wetland loss, and it is possible that the potential for inbreeding depression is low because deleterious alleles were purged during the bottleneck, but it still would be desirable to maximize the amount of genetic variation present in the reintroduced population (Sonsthagen et al. 2017). Taking birds from more than one source also would reduce the demographic impact of removal on any one site.

3.2.1. Criteria for Selecting Source Site(s).

Ownership and management authority. Capturing birds for translocation will require permission of the landowner to access the property and carry out the specified activities. This is true of government-owned lands and private lands.

Landowner capacity and knowledge of site. Knowledge and capacity of the landowner could make several aspects of a translocation easier at the source site. Existing knowledge of ʻAlae ʻUla distribution, habitat use, and territory locations would allow capture of birds more quickly.

Capacity to build holding pens, help monitor captive birds, and provide transportation and other logistical assistance would be beneficial. If the landowner does not have the capacity to help, all activities can be carried out entirely by the entity conducting the translocation, but this would require more funding.

Population size, trend, and impact of removal. One goal of most translocations is to reduce any negative effects on the source population and the species as a whole, and in general the impact of removing birds for translocation will be lower at sites with a larger population (Bain and French 2009, Verdon et al. 2021). If there is information about the population trend at individual sites, this would be useful for assessing the potential impacts of removing birds for translocation. Populations that are stable, increasing, or have high reproduction would be more able to withstand removal of birds for translocation. In declining populations, removal for translocation could accelerate the decline and lead to extirpation. Even a large population could be negatively impacted by removal of birds for translocation if it is already declining.

Rescue opportunity. If certain sites are unsafe for ʻAlae ʻUla or contain populations that are not expected to persist in the long-term because of unmanageable predation or declining habitat quality, or where ʻAlae ʻUla are not desired for some reason, birds can be "rescued" from such populations and used for translocation. This situation could occur at golf courses, wastewater treatment plants, and other sites where there is an incidental risk to ʻAlae ʻUla from hazards such as golf ball strikes, vehicle collisions, and entanglement in equipment. Rescue opportunities have been used in previous bird translocations in Hawaiʻi. Laysan Albatross (*Phoebastria immutabilis*) eggs have been removed from the Pacific Missile Range Facility (PMRF) on Kauaʻi, where they pose a collision hazard with aircraft, and placed in foster nests elsewhere on Kauaʻi (Young et al. 2014). In translocations of Newell's Shearwater (*Puffinus auricularis newelli*) and Hawaiian Petrels (*Pterodroma hawaiiensis*) on Kauaʻi, some chicks were taken from declining colonies that were not expected to persist because of habitat degradation by invasive alien plants and difficulty in effectively managing non-native predators (Young et al. 2021).

Infrastructure and logistics. A variety of logistical factors could make it easier or harder to obtain individuals for translation, including such things as vehicle access, facilities for storing equipment and temporarily housing or caring for birds, or constructing such facilities if needed, and transport time to an airport.

Capture feasibility. Certain aspects of the site might make it easier or harder to capture the prescribed number birds for translocation that are of the desired age class and in a reasonable time period. Such aspects include, but are not limited to, water depth, locations to place and check traps expeditiously, and disturbance to other species.

3.2.2. Kauaʻi. Kauaʻi supports approximately 80% (746 of 927) of the ʻAlae ʻUla population (Paxton et al. 2022) and has several sites at which some of the largest ʻAlae ʻUla numbers are regularly observed, particularly Hanalei National Wildlife Refuge (USFWS 2011).

Hanalei National Wildlife Refuge. The information below was taken from the Hanalei wetland management and waterbird conservation plan (USFWS 2021), the Important Bird Areas information sheet for Hanalei NWR (VanderWerf 2008; https://www.audubon.org/important-bird-areas), and personal communications with Bryn Webber.

The 917-acre (371-hectare) Hanalei National Wildlife Refuge is located in Hanalei Valley on the north shore of the island of Kauaʻi and was established in 1972 to conserve four species of endangered waterbirds and. All of the 917 acres (371 hectares) comprising Hanalei National Wildlife Refuge is owned by the U.S. Fish and Wildlife Service. The refuge consists of 300 acres (121 hectares) of the flat floor of Hanalei Valley, a portion of the Hanalei River, and adjacent slopes and ridges. The valley floor ranges in elevation from 10 feet (3 meters) near the Hanalei Bridge to 40 feet (12 meters) at the refuge's southern boundary, and the refuge extends up to 400 (121 meters) feet on adjacent ridges. Because of its elevation all the water in the refuge is fresh. A portion of the refuge, 186 acres (75 hectares), is used for taro farming under a special use permit. Water from the river is diverted through a system of ditches, channels, and pipelines to irrigate 186 acres of taro fields and 62 acres of wildlife impoundments before returning to the river. Habitats at Hanalei NWR include a section of the Hanalei River, various types of wetlands including open water, emergent wetlands, and taro fields, and upland forest on adjacent slopes and ridges. A paved county road passes through the refuge, providing viewing access to some areas, but the wetland portions of Hanalei NWR are not open to the public.

Hanalei NWR contains the largest population of ʻAlae ʻUla in Hawaiʻi, with an average of 284 individuals detected during the biannual waterbird count from 2018-2023. Paxton et al. (2022) reported that the Kauaʻi population increased 1.6% per year from 2006-2016, but in more recent years there was some indication that the number of birds detected at Hanalei declined over time, from 428 individuals in 2018 to an average of 252 individuals from 2019-2023. The Hanalei population is connected to other nearby populations and has high reproductive output (van Rees et al. 2018a, Bryn Webber pers. comm.). The refuge also supports the largest population of the Koloa or Hawaiian Duck, and large numbers of Hawaiian Stilt, Hawaiian Coot, and Nene or Hawaiian Goose, and a variety of migratory waterfowl, shorebirds, and other wetland birds from August-April. Outbreaks of avian botulism and large mortality events of waterbirds have occurred repeatedly as a result of nutrient-rich sediments, high water temperature, low dissolved oxygen, and fish mortalities (Staab et al. 2022).

Hanalei NWR contains extensive infrastructure, including offices, storage buildings, heavy equipment etc., but the refuge is short-staffed. The refuge staff were made aware of this feasibility assessment, but staff were not able to discuss the project and did not comment on whether they could support the project.

Hōkūala Resort (formerly known as Kauaʻi Lagoons and Westin Lagoons). This privately-owned resort is located in Lihue, Kauaʻi, adjacent to the airport. It contains numerous small wetlands and golf course water features that are attractive to the ʻAlae ʻUla and other waterbird species. In 2012, the USFWS and Hawaiʻi Board of Land and Natural Resources approved a Habitat Conservation Plan (HCP) prepared by Kauaʻi Lagoons LLC and issued them an incidental take permit to cover unintended mortality of endangered and threatened species that occurred at the site (Kauaʻi Lagoons 2012). Under that plan, surveys for ʻAlae ʻUla and other bird species are conducted regularly and predators are controlled to protect waterbird nests (David 2021). Because of the variety of water features present and the effective predator control, a relatively large number of ʻAlae ʻUla are resident at the site and their reproduction is high. An average of 65 ʻAlae ʻUla was detected during summer and winter biannual counts from 2018-

2023 (DOFAW unpubl. data). Similarly, an average 57 ʻAlae ʻUla was detected during 91 counts conducted by Kauaʻi Lagoons LLC from July 2020 to June 2021, and 30 nests were documented to have produced 113 chicks (David 2021). From 2013-2020, a total of 16 ʻAlae ʻUla are known to have been killed by vehicle collisions or golf ball strikes at the site, or an average of two per year (David 2021). Because the site supports a large number of ʻAlae ʻUla and productivity is high, birds could be removed from the site without seriously impacting the population size. Moreover, there are threats that are known to cause mortality, and the ownership probably would be open to having birds removed (R. David, pers. comm.). There is precedent for removing endangered birds from Kauaʻi Lagoons; in 2012, 300 Nene were removed from the resort area and moved to Maui and Hawaiʻi Island to bolster populations on those islands and reduce the number of Nene that sometimes wandered to the Lihue airport.

Mānā Plains. The Mānā Plains are located in coastal southwestern Kauaʻi and contain about 200 acres of wetland habitats distributed in several areas, including the Mānā Plains Forest Reserve (formerly known as the Kawaiʻele Waterbird Sanctuary and the Kawaiʻele Sand Mine, hereafter Kawaiʻele), the Mānā Base Pond, the Mānā House Reservoir, Mānā Ridge Reservoir, and various other ponds and ditches (USFWS 2012). The entire area formerly contained much more extensive wetland habitats totaling about 1,700 acres of permanent and seasonal wetlands, but most of it was drained and extensively modified for sugar cane production in the early 1900s (DOFAW 2014, van Rees and Reed 2014). Some of the current wetlands only provide marginal habitat for endemic Hawaiian waterbirds due to the presence of invasive vegetation, predatory mammals, and invasive fish species. Kawaiʻele is considered a core wetland in the federal recovery plan for Hawaiian waterbirds, and the base pond is considered a supporting wetland (USFWS 2012).

There has been substantial effort to restore and improve wetland habitat in the Mānā Plains, including the designation and expansion of the previous Kawaiʻele Waterbird Sanctuary into the Mānā Plains Forest Reserve (DOFAW 2014). As part of those efforts, a new 105-acre wetland is being created adjacent to the Kawai'ele Sand Mine Pond. About half the area has been graded and partially filled by rainwater, and pumps will soon begin to fill more of the site. Because the new wetland has no invasive fish and there will be capability to manage water levels, this wetland is expected to provide better habitat for waterbirds than the existing Kawai'ele wetland (Jason Vercelli, pers. comm.). It is hoped that ʻAlae ʻUla will naturally colonize the newly created wetland from the adjacent Kawaiʻele Sand Pond and nearby drainage canals.

An average of 27.7 ʻAlae ʻUla was detected in the Mānā Plains during summer and winter biannual state waterbird counts from 2018-2022, with the number ranging from 10 to 31. The number of ʻAlae ʻUla at the Kawaiʻele Sand Pond has fluctuated over time, with fewer birds present during times when the water level is lower and salinity is higher. Because the number of ʻAlae ʻUla present in the Mānā Plains is relatively small and it is hoped that birds will naturally disperse into the new wetland it would not be appropriate to remove ʻAlae ʻUla from the Mānā Plains. Furthermore, if the new wetland is not colonized by ʻAlae ʻUla naturally, they could be translocated there. This would provide an opportunity to test translocation and post-release monitoring methods by moving birds over a short distance with less risk.

3.2.3. Oʻahu. Oʻahu supports about 20% of the ʻAlae ʻUla population (Paxton et al. 2022). The only location on Oʻahu with a large population is James Campbell NWR. Hāmākua Marsh State

Wildlife Sanctuary also supports a fairly large population, which may be connected to some degree with other wetlands on the windward side of Oʻahu, but the number of ʻAlae ʻUla at Hāmākua appears to be declining (see below). Relatively large numbers are recorded during the Biannual State Waterbird survey at Waimea Valley, but that is a small site where detectability is high and the number recorded probably includes most of the birds present.

James Campbell National Wildlife Refuge. The information below was taken from personal communications with refuge biologist Kelly Goodale, and from VanderWerf (2008) and the Important Bird Areas information sheet for James Campbell NWR, which is available at https://www.audubon.org/important-bird-areas.

James Campbell National Wildlife Refuge is located near Kahuku Point at the northern tip of the island of Oʻahu. The refuge consists of three units totalling 1,100 acres; the 126-acre Ki`i unit, the 134-acre Punamano unit, and an 840-acre coastal unit. The Punamano unit contains a natural spring-fed marsh that formerly had deeper water than the Kiʻi unit, but more recently it has become overgrown with invasive plants. The Kiʻi unit contains several large, shallow impoundments that were created as settling ponds for the Kahuku sugar cane mill, which was built in 1890. These ponds were heavily used by waterbirds, but they began to dry up when the mill closed in 1971. In 1976, the ponds were leased from the estate of James Campbell by the U.S. Fish and Wildlife Service and managed as the James Campbell National Wildlife Refuge. In July 2005, the lands comprising the Kiʻi and Punamanō sections, as well as the new coastal section, were purchased from the Estate of James Campbell and are now owned by the U.S. Fish and Wildlife Service.

The primary purpose of the refuge is to protect and manage habitat for recovery of endangered waterbirds. Water levels in the impoundments at Kiʻi can be managed through a series of water control structures and wells to provide habitat for endangered and migratory waterbirds. Habitats include freshwater marsh, open water, emergent aquatic vegetation, mudflats, and adjacent grassland and shrubland dominated by alien plants. Several small islands provide predator-free nesting habitat. The refuge contains several buildings, equipment sheds, and storage containers, a variety of machinery and other equipment that are used for management purposes, and two kiosks that contain educational and interpretive information. The entire perimeter of the refuge is fenced against ungulates. Plans are underway to construct a predator exclusion fence around most of the refuge. The refuge is generally not open to the public, but public tours are conducted on a portion of the refuge by volunteers from October to February when waterbirds are not nesting.

James Campbell NWR contains one of the largest concentrations of wetland birds in Hawaiʻi. It is an important breeding, feeding, and resting area for three birds listed under the U.S. Endangered Species Act; the Hawaiian Stilt, Hawaiian Coot, and Hawaiian Common Moorhen (Hawaiian Gallinule), and also supports large numbers of migratory waterfowl and shorebirds. The number of ʻAlae ʻUla counted during the biannual waterbird counted averaged 77.5 in the last three years in which data were available (2018, 2019, 2022), with an increasing trend over time, from 53.5 in 2018 to 83 and 96 in 2019 and 2022, respectively. This is the second most of any site in Hawaiʻi, after Hanalei NWR. Outbreaks of avian botulism have been less severe and have occurred less often at James Campbell than at many other Hawaiian wetlands, because of water management capabilities and quick response to correct conditions leading to botulism outbreaks.

Pearl Harbor National Wildlife Refuge. The information below was taken from the Important Bird Areas information sheet for Pearl Harbor NWR (VanderWerf (2008; https://www.audubon.org/important-bird-areas).

The Pearl Harbor National Wildlife Refuge contains two wetland units, the Honouliuli and Waiawa units, which are located on the shores of Pearl Harbor, a large estuary on the southern coast of Oʻahu. The Honouliuli and Waiawa units were established in 1972 as mitigation for construction of the Honolulu International Airport Reef Runway, through cooperative efforts by the Federal Aviation Administration, the State of Hawaiʻi, the U.S. Navy, and the U.S. Fish and Wildlife Service. The refuge is owned by the U.S. Navy and managed by the U.S. Fish and Wildlife Service under a cooperative agreement with the U.S. Navy. The 15-hectare (37-acre) Honouliuli Unit borders the West Loch of Pearl Harbor and the 10-hectare (25-acre) Waiawa Unit borders the Middle Loch of Pearl Harbor.

The primary purpose of both units of the refuge is to provide protection and habitat for endangered waterbirds. Habitats at the refuge include open water, freshwater marsh, emergent aquatic vegetation, mudflats, and adjacent upland grassland and shrubland habitats that are dominated by alien plants. The Waiawa Unit is composed of two ponds, one of which is primarily managed for Hawaiian stilts. On-site brackish artesian well water is piped into the ponds for management purposes at the Waiawa Unit. At the Honouliuli Unit, on-site slightly brackish well water is pumped into two ponds. The Honouliuli Unit has greater habitat diversity resulting from fresher water and more gently undulating substrate. The two ponds at Honouliuli can be managed with greater water level flexibility and deeper water levels can be achieved when necessary. Habitats include open water, freshwater marsh, emergent aquatic vegetation, with interspersed mudflats, increasing habitat value for a variety of water-related birds. The Honoulilului unit is protected by a predator exclusion fence, and the Waiawa unit is protected with an ungulate fence. Neither unit is open to the general public. There are no facilities of any kind at either unit, equipment for management activities is brought from James Campbell NWR as needed.

The number of ʻAlae ʻUla at each of the two units of Pearl Harbor National Wildlife Refuge is low. An average of 8.3 adults was detected during summer and winter waterbird count from 2018-2023 at the Honouliuli unit, and three adults were detected at the Waiawa unit in 2023. The Pearl Harbor refuge also supports substantial numbers of Hawaiian Coots and Hawaiian Stilts, and a variety of migratory waterfowl, shorebirds, and other wetland birds from August-April.

Hāmākua Marsh State Waterbird Sanctuary. The information about this site was provided by Aaron Works of the Hawaiʻi Division of Forestry and Wildlife, including Works (2021) and unpublished data.

Hāmākua Marsh State Wildlife Sanctuary (heareafter ʻHāmākua Marsh') is a 91-acre wildlife sanctuary designated for the recovery of federally and state listed endangered waterbirds in Kailua, Oʻahu. Hāmākua Marsh is a seasonally brackish wetland on the windward side of Oʻahu. Hāmākua Marsh has been identified by the U.S. Fish and Wildlife Service as a ʻcore' wetland for the recovery of endangered waterbirds (USFWS 2012).

