

COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT

UNIVERSITY OF HAWAII AT MANOA

Department of Botany

Honolulu, Hawaii 96822

(808) 948-8218

Clifford W. Smith, Unit Director
Associate Professor of Botany

Technical Report 36

BIRDS OF THE KALAPANA EXTENSION

Sheila Conant

October 1980

UNIVERSITY OF HAWAII AT MANOA

NATIONAL PARK SERVICE Contract No. CX 8000 7 0007

Contribution Number CPSU/UH 004/13

ABSTRACT

An avifaunal survey of the Kalapana Extension of Hawaii Volcanoes National Park, conducted from 1976-1979, revealed the presence of 26 bird species in 24 genera and 17 families. There were six species endemic to the Hawaiian archipelago, of which one species and the subspecies of three others are endemic to the island of Hawai'i. One of the three indigenous species, the Pueo (Asio flammeus sandwichensis), is represented by a subspecies endemic to the Hawaiian Islands. Of the six endemic birds occurring in the Kalapana Extension, two, the Nēnē (Branta sandvicensis) and the 'Io (Buteo solitarius), are endangered species. Although all habitat types are inhabited by at least one native bird, no one native species occurred in all habitat types. Of the 15 exotic bird species, the Japanese White-eye (Zosterops japonicus), the Cardinal (Cardinalis cardinalis), and the House Finch (Carpodacus mexicanus) were found throughout the study area. The White-eye was by far the most abundant bird in the Kalapana Extension.

RECOMMENDATIONS

1. Continued control of feral goat populations and an increase in the efforts to control feral pig populations would be among the most important natural resource management programs in Hawaii Volcanoes National Park. The effect of feral pigs, especially in the spread of exotic plants such as strawberry guava (Psidium guajava), and the disruption of the herbaceous layer in mesic and rain forests of the Kalapana Extension are serious problems. Because the Kalapana Extension harbors the largest expanses of native rain forest, it is an important resource in terms of the maintenance and possible future enhancement of native forest bird populations, including at least two endangered species: the 'Ō'ū and the 'Io.
2. Continuation and expansion of avian predator control programs should be an important part of any resource management program. Trapping and shooting of predators (including Rattus spp., mongoose, cat, dog, and pig) should enhance the breeding success of the NĒNĒ and possibly benefit native forest birds.
3. It may be worthwhile to consider expanding programs to control populations of some exotic birds. At present, House Sparrows are being controlled because they are a potential disease reservoir. Exotic game birds also may carry diseases and parasites potentially harmful to native birds. In addition, game birds probably compete with NĒNĒ for food.
4. The Kalapana Extension's natural features, including those geological, botanical, and ornithological, are of considerable and unique value as natural resources. A conservation-oriented management program clearly seems preferable to land use practices including agriculture and ranching.

TABLE OF CONTENTS

ABSTRACT.	i
RECOMMENDATIONS	ii
LIST OF TABLES.	iv
LIST OF FIGURES	iv
INTRODUCTION.	1
MATERIALS AND METHODS	1
RESULTS AND DISCUSSION.	2
Species Accounts.	2
Nēnē.	2
'Io	2
Game Birds.	3
Kōlea	4
Noio.	4
Spotted Dove.	4
Barred Dove	5
Pueo.	5
Skylark	5
Melodious Laughing-thrush	5
'Oma'o.	6
Hawai'i 'Elepaio.	6
Japanese White-eye.	7
Common Myna	8
Hawai'i 'Amakihi.	8
'Apapane.	9
'O'ū.	9
Spotted Munia	10
House Sparrow	10
Cardinal.	10
House Finch	10
Native Birds.	11
Introduced Birds.	13
CONCLUSION.	13
SUMMARY	15
ACKNOWLEDGMENTS	16
LITERATURE CITED.	17
APPENDIX I.	35

LIST OF TABLES

Table

1.	Number and percentage of endemic, indigenous, and exotic birds in the Kalapana Extension.	20
2.	Densities (birds/40 ha) of native bird species in the different vegetation types of the Kalapana Extension. Vegetation types are based on Mueller-Dombois and Fosberg (1974).	21
3.	Densities (birds/40 ha) of introduced bird species in the different vegetation types of the Kalapana Extension. Vegetation types are based on Mueller-Dombois and Fosberg (1974).	22

LIST OF FIGURES

Figure

1.	Map showing the locations of the main Hawaiian Islands, the Island of Hawai'i, Hawaii Volcanoes National Park, and the Kalapana Extension	23
2.	Map of the known (as of April 1974) "unimpaired habitats" of native forest birds ('Io, 'Elepaio, 'Ākepa, 'Amakihi, 'Akiapōlā'au, 'Ō'ū, 'Apapane, 'I'iwi, and probably 'Ōma'o) in the Kalapana Extension, according to National Park Service (1974: Map D)	24
3.	Map of the major habitat types of the Kalapana Extension of Hawaii Volcanoes National Park. Vegetation types are based on Mueller-Dombois and Fosberg (1974).	25
4.	Map of the distribution of the Noio, Kōlea, Pueo, Nēnē, 'Io, and 'Ō'ū in the Kalapana Extension, Hawaii Volcanoes National Park.	26
5.	Map of the distribution of the 'Ōma'o in the Kalapana Extension, Hawaii Volcanoes National Park.	27

LIST OF FIGURES (Continued)

Figure

6.	Map of the distribution of the Hawai'i 'Elepaio in the Kalapana Extension, Hawaii Volcanoes National Park.	28
7.	Map of the distribution of the Japanese White-eye in the Kalapana Extension, Hawaii Volcanoes National Park	29
8.	Map of the distribution of the Hawai'i 'Amakihi in the Kalapana Extension, Hawaii Volcanoes National Park	30
9.	Map of the distribution of the 'Apapane in the Kalapana Extension, Hawaii Volcanoes National Park. .	31
10.	Map of the distribution of the Cardinal in the Kalapana Extension, Hawaii Volcanoes National Park. .	32
11.	Map of the distribution of the House Finch in the Kalapana Extension, Hawaii Volcanoes National Park. .	33
12.	Map showing native forest bird ('Io, 'Elepaio, 'Ōma'o, 'Amakihi, 'Ō'ū, 'Apapane) distribution in various habitats of the Kalapana Extension according to this study. Includes many habitats considered to be impaired by feral animals and exotic plants. . . .	34

INTRODUCTION

In recent years the National Park Service has been working to develop a feasible and sound management program for lands included in the approximately 49,000 acres of the Kalapana Extension (Fig. 1), which was acquired by Hawaii Volcanoes National Park between 1938 and 1960 (National Park Service 1974). The first step in planning analysis has consisted largely of inventory-type research aimed at identifying and locating the resources of the Kalapana Extension. An up-to-date inventory of the avifauna was called for as part of this research.

Most of the information on birds presented in the Draft Planning Analysis (National Park Service 1974: Map D, henceforth Fig. 2 of this report) was based on data gathered by Baldwin (1953) more than 25 years ago. Surveys by Dunmire (1962) and Berger (1972), as well as verbal communications from other researchers, provided some additional data. It should be noted that the map shows only what were called "unimpaired" bird habitats. Presumably, some forest birds had and still have today more extensive distributions than is suggested by this map.

MATERIALS AND METHODS

In 1976 field surveys began under contract with the Cooperative National Park Resources Studies Unit of the University of Hawaii (CPSU/UH). This report summarizes data collected through December of 1977, including observations reported by researchers other than the author.

Censuses of birds were conducted using either Emlen's (1971) transect count method or Ramsey and Scott (1979) variable circular plot method. For the rarer species not often detected during censuses, such as the 'Io (Buteo solitarius), sighting locations were recorded. Although I was unable to exhaustively survey all parts of the Kalapana Extension, I attempted to inventory the avifauna of the major habitats (Fig. 3), concentrating my field work in the closed 'ōhi'a (Metrosideros) rain forests near Nāpau Crater where Baldwin (1953) had reported several endangered species. I was interested to know if these species still occurred in the areas listed as "unimpaired habitats" as of 1974 (Fig. 2).

RESULTS AND DISCUSSION

Species Accounts

A total of 17 families, 24 genera, and 26 bird species presently occurs in the Kalapana Extension. Fifteen exotic (58%), three indigenous (12%), and six endemic (23%) bird species were observed during this study or by other researchers during the study period (Table 1).

Nēnē (Hawaiian Goose, Branta sandvicensis, Fig. 4).

This endangered native species was extremely rare. Many sightings of Nēnē were made by observers other than the author. J. and Z. Jacobi (pers. comm.), who lived at the 'Āinahou Ranch, reported Nēnē from scrub habitats along the border between the Ranch and the Kalapana Extension, where I also saw them. P. Banko (pers. comm.), who is conducting intensive studies of the National Park Service's Nēnē restoration program, also reported birds from this area. All of the birds sighted during this study were banded, indicating they were captive-raised birds, released by the State of Hawaii Division of Fish and Game.

According to P. Banko (pers. comm.), the National Park Service's "Nēnē Park" (Scott 1962; Pratt 1972) project has enjoyed some success. Several enclosures with breeding pairs have been placed at various locations in Hawaii Volcanoes National Park. Young birds have fledged successfully from these enclosures, and apparently some of the young have even attempted to nest in the same enclosure where they were hatched. Banko also has found a number of nests built by captive-raised, released birds, some of which have successfully fledged young.

Predation is probably one of the most important factors affecting reproductive success of this rare goose. P. Banko (pers. comm.) feels mongooses (Herpestes auropunctatus (Hodgson)) are a serious threat. In fact, mongoose predation on nesting Nēnē has been confirmed in a recent report by Baker and Russell (1979). Rats (especially Rattus rattus L.); feral cats (Felis catus L.); feral dogs (Canis familiaris L.); and feral pigs (Sus scrofa L.) also could destroy eggs, young, or even adults. The status of the Nēnē in both Hawaii Volcanoes and Haleakala National Parks is clearly not stable, and it appears that human intervention by assistance continues to be essential to the survival of the species.

'Io (Hawaiian Hawk, Buteo solitarius, Fig. 4, Table 2).

This endangered, endemic raptor (bird of prey) was uncommon, although individual birds were observed at least once in all habitat types except the low elevation rockland communities. I estimate that the birds observed represent two or three breeding

pairs at most. Individuals were observed regularly in two localities: Pua'i'ālua Crater and in the closed 'Ōhi'a forest near the eastern boundary of the Kalapana Extension. This latter area is traversed by the paved roads of the Hawaiian Homes Kalapana "subdivision." 'Io observed in the Kalapana Extension probably represent about half the birds occurring in all of Hawaii Volcanoes National Park, with the remainder being found in closed 'Ōhi'a forests north and west of Napau Crater and in the koa (Acacia koa Gray) mountain parkland in the Mauna Loa Strip area.

Game Birds: California Quail (Lophortyx californicus), Erckel Francolin (Francolinus erckelii), Closebarred Francolin (Francolinus adspersus), Green Pheasant (Phasianus versicolor), Ring-necked Pheasant (Phasianus colchicus) (Table 3).

The two species of francolin had the most restricted distribution of the game birds. Both species were introduced in 1957 (Hawaii Audubon Society 1978) and it is likely that the 'Āinahou Ranch was a release site. Although the few birds observed on the Ranch and near the western border of the Extension (J. & Z. Jacobi, pers. comm.) indicate that some successful breeding is occurring, neither species is abundant. Except for a single sighting of a flock of Erckel Francolin at Kīpuka Puaulu (Conant, in press), which is about 10 miles northwest of the 'Āinahou Ranch house, neither of the francolins has been reported at any great distance from the vicinity of the ranch house.

The California Quail and the Green and Ring-necked pheasants occupy much wider ranges than the francolins. All three species are common in the Mauna Loa Strip area and the adjacent Keauhou Ranch (Conant, in press), as well as parts of open, dry communities (oM, MD, oM, s, HEAn) in the Kalapana Extension. During this study neither California Quail nor Green Pheasant was observed below about 820 m (2700 ft) elevation, or in habitats east of Mauna Ulu flows. However, the Ring-necked Pheasant, probably Hawai'i's most common gallinaceous game bird, was observed in lowland scrub and grassland communities close to sea level, as well as throughout suitable habitats at higher elevations.

Previous survey work (Conant, in press) revealed that the two pheasant species have slightly different habitat preferences. The Green Pheasant is usually found in denser and more mesic habitats than the Ring-necked Pheasant. Field observations and an occasional taxidermy mount I have seen indicate that hybrids occur where the two species overlap on Hawai'i. The Ring-necked Pheasant may occur in habitats characteristically occupied by the Green Pheasant, which has been introduced only to Hawai'i Island.

It should be noted that field work was concentrated in 'Ōhi'a forests east of Mauna Ulu flows, where native forest birds were likely to be found. Additional field work in habitats west of these flows could reveal that the game birds mentioned here have broader ranges than described above.

