U.S. Fish & Wildlife Service

Revised Recovery Plan for the `Alalā

(Corvus hawaiiensis)

Drawing of adult `Alalā feeding nestlings by Patrick Ching, used by permission.

Revised Recovery Plan for the `Alalā (*Corvus hawaiiensis*)

(Original recovery plan approved October 28, 1982)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: Acting [signature]
Regional Director, U.S. Fish and Wildlife Service
David J. Wesley

Date: JAN 2 7 2009

U.S. FISH AND WILDLIFE SERVICE MISSION IN RECOVERY PLANNING

Section 4(f) of the Endangered Species Act of 1973, as amended, directs the Secretary of the Interior and the Secretary of Commerce to develop and implement recovery plans for species of animals and plants listed as endangered or threatened, unless such plans will not promote the conservation of the species. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service (National Oceanic and Atmospheric Administration [NOAA] Fisheries) have been delegated the responsibility of administering the Endangered Species Act. Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed and threats to its survival are neutralized, so that its long-term survival in nature can be ensured. The goal of this process is the maintenance of secure, self-sustaining wild populations of species with the minimum necessary investment of resources. A recovery plan delineates, justifies, and schedules the research and management actions necessary to support recovery of a species. Recovery plans do not, of themselves, commit personnel or funds, but are used in setting regional and national funding priorities and providing direction to local, regional, and State planning efforts. Means within the Endangered Species Act to achieve recovery goals include the responsibility of all Federal agencies to seek to conserve endangered and threatened species, and the Secretary's ability to designate critical habitat, to enter into cooperative agreements with the States, to provide financial assistance to the respective State agencies, to acquire land, and to develop Habitat Conservation Plans and Safe Harbor Agreements with applicants.

DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and protect listed species. We, the U.S. Fish and Wildlife Service, publish recovery plans, sometimes with the assistance of recovery teams, contractors, State agencies, Tribal agencies, and other affected and interested parties. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific actions and may not represent the views nor the official positions or approval of any individuals or agencies involved in recovery plan formulation, other than our own. They represent our official position *only* after they have been signed by the Regional Director or Director as *approved*. Recovery plans are reviewed by the public and submitted to peer review before we adopt them as approved final documents. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

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U.S. Fish and Wildlife Service. 2009. Revised Recovery Plan for the `Alalā (*Corvus hawaiiensis*). Portland, Oregon. xiv + 104 pages.

An electronic copy of this plan is available at <http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm> and also at <http://endangered.fws.gov/recovery/index.html>.

ACKNOWLEDGMENTS

The initial recovery plan for the `Alalā, or Hawaiian Crow, was approved in 1982. This plan updates the original recovery plan. The revised plan was prepared by the `Alalā Recovery Team that was appointed in late 1992 following the publication of the National Research Council's report *The Scientific Bases for the Preservation of the Hawaiian Crow*. Current members of the Recovery Team are: Paul Banko (U.S. Geological Survey, Biological Resources Discipline); Jeff Burgett, Leader (U.S. Fish and Wildlife Service), Scott Fretz (Hawai`i Division of Forestry and Wildlife); Reggie David (Hawai`i Audubon Society); Scott Derrickson (Smithsonian Institution/National Zoological Park); John Fitzpatrick (Cornell Laboratory of Ornithology); Alan Lieberman (Zoological Society of San Diego); Peter Simmons (Kamehameha Schools); Keith Unger (McCandless Ranch); and Peter Vitousek (Stanford University). The current Executive Secretary for the Recovery Team is Jay Nelson (U.S. Fish and Wildlife Service). We, the U.S. Fish and Wildlife Service, wish to express our sincere thanks to Cynthia Kuehler (Team Member, 1992 to 1993), Peter Shannon (Team Member, 1992 to 1996), Peter Harrity (Team Member, 1994 to 1999), John Marzluff (Team Member, 1992 to1999), Paul Conry (Team Member, 1992 to 2005) and Scott Johnston and Marilet Zablan (Executive Secretary, 1992 to 1997 and 1998 to 2001, respectively), for their contributions to the current recovery program and their assistance in plan revision.

Many individuals and organizations have contributed to the recovery program for the `Alalā in terms of support, advice, and personnel. We would especially like to thank the following individuals for their dedication, professionalism, and continuing support: Tonnie Casey, Ray and Cynthia Salley (McCandless Land and Cattle Company); Elizabeth Stack, Paul Kane, and Bobby McClure (Keālia Ranch); Doyal Davis and Bobby Lindsey (Kamehameha Schools); John Doebel, Tom Dwyer, Marvin Plenert, and Mike Spear (U.S. Fish and Wildlife Service, Portland); John Engbring, Barbara Maxfield, Robert Smith, Karen Rosa, Craig Rowland, and Eric VanderWerf (U.S. Fish and Wildlife Service, Honolulu); Ronald Walker; Jack Jeffrey, Dave Ledig, Glynnis Nakai, and Dick Wass (U.S. Fish and Wildlife Service, Hakalau National Wildlife Refuge); Donna Ball, Ken Clarkson, John Klavitter, Glenn Klinger, Kevin Reece, and Michael Sherman (`Alalā Field Team); Carter Atkinson, Steve Fancy, Calvin Harada, Jim Jacobi, Dennis LaPointe, Gerald Lindsey, Linda Miller, Glenn Olsen, Thane Pratt, Michelle Reynolds, John Slotterback, Tom Snetsinger, and Thierry Work (U.S. Geological Survey, Biological Resources Discipline); Michael Buck, Fern Duvall, Chris Eckert, Jon Giffin, and Greg

Massey (Hawai`i Division of Forestry and Wildlife); Gwen Campbell, Taylor Cockerham, Bill Druker, Angela Tracey Goltz, Sterritt Grune, Nancy Harvey, Robert Hayes, Donald Janssen, Susan Farabaugh, Hal Maxey, Barbara McIlraith, Pat Morris, Lynne Neibaur, Paul Oesterle, Kawika Ramler, Bruce Rideout, Marcie Roskop, Barbara Schmeling, Richard Switzer, John Turner, and Kim Williams (Zoological Society of San Diego); Peter Luscomb, James Majeur, and Ben Okimoto (Honolulu Zoo); Rob Fleischer (National Zoological Park); Michael Kochert, James Enderson, Michael Morrison, Beatrice Van Horne, and Mick Castillo (`Io Recovery Working Group); Don Duckworth, Tom Cade, Hampton Carson, Frances James, Stuart Pimm, Donna Gerardi, Norman Grossblatt, Scott Olson, and Mary Kay Porter (National Research Council staff/Committee members/advisors).

We would also like to acknowledge the many interns and volunteers who have assisted in: `Alalā Field Studies - Ron Batie, Natasha Bellis, Keali`i Bio, Jennifer Boyce, Sue Canniff, Dr. Yvonne Ching, Jeremy Clark, Cam Collins, Greg Cunningham, Shane DeMattos, Jessica Dooley, Guillermo Doval, Karen Fawcett, Vince Franke, Kelley Garrett, Jim Goetz, Wing Goodale, Mary Hershdorfer, Rose Jaffe, Mamuna Kahn, Kurt Karwacky, Terry Kreuger, Rowan Lockwood, Mary Maier, Kurt Manning, Jennfier Niese, Sophie Osborne, Jenny Osgood, Buck Pelkey, Mark Phillipart, Kevin Reese, Gretchen Ruhl, Lenna Schnell, Rachel Schultz, Michael Sherman, Kathleen Sherry, Rachel Shorten, Kelly Shropshire, Lynn Sieffermann, Andrea Smith, Eric Stackhouse, Christina Sulzman, Lance Tanino, Michael Thorsen, Keren Tischler, Hira Walker, Paul Wik, Laura Williams, Tana Wood, and Bronwen Wright; Biological Resources Discipline, Disease Vector Studies - Charles Beck, Walter Burak, Debbie Cobb, Clem Dombrowski, Beth Drake, Bob and Marsha Dusek, Jennifer Gergin, Maureen Henry, Claire Kane, Kerry Kenwood, Julie Lease, Melissa Langglue, Keri McRoberts, Jennifer Mitchell, Stuart Niven, Jennifer Osgood, Ramiel Papish, Jennifer Randall, Sue Rocciati, Nick Shima, Brad Smith, Carolyn Steve, Toyoshima Tetsuhiko, Nick Tucker, Jennifer Turner, and Chris Willet; Kona Forest Unit Operations - Bonnie Nielson, Christina Marento, Nicole Menard, and Mark Vekasy; and Corvid Surrogate Studies - Laura Valutis, Katherine Whitmore, Leslie Thomason, Colleen Marzluff and their volunteers: Jessica Anger, Rich Bachmeier, Marc Bechard, Nancy Clum, Ruth Denison, Jason Dransfield, Ethan Ellsworth, Sean Finn, Bruce and Connie Landon, Laura Gilson, Matthew Goewert, Jennifer Golch, Bob Gotfried, Scott Harris, Brian Herting, Robert Hogan, Marty and Erika Janstrom, Al King, Bruce and Greg Landon, Robert Lehman, Mary McFadzen, Mark Pavelka, Joe Pollard, Keith Ricketts, Linda Schueck, Clint and

Beth Telford, Marva Wertz, Kate Whitmore, Buzz Valutis, and Elizabeth and Joel Zeller. Financial support for surrogate studies was provided by the U.S. Fish and Wildlife Service, the Chicago Zoological Society, Kaytee Products, Inc., the Conservation Research Fund, and the Sustainable Ecosystems Institute.

Special thanks are also due to Cornell University, The Peregrine Fund, Kamehameha Schools, McCandless Ranch, Hawai`i Division of Forestry and Wildlife, Honolulu Zoo, Zoological Society of San Diego, Stanford University, the Smithsonian Institution's National Zoological Park, the University of Washington, and the U.S. Geological Survey's Biological Resources Discipline for allowing personnel from their organizations to serve as Team members and consultants, and to The Peregrine Fund, Student Conservation Association, U.S. Geological Survey, and Zoological Society of San Diego for assistance in recruiting the many interns and volunteers who have contributed to the `Alalā recovery program.

We would like to thank the major donors to the Zoological Society of San Diego, who have supported the construction and operation of the Hawaii Endangered Bird Conservation Program, to include the Moore Family Foundation, Kaytee Avian Foundation, Club 300, Wallace Research Foundation, Karasik Family Foundation, Strong Foundation, Cooke Foundation, McInerny Foundation, Atherton Foundation, Dodge Foundation, and Fred Baldwin Foundation.

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EXECUTIVE SUMMARY

Previous Recovery Plan: The first `Alalā Recovery Plan was published on October 28, 1982 (U.S. Fish and Wildlife Service [USFWS] 1982). Since January 4, 1993, guidance for the recovery program has also been based on the "Long-term Management Plan for the `Alalā" (USFWS 1993), the National Research Council report "The Scientific Bases for the Preservation of the Hawaiian Crow" (NRC 1992), and management recommendations formulated periodically by the `Alalā Recovery Team. The 1982 recovery plan and guidance documents from the early 1990s assumed continued reproduction in the wild and integration of captively-reared individuals into the wild breeding population. Neither of these assumptions was borne out in subsequent years; therefore the 1982 plan's strategy and accompanying criteria are obsolete. The current focus is necessarily on captive propagation to minimize loss of genetic variability. This is a major shift in recovery strategy. The objective of this revised plan is to guide urgent and essential steps in preventing the extinction of the species, while at the same time providing an overarching plan for the species' eventual recovery.

Current Species Status: The `Alalā, or Hawaiian Crow (*Corvus hawaiiensis*), is listed as endangered. There currently are no individuals known to exist in the wild. Between 1993 and 1998, twenty-seven juvenile `Alalā, originating from both captive and wild parents, were raised in captivity and released in South Kona at the McCandless Ranch, near where wild `Alalā were still known to exist. Twenty-one of the 27 released birds died from disease, were depredated, or disappeared. The remaining six were returned to captivity in 1998 and 1999. The prediction that released birds would integrate into the wild population was not borne out -- there was no reproduction, and only limited reproductive behavior was observed in the released birds. The wild population of 12 birds in 1992 dwindled to zero in 2002. In January 2008, there were 56 `Alalā, representing the entire population of the species, in captivity at the Keauhou and Maui Bird Conservation Centers on Hawai`i and Maui islands, respectively.

Habitat Requirements and Distribution: The `Alalā is endemic to the island of Hawai`i. Historically, the species was restricted to the dry and mesic forests in the western and southern portions of the island, from Pu`uanahulu in the North Kona District to the vicinity of Kīlauea Crater in the Ka`ū District. The species is associated with `ōhi`a (*Metrosideros polymorpha*) and `ōhi`a-koa (*Acacia koa*) forests with an understory of native fruit-bearing trees, vines, and shrubs.

Threats to Species Recovery: Current threats include potential predation by non-native mammals and the `Io or Hawaiian Hawk (*Buteo solitarius*), introduced diseases, and habitat loss and fragmentation. Inbreeding depression may be reducing the reproductive success of the captive population, and loss of wild behaviors in captivity might reduce survivorship of captive-raised birds released into the wild. Because the population is small and confined to captivity, the `Alalā is highly susceptible to stochastic environmental, demographic, and genetic events. These threats will challenge the species for many years, even after `Alalā have been reintroduced to the wild.

Recovery Goal: The ultimate recovery goal is to restore multiple self-sustaining populations within the historical range, and subsequently to delist the `Alalā. Because recovery will be based on releases of captive-bred `Alalā to the wild, quantitative determination of the population sizes and parameters necessary to consider downlisting and delisting cannot be accomplished until more complete data on the species' biology and threats are generated as part of a future release program.

Recovery Objectives: The `Alalā currently exists only as a small population in captivity, and so the exact needs of the recovery program cannot be specified beyond a relatively short time horizon. Recovery of this species will require both sustained, long-term conservation actions and repeated experimentation to determine the optimal means to reestablish wild populations. This recovery plan's structure reflects these needs by articulating both long-term strategies (the Strategic Plan) and short-term actions (Implementation Plans) which will be revised regularly. The elements of the recovery strategy are to (1) expand captive propagation to minimize the loss of genetic diversity, (2) identify, protect, and manage suitable habitat, and reduce threats at the selected release sites, (3) introduce birds into the wild in suitable managed habitat once the captive population is stabilized, (4) garner public support and funding, and (5) conduct research and adaptively manage the `Alalā recovery program.

Recovery Criteria: The size, distribution, age structure, and dynamics that the population must possess to be delisted are collectively referred to as the recovery criteria. Given that much of the biological and demographic data necessary to determine the population size and parameters needed for recovery of the species do not exist at this time, it is only possible to establish general recovery criteria. Downlisting criteria are not presented. Recovery criteria may change as additional data become available. The population will be recovered when:

1. The genetic diversity present in the `Alalā population in 2003 has been preserved to the maximum extent possible;
2. The population as a whole is demographically stable;
3. Two or more subpopulations exist in the wild;
4. Persistence of wild subpopulations does not require supplementation from a captive flock;
5. Peer-reviewed population models yield a probability of extinction of less than five percent within 100 years; and
6. Threats in suitable habitat have been managed so that `Alalā subpopulations in the wild are growing or stable in landscapes that include areas managed for native biodiversity.

Recovery Actions: The following actions, to be completed during the current Implementation Plan, address the strategic recovery objectives (in bold).

1. **Manage the population of `Alalā** by increasing the number of captive `Alalā from the current population of 56 to at least 75 individuals, to retain all possible genetic diversity and provide individuals for release into the wild. This will require construction and appropriate staffing of the captive propagation infrastructure necessary to accommodate the increasing size of the captive population.
2. **Identify suitable habitat and manage threats** by selecting and managing at least one site within historical habitat so that threats, including disease and predator numbers, are minimized to the extent the site is suitable for the release of captive-reared `Alalā.
3. **Establish new populations in suitable habitat** by selecting and preparing captive-reared `Alalā for release, and planning release protocols to maximize survival and obtain crucial information for improvement of subsequent releases.
4. **Garner public support** using professionally-designed strategies to develop non-governmental funding sources to support expanded captive propagation, habitat management and `Alalā reintroduction. Also, achieve stakeholder support for predator and ungulate management and post-release `Alalā monitoring.
5. **Conduct research and adaptively manage the recovery program**, by establishing a recovery implementation working group involving key

stakeholders, and by assigning overall recovery coordination to a single individual with performance milestones to be reviewed annually by the recovery team.

Some recovery actions are ongoing or were initiated prior to the publication of this revised plan.

Date of Recovery: Because the `Alalā currently survives only in captivity and numbers 56 individuals, and because future reproduction and success of reintroductions cannot be predicted, it is not possible to establish a date of recovery at this time. Twenty years is thought to be the minimum that this species will need to be captively maintained. To sufficiently increase the size of the captive population, restore habitat at reintroduction sites, successfully reintroduce birds to the wild, and manage and monitor the reintroduced population so that recovery criteria are met will require at least several decades if efforts are successful.

Total Estimated Cost of Recovery: It is not possible to determine the total estimated cost of recovery at this time. The estimated cost to implement all recovery actions described in the Implementation Plan Table over the next five years is $14,380,000. It can be assumed that continued intensive management will be required for several decades at similar cost for successive five-year management periods.

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A. STRUCTURE OF THE RECOVERY PLAN

The total number of `Alalā or Hawaiian Crow (*Corvus hawaiiensis* Peale 1848) has been declining precipitously for at least a century, and the species is apparently extirpated from the wild. A variety of factors have contributed to its decline, including many types of habitat change caused directly or indirectly by human activity. Significant features of the species' life history, behavior, ecological interactions, and habitat needs remain unknown. Due to these uncertainties, detailed long-term recovery planning is difficult, and the exact needs of the recovery program cannot be specified beyond a relatively short time horizon. Recovery of this species will require both sustained, long-term conservation actions and repeated experimentation to determine the optimal means to reestablish wild populations.

This recovery plan is divided into four major parts. Part I, the Introduction and Overview, provides information on the biology of the species, the history of its decline, and a summary of past recovery efforts. Part II, the Strategic Plan, outlines the overall long-term goals and broad strategies which we anticipate will remain effective throughout the recovery process for this species. Part III is the first of what will become a series of short-term Implementation Plans, which summarize relevant data gathered to date and outline actions needed to advance to the next steps in recovery. These implementation plans will use an adaptive management approach; that is, they will be used to manage the program by proposing actions as tests of hypotheses relevant to program management and by incorporating lessons learned from previous actions. We will update the implementation plan every 3 to 5 years to incorporate the knowledge gained and refinements to our management program to further enhance the effectiveness of our recovery efforts for the `Alalā. Part IV is the Implementation Schedule associated with the current Implementation Plan.

B. STATUS OVERVIEW

The `Alalā is endemic to the island of Hawai`i. Once abundant within its forested habitat on the island, the species has been in sharp decline for many years. This species is now believed to be extirpated from the wild, as no free-living `Alalā has been sighted since June 2002. There are currently 56 `Alalā, representing the entire remaining population of the species, in captivity at the Keauhou and Maui Bird Conservation Centers on the islands of Hawai`i and Maui, respectively.

The `Alalā has been on the State (and previously Territory) of Hawai`i's list of protected birds since 1931, and is currently listed as an endangered species under Hawai`i State law (Hawai`i Revised Statutes §195D *et seq*.). In March 1967, the `Alalā was one of the first species listed as endangered in the United States under the Endangered Species Preservation Act of 1966 (16 United States Code [USC] 668aa(c)), and is now protected under the Endangered Species Act of 1973, as amended (16 USC 1531 *et seq*.). This species has a recovery priority ranking of 2C on a scale from 1 (highest) to 18 (lowest) (U.S. Fish and Wildlife Service [USFWS] 1983a,b). The `Alalā's listing in 1967 preceded legal requirements to consider critical habitat designation, and critical habitat has not been designated for the `Alalā.

The first recovery plan for the `Alalā was published on October 28, 1982 (USFWS 1982). In 1991, we, the U.S. Fish and Wildlife Service, commissioned the National Research Council of the National Academy of Sciences to undertake a review of the status of the `Alalā and recommend appropriate recovery actions. The National Research Council released its report in 1992 (NRC 1992) and, based upon their recommendations, we developed a new long-term management plan for the recovery of the `Alalā which has directed our efforts since that time (USFWS 1993). The `Alalā Recovery Team also was established at that time, and their periodic management recommendations have also assisted in guiding recovery actions. The status of the `Alalā and the strategy for the recovery of this species have undergone some significant changes in the last decade, resulting in the need for new management direction. As a result, this revised recovery plan has been developed to incorporate our current knowledge of the species and guide future recovery actions.

C. SPECIES DESCRIPTION AND TAXONOMY

The `Alalā is a member of the family Corvidae, the family of birds that includes ravens, crows, jays, and magpies, among others. Members of the Corvidae are recognized for having a high degree of intelligence and excellent memory. They are generally relatively raucous and gregarious birds, and are known for their complex vocalizations. In appearance, the `Alalā is a typical medium-sized crow, from dark brown to black in color (see cover illustration). However, the `Alalā is endemic to the island of Hawai`i, and is the only surviving member of a group of crow species (three described, at least two undescribed) that inhabited the Hawaiian archipelago prior to human colonization (James and Olson 1991; Banko *et al.* 2002). Although the `Alalā bears some resemblance to the Common Raven (*Corvus corax*), the number of extinct Hawaiian corvids and the degree of morphological difference among them suggest that the group colonized the islands several hundred thousand years ago and may be only distantly related to other crows (R. Fleischer, unpubl. data). As with all members of the crow family, the sexes appear outwardly alike. The full description of the `Alalā and its relationship to other living and extinct corvids can be found in Banko *et al.* (2002).

D. CULTURAL SIGNIFICANCE

`Alalā translates from the Hawaiian language as: "to bawl, bleat, squeal, cry...; the Hawaiian Crow; a talkative person; and a style of chanting" (Pukui and Elbert 1986). The herald of a battle formation was also known as the `Alalā (L. Naone-Salvador, pers. comm. 2002). Munro (1944) suggested the bird's name might also reflect its habit of rising (*ala*) with the sun (*lā*). As the largest forest bird after the `Io or Hawaiian Hawk (*Buteo solitarius*), and among the most charismatic, the `Alalā is highly regarded by the Hawaiian people. Before the arrival of Europeans, it was kept as a ceremonial pet, regarded as a family guardian spirit or *`aumakua*, and its feathers were used to decorate statues and *kahili* (Cook 1784; Brigham 1899; Malo 1951; Handy *et al.* 1972; Medway 1981).

E. HISTORICAL AND CURRENT RANGE AND POPULATION DECLINE

Recent discoveries of subfossil (incompletely fossilized) bird and plant remains in Hawai`i have shown that the original distributions of native species prior to human colonization (ca. 500 AD) were often very different from what has been assumed based on historical observations (James and Olson 1991; Olson and James 1991). Polynesian settlers and the nonnative species that accompanied them completely transformed the Hawaiian lowlands prior to European contact (Athens 1997; Burney *et al.* 2002). Not only were many species rendered extinct by these changes, as on other oceanic islands, but species now known only from single islands or isolated locales were originally widespread and occupied a surprising range of habitats. Among birds, the Laysan Duck (*Anas laysanensis*), once thought to be endemic to remote Laysan Island, is now known to have previously inhabited upland forests of all of the main Hawaiian islands (Cooper *et al.* 1996), and several honeycreepers reported only from high elevations previously inhabited forests near sea level (e.g., Palila, *Loxioides bailleui*; Greater Koa-finch, *Rhodacanthis palmeri*; Lesser Koa-finch, *Rhodacanthis flaviceps;* Po`ouli, *Melamprosops phaeosoma*) (Olson and James 1982a,b; James and Olson 1991).

