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U.S. FISH AND WILDLIFE SERVICE
Pacific Islands Office, Ecological Services

SURVEYS OF FOREST BIRD POPULATIONS FOUND IN THE VICINITY OF PROPOSED GEOTHERMAL PROJECT SUBZONES IN THE DISTRICT OF PUNA, HAWAI'I

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INTRODUCTION

The endemic land birds of Hawai'i, particularly the Hawaiian honeycreepers, an endemic subfamily of the cardueline finches, provide one of the world's most dramatic examples of adaptive radiation and speciation in island ecosystems (Freed et al. 1987, Scott et al. 1988). From what is believed to have been a single successful colonization of the Hawaiian archipelago by an ancestral species from North America, the honeycreepers evolved into a diverse array of species and subspecies of birds with bills ranging from thick, seed-eating beaks of the Palila (*Loxioides bailleui*), small insectivorous bills as seen on the 'Amakihi (*Hemignathus virens*), woodpecker-like adaptations of the 'Akiapola'au (*Hemignathus munroi*), and large, decurved nectar-feeding bills of the 'I'iwi (*Vestiaria coccinea*). In addition to the honeycreepers, the historically documented endemic Hawaiian avifauna included other perching birds with a species of crow, and representatives of honeyeaters, thrushes, and Old World flycatchers; three seabirds; several waterfowl and two raptors, In all, 71 endemic species and subspecies of Hawaiian birds were known to exist at the time of Captain Cook's discovery of the Hawaiian Islands in 1778 (Berger 1981, Scott et al. 1986).

The arrival of humans to the Hawaiian Islands--starting with the Polynesians over 1,500 years ago and continuing following European contact--drastically changed many natural ecosystems, leading not only to the extinction of many plant and animal species, but also to a significant reduction in both range and abundance for many other taxa. Originally, the Hawaiian birds were found in all habitat zones on each island, including high-elevation communities on the large mountains on Hawai'i and Maui, the wet and moist forest zones on the windward and leeward sides of each island, and down to the lowland and coastal communities that provided additional wetland habitat for waterbirds and shorebirds (Berger 1981). Today, few native forest birds can be found below 610 m (2,000 ft) elevation, and many of the wetland areas that used to provide abundant habitat for waterbirds have been destroyed.

Of the historically documented 71 taxa of endemic Hawaiian birds, 23 are now extinct, and 31 of the remaining 48 species and subspecies are listed as Endangered or Threatened by the U.S. Fish and Wildlife Service (1992), many with few or only single populations remaining. Thus, 76% of the Hawaiian birds are either extinct or endangered, and several of the remaining unlisted species are showing significant population declines. Studies of recently discovered fossil bird bones have further identified nearly 40 additional species of Hawaiian birds never seen alive by the post-Cook naturalists; these became extinct after the Polynesians arrived (Olsen and James 1982; H. James, Smithsonian Institution, personal communication).

Many different factors have been suggested to explain the decline of Hawaiian bird species since human colonization (Ralph and van Riper 1985; Scott, et al. 1988). The most important and plausible of these include habitat loss (Berger 1981; Kirch 1982; Olsen and James 1982; Jacobi and Scott 1985), susceptibility to introduced avian diseases

(Warner 1968; Ralph and van Riper 1985; van Riper et al. 1986), predation by introduced mammals (Atkinson 1977; Snetsinger *et al.* 1994), and competition from introduced birds (Mountainspring and Scott 1985) and arthropods (Perkins 1903; Banko and Banko 1976). Although no one of these factors is believed to be the single cause for the loss or decline of the Hawaiian birds, many biologists believe that habitat loss and avian diseases have had the greatest effect on the native birds.

In 1993, the U.S. Fish and Wildlife Service (USFWS) entered an interagency agreement with the Department of Energy (DOE) to conduct biological surveys pertinent to identifying potential impacts of the proposed Hawai'i Geothermal Project (HGP) on the natural resources of the east rift zone of Kilauea volcano. This report presents data on the distribution and status of forest bird species found within the vicinity of proposed geothermal resource development on the Island of Hawai'i (Figure 1). Additionally, we address potential impacts of the proposed development on the native bird populations found in the project area. Other reports prepared separately under this contract address the seabird (Reynolds *et al.* 1994a) and Hawaiian hawk (Reynolds *et al.* 1994b) populations found within the study area.

The U.S. Department of Energy published a notice in the Federal Register on May 17, 1994 (Fed. Regis. 59:25638) withdrawing its Notice of Intent to prepare the HGP EIS. Because the State of Hawai'i is no longer pursuing or planning to pursue the HGP, DOE considers the project to be terminated. In light of these changes, this final project report has been prepared to make available and archive the background scientific data and related information on forest bird populations collected during the preparation of the environmental impact statement (EIS) for Phases 3 and 4 of the Hawai'i Geothermal Project.

PROJECT OBJECTIVES

The native and introduced forest birds along sections of the Kilauea east rift zone within the Puna district of the island of Hawai'i were first sampled in 1979 as part of the U.S. Fish and Wildlife Service's state-wide Hawai'i Forest Bird Survey (HFBS) (Jacobi 1985; Scott *et al.* 1986). For the current project, a series of new studies were proposed to evaluate the current status of the native forest bird populations within the Puna district on the island of Hawai'i, and to provide additional baseline information to be used in evaluating potential impacts of the proposed geothermal development along the Kilauea east rift zone (Figure 1).

Survey efforts were originally designed to address the following objectives.

1. Determine the current distribution, abundance, and status of forest bird populations within and adjacent to the proposed geothermal development areas.

2. Evaluate changes in bird populations within the upper Middle East Rift subzone since the original Hawai'i Forest Birds Survey in 1979.

3. Assess distribution and abundance of forest bird populations relative to distance from roads within native forest habitat in the upper Middle East Rift subzone.

Due to restricted land access in the Middle East Rift subzone, particularly for the lands controlled by True/Mid-Pacific and Campbell Estate, objective 3 was abandoned. Additionally, limited access to many sections of the Kama'ili and Kapoho subzones, and limited access into the Middle East Rift subzone reduced the opportunity to conduct some of the detailed forest bird surveys in support of objectives 1 and 2 as planned. However, the results presented in this report provide new data and interpretations of previous data pertinent to evaluating some of the potential impacts of proposed geothermal resource development within the Puna district.

METHODS

Field surveys for this project were conducted during August 1993 - February 1994. Several types of survey techniques were used to sample areas of varying accessibility.

1. The Area Search (AS) method is a timed walking survey in a limited area generally only accessible by foot, or where transect sampling was unfeasible (Ambrose 1989). This method allows the observer to compile a list of birds found within a sample area. AS surveys were conducted for periods of twenty minutes per selected survey site (Figure 2).

2. Extensive point surveys (EPS) were conducted using roads as transects with point stops every 3.2 km (2 miles) (Figure 3). Intensive point surveys (IPS) were conducted in several fragmented habitats (Figure 2). Survey points were placed at closer intervals than for the EPS sampling (0,8 km; 0.5 miles), so that all avian species detectable would be identified despite vegetation changes along the route. Data collected by these methods were summarized by number of birds per sample hour.

3. Variable circular plot (VCP) counts, following the methodology described by Scott *et al.* (1986), were conducted on 117 stations located on four transects established within the Kahauale'a Natural Area Reserve, just above the upper boundary of the Middle East Rift geothermal subzone (Figure 4). Two of these transects (37 and 38) included stations sampled during the 1979 Hawai'i Forest Bird Survey. The other two transects were established between the original transects to increase sample size in this area during the 1993 survey.