The wetland portion of Hāmākua Marsh is approximately 23.3 acres in size and is comprised of four basins. Basins A, B, C, and D vary in area (A: 4.6; B: 9.5; C: 6; D: 3.2 acres) and offer different proportions of open water to vegetation or mudflat. The wetland is fed from rainfall and runoff from the adjacent 68-acre Puʻu o ʻEhu hillside. Water from the adjoining

Kawainui Canal will flood the interior of the wetland during the rainy season or when the sand berm at Kailua Beach Park is removed and the ocean tides result in a net increase in water level. The dominant vegetation within the wetland is pickleweed (*Batis maritima*) and saltmarsh bulrush (*Bolboschoenus maritimus*). In 2021, water levels ranged from 0–21.6, 13.2–30.0, 0–22.8, and 0–25.2 inches in Basins A, B, C, and D, respectively. Salinity measurements were taken monthly and ranged from 2–66, 1–11, 1–42, and 2–15 ppt in Basins A, B, C, and D, respectively. Data on salinity and ʻAlae ʻUla abundance collected by Aaron Works of DOFAW in 2021 show an inverse relationship; the number of birds declined when salinity increased (Figure 3).

DOFAW biologists conducted 260 surveys at Hāmākua during 2017–2022 (n=25, n=44, n=45, n=49, n=50, n=47 per year, respectively). The average number of adult ʻAlae ʻUla detected each year was 69, 54, 72, 82, 57, and 34 individuals, respectively (Works 2021, Aaron Works unpubl. data). Fledging success averaged 73% from 2007 to 2021 (range 13% to 96%) and the number of fledglings per brood averaged 1.5 from 2019 to 2021 (range 0.6 to 2.2). There is some indication that abundance and reproduction of ʻAlae ʻUla has declined recently at Hāmākua, with the two lowest values of abundance, nest success, and fledglings per brood all occurring in 2020 and 2021 (Works 2021). Data from the biannual state waterbird count also show a decline, with an average of 38 adult gallinules detected from 2018-2023, with only 25 adults detected in 2023. The cause of the decline is unknown.

View of Hāmākua Marsh State Wildlife Sanctuary. From Works (2021). The basins mentioned in the text are labeled.

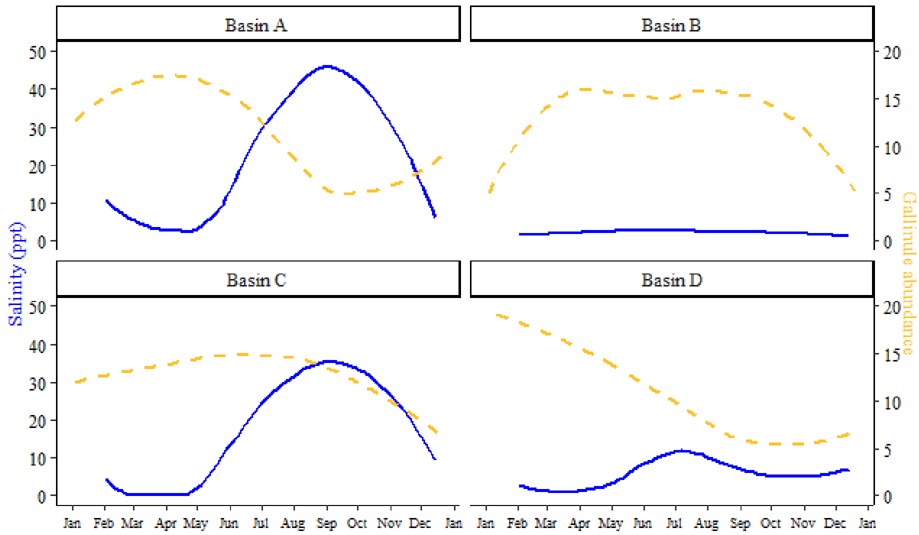


Figure 3. Salinity (ppt) and ʻAlae ʻUla abundance per basin at Hāmākua Marsh State Wildlife Sanctuary in 2021. Unpublished data provided by Aaron Works, DOFAW.

Kawainui Marsh Wildlife Sanctuary. The information about this site was obtained from DOFAW (2011).

Kawainui Marsh is a complex of wetlands located adjacent to Kailua, Oʻahu, encompassing about 830 acres and is the largest remaining wetland in Hawaiʻi. It was recognized as a Ramsar Wetland of International Importance in 2005 and is considered a supporting wetland for recovery of endangered Hawaiian waterbirds (USFWS 2012). The marsh contains several wetland types, including open ponds, Kahanaiki Stream, Maunawili Stream, flood control canals and dikes, and large expanses of dense emergent vegetation. Much of the interior of the marsh is difficult to access because of its large size and dense vegetation. Restoration efforts have been implemented along Kahanaiki Stream and in other areas, and there are ongoing efforts to control invasive alien plants and predators in some areas (DOFAW 2011). The average number of ʻAlae ʻUla detected during summer and winter waterbird counts from 2018-2023 was 14.4. The actual population probably is substantially larger, but much of the wetland is inaccessible and counts typically are made from the periphery.

3.3. Potential Release Sites.

3.3.1. Criteria for Selecting Release Site(s).

Ownership and management authority. Reintroducing the ʻAlae ʻUla and managing the new population will require a long-term commitment and secure management authority. In general, sites that are owned and managed by the government or by a non-profit organization for conservation purposes in the long-term are preferable. Private lands can provide equally suitable habitat along with robust management capabilities but would require a conservation easement or some other form of management assurance. Ownership also could affect what permits and environmental compliance documents would be required to implement the project.

Landowner capacity. Successful release and establishment of ʻAlae ʻUla will require a long-term commitment to maitain the habitat and ongoing labor. The responsibilities and monetary commitment required of the landowner or manager would depend on how the project is funded and implemented, but actions that might be required of the landowner or manager could include construction of release pens and other facilities, conducting or assisting with the releases, monitoring of the birds after release, control of predators and ungulates in perpetuity, maintenance of any fences to exclude predators or ungulates, management of water levels, management of invasive plant species and responding to botulism outbreaks.

Infrastructure and logistics. As with the source site, a variety of logistical factors and presence of existing infrastructure could make it easier or harder to establish and manage a reintroduced population, including such things as vehicle access, facilities for temporarily housing or caring for birds, or ability to construct such facilities if needed, transport time to an airport.

Wetland size. A larger area of wetland habitat is desirable in general because it could support a larger ʻAlae ʻUla population. Small sites might not allow room for population growth and might cause more emigration earlier and might not sustain a population in the long-term. ʻAlae ʻUla sometimes forage in grassy areas adjacent to wetlands, but the size of the wetland itself is of primary importance.

Wetland connectivity. Proximity to other wetlands also could help facilitate population persistence by allowing dispersal among the wetlands (van Rees et al. 2018). This could be especially important in areas where water level declines during dry periods and birds must move to find suitable habitat. Particularly for smaller ʻAlae ʻUla populations at smaller wetlands, they are more likely to persist if they are close to and/or connected to other wetlands, forming something of a metapopulation (van Rees and Reed 2018), so small wetlands could be suitable if they are connected to other wetlands and can be expected to function in concert.

Water salinity. ʻAlae ʻUla are known to prefer fresh water and rarely use even brackish water, but their exact salinity tolerance is not well known. At the Kawaiʻele Sanctuary on Kauaʻi, the number of birds declined from an average of 24 individuals to an average of 10 when the salinity rose to about 20 ppt, and in another instance when the number dropped to just 5 individuals when average salinity rose to about 22 ppt (Jason Vercelli, pers. comm). Similarly, at Hāmākua Marsh the number of ʻAlae ʻUla present in the various ponds was inversely related to their salinity (Works 2021, Aaron Works unpubl. data). Sites with highly saline water would not be suitable even if they have high food abundance and are used extensively by other wetland bird species. At larger wetlands, if there is variation in water salinity only a portion of the site may be suitable for ʻAlae ʻUla.

Water depth and seasonal water level fluctuations. Alae ʻUla prefer shallow water (less than 1 meter) for foraging and nesting and a mix of open water and emergent vegetation. Flooding of nests can be a problem, and sudden drops in water level could reduce suitable foraging habitat and expose nests to predators. Sites that dry out completely during the summer and fall are unlikely to support a population in the long-term, even if this only happens once every few years. Low relief, vegetated islands for nesting may help to protect nests from ground predators. Ability to control water level can help to avoid flooding and desiccation would be beneficial, and also provides a method of managing tilapia and other invasive species.

Hydrology. Sites with stable hydrology are preferable because they are more likely to provide suitable habitat in the future. Various land uses have altered the hydrology in many areas of Hawai‘i, including dredging and channelization of streams, water diversion for agriculture and development, and drilling of wells into the aquifer (van Rees and Reed 2014). At some sites it may be possible to restore the hydrology to some degree, through such actions as filling of drainage canals and removal of invasive plants that draw water from wetlands, including kiawe, mangrove, and *Pluchea*.

Climatic security. Sea level rise is anticipated to alter the hydrology of many coastal areas in Hawai‘i and increase the salinity of many coastal wetlands (Kane et al. 2015) and this could render them less suitable for ‘Alae ‘Ula and decrease their chance of persistence (van Rees and Reed 2018). Wetlands at lower elevation or closer to the coast are generally more vulnerable to climate change (Kane et al. 2015).

Food availability. ‘Alae ‘Ula have a broad diet that includes a variety of plant and animal material, and they prefer a mix of open water and emergent vegetation for foraging, presumably because this habitat structure provides maximal food availability. Sites that have extensive areas of this habitat type would be preferred for releases, and the ability to maintain the habitat in the preferred condition is important.

Nesting habitat. ‘Alae ‘Ula build nests in dense emergent vegetation, so the presence of this habitat type is essential for reproduction and long-term persistence of a population. Islands for nesting may help to protect nests from ground predators.

Ungulate management. Ungulates can trample vegetation and feral pigs especially can damage wetland habitat and prey on nests. If ungulates are present in the area, it is desirable to have a fence capable of excluding them. Ungulate exclusion fences must be inspected and maintained, and the ability to respond quickly to fence breaches is important.

Predator abundance and management. Predation on eggs, juveniles, and adults by invasive non-native animals including feral dogs, feral cats, mongooses, rats, and bullfrogs is a serious threat to the ‘Alae ‘Ula. Predation and inability to adequately control predators in the long-term is thought to have contributed to the failure of some previous ‘Alae ‘Ula reintroduction efforts. The best form of protection against non-native mammalian predators would be a predator exclusion fence (VanderWerf et al. 2014, Young et al. 2018). Predator trapping and removal can be effective and could provide adequate protection, but control efforts must be implemented indefinitely (Reed et al. 2012, Underwood et al. 2013). Bullfrog numbers may be more effectively controlled by seasonal management of salinity. Avian predators also could be a problem, including the native ‘Auku’u or Black-crowned Night-heron (*Nycticorax nycticorax*) and non-native Barn Owls (*Tyto alba*) and Cattle Egrets (*Bubulcus ibis*). These avian predators would be difficult to exclude, but ability to control them if necessary is essential, and their abundance should be considered.

Aquatic invasive species abundance and management. Invasive fish, especially tilapia (*Oreochromis* spp.), are food competitors with ‘Alae ‘Ula. High tilapia abundance can result in low invertebrate abundance and loss of food availability for ‘Alae ‘Ula and other birds. The presence of fish carcasses also can increase the risk of botulism if the carcasses are not removed (see disease risk below). The abundance of tilapia and other fish, and the ability to manage their abundance through water level management and other methods, should be considered in selecting a release site.

Hawaiian Cultural value and support. The ‘Alae ‘Ula is important in Hawaiian culture and is a prominent symbol in Hawaiian legends. Reintroduction of the ‘Alae ‘Ula could help to restore a cultural connection that has been locally lost or diminished, and cultural value and support may vary among locations. Consultation and engagement with the native Hawaiian community interested in conservation should be conducted before a reintroduction. Outreach at a point when plans have already been made is unlikely to be received favorably. Support of cultural practitioners and identification of a cultural group that identifies with the ‘Alae ‘Ula would increase the value of the project and the chance of successful reintroduction.

Community value and support. Support of the local community (in addition to the Hawaiian community) near the release site also is important for maximizing the chance of establishing a viable ‘Alae ‘Ula population in the long-term. Lack of community support, manifested as hunting of birds, is thought to have been a problem in at least one other previous attempt to reintroduce the ‘Alae ‘Ula.

Compatibility with other land uses and potential for conflict. Translocated birds could cause real or perceived problems for the landowner, neighboring landowners or managers, or other stakeholders. The translocated birds may move from the release site to other nearby wetlands. Such potential conflicts include, but are not limited to, restrictions on agricultural uses of wetlands such as taro farming, restrictions on management activities such as mechanical or chemical control of invasive plant species, and seasonal public access closures during nesting season.

Hazards. Mortality of Hawaiian waterbirds, including the ‘Alae ‘Ula, is known to have occurred from several anthropogenic hazards, such as vehicle collisions, and collisions with wind turbines and utility lines, and golf ball strikes. Proximity to hazards such as busy roads, wind turbines, and utility lines could result in increased mortality risk that might be especially important in a small, incipient population.

Disease risk. Avian botulism is a serious threat to wetland birds in Hawai‘i and has affected all native waterbirds species, including the ‘Alae ‘Ula (Work et al. 2010, Reynolds et al. 2020, Staab et al. 2022). The bacterium that causes botulism, *Clostridium botulinum*, is common in wetland sediments and may become more prevalent and produce more of the botulism neurotoxin under certain environmental conditions, such as in warm, stagnant water with low dissolved oxygen (Work et al. 2010, Reynolds et al. 2020, Staab et al. 2022). The toxin can bioaccumulate in invertebrates and fish, and botulism outbreaks can occur when an infected animal dies and maggots feeding on the carcass are eaten by other birds. Methods of controlling botulism include draining the wetland, hazing birds away from the area, and quickly removing carcasses of dead birds and fish to limit disease transmission (Reynolds et al. 2020, Staab et al. 2022). Staab et al. (2022) reported that from 1993 to 2021, botulism outbreaks were most common on Kaua‘i (359), particularly at Hanalei NWR, with fewer outbreaks on Maui (104), O‘ahu (72), and Moloka‘i and Lana‘i (47). Ability to manage water level and capacity to promptly remove carcasses of dead birds and fish killed by botulism could be important in promoting successful reintroduction of ‘Alae ‘Ula.

3.3.2. Maui.

Kealia Pond National Wildlife Refuge. Information about Kealia Pond NWR was taken from the following sources: 1) a refuge fact sheet provided to Eric VanderWerf in 2007 by former refuge manager Glynnis Nakai; 2) a 2001 refuge management plan (USFWS 2001) provided to Eric VanderWerf in 2007 by Glynnis Nakai; 3) personal communication by Eric VanderWerf with current refuge manager Brett Wolfe. The refuge contains several different wetlands that differ in size, salinity, and hydrology. Each is described separately below.

Kealia Pond National Wildlife Refuge occupies a natural basin along the south-central coast of Maui and is one of the largest natural wetlands in Hawai`i. The refuge was established in 1992 to permanently protect and enhance wetland habitat for endangered waterbirds and to provide dependable habitat for migratory wetland birds and wildlife-dependent opportunities for the public. The land occupied by Kealia Pond National Wildlife Refuge is owned by Alexander and Baldwin, Inc., but the U.S. Fish and Wildlife Service has a perpetual conservation easement. It is 280 hectares (691 acres) in size and includes open water (approximately 81 hectares or 200 acres on average), mudflats (182 hectares or 450 acres), and adjacent upland habitat (20 hectares or 50 acres). The large central pond varies in size seasonally, from as low as 40 hectares (100 acres) when water recedes in the hot, dry summer months, to about 182 hectares (450 acres) when water level rises during winter rains from November-March. Water depth ranges from a maximum of approximately 20 cm in summer to 145 cm in winter. The variable water depth and extensive mudflats that surround the pond provide valuable foraging habitat for a variety of birds. Several small islands provide predator-free nesting habitat, and additional nesting habitat is present among shoreline vegetation that surrounds the pond. Recent reconfiguration of the aquaculture ponds through a cooperative agreement with Ducks Unlimited resulted in repair and enhancement of 25 wetland acres and development of an additional water supply that will help provide consistent waterbird habitat. Specific goals of the refuge are to: 1) promote conservation of endangered species, especially endangered Hawaiian stilt and Hawaiian coot, through healthy functioning of this wetland floodplain; 2) optimize water levels for maximum habitat size and value for endangered, resident, and migratory waterbirds while reducing the growth and reproduction of invasive species; 3) expand understanding, appreciation, and stewardship of wetland and coastal ecosystems through wildlife-oriented educational opportunities, visitor services, and active participation of volunteers; 4) develop community partnerships to enhance wetland and watershed habitats. The refuge has extensive infrastructure and facilities, and a permanent, but small, staff. The refuge is fenced against ungulates, and pigs and deer have been nearly eradicated. The Refuge is open to the public for wildlife observation throughout the year, though some areas are closed during stilt and coot nesting seasons to reduce human disturbance. Partnerships with local organizations provide educational and interpretive opportunities. The refuge has an active volunteer program for habitat restoration, wildlife monitoring, environmental education, and maintenance projects. There is on-going predator trapping.