Historical distribution records for the `Alalā (Figure 1) should be regarded as snapshots of an ongoing history of range contraction and fragmentation. Similarly, documented habitat use may not reflect the full range of habitats originally used. The historical record, compiled by European and American naturalists and collectors, indicates that in the century following European contact the `Alalā inhabited a mid-elevation (300- to 2,500-meter [984 to 8,202 feet]) belt of native dry woodlands, and mesic `ōhi`a (*Metrosideros polymorpha*) and `ōhi`a-koa (*Acacia koa*) forests along the slopes of the Hualālai and Mauna Loa volcanoes (Perkins 1893, 1903; Munro 1944; Banko and Banko 1980). The species' range may well have originally extended to sea level, to other parts of the island of Hawai`i, and possibly other islands. Nevertheless, corvid fossils have been found only in dry or mesic sites (James and Olson 1991); no corvid species is known to have occupied wet forest habitats in Hawai`i. Subfossil bones of a corvid recovered on Maui may be those of a subspecies of `Alalā or of an ecologically equivalent sister taxon of similar size, according to DNA tests (Fleischer *et al.* 2003).

`Alalā occupied their entire documented historical range during the 1890s, and were observed in large numbers in both closed and disturbed forests (Perkins 1903; Munro 1944; Banko and Banko 1980). Subsequent observations document a pattern of range reduction and fragmentation typical of species in rapid decline. In the early 1900s, the population density of `Alalā was noticeably reduced and their range was becoming fragmented (Munro 1944; Baldwin 1969). The species was extirpated from lower

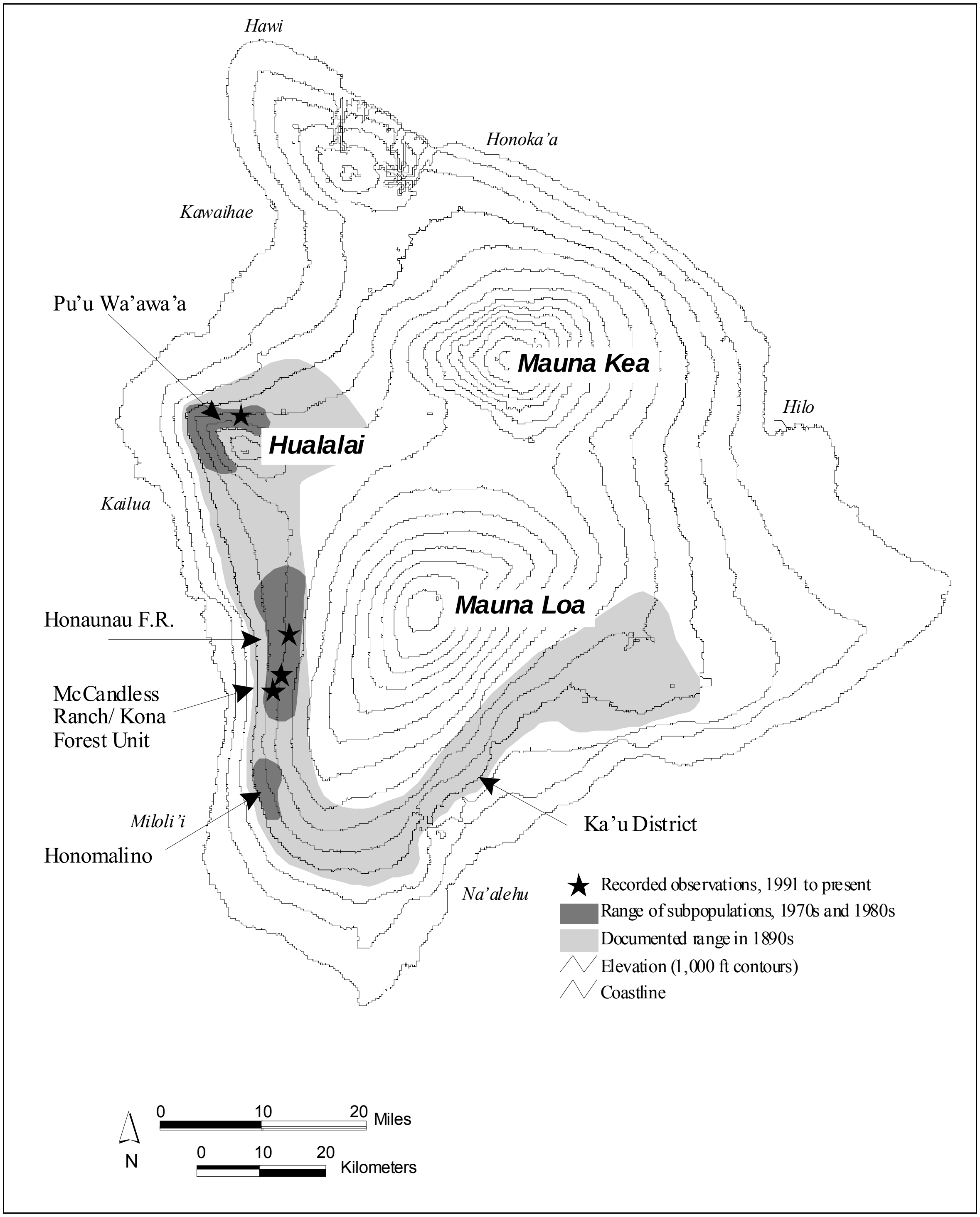

Figure 1. Range contraction and fragmentation of the `Alalā population on the island of Hawai`i.

elevations (below approximately 500 meters elevation) by the 1940s, and occupied only small areas of its historical range by the 1950s (Baldwin 1969; Banko and Banko 1980). Further declines occurred through the 1960s and early 1970s, and it was during this period that numerous extra-limital sightings of `Alalā were reported. In 1976, an estimated population of 76 ± 18 (95% confidence interval) birds was restricted to elevations from 900 to 1,900 meters (2,953 to 6,234 feet) in three areas in the Kona District (Hualālai, Hōnaunau Forest Reserve/McCandless Ranch, and Honomalino), and Ka`ū Forest Reserve in the Ka`ū District (Scott *et al.* 1986). `Alalā have not been encountered in the Ka`ū District since 1977, when a single bird was observed in Hawai`i Volcanoes National Park in the easternmost part of its known historical range (Banko and Banko 1980).

Declines in the Kona subpopulations during the period from 1975 to 1990 were well documented through breeding season surveys and field studies conducted by biologists with the U.S. Fish and Wildlife Service, the Hawai`i Division of Forestry and Wildlife, and other agencies and organizations (cf. Banko 1974, 1976; Sakai and Ralph 1980; Temple and Jenkins 1981; USFWS 1982; Giffin 1983; Sakai and Jenkins 1983; Sakai *et al.* 1986; Giffin *et al.* 1987; Jenkins *et al.* 1989; Sakai and Carpenter 1990). `Alalā subpopulations in Honomalino (the southernmost Kona subpopulation), Hōnaunau (part of the middle Kona subpopulation), and on Hualālai (the northernmost Kona subpopulation) demonstrated similar declines from 1975 to 1985, and limited banding information indicated unsustainably high rates of adult mortality (NRC 1992). `Alalā were extirpated from Honomalino by 1986. By 1987, the wild population had been reduced to a single 12-year-old female on Hualālai and an undetermined number of birds on the McCandless Ranch near Hōnaunau (NRC 1992). The Hualālai female was last observed in late 1991. A thorough survey of the McCandless Ranch in 1992 indicated a wild population of 12 birds, including a single juvenile (Engbring 1992). No additional `Alalā were found during a subsequent survey of extensive forest tracts around the island (Klavitter *et al.* 1995a).

After 1993, the wild population of `Alalā was monitored intensively. The number of birds gradually declined to a single pair in 2002, which inhabited parts of Keālia Ranch and the Kona Forest Unit of Hakalau Forest National Wildlife Refuge in South Kona. This pair has not been located since June 2002 and presumably no longer survives. Unconfirmed reports suggest a single `Alalā may have been present on the western slopes of Hualālai in 2001; this might possibly have been an individual that disappeared from the McCandless Ranch area between 1994 and 2000 (this area refers to the adjacent properties of Keālia Ranch, the Kona Forest Unit, and McCandless Ranch, all formerly part of a larger McCandless Ranch which was divided in 1992).

Concern over the rapid declines observed in the wild led the State of Hawai`i to begin opportunistically acquiring sick or injured `Alalā for rehabilitation in captivity. Beginning in 1970, a few birds were variously kept in the research aviary at Hawai`i Volcanoes National Park, at the Patuxent Wildlife Research Center in Maryland, and in the State's endangered species breeding facility at Pohakuloa, Hawai`i. Between 1970 and 1981, a total of 12 `Alalā were brought into captivity. Inadequate facilities and a low breeding success rate instigated the transfer of this program, with nine captive birds, to Olinda, Maui, in 1986. In 1984, the state Board of Land and Natural Resources set aside 3,806 acres (1,541 hectares) of forested land on the northern slope of Hualālai (the Pu`u Wa`awa`a Wildlife Sanctuary) for protection of native birds, including the `Alalā. Despite these significant efforts to captively propagate the `Alalā and conserve extant subpopulations and their habitat, the population continued to decline.  Initiation of aggressive recovery actions, construction of an additional breeding facility at Keauhou, Hawai`i and improvements in husbandry halted the decline in 1993 and resulted in growth of the total population that continues to the present. Although captive propagation of the `Alalā has proven difficult and remains a challenge, the existence of the captive flock has prevented the complete extinction of this endemic Hawaiian bird. The recovery of the species now hinges on the growth of the captive population, and reestablishment in the wild.

F. HABITAT REQUIREMENTS AND LIFE HISTORY

The full range of habitats that the `Alalā potentially could exploit cannot be defined adequately with available information because limiting factors are incompletely known and recent subpopulations were confined to a subset of current habitat types. Historical habitats, associated plant communities, foods, and known life history parameters are detailed by Banko *et al.* (2002), USFWS (1999), and NRC (1992), and are summarized below. Most of what is known about the `Alalā has come from observations of highly fragmented and declining populations, rendering incomplete our knowledge of the species' habitat needs, social behavior, movements, and life history.  For example, when the species was relatively abundant, flocks of `Alalā were observed to make extensive seasonal movements in response to weather and the availability of `ie`ie

(*Freycinetia arborea*) fruit and other native fruit-bearing plants (Munro 1944). Such movements were not observed recently, and flocking behavior was not well studied due to low population densities in recent decades.

Since it was first observed by naturalists, the `Alalā has been associated with closed to moderately open native forests with fruit-bearing understory vegetation. The habitat with the highest breeding densities of `Alalā during the period 1970 to 1982 was relatively undisturbed `ōhi`a-koa forest; `Alalā avoided disturbed forest (Giffin *et al.* 1987). In addition, a significant amount of protective understory cover appears to be important to `Alalā in avoiding predation by `Io (USFWS unpubl. data). The `Alalā feeds on native and introduced fruits, invertebrates gleaned from tree bark and other sites, and eggs and nestlings of other forest birds. Nectar, flowers, and carrion are minor diet components. A strong association was noted with `ie`ie vines, which formerly blanketed extensive tracts of mid-elevation mesic (moderate precipitation) and wet forest (Menzies 1920). This plant has edible flowering bracts and fruit, and was a prominent item in the `Alalā diet. However, `Alalā were not observed in wet forests where `ie`ie is also abundant (Perkins 1903), suggesting a preference for more mesic habitats. This close association with forested habitats and reliance upon fruit as a primary component of its omnivorous diet are among the factors that set the `Alalā apart from its continental relatives.

`Alalā are known to have lived 18 years in the wild (one female) and 25 years in captivity (one male; Banko *et al.* 2002). Age at first breeding is approximately 2 years for females and 2 to 3 years for males. In captivity, males 18 months old have copulated. `Alalā are monogamous and often have long-term pair bonds, although extra-pair copulations have been observed. In captivity, behavioral compatibility of potential mates is a prime consideration for pair formation.

Nest construction usually begins in March and first clutches are laid in April. Recorded nests have been predominantly in `ōhi`a, although other trees and `ie`ie vines may be used (Tomich 1971). All recorded nests have been at elevations between 1,000 and 1,800 meters (3,280 and 5,905 feet), although the species nested at lower elevations in the past (Munro 1944). Known nest sites have been in areas with 600 to 2,500 millimeters (24 to 98 inches) of annual rainfall (USFWS 1999). Nesting territory size probably varies with resource and population density; the shortest distance between active nests observed in recent times is 300 meters (984 feet). Pairs lay from two to five (usually three) eggs per clutch in the wild and raise one brood of one or two chicks per season (Banko *et al.* 2002). Pairs will re-lay upon loss or removal of the first clutch, and, at times, the second clutch, allowing for increased reproduction in captivity. Incubation lasts approximately 19 to 22 days. Juveniles fledge approximately 40 days after hatching, but are poor flyers initially and can remain near the ground for long periods. Wild juveniles remain dependent for 8 months or more and associate with their parents at least until the following breeding season. Past reports of flocking behavior suggest that prolonged association of multiple generations occurred when the species was abundant, as is the case with other corvid species (Madge and Burn 1994).

G. REASONS FOR DECLINE AND CURRENT THREATS

The historical decline of the `Alalā and the associated changes in its habitat have been examined in detail (NRC 1992; USFWS 1999; Banko *et al.* 2002). The following summary is largely abridged from these sources. Because reliable data on causes of wild `Alalā mortalities are lacking, and because many changes in the habitat have occurred simultaneously (Cuddihy and Stone 1990), the key processes driving the decline of the species are incompletely known. However, the entire historical range of the `Alalā has been modified by alien species and human activities with negative effects on the `Alalā's survival and/or reproduction. In addition, significant threats to the species are inherent in the small size of the surviving captive population.

Factors that may be implicated in the species' decline can be grouped within the five major threats that we use to list, delist, or reclassify a species:

A – Present or threatened destruction, modification or curtailment of habitat or range;

B – Overutilization for commercial, recreational, scientific, or educational purposes;

C – Disease or predation;

D – Inadequacy of existing regulatory mechanisms; and

E – Other natural or man-made factors affecting the continued existence of the species.

Three of these threats -- (A) present or threatened destruction, modification curtailment of habitat or range; (C) disease or predation; and (E) other natural or man-made factors affecting the continued existence of the species -- are considered the most significant factors impacting the `Alalā today. Of these, threats intrinsic to small populations such as the development of an uneven sex ratio and inbreeding depression (E) are most immediate to the near-term survival and future recovery potential of the species. Overutilization for commercial, recreational, scientific, or educational purposes (B) is not known to be a factor threatening the `Alalā, although in the past `Alalā were both hunted and collected (see summary, Banko *et al.* 2002).

1. Factor A: Present or Threatened Destruction, Modification or Curtailment of Habitat or Range

Habitat alteration on Hawai`i has been large-scale and is continuing. There is no existing forest within the historical range of the `Alalā that has not been substantially altered from its pre-European condition (Cuddihy and Stone 1990), much less from its condition prior to human colonization of the islands. The `Alalā evolved prior to human occupation of Hawai`i, when closed-canopy forest was the dominant vegetation type. Extensive grasslands were absent, understory vegetation was dense, grazing mammals were absent, fires were rare and localized, and many plants were dependent on birds for pollination and seed dispersal. Major changes in vegetation followed the arrival of Polynesians (Cuddihy and Stone 1990; Athens 1997; Burney *et al.* 2002), and these changes were greatly accelerated after European contact. Habitat changes include complete and partial deforestation, selective species loss, and invasion or replacement by nonnative plants. These changes are the result of a variety of processes linked to human activities. Aside from the obvious case of outright deforestation, the individual and collective impacts of forest changes to `Alalā is conjectural, but probably have played a role in the species' range reduction and extirpation from the wild. Because of the landscape-scale movements that allowed historical populations of `Alalā to exploit patchy food resources and escape harsh weather, alteration of small but crucial parts of their range and reduction in some food plants (*e.g.*, clearing low elevation forest for agriculture and vegetation changes throughout the species' range) may have reduced the `Alalā's ability to persist over large areas. In addition, opening of the forest structure through grazing and tree cutting may have made `Alalā more vulnerable to predation by `Io.

2. Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The `Alalā today is not used for commercial or recreational purposes, and scientific and educational uses are designed to eliminate potential negative effects.

3. Factor C: Disease or Predation

Avian diseases known to affect native forest birds, including the `Alalā, arrived with European settlement. Avian malaria and avian pox probably arrived in Hawai`i in the early 1800s and became highly transmissible when mosquitoes were introduced (Atkinson *et al.* 1993a,b). The sharp apparent decline in the `Alalā population between 1890 and 1910 coincided with a decline of other native birds in mid-elevation forests and may have been due to a malaria outbreak (Munro 1944). The lethality of avian malaria for `Alalā in the wild is unknown (Jenkins *et al.* 1989). Juvenile captive-reared `Alalā are able to survive malaria and pox infection with supportive care.

Recent studies have shown that `Alalā are highly susceptible to toxoplasmosis, a disease caused by a parasite (*Toxoplasma gondii*) that is spread by feral cats, which now exist throughout historical `Alalā habitat (Work *et al.* 2000). Whether this pathogen played any role in the decline of the wild population is unknown, but it has caused mortality of young `Alalā released into the wild. The potential establishment of a mosquito-borne pathogen, West Nile virus, could be devastating to `Alalā in the future due to its high lethality in corvids (Komar *et al.* 2003).

Other than two bat species, pre-human Hawai`i had no terrestrial mammals, and no ground-dwelling predators. The only potential predators of the `Alalā or any other large Hawaiian bird were the `Io and other, now-extinct, raptors. As a result, in their evolution `Alalā appear to have lost behavioral protection against mammalian predators, and fledgling `Alalā are extremely vulnerable to feral cats, mongooses, dogs, and other mammals. Feral cats have spread into all forested areas of the main islands since their introduction in the early 19$^{th}$ century. Mongooses were introduced to the island of Hawai`i in 1883 (Tomich 1969) and are now common throughout the historical `Alalā range. Mammalian predators are strongly implicated in the endangerment and extinction of many Hawaiian birds (Atkinson 1977, 1989; VanderWerf and Smith 2002), are known to kill `Alalā (USFWS unpubl. data), and undoubtedly have affected the `Alalā population.

Predation on `Alalā by `Io was not reported prior to 1992. However, intensive study began in connection with the reintroduction program initiated in 1993. Evidence from recovered carcasses suggested that juvenile and adult `Alalā can be killed and eaten by `Io in the wild; however, no actual predation by `Io on released birds was observed. Wild adult `Alalā were also observed being harassed and struck by `Io, and some individuals may have been killed. `Io depredation may be linked to altered forest structure, unnaturally high `Io densities, low `Alalā numbers, behavioral traits of released birds, or some combination of factors. No data exist to determine the role, if any, of `Io in the historical decline of the wild population. `Io are currently listed as Federally endangered, but have been proposed for delisting (U.S. Fish and Wildlife Service 2008)

4. Factor D: Inadequacy of Existing Regulatory Mechanisms

The `Alalā is listed as an endangered species under the Federal and Hawai`i State Endangered Species Acts, and is thus fully protected by law. Hunting and incidental shooting of `Alalā has occurred (Munro 1944), although the level of hunting and its effects on the `Alalā were never measured. Anecdotal reports of shooting in the 20th century suggest that legal protection of the `Alalā by the Territory of Hawai`i beginning in 1931 was not fully effective. Because the `Alalā has a relatively low reproductive rate, population persistence and growth depends upon high adult survivorship (NRC 1992). High mortality of adults, noted as the proximate cause of recent population loss in the NRC report (1992), may have been partly due to illicit shooting of the conspicuous and relatively tame `Alalā as late as the 1980s and 1990s.

State and Federal regulations controlling shipment of poultry and game birds to Hawai`i *via* first class mail, quarantine of birds shipped to Hawai`i, and cargo inspection programs may not be adequate to prevent the inadvertent importation of new diseases such as West Nile virus and the transfer of disease strains among islands that could seriously reduce the potential to recover the `Alalā (Kilpatrick *et al.* 2004).

To the degree that habitat loss and degradation has played a role in the loss of wild `Alalā, regulations that allow or promote logging and the maintenance of domestic and feral ungulate populations in forests within the species' historical range have been inadequate to protect the species.

5. Factor E: Other Natural or Man-made Factors affecting the Continued Existence of the Species

In addition to the extrinsic factors of habitat loss and degradation, disease, and predation that increased `Alalā mortality rates and decreased their reproduction, factors intrinsic to small populations may have played a role in the decline of the species. Fragmentation of the formerly contiguous population could have limited genetic exchange and increased the risk of inbreeding and genetic drift (see Appendix D for definition). Small populations of monogamous species are especially subject to demographic accidents, such as the development of an uneven sex ratio, which can further reduce the number of breeding pairs, or increase disruption of breeding pairs by unmated birds (USFWS, unpubl. data). Over the past several years, it appears that lethal abnormalities are occurring at a higher than normal rate in the captive flock, compared to avian species in other captive breeding programs, suggesting inbreeding depression (Zoological Society of San Diego, unpubl. data). When the `Alalā is reintroduced to the wild the possible threat of human-caused mortality will need to be reduced or eliminated by fostering broad public education about, and support for, the `Alalā and its needs.

6. Efforts to Reduce Threats

Habitat threats directly related to human activity are present but are potentially easier to control or eliminate than threats of disease or predation. Clearing of mid-elevation native forest for housing lots and agriculture is continuing in Kona as the human population grows. Loss of dry forests to fire and fire-associated introduced fountain grass (*Pennisetum setaceum*) continues, but new control strategies are being developed. Logging of old-growth koa continues on private lands, reducing the quality of upland forests, but reforestation with koa is becoming commercially attractive. Commercial cattle grazing in native forests is becoming less economically viable, and has been discontinued in some areas of historical habitat. Substantial areas of upland forest may see complete ungulate removal within the next decade.

None of the threats related to alien species that are suggested as contributing to the decline of the `Alalā have been eliminated within historical habitat. Feral and domestic cattle grazing is being reduced in much of central Kona, potentially leading to some vegetation response, but feral pigs and sheep remain common, and mouflon sheep populations are expanding into historical `Alalā habitat. Mosquitoes, rats, cats, and mongooses have yet to be reduced over significant areas of forest, although some promising control technologies exist or are being developed (Innes *et al.* 1995; Clapperton and Day 2001). Alien bird species, which act as potential disease reservoirs or competitors with `Alalā, are expanding their range in upland forests, as are invasive plant species (van Riper and Scott 2001; Loope *et al.* 2001). Serious avian diseases are well established, and potentially devastating new pathogens, such as West Nile virus, are spreading in North America (Marra *et al.* 2004). Currently, protection can be provided to captive birds either by placing mosquito netting over aviaries or possible immunization, but protection of large free-ranging populations is not feasible.

H. REVIEW OF RECOVERY PROGRAM 1993 TO 2005

Recovery actions and status of the captive and wild `Alalā between publication of the first `Alalā Recovery Plan (USFWS 1982) and 1992 were summarized by the National Research Council (NRC 1992). An intensive period of recovery work began in 1993 based largely on recommendations in the NRC report; these most recent recovery efforts will be briefly summarized below. This recovery work included field studies of wild and released `Alalā on McCandless Ranch, and captive propagation at the Maui Bird Conservation Center and Keauhou Bird Conservation Center. Data collected since 1992 are being managed, documented with metadata, and archived by the U.S. Geological Survey, Biological Resources Discipline, at its Kīlauea Field Station with financial support from the Service. Additional funding will allow for more detailed and thorough analyses of the data, and enable further refinement of our management efforts as the recovery program advances.