Kōlea (Golden Plover, Pluvialis dominica, Fig. 4, Table 2).

This common migrant enjoys a wide distribution in the Kalapana Extension. Kōlea are commonly seen during the non-breeding months (September through March), although early and late migrants are not uncommon, and an occasional bird may remain in Hawai'i during the summer. Rockland, scrub, and grass communities (r, s, HEAn) are the characteristic habitats in which the Kōlea occur at densities of from 1-5 birds/40 ha and usually as individuals rather than in flocks. Within the large expanse of 'ōhi'a forests there are some small patches of open scrub or grassland, for example, one area on the western rim of Nāpau Crater, where one or two individuals have been sighted.

Although I did not traverse the shoreline area between Ka'ena Point and Keauhou Landing, there are two migratory shorebirds likely to occur there during the period from September to March: the 'Ūlili (Wandering Tattler, Heteroscelus incanus) and the 'Akekeke (Ruddy Turnstone, Arenaria interpres). E. Funk (pers. comm.) described a bird that was probably an 'Ūlili she saw at Keauhou landing on 30 July 1978, but I have no records of 'Akekeke from this particular area.

Noio (Hawaiian Noddy, White-capped Noddy, Black Noddy, Anous tenuirostris melanogenys, Fig. 4, Table 2).

This indigenous subspecies of the Black Noddy occurs regularly along the rocky coast of the Kalapana Extension. Flocks ranging in size from 2 to 20 birds feed along the coast, and frequently come to rest on ledges in the low (up to 8-9 m) cliffs. The subspecies is known to breed "in caves or on rocky cliff ledges" (Hawaii Audubon Society 1978: 11) in the main Hawaiian Islands, mostly during late spring months. However, observations of this bird were not frequent or prolonged enough to verify any nesting activity. With the recent opening of the new Chain of Craters road, visitor traffic along the coastline will surely increase, and small nesting colonies of this bird may require some protection from disturbance, although existing warnings to visitors for their own safety may be sufficient to discourage disturbance to the noddies.

Spotted Dove (Chinese Dove, Lace-necked Dove, Streptopelia chinensis, Table 3).

This introduced dove is relatively common (11-20 birds/40 ha) in open lowland forests (olf). Occasional flocks of over 20 birds have been seen in scrub 'ōhi'a forests near the upper parts of the 'Āinahou Ranch, but such concentrations in this area are not consistent, and are probably associated with livestock kept near the ranch house. In 'ōhi'a-lama (Metrosideros-Diospyros) forests (MD), scrub communities, and grasslands, the species is uncommon (1-5 birds/40 ha) and patchily distributed.

Barred Dove (Geopelia striata, Table 3).

In Hawai'i, this small introduced dove is most successful as an urban bird, but it does occur in open, dry, sparsely populated areas. In the Kalapana Extension it is uncommon (1-5 birds/40 ha) and patchily distributed in open lowland forests (olf). It also occurs infrequently in scrub 'ōhi'a forests (oM) west of Mauna Ulu lava flows.

Pueo (Hawaiian Owl, Asio flammeus sandwichensis, Fig. 4, Table 2).

The field surveys indicate that this endemic subspecies is rare in the Kalapana Extension. I observed it only once, hunting over scrub habitat along the Kalapana Trail at 370 m (1200 ft). J. Jacobi and F. R. Warshauer (pers. comm.) both have observed individuals in open 'ōhi'a forest (oM) near Poliokeawe Pali. While the species is typically more common in scrub and grassland communities, it also occupies, or hunts in, rain forests (Shallenberger & Vaughn 1978; Conant, in press; Conant, Pratt, & Shallenberger, unpublished ms). The Pueo is probably more common in the Kalapana Extension than my data indicate, and lack of sightings is probably best explained by difficulty of observation and incomplete coverage of the area due to limited observation time.

Skylark (Alauda arvensis, Table 3).

This introduced species was uncommon (1-5 birds/40 ha), but widely distributed in grasslands, more rarely in scrub communities, especially below Poliokeawe and Hōlei pali's. The species commonly occurs in suitable habitat, particularly pasturelands, at higher elevations on the island of Hawai'i (Conant, in press & unpublished data).

Melodious Laughing-thrush (Chinese Thrush, Hwa-mei, Garrulax canorus, Table 3).

This long-established, introduced babbler was, on the whole, uncommon (1-5 birds/40 ha) in both open and closed 'ōhi'a forests [cM, cM(ns), oM, oM(C), MD]. However, it was locally common in closed 'ōhi'a forest between about 100 to 600 m (500-2000 ft) along the eastern border of the Extension. Except for concentrations of this species below about 1040 m (3400 ft) in closed 'ōhi'a forests north of Pu'u Huluhulu and Mauna Ulu, the Kalapana Extension harbors the largest numbers of the species yet found in Hawaii Volcanoes National Park.

'Ōma'o (Phaeornis obscurus obscurus, Fig. 5, Table 2).

The 'Ōma'o is the only form of Hawaiian thrush that is not considered endangered. The 'Ōhi'a forests of the Kalapana Extension comprise the largest expanse of suitable habitat for 'Ōma'o that is within the borders of Hawaii Volcanoes National Park. 'Ōma'o also are found in 'Ōhi'a forest south and east of Kīlauea Crater (continuous with Kalapana Extension forest) and in the 'Ōla'a Tract. The highest densities (20-30 birds/40 ha) of 'Ōma'o were found in closed 'Ōhi'a forests above 490 m (1600 ft). Open 'Ōhi'a forest with tree fern (Cibotium spp.) understory harbored densities of 'Ōma'o of slightly more than 10 birds/40 ha, while open 'Ōhi'a forests lacking a well-developed tree fern layer supported densities of 6-10 birds/40 ha. The upper reaches of mesic 'Ōhi'a-lama forests had very few 'Ōma'o (< 5 birds/40 ha).

The distribution of the 'Ōma'o in the Kalapana Extension includes virtually all habitat that could be considered suitable for the species within the Extension. Previous studies (Conant, in press) have shown that the bird has an unusual distribution with regard to habitats occupied: it is found in alpine scrub and in 'Ōhi'a rain forest, but only infrequently in dry or mesic native forests. It occurs throughout Kalapana Extension 'Ōhi'a rain forest, its densities gradually decreasing with decreasing elevation and rainfall, as rain forest undergoes the transition to mesic and then dry forest. The occurrence of 'Ōma'o well into the mosquito zone (below about 900 m/3000 ft) indicates that mosquito-borne diseases are not an exclusive limiting factor.

The presence of fruit-bearing plants such as 'Ōhelo (Vaccinium) and ōlapa (Cheirodendron) probably are important to this species, which takes both fruit and insects in its diet (van Riper & Scott 1979; Conant, in press), as does the Melodious Laughing-thrush.

Whether or not the Melodious Laughing-thrush competes with the 'Ōma'o for food or other ecological resources is not known. The Melodious Laughing-thrush is common in forests dominated by introduced plants on Hawai'i, Maui, O'ahu, and Kaua'i, while the species of Phaeornis survives primarily in native forests, and the distribution of the two species generally conforms to this pattern in the Kalapana Extension.

Protection of the Extension's rain forests from exotic plant invasion will probably be of great importance to the maintenance of a large 'Ōma'o population, as well as numbers of other native forest birds.

Hawai'i 'Elepaio (Chasiempis sandwichensis sandwichensis, Fig. 6, Table 2).

The Hawai'i 'Elepaio was distributed widely in wet and mesic forests of the Kalapana Extension, but in rather low densities. The only other native forest bird with a more extensive distribution was the 'Apapane (Himatione sanguinea sanguinea), which

was much more abundant. The 'Elepaio subspecies on O'ahu and Kaua'i occupy forests that can be classified as mesic to wet types, but on Hawai'i, the 'Elepaio occurs consistently and even abundantly in dry forest types (Pratt 1979; Conant, in press), which are much greater in area on Hawai'i than on either O'ahu or Kaua'i. Although the 'Elepaio may occur in a wider variety of habitat types than most other native forest birds, its total population size is undoubtedly less than that of the two most common Hawaiian honeycreepers, the 'Amakihi (Loxops virens virens) and the 'Apapane.

High 'Elepaio densities are associated with high structural diversity of habitat (Conant in press & this study). The wide variety of arthropods upon which 'Elepaio feed, available in more complex habitats (Gagné, in press), is undoubtedly an important factor affecting this species' abundance. Although 'Elepaio appear to survive in forests dominated by exotic plants on O'ahu, structural diversity of habitat nevertheless favors greater densities (Conant 1977).

The spread of aggressive exotic plants, such as guavas (Psidium cattleianum Sabine, P. guajava L.), which may form dense monospecific stands, can be viewed as a threat to the survival of the 'Elepaio. In the Kalapana Extension, low elevation mesic and rain forests are seriously threatened by exotic plant invasion.

Japanese White-eye (Zosterops japonicus, Fig. 7, Table 3).

The introduced Japanese White-eye was more abundant than any other bird species recorded from the Kalapana Extension. Only the Cardinal (Cardinalis cardinalis, Fig. 10) enjoyed a breadth of distribution about equal to the Japanese White-eye, but it occurred at much lower densities in all vegetation types. Clearly the White-eye is extremely adaptable, ranging from the driest scrub and grasslands to closed rain forests.

White-eyes are omnivorous, taking insects, fruit, and nectar, thus exhibiting a greater range of foraging strategies than any one species of native forest passerines. Although there is a distinct possibility that white-eyes may compete with native passerines for food, no studies clearly demonstrating or quantifying such competition have been published. Another major way in which white-eyes could have serious negative impact on native ecosystems is by spreading the seeds of introduced plants. Clarke (1978) suggested this possibility in relation to the establishment and spread of the particularly noxious firetree (Myrica faya Ait.) in Hawaii Volcanoes National Park.

Regardless of what the potential or actual adverse ecological effects of the Japanese White-eye may be, control or elimination of this highly successful bird would be virtually impossible. However, some knowledge of its role in the spread of introduced plants could be helpful to the planning and execution of management programs aimed at reducing or eliminating undesirable plant species.

Common Myna (Acridotheres tristis, Table 3).

The introduced Common Myna was uncommon in the Kalapana Extension except where it occurred in association with picnic areas, campgrounds, buildings, or livestock. Thus one expects to easily see the species along the Chain of Craters road at sea level, especially near the Waha'ula Visitor Center, as well as near livestock holding areas on the old 'Ainahou Ranch. In August 1979, C. W. Smith (pers. comm.) observed a flock of approximately 60 birds near a recently burned area adjacent to the 'Ainahou Ranch road. The Common Myna was observed regularly, but was not abundant, in open lowland forest, scrublands, and grasslands.

Hawai'i 'Amakihi (Loxops virens virens, Fig. 8, Table 2).

The Hawai'i 'Amakihi was present in low densities in open, dry scrub and forested areas throughout the Kalapana Extension. West of Mauna Ulu flows I observed it as low as 240 m (800 ft) in very open, mixed 'ōhi'a-lama-grassland habitats. Although 'Amakihi are nearly always found in the open 'ōhi'a west of Mauna Ulu flows, they were so uncommon in 'ōhi'a forest east of the flows and above about 600 m (2000 ft) that I have not indicated them as occurring there on the distribution map (Fig. 8). However, J. Jacobi (pers. comm.) mentioned hearing 'Amakihi very rarely at the edges of kīpuka (an "island" of vegetation surrounded by more recent lava flows) forest or in ecotones while he was working in the eastern part of the Kalapana Extension above 600 m (2000 ft). I regularly observed 'Amakihi as low as 120 m (400 ft) in 'ōhi'a forests east of recent lava flows, and F. R. Warshauer (pers. comm.) reported a sighting of 'Amakihi in lowland forest at only 15 m (50 ft) elevation.

Detecting this species is very difficult in the quiet, often very hot, midday hours. During July of 1979, I spent several days surveying habitats adjacent to or within short (1-2 hours) walking distance of the Chain of Craters road. 'Amakihi occurred in all habitats with even very scattered trees. However, I was unable to detect birds between the hours of about 1000 and 1400 hours in many of the same locations where birds could be heard calling immediately after I arrived on the spot during early morning and late evening hours.

Why 'Amakihi were scarce in the closed 'ōhi'a forests is not clear. Before concluding that the species is actually as rare as my data indicate, I would want to either increase the amount of data I have or compare notes with Fish and Wildlife Service bird survey teams who censused closed 'ōhi'a forest in the Kalapana Extension during the summer of 1979 (J. M. Scott, pers. comm.). The years of 1977 and 1978 were among the lowest rainfall years on Hawai'i during the last century. If this weather rendered some ecological resources limiting, this could explain low numbers of 'Amakihi (and other species). I have frequently observed individuals of the more aggressive 'Apapane chasing 'Amakihi from food sources, especially flowering 'ōhi'a. This may explain the complementarity of these two species' distributions in closed 'ōhi'a forest.