Kealia Pond supports one of the largest concentrations of wetland birds in Hawai`i. It is an important breeding, feeding, and resting area for endangered Hawaiian Stilts and Hawaiian Coots, and the refuge was created to protect these two species in particular. During spring and summer when water levels recede, the refuge may harbor almost half the entire population of Hawaiian Stilts, with a maximum of 1079 individuals observed in July 2003. Hawaiian Coot numbers peak when water levels are higher, with a maximum of 614 birds observed in February 2001.

Main Pond. This is by far the largest of the wetlands on the refuge, at up to 450 acres. The water level and salinity vary seasonally, ranging from about 13.7 ppt in the wet season when water levels are high, to 40+ ppt during the dry season when water level is low. The main pond is fed by Waikapu Stream, but flow in the stream varies substantially depending on the season and recent rainfall. The refuge has some ability to control water level in the main pond and can pump up to 1 million gallons a day into the pond, but even that amount will barely maintain water level during the dry season. It has a complex shoreline with many small bays and there is extensive and varied emergent vegetation along parts of the shoreline. Alien tilapia breed and become numerous during winter months when the pond is full, modifying the substrate with nests. Fish die-offs occur as the water recedes, occasionally promoting outbreaks of botulism.

Kanuimanu impoundments. These five former aquaculture ponds located near the center of the refuge are collectively 25 acres in size. They have no outflow and thus are highly saline, about 120 ppt, because of accumulated salt left by evaporation. The sediment underlying the ponds also has very high salt content. Currently there is no method of controlling water level the impoundments. They currently have no emergent vegetation.

Baitfish Pond. This pond is 3.25 acres in size and is located on the western side of the refuge. It was formerly used to raise fish and was filled with a sump pump, but the pump is no longer functional and the water level cannot be controlled currently. In some years when the water level was high it contained good waterbirds habitat, but it has been mostly dry in recent years.

Kanahā Pond Wildlife Sanctuary (KPWS). Information about this site was obtained from the KPWS management plan (DOFAW 2000), U.S. Army Corps of Engineers (2012), from personal communications with John Medeiros, Scott Fretz, and Sasha Smith of DOFAW, and during a site visit by Eric VanderWerf on 12 October 2023.

Kanahā Pond Wildlife Sanctuary encompasses approximately 237 acres and is located on the north coast of the isthmus of Maui. The property upon which KPWS is situated is owned by the State of Hawai‘i, Department of Transportation and is administered through an inter-agency agreement as a protected wildlife refuge by DOFAW. It is bounded on its northern (makai) side by Amala Place; by an industrial area on its western edge; by an open ditch at its eastern boundary, which is owned by Alexander and Baldwin (A&B); and at its southern (mauka) edges by Kahului Airport Road, Haleakala Highway, and Hana Highway.

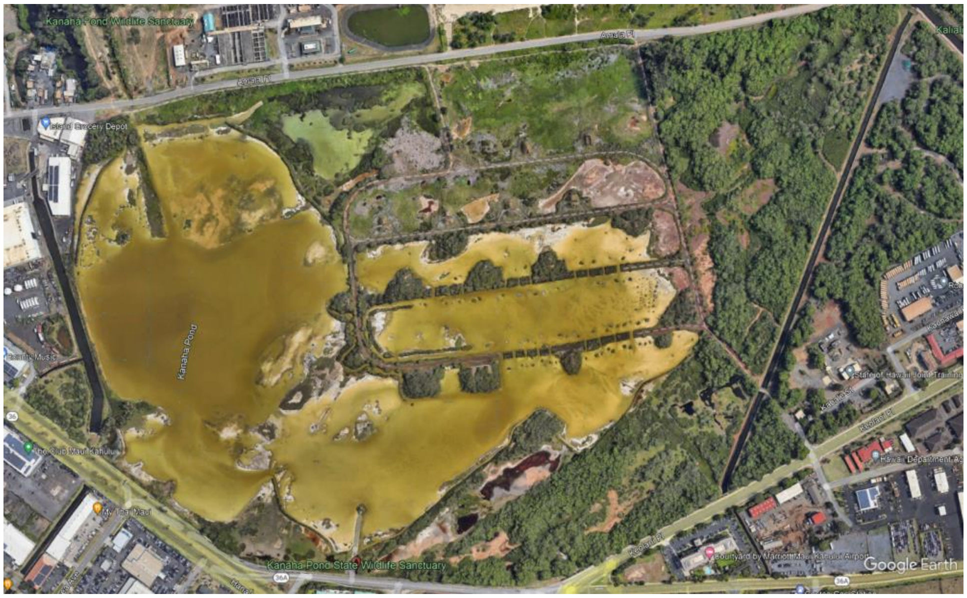
The natural springs and ponds in this area were modified by construction of fishponds during the rule of King ‘Kapi‘iohookalani over two hundred years ago for the purpose of raising fish for human consumption. When Kahului Harbor was dredged around 1910, a portion of Kanahā Pond in the vicinity of Kahului’s Main Street and Haleakala Highway was filled with material dredged from the harbor. During the partial filling of the pond, the existing overflow drainage ditch was replaced with a new channel, with control gates and an outfall to the ocean. The U.S. Navy also altered the land within KPWS considerably during construction of the Naval

Air Station Kahului (NASKA) in the 1940s. During and after World War II, numerous munitions bunkers and access roadways were constructed within the KPWS. As a result of these activities, the northeastern portion of the original pond was filled between 1930 and 1954.

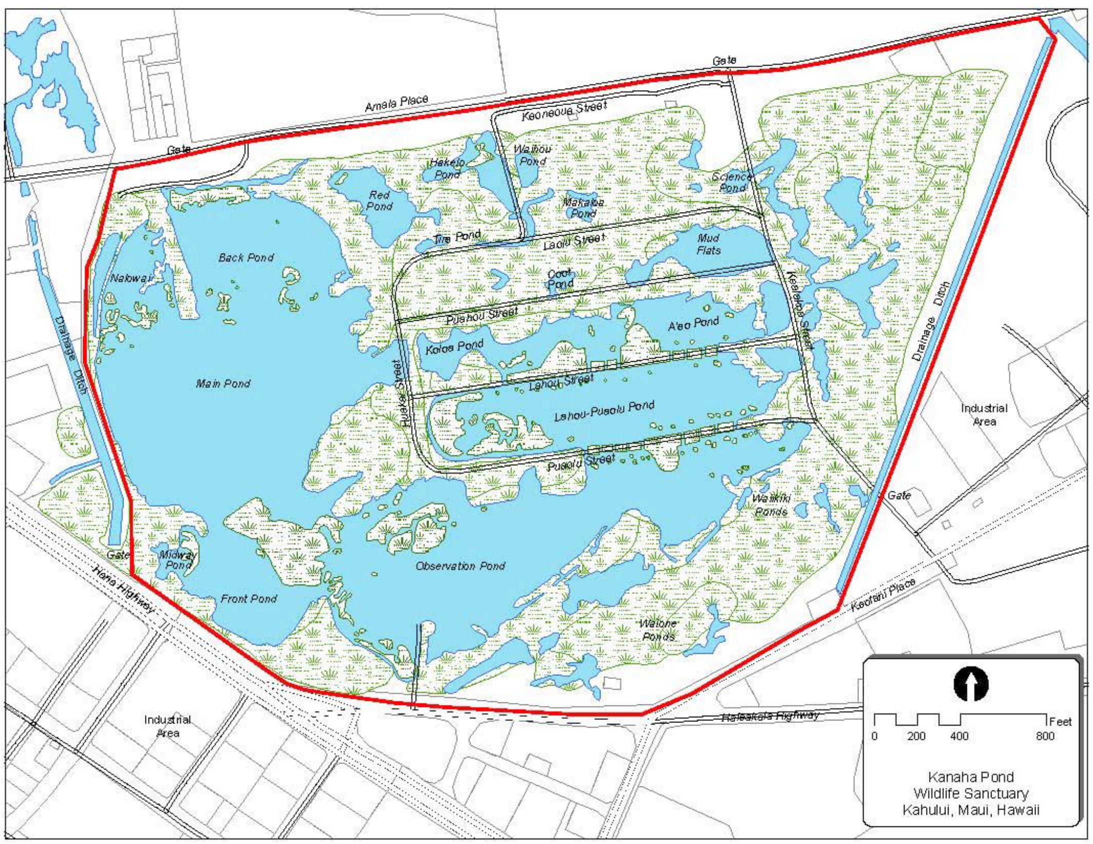
Habitats on the KPWS consist of brackish ponds and associated wetlands, mudflats, and adjacent dry lands with primarily non-native vegetation. The ponds are fed by surface flow and spring water, with fluctuating water levels due to tides and seasonal rainfall patterns. Water depth in the large pond averages about 1.7 feet overall but varies throughout different areas (DOFAW 2000) and is maintained around 1.50 to 2.00 feet deep at the water-gauge station with the use of a deep-well pump (J. Medeiros pers. comm.). During the summer months water is continuously pumped into the pond to prevent it from drying out. When the water level exceeds 2.50 feet, the pond outlet is opened to allow water to escape the ocean (J. Medeiros pers. comm.). The ponds are considered poikilohaline, which means they have variable salinity. Salinity measures taken in 1992 ranged from 3,927 to 20,000 mgCl/l (3.9-20.0 ppt), and surface water salinity was measured to be 3,600 mg (3.6 ppt) in 1999; DOFAW 2000).

During a site visit on 12 October 2023, Eric VanderWerf recorded the following salinity measurements using a refractometer: 36 ppt in the main pond in the small canal next to the pump at the public viewing area; 48 ppt in a cove of the main pond off Puahou Street; 44 in a small canal connected to the main pond at the junction of Puahou Street and Hunakai Street; 68 ppt in Tire Pond off Hunakai Street; 64 ppt in Waihou Pond at the makai end of Hunakai Street; 110 ppt in Coot Pond on the makai side of Puahou Street. The salinity in the canal near the pump outflow is likely to be the lowest anywhere in the site because it is located where fresh water is pumped into the pond and has deeper water. The small, isolated ponds appear to have generally higher salinity than the main pond, likely because they have no outflow and when they are cut off from the main pond their salinity increases as water evaporates, leaving the salt behind. The soil at the edges of these ponds had a crust of salt. Several other basins were completely dry and were covered in a salt crust. October is at the end of the summer dry season, when rainfall usually is low and evaporation is highest, so the salinity measures recorded during this visit likely represent high values within the seasonal variation. The salinity measurements from DOFAW (2000) were much lower, but they are 30 years old now, and it is possible the hydrology has changed, or that they were taken during a period of very high water level when salinity was low.

KPWS currently is surrounded by a chain link fence that excludes feral deer, pigs, and dogs. Trapping of feral cats and mongooses is ongoing to protect waterbirds. A predator exclusion fence is under construction and is expected to be completed by mid- or late 2024 (J. Medeiros pers. comm.), which should provide a high level of protection from invasive mammalian predators.



Google Earth view of Kanahā Pond and surroundings.



Map of Kanahā Pond, from USACE (2012).

Left: Kanahā main pond. Salinity in the pond was 36-48 ppt during a site visit on 12 October 2023. Right: Waihou Pond, which has sedges and is isolated from the main pond and had salinity of 64 ppt on 12 October 2023.

Waiheʻe Coastal Dune and Wetlands Refuge. Information about this site was obtained from the management plan (Fisher 2018), the Hawaiian Islands Land Trust webpage (https://www.hilt.org/waihee), personal communications with refuge manager Scott Fisher, and a site visit by Eric VanderWerf and Scott Fisher on 12 October 2023.

The Waiheʻe Refuge is owned and managed by the Hawaiian Islands Land Trust. The 277-acre parcel was acquired by the land trust in 2004. According to the refuge management plan (Fisher 2018), the three-fold vision for the Waiheʻe Refuge is to; 1) Create a welcoming site for the people of Waihe'e and Maui to retain (or regain) a sense of place, a location to connect with and benefit from the natural and cultural history of Waiheʻe and Maui Nui; 2) increase indigenous and endemic biodiversity through ecological restoration, while maintaining traditional and customary practices; and 3) promote learning about the unique history, cultural and ecological features of Waiheʻe for students of all ages." The plan states that "Two guiding principles will be used to determine the feasibility and priority of proposed projects. The first principle looks at the consistency between any proposed project and the vision described above. The second principle evaluates the project in relation to the needs and wishes of the community" (Fisher 2018). In addition to these principles, proposed projects should also meet the following criteria. First, to take on a project an individual or a group must demonstrate adequate resources, especially funding and personnel, to complete and maintain a project. Second, the proposed project should, directly or indirectly, benefit the people of Waiheʻe and Maui."

The Waiheʻe Refuge management plan specifically mentions reintroduction of the ʻAlae ʻUla (Fisher 2018): "according to Dr. Fern Duvall of the State Department of Land and Natural Resources the Kapoho wetlands would make an ideal candidate for the reintroduction to Maui of the Hawaiian Moorhen, or ʻAlae ʻUla (*Gallinula Chloropus Sandvicensis*). According to Dr. Duvall, a plan has already been developed for their reintroduction. While feasibility studies have yet to be conducted, returning these endangered birds (which are extinct on Maui) would be a significant milestone in the restoration of the wetlands. However, before such a project could begin significant habitat improvements would need to occur, and even more importantly, predator control strategies would need to increase dramatically."

The Waiheʻe Refuge contains 27 acres of wetlands, including a 7-acre fishpond that currently is filled with sediment but is being restored, and provides habitat for a number of indigenous and endemic plants and animals, including the Hawaiian Stilt or Ae'o and Hawaiian

Coot, or ʻAlae Keʻokeʻo. Currently, the fishpond and most of the wetlands are dry during a portion of the year, usually from June-October (S. Fisher pers. comm.). The reduced water levels are the result of several factors that have altered the hydrology of the area, including the digging of a drainage canal (the "dairy canal"), diversion of water from Kalepa Gulch, which may have fed the wetlands through underground seepage, use of water for agricultural purposes, filling of the fish pond and other wetlands with sediment, and the abundance of kiawe (*Prosopis pallida*), which extracts a considerable amount of water from the soil (Fisher 2018). There usually is some water in the "dairy canal", but this canal drains the wetland.

Habitat restoration work that is being carried out in the Waiheʻe Refuge will focus on three ecosystems, the wetlands, the sand dunes, and the coastal zone (Fisher 2018). The management plan identifies several restoration priorities, all of which are consistent with and conducive to ʻAlae ʻUla reintroduction and management, with the three most relevant being "Evaluation of appropriate indigenous and endemic species for reintroduction," "predator control (especially mongoose and cat" (Fisher 2018), and "Reestablishment of water regime in the wetlands" (Fisher 2018).

Restoration of the wetlands will include the following important actions relevant to waterbird habitat (S. Fisher pers. comm); 1) Dredging and grading of the fish pond to restore its original depth; 2) filling the drainage canal with material removed from the fish pond to help retain water in the wetlands; and 3) return of an allotment of 1.1 million gallons of water per day to the wetlands from Waihe'e Stream as part of a recent legal settlement. It is expected that these actions will raise the water table and result in retention of water in the fish pond and adjacent wetlands year round, and will reduce the salinity of surface and ground water in the area (S. Fisher pers. comm.). The bottom of the fish pond is about 3 feet in elevation above the level of the highest high tide. It is expected that the grading of the fish pond and filling of the canal will be completed by January 2025, and that the fish pond could be filled with water by June 2026, to coincide with the summer solstice. Once restored, the fishpond will become a focal point for Hawaiian cultural activities and community events.

During a site visit on 12 October 2023, Eric VanderWerf and Scott Fisher measured salinity in three test pits that had been excavated in the fish pond, called KAP1, KAP2, and KAP3, which were 25 ppt, 16 ppt, and 20 ppt, respectively. The pond was dry at the time of the visit and the measurements were from groundwater exposed in the pits. The dairy canal was mostly dry but had a few areas of stagnant muddy water.

Predator control at the Waiheʻe Refuge began in February 2004 in the areas where endangered waterbirds are most often seen; mongoose were trapped commonly at first but the numbers dropped by the summer of 2004, and a few feral cats were trapped (Fisher 2018). Predator trapping is continuing currently (S. Fisher pers. comm.). The refuge is not fenced against ungulates or predators. It probably will not be possible to build a fence around much of the land, because there are many Hawaiian burials and parts of the area are rocky. There are few ungulates currently and local residents actively hunt in the area.

Google Earth view of the Waihe‘e refuge. The Land Trust offices can be seen on the right. The rough outline of the fishpond walls is visible in the center.

Test pit at Waihe‘e in which salinity was 25 ppt. The fishpond rock wall is visible in the background.