1. Wild Population

The wild population on McCandless Ranch, South Kona, declined from 12 birds in 1992 to two birds in 2002, with the apparent loss of this population by 2003. As no other `Alalā are known to exist in the wild, the extirpation of the South Kona/ McCandless population means the `Alalā is presumed extirpated from the wild. The annual survival rate of the wild birds calculated during this period (79.8 percent; Figure 2) was similar to the modeled estimate in the National Research Council report from banded birds at this site (81 percent; NRC 1992). Because these wild birds were not

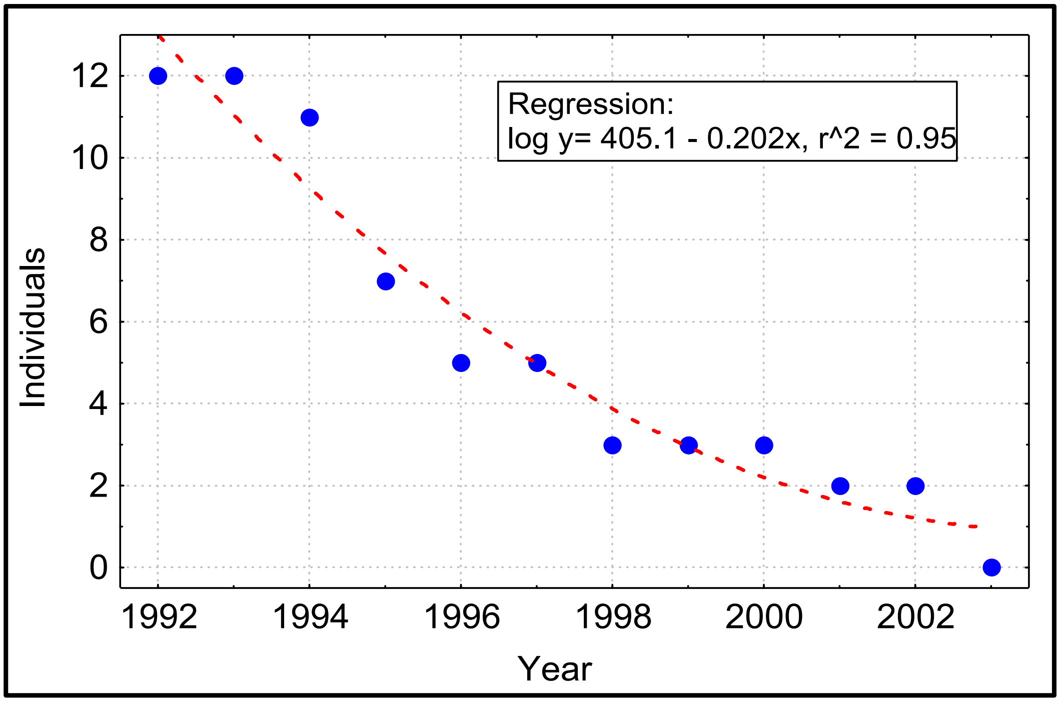

Figure 2. The decline of the wild `Alalā population in the South Kona/McCandless Ranch area fits a 20.2 percent mortality rate.

radio-tracked, their carcasses were not recovered and the causes of death are unknown. The only wild juvenile known to be produced between the years 1992 and 2003 (from a pair in Kalahiki in 1992) was last seen in 1997.

Wild `Alalā often would disappear from the study area for extended periods, usually after the breeding season. Their actual home ranges were therefore probably larger than documented. The median home range recorded was 480 hectares (1,186 acres) (range 59 to 1,456 hectares [146 to 3,598 acres]; n = 20; USFWS 1999). Several reports of `Alalā outside the McCandless area between 1992 and 2001 were investigated by Service biologists, but none were confirmed.

Behavioral observations were conducted and allowed limited comparisons of foraging and activity budgets of wild versus released birds (Sherman *et al.* 1994). Interactions of wild birds with juveniles in the field aviary and after release were usually aggressive. One wild male courted a captive-reared female and some pre-nesting behavior was observed, but no reproduction occurred.

2. Captive Propagation

Maintenance of the species in captivity began with the occasional acquisition of sick or injured `Alalā by the State of Hawai`i in 1970. In 1986, the nine `Alalā in captivity at Pohakuloa were transferred to a new breeding facility in Olinda, Maui (NRC [1992] and Banko *et al.* [2002] provide a history of the captive propagation program from 1970 to 1995). In 1993, The Peregrine Fund assumed management of the program to hatch, rear and release `Alalā; this organization was also commissioned to build a new captive propagation facility dedicated to reproduction of `Alalā and other endangered species of Hawaiian forest birds. This new facility, near Volcano on the island of Hawai`i, was completed in 1996 and designated the Keauhou Bird Conservation Center. In 1996, The Peregrine Fund also assumed the operations of the Olinda Endangered Species Propagation Facility from the State of Hawai`i, and renamed it the Maui Bird Conservation Center. The Zoological Society of San Diego took over the operation of both the Keauhou and Maui Bird Conservation Centers in 2000, and titled the combined program the Hawaiian Endangered Bird Conservation Program.

The captive propagation program was intended to produce juvenile `Alalā for release into the wild, both from captive-laid and wild-collected eggs, and did not attempt to capture or retain all genetic diversity present in the wild population. The program at inception assumed there would be continued reproduction in the wild and integration of released juvenile birds into the wild breeding population (NRC 1992). As it happened, neither of these assumptions held true. Due to the termination of the release program in South Kona and the demise of the wild flock, as of January 2008 the total `Alalā population was represented by 56 individuals in the captive flocks at the Keauhou and Maui Bird Conservation Centers (Figure 3).

Suboptimal rearing conditions prior to 1993 severely limited reproduction and created behavioral problems in some of the captive `Alalā (Harvey *et al.* 2002). Some of these problems have been resolved through construction of better housing and the use of different rearing methods. Research using surrogate species during the 1990s contributed to a better understanding of the effects of different hand-rearing methods on survivorship and growth rates of corvid species (Whitmore and Marzluff 1998) and the appropriateness of puppet-rearing birds for reintroduction (Valutis and Marzluff 1999). Even so, reproductive rates and viability of eggs in captivity are lower than those documented from the wild. In general, this species does not breed well in captivity; pairs require separate aviaries, many potential mates prove to be incompatible, infertile eggs

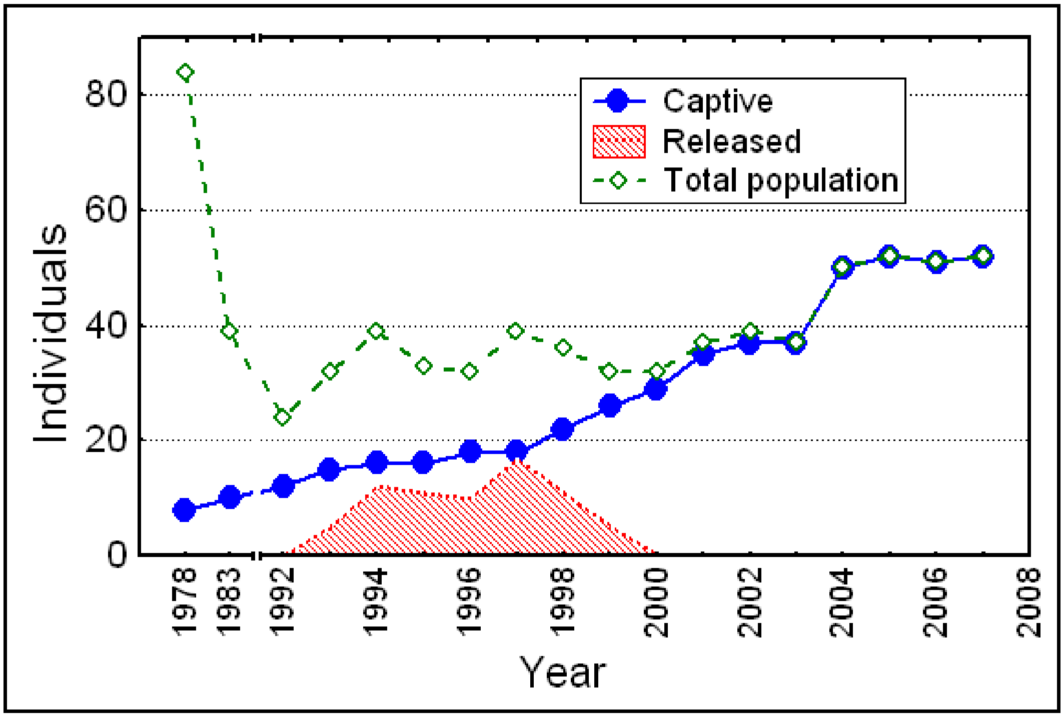

Figure 3. Components of the `Alalā population over time.

are common, and males tend to interfere with egg laying and incubation. Inbreeding is apparently affecting fertility and reproductive outcomes (NRC 1992, Zoological Society of San Diego, unpubl. data). The captive flock began reliably producing chicks in 1996, and each year has averaged 5.2 (range 2-10) chicks surviving to 30 days. No clear upward trend in chick production is evident to date, despite an increasing number of paired breeders and eggs laid per season. This is due in part to a gradual increase in the proportion of eggs that are infertile. Therefore, to maintain and improve the growth rate of the captive population, ongoing husbandry research to overcome problems of pair incompatibility, egg infertility, low egg hatchability, and the effects of inbreeding depression will need to continue.

Founder representation and gene diversity analyses of the captive flock (Appendix A) are based on the assumption that founders are unrelated (see Appendix B pedigree table) and that the wild population is extirpated. DNA analysis (Fleischer 2003) suggests that some founders are related, and therefore the level of inbreeding calculated from the pedigree is a minimum estimate. Assuming unrelated founders, the estimated mean inbreeding coefficient (F) is 0.11, and this will increase with time due to the small size of the population and the lack of additional genotypes. An increasing inbreeding coefficient is often associated with a reduction in traits closely associated with fitness, such as body size, fecundity, and longevity (Lande and Barrowclough 1987), but may not necessarily preclude the recovery of a species, as evidenced, for example, by the increase in numbers of the Mauritius Kestrel (*Falco punctatus*) from only four known individuals to several hundred through a combination of captive breeding, *in situ* breeding management, and habitat management (Jones *et al.* 1995).

At this point, it is not known whether there is a genetic basis for the observed rates of infertility and developmental abnormalities. Genetic variation in the current `Alalā population is low relative to other corvid species examined (NRC 1992, Fleischer 2003), supporting the contention that the `Alalā entered a "genetic bottleneck" during its 20th century population decline. It is possible that the species has always had low amounts of genetic variation, but genetic analysis of museum specimens would be needed to address this question. In any case, without the potential input of genes from wild individuals, prudent management of captive breeding is the only means available to mitigate the effects of inbreeding.

Of the gene diversity originally present in the captive flock's nine founders, the captive flock retains 81 percent. One founding lineage (Keālia, named for its area of geographic origin) has disappeared from the population due to mortality of all captive and released offspring. As modeled (see Appendix A), an estimated 79 percent of the founding gene diversity can be retained at the end of a ten-year period if the population grows to 75 birds. Achieving this goal will require an increase in the number of breeding pairs to keep the N_e/N at 0.35, and an increase in the number of chicks produced each year from the recent average of 5.2/year (from 1996 to 2007) to 6 to 7 chicks/year.

Currently, generation length is 9.2 years, and the rate of population increase (λ or lambda) is 1.07, representing a growth rate of 7 percent per year. The current combined capacity of both captive propagation facilities is 15 breeding pairs. Limited aviary space is available for juveniles, which become aggressive toward each other at about 18 months of age. The total captive population of 56 birds as of January 2008 includes several adults that do not breed due to various problems.

The achievement of an optimal genetic and demographic composition in the population requires active management consistent with maintenance of all possible existing genetic diversity, consistent with our policy regarding controlled propagation of listed species (U.S. Fish and Wildlife Service 2000) and guidelines of the Association of Zoos and Aquariums (Appendix C), for a period of at least 20 years. It is very unlikely within 20 years that `Alalā will be established in the wild such that the genetic future of the species is secured by the wild population alone. Therefore, 20 years is thought to be the minimum period of time during which the genetic and demographic security of this species will depend wholly or largely upon the maintenance of the captive flock. Depending upon success in establishing self-sustaining wild populations, it may be necessary to continue maintenance of all possible existing genetic diversity within the captive flock for a period greater than 20 years.

3. Reintroduction

Twenty-seven juvenile `Alalā, originating from eggs collected from both captive and wild parents, were raised in captivity and released in South Kona at the McCandless Ranch between 1993 and 1998. This location was chosen to allow maximal interaction and integration with the remaining wild population. All released birds were fitted with radio transmitters and relocated at frequent intervals, allowing detailed observations of behavior. Foraging behavior of juveniles was less efficient than that of wild adults but was sufficient for survival (Klavitter *et al.* 1995b).

Twenty-one of the released birds died over the program's duration, and the remaining six were recaptured in 1998 and 1999 for reintegration into the captive flock (Figure 4). Many of the birds died before reaching the age of sexual maturity (approximately two years), and the rate of mortality (approximately 40 percent per year) declined only slightly as the released birds matured. This mortality rate is approximately double that of the wild adults within the same habitat over the same period of time. The predicted maximum life span of released birds under these conditions would be about 5 years.

The cause of death was determined for 13 of 21 of the released birds (Figure 5). Seven were killed by `Io, three died from toxoplasmosis (Work *et al.* 2000), two died from other infections (Work *et al.* 1999), and one died from mammal predation. The bodies of eight of the birds were not recovered, so the cause of death for these individuals remains unknown. Necropsies of the remains that were found showed poor nutritional

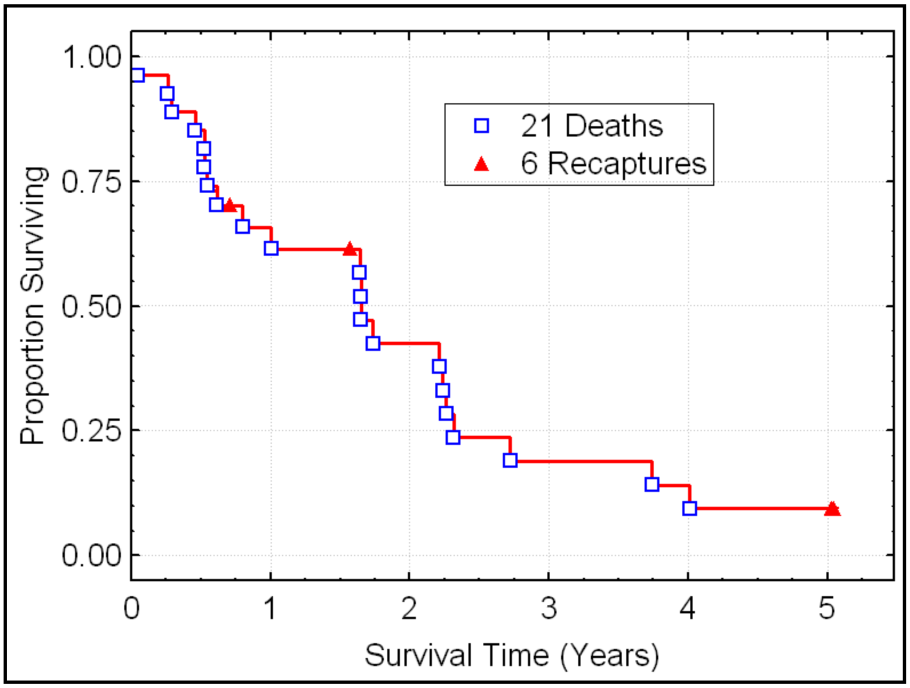

Figure 4. Kaplan-Meier survival function of the 27 `Alalā released at McCandless Ranch 1993 to 1998. Survival Time is the total time each bird was free in the wild. Two birds of the original 1993 cohort were recaptured after more than five years in the wild.

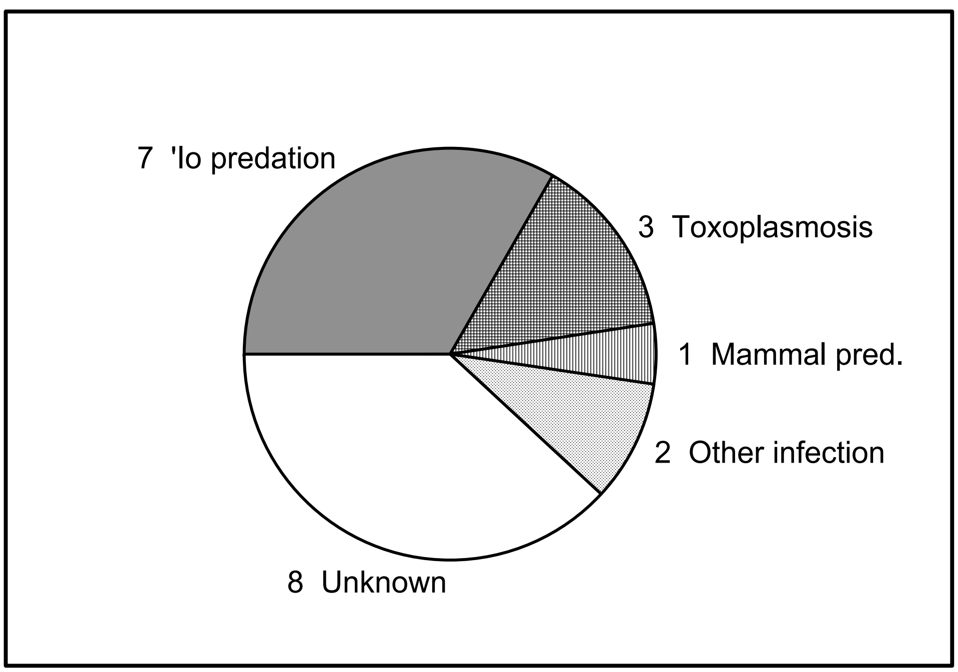

Figure 5. Causes of mortality of 21 captive-reared `Alalā released at McCandless Ranch. Cause could not be determined for eight birds whose remains were not recovered.

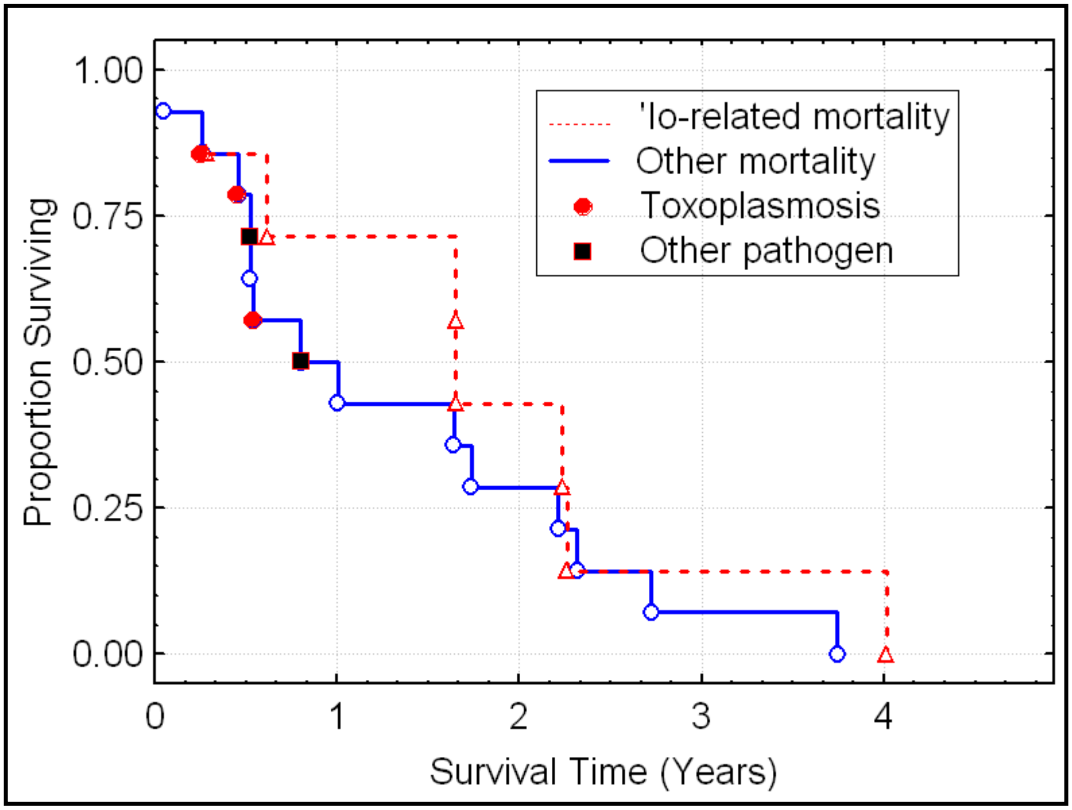

Figure 6. Survival function of released birds known to have died from `Io-related causes (dashed line), compared to deaths from all other causes (solid line). Survival rates of the two groups were not significantly different (Gehan's Wilcoxon test, $p = 0.35$). Recaptured birds omitted.

condition in some birds but not others. Habitat conditions (drought and poor fruit production) during the several years during which the reintroductions were completed may have influenced release mortality rates. Although a positive determination is not possible, it is conceivable that poor condition may have predisposed some birds to death by infection or predation.

Contrary to predictions (NRC 1992), avian malaria and pox were found not to be sources of mortality for released `Alalā, since all of the released birds survived exposure to these pathogens. However, several birds were provided with veterinary care prior to release when weakened by apparent malarial infections. Toxoplasmosis was a previously unknown source of mortality, as were the bacterial and fungal pathogens responsible for two deaths. Several released birds were observed manipulating cat feces (USFWS, unpubl. data), which is a known reservoir of the protozoan *Toxoplasma gondii*, and may have contracted toxoplasmosis from that source. Predation by `Io was also previously unknown. `Io were observed to chase and strike both captive-reared juveniles and wild adults. Wild adults appeared to have a larger and more effective behavioral repertoire to evade `Io attack, engaging in distraction displays and in some cases being observed to chase `Io. Additionally, most wild birds were paired, perhaps improving their ability to detect and avoid predator attacks. No actual predation by `Io on released birds was observed, but evidence from recovered carcasses was compelling.

Closer examination of the relative timing of the major known mortality factors (Figure 6) reveals that all of the known deaths due to infection (toxoplasmosis and other pathogens) occurred within the birds' first year in the wild. `Io depredation was not concentrated on any particular age class, and the temporal pattern of `Io-related mortality was not different from the pattern due to all other causes. These results suggest that controlling *Toxoplasma* exposure would reduce first-year mortality, allowing a larger proportion of released birds to survive to reproductive age.

No reproduction, and only limited sexual activity, was observed in the released birds despite 12 birds reaching an age of at least two years, when reproduction in wild `Alalā is known to begin (Banko *et al.* 2002). Two released birds formed a pair but did not reproduce. A second released female was courted by a wild male and showed early signs of nest initiation (carrying and placing a few sticks), but did not continue beyond this stage. The causes of this failure by released birds to reproduce are unknown, but may include the instability of the juvenile social group due to releases and mortalities, negative interactions with adult pairs, and incest avoidance mechanisms triggered by rearing birds together. Failure to reproduce also may have been related to the prevailing habitat conditions and the inability of females to obtain and mobilize the necessary food reserves for egg production.

The prediction that released juveniles would integrate into the wild population was not borne out. The majority of interactions with the wild population were aggression by adults toward released birds. The released birds ranged more widely than the wild birds, possibly to avoid interactions with the wild adults but perhaps also to exploit abundant and easily obtained fruit at lower elevations. In the absence of detailed studies on the social behavior of the species, it is possible that the release protocol used was not well matched to the social system of the `Alalā. Research on other corvids (Marzluff *et al.* 1995) suggests that reintroduction success could be optimized by experimentally examining the interaction of the `Alalā's social system with various rearing and release methods.