'Apapane (Himatione sanguinea sanguinea, Fig. 9, Table 2).

As is often the case in large expanses of native mesic and rain forests (Conant 1979 & in press), the 'Apapane was the most abundant native forest bird in closed 'Ōhi'a forests of the Kalapana Extension. The heaviest concentrations of this species were found in rain forests east of Mauna Ulu and above 490 m (1600 ft). However, the species occurred as low as 120 m (400 ft) and was found in open drier forests in the northwest corner of the Extension. Possible competitive interactions between 'Apapane and 'Amakihi that may affect their distributions were discussed above. Although 'Apapane are more common than 'Amakihi in most forests dominated by 'Ōhi'a, it appears that a certain minimum density of this tree species (or a minimum level of nectar availability) is required to support a population of 'Apapane.

The invasion of introduced understory trees, shrubs, and grasses, which is apparently facilitated by grazing and rooting activity of feral pigs, could eventually reduce the quality of habitat available to 'Apapane in the Kalapana Extension. During field surveys I passed through extensive areas where 'Ōhi'a is being replaced by strawberry guava (Psidium cattleianum) and exotic grasses. Severe control, preferably eradication of feral pigs, is indicated if preservation of suitable habitat for native forest birds is to be accomplished. Hawai'i's national parks may be the only areas in the State in which such an ambitious management program stands a chance of realization.

'Ō'ū (Psittirostra psittacea, Fig. 4).

The endangered 'Ō'ū is quite rare on Hawai'i and Kaua'i, and has been extirpated from Maui, Lāna'i, Moloka'i, and O'ahu. During recent field surveys by the U. S. Fish and Wildlife Service (J. M. Scott, pers. comm.; see Fig. 4), an 'Ō'ū was sighted in a small kīpuka near the northeast boundary of the Kalapana Extension where the pig-free rain forest is relatively undisturbed. D. Reeser (pers. comm.) also sighted 'Ō'ū in this kīpuka during 1978. Other recent sightings of 'Ō'ū have been made in the 'Ōla'a Tract (W. E. Banko, pers. comm.; pers. obs.) and near Park Headquarters and residences (van Riper 1978; W. E. Banko, pers. comm.).

J. M. Scott and C. B. Kepler (pers. comm.) of the U. S. Fish and Wildlife Service believe this species is highly mobile and speculate that the largest Hawai'i Island concentration of the species occurs in the 'Ōla'a Tract. The occurrence of 'Ō'ū in 'Ōla'a Tract and the Kalapana Extension points to the importance of Hawaii Volcanoes National Park as a refuge for this very rare species.

Spotted Munia (Lonchura punctulata, Table 3).

This tiny weaver-finch was distributed widely in the scrub and grasslands of the Kalapana Extension. While it was not particularly abundant, it was found at census locations in nearly all suitable habitat. Spotted Munia occurred most frequently in small flocks (4-20 birds), though larger flocks were observed.

House Sparrow (Passer domesticus).

Like the Common Myna, the House Sparrow in Hawai'i is primarily an urban bird. During this survey it was rarely observed near picnic areas, campgrounds, and buildings. As visitor traffic and its associated amount of "free" food available for scavengers increase, so will numbers of House Sparrows and Common Myna. Van Riper (pers. comm.) has found that the House Sparrow carries a disease that may seriously affect native forest birds, so its numbers should be controlled in areas adjacent to the habitats of native species. Such a program has been initiated near Park Headquarters.

Cardinal (Cardinalis cardinalis, Fig. 10, Table 3).

This long-established introduced finch was nearly ubiquitous in the study area, absent only from the large expanses of nearly barren rockland. However, it could be considered common (i.e., more than 20 birds/40 ha) only in the mesic 'ōhi'a-lama forests ranging in elevation from about 90 m to 370 m (300-1200 ft). It is doubtful that this species has any adverse competitive effects on native birds.

House Finch (Carpodacus mexicanus, Fig. 11, Table 3).

The House Finch proved to be quite widespread in the Kalapana Extension, but it shows a strong preference for open habitats. On a few occasions I was surprised to find birds in the open 'ōhi'a-hāpu'u (Metrosideros-Cibotium) areas because, for the most part, these habitats are surrounded by closed forests. This suggests that individual or flocks of House Finches are wide ranging, probably taking advantage of fluctuating food resources. Indeed, on a recent trip to Maui, I was surprised to see House Finches flying from Pōhakupalaha across the back of Kīpahulu Valley, to Pu'u Kuiki. This leaves little doubt birds can overfly large expanses of rain forest.

House Finches were nearly always observed in small flocks (4-8 birds), rarely as individuals, and only occasionally in large flocks. Like its fringillid relative the Cardinal, the granivorous House Finch does not seem to pose a competitive threat to native birds in the Extension.

Native Birds

Table 2 contains a summary of the estimated densities of native birds in five different habitats in the Kalapana Extension. Three native forest birds previously reported in or near the Kalapana Extension were not recorded there during this study. They are the 'Akiapōlā'au (Hemignathus wilsoni), the Hawai'i 'Ākepa (Loxops coccineus coccineus), and the 'I'iwi (Vestiaria coccinea). The first two are endangered species, and all belong to the Hawaiian Honeycreeper family (Drepanididae). It seems doubtful that the Hawai'i 'Ākepa may still occur in the Kalapana Extension, but a recent sighting of the 'Akiapōlā'au (Katahira 1979) in the 'Ōla'a Tract suggests that this species could still be found, very rarely, in the northernmost parts of the Kalapana Extension. The 'I'iwi is regularly seen near Thurston Lava Tube (Katahira 1979; Conant, in press), several miles northwest of Nāpau Crater in the Extension, and I am at loss to explain its absence from rain forests near Nāpau.

Because the native forest bird distribution plotted in Figure 2 included only "unimpaired habitats," it is impossible to determine whether or not the extent of native bird distribution has really changed. I suspect that present-day native forest bird distribution (Fig. 12, Table 2), regardless of habitat quality, is essentially the same as it was in 1974, and is more extensive than indicated in Figure 2, because several native species occupy "unimpaired" or disturbed habitats in the Kalapana Extension. No doubt volcanic activity has reduced bird distribution by destroying habitat since Baldwin's (1953) and Dunmire's (1962) studies. This change, as well as extensive alteration in forest habitats wrought by feral pig and goat activity and exotic plant invasion, may account, at least in part, for the disappearance of several forest bird species from the Kalapana Extension. It is probably botanically acceptable to say that there are virtually no "unimpaired" habitats remaining today. It should be noted that the National Park Service (1974) report must have inadvertently omitted Hawai'i 'Ōma'o from the forest birds listed on Figure 2.

Whether or not absolute densities of native birds have decreased or increased is not known because this information has not been available previously and the data herein represent "best approximations" based on selective sampling. If the indigenous Kōlea and Noio are included, than native birds have been observed in virtually every type of habitat in the Kalapana Extension (Table 2).

Although rain forests of the Extension [cM, cM(ns), oM(C), Fig. 3] appear to be suitable habitats for most of the Hawai'i Island forest birds, these areas were usually low in avian diversity, with Japanese White-eye, 'Apapane, and Hawai'i 'Ōma'o dominating the avifauna, although Hawai'i 'Elepaio and 'Io also occurred there. In fact, the Kalapana Extension harbors the most extensive population of 'Ōma'o to be found within Hawaii Volcanoes National Park.

Notably and unexpectedly absent from rain forests were the 'I'iwi and the Pueo. These species probably do occur there, but because of their very low numbers were not observed. Hawaii'i 'Amakihi were present in mesic and dryland forests generally above 60 m (200 ft) elevation, and Pueo and 'Io were recorded in lowland scrub. Kōlea are likely to be found in any open grassy area between approximately September and March, and Noio can be seen regularly along the coastline.

The endemic passerines reached relatively low elevations, some of which were recorded by observers other than the author. Low elevation records for native passerines were: 'Elepaio 120 m (400 ft); 'Ōma'o 490 m (1600 ft); 'Amakihi 15 m (50 ft); and 'Apapane 120 m (400 ft). East of Mauna Ulu flows, 'Amakihi were consistently observed no higher than 610 m (2000 ft), nor lower than 120 m (400 ft), except occasionally (J. Jacobi & F. R. Warshauer, pers. comm.). However, west of Mauna Ulu flows and in kīpuka's they were consistently observed in suitable habitat, regardless of elevation. While the 'Amakihi does not regularly inhabit homogeneous closed rain forest in substantial numbers, it can usually be found in openings and edges. This was not the case in the forests east of Mauna Ulu flows. Perhaps the lack of understory diversity characteristic of much of this feral animal disturbed area reduces available resources for birds, giving the much more abundant 'Apapane a competitive edge. This question is in need of further study.

None of the four relatively common native forest passerine birds appear to be severely limited by mosquito-borne diseases. 'Ōma'o, 'Elepaio, 'Amakihi, and 'Apapane were all found well within the zone of mosquito occurrence, although their population densities generally decrease with altitude. These decreases in abundance can probably be attributed to a concurrent decrease in suitable habitat. Until more is known about the susceptibility of these species to avian pox and avian malaria, it is impossible to invoke disease as an important environmental factor affecting or limiting the distributions of these native forest birds.

No specific searches were made for the nocturnal 'Ua'u (*Pterodroma phaeopygia sandwichensis*), which was previously reported to nest in Makaopuhi Crater, on the northern border of the Extension (U. S. Fish & Wildlife Service 1979). The species was heard recently in this vicinity by W. E. Banko (Kepler et al. 1979), though it is not known if there is a nesting colony. A number of recent sightings on Hawaii'i were reported by Kepler et al. (1979) and Conant (1980).

The Nēnē was recorded in western portions of the Extension during this study and by P. Banko (pers. comm.) and J. and Z. Jacobi (pers. comm.). Banko (1978) is presently working with the National Park Service on a new recovery program aimed at reintroducing a breeding population of Nēnē to lowland habitats in Hawaii Volcanoes National Park, and the birds observed during the study were banded captive-raised birds kept in enclosures or captive-raised, released birds attracted to those kept in enclosures.

The only widespread endangered species in the Extension was the 'Io, which was observed in all habitats except very dry scrub and grassland communities east of Mauna Ulu flows.

Introduced Birds

The open, drier habitats (oM, MD, olf, s, HEAn, r, Fig. 3, Table 3) were populated largely by introduced species, notably Japanese White-eye, Cardinal, and House Finch. The Skylark was widespread but not abundant in shrublands and grasslands. Other introduced bird species in these habitats were limited in distribution and numbers.

The Japanese White-eye was by far the most abundant and widely distributed bird species (Table 3). The Cardinal was as widely distributed as the Japanese White-eye, but was much less abundant (Table 3). The House Finch was the only other exotic bird that was either very common or widely distributed.

Five species of game birds (Table 3) were observed during this study and by J. and Z. Jacobi (pers. comm.) in open, dry habitats (oM, HEAn, s, Fig. 3) in the western part of the Extension bordering the old 'Āinahou Ranch. With the exception of the Ring-necked Pheasant, which I recorded in lowland scrub, game birds seem to have entered Kalapana Extension habitats from the 'Āinahou Ranch area. Limited field work in the drier habitats may have precluded additional sightings of Green Pheasant and California Quail, both well-established and fairly common in upland habitats of Hawaii Volcanoes National Park (Conant, in press). The two species of francolin were probably introduced to the Ranch before it became part of the National Park. It remains to be seen whether or not game birds will seriously compete for food with the NĒNĒ that are being reintroduced to these habitats. The francolins could probably be eliminated relatively quickly while their numbers are low, and this management action is recommended.

One exotic bird not found but previously recorded in the Kalapana Extension was the Red-billed Leiothrix (Leiothrix lutea). This species has undergone a rapid decline, for unknown reasons, in its Hawaiian Islands range during the last decade (Hawaii Audubon Society 1978).

CONCLUSION

Recent volcanic activity in the southeast rift zone of Kīlauea Volcano and its associated destruction of habitat by fire or inundation by lava have undoubtedly reduced density and distribution of bird populations in the Kalapana Extension. In addition, feral pig activity has dramatically changed the

character of rain forest areas by damaging the native plant understory, especially the structurally important tree ferns, and opening up forests to extensive invasion by exotic plants, resulting in a marked change in the overall character of forest habitats. The National Park Service is attempting to eliminate or at least strictly control feral pigs in these areas. If elimination and/or control are successful, habitat quality for native forest birds could be enhanced.

Feral goats (*Capra hircus* L.) have severely damaged native plant communities in dry habitats resulting in the conversion of dryland forests and shrub communities to dense stands of introduced grass species. The National Park Service has nearly eliminated goats in recent years and some native plants are naturally colonizing or being reintroduced to goat-impacted areas. It remains to be seen whether or not native plants will be able to maintain themselves if frequent fires continue to sweep through communities predominated by exotic, fire-maintained grass communities (Parman 1977).