Nu‘u Refuge. The Nu‘u Refuge is owned and managed by the Hawaiian Islands Land Trust. The 78-acre parcel was acquired by the land trust in 2010. According to the refuge management plan (Fisher 2013), the “goal for the Nu‘u Refuge includes restoring the ecological integrity, protecting its historical and cultural resources, providing venues for education and to encourage respectful recreational activities.” The southern boundary is the Pacific Ocean, on other sides it is bordered by cattle ranches. The pond itself is 6 acres in size and is a palustrine discharge wetland that is surrounded by dry forest. The Nu‘u wetlands have retained much (~90%) of the emergent vegetation and a significant percentage of its indigenous floral composition, particularly *Schoenoplectus juncoides* (Kaluha), *Cyperus laevegeticus* (Makaloa), *Sesuvium portulacastrum* (Akulikuli), *Bacopa monnieri* (‘ae ‘ae), and *Heliotropium currasavicum* (Kipukai) (Fisher 2013). The retention of the wetlands indigenous floral composition may have resulted from its relatively isolated location and intact hydrology (Fisher 2013). Ecological restoration of the refuge is underway, and the first phase of will focus on the 6-acre wetland to provide habitat for Hawaii’s endangered waterbirds and for migratory birds. There are plans to build a predator exclusion fence around the wetland, and a cost estimate has been obtained (S. Fisher pers. comm.). Water level in the pond fluctuates seasonally depending on rainfall, and it has dried out completely during the summer/fall in 2 of the past 10 years (Scott Fisher pers. comm.).

Google Earth view of the Nuʻu refuge.

3.3.3. Molokaʻi.

This assessment includes all wetlands on Molokaʻi that have been described in the literature as potentially suitable for conservation restoration or that were recommended by experts during interviews with Eric VanderWerf in 2023. Based on the information compiled for this project, it appears that some of the sites are unlikely to be suitable for reintroduction of ʻAlae ʻUla, or that there might be substantial community opposition to restoration at certain sites. Such sites are still included in this assessment because it is important to provide a record of why they may not be suitable, but they are not included in the site selection worksheet (Appendix 2), and there is a statement at the end of the wetland description explaining why each was not included.

The status and restoration priority of 12 wetlands on Molokaʻi were described in detail by Drexler et al. (2023), with restoration priority based on hydrology, sea level rise, soils, vegetation, bird abundance, and community support. Drexler et al. (2023) also assessed and ranked the wetlands in terms of habitat quality for endangered and migratory waterbirds using 12 criteria, some of which were similar to the criteria used in this feasibility assessment.

This feasibility assessment for ʻAlae ʻUla reintroduction includes all 12 sites assessed by Drexler et al. (2023), and two additional sites they did not include. Information for these 14 sites was obtained from Drexler et al. (2023), especially supplemental Table 11, personal communications with experts, particularly Arleone Dibben-Young, and personal observations by Eric VanderWerf during a site visit on 11 October 2023.

To assess community support for ʻAlae ʻUla reintroduction at each site, information about support for wetland restoration and the score from Drexler et al. (2023) was used as a starting point, and the value was increased or decreased if there was reason to believe support for ʻAlae ʻUla reintroduction would be different. Community support score definitions from Drexler et al. (2023): 1 = likely community opposition; 2 = possible community opposition; 3 = community neutral; 4 = community supportive; 5 = community highly supportive.

Table 1. Summary of Moloka‘i wetland characteristics. An asterisk (*) indicates sites not evaluated by Drexler et al. (2023). See previous paragraph for definitions on community support scores.

Wetland Name	Ownership	Salinity (PPT)	Size (ac)	Community support score	Notes
Ipuka‘iole Pond	Private	41[1]	0.8	3	
Kakahai‘a NWR	USFWS	Dry	13.2	5	
Kalaupapa Airport wetland	NPS	Dry	5.2	2	Lack of support, not being evaluated
Kalua‘apuhi Pond/ Piliwale Spring /‘Ō‘ō‘ia Pond*	Private	?	100+	?	Covered in mangrove
Kamahu’ehu’e Pond	DHHL	1,750	81.6	5	
Kaunakakai WWTP	Private	2184[1]/34[2]	12.3	2	
Kaupapalo‘i o Ka‘amola (Lo‘i Kalo)	Private	fresh	0.1	2	Very small, no support, not being evaluated
Kōheo*	Private	70[2]	6	4	
Moku Pond	Private	?	0.3	3	Very small, no support, not being evaluated
Ohi‘apilo	DHHL	17+	24.1	2	
Pahuauwai	Private	22-24	89.0	3	
Paialoa Pond	DOFAW	?	16.8	1	Community opposition, not being evaluated
Pohoele Pond	DOFAW	?	132.7	2	Dry, not being evaluated
Punalau Pond	Private	7-80	44.6	3	

[1] Salinity measurements reported by Drexler et al. (2023), who measured salinity in soil pits dug in the wetland and reported as Practical Salinity Units (PSU), in which the value of seawater (35 parts per thousand, or ppt) is used as a standard and given a value of 1.0. In this table PSU has been converted to parts per thousand (PPT).
[2] Salinity measurements by Eric VanderWerf on 11 October 2023.

Ipuka‘iole Pond. This is a former inland fishpond that was filled with sediment over time, and then dredged and partially restored in 2012. The fishpond walls are now destroyed or covered in sediment. It is very small (0.8 acres) and Drexler et al. (2023) measured salinity as 1.16 PSU (or 41 PPT), slightly higher than seawater.

Community Support. Drexler et al. (2023) indicated there were no major community support concerns, but also that there was no existing or potential supporting partner, and therefore scored community support as 3. Support for ‘Alae ‘Ula reintroduction presumably would be similar.

Kakahai‘a National Wildlife Refuge. This is a former inland fishpond that consisted of two ponds. It is owned and managed by the USFWS. Originally the wetland consisted of two ponds, but currently the site is overgrown with invasive plants and has filled with sediment and contains little or no water most of the time. The “Old Pond” was about 20 acres in size and formerly provided deep-water habitat that was used by Hawaiian Coots and migratory ducks. The “New Pond” was about 5 acres in size and had shallower water that was used by Hawaiian stilts and migratory wading birds and shorebirds. The Old Pond is fed by groundwater, the New Pond required water from an outside source, such as rainfall, especially during the summer months. This was the site of a previous reintroduction of ‘Alae ‘Ula in 1983 (see section 3.1.1 for details).

Drexler et al. (2023) reported three salinity measurements from the site; 1.03 and 0.7 PSU (36 and 24.5 PPT), which presumably were from the Old Pond, and 42 PSU (1,470 PPT) presumably from the New Pond. These salinity measurements are not listed in the site assessment sheet and this site is listed as “dry” because it is dry most of the time. During a site visit by Eric VanderWerf on 11 October 2023 the site was completely dry.

Community Support. Drexler et al. (2023) indicated there was broad support among surrounding landowners and scored community support as 5, but they noted some community concerns about (1) possible exclusion of people physically and in planning, (2) ownership and management by outsiders, (3) previous abandonment of the site by USFWS. Support for ‘Alae ‘Ula reintroduction presumably would be similarly high.

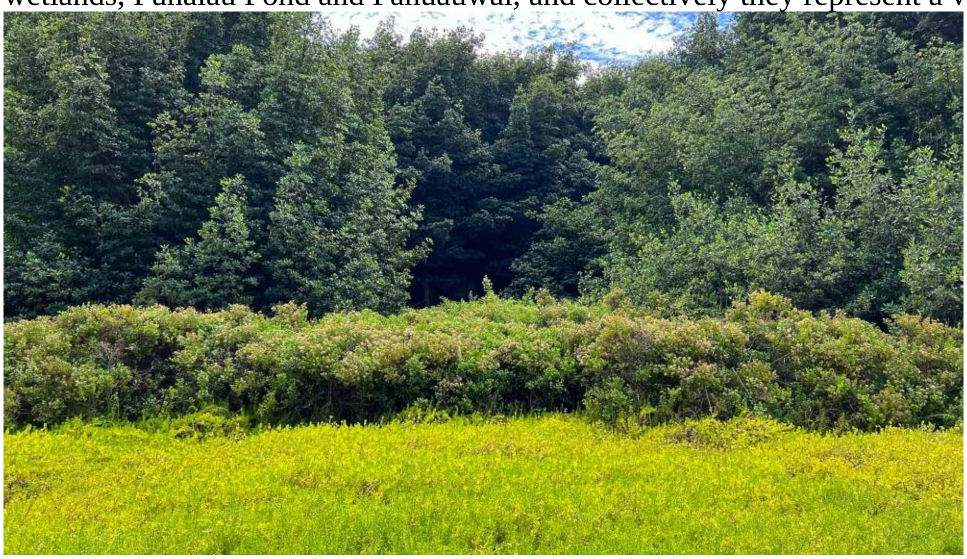
Kakahai‘a NWR during site visit on 11 October 2023. The site was completely dry.

Kalaupapa Airport wetland. Drexler reported that this small (5.2 acres) wetland was a “flat site with lithified (rock hard) sand base and only a few cms of soil” and was largely rain-fed. No salinity measurements were available because the site was dry. The site is owned by the National Park Service (NPS).

Community Support. Drexler et al. (2023) scored support as 2 and indicated there were serious community concerns about wetland restoration at Kalaupapa because (1) future management is undecided between the Hawai‘i Department of Health DoH and NPS, (2) community access is uncertain, (3) iwi kupuna are present, and (4) unexploded ordnance are present. Some of these concerns are more related to ground work involved in wetland restoration and might not apply to reintroduction of ‘Alae ‘Ula, but ‘Alae ‘Ula could not be reintroduced without habitat restoration, so community support is essentially the same.

This site is not included in the site assessment worksheet because it is clearly unsuitable for ‘Alae ‘Ula and there likely would be opposition to wetland restoration that would be necessary to reintroduce the ‘Alae ‘Ula.

Kalua‘apuhi Pond/Piliwale Spring/‘Ō‘ō‘ia Pond. These three sites are privately owned by Moloka‘i Ranch. They are adjacent to each other and function as a single wetland, so they are treated here as a single site. Piliwale Spring issues about 500,000 gallons of fresh water per day, and this water feeds into Kalua’apuhi Pond, and subsequently flows into ‘O’o’ia Pond. Piliwale spring is considered the birthplace of ‘Alae ‘Ula in Hawaiian mythology and thus has special cultural significance for this species. Additional springs are located in ‘O’o’ia Pond but their output is unknown. However, all three sites currently are largely overgrown with mangroves, *Pluchea*, and other invasive plants and this has altered the hydrology of the region and rendered it unsuitable for ‘Alae ‘Ula. Kalua’apuhi Pond and Piliwale Spring in particular are almost completely overgrown with mangroves. If the mangroves and other invasive plants were removed, this would help to restore the hydrology and likely would result in a large area of potentially suitable habitat in which the salinity presumably would be relatively low because of the high input of spring water. Additional restoration actions also might be required, such as replanting with emergent plant species favored by ‘Alae ‘Ula. This site is adjacent to two other wetlands, Punalau Pond and Pahuauwai, and collectively they represent a very large habitat area.



Piliwale Spring viewed from north during site visit on 11 October 2023. The spring is open but is not accessible from this side because it is overgrown with mangroves and *Pluchea*.

Kamahu‘ehu‘e Pond. This is a large (81.6 acres), sediment-filled fishpond that consists primarily of extensive mudflats that become inundated during high tides or following heavy rainfall. The highway goes right through the wetland, so vehicle collisions would be a hazard. Drexler et al. (2023) reported two salinity measurements from soil pits, 81 and 19 PSU, for an average of 50 PSU or 1,750 PPT, indicating the mudflat areas are highly saline. When filled by rainwater the salinity would be lower, but probably still would be quite high. During a site visit by Eric VanderWerf on 11 October 2023, there was an area of open water and mudflats on the makai side of the highway, and some areas of dry bare soil had a white crust of salt.

Community Support. Drexler et al. (2023) indicated there was broad community support for wetland restoration in general and scored support as 5, but that Kamehameha Schools may have concerns including that restoration must not impact access and the community must be included in planning and restoration. Currently a Right of Entry exists with hunting club for ungulate control, and TNC has access rights. Support for ‘Alae ‘Ula reintroduction presumably would be similar, provided the concerns were honored, though continued access for hunting could expose ‘Alae ‘Ula to hunting too.

Views of Kamahuehue Pond during site visit on 11 October 2023, looking mauka (north; top photo) and makai (south; bottom photo). Both photos were taken from the highway.

Kaunakakai Wastewater Treatment Plant. This site is a complex that contains several types of wetlands encompassing a total of 12.3 acres, including the Kaunakakai wastewater treatment plant settling pond and sewage pond. The settling pond and sewage pond support relatively large numbers of Hawaiian Coots, Hawaiian Stilts, and migratory waterfowl and shorebirds. Hawaiian Coots and Stilts already nest at the site. Artificial nesting platforms have encouraged coot nesting. To the west of the treatment plant there is a natural wetland area, but a large portion of the natural wetland currently is covered with mangroves and there is some concern about possible contamination of this area. Drexler reported salinity as 62.4 PSU, or 2184 ppt. The suitability of the settling pond and sewage pond for ‘Alae ‘Ula seems low because they have little emergent vegetation, but they presumably have low salinity. If ‘Alae ‘Ula were released into the natural wetland following habitat restoration, it is possible they might move to the settling pond and sewage pond during dry periods. There is ongoing trapping of feral cats and mongooses to protect nesting coots and stilts.

During a site visit by Eric VanderWerf on 11 October 2023, most of the wetland area to the west of the wastewater treatment plant was dry and there was only a single small puddle of water, which had a salinity of 34 ppt. Much of the bare soil in this area had a crust of salt on the surface. The vegetation consisted primarily of pickleweed, with scattered kiawe and other shrubs. The portion of the wetland currently covered by mangroves may contain more fresh water. If the mangroves were removed the hydrology might be improved and the water table raised, resulting in more suitable habitat for ‘Alae ‘Ula, but the potential presence of contaminants in the soil might warrant investigation.

Community Support. Drexler et al. (2023) reported that the community felt this is not a suitable site for conservation and scored support as 2. Similar concerns presumably would apply to reintroduction of ‘Alae Ula, and their presence could create conflicts for the landowner. On the other hand, Hawaiian Coots and Stilts already nest at the site and do not seem to have caused problems.

Kaunakakai WWTP during site visit on 11 October 2023. Salinity in the puddle was 34 ppt; this was the only surface water present at the time.

Kaupapalo‘i o Ka‘amola (Lo‘i Kalo). This privately owned wetland is actively used for taro farming. It consists of about 12 small taro lo’i, with a cumulative size of about 0.1 acres. It is located next to the highway, which might pose a collision hazard for ‘Alae ‘Ula. Salinity was not measured at this site but Drexler et al. (2023) scored freshwater availability as 5, meaning it was abundant, and it presumably is close to fresh because it is used for taro farming.

Community Support. Drexler et al. (2023) scored community support as 5 and indicated the community was highly supportive of wetland restoration because it presumably would increase food sustainability through improved fish habitat, but that there was concern by the land manager about interaction with threatened and endangered birds. The support for ‘Alae ‘Ula reintroduction thus likely would be lower than support for wetland restoration. This site is not included in the site assessment worksheet because of its very small size and concerns expressed by the land manager about endangered birds.


View of Lo‘i Kalo from the highway on 11 October 2023.

Kōheo. This wetland is privately owned by Goodfellows Construction and is managed on a volunteer basis by Arleone Dibben-Young. The wetland consists of a single pond with varying amounts of exposed mudflat depending on water level. Currently the wetland is about 6 acres in size and is highly saline, but in the past it was larger and fresher. It is located directly adjacent to the shoreline and there has been substantial loss of land to coastal erosion, and high wave events can cause seawater to enter the wetland. Water level fluctuates seasonally depending on recent rainfall and evaporation. During the summer and fall the water level is lower and salinity is higher. During a site visit by Eric VanderWerf on 11 October 2023 the salinity was measured to be 70 ppt, or twice as salty as seawater, and some of the dry bare soil around the pond had a white salt crust. The primary vegetation is salt-tolerant pickleweed. The site is used extensively by migratory shorebirds, including Kioea or Bristle-thighed Curlews and a lone Whimbrel.

Community support. This site was not evaluated by Drexler et al. (2023). Kōheo is used regularly for educational purposes by school groups and there likely would be community support for habitat restoration, but because of its high salinity and proximity to the ocean it probably cannot be made suitable for ‘Alae ‘Ula.


Kōheo Pond during site visit on 11 October 2023.

Moku Pond. This small wetland is privately owned by Kawela Plantation. During a site visit by Eric VanderWerf on 11 October 2023 it contained a small area of open with, in which there were two Hawaiian Stilts. It is completely surrounded and overgrown by kiawe trees.

Community Support. This site is located adjacent to residential homes, and Drexler et al. (2023) reported that the Home Owners Assocation may be concerned about liability and public access. Concern about ‘Alae ‘Ula reintroduction presumably would be similar. This site is not included in the site assessment spreadsheet because it is too small and because of the likely community opposition.