The AS, EPS, and IPS methods were used in areas that were either too small or too fragmented to allow for enough similar samples necessary for quantitative sampling by

habitat. Data from these surveys were simply used to prepare species lists for the area in general, and to provide a rough index of abundance (number of individuals per count hour) for each species found throughout the study area.

Survey time was eight minutes at each point stop (or station) for all surveys except the AS sampling. The EPS and IPS point surveys were conducted with a trained observer standing at a fixed point, recording all birds heard or seen at distances designated as greater than, or less than, 30 meters. This sampling method is similar to that used by the USFWS for the North American Breeding Bird Surveys (Bystrak 1981). Routes were designed to encompass all the habitats of the Puna district accessible by road. Points were moved off primary roads to minimize traffic noise. All surveys were conducted between 0700 and 1100 hours.

Data recorded for each EPS and IPS survey included: survey start and end time, elevation, location, vegetation association, species, number of birds, distance from observer to bird greater than or less than 30 m, weather conditions, and detection type for each bird.

The VCP counts represented the most quantitative bird surveys conducted during this project. These counts were conducted only in areas of continuous native forest within the Kahauale'a Natural Area Reserve (NAR), just above the Middle East Rift subzone. For these counts a trained observer records the distance to each individual bird detected either visually or audially during an eight minute count period. Counts are conducted only during the first four hours after sunrise on days that have relatively clear and calm weather conditions. The data resulting from the VCP surveys are analyzed to determine a density for each bird species at each station sampled (Scott *et al.* 1986). Pooled data from these counts yields mean density values for each species which can be compared with the results from similar counts conducted during the Hawai'i Forest Bird Survey in 1979. Additionally, results of each survey are compared based on mean number of birds per count period and frequency of stations occupied for each species.

RESULTS

Species distributions within the two lower subzones

The combined daytime bird surveys conducted throughout the Kapoho and Kama'ili subzones yielded a total of 27 different species of birds (Table 1; Figure 5). Six of the birds listed are endemic species, two of which (Newell's shearwater and Hawaiian hawk) are listed as Threatened and Endangered respectively by the U.S. Fish and Wildlife Service (1992). Three of the remaining species are seasonal migrants and sixteen other species are introduced. Species that appear to be new to the lower Puna area since the 1979 forest bird survey include the Saffron finch, Kalij pheasant, and unidentified parrot species.

The most common species throughout the lower two subzones was the introduced Japanese white-eye, followed closely by the introduced House finch (Table 2). All of the endemic forest bird species in these lower two subzones were found in areas dominated by native vegetation, primarily an 'ohi'a (*Metrosideros polymorpha*) forest with a mixture of native tree, shrub, and fern species.

Detailed population surveys in the vicinity Middle East Rift subzone

Detailed surveys of bird populations conducted within the Kahauale'a NAR in June-July 1979 and December 1993 recorded a total of 14 species of birds, only six of which were recorded in both counts (Table 3). Although these counts were conducted at different times of the year, the sampling periods were both during the non-breeding season, either after the end of breeding (June 1979) or just prior to the start of breeding (December 1993). Based upon previous surveys of bird populations in this habitat and elevational range in other sections of the island of Hawai'i, the June and December counts were considered to be sampling comparable segments of the bird community.

The endangered 'O'u (*Psittitostra psittacea*) and the endemic 'I'iwi (*Vestiaria coccinea*), both rare during the 1979 counts, were not located anywhere in the study area during the 1993 survey. Two other species, the endemic 'Amakihi and the introduced House finch, were also not recorded during the 1993 VCP counts, but were commonly found in other parts of the study area. Three of the four species found along the transects only during the 1993 survey (Hawaiian Hawk, Red-billed Leiothrix, and Spotted dove) were similarly located elsewhere during the 1979 surveys (Scott *et al.* 1986). However, the Kalij pheasant is a species that has moved into the Puna forests only since the mid-1980's (Scott *et al.* 1986).

Four species of birds common to both the 1979 and 1993 VCP counts had sample sizes large enough for comparison between the years. Two of these species, 'Apapane and 'Oma'o showed similar or only slightly reduced status in frequency (Figure 6), birds per count period (Figure 7), and population density (Figure 8). The 'Elepaio population was considerably reduced in the 1993 count with more than a 50% reduction in both frequency and birds per count period, and nearly 50% decrease in density. The Japanese white-eye showed an increasing trend in each of the parameters, with a particularly significant increase in density and birds per count period for this introduced species (Figure 8).

DISCUSSION

Native bird populations

The Hawaiian Hawk was the only endangered forest bird found within the study area during the current field survey. 'O'u were located in the northwestern corner of the James Campbell Estate lands in the former Wao Kele O Puna reserve and in what is now

the state's Kahauale'a Natural Area Reserve during the 1979 forest bird survey, and another 'O'u was located in a small kipuka just within the Hawai'i Volcanoes National Park boundary that same year (Jacobi 1985; Scott *et al.* 1986). It is possible that the extremely rare 'O'u may still be found in some of the remaining native forest habitats within the study area that were not surveyed during the current project, particularly on the lands controlled by James Campbell Estate in the Middle East Rift subzone.

A single 'Alala (Hawaiian crow, *Corvus hawaiinesis*) was sighted over a several month period during 1976 in the Waha'ula section of Hawai'i Volcanoes National Park (P. Banko, National Biological Survey, personal communication). However, it was concluded that this was a wandering bird that was far away from its' normal range on the Kona side of the island of Hawai'i. It is not expected that this extremely endangered species of Hawaiian bird is resident in the Puna area. However, this record emphasizes the need to have further detailed surveys conducted throughout the study area.

With the exception of the Hawaiian Hawk, the four native forest bird species that were located during this survey were found exclusively in tracts of native-dominated forest vegetation. Although these species were found in some of the small native tracts sampled in or adjacent to the two lower geothermal subzones, they were at lower densities than found in the large tract of forest above the Middle East Rift subzone in the Kahauale'a NAR. Lack of access into the James Campbell Estate lands precluded surveys in this middle section of relatively continuous native forest that would also be expected to have populations of the four native bird species.

The absence or reduced populations of native birds in the lower sections of the study area may be attributable to small and fragmented habitat units with limited food and nesting resources, increased pressure from introduced predators coming in from the adjacent disturbed habitats, and competition from introduced birds. There may not be a significant difference in the prevalence of avian malaria throughout the study area as all habitats sampled, including the forests above the Middle East Rift subzone, are well within the distribution of *Culex* mosquitoes that are principal vector of this avian disease.

The detections of two of the native forest bird species, 'Apapane and 'Amakihi down to approximately 200 m elevation, and the 'Oma'o at 400 m (Figure 5) represent some of the lowest elevational distribution records for these species on the island of Hawai'i in recent years. The forest fragments these birds are found in remain scattered throughout the lower two subzones in pit craters, cinder cones, and in some sections of the Nanawale Forest Reserve. Maintenance of these native bird populations can only be accomplished by protecting and managing the remaining pieces of native forest habitat that remain in this lower section of the project area.

Introduced bird populations

Next to habitat loss and fragmentation, introduced species of plants and animals represent the greatest threat to the remaining populations of Hawaiian species of plants and animals. Of particular concern are predator populations, specifically rats (*Rattus* spp.), feral cats (*Felis catus*), and mongooses (*Herpestes auropunctatus*), that directly impact the native bird species in an area, as well as introduced birds that compete with the native forest birds for available resources, and may serve as introduction points or reservoirs for avian diseases.