Recovery of dryland habitats through reestablishment of native plant communities would probably enhance survival prospects for the Nēnē, which is being reintroduced to these areas (Banko 1978), provided rat and mongoose predation are not limiting.

Three species (including two endangered forms) of native birds apparently no longer occur in the Kalapana Extension where they were reported about 25 years ago (Baldwin 1953). One endangered and very rare species, the 'Ō'ū, was recorded once in the northeast corner of the Extension. Each of the different habitat types in the Extension is still occupied by at least one native bird species, with closed 'ōhi'a rain forests, and open 'ōhi'a forests, including scrub forests, harboring the greatest diversities of native birds. The closed 'ōhi'a rain forests provide the best and most extensive habitats available in Hawaii Volcanoes National Park for the Hawai'i 'Ōma'o, the only non-endangered form of *Phaeornis* (Hawaiian thrushes). Furthermore, should populations of endangered Hawai'i Island forest birds (e.g., 'Ō'ū, 'Akiapōlā'au, 'Ākepa, *Loxops maculatus manus* or Hawai'i Creeper) stage a comeback in the Park, it would most likely occur in extensive tracts of rain forest, such as those found in the 'Ōla'a Tract and the Kalapana Extension. For these reasons forest habitats should be managed to protect or restore their integrity. Of extreme importance in this regard is the control of feral pigs and exotic plants.

When the natural features of the Kalapana Extension, especially those geological and botanical, but also ornithological and archaeological, are measured against its questionable value as homestead land (e.g., high volcanic risk, unsuitability for agriculture and ranching), it seems clear that management of these lands should have conservation of natural resources as its highest priority.

SUMMARY

During a three-year survey of the Kalapana Extension of Hawaii Volcanoes National Park, the author and other observers reported 26 bird species in 24 genera and 17 families. Of the 10 native species, six were endemic to the Hawaiian archipelago, one species, the 'Io, and the subspecies of three others, being endemic to the Island of Hawai'i. The three indigenous species included the migratory Kōlea, the Noio, and the Pueo, which occurs as an endemic Hawaiian subspecies. The remaining 15 species were all introduced, five of these being game birds of common to rare occurrence. Two doves and eight passerines make up the remaining exotic species.

The Nēnē and the Pueo were the rarest native birds, and the 'Io, though frequently observed, was not common. The Kōlea and the Noio were relatively common in suitable habitats. The 'Apapane and 'Ōma'o were the most abundant forest birds, occurring in open and closed native forests down to elevations of 120 m (400 ft) and 490 m (1600 ft), respectively. The 'Elepaio was uncommon with a relatively wide distribution down to as low as 120 m (400 ft) in mesic forests. The 'Amakihi was less common and of more limited distribution than expected but reached very low elevations (15 m/50 ft).

The exotic game birds were rare to common in open dry habitats. The Ring-necked Pheasant, a long established species, had the widest distribution. The remaining four species were observed only in habitat immediately east of the old 'Āinahou Ranch.

The Japanese White-eye was the most common and widely distributed bird in the study area. The Cardinal had a very wide distribution also, but was not common. In contrast, the House Finch was more abundant than the Cardinal but limited to the drier habitats. The Spotted Dove was recorded as an uncommon bird in lowland open areas, while the Melodious Laughing-thrush was uncommon in upland habitats.

Loss of native species and increase in most exotic species since the 1950's is probably attributable primarily to alteration of habitat by feral goats and pigs (Mueller-Dombois & Spatz 1975; Spatz & Mueller-Dombois 1975), though lava flows have taken their toll of native bird habitat. Feral pigs and exotic plants are probably the most serious threat to the remaining native bird species, which occupy mostly mesic and rain forest habitats. Recent recovery of dryland ecosystems following near extermination of feral goats from the National Park attests to the importance of feral ungulate control and provides good support for programs resulting in reduction of feral pigs.

Although bird populations in the Kalapana Extension do not harbor large numbers of endangered species, the rain forests of the Extension are of great expanse and provide, with the much smaller area of the 'Ōla'a Tract, an important resource for the

native birds now present and enjoying the protective status provided by the National Park Service. This is particularly important in light of the fact that the Kalapana Extension provides habitat for a large population of the only non-endangered form of the Hawaiian thrushes. Finally, should endangered forest bird populations on Hawai'i begin to recover, large expanses of protected rain forest will be an important factor affecting their success.

ACKNOWLEDGMENTS

I thank June Saito for typing and editing the manuscript; Terry Parman, Maile Stemmermann, and Rick Warshauer assisted with field work. The National Park Service has been particularly helpful with logistics, and I appreciate Dr. Cliff Smith's assistance with several aspects of the project. The project was funded by the National Park Service through the Cooperative National Park Resources Studies Unit at the University of Hawaii (Contract Number CX 8000 7 0007).

LITERATURE CITED¹

- American Ornithologists' Union. 1973. Thirty-second supplement to the American Ornithologists' Union Check-list of North American Birds. Auk 90: 411-419.
- _____. 1976. Thirty-third supplement to the American Ornithologists' Union Check-list of North American Birds. Auk 93(4): 875-879.
- Baker, J. K., and C. A. Russell. 1979. Mongoose predation on a nesting Nene. 'Elepaio 40: 51-52.
- Baldwin, P. H. 1953. Annual cycle, environment and evolution in the Hawaiian honeycreepers (Aves: Drepaniidae). Univ. Calif. Publ. Zool. 54: 285-398.
- Banko, P. C. 1978. Nene reintroduction program and research in Hawaiian national parks. Pages 6-16 in C. W. Smith, ed. Proceedings, Second Conf. in Natural Science, Hawaii Volcanoes National Park. CPSU/UH (University of Hawaii, Botany Dept.).
- Berger, A. J. 1972. Birds of Hawaii Volcanoes National Park. Island Ecosystems IRP, US/IBP Tech. Rep. 8. 49 pp.
- _____. 1976. Names for Hawaii's introduced birds. 'Elepaio 36: 143-146.
- Clarke, G. 1978. The distribution of *Myrica faya* and other selected problem exotics within Hawaii Volcanoes National Park. Page 51 in C. W. Smith, ed. Proceedings, Second Conf. in Natural Science, Hawaii Volcanoes National Park. CPSU/UH (University of Hawaii, Botany Dept.).
- Conant, S. 1977. The breeding biology of the Oahu 'Elepaio. Wilson Bull. 89: 193-210.
- _____. 1979. Haleakala National Park Crater District Resources Basic Inventory: Birds. CPSU/UH Tech. Rep. 26 (Dept. of Botany, University of Hawaii). iv-53 pp.
- _____. 1980. Recent records of the Hawaiian races of the Dark-rumped Petrel and the Manx Shearwater on the island of Hawai'i. 'Elepaio 41: 11-13.
- _____. Bird distribution along an altitudinal gradient on Mauna Loa, Hawai'i. Studies in Avian Biology. (In press).
- Dunmire, W. W. 1962. Bird populations in Hawaii Volcanoes National Park. Elepaio 22: 65-70.

¹ Also contains references cited in Appendix only.

- Emlen, J. T. 1971. Population densities of birds derived from transect counts. *Auk* 88: 323-341.
- Gagné, W. C. Altitudinal distribution of organisms along an island mountain transect: Canopy-associated arthropods. Chap. 7.5 in D. Mueller-Dombois and K. W. Bridges, eds. *Island Ecōsystems: Biological organization in selected Hawaiian communities*. Dowden, Hutchinson, and Koss. (In press).
- Hawaii Audubon Society. 1978. *Hawaii's birds*. Second Edition. Honolulu: Hawaii Audubon Society. 96 pp.
- Katahira, L. 1979. Volcano, Hawaii, Christmas Count. *Elepaio*: 119-121.
- Kepler, C. B., J. Geffrey, and J. M. Scott. 1979. Possible breeding colonies of Manx Shearwater on the Island of Hawaii. *'Elepaio* 39: 115-116.
- Mueller-Dombois, D., and F. R. Fosberg. 1974. Vegetation map of Hawaii Volcanoes National Park. CPSU/UH Tech. Rep. 4. (Dept. of Botany, University of Hawaii). 44 pp.
- Mueller-Dombois, D., and G. Spatz. 1975. The influence of feral goats on the lowland vegetation in Hawaii Volcanoes National Park. *Phytocoenologia* 3: 1-29.
- National Park Service. 1974. Draft Planning Analysis, Kalapana Extension Homesites, Hawaii Volcanoes National Park. Western Region, National Park Service, Dept. of the Interior. 43 pp. Appendix of 6 maps.
- Parman, T. T. 1977. The Hilina Pali fire: A controlled burn exercise. CPSU/UH Tech. Rep. 18 (Dept. of Botany, University of Hawaii). i + 28 pp.
- Pratt, H. D., Jr. 1979. A systematic analysis of the endemic avifauna of the Hawaiian Islands. Ph.D. Dissertation in Zoology and Physiology, Louisiana State University, Baton Rouge.
- Pratt, J. J. 1972. Research study proposed for investigation of behavior of the Hawaiian Goose under the "Nene Park" plan. *Elepaio* 33: 33-34.
- Pyle, R. L. 1977. Preliminary list of the birds of Hawaii. *'Elepaio* 37: 110-121.
- Ramsey, F. L., and J. M. Scott. 1979. Estimating population densities from variable circular plot surveys. Pages 155-181 in R. M. Cormack, G. P. Patil, and D. S. Robson, eds. *Sampling biological populations*. Fairland, Md.: International Cooperative Publishing House.

- Scott, P. 1962. A project for a Nene Park in Hawaii. *Elepaio* 22: 80-81.
- Shallenberger, R. J., and G. Vaughn. 1978. Avifaunal survey of the central Koolau Range, Oahu. Ahuimanu Productions. 106 pp.
- Spatz, G., and D. Mueller-Dombois. 1975. Succession patterns after pig digging in grassland communities on Mauna Loa, Hawaii. *Phytocoenologia* 3: 346-373.
- Titcomb, M., and W. C. Gagne. 1976. List of Hawaiian bird names. *'Elepaio* 36: 117-126.
- U. S. Fish and Wildlife Service. 1979. List of endangered and threatened wildlife and plants. *Federal Register* 44: 3635-3654.
- van Riper, C., III. 1978. An 'O'u observation at Hawaii Volcanoes National Park. *'Elepaio* 39: 32-33.
- van Riper, C., III, and J. M. Scott. 1979. Observations on the distribution, diet, and breeding of the Hawaiian Thrush. *Condor* 81: 65-71.

TABLE 1. Number and percentage of endemic, indigenous, and exotic birds in the Kalapana Extension.

Bird Forms	Number	Percentage
Endemic	7	27%
Indigenous	4	15%
Exotic	<u>15</u>	<u>58%</u>
TOTAL	26	100%

TABLE 2. Densities (birds/40 ha) of native bird species in the different vegetation types of the Kalapana Extension ($P = < 1$ bird/40 ha; + = irregularly present). Vegetation types are based on Mueller-Dombois and Fosberg (1974).

	cM	cM(ns)	oM	oM(c)	MD	olf	s	HEAn	r	Comments
'Io	P	P	P	P	P	P	P	P		
Kolea								P	P	P
Nbio										P (shoreline)
Pueo								P	P	
'Oma'o	23	18	4	11	P					above 1600 ft
'Elepaio	4	2	2	+	13					above 400 ft
'Amakihi	+	+	5	+	47	P				400-1600 ft E of Mauna Ulu flows
'Apapane	100	102	106	42	65					above 400 ft
'O'u	P									

cM = closed Metrosideros forests, various understory types

cM(ns) = closed Metrosideros forests with native shrub understory

oM = open Metrosideros forests, various understory types
(includes scrub Metrosideros communities)

oM(c) = open Metrosideros-Cibotium forests

MD = Metrosideros-Diospyros forests, various understory types

olf = open mixed lowland forests

s = mixed lowland scrub communities

HEAn = lowland Heteropogon-Eragrostis-Andropogon grasslands, sometimes with mixed shrubs

r = rockland communities with scattered grasses and shrubs, includes salt spray communities

TABLE 3. Densities (birds/40 ha) of introduced bird species in the different vegetation types of the Kalapana Extension (P = < 1 bird/40 ha; + = irregularly present). Vegetation types are based on Mueller-Dombois and Fosberg (1974).

	cM	cM(ns)	oM	oM(c)	MD	olf	s	HEAn
California Quail			P					
Erckel Francolin			P					
Closebarred Francolin			P					
Green Pheasant			P					
Ring-necked Pheasant							P	
Spotted dove					P	15	P	P
Barred Dove			P			P		
Skylark							P	P
Melodious Laughing-thrush	P	P	P		P			
Japanese White-eye	78	156	266	193	149	213	80	64
Common Myna						P	+	+
Spotted Munia						P	P	P
Cardinal	P	3	P	6	22	7	P	3
House Finch	+	+	2	+	P	15	27	14