Moku Pond during site visit on 11 October 2023. The pond is overgrown with kiawe, a small area of open water fringed with much is visible in the background

Ohi‘apilo Pond Bird Sanctuary. This large wetland is owned and managed by the Department of Hawaiian Homelands. The primary vegetation is pickleweed, with clumps of Indian fleabane (*Pluchea odorata*), and a few stands of the native sedge kaluha (*Bolboschoenus maritimus*). This sedge likely would provide good nesting habitat for the ‘Alae ‘Ula. The western part of the wetland is covered in mangroves and there is a connection to the ocean on the western side through the mangroves. Most of the wetland was not accessible during a site visit by Eric VanderWerf on 11 October 2023, but salinity in a remnant pond on the edge of the wetland was 17 ppt. Salinity in the larger area of open water in the center of the wetland is likely to be higher because it is closer to the ocean connection (Arelone Dibben-Young pers. comm.). Suitability of this site for ‘Alae ‘Ula could be improved with restoration, specifically by increasing the amount of native sedge, removing mangroves to increase the wetland size and improve hydrology, and managing water level to reduce salinity. There have been serious outbreaks of avian botulism at this site in the past, and currently there is no monitoring and no response capacity. The site would need re-engineering work to ensure that the flooding that causes mass deaths of tilapia, followed by botulism outbreaks, could be managed.

Community Support. Drexler et al. (2023) scored community support as a 4, but indicated that DHHL beneficiaries were protective of the site because of their rights due to its DHHL status, that beneficiary involvement was imperative in planning, stewardship, and restoration, and that culturally-based education and involvement of cultural practitioners would be required. The focus of habitat restoration would be for agricultural homesteads and food production, and not necessarily for ecological restoration or native species. The presence of an additional endangered species could exacerbate these concerns, and support for reintroduction of the ‘Alae ‘Ula likely would be lower.

Ohi‘apilo Pond during site visit on 11 October 2023. Salinity was 17 ppt in the small pond on the lower right. The larger area of open water and mangroves are visible in the background.

Pahuauwai Aquaculture Site (Moloka‘i Sea Farms). This large wetland is privately owned and managed by Moloka‘i Sea Farms. There are several springs on the property that feed the wetland. In addition to the aquaculture ponds, there are extensive areas covered in pickleweed, scattered clumps of *Pluchea*, and other invasive plants. On the southern edge of the wetland close to the shoreline there is a fringe of mangroves.

During a site visit by Eric VanderWerf on 11 October 2023, salinity in a spring near the aquaculture office was measured at zero, though the owner reported that it usually is about 4 ppt. Three other salinity measurements taken that day all were 22-24 ppt, in a long canal used for raising tilapia, a deeper pool about 30 meters north of the mangroves, and in a pool about 500 meters from the shoreline. There are a large number of standing dead trees throughout the wetland, suggesting that salinity, or water level, or both, may have been lower in the recent past. Removing the mangroves could improve the hydrology and result in more suitable habitat. The salinity over much of the wetland currently is moderate, and only a small reduction might result in substantial habitat improvement.

Community Support. Drexler et al. (2023) did not identify any known concerns and scored community support as a 3. Support for ‘Alae ‘Ula reintroduction presumably would be similar. The owner seems to appreciate native birds and is supportive of them being monitored, but any habitat alterations presumably would need to be compatible with continued aquaculture activities.

Pahuauwai Aquaculture Site during site visit on 11 October 2023. Salinity in the canal was 24 ppt. Standing dead trees are visible in the background. The fringe of mangroves on the coast is visible on the right.

Paialoa Pond. Drexler et al. (2023) reported there were serious community concerns because of historical trauma from past development efforts in which dredging of a neighboring fishpond resulted in filling of paialoa and disturbance to the mo'o (shapeshifting water dragon) present at the site. They also reported that no locals would be prepared to work on site and that families in the area do not want any restoration for wildlife as that would limit access for hunters and fishers. There presumably would be similar concerns about ʻAlae ʻUla reintroduction. This site is not included in the site assessment worksheet because of the strong community opposition.

Pohoele Pond. This large wetland is owned by the State and managed by DOFAW. It is generally dry and only has water temporarily after rain.

Community Support. Drexler et al. (2023) reported that local fishers and hunters may have concerns and scored community support as 2. Support for ʻAlae ʻUla reintroduction presumably would be similarly low. This site is not included in the site assessment worksheet because it does not contain suitable habitat and there is likely to be community opposition.

Punalau Pond. This large wetland is privately owned, but will soon be purchased by the Molokaʻi Land Trust. The long term goal for this site is ecological restoration. This site forms part of a large wetland complex and is adjacent to Kaluaʻapuhi, ʻŌʻōʻia Pond, and Molokaʻi Sea Farms. The water level fluctuates seasonally depending on rainfall and evaporation. The primary vegetation is pickleweed, with clumps of Indian fleabane, and one side of the wetland is covered in mangroves. There are six freshwater springs that feed the wetland, but currently they are completely overgrown with mangrove.

During a site visit by Eric VanderWerf on 11 October 2023, there was a small amount of open water surrounded by some mudflats, but most of the open area was covered in pickleweed. Several salinity measurement were taken during the site visit, which were: 7 ppt in a small pool on the northern edge of the wetland, 80 ppt in a small well near the old house (not the large well next to the house), 64 ppt in a small canal south between the open flats and the burn area. Many areas of bare soil in the extensive flats south of the house were covered with white salt crust.

Currently the site is too salty for ‘Alae ‘Ula, but it might become more suitable if the mangroves covering the freshwater springs were removed and a more natural hydrology was restored that returned more fresh water to the wetland and reduced salinity. The Molokai Land Trust has been awarded funding to begin habitat restoration and expects to begin work soon (H. Raine pers. comm.).

Community Support. Drexler et al. (2023) reported that the community was likely to be neutral or supportive, but that local fishers and hunters may have concerns and scored community support as 3. Support for ‘Alae ‘Ula reintroduction presumably would be similar.

Two views of Punalau Pond during the site visit on 11 October 2023. Salinity was 7 ppt in the small pond in the left photo. Salinity was 64 ppt in a small canal adjacent to the flats in the right photo. White salt crust is visible on the bare ground in the right photo.

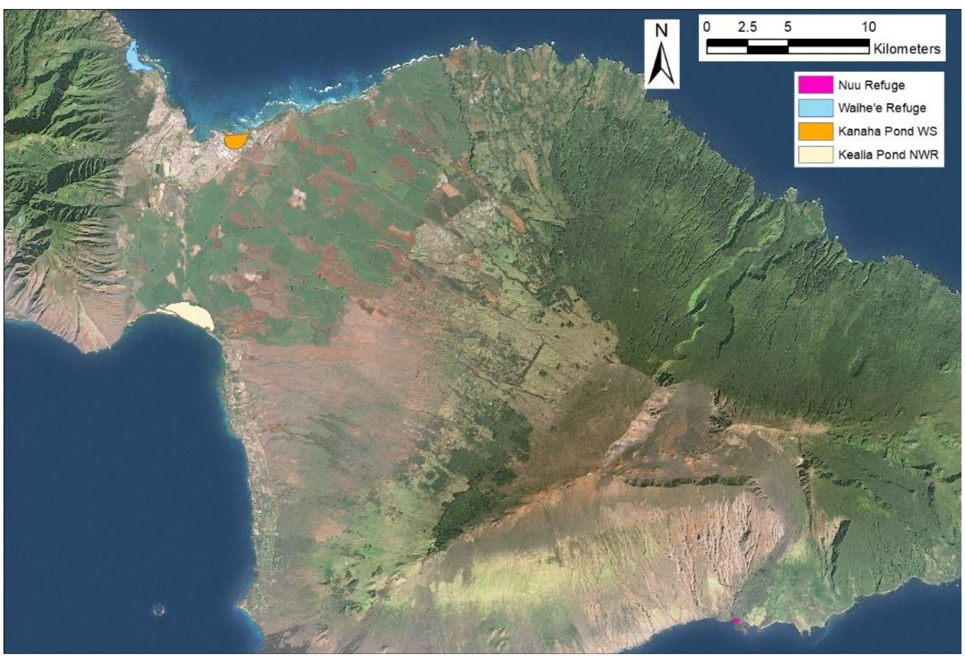


Figure 4. Map of potential release sites for ‘Alae ‘Ula on Maui.

3.3.4. Hawai‘i Island.

Loko Waka and Kionakapahu Ponds. These ponds are located in Keaukaha, about 4 miles east of Hilo on the eastern side of the island. The two ponds are separated by about 500 feet of mostly grassy habitat and could act as a single wetland complex. Loko Waka Pond is owned by the State and is zoned for conservation but is leased to the Seaside Restaurant and Aqua Farm. The state parcel is 50.9 acres in size, but the wetland is smaller, about 20 acres. Kionakapahu Pond is owned and managed by Kamehameha Schools. The parcel containing Kionakapahu Pond is 9.3 acres in size, but again the wetland is smaller, about 4 acres. The Kumuola Marine Science Education Center run by the University of Hawaiʻi Sea Grant program is located on the edge of Kionakapahu Pond and might be a potential partner if the site proves to be suitable. Both wetlands consist primarily of relatively deep ponds that support a variety of fish species that are harvested for human consumption. Both ponds also contain some areas of shallower water supporting emergent vegetation on their fringes, though Kionakapahu Pond contains more emergent vegetation. Both ponds support large numbers of ʻAlae Keʻo Keʻo. Some habitat restoration work has been done at Loko Waka Pond by the Seaside Restaurant, mostly invasive plant removal. During a site visit by Eric VanderWerf on 30 December 2023, the salinity was measured at 9 ppt in both ponds. Both wetlands are spring fed, but their water levels change with the tide and they appear to have a direct connection to the ocean through a culvert under the road, explaining their somewhat brackish water. Both wetlands are located next to a busy road, which could be a hazard to birds. Because both are privately owned or managed, the potential release of ʻAlae ʻUla would need to be discussed with the owners or managers first.

Waipiʻo Valley. Waipio is a large valley on the northeastern side of Hawaiʻi Island. The bottom of the valley contains many small taro fields and other natural and semi-natural wetlands that cumulatively amount to several hundred wetland acres and form a complex along about two miles of Wailoa Stream and other streams. One of the previous ʻAlae ʻUla reintroduction attempts occurred in Waipio Valley in 1959; several birds persisted for more than a year, but there was speculation that some birds were killed for food. Ownership of the area is complex, consisting of literally hundreds of small parcels with different owners. Most of the parcels are privately owned, but some of the larger parcels are owned by Bishop Museum, and one large parcel of 45.9 acres with an open-water pond near the mouth of the valley is owned by the State of Hawaiʻi. The entire area is zoned for agriculture and much of it is used for taro farming. The local community has expressed frustration with use of the valley for tourism and has advocated that visitation and use of the access road be limited to reduce traffic and disruption. Waipiʻo Valley contains the best habitat for ʻAlae ʻUla on the island, but because of the complex land ownership and sensitivity of the local community, extensive outreach with the local community would be essential before any plans are made. Even with outreach it is possible there would be opposition by some community members to the reintroduction of ʻAlae ʻUla. It would be important that the outreach be done by someone familiar with the area and with the local community, and if a decision was made to attempt a reintroduction, community members would need to be involved in all aspects of the planning and implementation.

ʻAimakapā Pond, Kaloko-Honokōhau National Historical Park. Information about this site was obtained from NPS (2015) and from personal communications with NPS biologist Jackson Letchworth.

ʻAimakapā is a natural pond that is separated from the ocean by a sand berm that runs parallel to the sea. It was modified for human use by Hawaiians to hold and grow fish and contains a variety of internal rock-wall partitions and was an active Hawaiian aquaculture pond until the 1950s (NPS 2015). It is owned and managed by the NPS. It is the largest natural wetland on the Kona side of Hawai‘i Island, consisting of about 12 acres of open water with a maximum depth of about 5 feet, and an additional 8 acres of adjacent shallow wetlands dominated by pickleweed and seashore paspalum. There also are several anchialine pools on the southeastern corner of the main pond. The pond is fed by fresh water springs and has no direct connection to the ocean, but there is ground water exchange through the barrier beach and the water level fluctuates slightly with the tide (Hoover and Gold 2005). The water is thus brackish, currently averaging 11-13 ppt (J. Letchworth pers. comm.). Salinity was lower in the past, with previous measurements ranging from 7-9 ppt, but it has increased because of changes in hydrology upslope from the park, decreased rainfall, and invasive plants (NPS 2015). Salinity in the mauka (eastern) side of the wetland away from the ocean may be lower because of freshwater input from springs on that side, especially during the winter following heavy rains when there is visible water flow (J. Letchworth pers. comm.).

‘Aimakapā Fishpond is recognized as important waterbird habitat that provides vital foraging and breeding habitat, and is considered a “core wetland” necessary for the recovery of the endangered ae‘o (Hawaiian stilt) and the endangered ‘Alae Ke‘oke‘o (Hawaiian Coot; Engilis and Pratt 1993, USFWS 2011b). The habitat quality of ‘Aimakapā pond declined during the 1990s and early 2000s because of nonpoint source pollution originating from urban activities upslope and carried into the pond in the groundwater (Hoover and Gold 2005), and by changing climate conditions, particularly lower rainfall, and water wells upslope of the park that have reduced the quantity of groundwater available to the ‘Aimakapā ecosystem (Oki et al. 1999). Endangered waterbird populations at ‘Aimakapā declined seriously due to loss and degradation of suitable habitat and outbreaks of avian botulism in the mid-1990s, which killed many waterbirds (Morin 1996a,b, 1998).

Ecosystem restoration efforts by NPS at ‘Aimakapā began in the early 1990s with removal of some invasive alien plants, and a variety of more extensive management actions began in 2016 (NPS 2015, J. Letchworth pers. comm.), including removal of invasive mangroves and kiawe trees and outplanting of native species. There have been no botulism outbreaks since the late 1990s (J. Letchworth pers. comm.), possibly because removal of invasive alien plants has resulted in improved water flow and less stagnation. Continuing restoration actions are expected to further improve the hydrology and possibly result in lower salinity. However, because of its proximity to the ocean, it is possible that salinity could increase as a result of climate change, from high waves that overtop the sand berm, and infiltration of ocean water into the groundwater. Predator control began in 2016 with weekly trapping to protect waterbird nests and is conducted around the entire perimeter of the pond (J. Letchworth pers. comm.). Funding is available to continue habitat restoration and predator control.

View of ‘Aimakapā Pond from Google Earth.

3.4. Structured Site Selection Exercise

3.4.1. Structured Site Selection Methods. A structured site selection exercise was conducted as part of the reintroduction feasibility assessment to help experts assess which source and release sites would be best. All experts who were contacted during the information gathering phase of the project were invited to participate in the structured prioritization exercise. Each participant was sent a spreadsheet containing a matrix of the site selection criteria described above and a list of potential source sites and release sites, which is shown in Appendix 2. In addition, each participant was sent a file with descriptions of the potential source sites and release sites, as written in sections 3.2 and 3.3 of this report. Each participant was asked to assign a score to each site for each criterion, ranging from 1 (worst) to 5 (best). The assessment was based on current conditions at the release site and did not account for any restoration planning. During the information gathering phase of the assessment, experts were asked whether any of the selection criteria were especially important and therefore should be weighted more than others when selecting a site. Based on the responses, a weighting factor was assigned to some criteria based on the cumulative expert opinions. Not all experts mentioned the same criteria that should be weighted, but an effort was made to weight factors that represented the majority opinions. The spreadsheet contained formulas to automatically add all the scores for each wetland and to produce a total score for each wetland, with and without the weighting factors. The total score is an indication of the suitability of each site. The scores of all experts who completed the exercise were averaged, and the standard deviation (SD) of the scores also was calculated to provide a measure of agreement among the experts; lower SD values indicate greater agreement.

3.4.2. Structured Site Selection Results. A total of 10 responses were received for the site prioritization exercise. Some respondents scored only some of the sites with which they were most familiar, so the number of responses was not the same for all source sites or release sites.

Summaries of the results for sources sites and release sites are presented in Tables 2 and 3, respectively. Weighting of some criteria had little effect on the site rankings.

The source site with the highest average score on Kaua‘i was Hōkūala Resort, with a weighted score of 30.7±4.5, though Hanalei NWR was a close second with a weighted score of 29.0±1.8. The source site with the highest score on O‘ahu was James Campbell NWR with a weighted score of 28.6±1.7. The relatively small standard deviation values associated with the scores for all source sites indicate there was a high level of agreement among experts.

For release sites, several sites had similar values and there was no site that was clearly above the others. The five sites with the highest scores, in order starting with the highest, were ‘Aimakapā Pond on Hawai‘i, and Kanahā Pond, Kealia Pond, Nu‘u, and Waihe‘e on Maui. The site on Moloka‘i with the highest score was Punalau Pond, which ranked seventh overall. The relatively large SD values indicated there was less agreement among experts about which sites were best. The top five sites and the top site on Moloka‘i are described below in more detail.