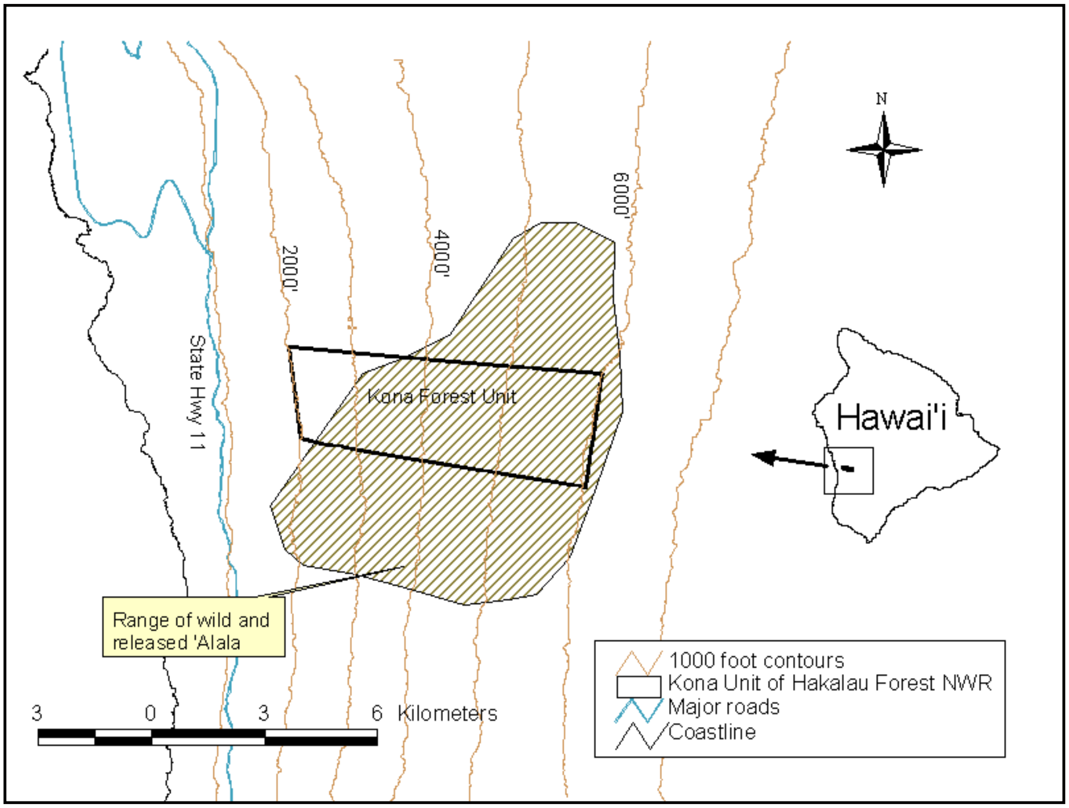

Figure 7. Location of Kona Forest Unit and approximate boundaries of `Alalā population during release program, circa 1997.

4. Habitat Management

The Kona Forest Unit of Hakalau Forest National Wildlife Refuge was purchased in 1997. This tract (Figure 7) of 2,145 hectares (5,300 acres) was acquired in order to begin intensive habitat improvements in the core of the `Alalā's former range. Due to legal and operational constraints on activities, however, significant habitat improvement actions have not yet begun. A private foundation grant of one million dollars was obtained in 1999 to fence the Unit and eradicate feral ungulates, but the work could not be done because of legal disputes on access and other topics with the former landowners. Because the project was not completed, the grant was reclaimed by the grantor in 2003. Since that time, Federal funds have been secured to complete fencing and ungulate eradication. These actions are due to begin in 2008.

No organized feral ungulate removal actions took place in occupied `Alalā habitat during the release program. Trapping of mammalian predators was begun by the McCandless Ranch and continued by the Service during this time. Although data on captured predators were collected, the program's effect on predator populations was not measured. Trials in 2002 of predator-proof fencing show that this technology could keep all small mammals out of natural areas in Hawai`i, but would require large capital investment and maintenance costs. Using American Crows (*Corvus brachyrhynchos*) as surrogates for `Alalā, studies were conducted to assess the non-target risk posed by potential use of the toxicant diphacinone to control rats. The crows were found to tolerate the toxicant with only minor ill effects (Massey *et al.* 1997). No field applications of rodenticide were conducted in occupied `Alalā habitat.

Once `Io were recognized as a threat to released `Alalā, some resident `Io in the release area were captured and relocated to other parts of the island. In addition, ten `Io were taken from the release area in 1997 and 1998 and sent to mainland zoos for captive breeding. Relocation efforts were not successful in reducing the numbers of `Io for more than a few weeks because the `Io that were moved soon returned to their capture area, and vacated territories were rapidly filled by adjacent `Io.

Observations of interactions between `Io and `Alalā by program biologists strongly suggested that forest areas lacking dense vegetation structure, especially in the subcanopy and understory layers, afforded few opportunities for `Alalā to evade aggressive `Io (Banko *et al.* 2002; USFWS, unpubl. data). These "park-like" areas of native trees with alien grasses, typically found in forest areas grazed by feral and domestic ungulates, were common at the South Kona release site. A study of `Io densities around the island of Hawai`i found that this habitat type had higher densities of `Io than did native forest with more intact understory (Klavitter *et al.* 2003).

Consultation with the `Io Recovery Working Group (an advisory team formed by the U.S. Fish and Wildlife Service) resulted in their recommendation to release `Alalā in sites without resident `Io (*i.e.*, on another island) in order to remove a major documented mortality agent for the released birds (`Io Recovery Working Group 2001). This group felt that other proposed actions to address potential `Io predation were infeasible or of questionable efficacy in the short term.

Based on sites prioritized by the `Alalā Recovery Team, a draft Environmental Assessment was prepared in 1999 examining the potential of five sites on Hawai`i to support an `Alalā release program (USFWS 1999). The sites were publicly owned lands at Pu`u Wa`awa`a, Honomalino, Kapāpala, Kūlani, and Hakalau Forest, in addition to the McCandless Ranch area. Public comments on the draft Environmental Assessment suggested additional `Alalā release sites outside of the historical range, where some threats, notably `Io, may be reduced or absent. These and several other potential release sites will be investigated, scored, and ranked with the assistance of the `Alalā Recovery Team and others before a final recommendation is made on the next release sites for the `Alalā program. Completion of this process is a high priority action in the Implementation Plan.

5. Public Awareness

During much of the release program, the McCandless Ranch and Cattle Company operated an ecotourism business that highlighted the `Alalā. Personnel from both the U.S. Fish and Wildlife Service and The Peregrine Fund interpreted the release program for clients. Substantial numbers of bird enthusiasts were able to see the `Alalā and better understand the recovery efforts underway.

The Keauhou Bird Conservation Center has had an active outreach program since its inception. Emphasis is on elementary school students, but adults are also exposed to the plight of native birds and the role of captive propagation in their recovery. As one example, for several years under The Peregrine Fund, names for hatchling `Alalā were solicited from schoolchildren in a "Name the `Alalā" contest.

As a direct outcome of collaboration between landowners and agency personnel working on `Alalā recovery, the State of Hawai`i's law concerning endangered species was amended in 1997 to allow incidental take of listed species through Habitat Conservation Plans and Safe Harbor Agreements. In 2000, following publication of the draft Environmental Assessment for `Alalā reintroduction, meetings were held with landowners of large parcels bordering proposed release sites. At these meetings, we described the Safe Harbor program as a tool for reintroduction of `Alalā that allows for incidental take of listed animals. We also discussed concerns of the landowners regarding endangered species recovery. More recently, in 2003, representatives from the U.S. Fish and Wildlife Service, the State of Hawai`i, Keauhou Bird Conservation Center managers, and Federal researchers met with Hawaiian cultural practitioners to discuss the `Alalā as part of the Hawaiian community's cultural heritage.

6. Program Management

The `Alalā Recovery Team, formed in 1992, includes representatives of private landowners and conservation organizations in addition to technical experts and agency personnel. This configuration was intended to facilitate resolution of non-biological issues in the recovery planning process. Meetings occurred once or twice per year from 1993 to 1998 during the period of releases, and now occur approximately annually.

A second group, the `Alalā Partnership, was formed to work out problems of program implementation on private lands in the South Kona release area. This group included some members of the Recovery Team as well as additional landowner representatives, and met monthly during the release program. After the recapture of the remaining captive-released `Alalā from the wild in 1999 and the decline of the wild population to three birds in 2000, the `Alalā Partnership ended its meetings.

Field monitoring of the `Alalā under the leadership of the U.S. Fish and Wildlife Service and the U.S. Geological Survey, Biological Resources Discipline involved the extensive use of volunteers which reduced costs but also affected the continuity of data collection. Following the recapture of the last released birds in 1999, monitoring of the remaining three wild birds was conducted solely by biologists from the U.S. Fish and Wildlife Service.

II. STRATEGIC PLAN

Recovery of the `Alalā will in part depend on characteristics of the species that are unknown at this time, and characteristics of the environment will continue to change during the recovery process, so it is not practical to develop a detailed plan at an early stage in the recovery program when these factors are not well understood. Rather, the most efficient way to determine these unknown characteristics and refine the course of the recovery program is through the continuous application of adaptive management (Johnson 1999). Here in Part II we apply this concept by developing a Strategic Plan, which sets out the broad principles that we believe will hold for the duration of the recovery process. Specific short-term actions are described subsequently in the Implementation Plan (Part III)

A. RECOVERY STRATEGY OVERVIEW

1. Expand Captive Propagation to Minimize Loss of Genetic Variability

The `Alalā survives today only because a captive flock has been established and maintained; it would otherwise be extinct. This is the first Hawaiian forest bird whose extinction has been prevented by captive propagation. However, this captive flock (56 individuals in January 2008) represents the progeny of only 9 founding individuals, and thus is an extremely small sample of the species' original gene pool. Because no `Alalā are known to remain in the wild, no further genetic variation can be added to the captive population. For all practical purposes, genetic diversity, once lost, cannot be regained, and the rate of loss in small, closed populations is high (Lande and Barrowclough 1987). Therefore, the most urgent recovery need is to increase the size of the population in order to slow this loss and retain all possible genetic diversity for the future. Although the threats of disease, predation, and habitat degradation in the wild will be significant when captive birds are released, at this time loss of genetic variability remains the primary near-term threat to the recovery of this species.

The original recovery strategy (NRC 1992) aimed to achieve this necessary population growth in the wild, by augmenting the wild flock with captive-bred birds. This was the most cost-effective strategy and had many potential advantages, but was not successful due to high mortality rates of captive-reared `Alalā and a lack of integration and reproduction with the wild flock. It now appears that the habitat at the site used for the releases from 1993 to 1998, as well as throughout the historical range of the species, requires restoration in order to support an expanding `Alalā population. Control of multiple mortality factors will be required. Although some potential habitat may exist on `Io-free islands outside the historical range of the species, mortality factors in addition to `Io would have to be managed at such an alternative site to substantially increase the survival of released birds and allow net population growth. No such site currently is known to be available. The suitability of sites on islands other than Hawai`i has not been adequately addressed. However, more thorough evaluation of habitat conditions at potential release sites on different islands should be undertaken, and is a priority recovery action.

Because no field site is known to exist that would support rapid growth of the population, increasing `Alalā numbers in captivity, where reproduction can be maximized and mortality minimized, is the most rapid and efficient means to protect the genetic potential of the species. This recommendation to focus on captive propagation in the near term to achieve population growth represents a major shift in recovery strategy for the `Alalā.

The `Alalā is difficult to breed in captivity, requires expert husbandry and separate aviaries for each pair, and has a relatively low rate of successful reproduction (Kuehler *et al.* 1994). These factors all make captive propagation a challenging and expensive enterprise requiring funding to keep pace with growth of the population. During the 1990s, levels of funding were intended to support a small captive flock that would supplement a growing wild population. All of this growth must now occur in captivity, and until populations are recovering in the wild, the captive flock must become large enough to maintain the genetic potential of the species. With the change to a near-term captive propagation strategy outlined in this document, additional funds are required to meet the expanding needs of this aspect of the `Alalā recovery program, in addition to the funding needed for habitat restoration and reduction of mortality factors.

2. Identify Suitable Habitat and Manage Threats

The second strategic goal for `Alalā recovery is to identify suitable habitats for reintroduction and restore native forests at these sites to the point that released `Alalā can survive and reproduce. Methods that will be used to identify currently and potentially suitable habitats include: remote sensing, ground-truthing of these data, and the use of a structured decision matrix to differentiate among the potential release sites identified. Forests within the historical range of the `Alalā have been severely impacted by human activities, and by diseases and nonnative predators and competitors (Atkinson 1989; Atkinson *et al.* 1993b; Cuddihy and Stone 1990), to the extent that the `Alalā can no longer persist unaided in its former habitat. While some direct mortality factors are known, the levels to which direct and indirect threats must be reduced to support recovery of the `Alalā are not clear, and will be the subject of specific research as restoration proceeds. Ecosystem recovery is a slow process, so restoration of sites that will be used for `Alalā recovery must begin at once. Otherwise, the program risks producing birds for which no suitable habitat exists.

Downlisting and eventual delisting of the `Alalā will require repopulation of extensive landscapes within which the birds' resource needs are met and mortality rates are low enough for the population to be sustainable. Restoration of Hawaiian mesic and dry forests requires intensive and sustained management (Stone *et al.* 1992), and is currently constrained by financial resources and competing priorities for land use. Innovative financial and political solutions must be found to the problems that currently impede restoration of those large areas of `Alalā habitat that are in public ownership. Full use must be made of the fact that recovery of numerous listed plants and animals that exist within the `Alalā's historical range will require land management actions that are also key to `Alalā recovery.

Protected natural areas managed for native biodiversity conservation will be important restoration sites, but expanding populations of `Alalā will eventually inhabit larger areas that will include private lands as well. It is likely that much of the area required for `Alalā recovery will be managed primarily for goals other than conservation, given the limited size of protected areas. Some means of keeping `Alalā mortality rates low in these altered landscapes must be found, through enhancement of key habitat components and development of threat reduction strategies in collaboration with private landowners.

3. Establish New Populations in Managed Suitable Habitat

Recovery of the `Alalā will initially be based on the reintroduction of captive-reared birds to the wild (Kuehler *et al.* 1995). Such reintroductions are an active area of conservation research (Marzluff *et al.* 1995; Whitmore and Marzluff 1998), and often require multiple attempts and innovative methods before success is achieved (Armstrong and McLean 1995; Haight *et al.* 2000). The high initial mortality risks and high value of each bird necessitate careful design of the release program and intensive field monitoring to gain maximum information (Seddon and Cade 1999; Collazo *et al.* 2003). A variety of rearing and release protocols may need to be evaluated and tested to determine those that yield the highest rates of survival and reproduction in `Alalā.

In social species such as the `Alalā, many learned parental behaviors are transferred to young birds, increasing their survival skills (Bolles 1970). Birds reared in captivity are thought to be at a disadvantage in the wild, at least initially, due to lack of parent rearing and lack of exposure to real-world resources and threats (Griffin *et al*. 2000). It may be possible to provide learning experiences prior to release that will increase the lifespan of released `Alalā, as has been shown in other species (Van Heezik *et al.* 1999). There is evidence that corvids have critical periods for learning (Heinrich 1995, Harvey *et al.* 2002), which could be used to better prepare `Alalā for release if the proper stimuli are provided at those times. Ultimately, reproduction and parental rearing in the wild should eventually produce young `Alalā with an effective and naturally-acquired behavioral repertoire.

4. Garner Public Support and Funding

The `Alalā is a potent symbol of Hawai`i's natural heritage, and exposure of the public to this species and its plight is needed for many aspects of the recovery program to succeed. Financial support for the captive program and habitat restoration, acceptance of ungulate and predator management in natural areas, and cooperation by private landowners all depend on broad public understanding of the program's goals. The program managers will seek professional assistance in articulating these goals and needs to key groups and the general public.

5. Conduct Research and Adaptively Manage the `Alalā Recovery Program

Because the effectiveness of many recovery actions are not completely known, and recovery actions may need to be modified based on experience, management of all aspects of the recovery program should be based on adaptive management whereby proposed actions are treated as hypotheses to be tested by monitoring measurable outcomes. Banko *et al.* (2002) summarize research needs including investigation into ways to increase productivity of the captive flock, reduce the time before captive-reared birds pair and reproduce, techniques to reduce predatory threats of small mammals and `Io, the role of disease in limiting `Alalā recovery, and habitat restoration and management.

B. RECOVERY CRITERIA

The ultimate goal of this recovery strategy is to restore multiple self-sustaining populations of the `Alalā within its historical range, and to reduce or eliminate the threats to its existence to the point that it will no longer require the protections of the Endangered Species Act and may be delisted. As noted above, much of the biological and demographic data necessary to determine the population sizes and parameters needed for recovery of the species do not exist. These data will become available over the next few decades as the species is reintroduced to the wild and the characteristics of those expanding populations are measured. After multiple years of survival and reproductive data on reintroduced populations are available, population modeling will allow us to propose more detailed recovery criteria. Given our current state of knowledge, six general recovery criteria for the `Alalā are recognized at this time:

Criterion 1: The genetic diversity present in the `Alalā population in 2003 has been preserved to the maximum extent possible;

Criterion 2: The population as a whole is demographically stable;

Criterion 3: Two or more subpopulations exist in the wild;

Criterion 4: Persistence of wild subpopulations does not require supplementation from a captive flock;

Criterion 5: Peer-reviewed population models yield a probability of extinction of less than five percent within 100 years; and

Criterion 6: Sites with potential suitable habitat have been identified and threats in suitable habitat have been managed so that `Alalā subpopulations in the wild are growing or stable in landscapes that include areas managed for native biodiversity and lands managed for other compatible uses.

These criteria address the threats to the species discussed in section I.G. above. Criterion 1 focuses on the threat of inbreeding and genetic drift (Listing Factor E). Criteria 2 through 5 address different aspects of the threat from small population size, including vulnerability to catastrophic events and random demographic fluctuations. Criterion 6 applies to other threats that can be ameliorated through management, including habitat destruction and modification by deforestation, fire, invasive plants, or ungulates (Listing Factor A); diseases such as malaria, pox, and toxoplasmosis (Listing Factor C); predation by `Io and introduced mammals (Listing Factor C); failure to appropriately protect and manage suitable habitat (Listing Factor D); and human-caused mortality (Listing Factor E).

C. RECOVERY ACTIONS

In this Strategic Plan we have described long-term objectives to achieve the recovery of the `Alalā. General recovery actions are presented below together with guiding principles and priority issues for research and management action. Specific recovery actions to achieve interim recovery goals are presented in the five-year Implementation Plan (Section 3). The threats (listing factors) addressed by each recovery action are provided in the Implementation Schedule (Section 4).

Action 1: Manage the `Alalā Population

Recovery Objective: Manage the population of `Alalā so the genetic diversity present in the `Alalā population in 2003 has been preserved to the maximum extent possible, the population as a whole is demographically stable, and population models yield a probability of extinction of less than five percent within 100 years.

Principles:

1. Until the recovery objective is achieved, the purpose of the captive flock is primarily to act as a safe repository of the species' genetic diversity, and secondarily to produce birds for release and population reestablishment.
2. The achievement of an optimal genetic and demographic composition in the population requires active management consistent with maintenance of all possible existing genetic diversity for a period of at least 20 years. This management must be consistent with Service policy regarding controlled propagation of listed species (USFWS 2000) and guidelines of the Association of Zoos and Aquariums (see Appendix C).
3. Only birds that are genetically and demographically surplus to the captive flock or are post-reproductive may be subjected to higher mortality risk than exists under normal captive propagation conditions (which may occur during reintroduction, parent rearing, and zoo display).
4. Because techniques that may increase behavioral competence of `Alalā for release (*e.g.*, parent rearing, pair releases) could reduce population growth rate, explicit consideration of the population consequences of such tradeoffs should be part of each Implementation Plan.
5. Populations in the wild should be managed together with the captive flock as a single population for purposes of genetic and demographic optimization, until the recovery objective is achieved. Subsequently, management of wild subpopulations should aim to prevent genetic drift and subpopulation decline.

Priorities for Research and Management:

1. Secure sufficient financial and institutional resources to adhere to the above principles and allow the captive flock to support growth, maintenance, and other needs of the population.
2. Increase the population growth rate, the proportion of breeding birds, and the reproductive success of under-represented birds.
3. Maintain and transmit between generations a behavioral repertoire that is as natural as possible under captive conditions, in order to maximize the potential success of reintroductions.

Action 2: Identify Suitable Habitat and Manage Threats

Recovery objective: Identify suitable habitat and manage threats so that `Alalā subpopulations can be successfully reintroduced into the wild and maintain or increase their population levels in landscapes that include areas managed for native biodiversity and lands managed for other compatible uses.

Principles:

1. The captive flock will be crucial to the `Alalā's recovery for the foreseeable future, but there must also be appropriate habitat for release. Therefore, growth and maintenance of the captive flock should have equal priority with habitat restoration, and both should have priority over other uses of limited funds for `Alalā conservation.
2. Efforts to reestablish wild `Alalā populations should be focused on the largest and most intact areas of native vegetation. To the extent possible, forest ecosystems in these areas should be restored to the conditions believed to have supported stable populations of `Alalā in the past.
3. Restoration of forest vegetation in `Alalā habitat should be achieved by active management of disturbance agents, *e.g.*, through removal or effective control of herbivorous mammals and invasive alien plants, increasing the density of plants utilized by `Alalā, and control of fire and fine fuel loads where needed.
4. Habitat restoration efforts to benefit `Alalā should be fully integrated with other, complementary efforts to conserve other elements of native biodiversity within historical `Alalā habitat.
5. The opportunity for `Alalā to exploit patchy, seasonal food resources should be ensured by preserving or restoring areas of native forest at a range of elevations within foraging distance of each subpopulation.
6. The threat posed by avian diseases should be determined for each pathogen, and should be addressed as needed by controlling disease vectors and other factors linked with these diseases within areas used for population reestablishment (*e.g.*, mosquitoes and feral pigs associated with malaria, feral cats associated with transmission of toxoplasmosis).
7. The threat posed by predatory mammals should be addressed by removing these predators from areas used for population reestablishment, and working with neighboring landowners to extend predator control to surrounding areas.
8. Recognizing that `Io are endemic and valuable components of the native ecosystem, the `Io predation on `Alalā should be reduced or eliminated through habitat management, improved `Alalā rearing and release techniques, or other methods that are not lethal to `Io.

9. The threat of human-caused mortality of `Alalā should be eliminated by fostering broad public education about, and support for, the `Alalā and its needs.
10. The threats in `Alalā habitat should be kept from increasing in number and severity by a strong state-wide program to prevent new alien species introductions and to remove incipient threats before they become broadly distributed.

Research/Management Priorities:

1. Evaluate the condition of existing forest at potential release sites on different islands using remote sensing methods and ground-truthing. After sites have been evaluated a structured decision matrix can be used to help select the most appropriate site(s) for habitat management.
2. Remove alien herbivores and initiate active restoration of vegetation in large areas of historical range, while controlling the threat of fire, in a range of forest types between 300 and 1,800 meters (984 to 5,905 feet) elevation, the approximate historical elevation range of the `Alalā.
3. Test the effectiveness of forest understory restoration, prey base reduction, and other habitat manipulations on `Io density and `Io/`Alalā interactions.
4. Test and implement techniques for maintaining significant forest areas free of mammalian predators.
5. Use regulatory incentives and other programs to increase effective management of `Alalā habitat on private lands, in order to expand the area and variety of sites for re-establishment, and to promote planting/restoration of native fruit-bearing plants at middle and low elevations.
6. Foster significant local awareness of, and support for, `Alalā restoration in the communities surrounding potential release sites.
7. Maintain the State-wide alien species interdiction and incipient control programs (including the Coordinating Group on Alien Pest Species, the Hawaii Invasive Species Council, and the Big Island Invasive Species Committee) that address wildlife diseases and their vectors.
8. Determine the impact of avian diseases, including malaria and pox, on `Alalā survival and reproductive success.
9. Test and implement techniques for maintaining significant habitat areas free of mosquito vectors of avian disease.