Several species of birds appear to have become established within the project area since the 1979 forest bird surveys were conducted. These species include the Kalij pheasant, Saffron finch, and possibly several species of unidentified parrots or parakeets that were detected during the current surveys. The Japanese white-eye, first introduced to the O'ahu in 1929 and to the island of Hawai'i in 1937, is now found in all habitats on all of the major Hawaiian islands, and is believed to be a significant competitor with many of the native forest birds (Mountainspring and Scott 1985).

MANAGEMENT OF POTENTIAL IMPACTS OF THE PROPOSED GEOTHERMAL DEVELOPMENT ON NATIVE FOREST BIRD POPULATIONS

Geothermal resource development may affect the native forest bird populations found within the project area in several ways. These include habitat loss or degradation resulting from road construction and site clearing, increasing overall predator population populations within the forest bird habitat, creating more access routes for introduced predators to travel through forest bird habitat, increasing access routes for more potentially competitive introduced bird species into the native bird habitat, and enhancing conditions for avian disease within this habitat.

The results of the field studies conducted during this project provide information pertinent to determining the current status of native and introduced forest bird populations within portions of the study area and an evaluation of some of the potential impacts of the proposed geothermal development program within the three subzones. However, a more complete evaluation of the research objectives cannot be obtained without further field work on the study components that were eliminated from this project due to denied access into significant portions of the proposed development area.

The following recommendations are presented as possible steps to minimize the impacts of the proposed geothermal development on native forest bird populations within the Puna subzones.

1. Complete forest bird surveys as originally planned. Due to limited land access, many portions of the study area were not surveyed during this project. As a result, the new data presented in this report do not display a complete picture of the current

distribution or abundance of forest bird populations that may be affected by the proposed geothermal development. Specifically needed are complete survey coverage of all remaining areas of native vegetation within the project area to determine if the endangered 'O'u is still found within the project area. Additionally needed are the detailed studies evaluating possible density change in native bird populations away from disturbance areas within the Middle East Rift subzone on James Campbell Estate land (Objective 3). Any assessments of geothermal development in the areas that were not surveyed would be limited without the additional studies being completed.

2. Do not allow further loss or fragmentation of the remaining areas of native forest habitat. Habitat loss and fragmentation appears to be two of the major factors influencing the abundance of native forest birds in this lowland habitat. The remaining patches of native forest within the project area need to be maintained and managed to the benefit of the native species residing within them. Besides reducing the amount of available habitat and resources for the bird populations, fragmentation increases access routes for introduced predators into a forest, either at the interface between native and disturbed habitat or along roads cut into the habitat units (Ebenhard 1988).

3. Conduct regular predator control along project access routes. Reducing predator populations throughout the project area, particularly along access routes, may provide more suitable conditions for the native forest birds found in these areas (Ebenhard 1988). Control programs should be aimed at significantly reducing populations of feral cats and mongooses along roads and within other cleared areas using adequate control means (e.g., trapping and/or toxicants)

4. Do not allow garbage dump sites in or adjacent to the project area. Dump sites attract and support large populations of predators (cats, rats, mongoose) that will impact native forest bird populations up to 2 km (1.2 miles) away from the area.

5. Eliminate water impoundments that may serve as breeding sites for mosquitoes. Introduced mosquitoes are the major vector for two of the most virulent introduced bird diseases, avian malaria and avian pox. Elimination or reduction of breeding sites for these insects may decrease the threat of malaria and pox in these areas. At a minimum, geothermal development in this area should not result in any increase in breeding sites for mosquitoes. If water impoundments are a necessary element of the development, they must be managed appropriately with chemical or biological control agents to make them unsuitable for mosquito breeding sites.

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Table 1. Bird species detected during surveys in the Puna district between August 1993 and February 1994.

Common name	Scientific name	Status[a]
A'o (Newell's shearwater)	*Puffinus puffinus newelli*	N,T
'Apapane	*Himatione sanguinea*	N
Barn owl	*Tyto alba*	X
Common myna	*Acridotheres tristis*	X
'Amakihi	*Loxops virens virens*	N
Domestic chicken	*Gallus domesticus*	X
'Elepaio	*Chasiempsis sandwichensis*	N
Green pheasant[b]	*Phasianus colchicus*	X
House finch	*Carpodacus mexicanus*	X
'Io (Hawaiian hawk)	*Buteo solitarius*	N,E
Japanese white-eye	*Zosterops japonicus*	X
Kalij pheasant	*Lophura leucomelana*	X
Kolea, Pacific golden plover	*Pluvialis dominica*	M
Melodius laughing-thrush	*Garrulax canorus*	X
Northern cardinal	*Cardinalis cardinalis*	X
Nutmeg mannikin	*Lonchura punctulata*	X
'Omao, Hawaii thrush	*Myadestes obscurus*	N
Red-billed leiothrix	*Leiothrix lutea*	X
Saffron finch[b]	*Sicalis flaveola*	X
Spotted dove	*Streptopelia chinensis*	X
Teal species	*Anas* sp.	M
Ulili, Wandering tattler	*Heteroscelus incanus*	M
Unkown parrot species	Family: Psittacidae	X
Zebra dove	*Geopelia striata*	X

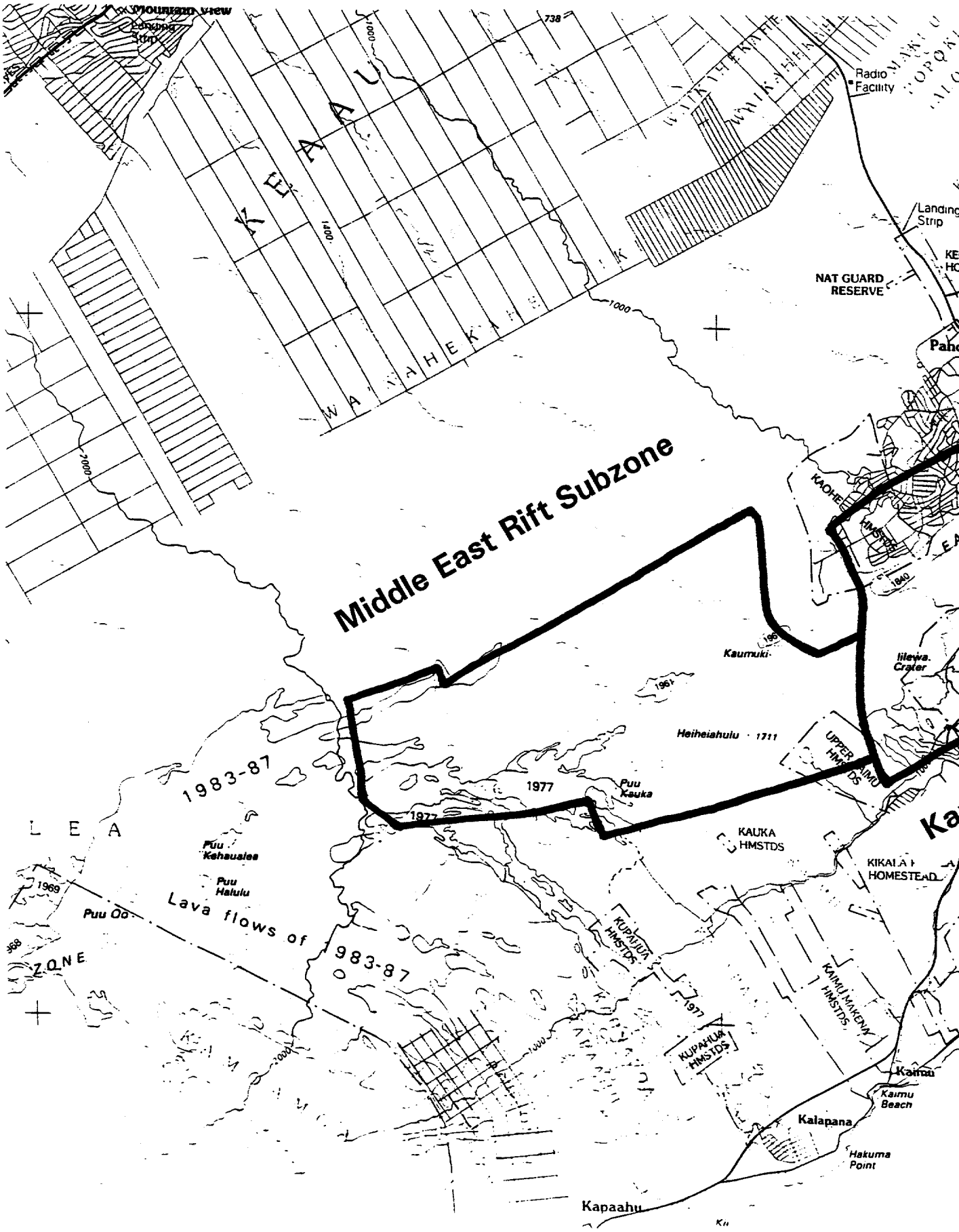
[a] E = listed as Endangered; M = migrant species; N = native endemic species; T = listed as Threatened; X = introduced species.

