REVISED RECOVERY OUTLINE (Version: May 30, 2001)
O`ahu `elepaio from Hawai`i

Species Name:

Common: O`ahu `elepaio Scientific: *Chasiempis sandwichensis ibidis*

Date Listed: May 18, 2000

Population Trend: Decreasing

Recovery Priority Number: 3

Lead Region/Field Office: 1/Honolulu

Land Ownership Pattern:

- **Federal:** Major parcels include U.S. Naval Magazine Pearl Harbor Lualualei Branch, U.S. Army Schofield Barracks, U.S. Army Mākua Military Reservation, U.S. Army Kawailoa Training Area, and U.S. Fish and Wildlife Service O`ahu Forest National Wildlife Refuge.

- **State of Hawai`i:** Major land parcels include Honolulu Watershed Forest Reserve (FR), Waimānalo FR, `Ewa FR, Waiāhole FR, Kaipapa`u FR, Nānākuli FR, Wai`anae Kai FR, Mokulē`ia FR, Mākua-Kea`au FR, Kuaokalā FR, Pūpūkea-Paumalū FR, Pahole Natural Area Reserve (NAR), Ka`ala NAR, Kahana Valley State Park, and Keaīwa Heaiau State Recreation Area.

- **City and County of Honolulu:** Major land parcels include upper Mākaha Valley and portions of Mānoa, Pālolo, and Wailupe valleys.

- **Private:** Major land owners include Kamehameha Schools (north Hālawa Valley, Kapakahi Gulch, Wai`alae Nui Ridge and Gulch), James Campbell Estate (Honouliuli Preserve), Samuel Damon Estate (Moanalua Valley), Waiāhole Irrigation and SMF Enterprises (Waianu and Waikāne Valleys), Queen's Medical Center (Tripler Ridge and south Hālawa Valley), Bishop Museum (Kalauao Valley), James Pflueger (upper Pia Valley), Benjamin Cassiday (lower Pia Valley), Hawai`i Humane Society (Kūpaua Valley), and Joseph Paiko Trust (western Kuli`ou`ou Valley).

Scope of the Recovery Effort: Species/Multispecies. The revised Hawaiian Forest Bird Recovery Plan will include 19 listed species, 1 candidate species, and 1 species of concern, but the `elepaio is the only species on O`ahu for which recovery efforts beyond continued surveying are planned. The recovery goals, criteria, and actions specified in this revised recovery outline reflect the Hawaiian Forest Bird Recovery Team's discussions through May 4, 2001.

Listing Factors/Current Threats:

- **Small Population Size** - The current population of O`ahu `elepaio is small, approximately 1,982 birds distributed in six core subpopulations and several smaller subpopulations (Table 1, Figure 1; VanderWerf *et al*. 2001). The only previous population estimate (200-500 birds; Ellis *et al*. 1992) was not accurate because little information was available when the estimate was made. The number of birds is divided about evenly between the Wai`anae Mountains in the west and the Ko`olau Mountains in the east, with three core subpopulations in each mountain range. At least seven tiny remnant subpopulations consisting entirely of males remain in both the Wai`anae and Ko`olau mountains (Table 1), but because there is no chance of reproduction and rescue by immigration is unlikely, these relicts probably will disappear in a few years as the last adults die.

  The breeding population, about 1,774 birds, is less than the total population because of a male-biased sex ratio; only 84% of territorial males have mates in large populations (n = 147, E. VanderWerf unpubl. data), and many small, declining populations contain mostly males (Table 1). The genetically effective population size is probably even smaller than the breeding population because of the geographically fragmented distribution (Grant and Grant 1992). Natal dispersal distances in `elepaio are usually less than one kilometer (0.62 miles) and adults have high site fidelity (VanderWerf 1998), but most `elepaio populations on O`ahu are separated by many kilometers of unsuitable urban or agricultural land. There may be some exchange among subpopulations within each mountain range, but dispersal across the extensive pineapple fields that separate the Wai`anae and Ko`olau mountains is unlikely, and most subpopulations probably are isloated. The current distribution superficially appears to constitute a metapopulation (Hanski and Gilpin 1997), but this would be true only if dispersal occurred among subpopulations. There have been no observations of banded `elepaio moving among subpopulations. The genetic population structure is unknown.