Action 3: Establish New Populations in Managed Suitable Habitat

Recovery Objective: A successful release program creates two or more subpopulations in suitable habitat that are self-sustaining and do not require supplementation from a captive flock.

Principles:

1. Each release of captive-reared `Alalā should be designed around defined management questions and should be conducted and monitored so as to obtain data needed to answer these questions.
2. Because not all threats to `Alalā are known or quantified, causes of mortality should be determined for all `Alalā released. This will require telemetry of all released birds and a field crew to monitor and recover birds as needed.
3. Reintroduction sites should be managed to reduce or eliminate threats to `Alalā, and site management practices should be modified in response to analyses of mortality and morbidity of released birds.
4. Support for `Alalā reintroduction at the local level is a prerequisite for a successful program. Partnerships, focused on the needs of the program, should be actively fostered with the communities surrounding release sites to facilitate habitat management, monitoring of the subpopulation, and to reduce one potential cause of `Alalā mortality.
5. Mortality rates, mortality factors, and population trends of released `Alalā and resulting wild subpopulations should be reviewed at least annually, to enable adjustment of the release program to achieve the recovery objective in the shortest possible time.
6. The acquisition and intergenerational transfer of adaptive behaviors should be exploited whenever possible to reduce vulnerability of reintroduced `Alalā to documented threats.
7. `Alalā intended for release should be so designated at the earliest possible stage and reared so as to maximize acquisition of behaviors intended to reduce mortality risks and increase reproductive success.

Research/Management Priorities:

1. Designate one or more `Alalā release sites and commence habitat management meant to reduce threats to `Alalā.
2. Secure sufficient financial resources and cooperative agreements to support necessary management of release sites and adjacent lands with suitable habitat.

3. Determine the habitat criteria that must be met prior to initiating a release program at a particular site.
4. Plan and refine release and monitoring protocols to maximize potential success of `Alalā reintroductions while ensuring adequate tests of important management hypotheses.
5. Gain the participation of experts to assist in behavioral management of birds intended for release, predator control, forest restoration, and public/private liaison.
6. Determine the route of *Toxoplasma* exposure, and potentially develop behavioral protocols to minimize risk of infection while reducing disease reservoirs by removing feral cats.
7. Develop protocols to enhance the ability of `Alalā to respond appropriately to small mammalian predators and `Io.
8. Initiate a breeding population in the wild as soon as possible, while minimizing the risk of mortality given the need to safeguard the genetic and demographic integrity of the population. This will allow parental transmission of behaviors in a natural context, and provide for estimation of vital rates in a reintroduced population.

Action 4: Garner Public Support and Funding

Recovery Objective: Manage public outreach activities so the public sees the `Alalā as a cultural asset, funding is adequate to support program needs, and active public support for the recovery program is evident.

Principles:

1. Financial and in-kind support for the `Alalā recovery program should be broad-based, including governmental and non-governmental sources, so that the resources necessary for flock growth and habitat management are available as they are needed.
2. Public support for the `Alalā recovery program should be widespread locally and nationally so that the local cooperation and participation, and overall financial support, necessary for success exist.
3. Public support for `Alalā conservation within the state of Hawai`i should be informed by Hawaiian cultural values and the best available science.

Management/Research Priorities:

1. Project the monetary needs for the captive flock for the time period covered by the current Implementation Plan, assuming optimum population growth rate.
2. Project the monetary and other needs of release site habitat management, for the time period covered by the current Implementation Plan.
3. Develop and maintain an income stream, supplementing government funding, to meet the projected needs for flock maintenance and habitat management.
4. Fund, as needed, contracts with outside consultants to help garner public support for the `Alalā, increase acceptance of reintroduction, and promote habitat management on private lands.
5. Coordinate efforts with other conservation programs in Hawai`i to increase public support for forest bird recovery and native ecosystem restoration.
6. Use existing incentives and develop new incentives for landowners to conserve and restore `Alalā habitat and support reintroduction.
7. Establish and maintain productive relationships among all parties active in `Alalā recovery, including the `Alalā Recovery Team, Hawaiian cultural leaders, and private landowners.
8. Prior to reintroduction, work with the surrounding community and hunters to eliminate possible danger to `Alalā either through accidental or intentional shooting or harm.

Action 5: Conduct Research and Adaptively Manage the Recovery Program

Recovery Objective: Conduct research and adaptively manage the recovery program so that monitoring and habitat management is focused on the self-sustaining reintroduced subpopulations.

Principles:

1. Management of all aspects of the recovery program should be based on an adaptive management cycle. In this cycle, proposed actions are treated as hypotheses to be tested by monitoring measurable outcomes. The results of these actions should be reviewed as soon as outcomes are analyzed, and subsequent actions proposed and tested in an iterative cycle.
2. The `Alalā Recovery Team should review management actions and results on at least a yearly basis, and at five-year intervals, or as appropriate, prepare a new Implementation Plan summarizing program results and proposing further actions and tests, with estimated completion times and costs. The Implementation Plans

should be peer reviewed before being published as Addenda to the Revised Recovery Plan.

3. All biological research to be conducted in the `Alalā recovery program should be prioritized based on immediate program needs.
4. An unbiased, outside appraisal of progress in meeting the objectives of the recovery program should be part of each Implementation Plan. This extends the adaptive management principle to the management of the program itself, and cannot be performed by the Recovery Team due to inherent conflicts of interest.

<u>Research/Management Priorities</u>:

1. Convene Recovery Team meetings on a regular, fixed schedule to include reviews of all program aspects.
2. Review all program data collected in both captive and field programs, and financially support analysis and publish important data sets.
3. Establish performance goals for the Recovery Team and management/regulatory agencies based on program needs outlined in the most recent Implementation Plan.

III. IMPLEMENTATION PLAN

In order to achieve long-term recovery goals for the `Alalā, the specific short-term goals presented below must be accomplished. Goals for the implementation period covered by this plan are defined below for each Recovery Action in light of results from the program to date and following the principles set out in the Strategic Plan (Part II of this recovery plan). Special emphasis is given to those Research and Management Priorities that can be addressed within the five-year Implementation Plan time frame. This implementation plan is to be revised and updated every 3 to 5 years, integrating the most current information and the results of the program to date.

Actions are assigned priorities based on Service policy (see pg. IV-1). All actions listed in this Implementation Plan are considered either essential to prevent extinction (Priority 1) or to prevent an irreversible decline of the species (Priority 2). Note that there are no Priority 3 recovery actions listed as we are faced with the imminent possibility of extinction of this species. To move this species closer to recovery, all actions described must be completed. Some recovery actions listed below were ongoing prior to publication of this revised plan.

A. ACTION 1: MANAGE THE `ALALĀ POPULATION

Short-term Goal: Expand the size of the captive flock to slow the loss of genetic diversity, make it genetically and demographically more stable, and large enough to generate juveniles for release.

Because the `Alalā is apparently extirpated from the wild, continuing appropriate management of the captive flock is the first and most important step to recover the species. Retention of the highest possible level of genetic diversity is essential to maintaining recovery potential. Maximum genetic diversity can be retained only by increasing the size of the captive population rapidly and by minimizing mortality risk. Flock managers suggest that population growth rate and proportion of breeders may increase, respectively, to $\lambda = 1.10$ and $N_e/N = 0.35$. These estimates are based on an evaluation of the potential growth rate of the captive flock after the removal of birds released to the wild that did not breed and which had a higher mortality rate than in captivity. Maintenance of the approximate maximum possible genetic diversity (80 percent) at the end of five years will require increasing the number of birds to at least 75 (see Appendix A). This is consistent with the strategic goal to conserve maximal genetic diversity in the species for at least 20 years.

Previously released birds have suffered high mortality that could not be readily reduced. Thus the need to minimize mortality to increase numbers leads us to conclude that the flock should be managed in captivity during this period. The financial costs of captive propagation are already substantial, and increased aviary space and support personnel will be needed to keep pace with population growth. Adequate land area is currently available for new aviary construction at the Keauhou Bird Conservation Center on Hawai`i. Securing funding sources beyond the current Federal and State government allocations is the only feasible means to accomplish this. To that end, professional fundraising assistance is needed (see Action 4, pg. III-11).

In the event that adequate funding cannot be obtained to support the target increase in flock size at the Keauhou and Maui Bird Conservation Centers, options for expanding the flock using existing captive propagation facilities in North America should be considered. This approach is less desirable because of biosecurity concerns (*e.g.*, the risk of birds held at mainland facilities contracting diseases not found in Hawai`i) and added difficulties of flock management, but must be considered if the required rate of flock increase is limited by aviary space.

Additional means of lowering captive propagation costs while maintaining population growth should be considered. Options include lower-cost aviaries at existing facilities or at prospective release sites, and releases of reproductive pairs in intensively managed, predator-free habitats. To be viable, such alternatives should offer substantially reduced costs, behavioral or other benefits not possible in alternative facilities, and should conform to the strategic principles for population management listed in Section 2.4.1.

Although it appears at this time that the `Alalā is extirpated from the wild, should any wild `Alalā be located, the individual(s) should be captured, if possible, and paired with a captive bird to incorporate wild genes into the captive flock. In such an event, juvenile `Alalā should be exposed to the behavioral repertoire of these individuals, including their calls.

1. Manage the captive population of `Alalā.

1.1 Stabilize the captive flock genetically and demographically.

1.1.1 Manage the captive flock according to the small population guidelines of the Association of Zoos and Aquariums (AZA), conserving maximal existing gene diversity in the species for at least 20 years.

1.1.1.1 Increase the number of individuals in the captive flock from 56 to at least 75 over the next five years. (Priority 1)

1.1.1.2 Reexamine existing pedigree and founder relatedness using recently completed DNA analysis. Provide analysis to the `Alalā Recovery Team by end of each calendar year. (Priority 2)

1.1.1.3 Protect captive flock from infection with West Nile virus by mosquito exclusion and/or immunization. Potential side effects of West Nile virus immunization should be known (particularly possible effects on reproduction) prior to immunization if this is to be done. The Center for Disease Control (CDC) will be included in discussions as they are currently the lead agency for West Nile virus research. (Priority 2)

1.1.1.4 The flock manager will annually review captive flock status and new information related to captive propagation, suggest new studies and protocols, and prepare a summary for the `Alalā Recovery Team. These activities can be done in consultation with others if requested by the Service. (Priority 2)

1.1.1.5 Continue existing and initiate new research aimed at improving breeding and reproductive success of the captive flock. Continue to explore all possible means to encourage breeding of individuals that have not bred or are under-represented in the captive flock.

1.1.1.5.1 Consider giving ineffective or inept breeders hormone implants to improve reproductive behavior. This action will require documentation of current hormonal profiles in a sample of laying/breeding and non-laying/non-breeding pairs. (Priority 2)

1.1.1.5.2 Allow greater opportunities for mate selection through non-breeder group socialization. (Priority 2)

1.1.1.5.3 Structure captive socialization to maintain several single-sex groups that can be introduced after the natal period to limit inbreeding avoidance in unrelated birds. (Priority 2)

1.1.1.5.4 Incorporate genes of any rediscovered wild `Alalā by temporary or permanent capture and captive breeding. (Priority 2)

1.1.2 Increase capacity of captive facilities to allow all potentially breeding birds to mate.

1.1.2.1 Build two new breeding aviaries and three new holding aviaries each year over the next five years at current facilities, for a total of 25 new aviaries built. (Priority 2)

1.1.2.2 Secure funding to support increased staff, operations needs, and construction costs for item 1.1.2.1. (Priority 2)

1.1.2.3 Evaluate mainland facilities for their potential to provide for flock growth. If `Alalā must be moved to the mainland, obtain authorization from the Association of Zoos and Aquariums for the `Alalā Studbook and to develop a Species Survival Plan, as required for species held in multiple AZA institutions. (Priority 2)

1.2 If wild birds are discovered and brought into captivity, maximize potential transmission of their behaviors to juvenile birds. (Priority 2)

B. ACTION 2: IDENTIFY SUITABLE HABITAT AND MANAGE THREATS

Short-term Goal**:** Potential release sites should be evaluated and one or more selected for habitat management. By the end of 2010, two or more forest sites containing suitable habitat for the `Alalā should be under active management as potential release sites. At least one managed site of at least 1,000 hectares (2,480 acres) in size within the historical range of the `Alalā should have better vegetation structure and lower predator densities than those that existed at the McCandless release site.

Active habitat management is needed to restore understory vegetation and reduce predator and disease abundance to reduce mortality rates in released birds. Final selection of release sites must be made in the very near future to allow preparation of the sites by the time birds are available for release. As of June 2008, preferred sites for reintroduction have been identified by the `Alalā Recovery Team, but no final decision has yet been made to implement habitat management actions. Features that are assumed at this time to be critical to a successful release program include: protection from human disturbance, presence of forage plants and invertebrates, presence of suitable roost and nest site forest structure, ability to manage limiting factors (*e.g.*, predators), and access to adjacent lands for monitoring. Depending upon release strategies chosen, it is possible initially that a managed release area could be smaller than 1,000 hectares (*e.g.*, if a semi-captive release were used). However, it is anticipated that for self-sustaining wild populations to be established, each wild population will require a minimum of 1,000 hectares of habitat.

Once sites are selected, managing these areas will require funding and cooperative agreements to conduct needed management actions, as well as support by the public and private landowners for all measures required for eventual use of the area for `Alalā reintroduction. It is important to begin habitat restoration actions several years before projected releases because predator control programs, vegetation response to herbivore removal, and potentially `Io emigration, will occur over a multi-year time frame.

Regulatory mechanisms currently in place may not be sufficient to keep some threats out of Hawai`i. Alien predators and diseases that make `Alalā recovery all but impossible are prevalent on other Pacific Islands (*e.g.*, brown treesnake, *Boiga irregularis*, on Guam) and in North America (*e.g.*, West Nile virus). All available means must be used to keep these and other alien threats to forest birds from becoming established in Hawai`i.

2. Identify suitable habitat and manage threats.

2.1 Provide suitable habitat to prepare for reintroduction.

2.1.1 Gather additional habitat information using remote sensing, ground-truthing, and knowledge of local land managers as needed to compare release sites. (Priority 2)

2.1.2 Establish selection criteria for release sites and choose one or more reintroduction sites. (Priority 2)

2.1.3 Finalize the Environmental Assessment for population reestablishment of the `Alalā as appropriate, selecting one or more release sites for `Alalā on Hawai`i and possibly other islands of at least 1,000 hectares each, at various elevations within historical range of `Alalā on Hawai`i or in suitable habitat identified outside historical range. (Priority 2)

2.1.4 Secure habitat areas for habitat restoration.

2.1.4.1 Use Safe Harbor and Partnership Agreements and other regulatory and incentive programs as appropriate to increase effective management of `Alalā habitat on private lands. (Priority 2)

2.1.4.2 Use mechanisms such as conservation easements, cooperative agreements, changes in land use designation, leases, direct compensation, or purchase from willing sellers as appropriate to secure habitat areas. (Priority 2)

2.1.5 Fence and remove feral ungulates from all release sites. (Priority 2)

2.1.6 Document initial vegetation condition and measure response to ungulate exclusion, comparing to pre-established criteria for release sites. (Priority 2)

2.1.7 Increase populations of selected native plants as needed to restore food base for `Alalā, including out-planting of sub-canopy fruit bearing plants. (Priority 2)

2.1.8 Coordinate `Alalā recovery actions to benefit from funding and management of other endangered species programs and to assist these programs. (Priority 2)

2.2 Reduce threats from alien predators and diseases at designated release sites.

2.2.1 Remove all feral cats from release sites and maintain cat-free status. (Priority 2)

2.2.2 Reduce rodent and mongoose populations in all release sites and maintain at less than 20 percent of initial densities. (Priority 2)

2.2.3 Establish a mammal-free area within one of the release sites and document response of plant and animal communities and cost of maintenance. (Priority 2)

2.3 Reduce threat of `Io predation on `Alalā at designated release sites on Hawai`i.

2.3.1 Establish baseline `Io densities at all designated release sites, and monitor yearly. (Priority 2)

2.3.2 Determine by experiment if `Io density will be reduced by controlling rodent and game bird (*e.g.,* kalij pheasant) prey base. (Priority 2)

2.3.3 Evaluate relationship between forest vegetation structure and ability of `Io to prey on `Alalā. (Priority 2)

2.4 Prevent alien pathogens and predators from becoming established in Hawai`i that would preclude recovery of `Alalā (*e.g.*, West Nile virus, brown treesnake). (Priority 1)

C. ACTION 3: ESTABLISH NEW POPULATIONS IN MANAGED SUITABLE HABITAT

Short-term Goal: Determine the captive rearing conditions that best prepare juvenile `Alalā for survival after release and develop reintroduction plans. In the event that flock growth targets are exceeded and genetic diversity maintained, release excess juveniles (or other individuals) into managed habitat.

During the time frame of this Implementation Plan, captive `Alalā will be considered for release if the following conditions are met:

a) Their removal from the captive population will not negatively impact the demographic stability of the captive population or reduce the ability of the population to achieve growth targets.

b) Each of the founders from which they are descended are represented in the captive flock to the maximum extent feasible. The goal is maintenance of 96 percent of the genetic diversity of each founder line (*e.g.*, five F1 [first generation] offspring). Founders that died before producing five F1 descendants will require more representatives in the captive flock to minimize the loss of genetic diversity. The 96 percent goal may not be feasible for all founder lines.

c) Annual population growth targets (*e.g.*, 7-8 birds/year to maintain maximum possible genetic diversity of 79.4 percent at the end of five years) have been exceeded and birds fitting these criteria are projected to be available for at least two more years, enough to justify starting a release program (*i.e.*, a sufficient number of birds are projected to be available for three consecutive years of releases). The type of release planned will partly determine the number of birds needed for releases.

d) Forest habitat appropriate for release is being actively managed to reduce known mortality factors, including predation by `Io.

e) Highest priority for release will be birds reared by their parents and adults that are paired or have formed a pair bond.

Because it is doubtful that a cohort of such juveniles or pairs will be available for release within the time period covered by this Implementation Plan, activities under this action focus on habitat management, planning, and behavioral experimentation.

Management of the captive flock must focus primarily on increasing population size and maintaining genetic diversity (Action 1). To the extent possible without compromising those goals, investigations aimed at optimizing rearing techniques to increase survival rates in the wild should be conducted. Because there is a risk that some of these potential modifications may reduce breeding efficiency, birds that are genetically and demographically surplus or post-reproductive should be used if feasible.

3. Conduct experimental releases at a managed site as soon as genetically and demographically redundant birds are available.

3.1 Using demographic models, project when birds suitable for release will be available, updating projections yearly. (Priority 2)

3.2 Determine the potential efficacy of behavioral management of juvenile `Alalā in reducing post-release mortality rates.

3.2.1 Appoint a subcommittee of the Recovery Team that includes outside experts to review research on other species and draft a set of hypotheses, tests, and conditions for determining the effectiveness of behavioral conditioning in `Alalā. (Priority 2)

3.2.2 Experimentally test whether `Alalā can be trained to avoid cat feces as a means to reduce risk of toxoplasmosis. (Priority 2)

3.2.3 Experimentally test whether `Alalā can be trained to avoid small mammalian predators. (Priority 2)

3.2.4 Experimentally test whether `Alalā can be trained to avoid predation by `Io. (Priority 2)

3.3 Optimize aviaries and rearing/socialization techniques to maximize behavioral fitness of selected birds for release.

3.3.1 Allow parent-rearing by well-represented pairs and compare the behavior of juveniles reared by parents to those reared using the standard puppet method. (Priority 2)

3.3.2 Improve mutual learning opportunities by young `Alalā as members of non-breeding flocks. (Priority 2)

3.3.3 Enhance opportunities for learning wild social and foraging behaviors by allowing juveniles contact with birds previously released into the wild, playing recordings of known vocalizations, and other means. (Priority 2)

3.4 Determine the potential efficacy of different reintroduction approaches.

3.4.1 Examine the history of the release program from 1993 to 1999 with particular emphasis on known mortality factors, and propose changes in rearing and release methodologies to reduce mortality and increase program success. (Priority 2)

3.4.2 Compare the inferred social system of the `Alalā with social systems of other corvid species (*e.g.*, Common Raven [*Corvus corax*], Mariana Crow [*C. kubaryi*], and Grey Crow [*C. tristis*]), and propose release protocols that would favor early pair formation and breeding. (Priority 2)

3.4.3 Rank all potential release protocols, and any associated captive husbandry regimes, by order of likely success at the chosen release site, and prepare to implement (or actually implement) the highest priority protocol on an experimental basis. Potential release protocols may include: multiple age groups that have formed a large group dynamic, paired individuals, juvenile cohorts, soft-release methods where support is provided for extended periods of time, breeding pairs held in field aviaries, mixed-age cohorts held in large field aviaries, and other approaches. (Priority 2)

D. ACTION 4: GARNER PUBLIC SUPPORT AND FUNDING

Short-term Goal: Fund the recovery program sufficiently to achieve all goals of this Implementation Plan, while measurably increasing the support of people in Hawai`i for `Alalā recovery.

Expansion of the captive flock and active management of large forest areas for releases will require a significant increase in funding over existing program support available through the budgets of the implementing agencies. Captive flock growth will require capital expenditures of approximately $150,000 per year for the implementation plan period, and increases in operational base funding of $50,000 every other year. Fencing, ungulate control, and predator control are expensive and will require ongoing commitments of personnel: the estimated cost of fencing and ungulate eradication at the

2,145-hectare (5,300-acre) Kona Forest Unit is approximately $1 million. Because habitat management actions and endangered species conservation may take place on private lands and public lands managed for multiple uses, it is very important to identify key stakeholders and to achieve cooperation with them.

To effectively raise funds from the private sector and to design and manage a public awareness campaign requires expertise and flexibility not available in government agencies. Therefore, obtaining the assistance of non-Federal professional services such as non-profit organizations or private consultants is recommended. These groups and individuals could conduct fund raising activities and provide funds raised from the public sector directly to non-governmental entities implementing recovery actions for `Alalā. Fundraising efforts should benefit from increased public awareness, and will in turn generate on-the-ground results that further increase public support.

The `Alalā itself can help to increase awareness and support due to its intrinsic appeal and status as a bird of spiritual significance to the Hawaiian people. Using non-breeding birds for education to increase public exposure to live `Alalā also will provide an option to free cage space at the captive propagation facilities, as necessary.

4. Garner public support and funding.

4.1 Secure funding adequate to support the `Alalā recovery program through 2013.

4.1.1. Determine the financial and non-financial needs of the program, including flock management, habitat management, and public awareness programs. (Priority 2)

4.1.2 Design and implement a funding strategy adequate to meet these needs. (Priority 2)

4.2 Incorporate Hawaiian cultural viewpoints into recovery planning and implementation by including one or more experts in the recovery implementation working group and/or the public portion of `Alalā Recovery Team meetings. (Priority 2)

4.3 Communicate with local communities to prepare for toxicant use, cat control, ungulate control, and `Alalā presence, and seek feedback from the communities for improving outreach and informational programs. (Priority 2)

4.4 Contract with a specialist in public/private landowner relationships to design and conduct a program to enlist landowner collaboration. (Priority 2)

4.5 In coordination with the Hawai`i Forest Bird Recovery Team, contract with an independent public outreach specialist to meet public outreach performance milestones. (Priority 2)

4.6 Display non-breeding `Alalā in one or more educational settings within the State of Hawai`i. (Priority 2)

E. ACTION 5: CONDUCT RESEARCH AND ADAPTIVELY MANAGE THE RECOVERY PROGRAM

Short-term Goal: Achieve short-term goals for all recovery actions through exemplary program management and prepare the next Implementation Plan by the end of calendar year 2013.

Adaptive management requires actions that are posed as well-framed questions, collection of data to address them, analyses that answer the questions, and incorporation of these answers into further management. Data generated from the recovery program to date must be managed, catalogued, and analyzed or made available for analysis in order to manage the recovery program adaptively.