Table 2. Species detected during point count surveys in habitats located within the two lower subzones in the Puna study areas.

Species	Number of birds detected	Detection rate (birds/hour)
'Amakihi	89	8.9
'Apapane	78	7.8
Common myna	139	13.9
Domestic goose	1	0.1
Domestic rooster	24	2.4
Golden plover	9	0.9
Hawaiian hawk	6	0.6
House finch	252	25.2
Japanese white-eye	286	28.6
Melodious laughing-thrush	19	1.9
Northern cardinal	145	14.5
Nutmeg mannikin	163	16.3
Parrot sp.	3	0.3
Red-billed leiothrix	5	0.5
Spotted dove	63	6.3
Unknown	1	.01
Zebra dove	21	2.1

Table 3. Summary of VCP bird counts in the Middle East Rift geothermal subzone. Values coded with "NA" had sample sizes too small for computation of sample statistic.

	Density (birds/km2)		Standard deviation around density		Mean birds/count period		Frequency of stations occupied	
	1979	1993	1979	1993	1979	1993	1979	1993
Number of stations sampled	113	117	113	117	113	117	113	117
Native species								
ʻAmakihi	2	0	1	0	0.06	0	2	0
ʻApapane	847	706	154	119	8.12	4.98	100	94
ʻElepaio	64	37	13	11	0.65	0.21	43	17
Hawaiian hawk	NA	NA	NA	NA	0.21	0.02	0	2
ʻIʻiwi	1	0	1	0	0.03	0	3	0
ʻOmaʻo	134	148	18	21	2.82	2.31	96	91
ʻOʻu	NA	0	NA	0	0.01	0	1	0
Introduced species								
House finch	NA	0	NA	0	0.01	0	1	0
Japanese white-eye	528	769	75	95	2.33	3.19	91	99
Kalij pheasant	0	NA	0	NA	0	0.02	0	2
Melodious laughing-thrush	5	1	1	0	0.28	0.15	20	13
Northern cardinal	4	1	1	1	0.15	0.03	13	3
Red-billed Leiothrix	0	1	0	1	0	0.04	0	4
Spotted dove	0	NA	0	0	0	0	0	1


Middle East Rift Subzone
Mountain View Landing Strip
Radio Facility
Landing Strip
NAT GUARD RESERVE
KAOHE
KIMSTDS
1840
Kaumuki
1961
Heiheiahulu 1711
Puu Kauka
1977
1983-87
Puu Kahaualea
Puu Halulu
1969
Puu Oo
Lava flows of 1983-87
ZONE
KAUKA HMSTDS
KIKALA HOMESTEAD
KUPAHUA HMSTDS
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738
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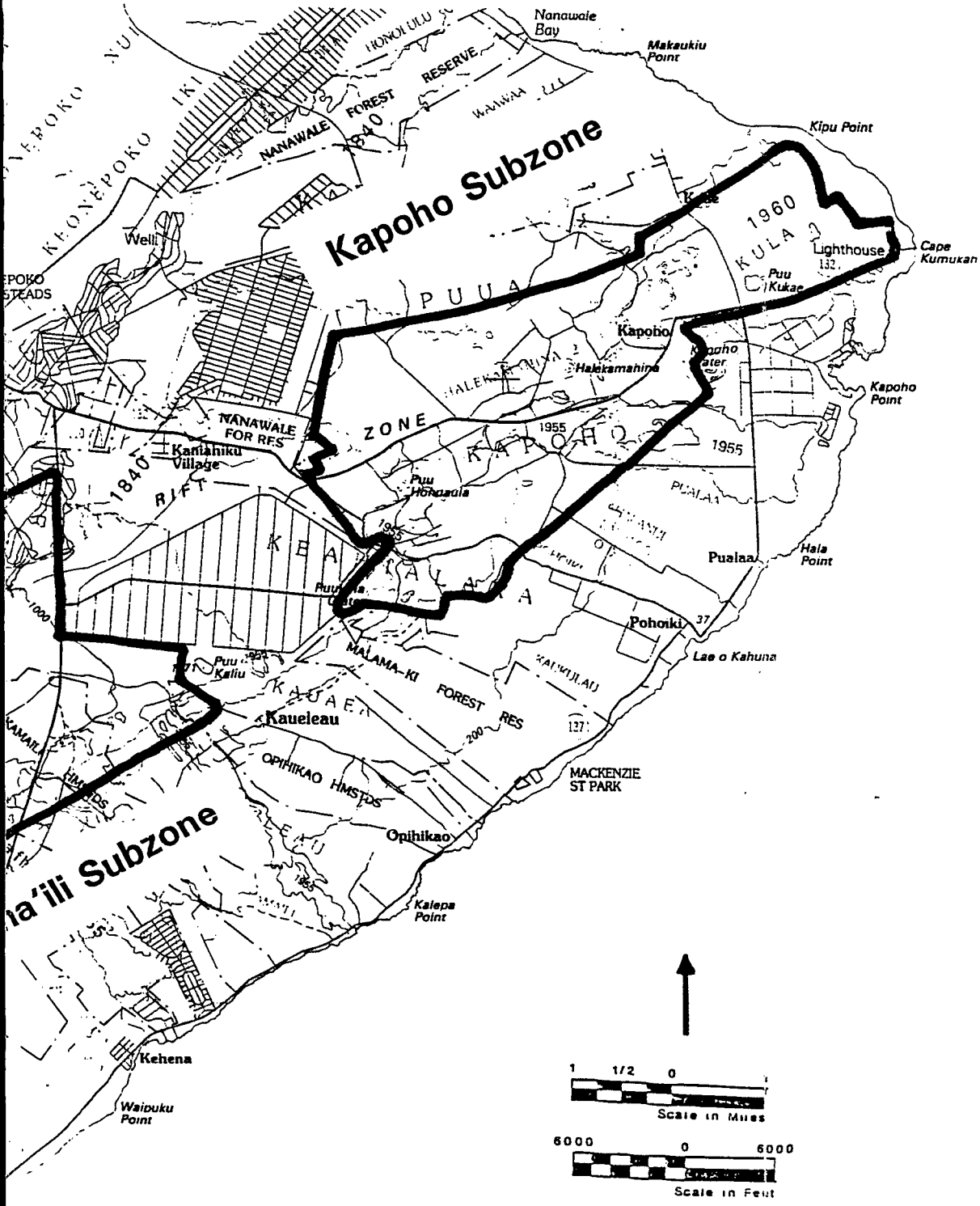