- **Decline in Range** - Despite its adaptability and tolerance of disturbance, the O`ahu `elepaio has declined seriously and has disappeared from many areas where it was formerly common (Shallenberger 1977, Shallenberger and Vaughn 1978, Williams 1987, VanderWerf *et al*. 1997, VanderWerf *et al*. 2001). Before humans arrived, forest covered about 127,000 hectares (ha) on O`ahu (Figure 2; Hawai`i Heritage Program 1991), and it is likely that `elepaio once inhabited much of that area. `Elepaio are generalized in habitat selection and are able to forage and nest in a variety of plant species (Conant 1977, VanderWerf 1993, 1994, 1998). Reports by early naturalists indicate that the O`ahu `elepaio once had a "universal distribution" (Perkins 1903), occurred "from the sea to well up into the higher elevations" (Bryan 1905), and was "abundant in all parts of its range" (MacCaughey 1919).

  The aggregate geographic area occupied by all current subpopulations is approximately 5,657 ha (13,792 ac; Table 1). The O`ahu `elepaio thus currently occupies only about 4% of its original prehistoric range, and its range has declined by roughly 96% since humans arrived in Hawai`i 1,600 years ago (Kirch 1982). In 1975, `elepaio inhabited approximately 20,900 ha on O`ahu, almost four times the area of the current range (Figure 2, VanderWerf *et*

al. 2001). The range of the O`ahu `elepaio has thus declined by roughly 75% in the last 25 years.

- **Reasons for Decline and Current Threats** - Much of the historical decline of the O`ahu `elepaio can be attributed to habitat loss, especially at low elevations. Fifty-six percent of the original prehistoric range has been developed for urban or agricultural use, and practically no `elepaio remain in developed areas (VanderWerf *et al*. 2001).

  However, many areas of O`ahu that recently supported `elepaio and still contain apparently suitable forest habitat are currently unoccupied, demonstrating that habitat loss is not the only threat. More recent declines in O`ahu `elepaio populations are due to a combination of low adult survival and low reproductive success. Both annual adult survival and reproductive success are lower on O`ahu (0.76, 0.33, respectively) than in a large, stable `elepaio population at Hakalau Forest National Wildlife Refuge on Hawai`i Island (0.85, 0.62; VanderWerf 1998). The main cause of reduced adult survival on O`ahu appears to be diseases that are carried by the introduced southern house mosquito (*Culex quinquefasciatus*). Annual survival of birds with active avian pox (*Poxvirus avium*) lesions (60%) was lower than annual survival of healthy birds (80%; E. VanderWerf unpubl. data). Avian malaria (*Plasmodium relictum*) is a serious threat to many Hawaiian forest birds (Warner 1968, van Riper *et al*. 1986, Atkinson *et al*. 1995), but its effect on `elepaio has not been investigated.

  The primary reason for low reproductive success is nest predation by the introduced black rat (*Rattus rattus*). An experiment in which automatic cameras were wired to artificial `elepaio nests containing quail eggs showed that a black rat was the predator in all 10 predation events documented (VanderWerf 2001). Control of rats with snap traps and diphacinone (an anticoagulent rodenticide) bait stations was effective at improving `elepaio reproductive success, resulting in a 76% increase in nest success and a 112% increase in fledglings per pair compared to control areas (VanderWerf 1999). Reproductive success of `elepaio is also affected by disease. Pairs in which at least one bird had pox lesions produced fewer fledglings than healthy pairs or those in which at least one bird had recovered from pox (E. VanderWerf, unpubl. data). Many birds with active pox infections did not even attempt to nest, and infected birds were sometimes deserted by their mate.

Recovery Goals:

The recovery goals listed below were developed by the Hawaiian Forest Bird Recovery Team for use in the draft revised Hawaiian Forest Bird Recovery Plan. Similar recovery goals are being used for all species covered by the Recovery Plan.

- 1) Restore populations of O`ahu `elepaio to levels that allow persistence despite demographic and environmental stochasticity and that permit natural ecological and evolutionary processes to occur.
- 2) Protect enough habitat to support these populations.
- 3) Identify and remove threats responsible for the decline of the O`ahu `elepaio.