These species probably limited to plant communities in the northwestern corner of the Kalapana Extension, adjacent to upper portions of the 'Ainahou Ranch.

cM = closed Metrosideros forests, various understory types

cM(ns) = closed Metrosideros forests with native shrub understory

oM = open Metrosideros forests, various understory types
(includes scrub Metrosideros communities)

oM(c) = open Metrosideros-Cibotium forests

MD = Metrosideros-Diospyros forests, various understory types

olf = open mixed lowland forests

s = mixed lowland scrub communities

HEAn = lowland Heteropogon-Eragrostis-Andropogon grasslands, sometimes with mixed shrubs

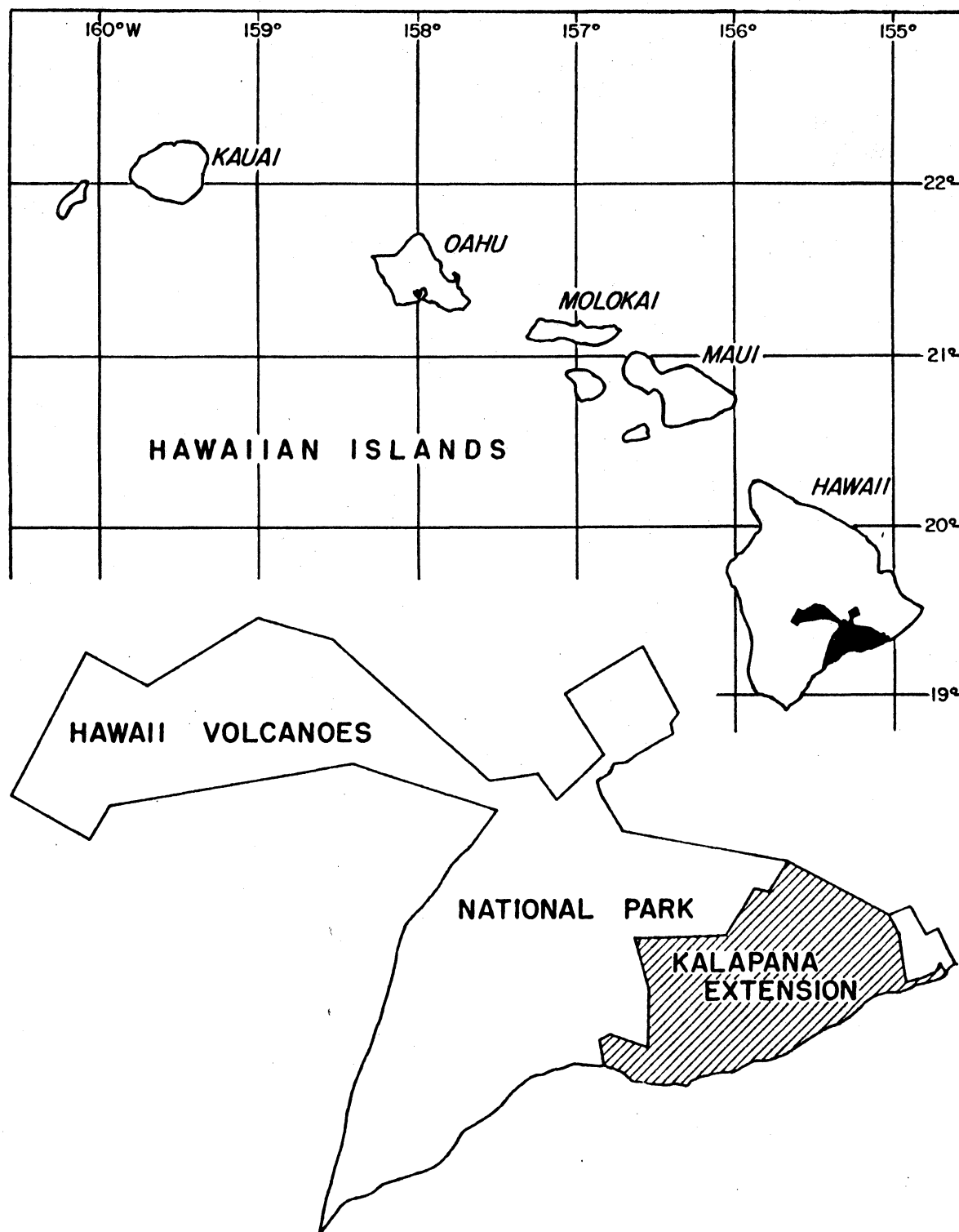
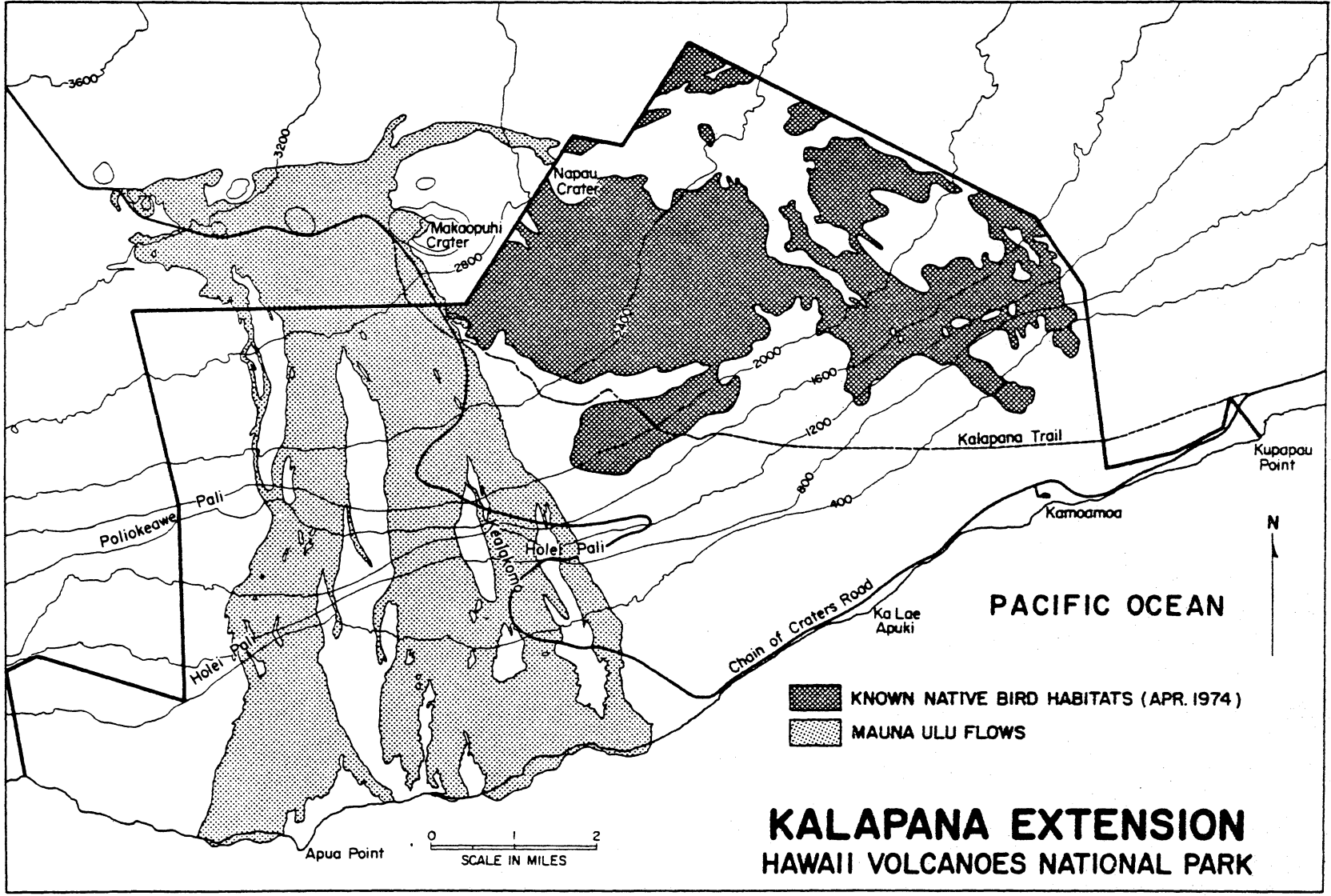


FIGURE 1. Map showing the locations of the main Hawaiian Islands, the Island of Hawai'i, Hawaii Volcanoes National Park, and the Kalapana Extension.

FIGURE 2. Map of the known (as of April 1974) "unimpaired habitats" of native forest birds ('Io, 'Elepaio, 'Akepa, 'Amakihi, 'Akiapōlā'au, 'O'ū, 'Apapane, 'I'iwi, and probably 'Ōma'o) in the Kalapana Extension, according to National Park Service (1974: Map D).



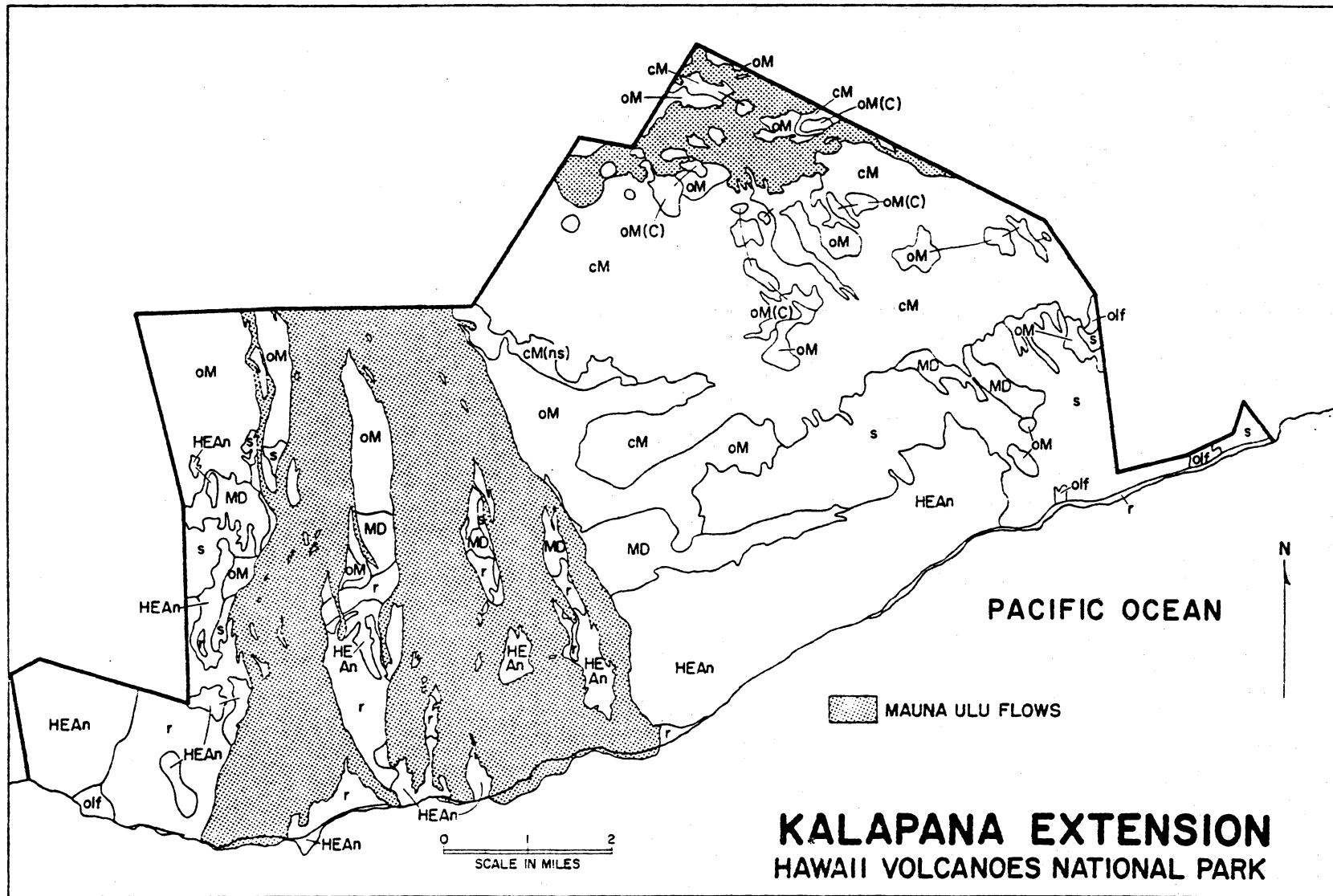
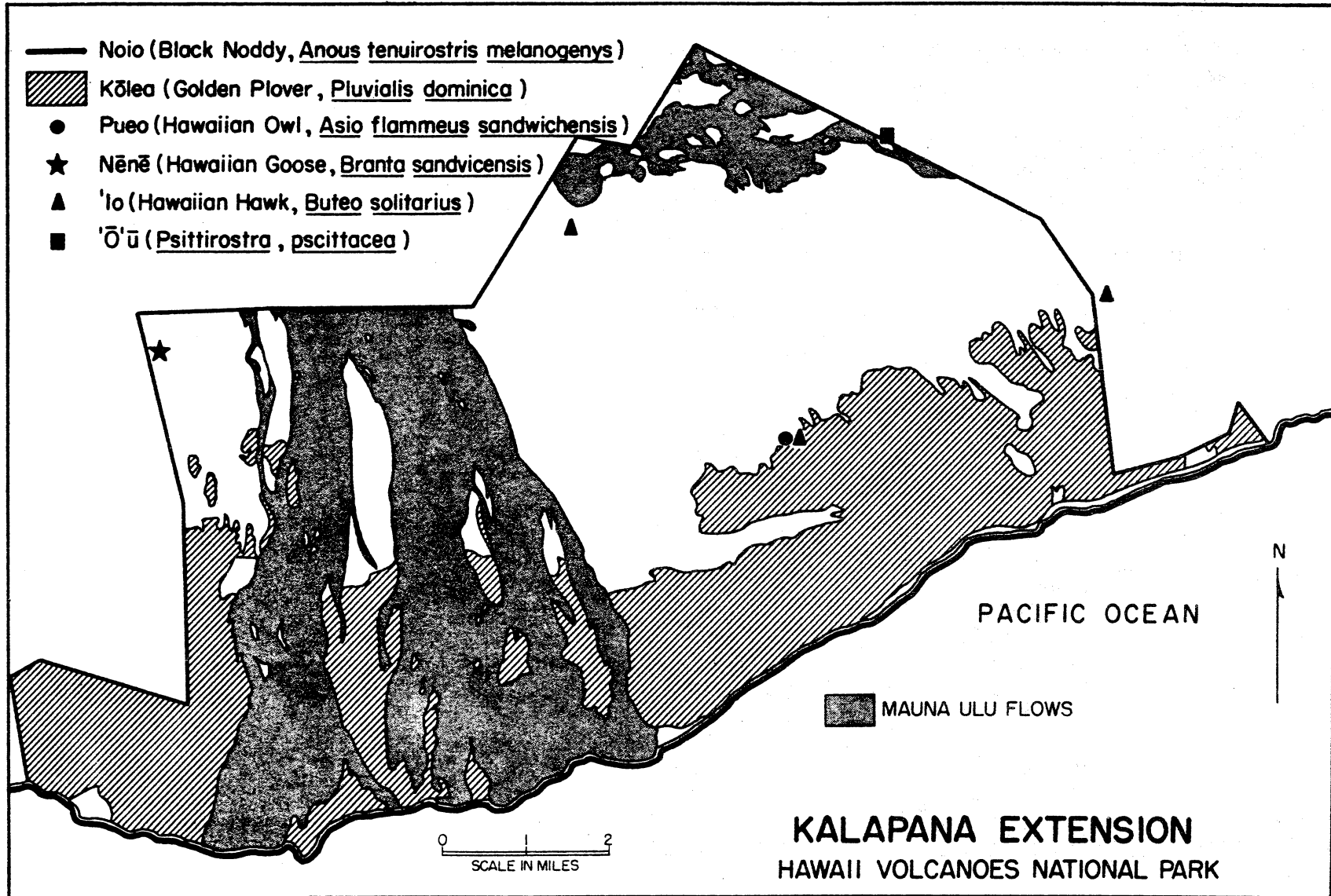