This Implementation Plan is itself a proposed management action, and like all actions in adaptive management, it should not be assumed to be effective. Progress toward the short-term goals must be continually monitored, methods changed as needed, and an overall assessment conducted prior to the formulation of the next Implementation Plan.

5. Conduct research and adaptively manage the recovery program.

5.1 Use existing data sets to address questions regarding `Alalā management.

5.1.1 Complete the inventory of field data collected from 1992 through 2001, and present to Recovery Team. (Priority 2,)

5.1.2 Formulate list of relevant questions to be addressed by analysis of these data (action 5.1.1) and conduct analyses. (Priority 2)

5.2 Prioritize new research based on relevance to implementation plan tasks, and modify management actions based on analysis of results. (Priority 2)

5.3 Hold Recovery Team meetings twice per year, preceding and following the `Alalā breeding season, or as determined necessary by the Team. (Priority 2).

5.4 Establish a recovery implementation working group. (Priority 2)
This group, under the direction of the Service and reporting to the `Alalā Recovery Team, among other tasks will identify long-term habitat restoration planning needs, analyze available data to be used for habitat evaluation, take responsibility for conducting quantitative vegetation analyses for habitat suitability and the evaluation of habitat criteria for release site selection, and gather additional habitat data as needed. The group will also help participate in release planning, among other and changing responsibilities as needed. Membership on this group can be fluid as tasks and expertise needed will change over time.

5.5 Hire a person whose sole responsibility will be to coordinate implementation of recovery actions for the `Alalā and/or dedicate at least one full-time employee to oversee recovery implementation. (Priority 2)
An individual solely responsible for coordinating implementation of recovery actions for the `Alalā will help to implement recovery actions most effectively. Activities the individual may be responsible for include release site habitat evaluation and the gathering of additional habitat data, finalization of the draft Environmental Assessment for reestablishment of the `Alalā, public outreach, habitat management at the release site, and `Alalā releases.

5.6 Performance milestones for the Recovery Team, the Service, and private contractors should be adopted and progress measured annually, and corrective actions proposed if milestones are not achieved. (Priority 2)

5.7 If appropriate, beginning in early 2012, prepare implementation plan for 2014 through 2018. (Priority 2)

5.8 In 2012 obtain a thorough, impartial assessment of the `Alalā recovery program's progress toward stated goals and identify impediments to goal achievement. Incorporate this review into the next Implementation Plan and, following peer review, publish as an addendum to the Revised Recovery Plan. (Priority 2)

IV. IMPLEMENTATION SCHEDULE

The Implementation schedule that follows lists the actions and estimated costs for the recovery program for the `Alalā. It is a guide for meeting the recovery goals outlined in this plan. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. When more than one party has been identified the proposed lead party is indicated by an asterisk (*). The listing of a party in the Implementation Schedule does not require, nor imply a requirement, that the identified party has agreed to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover `Alalā. Also, section 7(a)(1) of the ESA directs all federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species.

A. DEFINITION OF ACTION PRIORITIES

Priorities in the Implementation Schedule are assigned according to the following definitions for recovery actions:

Priority 1 – an action that must be taken to prevent extinction or to prevent a species from declining irreversibly in the foreseeable future.
Priority 2 – an action that must be taken to prevent a significant decline in species population or habitat quality or some other significant negative impact short of extinction.
Priority 3 – all other actions necessary to meet recovery objectives.

B. LISTING/DELISTING FACTORS

The Service evaluates five major factors when considering whether to list, delist, or reclassify a species:

A – Present or threatened destruction, modification or curtailment of habitat or range;

B – Overutilization for commercial, recreational, scientific, or educational purposes;
C – Disease or predation;
D – Inadequacy of existing regulatory mechanisms; and
E – Other natural or man-made factors affecting the continued existence of a species.

The Listing Factor column in the Implementation Plan Schedule indicates which of the five factors the recovery action addresses for recovery goals described in the `Alalā Recovery Strategic Plan and Implementation Plan. The majority of recovery actions in the Implementation Plan Schedule address threats to habitat (factor A), disease and predation (factor C), and preventing loss of genetic diversity in the captive flock, garnering public support, and formulating relevant questions and data analysis (factor E).

C. ACTION DURATION AND RESPONSIBLE PARTIES

The U.S. Fish and Wildlife Service has the statutory responsibility for implementing this recovery plan. Only Federal agencies are mandated to take part in the effort. Recovery actions identified in this plan imply no legal obligations of State and local government agencies or private landowners. However, recovery of the `Alalā will require the involvement and cooperation of Federal, State, local, and private interests. For each recovery action described, the column titled "Responsible Parties" lists the primary Federal and State agencies we have identified as having the authority and responsibility for implementing recovery actions and other groups, partners, and partnerships, who are actively involved in recovery implementation.

D. COST ESTIMATES FOR RECOVERY ACTIONS

The Implementation Plan Schedule provides total estimated costs of implementing recovery actions for the fiscal years 2009 through 2013. Estimates for recovery actions are based on average costs of similar actions implemented to date for habitat management, predator control, and captive propagation. For habitat management, these costs may vary considerably depending upon the condition of the forest habitat, features of terrain, and type of management actions already occurring in the area.

Cost by year: 2009 = $2,200,000
2010 = $3,350,000
2011 = $2,900,000
2012 = $2,940,000
2013 = $2,990,000

Total cost to implement this Plan for years 2009 through 2013: $14,380,000.

E. KEY TO ACRONYMS AND RESPONSIBLE PARTIES

ART – `Alalā Recovery Team
AZA – Association of Zoos and Aquariums (formerly American Zoo and Aquarium Association)
DLNR – Hawai`i Department of Land and Natural Resources
HDOA – Hawai`i Department of Agriculture
HFBRT – Hawaiian Forest Bird Recovery Team
HZ – Honolulu Zoo
NMNH – National Museum of Natural History
TBD – To Be Determined
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
ZSSD – Zoological Society of San Diego

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Revised Recovery Plan for the `Alalā: Implementation Schedule 2009 through 2013

Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
1.1.1.1	1	E	Increase the number of individuals in the captive flock from 56 to at least 75 over the next five years.	5 years	ART, USFWS, ZSSD*, DLNR, USGS, NMNH	0.0	0.0	0.0	0.0	0.0	Costs appear separately under recovery actions below for managing the captive population of `Alalā
1.1.1.2	2	E	Reexamine existing pedigree and founder relatedness using recently completed DNA analysis.	1 year	ZSSD*, NMNH	0.1	0.0	0.0	0.0	0.0	
1.1.1.3	2	C	Protect captive flock from infection with West Nile virus by mosquito exclusion and/or immunization.	5 years	ZSSD*, USFWS, DLNR	0.2	0.2	0.2	0.2	0.2	
1.1.1.4	2	E	The flock manager will annually review captive flock status and new information related to captive propagation, suggest new studies and protocols, and prepare a summary for the `Alalā Recovery Team.	5 years	ART, USFWS, ZSSD, DLNR,	0.1	0.1	0.1	0.1	0.1	
1.1.1.5.1	2	E	Consider giving ineffective or inept breeders hormone implants to improve breeding and parental care.	5 years	ART, USFWS, ZSSD*, DLNR	0.1	0.1	0.1	0.1	0.1	

Revised Recovery Plan for the `Alalā: Implementation Schedule 2009 through 2013

Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
1.1.1.5.2	2	E	Allow greater opportunities for mate selection through non-breeder group socialization.	5 years	ZSSD	0.1	0.1	0.1	0.1	0.1	Costs are for increased management expenses. Costs for aviary construction are under 1.1.2.1.
1.1.1.5.3	2	E	Structure captive socialization to maintain several single-sex groups that can be introduced after the natal period to limit inbreeding avoidance in unrelated birds.	5 years	ZSSD	0.1	0.1	0.1	0.1	0.1	Costs are for increased management expenses.
1.1.1.5.4	2	E	Incorporate genes of any wild `Alalā by temporary or permanent capture and captive breeding.	2 years	ZSSD	0.5	0.5	0.0	0.0	0.0	
1.1.2.1	2	A, C, E	Build two new breeding aviaries and three new holding aviaries each year over the next five years at current facilities.	5 years	ZSSD*, USFWS, DLNR	2.0	2.0	2.0	2.0	2.0	Accommodate an increase the number of individuals in the captive flock from 56 to at least 75 over the next five years.
1.1.2.2	2	E	Secure funding to support increased staff, operations needs, and construction costs for item 1.1.2.1.	5 years	ZSSD, USFWS*, DLNR	0.5	0.5	0.5	0.5	1.0	

Revised Recovery Plan for the `Alalā: Implementation Schedule 2009 through 2013

Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
1.1.2.3	2	A, E	Contact potential mainland facilities to provide for flock growth.	2 years	ZSSD	0.1	0.1	0.0	0.0	0.0	If `Alalā must be moved to the mainland, obtain authorization from the American Zoo and Aquarium Association for the `Alalā Studbook and to develop a Species Survival Plan.
1.2	2	A, E	If wild birds are discovered and brought into captivity, maximize potential transmission of their behaviors to juvenile birds.	5 years	ZSSD	0.1	0.1	0.1	0.1	0.1	Costs are for increased management expenses.
2.1.1	2	A, C	Gather additional habitat information using remote sensing, ground-truthing, and knowledge of local land managers as needed to compare release sites.	1 year	ART, USFWS*, DLNR, USGS	0.2	0.0	0.0	0.0	0.0	Preliminary assessments completed. Costs are for additional studies.
2.1.2	2	A, C	Establish selection criteria for release sites and choose one or more reintroduction sites.	1 year	ART, USFWS*, DLNR, USGS	0.2	0.0	0.0	0.0	0.0	
2.1.3	2	A, C	Finalize Environmental Assessment for population reestablishment of the `Alalā.	2 years	USFWS*, DLNR	0.0	0.2	0.2	0.0	0.0	

Revised Recovery Plan for the `Alalā: Implementation Schedule 2009 through 2013

Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
2.1.4.1	2	A, C, D, E	Use Safe Harbor and Partnership Agreements and other regulatory incentive programs to increase effective management of `Alalā habitat on private lands.	5 years	USFWS*, DLNR, TBD	0.2	0.2	0.2	0.2	0.2	
2.1.4.2	2	A, C, D, E	Use mechanisms such as conservation easements, cooperative agreements, changes in land use designation, leases, direct compensation, or purchase from willing sellers to secure habitat areas.	5 years	USFWS*, DLNR	0.2	0.2	0.2	0.2	0.2	
2.1.4.3	2	A, B, C, E	Design and implement a program to inform the communities near release sites of the recovery program and its benefits (see action 4.3).	5 years	USFWS*, DLNR, TBD	0.2	0.2	0.2	0.2	0.2	
2.1.4.4	2	A, C, E	Coordinate `Alalā recovery actions to benefit from funding and management of other endangered species programs and to assist these programs.	5 years	USFWS*, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	
2.1.5	2	A, C	Fence and remove feral ungulates from all release sites.	5 years	USFWS*, DLNR*, TBD	7.0	7.0	7.0	7.0	7.0	

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Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
2.1.6	2	A, C	Document initial vegetation condition and measure response to ungulate exclusion, comparing to pre-established criteria for release sites.	5 years	USFWS*, DLNR, TBD	0.5	0.5	0.5	0.5	0.5	
2.1.7	2	A, C	Increase populations of selected native plants as needed to restore food base for `Alalā, including outplanting of sub-canopy fruit-bearing plants	5 years	USFWS*, DLNR, TBD	0.5	0.5	0.5	0.5	0.5	
2.2.1	2	A, C	Remove all feral cats from release sites and maintain cat-free status.	5 years	USFWS*, DLNR, TBD	0.5	1.0	2.0	2.0	2.0	
2.2.2	2	A, C	Reduce rodent and mongoose populations in all release sites and maintain at less than 20 percent of initial densities.	5 years	USFWS*, DLNR, TBD	1.0	2.0	2.0	2.0	2.0	
2.2.3	2	A, C	Establish a mammal-free area within one of the release sites and document response of plant and animal communities and cost of maintenance.	5 years	USFWS*, DLNR, TBD	1.0	9.0	4.0	4.0	4.0	
2.3.1	2	A, C	Establish baseline `Io densities at all designated release sites, and monitor yearly.	5 years	USFWS*, DLNR, TBD	0.5	0.5	0.5	0.5	0.5	
2.3.2	2	C	Determine by experiment if `Io density can be reduced by controlling rodent and game bird prey base.	5 years	USFWS*, DLNR, TBD	1.0	1.0	1.0	1.0	1.0	

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Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
2.3.3	2	A, C	Establish relationship between forest vegetation structure and ability of `Io to prey on `Alalā	5 years	USFWS*, DLNR, TBD	1.0	1.0	1.0	1.0	1.0	
2.4	1	C, D	Prevent alien pathogens and predators from becoming established on Hawai`i that would preclude recovery of `Alalā.	5 years	HDOA*, USFWS, DLNR, TBD	TBD	TBD	TBD	TBD	TBD	
3.1	2	C, E	Using demographic models, project when birds suitable for release will be available, updating projections yearly.	5 years	ART, USFWS, ZSSD*, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	
3.2.1	2	C, E	Appoint a subcommittee of the Recovery Team that includes outside experts to draft a set of hypotheses, tests, and conditions for determining the effectiveness of behavioral conditioning in `Alalā.	2 years	ART, USFWS, ZSSD*, DLNR, TBD	0.2	0.2	0.0	0.0	0.0	
3.2.2	2	C	Experimentally test whether `Alalā can be trained to avoid cat feces as a means to reduce risk of toxoplasmosis.	4 years	USFWS, ZSSD*, DLNR, TBD	0	0.1	0.1	0.2	0.2	
3.2.3	2	C	Experimentally test whether `Alalā can be trained to avoid small mammalian predators.	4 years	USFWS, ZSSD*, DLNR, TBD	0.0	0.1	0.2	0.2	0.2	

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Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
3.2.4	2	C	Experimentally test whether `Alalā can be trained to avoid predation by `Io.	4 years	USFWS, ZSSD*, DLNR, TBD	0.0	0.1	0.2	0.2	0.2	
3.3.1	2	E	Allow parent-rearing by well-represented pairs and compare the behavior of juveniles reared by parents to those reared using the standard puppet method.	5 years	USFWS, ZSSD*, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	Costs are for increased management expenses. Costs for associated aviary construction are under 1.1.2.1.
3.3.2	2	E	Improve mutual learning opportunities by young `Alalā as members of non-breeding flocks.	5 years	USFWS, ZSSD*, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	Costs are for increased management expenses. Costs for associated aviary construction are under 1.1.2.1.
3.3.3	2	E	Enhance opportunities for learning wild social and foraging behaviors by allowing juveniles contact with birds previously released into the wild, playing recordings of known vocalizations, and other means.	5 years	USFWS, ZSSD*, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	Costs are for increased management expenses. Costs for associated aviary construction are under 1.1.2.1.

Revised Recovery Plan for the `Alalā: Implementation Schedule 2009 through 2013

Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
3.4.1	2	C, E	Examine the history of the release program from 1993 to 1999 with particular emphasis on known mortality factors, and propose changes in rearing and release methodologies to reduce mortality and increase program success.	5 years	ART, USFWS, ZSSD*, DLNR, USGS*, TBD	0.1	0.1	0.2	0.4	0.4	
3.4.2	2	C, E	Compare the inferred social system of the `Alalā with social systems of other corvid species (*e.g.*, Common Raven *Corvus corax*, Mariana Crow *Corvus kubaryi*, and Grey Crow *Corvus tristis*), and propose release protocols that would favor early pair formation and breeding.	3 years	ART, USFWS, ZSSD, DLNR, USGS*, TBD	0.1	0.2	0.2	0.0	0.0	
3.4.3	2	C, E	Rank all potential release protocols, and any associated captive husbandry regimes, by order of likely success at the chosen release site, and prepare to implement (or actually implement) the highest priority protocol on an experimental basis.	2 years	ART, USFWS, ZSSD, DLNR, USGS*, TBD	0.0	0.4	0.4	0.0	0.0	

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Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
4.1.1	2	E	Determine the financial and non-financial needs of the program, including flock management, habitat management, and public awareness programs.	5 years	TBD	0.1	0.1	0.1	0.1	0.1	
4.1.2	2	E	Design and implement a funding strategy adequate to meet needs.	5 years	TBD	0.5	0.5	0.5	0.5	0.5	
4.2	2	E	Incorporate Hawaiian cultural viewpoints into recovery planning and implementation by including one or more experts in the public portion of all `Alalā Recovery Team meetings.	5 years	USFWS*, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	
4.3	2	B, E	Communicate with local communities near release sites to prepare for toxicant use, cat control, ungulate control, and `Alalā presence, and seek feedback from the communities for improving outreach and informational programs (see action 2.1.4.3).	5 years	USFWS*, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	
4.4	2	E	Contract with a specialist in public/private landowner relationships to design and conduct a program to enlist landowner collaboration as outlined in action 2.1.4.1.	5 years	USFWS*, DLNR, TBD	0.2	0.2	0.2	0.2	0.2	

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Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
4.5	2	E	In coordination with the Hawai`i Forest Bird Recovery Team, contract with an independent public outreach specialist to meet public outreach performance milestones.	5 years	USFWS*, DLNR, HFBRT, TBD	0.2	0.2	0.2	0.2	0.2	
4.6	2	E	Display non-breeding `Alalā in one or more educational settings within the State of Hawai`i.	5 years	ZSSD, USFWS, DLNR, HZ*, TBD	0.2	0.2	0.2	0.2	0.2	
5.1.1	2	A, C, E	Complete the inventory of field data collected from 1992 to 2001, and present to the Recovery Team.	1 year	USGS	0.0	0.0	0.0	0.0	0.0	Field data presentation completed in 2008.
5.1.2	2	A, C, E	Formulate list of relevant questions to be addressed by analysis of these data (action 5.1.1) and conduct analyses.	4 years	ART*, ZSSD, USFWS, DLNR, USGS, TBD	0.0	0.5	0.5	0.5	0.5	
5.2	2	A, C, E	Prioritize new research based on relevance to implementation plan tasks, and modify management actions based on analysis of results.	5 years	ART*, ZSSD, USFWS, DLNR, USGS, TBD	0.1	0.1	0.1	0.1	0.1	
5.3	2	A, C, E	Hold Recovery Team meetings once a year on a fixed schedule, and as may be needed should time sensitive issues develop requiring immediate discussion.	5 years	ART*, ZSSD, USFWS, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	

Revised Recovery Plan for the `Alalā: Implementation Schedule 2009 through 2013

Action Numbers	Priority Number	Listing Factor	Action Description	Action Duration	Responsible Parties *	Cost Estimate ($100,000 units)					Comments/ Notes
						FY 09	FY 10	FY 11	FY 12	FY 13	
5.4	2	A, C, E	Establish a recovery implementation working group.	5 years	ART*, ZSSD, USFWS*, DLNR, TBD	0.5	0.5	0.5	0.5	0.5	
5.5	2	A, C, E	Hire a person whose sole responsibility will be to coordinate implementation of recovery actions for the `Alalā and/or dedicate at least one full-time employee to oversee recovery implementation.	5 years	USFWS, DLNR, TBD*	1.0	2.0	2.0	2.5	2.5	
5.6	2	A, C, E	Adopt performance milestones for the Recovery Team, the Service, and private contractors, measure annually, and propose corrective actions if milestones are not achieved.	5 years	ART*, ZSSD, USFWS, DLNR, TBD	0.1	0.1	0.1	0.1	0.1	
5.7	2	A, C, E	If appropriate, beginning in early 2012, prepare Implementation Plan for 2014 through 2018.	2 years	ART*, USFWS*, DLNR, TBD	0.0	0.0	0.0	0.1	0.1	
5.8	2	A, C, E	In 2012 obtain a thorough, impartial assessment of progress toward stated goals and identify impediments to goal achievement. Incorporate this review into the next Implementation Plan.	2 years	USFWS*, DLNR, TBD	0.0	0.0	0.0	0.3	0.3	
TOTAL						22.0	33.5	29.0	29.4	29.9	

* Identifies lead partners for implementing recovery actions.

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B. PERSONAL COMMUNICATIONS

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C. ADDITIONAL DATA SOURCES

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APPENDIX A

Genetic Diversity and Projected Population Growth Modeling Using PM2000 (Population Management 2000)

The population management of captive Alalā is based on genetic/demographic modeling using the Population Management 2000 software (PM2000) (Pollak *et al.* 2002). PM2000 is recommended for captive management of animals by the Association of Zoos and Aquariums (AZA). Modeling is done on an annual basis and estimates of future flock growth may change based on actual captive production.

This model assumes unrelated founders and calculates genetic data from the pedigree only, using Mendelian inheritance rules. Actual DNA analysis (Fleischer 2003) suggests that the founders were not entirely unrelated, but the relative degrees of relatedness cannot be specified without further genetic tests. The actual genetic diversity of the captive `Alalā flock is therefore likely to be lower than is assumed in the PM2000 model.

Definition of Terms (Pollak *et al.* 2002):
Founder is an individual at the top of a pedigree, assumed to be unrelated to all other founders. An individual is not a founder of the captive-hatched population unless it has living descendants in the population.
Founder Genome Equivalents (fge) is the number of equally represented founders that would produce the same gene diversity as that observed in the living descendant population with no loss of alleles. Equivalently, the number of animals from the source population that contains the same gene diversity as does the descendant population.
Founder Genomes Surviving is the sum of allelic retentions of the individual founders.
Founder representation (Figure A1) is the proportional contribution of each founding individual to the genetic composition of the descendant population.

Gene Diversity (GD) is the heterozygosity expected in a population if the population were in Hardy-Weinberg equilibrium. Gene diversity is calculated from allele frequencies, and is the heterozygosity expected in a progeny produced by random mating. It is important for the population as it defines in part the rate of genetic drift as well as the rate of genetic adaptation to a given selection pressure. Gene diversity can be viewed as the variation in the founder's representatives in the living descendant population. Gene diversity is lost when founder lines become over-represented relative to or at the expense of other founder lines.

Gene Value (GV) is the expected heterozygosity or gene diversity that would be expected in the next generation if all animals bred at random and produced a number of progeny for the next generation equal to their reproductive values.

Heterozygosity is a measure of the percent of loci that are polymorphic within an individual and is calculated as one minus an individual's inbreeding coefficient (F). Heterozygosity is important for the health and vitality of birds, by masking the effect of deleterious recessive alleles and maintaining hybrid vigor. Loss of heterozygosity occurs as a result of inbreeding, and reduces fertility, survivability, disease resistance, and reproduction in domestic and exotic captive populations.

Inbreeding Coefficient (F) is the probability that two alleles at a genetic locus are identical by descent from a common ancestor to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in the observed heterozygosity relative to the expected heterozygosity of a founder population.

Mean Kinship (MK) is the average relatedness of an animal to all animals in the living descendant population. Individuals with low mean kinships have genes that are on the average under-represented in the population and are therefore animals with high breeding priority. A drawback to using mean kinship is that full sibships have identical mean kinship values until they produce offspring. This means that full siblings would often be paired if only mean kinship was used to make pairings resulting in substantial loss of heterozygosity. Therefore, the inbreeding coefficient of potential offspring is evaluated secondarily when pairings are made.

Lambda (λ) is the instantaneous population growth rate. Values >1.0 represent population growth.

r is the instantaneous mortality rate

Stable age distribution is a theoretical distribution of age classes in a population with exponential growth, in which the growth rate of each age class is equal and does not change over time. Such a population is also referred to as demographically stable.

T is generation length in years.

N is current number of males and females.

N_e/N is the potential proportion of breeders to the total population size.