1. ‘Aimakapā Pond, Kaloko-Honokōhau National Historical Park, Hawai‘i. This site scored the highest of any site and appeared to be the only site that currently is ready to receive ‘Alae ‘Ula. It received generally high scores for most criteria, particularly ownership, management capacity, water depth, food availability, nesting habitat, and various types of ongoing management. The only criteria for which this site received low scores were wetland connectivity and climatic security. There are few other wetlands on the Kona side of Hawai‘i Island and they are scattered along the coast and separated by relatively long distances of unsuitable habitat. The wetland is large enough to support a substantial population, but there would be limited opportunities for dispersal to or from other wetlands. Lack of climatic security is perhaps the biggest drawback to this site. It is directly adjacent to the coast and separated from the ocean by a narrow sand berm that is known to be somewhat permeable to sea water. The salinity probably is acceptable for ‘Alae ‘Ula currently, but it is known to have increased recently and could continue to increase. Ongoing and planned management activities such as removal of invasive plants like kiawe may improve hydrology and reduce or even reverse trends in salinity, but the efficacy of such actions remains to be seen.

2. Kanahā Pond Wildlife Sanctuary, Maui. The factors that were favorable here were ownership, wetland size, water depth, and most forms of management. It is the only site with a predator exclusion fence, which is expected to be completed in 2024. As with Kealia Pond, the primary issue at Kanahā is high water salinity. Climatic security also was scored low by several experts. Water level, and thus salinity, can be controlled to some degree by pumping in fresh water, but because it is directly connected to the ocean it will be difficult to prevent salinity from reaching high levels seasonally. The smaller, isolated ponds in the sanctuary are highly saline and appear to be accumulating salt from evaporation because they have no outflow.

3. Kealia Pond NWR, Maui. This site received high scores for most criteria, particularly ownership and most types of management. The main problem at this site is high water salinity and large seasonal fluctuations in water depth. Several experts gave this site high scores for salinity despite the known problems. The refuge manager indicated there are plans for various actions that would result in improved ability to regulate water level, but it will be difficult to substantially reduce the high salinity that develops during periods of lower water levels.

4. Nu‘u Refuge, Maui. This site was scored highly for most criteria, including ownership and management capacity. The criteria for which this site received low scores were the small size, lack of connectivity, and water depth and fluctuations. It probably would support only a few pairs of ‘Alae ‘Ula and it is isolated from other wetlands on Maui by long expanses of unsuitable habitat. Several experts scored it high for water depth even though it is known to dry out completely in some years. If it did dry up completely and translocated birds were forced to disperse the probability of them returning might be low because of the isolation.

5. Waihe‘e Coastal Dune and Wetlands Refuge, Maui. This site received generally high scores from most experts for most criteria. However, the standard deviation of scores for this site was the highest of any site, indicating there was the most disagreement among experts about this site. This resulted primarily from one expert who scored it very low for almost all criteria. If the scores of that one expert were excluded this site would have ranked third. The primary issue at Waihe‘e is lack of water, and the wetland often dries up completely during the summer and fall. Restoration work is underway, and it is anticipated that water level, and consequently habitat quality, will improve when water is returned to the site, which could occur as soon as 2026.

6. Punalau Pond, Moloka‘i. This site currently is privately owned but it is expected that it will be acquired soon by the Moloka‘i Land Trust, which would result in and improved score for ownership and allow for improved management. Currently, much of the site, including several springs that are important sources of fresh water, are covered in invasive mangrove trees that prevent circulation of fresh water to much of the wetland, resulting in high salinity and drying in portions of the site. Restoration of the site is planned, including mangrove removal, which should help decrease salinity and improve water depth, but the efficacy of those actions remains to be seen.

Table 2. Source site assessment results. Participants were asked to use a spreadsheet to assign a score from 1 (worst) to 5 (best) to each site for each of six criteria. Values in this table are averages ± SD from all participants. For a list of criteria and their weights see section 3.2.1 above. The spreadsheet is presented in Appendix 2.

Site	Ownership/ management	# ‘Alae ‘Ula*	Total score unweighted	Total score weighted	# responses
Kaua‘i					
Hanalei NWR	USFWS	284	22.8±1.3	29.0±1.8	5
Mānā Wetlands	DOFAW	28	19.0±2.1	21.5±1.6	5
Kaua‘i Lagoons	Private	65	22.4±3.3	30.7±4.5	5
O‘ahu					
James Campbell NWR	USFWS	78	23.7±1.6	28.6±1.7	5
Pearl Harbor NWR Honouliuli unit	USFWS	8	17.0±2.4	19.0±2.4	4
Hāmākua Marsh	DOFAW	38	22.0±2.0	26.0±2.5	5
Kawainui Marsh	DOFAW	14	18.6±3.4	21.2±4.0	5

* The number of ‘Alae ‘Ula is the average number detected during summer and winter waterbird counts from 2018-2022, or from the 5 most recent years from which data were available.

Table 3. Release site assessment results. Participants were asked to assign a score from 1 (worst) to 5 (best) to each site for each of 18 criteria. Values in this table are averages of total scores from all participants. For a list of criteria and their weights see section 3.3.1 above. The spreadsheet is presented in Appendix 2.

Site	Ownership/ management	Size (acres)	Salinity (ppt)	Avg. score unweighted	Avg. score weighted	# resp.
Maui						
Kanahā Pond	State	237.0	4 to 68	65.8±8.2	82.1±11.6	6
Kealia NWR Main Pond	USFWS	450.0	13 to 40	65.4±5.0	80.9±5.2	7
Kealia NWR Kanuimanu	USFWS	25.0	120	61.9±7.1	77.4±8.4	5
Kealia NWR Baitfish Pond	USFWS	3.3	dry	55.7±14.1	71.2±17.1	5
Waiheʻe Wetlands	HILT	27.0	16 to 24	58.1±14.6	73.4±19.3	7
Nuʻu Pond	HILT	6.0	?	59.6±12.2	76.1±16.7	7
Molokaʻi						
Ipukaʻiole Pond	Private	0.8	41	30.3±13.5	37.8±17.3	6
Kakahaʻia NWR	USFWS	13.2	dry	42.4±6.4	53.5±6.9	8
Kaluaʻapuhi Pond/ Piliwale Spring /ʻŌʻōʻia Pond	Private	100+	?	43.4±9.0	53.5±13.4	4
Kamahuʻehuʻe Pond	DHHL	81.6	1,750	40.2±1.7	48.5±2.9	6
Kaunakakai WWTP	Private	12.3	2184, 34	39.4±10.7	49.0±13.7	7
Kōheo	Private	6.0	70	37.8±5.8	46.6±8.7	7
Ohiʻapilo	DHHL	24.1	17+	44.3±8.1	53.9±11.3	7
Pahuauwai (Molokaʻi Sea Farms)	Private	89.0	22 to 24	50.1±12.7	61.0±16.7	7
Punalau Pond	Private (MLT)	44.6	7 to 80	49.1±12.6	61.8±17.1	7
Hawaiʻi Island						
Aimakapā Pond	NPS	20.0	11 to 13	65.3±7.9	82.6±10.8	5
Waipiʻo Valley	Mixed	100s	fresh	55.3±4.0	67.6±6.8	6
Loko Waka/Kionakapahu Ponds	State/private	20+4	?	47.1±6.7	58.2±9.6	6

3.5. Translocation Methods.

The methods described below are those recommended by Eric VanderWerf based on information in the literature, conversations with experts on the ʻAlae ʻUla and captive care of wild bird, and personal experience. Alternative scenarios and methods are described when one method is not clearly best. The recommended methods may change as more information becomes available and based on any initial attempts at reintroduction.

3.5.1. Number, Size, and Composition of Translocation Cohorts. The optimal number, size, and composition of translocation cohorts has been the subject of much debate, and several studies of conservation translocations have examined the effects of release cohort composition on survival, dispersal, and eventual population establishment using modeling approaches and empirical evidence to examine the influence of such factors as age, sex, familiarity, cohort size, and rearing technique. Not surprisingly, the results have varied among species, often as a result of their particular life histories (Griffith et al. 1989, Wolf et al. 1996, Sarrazin and Legendre 2007). Selecting birds for translocation must balance the need for ensuring the continued viability of the source population, the chances of successfully achieving the goal of establishing a new population, and the logistical constraints imposed by the source and release sites and transport options.

One of the most consistent patterns in previous translocations has been a positive relationship between the numbers of animals released and the likelihood of establishing a population. Small founding populations are more sensitive to stochastic demographic and environmental fluctuations and are less likely to persist (Griffith et al. 1989, Wolf et al. 1998, Fischer and Lindenmayer 2000). A smaller number of founders often leads to a smaller resulting population and can cause increased rates of inbreeding depression and loss of genetic diversity, a biased sex ratio, and skewed breeding success (Jamieson et al. 2010). However, this pattern did not affect all species or translocations uniformly, and a survey of 31 translocations using small numbers of Saddlebacks (*Philesturnus carunculatus*) and New Zealand Robins (*Petroica australis*) found that most of the releases succeeded, and that there was no relationship with the number of birds released (Taylor et al. 2005). Tracy et al. (2011) used a modeling approach to show that a founding population of at least 60 individuals is needed in order to achieve a 95% probability of retaining all alleles that have an initial frequency of >0.05 for five generations. This number varies, however, with the population growth rate and genetic diversity and allele frequency within the source population. Not all individuals need be released at once, and periodic releases of additional individuals can be equivalent to a larger initial release (Tracy et al. 2011).

Virtually all translocations have attempted to move equal numbers of males and females to maximize the number of potential breeding pairs and the population growth rate. There is variable information in the literature about the benefits of translocating animals of varying ages, social status, and familiarity with each other. Adults have been moved in most cases (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 also have been translocated (Reynolds et al. 2008). Removing juveniles is less likely to negatively affect the source population because they typically have higher natural mortality than adults (VanderWerf 2004, 2009, Dimond and Armstrong 2007), and juveniles may be more plastic in their behavior and might adjust more easily to a new environment (Armstrong and McLean 1995). On the other hand, territorial adults are easier to catch using playback methods, are already known to be compatible as mates, and might breed more quickly upon release because of their familiarity (Komdeur 1994). Sarrazin and Legendre (2000) used a modeling approach to show that population establishment in long-lived species could be achieved more efficiently by releasing adults rather than juveniles, though this might be less important for the ‘Alae ‘Ula because they are relatively short-lived. Masuda and Jamieson (2012) found that in Saddlebacks reintroduced to a fenced sanctuary, significantly more subadults than adults survived and remained at the release site, and they concluded the primary cause was greater dispersal by adults because of their previous territorial status and stronger homing behavior. In Thick-billed Parrots (*Rhynchopsitta pachyrhyncha*), Snyder et al. (1994) found that wild-caught birds translocated as adults showed the best potential for re-establishment. Armstrong (1995) found that there was no benefit to moving North Island Robins that had been neighbors through reduced aggression at the release site. Armstrong and Craig (1995) found that previous familiarity allowed Saddleback pairs to form more quickly, but had no long-term effect on reproduction or population persistence.

For the ‘Alae ‘Ula, the recommendation is to move approximately 20-40 adults in at least two cohorts, including an equal number of males and females. There should be at least one cohort from Kaua‘i and one from O‘ahu to represent a reasonable amount of the existing genetic diversity. However, the number of birds moved may depend on the size of the release site selected and the number of birds it can support. If the release site is small, it may support only a few pairs and attempting to release more birds could result in aggression and dispersal. If the release site is large and can accommodate many birds, and depending on how long it takes to complete all aspects of capture and release, it may be possible to move more than one cohort per year. If there are no suitable large sites but several smaller suitable sites are available that are close to each other or linked by drainage ditches or other bodies of water, it may be possible to release a cohort at more than one site simultaneously. In the first year it is recommended to start with a smaller number of birds, about 10, to test the methods and work out any problems, and, if all goes well and it is logistically feasible, to increase the number to 20 birds in subsequent years. If translocation is done in the winter months just before the breeding season (see section 3.4.2 below), then it likely will be necessary to move adults because few juveniles would be present. ‘Alae ‘Ula are sedentary and rarely disperse (van Rees and Reed 2018b), so even if adults have fidelity to the source site where they were captured, it is anticipated that they are likely to remain at the release site (C. van Rees pers. comm.). Trimming the flight feathers of translocated birds before release also would increase the chance that they would remain at the release site. ‘Alae ‘Ula molt all of their flight feathers simultaneously and are thus naturally unable to fly for a portion of the year (C. van Rees pers. comm.).

Another possible strategy for the ‘Alae ‘Ula would be to translocate juveniles, which have a lower survival rate (van Rees et al. 2018b), and thus would be less of a loss to the source population. Moving juveniles would require that the translocation occur later in the year after more reproduction has occurred, such as April-July, when water level, and thus habitat quality, tends to be lower.

3.5.2. Timing of Translocations. For the ‘Alae ‘Ula, it is recommended that translocations be done in the winter months from January to March, for two reasons: 1) water levels at wetlands in Hawai‘i usually are highest in winter because of higher rainfall at this season, which is more likely to result in the habitat conditions preferred by ‘Alae ‘Ula and encourage birds to stay at the release site and not disperse; and 2) these months are just before the usual nesting season for ‘Alae ‘Ula, which might result in breeding more quickly. Dispersal in the ‘Alae ‘Ula is thought to be rare, with only three known instances of movements among wetlands on O‘ahu (van Rees et al. 2018b, Paxton et al. 2023), but in the Mariana Common Moorhen, dispersal was more frequent during drier conditions with low water levels (Takano and Haig 2004). In the Crested Coot, releases in the late winter (February-March) resulted in higher post-release survival and reproduction, which was attributed to better (wetter) habitat conditions and onset of the usual breeding season (Tavecchia et al. 2009).

3.5.3. Capture and Holding Methods at the Source Site. In previous studies of the ‘Alae ‘Ula, most birds have been captured in metal walk-in traps placed on land, such as Tomahawk and Have-a-Heart brand traps (Aaron Works, C. van Rees, Bryn Webber, pers. comm.). However, ‘Alae ‘Ula have injured themselves after being captured in these types of traps and exhibited abrasions on their head from the metal surfaces of the trap (A. Dibben-Young, C. van Rees pers. comm.). It is essential that the traps be monitored closely so that birds can be removed immediately after capture. In addition, lining the inside of the trap with a soft material, such as plastic window screen, is strongly advised to further decrease the chance of injury; use of this technique made it possible to use metal traps without any injuries to the birds (C. van Rees pers. comm.). Cracked corn and mango pieces have been effective baits in previous work. If ‘Alae ‘Ula are observed commonly eating a natural food at the capture site, that food type also could be used as bait opportunistically (C. van Rees, A. Works pers. comm.).

To facilitate rapid capture of the prescribed number of birds and to ensure an even sex ration, it is advisable to conduct a preliminary study in advance of the translocation. During this preliminary study, birds would be captured and each individual would be banded with a metal band and a unique combination of colored plastic bands, a blood and/or feather sample collected for genetic analysis, and then released at the site of capture. The samples would be tested to determine the gender of each bird, and the color band combination would allow later identification of each individual.

Because ‘Alae ‘Ula are territorial and do not usually wander into adjacent territories, it likely will be necessary to target individual pairs, with at least one trap for each pair. To facilitate quickly capturing enough birds for a translocation cohort, it would be useful habituate each pair to traps by pre-baiting them in advance for several days with the trigger mechanism disabled. The birds will become accustomed to entering the trap and eating the bait, then all the traps can activated simultaneously and the birds can be reliably captured quickly when everything is ready. An effort should be made to capture both members of a pair, which can be released together. Occasionally both members of a pair can be captured simultaneously, but this is rare (C. van Rees pers. comm.). If one member of a pair is captured first, the trap should be replaced in the same location to catch its mate. At sites with large ‘Alae ‘Ula populations and where the location of individual territories is known, it would be desirable to spread out the birds targeted for capture and to not take all birds from one area. This would avoid the creation of large gaps in the distribution and might result in more rapid refilling of territories and less overall impact to the source population.

After capture, each bird would be placed in an individual carrying container and taken to a central processing location, where it would be immediately weighed and banded, a feather sample collected for genetic analyses, then placed in a temporary holding pen (see description of recommended pen design in section 3.4.8). If mates are captured together in the same trap, they should be placed in separate transport containers because the stress of capture and transport could cause even mates to attack each other while in a confined space.

Because the goal is to translocate an equal number of males and females, it will be necessary to determine the sex of birds before they are moved. Male ‘Alae ‘Ula tend to be a little larger than females and to have a larger head shield, but there is overlap in size and their sex cannot be reliably determined by measurements (Charles van Rees, Bryn Webber, pers, comm.). Young males also can look a lot like females, and sometimes a third bird, usually another female, may associate with a pair and help to raise young, so even if two birds are captured together it is not guaranteed that they are male and female (Bryn Webber pers. comm.). If the identity and sex of pairs is known in advance based on a preliminary study, this information can be used to determine if captured birds are a pair. In the absence of such information, birds that are captured together can be assumed to be a pair or part of a trio and placed in the same holding pen.

Individuals captured at the same location but at separate times may be a pair and also can be placed together in the same holding pen. However, all birds placed together in holding pens should be monitored closely. If the birds are aggressive toward each other, then they probably are the same sex and should be separated immediately. If no aggression is observed between the birds when they are in close proximity and one is noticeably larger than the other it can be assumed that they are a pair. In other situations, the sex of birds will need to be determined genetically from a feather or blood sample, including birds that are captured individually, in cases where two birds captured together are very similar in size, and if observations in the holding pen are inconclusive.