FIGURE 3. Map of the major habitat types of the Kalapana Extension of Hawaii Volcanoes National Park. Vegetation types are based on Mueller-Dombois and Fosberg (1974).

FIGURE 4. Map of the distribution of the Noio, Kōlea, Pueo, Nēnē, 'Io, and 'Ō'ū in the Kalapana Extension, Hawaii Volcanoes National Park.



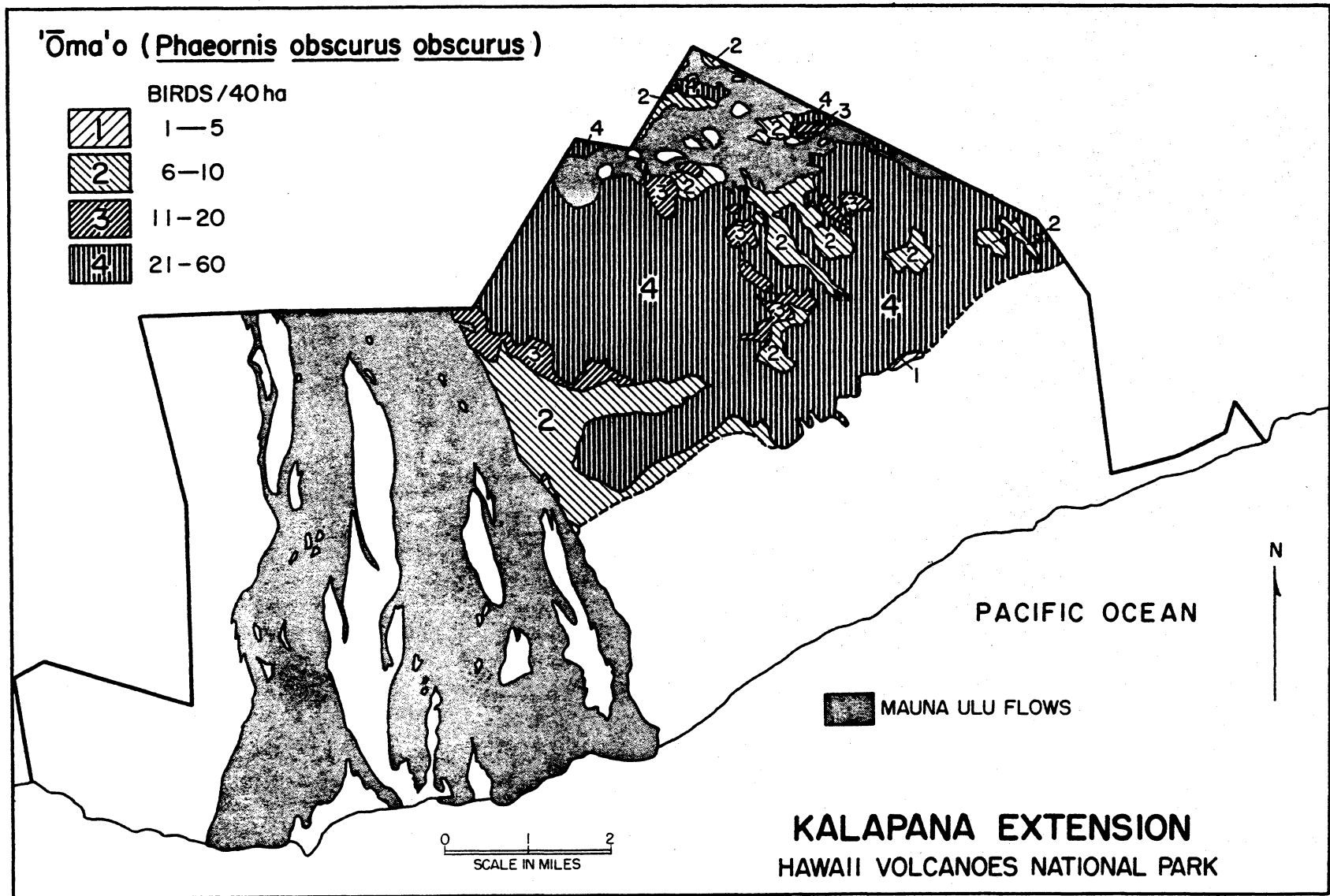
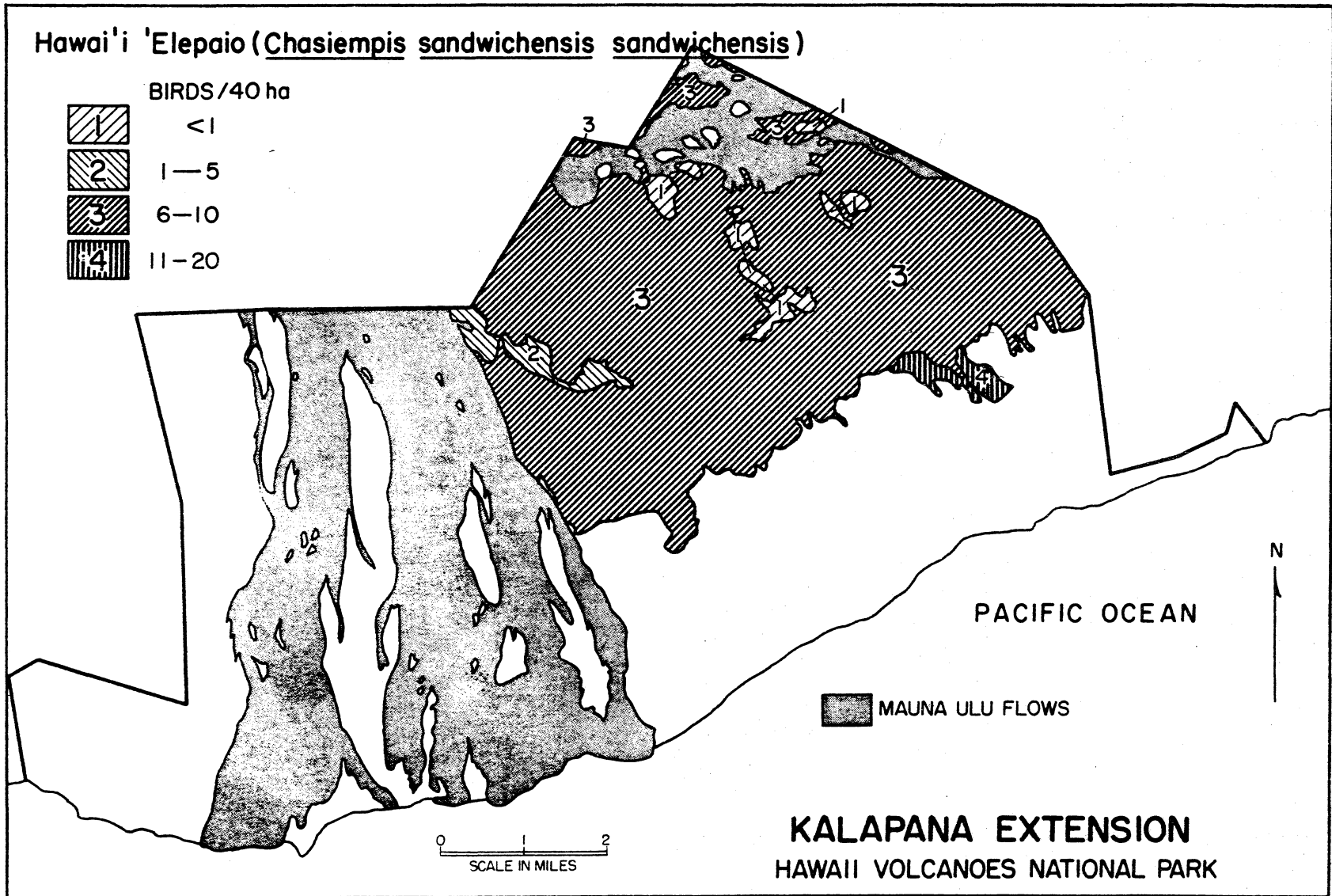


FIGURE 5. Map of the distribution of the 'Ōma'o in the Kalapana Extension, Hawaii Volcanoes National Park.

FIGURE 6. Map of the distribution of the Hawai'i 'Elepaio (*Chasiempis sandwichensis sandwichensis*) in the Kalapana Extension, Hawaii Volcanoes National Park.