Figure 1. Map of the project study area showing the three geothermal subzones

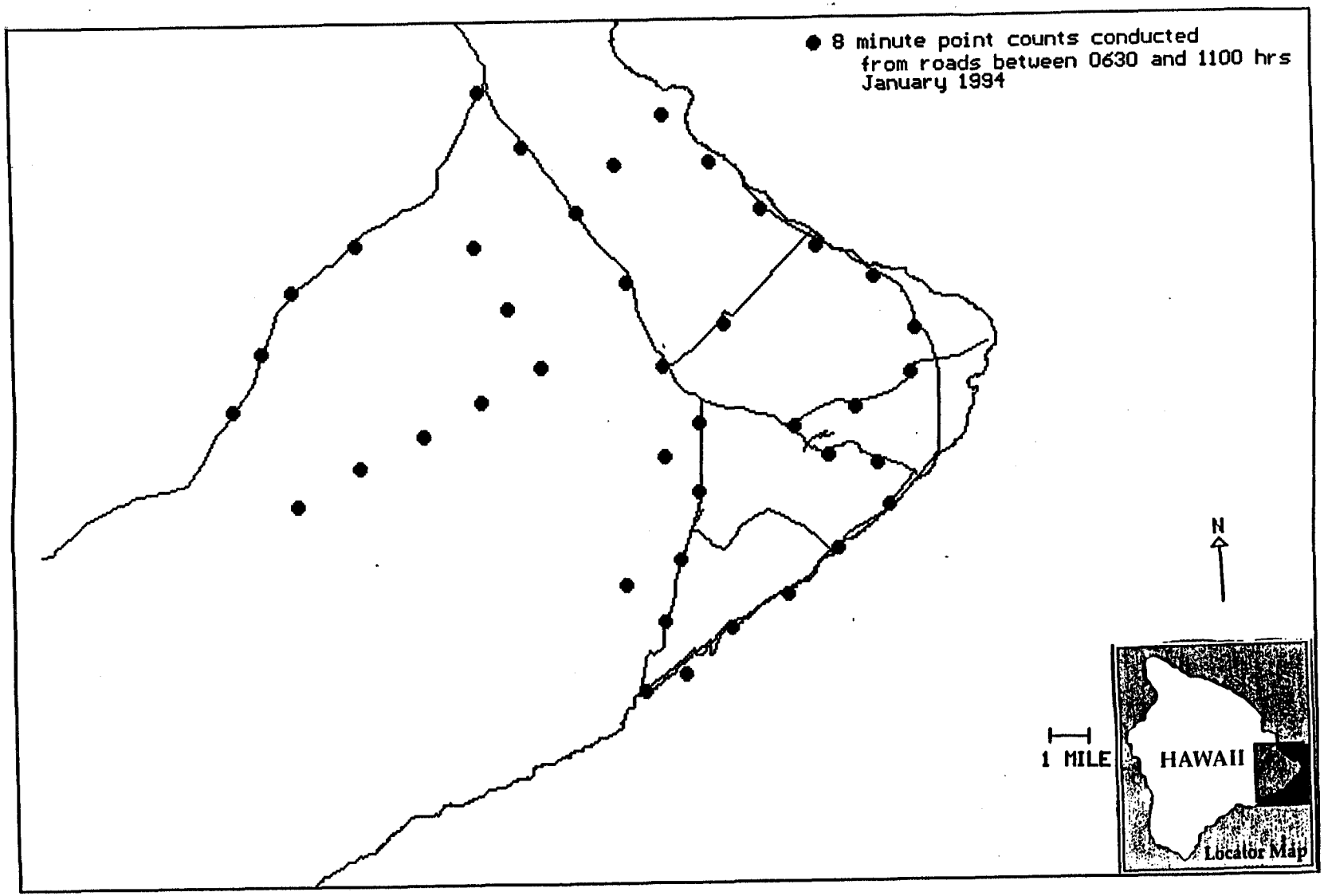

Figure 2. Location of AS and IPS sample sites within Puna study area.