Recovery Criteria:
The recovery criteria listed below were developed by the Hawaiian Forest Bird Recovery Team for use in the upcoming draft revised Hawaiian Forest Bird Recovery Plan. Criterion 1 was adapted to each species based on its particular life history and recovery needs; criteria 2 and 3 are the same for all species covered by the plan.

The O`ahu `elepaio can be downlisted from endangered to threatened when all 3 of the following have been achieved:

- 1) The six existing core subpopulations in Waikāne/Kahana, southern Ko`olau, central Ko`olau, Honouliuli/Lualualei, Schofield Barracks West Range, and Mākaha/Wai`anae Kai/Mākua, which represent the ecological, morphological, behavioral, and genetic diversity of the species, are viable (as defined in criterion 2 below); or these subpopulations function as viable metapopulations on both the windward and leeward sides of the Ko`olau and Wai`anae Mountains;
- 2) Either a) quantitative surveys show that the number of individuals in each population or metapopulation has been stable or increasing for 15 consecutive years, or b) demographic monitoring shows each population or metapopulation has an average intrinsic growth rate (lambda) not less than 1.0 for at least 15 consecutive years; and total population size is not expected to decline by more than 20% within the next 15 consecutive years for any reason; and
- 3) Sufficient recovery habitat is protected and managed to achieve criteria 1 and 2 above, and the major threats that were responsible for the decline of the O`ahu `elepaio have been identified and controlled.

The O`ahu `elepaio can be delisted (removed from the endangered species list) when:

- Criterion 2 above has been achieved for at least 30 consecutive years; and
- Criteria 1 and 3 above are still true.

`Elepaio from different areas of O`ahu vary in appearance and behavior, and there also may be genetic variation. Birds from the wet windward (eastern) side of each mountain range are darker and more red in color than birds from the drier leeward side, and vocalizations are noticeably different in the Wai`anae and Ko`olau Mountains (E. VanderWerf, unpubl. data). The six core subpopulations listed in criterion 1 above are distributed throughout the island, and their recovery would preserve birds representing the known variation in the species. It is unlikely that each existing core subpopulation will be viable on its own, and a metapopulation composed of several subpopulations may be necessary in each portion of the island to preserve the species' variation.

Setting a criterion of demographic persistence highlights the need for monitoring, and helps ensure that threats have been adequately managed and that population increases are not transient. A lambda value of 1.0 indicates no change in population size, a value greater than 1.0 indicates population growth. If populations are stable or increasing in the long-term despite periodic episodes of increased disease and predation, then the species can be considered recovered.

Research to date indicates that survival and reproduction of `elepaio fluctuate from year to year, probably due to variation in disease prevalence and predator (rodent) populations (VanderWerf 1999, unpubl. data). Epizootics of disease and irruptions in rodent populations appear to occur approximately once every five years (VanderWerf 1999), possibly in association with rainfall patterns, so the time frames for demographic recovery criteria likely coincide with either three (15 years for downlisting) or six (30 years for delisting) `elepaio population cycles.

Anticipated Recovery Actions

- **Appoint Recovery Team** - The Pacific Islands Fish and Wildlife Office has already assembled a Hawaiian Forest Bird Recovery Team that provides guidance on most listed forest birds in the State of Hawai`i, including the O`ahu `elepaio.

- **Prepare Recovery Plan** - The Hawaiian Forest Bird Recovery Team is in the process of revising the recovery plan for 21 Hawaiian forest bird species, including the O`ahu `elepaio. The O`ahu `elepaio was not included in the previous version of the recovery plan because it was not listed at that time; it is being added to the revised recovery plan. The Pacific Islands Fish and Wildlife Office plans to submit the revised recovery plan to the Regional Office by September 30, 2001.

- **Acquire Habitat** - The new O`ahu Forest National Wildlife Refuge protects 1,831 ha (4,525 ac) in the central Ko`olau Mountains that provides suitable forest habitat for `elepaio (USFWS 2000b). `Elepaio are not currently found on the refuge, but the area has high potential for recovery of `elepaio through reintroduction and predator control.

- **Recovery Habitat** - Draft recovery habitat for the O`ahu `elepaio has been identified for the revised Hawaiian Forest Bird Recovery Plan (Figure 2). Recovery habitat is defined as those areas that will allow for the long-term survival and recovery of the species.