Customized report

Project: Alala
Report compiled under Population Management 2000, version 1.213
11:17:27 AM, 3/15/2008
Date to be used for calculations: 3/15/2008
Demographic data from: C:\sparks\Alala\mAlala.prn and C:\sparks\Alala\fAlala.prn
Genetic data from: C:\sparks\Alala\Alala.ped
Data exported on: 15 Mar 2008   from Sparks v1.53
Data compiled by: Alan Lieberman for ZSSD
Data current thru: 15 Mar 2008

Additional Genetic Information:
Founders = 9
Potential Founders = 0 additional
Living Descendants = 56.00
Percent Known = 100.0
Gene Diversity (GD) = 0.8095
Potential gene diversity = 0.9101
Gene Value (GV) = 0.8082
Founder genome equivalents (fge) = 2.62
Potential fge = 5.56
Founder Genomes Surviving = 5.56
Potential Founder Genomes Surviving = 5.56
Mean Inbreeding coefficient (F) = 0.1119

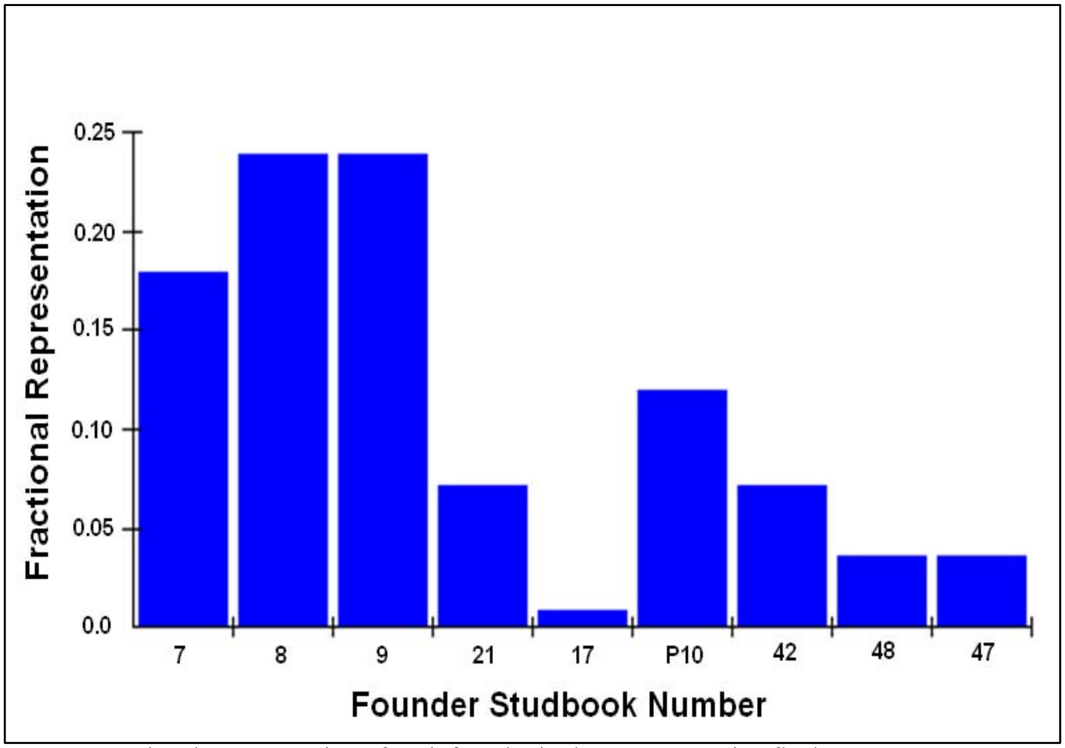

Figure A1. Fractional representation of each founder in the current captive flock.

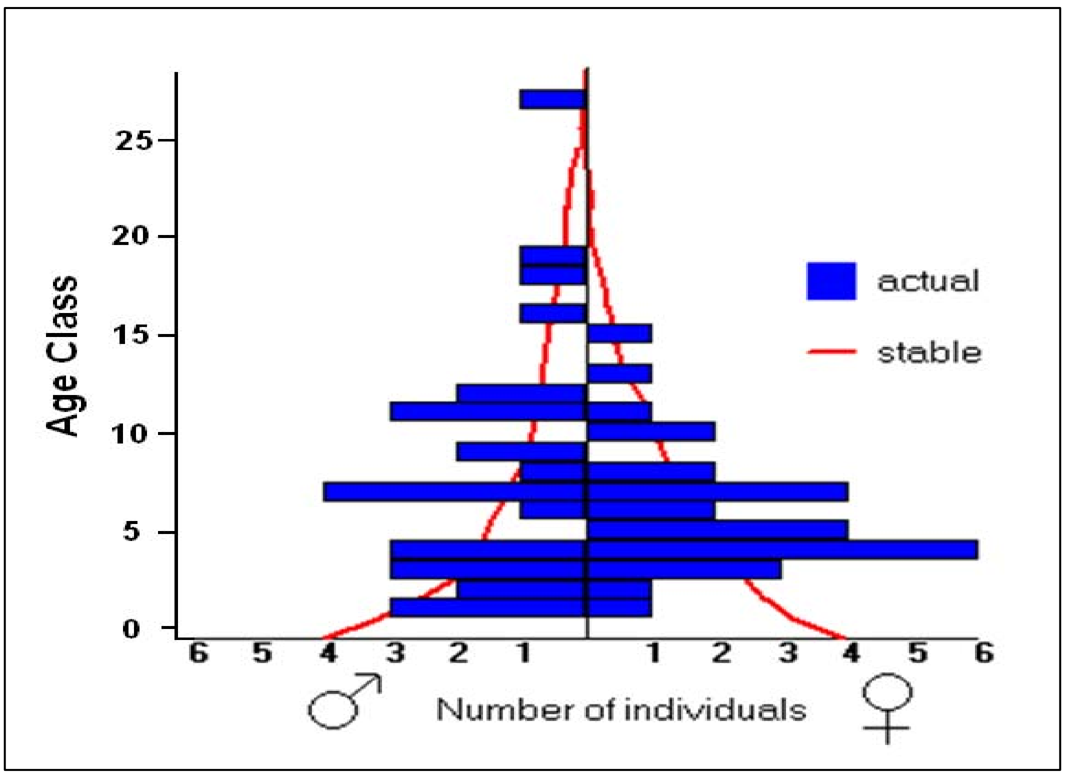

Figure A2. Age pyramid of the captive flock (males on the left, females on the right). The red line represents the stable age distribution given the sex-specific vital rates.

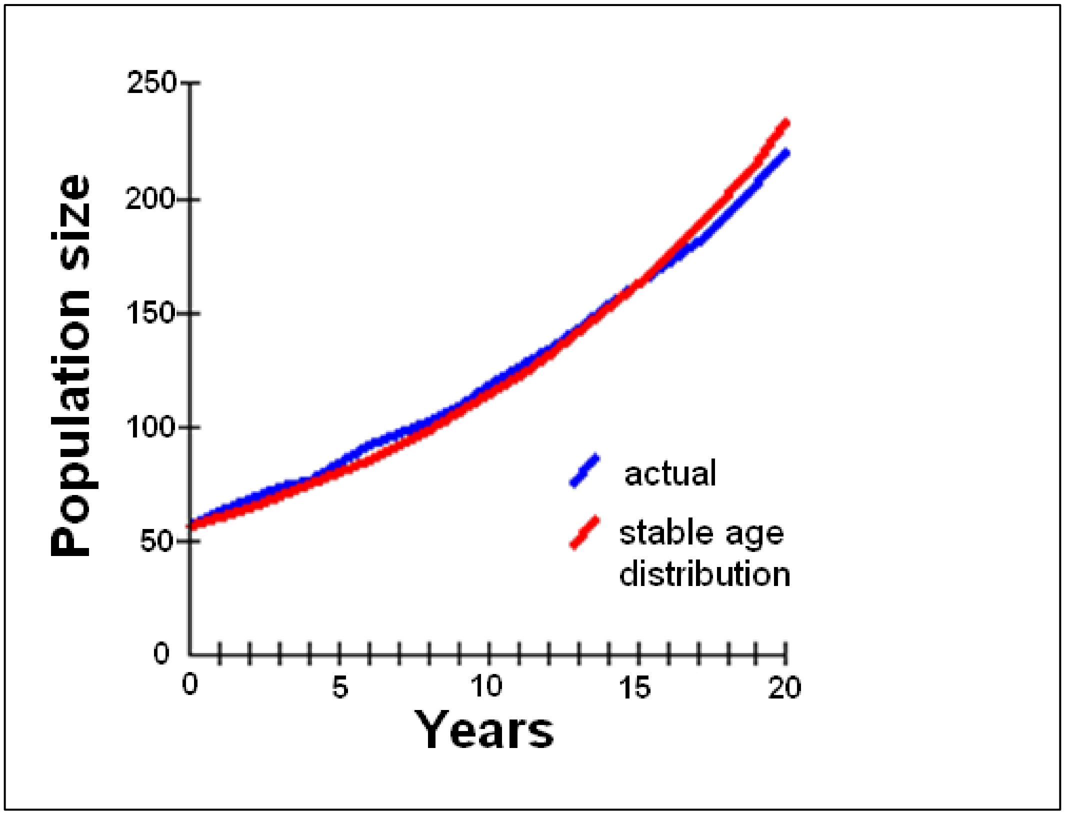

Figure A3. The expected number of `Alalā in the future (0=2008) given the model life-table and the actual age distribution. The projected numbers with a stable age structure are also shown. The difference between the actual and stable projections shows the impact of the age distribution. For example, a population with fewer breeders than if the population were stable might temporarily decrease in size as a result even though the life-table predicts a positive growth rate (lambda > 1.0).

Actual Data	**Males**	**Females**
Mortality rate (r)	0.0766	0.0766
Growth rate (λ)	1.0796	1.0677
Generation length (T)	9.18	9.18
Number of birds (N)	28	28
Projected N at 20 years	130	104

The genetic diversity within a small closed population will decline over time, but the rate of decline can be minimized by growing the population as rapidly as possible, in addition to pairing individuals for breeding based (partly) on genetic considerations. The PM2000 model provides estimates of the rate of gene diversity loss (see definition above) with a captive population capped at 75 individuals, at which point reintroduction efforts are expected to begin.

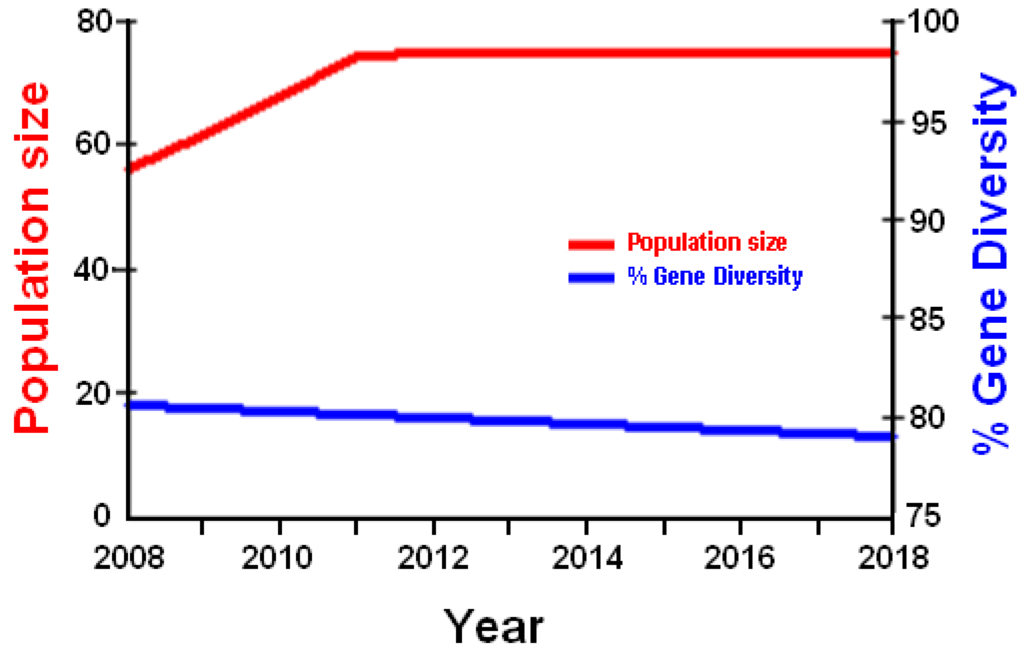

Figure A4. Decline in gene diversity over time, with a captive population that is capped at 75 individuals. Note that capping the population does not increase the rate of gene diversity loss.

Target or Managed Population Size Needed = 75
Program Objectives: 79% Gene Diversity at the end of 10 years

Generation Length = 9.2000
Maximum Potential Population Growth Rate = 1.1000
(Model uses lambda slightly higher than the current rate, but one considered achievable by flock managers.)
Current Population Size = 56.0000
Current Effective Size = 19.6000
Ratio of Ne/N = 0.3500
Current Gene Diversity = 0.8095

References:

Pollak, J. P., R. C. Lacy and J. D. Ballou. 2002. Population Management 2000, version 1.163. Chicago Zoological Society, Brookfield, IL.

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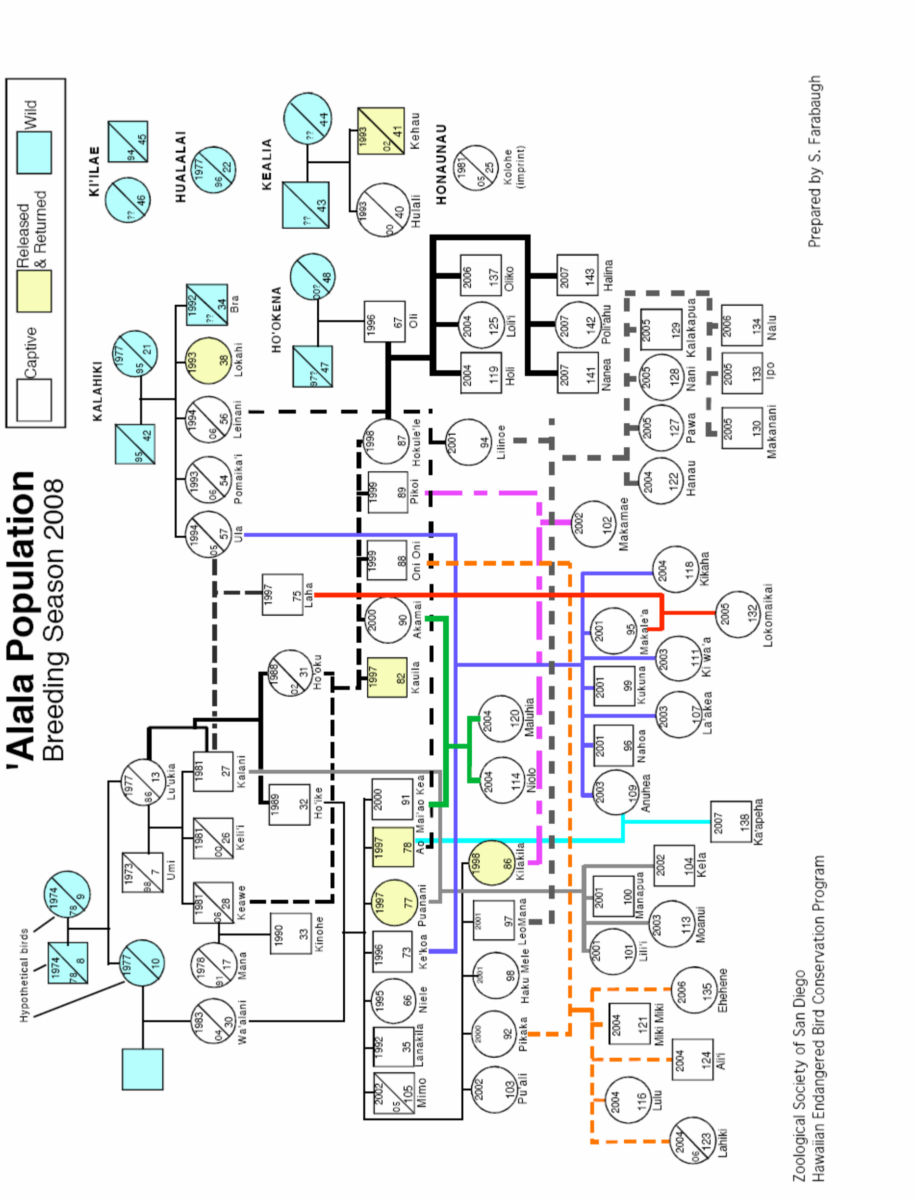
APPENDIX B

`Alalā Captive Population Pedigree

The following pedigree table is a visual diagram of pairings and offspring of birds in the captive flock as of January 2008. Most birds represented are living; however, some founders and first offspring no longer living are represented so the pedigree is complete. The numbers in the circles (females) and squares (males) are hatch year, year of death (if bar present) and studbook number. This table was produced by Susan Farabaugh, Ph.D., Center for Research and Endangered Species (CRES), Zoological Society of San Diego.



APPENDIX C

From Association of Zoos and Aquariums (AZA) 2003 Population Management Handbook: Integrating Data Analyses For Breeding Recommendations

Once the goals of the population have been set, the number of offspring needed to be produced each year to meet those goals can be determined. Once the number of offspring required per year has been determined the managers must decide which animals in the population should produce them. This leads to the managers making animal-by-animal recommendations. Each animal in the managed population should receive a recommendation. In this way there is no confusion over what is to be done with the animal. The recommendation for the majority of animals may be to simply hold the animal in the current condition without breeding. The recommendation may be to move the animal to another location within the managed population, to breed the animal, to use the animal for a specific research program, or to move the animal out of the managed population.

STRATEGY FOR PAIRING ANIMALS FOR BREEDING

For those animals that are to be bred in an effort to maintain gene diversity in the managed population, the following strategy is recommended by the AZA.

I. The first priority is to breed individuals of the lowest Mean Kinship (MK) that are under represented and, therefore, possess the rarest alleles in the population.

II. If breeding is limited due to space considerations, among individuals with low MK, the second priority is to breed those whose alleles may be lost soon. This priority setting should be determined by the manager’s knowledge of the individual’s age, health, and or reproductive condition. If the population has a long history of breeding in captivity and good demographic information, low Kinship Value (KV), can be used.

III. During Pairing, pair individuals according to the following ordered criteria:

1ST mate individuals with roughly similar MK to avoid combining rare and common alleles in offspring. Breeding animals with the same MK increases retention of gene diversity in the long-term. Long-term inbreeding is also reduced even if short-term inbreeding rises faster.

2ND mate individuals whose offspring will have low inbreeding coefficients (f), for the best probability of viable, healthy offspring. As a general rule, inbreeding coefficients below the population's mean MK should be accepted.

3RD maximize mating success based on the species' biology, including suitable age of individuals, mate choice, social structure, behavior, etc.

4TH minimize logistical difficulties of moves (*e.g.*, distance, cost, quarantine).

5TH maximize inter-institutional harmony and minimize political conflicts; hopefully this will never enter into the final decision, which should be based on the science.

Excerpted from Wiese and Willis (1996-2007).

APPENDIX D

Glossary Of Technical Terms

allele	Alternative forms of a gene that code for the same trait. Alleles usually occur in pairs, one at the same genetic locus on each of a pair of chromosomes. For example, in humans there are multiple alleles for blood type: O, A, and B. If both of the alleles are the same (*e.g.*, AA), the individual is said to be *homozygous* at that locus. If the alleles are different (*e.g.*, AB), the individual is *heterozygous*.
corvid	A bird in the family Corvidae, which includes crows, ravens, jays, magpies, and other related species
effective population size	The functional size of a population, from a genetic perspective, based on the number of breeding individuals (often abbreviated N_e). The effective population size is generally smaller than the census population size (*i.e.*, there may be numerous individuals in the total population that are not reproducing, such as juveniles or senescent adults).
endemic	Native or confined to a certain region.
genetic drift	Random changes in the frequency or proportional occurrence of a particular gene in a small population due purely to chance (*i.e.*, not due to selection). Large populations tend to be insulated from the effects of genetic drift.
heterozygosity	A measure of the degree of genetic diversity in a population, as measured by the proportion of heterozygous loci across individuals (see *allele*, above).
Hardy-Weinberg equilibrium	The stable proportions of genes in a large population with opportunities for random mating, assuming no migration, mutation, or selection.
mesic	Characterized by a moderately moist habitat.
polymorphic	Having more than one form; in regard to genes, refers to the existence of multiple alternative alleles for the same gene.
recessive	An allele that is expressed only when it occurs in homozygous state (both alleles are recessive). When a recessive allele is paired with a *dominant* allele (the heterozygous condition), the recessive trait is masked, and only the dominant trait is expressed. Deleterious recessive alleles begin to impact a population as homozyosity increases (diversity decreases) and these alleles are expressed.

ungulate	Any hoofed mammal. Typically refers to animals in the orders Perissodactyla (odd-toed animals such as horses) and Artiodactyla (even-toed animals such as cows, goats, sheep, deer, and pigs).

APPENDIX E

Summary of Agency and Public Comment on the Draft Revised Recovery Plan for the `Alalā (*Corvus hawaiiensis*)

In December 2003, the U.S. Fish and Wildlife Service (Service) released the Draft Revised Recovery Plan for the `Alalā (*Corvus hawaiiensis*) for review and comment by Federal agencies, state and local governments, and members of the public. The public comment period was announced in the Federal Register (68 FR 70527) on December 18, 2003 and closed on February 17, 2004. Over 250 copies of the draft plan were sent out for review during the comment period. In addition, the draft revised plan was distributed to the following scientific peer reviewers for comment prior to finalization and publication of this revised plan.

Dr. Ian Jamieson
University of Otago, New Zealand

Dr. John Marzluff
University of Washington

Dr. Sheila Conant
University of Hawai`i

Dr. David Duffy
University of Hawai`i

Dr. Kevin McGowan
Cornell Laboratory of Ornithology

Dr. Renee Robinette Ha
University of Washington

Twenty-one letters/comments were received. Since the time the comment period closed, a few additional comments and information or updates to the plan have been received by the Service. All comments received have been considered and are reflected in the approved recovery plan. Many comments suggested additions or changes for clarification. These suggestions are reflected in the approved recovery plan. Other comments included additional recovery actions.

Summary of Comments and Service Responses

Issue 1: Release site(s) selection

Comment: Two commenters suggested that additional information gathering is needed to be able to compare the potential release sites.
Response: A new recovery action (2.1.1) to gather additional habitat information as needed has been added to the plan.

Comment: One commenter suggested that although the need to select a release site is described in the text of the plan, the action is sufficiently important that a specific recovery action is required.
Response: A new recovery action (2.1.2) to establish selection criteria for release sites has been added to the plan.

Comment: One commenter suggested other Hawaiian islands be considered as release sites. A second commenter suggested that the island of Maui be considered a priority for the next release because there are no `Io (a known predator of `Alalā) on Maui.
Response: As stated in the plan, other Hawaiian islands including Maui are being considered as release sites (recovery actions 2.1.1, 2.1.2, and 2.1.3). Procedures are currently being developed, as described in section 3.2 of the plan, Action 2: Identify Suitable Habitat and Manage Threats, to gather data that will be used to select release sites.

Comment: One commenter felt that priority release sites should be identified in the plan.
Response: Six potential release sites on Hawai`i are identified in the 1999 Draft Environmental Assessment for population reestablishment of the `Alalā. Other sites have been added to this list (including sites on Maui). It is not possible to identify priority sites before full data on all sites is compiled and the process for weighing factors among sites has been finalized and used to rank the sites.

Comment: Two commenters emphasized the importance of selecting a release site as soon as possible and beginning habitat management immediately.
Response: As stated in the plan, selecting a release site(s) is a Priority 1 recovery action. As of June 2008 the recovery team has identified preferred release sites, but no final decision has

yet been made to implement habitat management actions.