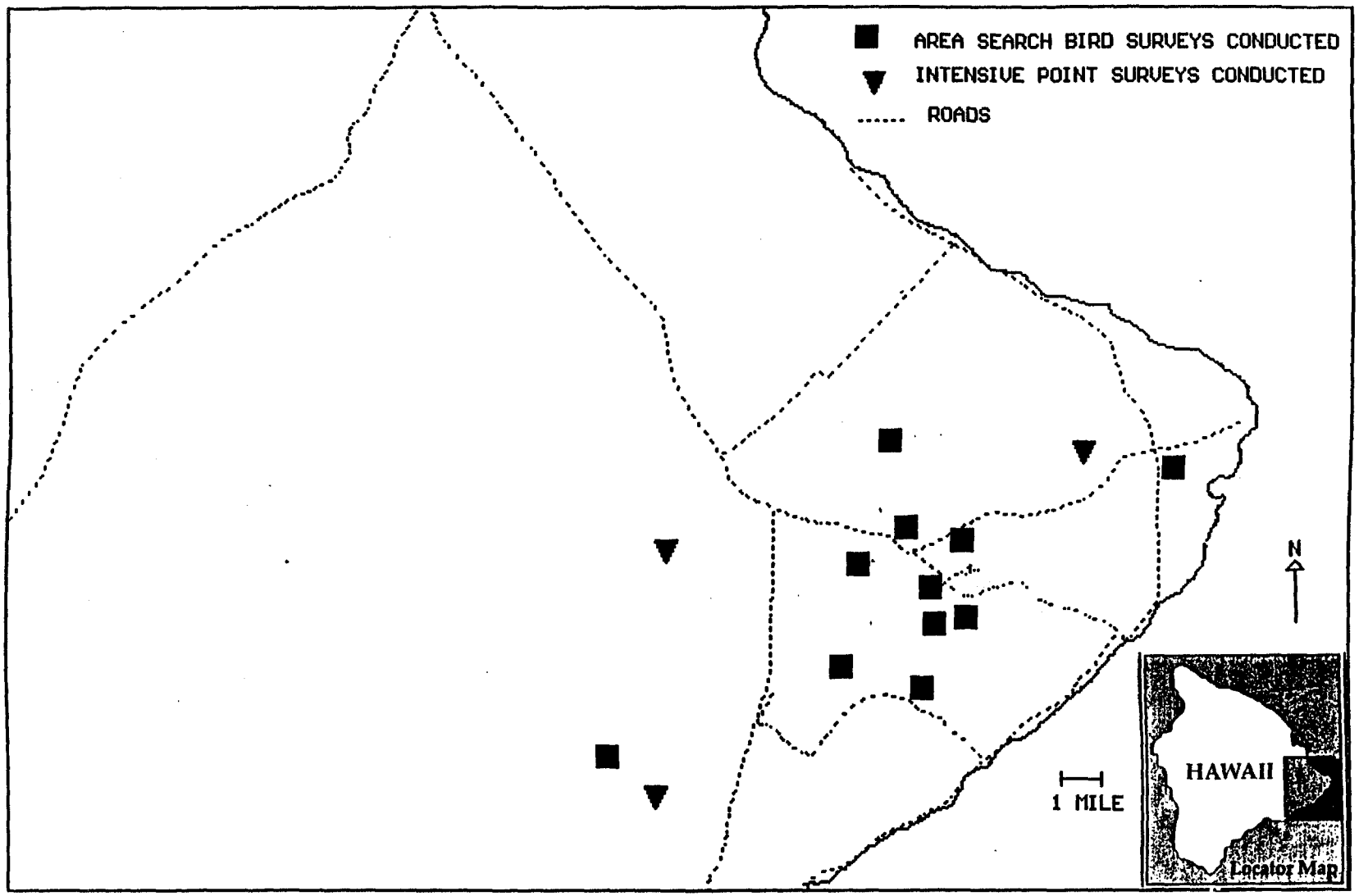

Figure 3. Location of EPS sample sites within the Puna study area.

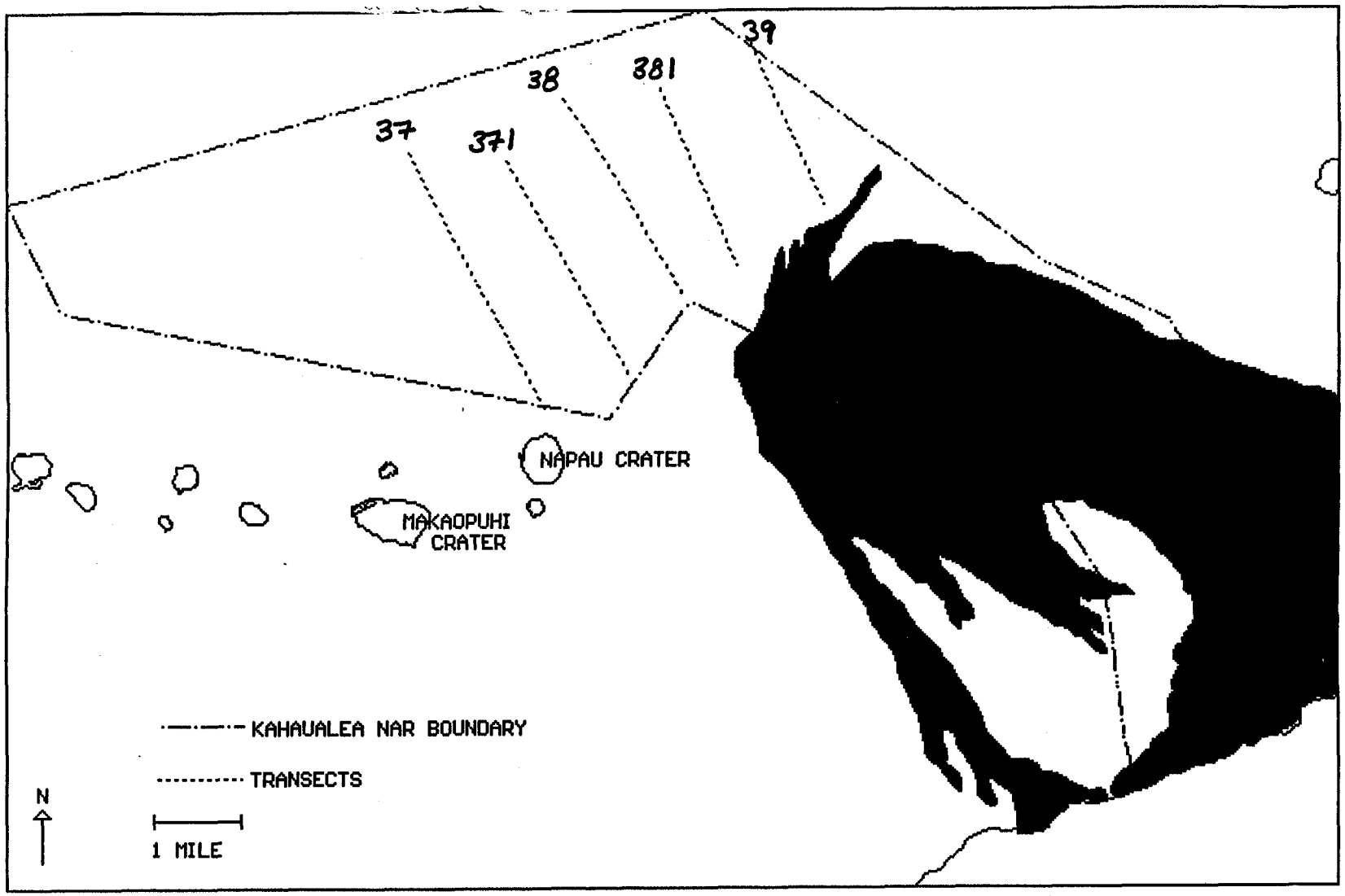

Figure 4. Map of transects sampled using VCP method within the Kahauale'a Natural Area.