  `Elepaio are adaptable and able to forage and nest in a variety of forest types composed of both native and introduced species (Conant 1977, VanderWerf 1993, 1994, 1998). Nest site selection by `elepaio is non-specialized; nests have been found in seven native and 13 introduced plant species (E. VanderWerf, unpubl. data). Shallenberger and Vaughn (1978) found the highest relative abundance of `elepaio in forest dominated by introduced guava (*Psidium* sp.) and kukui (*Aleurites moluccana*) trees, but they were also found in the following forest types (in order of decreasing abundance): mixed native-exotic; tall exotic; koa (*Acacia koa*) dominant; mixed koa-`ōhi`a (*Metrosideros polymorpha*); low exotic; `ōhi`a dominant; and `ōhi`a scrub. VanderWerf *et al*. (1997) found that (1) forest structure was more important to `elepaio than plant species composition, (2) most `elepaio occurred in areas with a continuous forest canopy and a dense understory, and (3) population density was roughly twice as high in tall riparian vegetation in valleys than in scrubby vegetation on ridges. Suitable habitat for recovery of O`ahu `elepaio thus includes wet, mesic, and dry forest consisting of native and/or introduced plant species, but higher population density can be expected in closed canopy riparian forest.

The area currently occupied by the O`ahu `elepaio represents only about four percent of the species' original range, and the distribution has contracted into numerous small fragments (Figure 2). The remaining `elepaio subpopulations are small and isolated, comprising six core subpopulations that contain between 100 and 500 birds, and numerous small remnant subpopulations, most of which contain fewer than 10 birds (Table 1). Even if the threats responsible for the decline of the `elepaio were controlled, the existing subpopulations would be unlikely to persist because their small sizes make them vulnerable to extinction due to a variety of natural processes, including: reduced reproductive vigor caused by inbreeding depression; loss of genetic variability and evolutionary potential over time due to random genetic drift; stochastic fluctuations in population size and sex ratio; and catastrophes such as hurricanes (Lande 1988, IUCN 2000).

`Elepaio are highly territorial; each pair defends an area of a certain size, depending on the forest type and structure, resulting in a maximum population density or carrying capacity (VanderWerf 1998). Although `elepaio have declined and the range has contracted, density in the remaining core subpopulations is high, and much of the currently occupied land is at or near carrying capacity (VanderWerf *et al*. 1997, in press). Consequently, the currently occupied areas are too small to support `elepaio populations large enough to be considered safe from extinction. Complete recovery will require restoration of `elepaio in areas where they do not occur at present, through translocation, captive propagation and release, or natural dispersal. The draft recovery habitat therefore includes areas that currently are not occupied by `elepaio, but that still contain suitable forest.

`Elepaio are also relatively sedentary; adults have high fidelity to their territory and juveniles rarely disperse more than one km (0.62 mi) in search of a territory (VanderWerf 1998). Because the areas currently occupied by `elepaio are separated by many kilometers (Figure 1) and `elepaio are unlikely to disperse long distances, the existing subpopulations probably are isolated (VanderWerf *et al*. in press). The O`ahu `elepaio evolved in an environment with large areas of continuous forest habitat covering much of the island (Figure 2), and their dispersal behavior is not adapted to a fragmented landscape. In the past, subpopulations were less isolated and dispersal and genetic exchange among subpopulations probably were more frequent. Maintaining or restoring links among subpopulations by providing habitat for dispersal would increase the overall effective population size through meta-population interactions, thereby helping to alleviate the threats associated with small population size. In particular, enlargement of small subpopulations by expansion onto adjacent lands not only would increase the chances of their long-term survival, but also would improve connectivity among subpopulations by enhancing their value as "stepping stones" within the distribution of the entire population.

Based on the information provided above, the Hawaiian Forest Bird Recovery Team has drafted recovery habitat using the following criteria:

(1) All areas that are currently occupied by the O`ahu `elepaio, excluding one very small, isolated area at Hau`ula that contains only a single male (Figure 1; subpopulation Q).