Birds would be held at the capture location until the prescribed number of birds of each sex have been captured. If birds have been banded and their gender determined genetically in advance in a preliminary study, then all birds should be moved to the release site as soon as possible. If birds have not been banded and identified in advance, then it may be necessary to hold them until genetic tests are complete or their genders have been determined with confidence by observation.

During the holding period at the capture site, the behavior and body weight of each bird should be closely monitored; any birds that refuse to eat and lose more than 15% of their body weight or that do not settle down and show signs of distress should be released at the location where they were captured, hopefully before any mortality occurs. In the Henderson Crake, mortality in captivity from refusal to eat resulted in death of 20% of captive birds within four days, with birds that died losing 15-47% of body weight (Oppel et al. 2014). Careful monitoring during the first few days will be crucial to minimizing mortality of ʻAlae ʻUla during translocation. The holding period should be as short as possible but is needed to allow time to capture the prescribed number of birds and monitor their behavior. Capturing and banding birds in advance of the translocation to determine their gender would help to shorten the holding period.

3.5.4. Criteria for Selecting Birds for Translocation. Birds will be selected for translocation based on: 1) their behavior and acclimation to captivity; 2) their trend in body mass while in captivity; and 3) the confidence of their sex classification. Birds that fail to consume the captive diet and fall more than 15% below their capture weight and do not begin to regain body mass will be released at the same location where they were captured, with the goal being to return any bird not acclimating to captivity to the wild before its health is compromised. Behaviors such as being hyperactive or lethargic in captivity also could be considered conditions for release.

3.5.5. Diet and Feeding. ʻAlae ʻUla are known to be difficult to keep in captivity because they are easily stressed and sensitive to noise and disturbance, and they do not feed well in captivity (Jacqueline Nelson, pers. comm.). The birds will need to be fed while in the holding pens at the source site and the release site. At the source site, the holding period is anticipated to be 2-3 days in duration, and at the release site it is anticipated to be several days. The birds may not survive 3 days without eating. Because birds have a high metabolism and require a lot of food for their size (VanderWerf et al. 2019, VanderWerf et al. 2020), it is not practical to provide only natural foods obtained from the source or release site. ʻAlae ʻUla in rehabilitation at Save Our Shearwaters program have been fed a varied diet that included: scratch, commercial insectivore diet, dried mealworms, cut vegetables, and various invertebrates including blood worms, krill, and snails (Jacqueline Nelson pers. comm.). Mazuri waterfowl maintenance diet also would be good because it is designed specifically for waterfowl and other wetlands birds with a diverse diet; this was used for Laysan Ducks (VanderWerf et al. 2022). Each bird is anticipated to need about 15% of its body weight in food every day. Food would be placed in bowls twice a day, or more often if the birds eat all the food provided. The commercial food could be supplemented with natural food from the site, especially if some birds are reluctant to eat the commercial food, but it probably will not be practical to provide entirely natural food for any birds. It might be advisable to begin collecting some natural food in advance of capturing the birds to help with the transition to commercial food.

3.5.6. Transport Methods. Birds would be transported in plastic pet carriers that have been used in several other bird translocation projects (VanderWerf et al. 2019). Each bird would be placed in a separate carrier; mates would not be placed together to avoid any possible aggression during the stress of transport. It is desirable to fly birds as quickly as possible between islands. If there is sufficient funding, helicopter would be the fastest and thus the preferred method of interisland transport and would avoid delays with airport security and possible delays involved commercial fixed-wing flights. If helicopter transport is not feasible, then a small, private fixed-wing aircraft would be the next most desirable option. Commercial fixed-wing aircraft transport is feasible but less desirable because of the extra time required for security clearance, check-in, and possible flight delays. After arrival on the new island, birds should be driven to the release site and placed in temporary holding cages as quickly as possible.

3.5.7. Holding Pen Design and Placement. ʻAlae ʻUla are easily stressed and sensitive to disturbance; a reasonably large holding pen with adequate cover will be important to minimizing stress and mortality during captivity. The holding pen design described below is a composite of features used in previous reintroduction attempts for the ʻAlae ʻUla and for other rail species. The specifications do not need to follow these exactly and can be modified somewhat if necessary based on any constraints at the source and release sites, and on the dimensions of materials available.

A separate pen should be constructed for each pair of ʻAlae ʻUla. Birds that are not mates, especially birds of the same sex, should not be held together. During a translocation of the Aldabra Rail, the only two mortalities were two males that were thought to be a pair and were housed together by mistake (Wanless et al. 2002).

At the capture site, the pens can be placed near each other in a central processing location to facilitate feeding and monitoring, but there should be visual barriers between the pens so the birds cannot see each other, which could trigger aggression and increased stress levels.

At the release site, potential ʻAlae ʻUla territories should be identified in advance based on habitat features known to be important- a dense patch of vegetation for cover, open water for escape, and some dry land with grass and mud for foraging. A pen intended for each pair then should be placed in advance at each of the identified potential territories. The pens should be positioned so that roughly half of the pen is on dry land and half is in the water, to allow the birds access to water if they want it and allow them to explore and forage in both areas. If possible, placing the pen partially over an existing patch of vegetation would be desirable to provide natural cover and hiding places.

The dimensions of each pen would be about 200 x 120 x 60cm (length x width x height) and would have a roof but not a floor. This is somewhat larger than pens used for the Aldabra Rail (Wanless et al. 2002), but small enough to be transported in the bed of a pick-up truck. The dimensions can be adjusted if necessary based on the dimensions of materials available to build them and vehicles to move them. The pen would be constructed from a frame of PVC pipes and covered with mesh. A design in which the roof could be detached on one side would allow the pen to be folded up for easier transport and storage. Ideally there would be two layers of mesh on each side; a softer inner layer, such as plastic window screen, that would be less likely to injure the birds, and a stronger outer layer that would be resistant to predators, such as aquamesh, which is a PVC-coated galvanized wire mesh material that can withstand immersion in water, with a mesh size no larger than half-inch to exclude predators as small as rats. Wood could be used for the frame instead, but would be heavier and would not last as long. Chicken wire could be substituted instead of aquamesh, but would be more prone to rust. Netting also could be used instead of aquamesh but would not be as secure against predators. The pens should contain two doors, one on the top allow access for providing food and water and other activities, and one on the side from which the birds can be released. Each pen must contain at least two areas of cover, one for each bird. If no natural cover is enclosed within the pen, then some other type of cover should be provided, such as tall turf grass, rows of potted plants, or something else.

3.5.8. Release Methods. A soft release approach is recommended for reintroduction of the ‘Alae ‘Ula based on outcomes of previous projects with the ‘Alae ‘Ula and other similar species (Dickens et al. 2008, Parker et al. 2012). The soft release would involve a holding period of one to several days at the release site to allow the birds to acclimate to the new location and to allow monitoring of their behavior and feeding. If birds are feeding well, maintaining their body weight, and do not seem overly stressed, they could be held for several days to allow more acclimation and decrease the chance that they disperse away from the site immediately after release. If some birds seem stressed, refuse to eat, and lose weight, it may be necessary to release them sooner. If a bird falls more than 15% below its capture weight and does not begin to regain weight it should be released. If such a bird is part of a pair, then it may be advisable to release both members of the pair together. The actual release would be accomplished by simply opening the door to the pen and allowing the birds to leave when they are ready. If a stressed bird remains under cover and will not leave on its own, it may be necessary to gently encourage it to leave.

4. POST-RELEASE MONITORING

Monitoring animals after release to provide data on their status, movements, and population size is critical to optimizing the translocation methods and assessing the outcome (IUCN 1998, Sutherland et al. 2010). Various aspects of ‘Alae ‘Ula natural history have been monitored in previous projects, which provide a wealth of information about monitoring methods and baseline data for comparison (DesRochers et al. 2008, van Rees et al. 2018, Works 2021, Webber 2022).

4.1. Source Sites. Of primary interest at the source site is whether and how quickly territories are refilled after birds are collected for translocation, and thus if the removal resulted in a decrease in the population size. Each territory from which birds were taken should be visited at weekly intervals for a month after removal, or opportunistically if necessary, to monitor for the presence of ‘Alae ‘Ula. If no birds are observed after 15 minutes of passive observation, playbacks should be used to increase the detection probability. If birds are detected in a territory and the observer is confident they are new territory holders, the monitoring can be discontinued at that territory. If no birds are detected in a territory after a month of weekly visits, additional visits should made at monthly intervals for the next six months, or until birds are detected. The intervals and duration of monitoring are flexible and can be modified if necessary to fit with other monitoring activities and workload responsibilities. The main thing is to document if the territories are refilled and approximately how long it takes.

4.2. Release Sites. After the birds are released, it will be important to monitor their presence and activities to determine survival rates and whether any problems are occurring. For at least the first two weeks after release an effort should be made to find every bird every day. Each location where birds are released should be visited daily for the first two weeks, unless the birds that were released there are known to have moved somewhere else. For at least the first 2-3 days, only passive observation should be used without playbacks, which could instigate aggression among birds and cause them to move. Each day a bird is found, an effort should be made to observe it for at least 10 minutes to monitor its behavior. If some birds are not found after 2-3 days, playbacks can be used to help find them. If birds are missing from the locations where they were released, searches should cover an ever-expanding area until they are located. If a bird or pair appears to have settled into a territory within two weeks and is regularly found in the same area, monitoring frequency can be reduced to twice a week, then once a week as deemed appropriate.

The monitoring strategy and data collection methods will be different if radio transmitters or GPS tracking devices with remote data uploading capabilities are used. If radio transmitters are used, any birds that are not found visually should be searched for by their radio signal. If remote uploading GPS tags are used, the uploaded data should be examined every day to check for the presence and location of each bird. If some birds are missing, the next steps would depend on whether the GPS data are uploaded to a dedicated GPS antenna or whether they use cell phone signal, and whether they have a mortality indicator signal. If radio transmitters are used, and depending on the size of the wetland at the release site, it might be useful to place antennas on towers in different parts of the site to help with determining the locations of birds.

4.2.1. Movements, Habitat Use, and Territory Size. Although the ‘Alae ‘Ula will be released into what is believed to be patches of their preferred habitat, it is likely that they will begin exploring their new environment and that some or even all birds may move to new locations. Monitoring these movements and recording the habitats in which they are observed will help us understand their habitat preferences and how they are using the release site. Each day a bird is found, an effort should be made to observe it for at least 10 minutes to determine if it appears to have settled down or if it is still moving around. A GPS point should be recorded for each bird each time it is found. If the bird is moving, a new GPS point should be taken 10 minutes later or after the bird has moved 50 meters. Information about the bird’s behavior and the habitat at each GPS point should be recorded, including the dominant plant species, proportion of open water, and amount of open ground. The collection of GPS points can be used to map and measure the bird’s territory. If GPS tags are used, then obviously it will not be necessary to record GPS points with a hand-held unit, but the locations should be visited in person to record information about habitat.

4.2.2. Survival. Survival of translocated ‘Alae ‘Ula will be measured by visually monitoring individual birds using their unique color band combinations. Survival can be calculated with simple enumeration (number surviving out of the total number of birds) and with mark-recapture methods (e.g., with program MARK or R). Survival estimates based on simple enumeration are intuitive and easy to compare with other studies, but mark-recapture methods can result in more precise estimates with variance that facilitate comparison of survival among different groups or over different time periods (e.g., VanderWerf 2009). Survival can be compared among different groups of birds, such as males and females, birds in the first vs. second translocation cohort, those with vs. without transmitters, and any other groupings of interest. Mark-recapture methods used to estimate survival also can be used to measure population size, but it would be preferable to based population size estimates on the actual number of birds observed, at least initially (VanderWerf et al. 2015).

4.2.3. Reproduction. Signs of breeding behavior, such as carrying of nest material, should be watched for during other observations, and if any such behavior is observed an effort should be made to discreetly follow the bird to locate the nest. Otherwise, nests can be searched for systematic transects through appropriate habitat with emergent vegetation standing in water (Webber 2022). If a nest is found, it should be monitored with a remote trail camera to help determine the nest outcome and any cause of failure. Webber (2022) found no difference in nest success in nests monitored with cameras and those monitored in person. An effort should be made to determine the outcome of all nesting attempts, and the number of chicks hatched and surviving from each nest. Young from each nest should be banded with a unique combination of colored leg bands, if this can be done without causing too much distress to the chicks or parents.

4.2.4. Population Size. The most important measure of success is whether the translocations result in the establishment of a self-sustaining breeding population. Even if survival and reproduction are high in the first year(s), it will take several years to determine whether the population is self-sustaining and persists in the long-term. Population size is an important predictor of whether a population will persist; all else aside, larger populations are more likely to persist (Conant and Morin 2001, Miskelly and Powlesland 2013).

‘Alae ‘Ula are secretive and can be difficult to detect, which has hindered estimation of their population size and trend. Counts of ‘Alae ‘Ula during the biannual State waterbird count generally are recognized as an underestimate of the actual population (DesRochers et al. 2008, Paxton et al. 2022). For example, the number of Hawaiian common moorhens detected at Hāmākua Marsh during waterbird counts averaged 3.8 from 2000 to 2002, but repeated observations for longer periods revealed 10 pairs at the same site (Smith and Polhemus 2003). One method that can enhance detection of Hawaiian common moorhens during is playbacks, which increased detections of ‘Alae ‘Ula by 30 percent on O‘ahu and 56 percent on Kaua‘i (DesRochers et al. 2008).

Population size in the first year after release, when the population is still small, can be measured by a complete census of the number of banded individuals known to have survived, based on the efforts to locate individual birds. Depending on whether and how rapidly the population grows as a result of reproduction, and whether any young birds are banded, it may be possible to continue censusing the entire population of banded birds for the first several years. If the population grows large or it becomes difficult to determine how many unbanded individuals are present, the number of apparent breeding pairs in discrete locations can be used to estimate the breeding population size.

4.3. Project Assessment and Measures of Success. The ultimate goal of translocation is to establish a self-sustaining ‘Alae ‘Ula population on the new island, and there are short-term milestones that can be used at various stages to help assess whether the project is on track and likely to succeed. It is desirable to minimize mortality during all phases of the project, but some deaths are inevitable and natural, and a reasonable goal is to not exceed natural levels of mortality or nest failure. If mortality or nest failure occurs, efforts should be made to determine the cause(s) any make any possible corrections to prevent it from occurring again.

4.3.1. Survival During Capture and Transport. The goal in all translocations is to have 100% survival during transport, but it is possible that some birds may die during capture, holding, and transport simply from stress, even if everything goes according to plan. Mortality rate during translocations is highly variable, depending on the species, the distance and type of transport, and many other factors. During previous reintroduction attempts for the ‘Alae ‘Ula no deaths were reported during transport, but limited information was available about some efforts (Dibben-Young 2009). In the Aldabra Rail, 2 of 20 adults died in captivity during a soft release approach (Wanless et al. 2002). In a captive program for the Henderson Crake, 22 of 108 birds (20%) died in captivity within an average of four days because they refused to eat and died of starvation and releasing them was not an option (Oppel et al. 2016). For the ‘Alae ‘Ula, a reasonable goal would be to not exceed 10% mortality during each translocation. For example, if 10 birds are moved and more than one dies during transport, the cause should be identified and corrected before more translocations are undertaken.

4.3.2. Short-term (30-day) Post-release Survival. Again, the goal is always for all birds to survive the first few days and weeks after release, but it is possible that some birds may die, or that they cannot be found and must be assumed to be dead. Mortalities occur shortly after release in many translocations due to cumulative stress and environmental change (Armstrong and Ewen 2002, Miskelly and Powlesland 2013). In reintroduction efforts for the Crested Coot, one-third of post-release mortality occurred within the first month after release, likely due to inexperience of captive-bred birds and difficulty in adapting to the wild environment (Tavecchia et al. 2009). For the ‘Alae ‘Ula, a reasonable goal would be about 70% survival during the first month after release if adults are released, lower if juveniles are released.

4.3.3. Long-term (1-year) Post-release Survival. In the Cocos Buff-banded Rail, 30 of 39 individuals (77%) were observed post-release, with an average post-release survival length of 5.1 months, which resulted in successful establishment of a new population (Woinarski et al. 2016). In the Buff Weka, reintroduction to an unfenced site resulted in predation on 12 of 20 birds within four months after release, despite predator control, and eventual failure of the project (Watts et al. 2017). In the ‘Alae ‘Ula, annual adult survival has been estimated to be 0.66 (95% CI 0.55-0.76; Van Rees et al. 2018b), so a reasonable goal for translocated birds would be to not exceed the natural mortality rate of 66% in the first year.