Comment: One commenter felt the plan dismissed releasing `Alalā on Maui without due consideration.
Response: We have revised the plan to correct this misperception and to emphasize that release sites considered for selection include Maui.

Comment: One commenter was concerned that active discussions on possible release site locations have not been held since the end of the releases at the McCandless Ranch in 1999, and that release site discussions should be held in cooperation with interested parties who may want to host releases on lands where they have management oversight.
Response: We agree that active discussion and a prompt decision on release sites are a top priority and that habitat management, wherever the release site or sites will be, should begin immediately in cooperation with local stakeholders.

Issue 2: Habitat management

Comment: One commenter felt it is important to begin habitat management on Hawai`i as soon as possible to recover understory vegetation that provides cover to `Alalā and reduce the threat of predation by `Io on released `Alalā.
Response: The importance of beginning habitat management and threats reduction actions as soon as possible is emphasized in the plan, including restoration of understory vegetation necessary to provide cover for `Alalā.

Comment: Two commenters recommended that more options and ideas be considered for working with land managers (public and private) to achieve habitat management goals. Specific suggestions included that state, federal, and private landowners develop programs of cooperative agreements, easements, and modes of direct compensation to promote a system of ungulate exclosures of various sizes and locations.
Response: We have added a new recovery action to the plan (2.1.4.2) that promotes habitat conservation by use of conservation easements, cooperative agreements, and change in land use designation, lease, direct compensation, or land purchase from willing seller to secure habitat areas for dedication to habitat restoration. Recovery action 4 (Garner Public Support and Funding) also relates closely to implementation of habitat management recovery actions,

and recommends contracting with a specialist in public/private landowner relationships to design and conduct a program to garner landowner collaboration to achieve habitat management goals.

Comment: One commenter suggested that the scale at which predators are to be controlled and the number of sites where habitat management will be conducted should be made clearer and that the plan may be overly ambitious in its habitat management objectives considering financial realities and the need to replicate management actions experimentally.
Response: We have not been able to clarify the exact number of areas in which predators will need to be controlled, but we have clarified the minimum size of the individual habitat units (1,000 hectares). It is not clearly known what size area or how many habitat units are required for `Alalā to breed successfully and establish a viable wild population. The biology of the species suggests that it requires large habitat areas over a broad elevational range and, therefore, recovery will likely require predator control over a number of large areas. Although replication is an important part of experimental design, there are other effective ways to measure the effects of habitat management actions, such as monitoring response variables pre- and post-treatment and comparing treated and control (non-treatment) areas.

Comment: One commenter felt the plan stated that there is no suitable habitat for the `Alalā and it is unlikely there will be suitable habitat in the future. The commenter questioned as unsupported the perceived conclusion in the plan that habitat on Maui in its current condition is unsuitable for `Alalā. The commenter suggested including a new recovery action in the plan for an analysis of the availability of suitable habitat and that the plan provide an outline of the methods and criteria that will be used for this evaluation.
Response: We have clarified in the Recovery Strategy Overview that although it appears that habitat on the island of Hawai`i may not be suitable at this time, many recovery actions in this plan are designed to improve habitat to the point where successful releases into the wild will be possible. We also clarify that there are other limiting factors, besides habitat, which led to failure of `Alalā released into the wild from 1993 to 1999 to survive, to integrate with the wild population, and to reproduce and that these factors also will be managed. We have added a new recovery action (2.1.2) to establish site selection criteria, and as described in the 3.2 Action 2 Short-term Goal, we will use a structured decision making process to evaluate potential release sites. We have modified statements regarding Maui habitat conditions that might be interpreted to imply Maui habitat is less optimal than habitat on

Hawai`i. We agree that a careful evaluation of habitat conditions and all limiting factors for all release sites is necessary before selecting the next release site for the `Alalā.

Issue 3: Available funding will not be adequate to implement recovery actions

Comment: One commenter was concerned about possible funding shortfalls and felt that funding should be allocated to some habitat and captive management actions in preference to others.
Response: The actions described in this recovery plan constitute all actions necessary over the next five years to move the `Alalā closer to recovery. The priority numbers assigned to recovery actions reflect best current understanding regarding the relative importance of the recovery actions described.

Comment: One commenter was concerned that because of lack of funding there may be a one-sided build up of the captive flock. In the absence of concurrent habitat restoration this could result in delays in releases and inability to release captive-raised birds successfully.
Response: We also are concerned that funding may not be adequate to both grow the captive flock and prepare habitat for releases. However, we have included in the plan provisions to meet both these funding needs. The plan also promotes coordination with other species recovery and habitat management programs for potentially releasing birds in habitat areas where habitat management actions are ongoing; i.e., the plan has provisions encouraging program outreach to other recovery programs and encourages funding and conservation synergies.

Comment: One commenter felt, given limited funding available, that once the target of 75 birds in captivity is reached, funds should not be used to construct more captive aviaries.
Response: The plan calls for releases of captive `Alalā into the wild once the captive population is stabilized genetically and demographically (at approximately 75 birds). At that point, we predict that funding to build the captive flock (which includes construction of new captive aviaries) will be less and that emphasis will shift to releases of captive raised birds into the wild. Substantial funding will be needed to maintain the captive flock at the target number of 75 birds. However, this likely would not include the construction of additional aviaries for birds in captivity, except potentially special use aviaries for birds that are planned for release into the wild.

Issue 4: Input from native Hawaiian constituencies

Comment: One commenter stated that greater input from native Hawaiians and long-time local residents had been needed during recovery planning and that this input will be needed during recovery implementation and future meetings of the `Alalā Recovery Team.
Response: A Priority 2 recovery action in the plan is to bring Hawaiian cultural viewpoints into recovery planning and implementation by including one or more experts in the public portion of all `Alalā Recovery Team meetings. The Service met with Hawaiian cultural practioners in February 2003 during recovery planning to discuss the cultural significance of the `Alalā for conservation and recovery.

Issue 5: Recovery strategy

Genetics

Comment: Two commenters stated that the highest priority near-term recovery goal is securing the genetic and demographic integrity of the captive flock by increasing the number of birds in captivity. One of the commenters felt that getting more birds to breed, even at the expense of sub-optimal genetic relatedness, would be key to achieving this goal.
Response: We agree with the commenters' perspectives. The captive flock is being managed for maximum production while minimizing as much as possible pairings that may be sub-optimal genetically.

Comment: One commenter felt the plan overstated the consequences of the loss of genetic diversity.
Response: We feel the emphasis in the plan on retaining as much of the species' genetic diversity as possible is appropriate. Although the threats of disease, predation, and habitat degradation in the wild may be equally if not more significant than loss of genetic diversity when captive birds are released, the loss of genetic variability is currently the primary threat affecting the species' near-term recovery potential.

Comment: One commenter felt the plan failed to adequately quantify consequences of loss of genetic diversity. The commenter suggested that because it is not possible to know

exactly what these consequences might be, the plan risks a more significant loss to the species' recovery potential by not focusing limited funding on recovery actions such as habitat restoration, re-establishing a wild flock, advancing the release program, and testing and learning about species management and survival in the wild.
Response: We agree it is difficult to quantify precisely what the consequences may be of loss of genetic diversity. In general, these have been shown for many species to be a reduction in traits associated with fitness such as body size, fecundity, and longevity. In addition, the `Alalā may be showing signs of inbreeding depression, including what appears to be a higher than normal frequency of chicks hatched with physical abnormalities. The Association of Zoos and Aquariums recommends as a goal the retention of maximum genetic variability for species held in captivity, and therefore the captive breeding of the species should be managed intensively to minimize loss of genetic diversity. Even though funding may be limiting and we may not be able to move forward with habitat restoration immediately and to re-establish a wild flock as soon as hoped, evidence as presented in the plan strongly supports securing the genetic integrity of the captive flock as a necessary first step for recovery of the species.

Adaptive management approach

Comment: Two commenters agreed with the adaptive management approach described in the plan.
Response: We have adopted an adaptive management approach in order to evaluate results of management actions and to continue, modify, and/or change management as needed. We feel that how well management actions are working and ways to improve these often become apparent over time. The adaptive management framework provides an important element of flexibility in response to the acquisition of new information and experience gained.

Peer review

Comment: One commenter felt peer review of the recovery program is important.
Response: We agree with the commenter's perspective. The plan includes provisions for independent outside review of the recovery program at the end of each 5-year implementation time-frame.

Recovery objectives

Comment: One commenter recommended that the recovery criteria be defined more clearly to better measure progress toward achieving recovery objectives.
Response: We have restated more clearly recovery criteria into long-term (de-listing) and short-term (5-year) goals.

Comment: One commenter suggested conducting a sensitivity analysis for a demographic model to obtain values for adult survival and other factors to be used to better describe recovery objectives.
Response: Because the basic demographic parameters for the species in the wild needed for such a model are largely unknown, we believe at this time that results would be overly speculative. As more information on these parameters is obtained during releases, such as the size, extent, age structure and dynamics of established populations, we plan to conduct this type of modeling exercise.

Public support

Comment: One commenter stated the plan's efforts to improve public opinion are good and suggested that a strong public relations plan will help.
Response: Included in the plan is a recovery action to contract with an independent public outreach specialist to meet public outreach performance milestones.

Alternative recovery strategies

Comment: One commenter proposed alternative recovery strategies including establishing a wild production flock in secure habitat on Maui, establishment of a semi-captive experimental flock through releases on Maui, and developing a semi-captive, managed flock in the wild to be used to build up population numbers as an alternative to building new captive propagation facilities and that would answer questions specific to releases on Maui. Wild or semi-wild flocks would be established using `Alalā from the captive flock and the captive flock would continue to be managed for maximum production. The commenter suggested that these approaches would advance efforts for habitat restoration, refine release techniques, and provide information on survival and management of birds released in the

wild. The commenter felt that a semi-captive managed-flock on Maui may have high enough survival (in absence of `Io predation) to allow the desired rapid build up of the species population for recovery purposes.
Response: We believe the current strategy as described in the plan correctly places securing the genetic and demographic integrity of the captive flock as a first priority. At this time, although Maui does not have `Io, mortality likely would be higher for birds released into the wild than birds managed in a captive setting. As described in the plan, `Alalā should be released only if their removal from the captive population will not negatively impact the genetic and demographic stability of the captive flock or reduce the ability of the captive population to achieve growth targets needed to stabilize the captive flock and for the production of genetically surplus birds for release. However, the suggestion to release birds into the wild and to maintain them in a semi-captive state holds promise as a means to minimize mortality risk during releases and either to accelerate and/or enhance reproduction in the wild.

Comment: One commenter recommended that a number of recovery options that are technically feasible and could lead to species recovery be considered, and that a combination of recovery strategies may prove the best overall given the different biological, social, economic, and environmental factors involved. The commenter suggested that a structured decision analysis might provide the most informative approach for the overall guidance of the recovery plan.
Response: During writing of this plan we considered many recovery options and approaches. This plan represents the strategy we feel is most likely to succeed at this time. The adaptive management approach as part of the plan allows for ongoing evaluation of strategies and their results and modification of the overall recovery approach as needed.

Comment: One commenter suggested that should funding shortfalls result in reduced growth of the captive population a more optimal strategy may be to release some birds into the wild into managed habitat prior to the genetic stabilization of the captive flock.
Response: Given mortality and reproductive data from the first captive releases from 1993 to 1999, which include zero reproduction in the wild, under similar release conditions we feel likely higher mortality and lower reproduction in the wild will fail to offset possible funding related reduced growth of the captive population. Many recovery actions in the plan suggest new approaches to reduce mortality and to improve reproduction in the wild. These

approaches will need to be tested experimentally and their effectiveness evaluated. Because the effectiveness of habitat management actions and new release approaches are not clearly known, we promote as the most responsible course first securing the genetic integrity of the captive population, and releasing non-genetically essential birds into the wild.

Comment: One commenter felt the plan is proposing to keep the species in captivity for the foreseeable future.
Response: This perception is incorrect. The plan intends to secure the genetic integrity of the species in captivity within five years, after which non-genetically essential individuals will be released into the wild in suitable managed habitat. The long-term recovery goal of the plan is to recover the `Alalā by reintroducing the species into the wild. We predict that reintroductions to the wild could begin as early as 2011.

Comment: One commenter felt because reproduction in captivity is lower than for birds in the wild there is the potential to increase reproduction overall by releasing captive birds in suitable habitat.
Response: It is unknown whether reproduction of wild `Alalā is higher than that of `Alalā in captivity. It is known, however, that captive-reared `Alalā released into the wild failed to reproduce and suffered higher mortality than `Alalā in captivity. Because the effectiveness of habitat management actions and new release approaches are not clearly known, we promote a course of first securing the genetic integrity of the captive population under conditions of minimum mortality risk and known reproduction until the population is genetically and demographically secure, and then exposing non-genetically essential birds to conditions of likely higher mortality and potentially lower reproduction in the wild.

Comment: One commenter proposed changing wildlife laws to allow local people (preferably those of Hawaiian ancestry) to keep and rear `Alalā in their homes as pets.
Response: Even though the historical record suggests that `Alalā were kept by Hawaiians as pets, such an approach to recovery would not be effective. Costly infrastructure and specialized husbandry experience are required to maintain and breed `Alalā, and captive management is most effective when the number of holding sites are few. These criteria are met optimally by the current captive propagation facilities.

Comment: One commenter recommended building aviaries at a release site within the next

five years and breeding birds on site. The commenter felt that this approach would be more productive than shipping birds to the mainland if captive aviary space becomes limiting, and the approach would establish needed infrastructure at a release site.
Response: We have included this propagation strategy (recovery action 3.4.3) among others for consideration when designing future captive release. Once a release site is selected, this and other approaches will be considered using the principles outlined in the strategy section of the plan for species reintroduction. Releases should use birds that are genetically and demographically surplus to the captive flock or are post-reproductive. Birds that are valuable genetically or demographically should not be placed in a wild setting prior to the genetic and demographic stabilization of the captive flock if the mortality risk exceeds that under normal captive propagation conditions. We agree that the approach suggested, if the above conditions are met, holds considerable promise for accelerating the captive release program and possibly increasing the productivity of pairs held in a wild setting.

Comment: Two commenters recommended releasing birds on remote or small islands where most threats and limiting factors can be controlled. One of the commenters suggested searching carefully for a possible small island site where threats can be completely eliminated and that such an island then function as a breeding refugia while larger sites are prepared. The reviewer said this approach has been used successfully in New Zealand to stabilize several endangered avian species.
Response: The approach recommended would be valuable, but unfortunately there are no islands or other types of isolated refugia in Hawai`i we know of with habitat suitable for the `Alalā.

Implementation

Comment: One commenter suggested that a recovery action be included in the plan to form an implementation team or working group. This team would be responsible for coordinating the deployment of personnel to begin the analysis of habitat criteria, finalize the Draft Environmental Assessment for Population Reestablishment of the `Alalā, identify release sites, implement habitat management, and assist with release planning.
Response: We agree it is of great importance that we move forward quickly with implementation of recovery actions. We have included as a new recovery action (5.4) the formation of an interagency and landowner recovery implementation working group under

the guidance of the Service to help coordinate the implementation of recovery actions.

Comment: One commenter suggested that the Service contract out `Alalā recovery, with the Service and the Recovery Implementation Working Group serving a primarily monitoring function.
Response: We agree that a paid contractor responsible for implementing recovery for the `Alalā will likely be able to implement recovery actions most effectively. We have added a new recovery action (5.5) to the plan to hire or appoint a single individual whose sole responsibility will be to coordinate implementation of recovery actions for the `Alalā.

Issue 6: Species genetics

Comment: One commenter recommended that more information be provided on the species' genetics. A second commenter stated that although many aspects of the genetics are either not fully understood or are in process of research, the genetics sections in the plan could be reorganized and improved to include discussion of research concerning the potential genetic bottleneck the species experienced during the 20th century and its implications and clarification of the genetic targets for captive propagation.
Response: The genetics sections of the plan have been revised to include the topics described and improve the discussion of genetic targets for captive propagation.

Comment: One commenter complimented efforts to complete molecular genetic analysis of the captive flock and suggested that the Whooping Crane (*Grus americana*) recovery program be considered as an example of ways to manage a captive population in somewhat similar genetic and demographic circumstances. The commenter also provided a list of contacts in New Zealand for advice on how New Zealand endangered species programs have established funding partnerships, conducted community-based management of private lands, conducted predator control and predator avoidance training, and compared puppet versus parental rearing.
Response: We appreciate the suggestions and will as the recovery program proceeds continue to make contacts to learn as much as possible about management approaches used by other endangered species programs.

Issue 7: Captive releases

Comment: Two commenters suggested that priority numbers should be lowered from 2 to 3 for actions related to pre-release behavioral conditioning because they felt that threats reduction using habitat management and releasing parent-reared birds will be the most effective means to maximize post-release survival.
Response: Habitat management actions generally received similar priority rankings to behavioral conditioning. We feel the Priority 2 designations for behavioral conditioning are appropriate because possibly taught behaviors and behaviors learned through parent rearing together will enable `Alalā best to avoid threats, improving the survival of captive-released birds as much as possible.

Comment: One commenter suggested that a successful release strategy will likely include the release of mixed age groups of `Alalā that have formed a large group dynamic. The commenter thought the lack of a functional flock social structure was likely responsible for the failure of the captive releases from 1993 to 1999.
Response: This comment provides insight into possible reasons why the mortality rate of captive-released birds was high and the released birds failed to breed, possibly due to the absence of large social groups of `Alalā that could either mob predators or warn the flock of a predator's presence, and from which breeding pairs could form. We have included this release strategy (recovery action 3.4.3) among others in the plan for consideration for future captive releases.

Comment: One commenter recommended socializing birds in large flocks prior to release. One commenter suggested building aviaries at a release site and holding one or two pairs at the site with young able to come and go from a section of the aviary.
Response: We have included these socialization and release strategies in the plan (recovery action 3.4.3) for consideration for future captive releases.

Comment: One commenter recommended considering placing birds on another island (perhaps post-reproductive or non-breeding birds) that could test the environment and that might possibly breed in a wild setting and/or serve an educational function.
Response: Because the immediate goal is to stabilize the captive flock genetically and demographically, this approach might be considered for birds that are genetically and

demographically surplus to the captive flock.

Comment: One commenter felt that research completed on corvid rearing and release methods was not adequately discussed in the recovery program review.
Response: We agree that we inadvertently omitted mention of surrogate research conducted to assist in developing captive rearing and release methods for the `Alalā. The plan now states that there needs to be a review of completed surrogate research on corvid species for testing reintroduction outcomes for different rearing and release approaches, and that the study of corvid social systems as these relate to reintroduction outcomes is highly important for planning future captive releases.

Comment: One commenter suggested beginning behavioral training immediately in order to improve post-release survival. The commenter felt the plan over-emphasized the need for research in this area because there are already ample research reports and experience from other programs to draw upon.
Response: We have revised recovery actions for behavioral training to include an evaluation of existing research and other program results for designing a behavioral training program. However, until genetic goals are met, implementation of behavioral training will need to be balanced against potential effects on achieving production targets and risks (if any) of the training.

Comment: One commenter suggested exploring the possibility of immunizing `Alalā for toxoplasmosis.
Response: At this time there is no known vaccine for toxoplasmosis in birds or humans. To create such a vaccine (it is not known if this will be possible) would require substantial funding, several years of research and development, testing for safety and efficacy both in the laboratory and under field conditions, and follow-up monitoring to determine longevity of protection. It appears at this time that the most direct and effective approach to reduce the threat posed by toxoplasmosis is to remove all feral cats from habitat areas into which `Alalā will be introduced. This approach not only removes the disease reservoir but also a significant predator on `Alalā and as such accomplishes two important threat reduction actions at the same time.

Comment: One commenter suggested that an important avenue of learning for the `Alalā is

juvenile and mixed-age cohorts and that further research into the social systems of the `Alalā or behaviorally similar corvid species will assist in planning future releases. The commenter suggested that `Alalā pairs in the wild likely formed from aggregations of mixed aged birds without established territories, and that releases in the future likely should be of individuals of differing ages. The commenter thought that much information was originally learned by young `Alalā not from parents, but from membership in a non-breeding flock.
Response: We have added recovery action 3.3.2 to the plan to promote mutual learning opportunities of mixed-age cohorts in captivity and the study of the social system of the `Alalā and similar corvid species (recovery action 3.4.2) to better understand the social system of the `Alalā as this relates to potential efficacy of different reintroduction approaches.

Comment: One commenter thought it was important that individual birds be able to pass along cultural knowledge and suggested enhancing opportunities for learning wild behaviors in captivity.
Response: A new recovery action (3.3.3) has been added to the plan to enhance opportunities for learning wild behaviors by allowing juveniles contact with birds released into the wild and that were subsequently returned to captivity, playing tapes of wild vocalizations, and other means.

Comment: One commenter suggested that the plan discuss why the `Io apparently shifted its prey base to `Alalā during the captive releases from 1993 to 1999.
Response: It is not possible to address this question adequately because information is lacking for `Io predation on wild `Alalā. It is conjectural that `Io did not prey on `Alalā in the past. However, the comment does suggest that we will want to examine closely the mortality factors that contributed to the death and disappearance of captive-released `Alalā from 1993 to 1999. Recovery action 3.4.1 examines the history of the captive-release from 1993 to 1999 with emphasis on known mortality factors and changes in rearing and release methodologies and threats reduction to reduce post-release mortality for future releases.

Issue 8: Captive propagation

Comment: Two commenters suggested that the priority number for establishing a small population consulting group should be lowered from 2 to 3 because needed expertise is currently available to address most if not all questions regarding captive propagation and other captive population management needs. One of the commenters felt that information and reports provided by the captive flock managers to the Service on the status of the captive flock are adequate for most potential needs.
Response: The species currently faces problems of low egg fertility and hatchability, low chick survival, possible high rates of congenital defects, and a low proportion of pairs that breed successfully. It appears all avenues are currently being explored to remedy these concerns and that the small founder population and difficulties breeding `Alalā in captivity preclude complete resolution to some of these problems. Nonetheless, we feel the priority number is correct because of the importance of actively seeking additional assistance and expertise to address ongoing problems with the captive flock. The reports mentioned are useful in general terms for tracking the progress of the captive flock but lack the detail to address some problems. Recovery action 1.1.1.4 has been rewritten so that the flock manager assumes primary responsibility for reviewing captive flock status and new information and suggesting new studies and protocols, but that the Service may request this be done in consultation with other experts.

Comment: One commenter suggested that a fuller range of measures be used to encourage the breeding of birds that lack offspring representation and to increase the number of breeders. The same commenter thought that inbreeding avoidance may make `Alalā try to breed outside natal groups and suggested maintaining single-sex groups that would be introduced for pairing after the natal period.
Response: We have added recovery actions (1.1.1.5.1, 1.1.1.5.2, and 1.1.1.5.3) to the plan for developing and implementing approaches to increase the number of captive breeders including giving ineffective or inept breeders hormone implants to improve breeding and parental care, allowing greater opportunities for mate selection through non-breeder group socialization opportunities, and greater structuring of captive socialization to maintain several single-sex groups that can be introduced after the natal period so that inbreeding avoidance behavior is minimized between birds that are not genetically related.

Comment: One commenter cautioned not to remove non-breeders from the captive flock before innovative methods to encourage breeding have been tried and shown to be ineffective.
Response: We have added new recovery actions (1.1.1.5.1, 1.1.1.5.2, and 1.1.1.5.3) to the plan to address the need to fully explore all means to encourage breeding of individuals that have not bred or are under-represented in the captive flock.

Comment: One commenter cautioned that before vaccinating `Alalā for West Nile virus, potential side effects should be known (particularly possible effects on reproduction).
Response: We have added a cautionary statement to recovery action 1.1.1.3 for potential vaccination of captive `Alalā for West Nile virus that potential side effects of West Nile virus immunization should be known before immunization (particularly possible effects on reproduction).

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January 2009