(2) Addition of currently unoccupied lands needed for recovery of a viable population. Lands were considered to have greater recovery value and were given preference if they (a) provided more preferred forest types, (b) were more recently occupied, or (c) were contiguous and formed large blocks of suitable habitat and helped link existing subpopulations.

(3) Boundaries of draft recovery habitat units were determined by the extent of suitable forest, which in many areas coincided with the boundaries of State Forest Reserves, Natural Area Reserves, and other conservation lands. Urban and agricultural lands generally were not included because they did not contain suitable forest, but lower Wailupe Valley, which is zoned for urban use but has not been developed yet, was included because it contains suitable forest and is currently occupied by `elepaio.

The potential `elepaio population in the draft recovery habitat (10,104 birds) was estimated by multiplying the area of each recovery habitat unit by the current density of `elepaio in each part of the island (Table 2). These estimates are approximate, and the actual population in each unit may be larger if density can be increased beyond current levels, or lower if it proves difficult to establish dense populations in some currently unoccupied areas.

- **Rodent Control** - Rodent control has been an effective method of improving reproductive success of `elepaio in several areas (VanderWerf 1999, in press), and control programs should be continued and expanded. Ground-based methods of rodent control using snap traps and diphacinone bait stations have been effective on a small scale, but are labor intensive. Large-scale rodent control probably will be necessary for recovery of `elepaio, and this can be achieved more efficiently through aerial broadcast methods. Registration of aerial broadcast of diphacinone for rodent control with the U.S. Environmental Protection Agency should be actively pursued and supported.

- **Fencing and Feral Ungulate Control** - The actions of feral pigs and other ungulates may not be an important direct threat to the O`ahu `elepaio, but due to concerns about secondary poisoning and the threat to hunters it is possible that aerial broadcast of rodenticide may be feasible only in fenced areas that are considered free of feral pigs. Fencing and pig eradication are therefore an important part of the recovery strategy for `elepaio.

- **Research on Disease Resistance** - No areas of O`ahu are of sufficient elevation to be free from disease-carrying mosquitoes (Warner 1968), and all O`ahu `elepaio populations appear to be affected by disease (E. VanderWerf, unpubl data). Reducing mosquito numbers by removing breeding sites or treating them with larvicides would be extremely difficult due to the abundance of breeding sites (C. Atkinson and D. LaPointe, pers. commun.). The best method of reducing the threat from disease may be to investigate disease resistance and its genetic basis to identify birds for use in captive propagation and release.

- **Captive Propagation** - Captive propagation and/or rear and release of O`ahu `elepaio may become necessary if reproduction in the wild is insufficient to allow recovery, and would be

especially valuable if genetically disease-resistant birds can be identified for use as breeding stock. Any attempts at captive propagation should use eggs taken from birds known to have recovered from pox or identified as resistant. If rat-free or disease-free refugia can be created by habitat management, translocation of wild birds or release of captive birds could be an effective means of re-establishing or augmenting populations in those areas.

- **Population Surveys and Monitoring -** To determine whether the overall recovery strategy is effective and whether the recovery criteria have been met it will be necessary to conduct range-wide population surveys and/or monitor demography. Standard survey routes should be established to determine distribution and measure population density. Surveys should be conducted at least once every five years to address whether the recovery criteria have been met, and annually if possible to more closely monitor population trends and fluctuations. Demographic monitoring will require mist-netting, banding, and resighting of birds to measure survival rate, nest searching and monitoring to measure reproductive success, and data analysis. Measurement of demographic parameters should follow methods used in VanderWerf (1999). Depending on what data is available, calculation of lambda values should follow Pulliam (1988), Pease and Grzybowski (1995), Caswell (1989), or another peer-reviewed method appropriate for measuring avian demography.

- **Consult and Work with Federal and State Agencies and Private Interests -** Rodent control using snap traps and diphacinone bait stations has been conducted by the Hawai`i State Division of Forestry and Wildlife in the Honolulu Watershed Forest Reserve since 1997, by the U.S. Army Environmental Division at Schofield Barracks West Range and Mākua Military Reservation since 1998, and by The Nature Conservancy of Hawai`i at Honouliuli Preserve since 2000. These groups are committed to continuing their rodent control programs in the future, and the Service is working with Kamehameha Schools to begin rodent control in North Hālawa Valley and Kapakahi Gulch.