4.3.4. Breeding. In previous reintroduction attempts with the ‘Alae ‘Ula, breeding was documented only following releases on Moloka‘i in the 1960s. If breeding occurs, some nest failure must be expected. Van Rees et al. 2018b reported that nest success averaged 66% (SD=11%, range 42%-77%) at six sites combined, with an average of 3.86 chicks per successful nest (SD=0.83, range 2.25-4.51;). Works (2021) reported that fledging success at Hāmākua

Marsh averaged 73% from 2007-2021 (range 13%-96%) and that the number of fledglings per brood averaged 1.5 (range 0.6 to 2.2). Webber (2022) found daily nest survival probability of 0.979 (95% CI 0.972-0.984) and nest success of 59% at Hanalei NWR. For chick survival, van Rees et al. (2018b) reported that survival of ‘Alae ‘Ula from hatching to fledging was 42% at JCNWR (Chang 1990) and 37% at Hanalei NWR (Gee 2007). Webber (2022) reported that chick survival was 0.18 ± 0.08 from hatch to 40 days, and that chick survival was lower in the first half of the 40-day, pre-fledging period (0.78 ± 0.05 per 4-day interval) than the second half (0.88 ± 0.09).

4.3.5. Population Size. The ultimate measure of success is whether the translocation results in establishment of a self-sustaining population, so the primary measure of success is a population size that is stable or increasing. Because adult survival of ‘Alae ‘Ula is relatively low (66%), reproduction will be necessary to main a population that is stable, and obviously would be required for population growth.

5. KNOWLEDGE GAPS AND ADDITIONAL NEEDS

5.1. ‘Alae ‘Ula Salinity Tolerance. ‘Alae ‘Ula are known to prefer fresh water, but they do occur in some areas with brackish water, and the exact salinity levels they will tolerate are not well known. At the Kawaiele Sanctuary on Kaua‘i, the number of birds declined from an average of 24 individuals to an average of 10 when the salinity rose to about 20 ppt, and in another instance when the number dropped to just 5 individuals when average salinity rose to about 22 ppt (Jason Vercelli, pers. comm). At Hāmākua Marsh on Oahu there already are monthly data on salinity and ‘Alae ‘Ula abundance, which showed that ‘Alae ‘Ula numbers were inversely related to salinity in four basins (Works et al. 2021), and this would be a good location to collect more precise data on salinity tolerance of ‘Alae ‘Ula.

5.2. Climate Security and Anticipated Changes in Wetland Suitability. Sea level rise and increasing storm surge associated with global climate change are expected to result in inundation of some coastal wetland and increasing salinity in groundwater over a broader area of coastal Hawai‘i (Kane and Fletcher 2013). Because ‘Alae ‘Ula prefer fresh water, increases in salinity may render some wetlands less useful for them, depending on the amount of increase (van Rees et al. 2018b). Changes in rainfall patterns, particularly decreased rainfall that results in lower water level and higher salinity, also would affect habitat availability for the ‘Alae ‘Ula. Infiltration of salt water into groundwater also could decrease wetland suitability, and this might be more difficult to detect because changes might occur at greater water depths, while surface salinity remained unchanged. More precise and specific information about anticipated changes in rainfall, inundation, groundwater infiltration, and salinity at coastal wetlands in Hawai‘i would be useful for predicting population trends in the current range on Kaua‘i and O‘ahu, and for assessing the suitability of wetlands on other islands for reintroduction. Some of this information may exist already, and additional effort to locate it might answer some questions related to this topic.

5.3. Community Support. Another important need for successful ‘Alae ‘Ula reintroduction is information about the level of community support and the amount of public outreach that will be needed. If the local community does not support the action, there is more chance that there will be legal challenges to implementation and greater potential for vandalism and hunting of the birds for sport or food. Expert interviews indicated that there might be some opposition in certain areas, but it would be valuable to know how widespread those feelings are. Public outreach and community engagement will be necessary in advance of any reintroduction efforts, regardless of the location, to gauge support and help to choose a release site.

6. OUTREACH AND COMMUNICATIONS

6.1. Site Visits

Eric VanderWerf visited 10 potential release sites on Molola‘i on 11 October 2023, three sites on Maui on 12 October 2023, and two sites on Hawai‘i on 30 December 2023, as listed below.

Moloka‘i:

- Kakahai‘a National Wildlife Refuge
- Kalua‘apuhi Pond/ Piliwale Spring /‘Ō‘ō‘ia Pond
- Kamahu‘ehu‘e Pond
- Kaunakakai Waste Water Treatment Plant
- Kaupapalo‘i o Ka‘amola (Lo‘i Kalo)
- Kōheo Wetland
- Moku Pond
- Ohi‘apilo Pond
- Pahuauwai (Moloka‘i Sea Farms)
- Punalau Pond

Maui:

- Kanahā Pond Wildlife Sanctuary
- Waihe‘e Coastal Pond and Dunes Refuge
- Kealia Pond National Wildlife Refuge

Hawai‘i Island:

- Loko Waka and Kionakapahu Ponds

6.2 Community Outreach

During this feasibility assessment, Eric VanderWerf contacted the owner and manager of all public lands being assessed, and also the managers of most private lands that are managed for conservation purposes, such as the Hawai‘i Islands Land Trust. Managers were generally very responsive and helpful, and accompanied Eric on all site visits. More extensive community outreach, including public meetings and meetings with other private landowners is beyond the scope of this feasibility assessment.

6.3. Important Messages

Several messages will be important during community outreach about the project:

- The ʻAlae ʻUla is a native bird that is endemic to Hawai'i (found nowhere else).
- The ʻAlae ʻUla formerly occurred on all the larger Hawaiian Islands, but it was wiped out on all islands except Kauaʻi and Oʻahu by human activities like hunting, draining of wetlands, and habitat degradation.
- It is our kuleana (responsibility) to protect the ʻAlae ʻUla and restore it to its former homes on other islands to ensure its continued survival.
- The ʻAlae ʻUla is important in Hawaiian culture and mythology.
- No decisions have been made yet about where to attempt reintroduction of the ʻAlae ʻUla. This is only a feasibility assessment.

7. CONCLUSIONS

Translocation of ʻAlae ʻUla to a third island is feasible using existing knowledge and techniques. Some additional information would be useful in making decisions about the reintroduction site, such as more precise data on salinity tolerance of ʻAlae ʻUla, more information about climate security of certain sites, and community support at each site, but lack of this information would not necessarily preclude reintroduction of ʻAlae ʻUla.

It is recommended that translocations be done over a period of at least two years. Translocations of adults probably would be best done in the winter months from January to March when habitat quality is likely to be best and prior to the usual breeding season, to discourage birds from dispersing away from the release site. If juvneiles are moved to reduce impacts to the source population, translocations could be done when young have reached independence. ʻAlae ʻUla are known to be stressed in captivity and are territorial and can be aggressive toward each other, so capture, transport, and release must be done carefully and as quickly as possible to avoid mortality. Translocation cohort size is recommended to be no more than 10 birds in the first year, including pairs if possible, to allow rapid capture and release and minimize effects on the source population. A preliminary study at the source site in advance of the translocation is advisable to identify the gender of birds and breeding pairs.

For sources of ʻAlae ʻUla to translocate to a third island, it would be desirable to collect birds from both Kauaʻi and Oʻahu to ensure adequate genetic representation in the founding population. On Kauaʻi, the highest ranked potential source site was Hōkūala Resort, formerly known as the Kauaʻi Lagoons or Westin Lagoons. This site received high scores because ʻAlae ʻUla are relatively numerous, their reproductive rate is high, and accidental mortality of ʻAlae ʻUla occurs there each year and they could be "rescued." Hanalei NWR has the largest ʻAlae ʻUla population of any site and also scored highly as a potential source site, but the refuge is extremely short-staffed and has had chronic difficulties dealing with management issues. The refuge staff were made aware of this feasibility assessment but did not provide any input and did not comment on whether they could support the project. On Oʻahu, the best source would be James Campbell NWR, which supports a relatively large population of ʻAlae ʻUla and where support from the refuge staff can be relied on.

The highest ranking release site was ʻAimakapā Pond on Hawai'i, and that also was the only site that has currently has suitable habitat and seems ready to receive ʻAlae ʻUla, though there is concern about long-term climate security and the potential for future increases in salinity at that site. Several other sites scored only slightly lower and probably could be suitable, pending the outcome of various management actions. The sites that seem most likely to become suitable in the near future are Waiheʻe Coastal Dune and Wetlands Refuge on Maui and Punalau Pond on

Molokaʻi. At Waiheʻe the main reason the site currently is not suitable for ʻAlae ʻUla is lack of water. Funding has been secured and actions are already underway to correct the lack of water, and it is expected that the site might be suitable for ʻAlae ʻUla by June 2026. Two other large wetlands on Maui, Kealia Pond NWR and Kanahā Pond, were suitable in most respects, but their variable water level and high or variable salinity renders them unsuitable for ʻAlae ʻUla, and those issues will be difficult to change. Punalau Pond on Molokaʻi is expected to be acquired soon by the Molokaʻi Land Trust, and there are subsequent plans for habitat restoration including removal of invasive mangroves that have overgrown freshwater springs and changed the hydrology of the area. Some sites on Molokaʻi should not be considered for reintroduction of ʻAlae ʻUla because of expressed community opposition. On Hawaiʻi Island, Waipiʻo Valley has extensive suitable habitat and may warrant additional consideration, but the complex land ownership and potential for community opposition mean that delicate community outreach would be required.

Factors that will be important to ensuring success of reintroduction are effective, long-term habitat management and predator control or a predator proof fence at the release site, and community engagement and inclusion in advance to gain support.

8. BUDGET

The budget presented below is for two years of translocations in which birds are captured at two source sites (one on Kauaʻi in the first year and one on Oʻahu in the second year) and released at a single site on Maui, Molokaʻi, or Hawaiʻi. The project would be implemented by a team of three people including a Principal Invesigator, a senior biologist, and a technician. The budget includes the following items, which are listed in Table 4 under separate lines with an estimated cost for each.: 1) labor for administrative tasks such applying for permits, obtaining other permissions, procuring equipment and materials, and grant administration; 2) labor for a 1-month study at each source site in advance of the translocation to capture and band birds for gender and individual identification and to locate territories; 3) labor for preparing the source site, including modification of traps and construction of holding pens; 4) labor for preparing the release site, including selection and small-scale habitat improvements at release locations and construction of holding pens; 5) labor for capturing, moving, and releasing birds and 30 days of intensive post-release monitoring; 6) labor for one year of monitoring and predator control after the 30-day post-release period; 7) travel costs for people and birds, including helicopter flights to transport birds between islands, vehicle rental cost at the source site for one month each year, and vehicle purchase at the release site; 8) equipment and materials, including traps to capture birds, predator removal traps, materials for building holding pens, GPS tags and receiver to monitor bird movements, tools, and genetic tests to determine gender of captured birds. For compliance with the National Environmental Policy Act (NEPA), it is assumed that that the project will be covered by a categorical exclusion or, if it is determined that an Environmental Review (EA) or Environmental Impact Statement (EIS) is needed, that the document will be completed by DOFAW and/or the USFWS.

The budget does not include the following costs: 1) any large-scale habitat restoration needed at the release site before the translocation could occur, such as removal of non-native vegetation or dredging; 2) construction of a predator exclusion fence at the release site; 3) completion of an EA or EIS if one is required; 4) community outreach and engagement needed before the project starts; and 5) long-term monitoring and predator control at the release site beyond a year after each release.

The actual cost of reintroducing ‘Alae ‘Ula to a third island could differ from the cost presented in this assessment for several reasons. For example, the time and expense required to prepare for capturing birds at the source site and will depend on which site is selected and the level of support provided by the land owner or manager. The cost will be lower if there are facilities where equipment can be stored, tools that can be borrowed to build pens, a vehicle to help transport equipment and birds, housing for staff, and partners who can assist with various aspects of the work. Similarly, at the release site the effort and cost will be lower if the land manager can assist with preparing the site, building release pens, monitoring of the released birds, and predator control. The budget presented below assumes there will be no support of any kind from the land manager at either the source site or the release site, and that it therefore will be necessary to rent or purchase a vehicle at each site, rent housing for staff, and buy all equipment, including traps to capture birds and predators, and tools to build release pens.

The budget also depends on other aspects of the project, including how many birds are moved per year, how many years the project extends, and decisions about post-release monitoring methods, particularly whether radio transmitters or GPS tags will be used to help monitor survival and movements. The budget presented below assumes that 10 birds would be moved in each of two years, and that GPS tags will be used, which would be the most expensive and most informative monitoring method. It may be desirable to continue the project for more than two years, but whether this is necessary, or advisable, may depend on the outcome in the first two years.

Finally, the cost may vary depending on who does the work. The budget below is based on costs projected by PRC from experience with previous translocations and current PRC salary guidelines; the cost of the project may differ if it is implemented by another organization.

Table 4. Estimated budget for ‘Alae ‘Ula translocation over two years.

Budget item	Year 1	Year 2	Total
Labor			
Admin: permits, approvals, procurement, grant administration	$21,160	$15,870	$37,030
Labor for pre-translocation study and banding	$20,716	$20,716	$41,432
Source site prep.	$8,845	$8,845	$17,690
Release site prep.	$10,085	$2,918	$13,003
Bird capture, transport, release, 30-day post-release monitoring	$23,890	$23,890	$47,780
One year of monitoring and predator control	$78,000	$78,000	$156,000
Data entry, analysis, reporting	$8,390	$8,390	$16,780
Labor Subtotal	$171,086	$158,629	$329,715
Travel	$85,158	$47,380	$132,538
Equipment+supplies	$30,445	$22,569	$53,014
Total	$286,689	$228,578	$515,266

Table 5. Equipment and supplies budget details. Note: The cost of each item includes15% for overhead.

Item	number	cost	Total cost	Notes
bird traps	12	$125	$1725	tomahawk raccoon size
trap prep materials	2	$100	$230	shade cloth etc.
materials for pens	15	$300	$5175	5 pens at source site, 5 at release site, 2 birds (pair) per pen
tools	1	$805	$805	
pet carriers for travel	12	$25	$345	1 per bird for 10 birds, 2 replacements
bird food	2	$200	$460	
GPS tags	20	$1,500	$34,500	1 per bird for 10 birds each year
GPS receiver	2	$1,500	$3,450	
predator live traps	25	$125	$3594	tomahawk
predator kill traps (DOC200)	40	$50	$2300	includes wooden exclusion box for each trap
predator bait		$430	$430	
Total			$53,014	

9. TIMELINE AND NEXT STEPS

Next 3 years (2024-2026). These are actions that can, and should, begin right away, and which in most cases are described in this feasibility study.

- **Identify a working group.** A small group of people is needed to focus on moving forward with reintroduction of ‘Alae ‘Ula to a third island, using this feasibility study to help with planning as needed.
- **Draft a translocation plan.** This feasibility study can serve as a starting point, and the translocation plan would include more details and decisions about the sources of birds, the release site(s), the numbers of bird to be moved, monitoring methods, etc. It would be similar to previous translocation plans written for the Laysan Duck and Nihoa Millerbird.
- **Prioritize sites for habitat restoration.** This feasibility study and other documents (e.g. Drexler et al. 2023) have identified several sites that could be used as reintroduction sites for the ‘Alae ‘Ula, but where restoration would be needed first to improve the habitat. Identifying which sites would be most valuable if restored, the amount and type of restoration required, and the cost of habitat restoration is beyond the scope of this feasibility, and a more specific process is needed to prioritize sites and determine costs.
- **Collect additional data on salinity tolerance of ‘alae ‘ula and climate security of potential reintroduction sites.** As described in this assessment, additional information about salinity tolerance of ‘Alae ‘Ula and climate secutrity of potential release sites, particularly ‘Aimakapā Pond, will be useful in selecting a reintroduction site.

Next 5 years (2024-2029). These are actions that can start soon, but for which some additional research, planning, or funding may be needed.

- **Begin habitat restoration at potential reintroduction sites.** Restoration has already begun at some sites, such as the Waihe‘e Refuge on Maui. At other sites funding has been secured but the actual work has not begun, such as at Punalau Pond on Moloka‘i. At other sites an assessment may be needed to determine what actions are required and the size of the area to be restored, and funding proposals can be prepared once this information is available.

- **Conduct a pilot translocation.** The pilot translocation could follow one of two strategies: 1) move birds within an island on which they already occur, primarily to work out the methods involved in capturing, moving, and caring for ‘alae ‘ula in captivity. As described previously in this assessment, the newly created wetland in the Manā Plains offers an opportunity for conducting a pilot translocation in an easily accessible area and where establishing a new population would also be useful. 2) move a small number of birds to a wetland on a third island that is thought to be suitable or nearly so.

Next 10-15 years (2024-2039). These are longer-term actions that either are continuous and ongoing or that must await results of other recovery actions before they are relevant.

- **Continue habitat restoration** at multiple sites and enhance connectivity among restored wetlands to create a larger landscape more conducive to waterbird conservation.
- **Continue translocations to new islands.** Once wetlands have been sufficiently restored and are ready to receive ‘alae ‘ula, more birds should be moved to those sites using methods refined during the pilot translocation.
- **Continue monitoring.** Continued monitoring of existing ‘Alae ‘Ula populations is important for understanding the status of the species, the severity and any changes in threats, habitat conditions and changes, the success of any translocations, and any impacts on source populations.

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