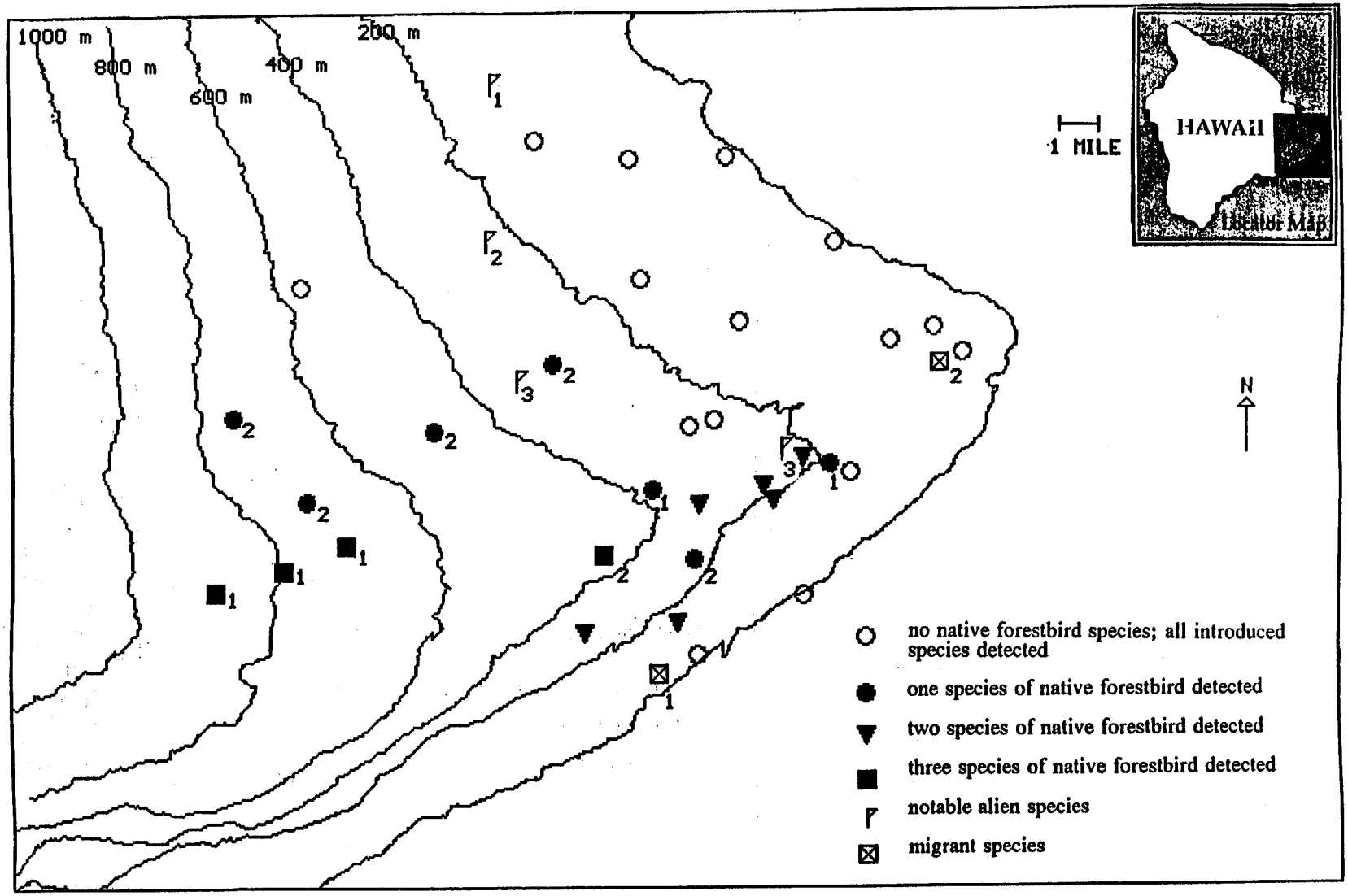

Figure 5. Summary of the distribution and composition of bird populations detected during AS, EPS, and IPS sampling within the study area. Note that all sites sampled had introduced bird species in addition to those noted on the legend.

Species codes: ■ 1 Apapane, Elepaio, Omao, 2 Amakihi, Apapane, Omao; ▲ Amakihi, Apapane; ● 1 Amakihi, 2 Apapane; ⚑ 1 Saffron finch, 2 Green pheasant, 3 Unknown parrot species; ⊠ 1 Wandering tattler, 2 Teal species

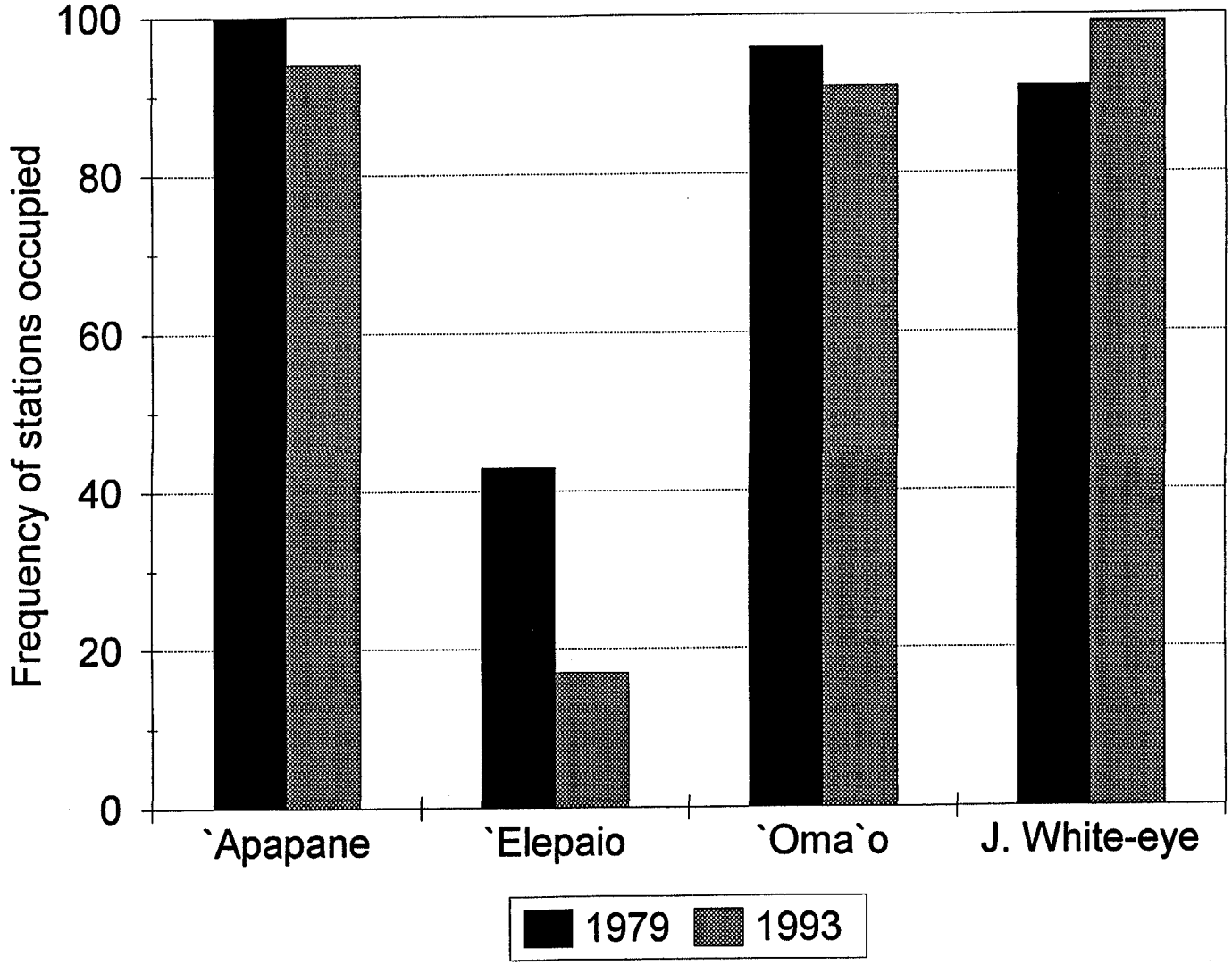

Figure 6. Frequency of stations occupied by four bird species recorded during VCP sampling in the Kahauale'a Natural Area Reserve in 1979 and 1993.