  Researchers at the University of Hawai`i are using blood samples collected during previous demographic research to investigate genetic population structure of O`ahu `elepaio, and hope to identify genetic markers associated with disease resistance (VanderWerf 1999).

  The Zoological Society of San Diego has begun captive breeding of the Hawai`i `elepaio (*C. s. sandwichensis*) as a surrogate to develop techniques for a possible captive propagation or rear and release program for the O`ahu `elepaio.

Table 1. Estimated size and area of O`ahu `elepaio subpopulations. Data from VanderWerf *et al*. (2001). Letters in front of each population correspond to those on Figure 1.

Subpopulation	Total population size	Breeding population size	Area (ha)
Wai`anae Mountains A. southern Wai`anae (Honouliuli Preserve, Lualualei Naval Magazine)	458	418	1,170
B. Schofield Barracks West Range	340	310	532
C. Mākaha, Wai`anae Kai Valleys	123	112	459
D. Pahole, Kahanahāiki	18	4	256
E. Schofield Barracks South Range	6	0	20
F. Mākua Valley	7	2	49
G. Ka`ala Natural Area Reserve	3	0	21
H. Makaleha Gulch	2	0	7
I. Kuaokalā	3	2	14
J. Kaluakauila Gulch	1	0	6
Ko`olau Mountains K. southern Ko`olau (Pia, Wailupe, Kapakahi, Kuli`ou`ou, Wai`alae Nui)	475	432	1,063
L. Waikāne, Kahana Valleys	265	242	523
M. central Ko`olau (Moanalua, north and south Hālawa, `Aiea, Kalauao)	226	206	1,396
N. Pālolo Valley	46	42	78
O. Waihe`e Valley	5	4	32
P. Mānoa	2	0	19
Q. Hau`ula	1	0	4
R. Waianu Valley	1	0	8
TOTAL	1,982	1,774	5,657

Table 2. Area of recovery habitat units and potential `elepaio populations. Unit 4 is not currently occupied by `elepaio; the density used to estimate the potential `elepaio population of this unit is an average of the densities in the two nearest units, central and southern Ko`olau.

Recovery habitat unit	Area	`elepaio density in currently occupied parts of unit	Potential `elepaio population in unit
1. Northern Wai`anae Mountains	4,501 ha 11,122 ac	0.45 per ha 0.18 per ac	2,025
2. Southern Wai`anae Mountains	2,515 ha 6,215 ac	0.39 per ha 0.16 per ac	981
3. Central Ko`olau Mountains	14,840 ha 36,669 ac	0.33 per ha 0.14 per ac	4,897
4. Kalihi-Kapālama	800 ha 1,977 ac	0.39 per ha 0.16 per ac	312
5. Southern Ko`olau Mountains	4,197 ha 10,371 ac	0.45 per ha 0.18 per ac	1,889
All Units	26,853 ha 66,354 ac	0.38 per ha 0.15 per ac	10,104

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Signature of Regional Director, U.S. Fish and Wildlife Service