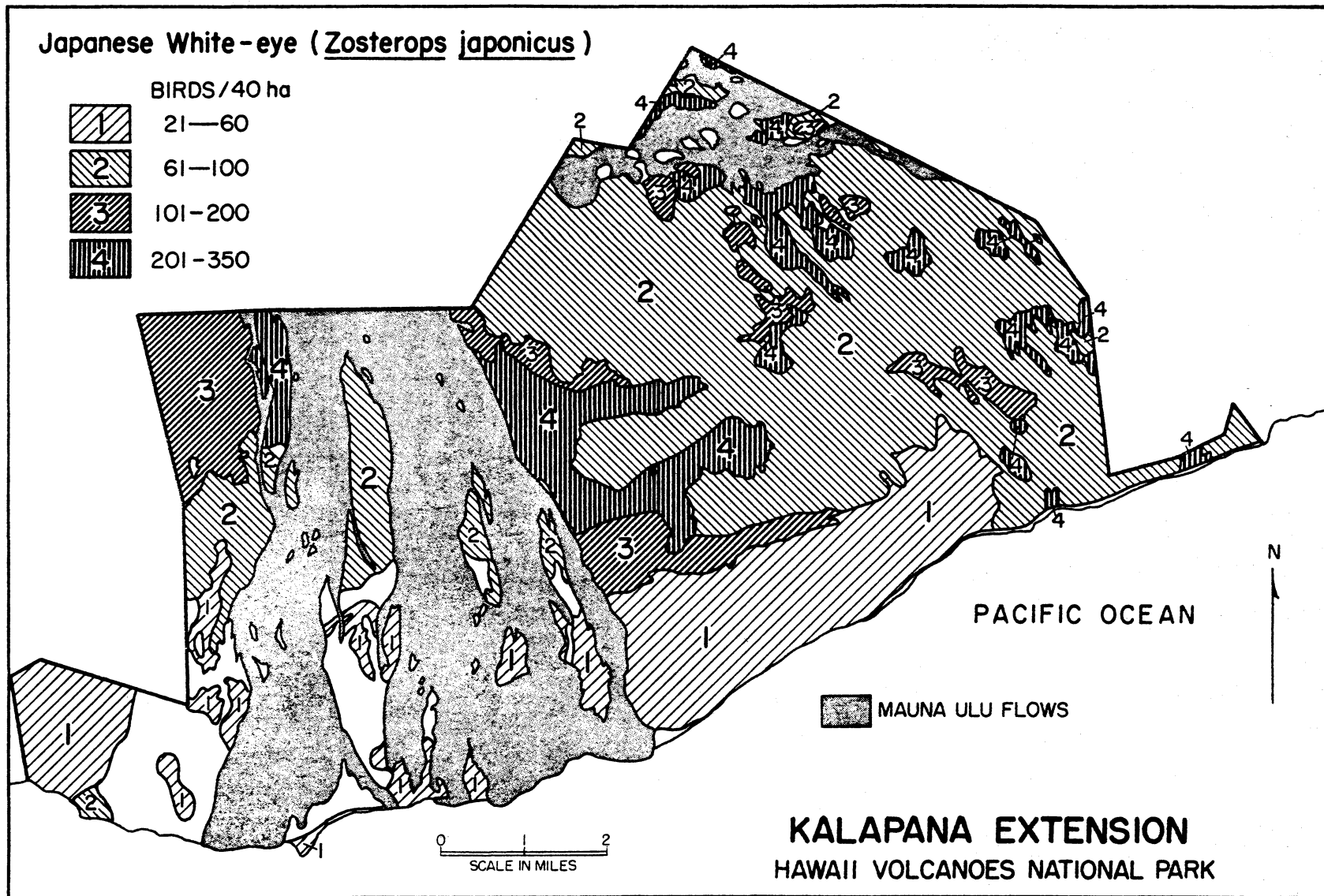
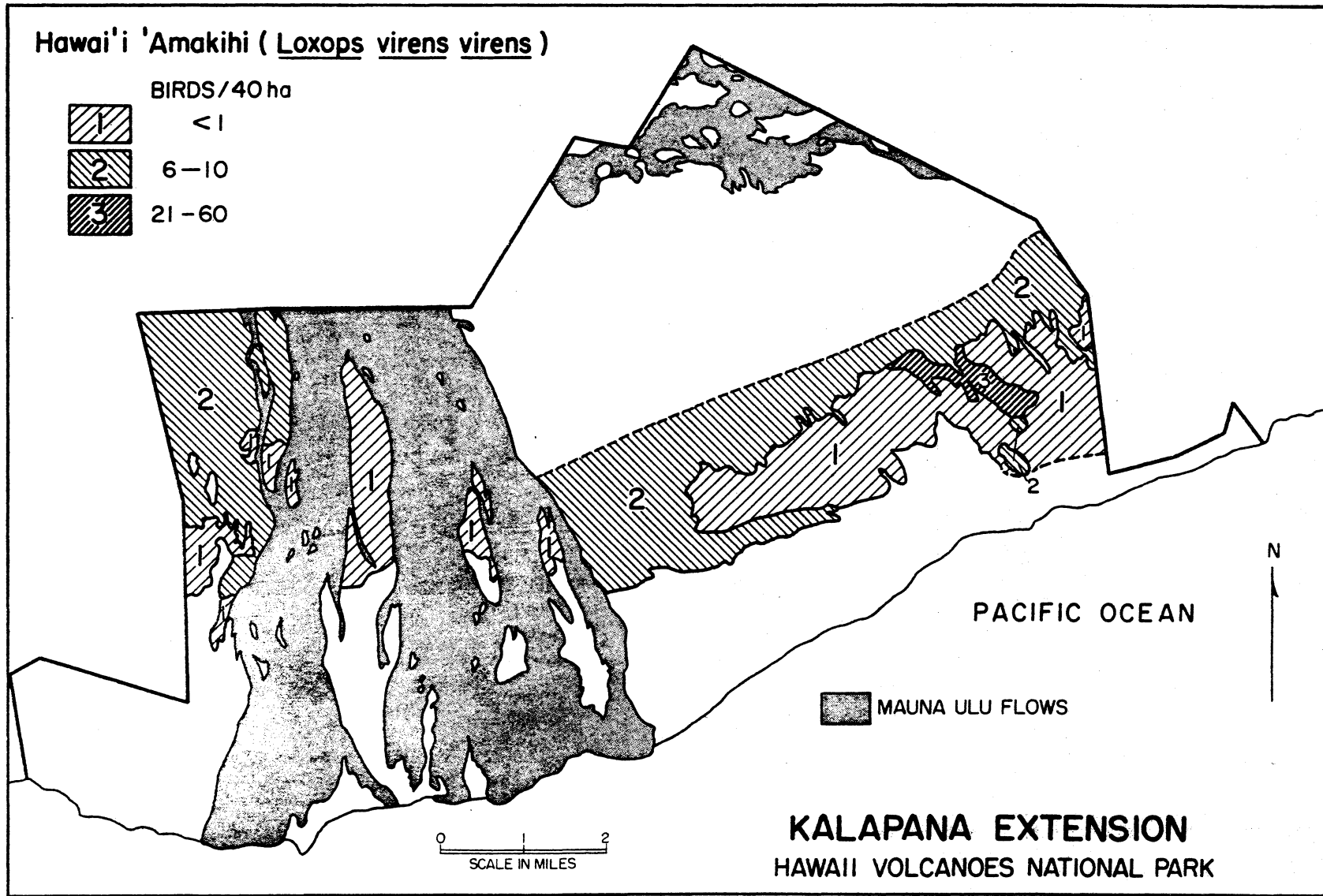


FIGURE 7. Map of the distribution of the Japanese White-eye in the Kalapana Extension, Hawaii Volcanoes National Park.

FIGURE 8. Map of the distribution of the Hawai'i 'Amakihi in the Kalapana Extension, Hawaii Volcanoes National Park.



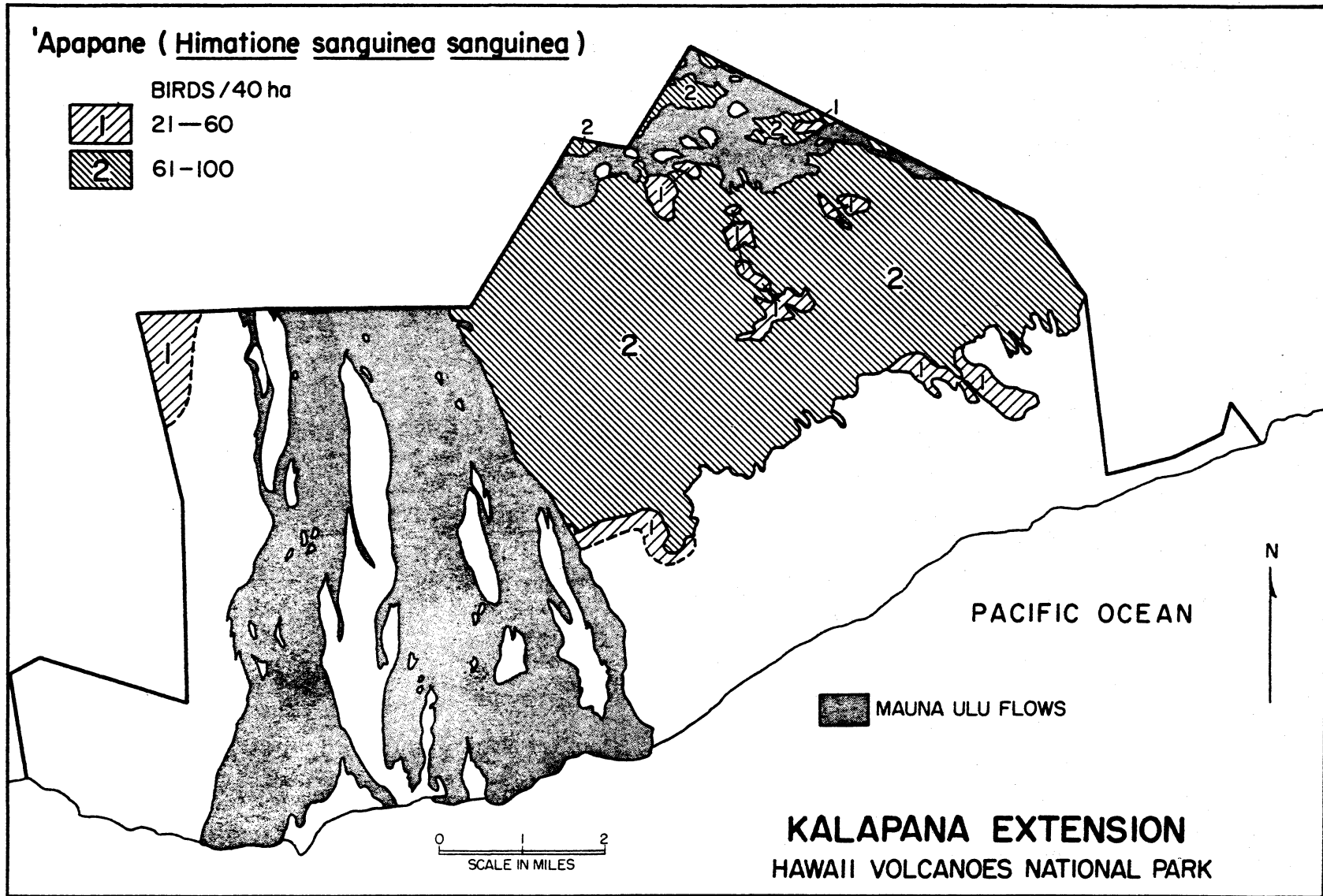
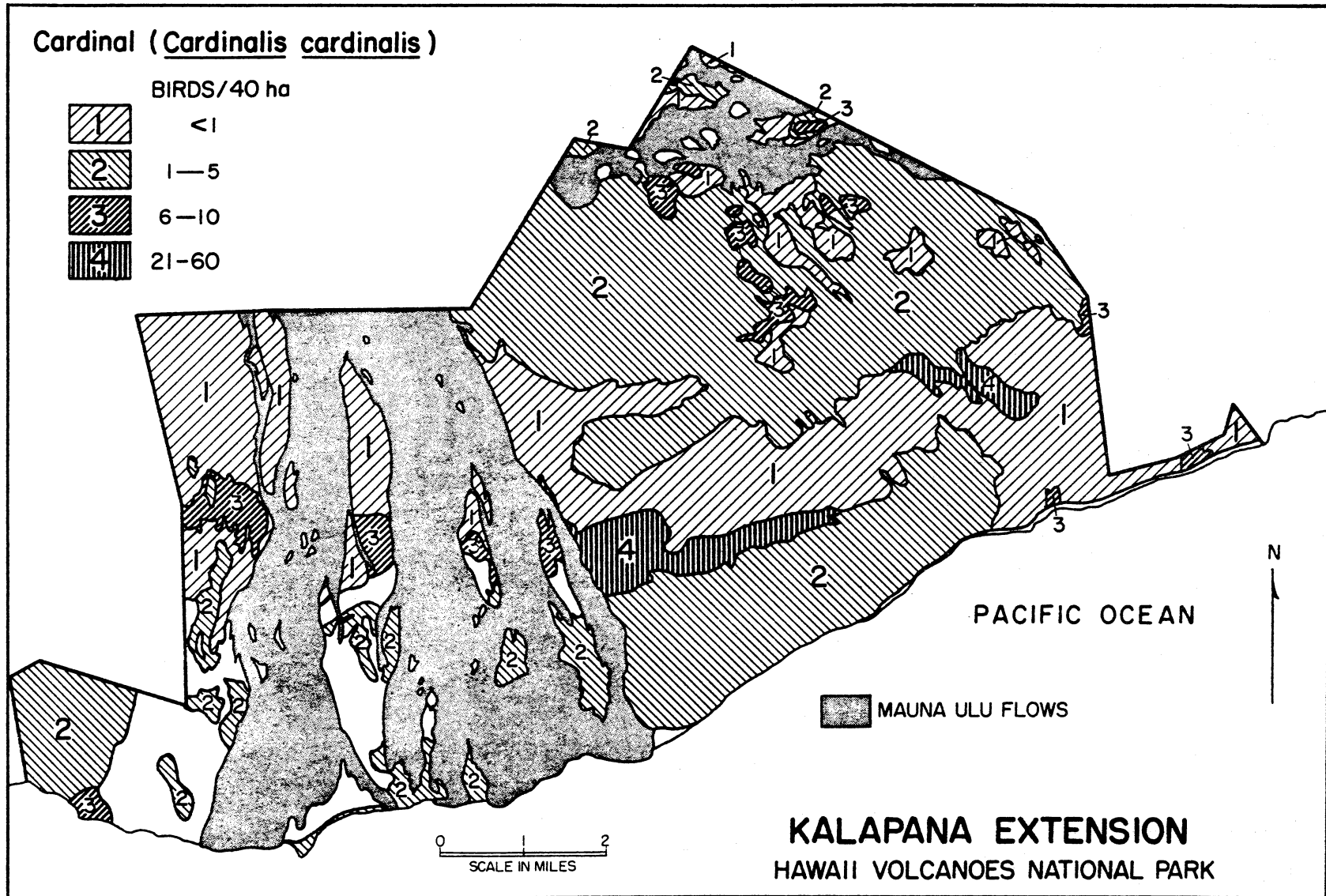


FIGURE 9. Map of the distribution of the 'Apapane in the Kalapana Extension, Hawaii Volcanoes National Park.