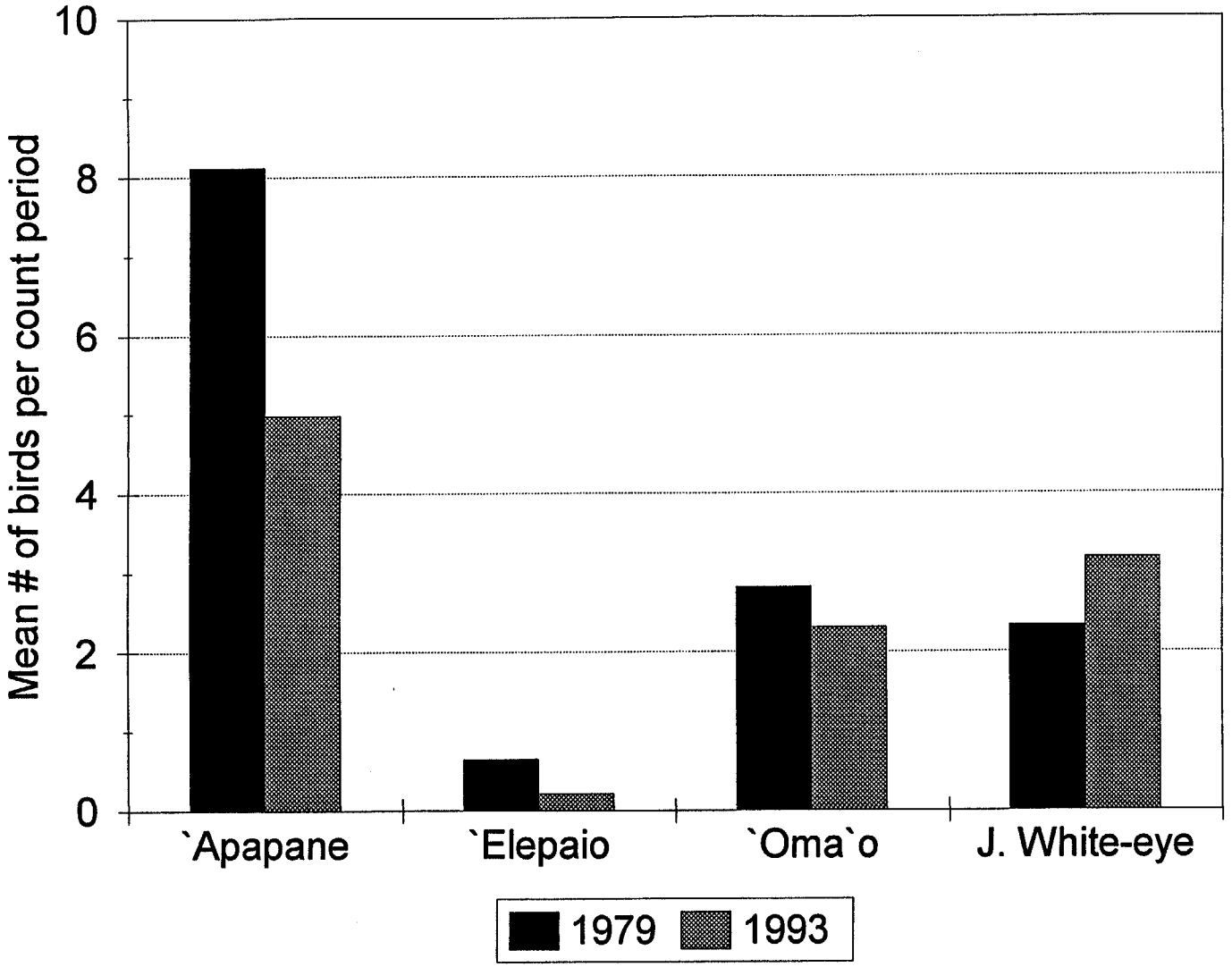

Figure 7. Birds per count period for four bird species recorded during VCP sampling in the Kahauale'a Natural Area Reserve in 1979 and 1993.

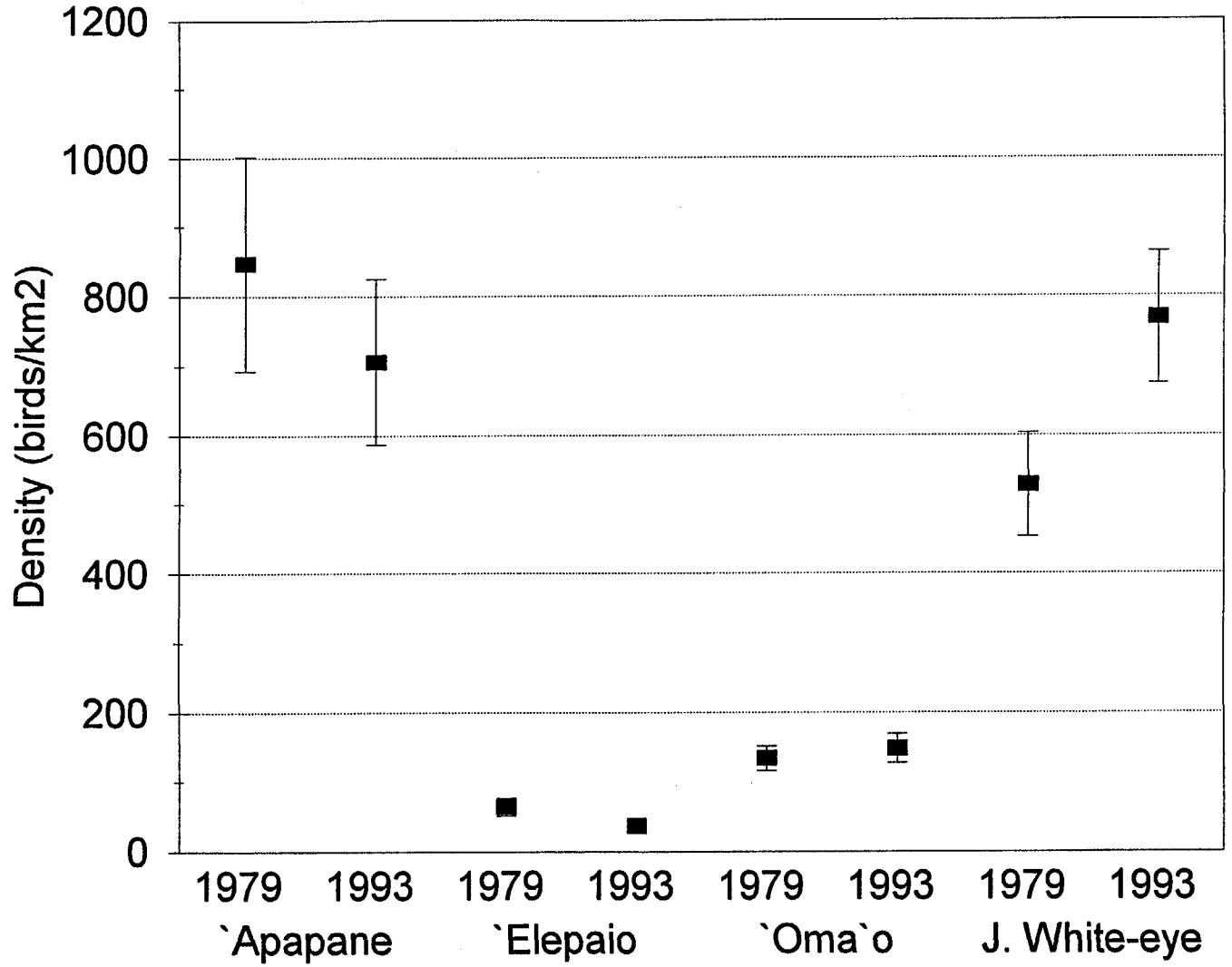

Figure 8. Density of four bird species recorded during VCP sampling in the Kahauale'a Natural Area Reserve in 1979 and 1993.

Appendix 1. List of acronyms used in the text.

AS	Area search survey method
DOE	U.S. Department of Energy
EIS	Environmental impact statement
EPS	Extensive point survey method
HFBS	Hawai'i Forest Bird Survey
HGP	Hawai'i Geothermal Project
IPS	Intensive point survey method
NAR	Natural Area Reserve, Hawai'i Department of Land and Natural Resources
USFWS	U.S. Fish and Wildlife Service
VCP	Variable circular plot survey technique