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Date

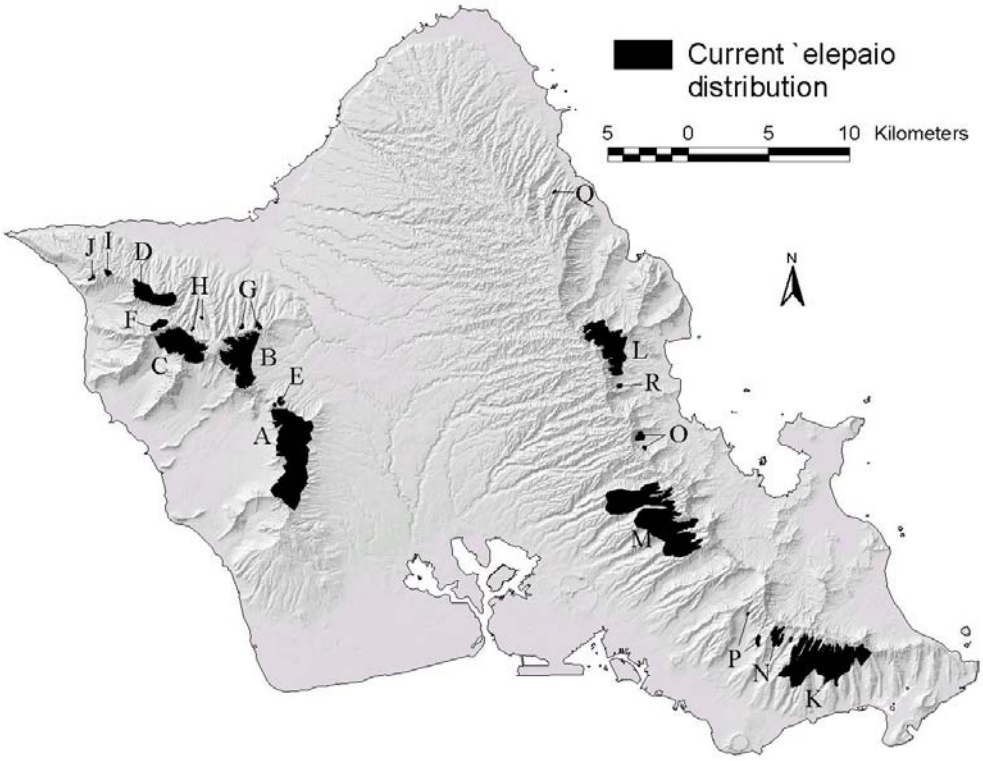

Figure 1. Current distribution of the O`ahu `Elepaio. Subpopulations are identified by letters corresponding to those in Table 1.

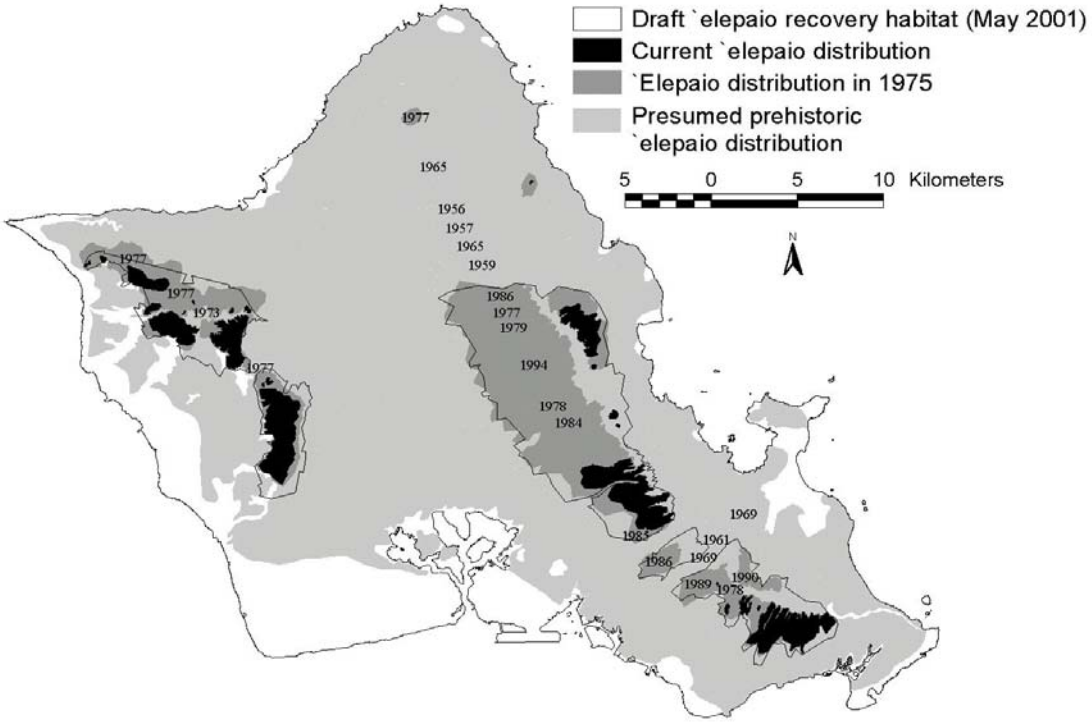

Figure 2. Current, recent historical (1975), and presumed prehistoric distributions of the O`ahu `elepaio. Years indicate when `elepaio were last observed in that area.