FIGURE 10. Map of the distribution of the Cardinal in the Kalapana Extension, Hawaii Volcanoes National Park.



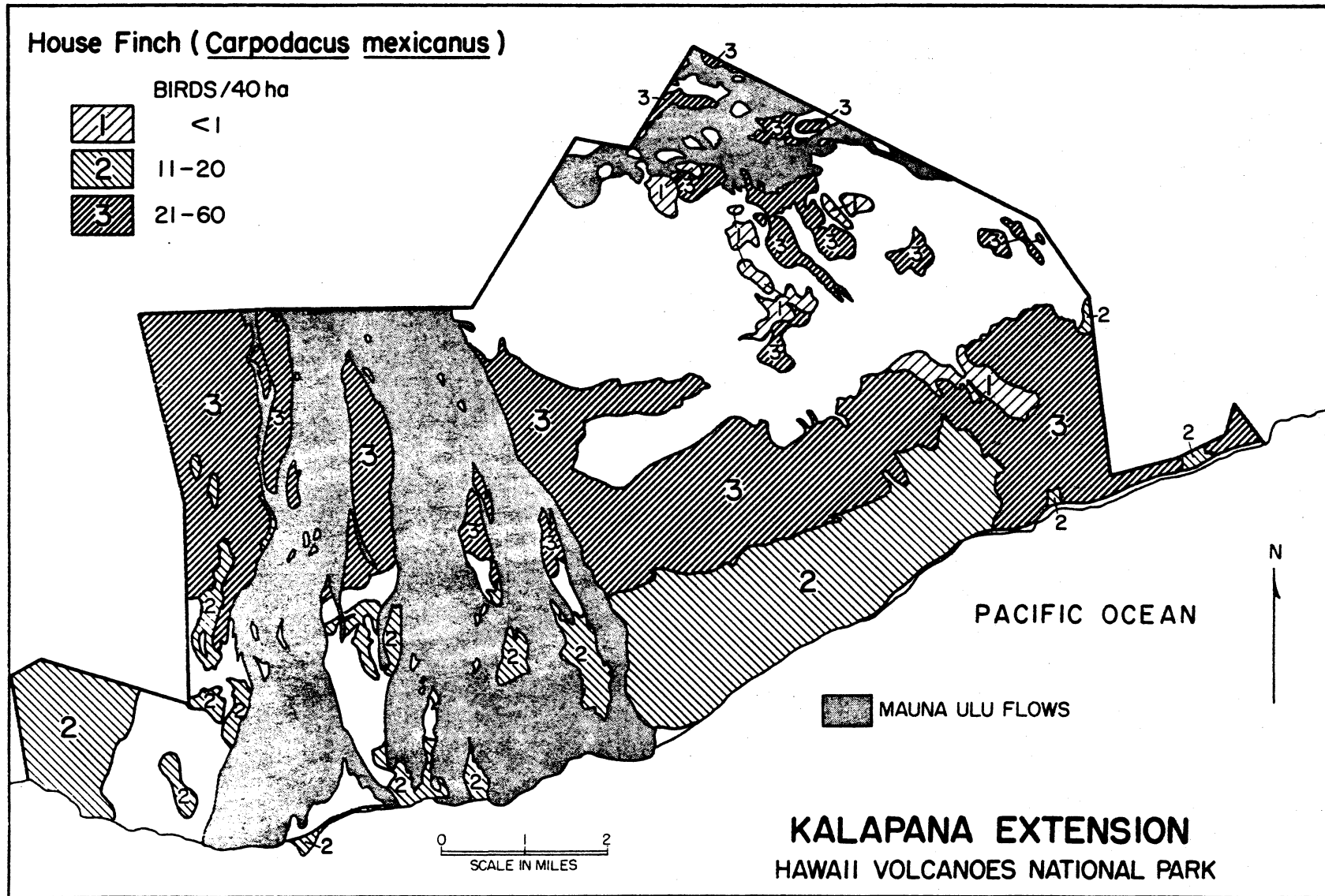
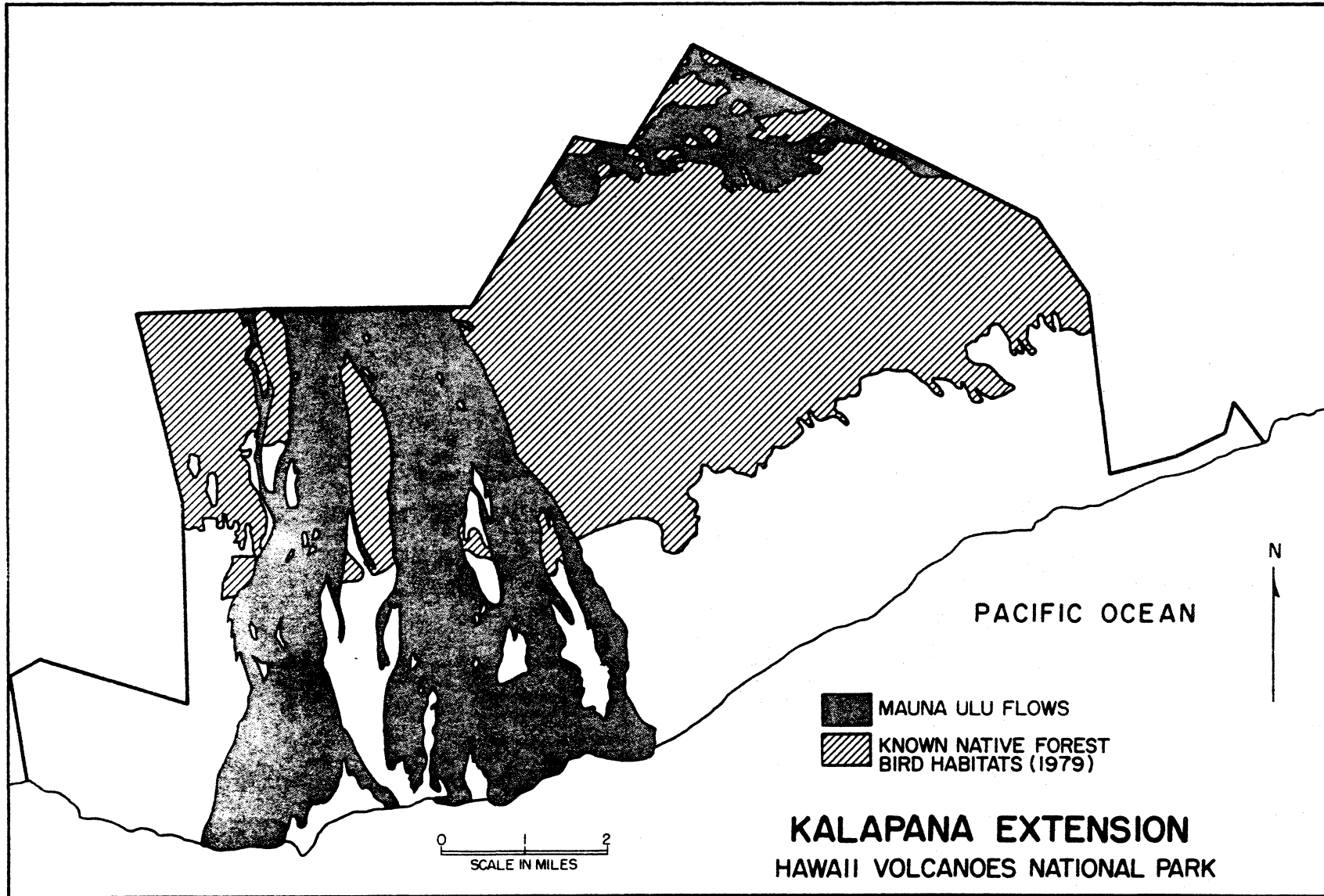


FIGURE 11. Map of the distribution of the House Finch in the Kalapana Extension, Hawaii Volcanoes National Park.

FIGURE 12. A map showing native forest bird ('Io, 'Elepaio, 'Ōma'o, 'Amakihi, 'Ō'u, 'Apapane) distribution in various habitats of the Kalapana Extension according to this study. Includes many habitats considered to be impaired by feral animals and exotic plants.



APPENDIX I

This list is based on field surveys conducted by the author from 1976 to 1978, on recently (since 1970) published records, and on incidental observations of biologists working in the study area in recent years. The geographic scope of the list is the Kalapana Extension of Hawaii Volcanoes National Park, and is shown in Figure 1.

The checklist format, particularly the species status symbols, closely follows Pyle (1977). Vernacular and scientific names follow the American Ornithologists' Union Check-list of North American Birds, 1957 edition, including the 32nd (A.O.U. 1973) and 33rd (A.O.U. 1976) Supplements. Nomenclature for introduced species not on the A.O.U. Check-list follows Berger (1976); names for native Hawaiian species follow Hawaii Audubon Society (1978) and Pyle (1977); and/or Hawaiian language names follow Titcomb and Gagné (1976).

Most species densities reported in this list were derived from censuses made using the transect count method described by Emlen (1971) or the circular plot method described by Ramsey and Scott (1979). Densities represent average values for similar habitat types.

STATUS SYMBOLS

RESIDENT SPECIES; NATIVE

- Re = Resident--endemic at species level;
not extinct
- Ri = Resident--indigenous species;
Hawaiian form not endemic
- Ris = Resident--indigenous species;
Hawaiian subspecies endemic

FOREIGN OR INTRODUCED SPECIES; RESIDENT

- Fl = Foreign--long-established;
breeding for more than 25 years
- Fn = Foreign--new introduction;
apparently established and breeding,
but for less than 25 years

BREEDING SPECIES IN HAWAI'I; NATIVE; MOST INDIVIDUALS LEAVE
HAWAI'I WHEN NOT BREEDING

- Bi = Breeder--indigenous species;
Hawaiian form also breeds elsewhere
- Bis = Breeder--indigenous species;
Hawaiian subspecies breeds only in
Hawaiian Islands

VISITOR SPECIES; BREEDS ELSEWHERE; OCCURS IN HAWAI'I WHEN NOT
BREEDING

- Vr = Visitor--regular migrant

ENDANGERED SPECIES (*)

An asterisk preceding the scientific name of the bird indicates that the species is currently on the federal list of endangered species (U. S. Fish & Wildlife Service 1979).

ANNOTATED LIST

FAMILY PROCELLARIIDAE (SHEARWATERS, PETRELS)

*Pterodroma phaeopygia sandwichensis 'Ua'u
 Bis Hawaiian Petrel
 (Dark-rumped Petrel)

Extremely rare. Species has been heard near Makaopuhi Crater by W. E. Banko (Kepler et al. 1979), but existence of nesting colony is not confirmed.

FAMILY ANATIDAE (DUCKS, GEESE)

*Branta sandvicensis Nēnē
 Re Hawaiian Goose

Endemic; endangered species.

Rare in scrub and grassland communities west of Mauna Ulu flows (P. Banko, J. & Z. Jacobi, pers. comm.; pers. obs.).

FAMILY ACCIPITRIDAE (HAWKS, EAGLES)

*Buteo solitarius 'Io
 Re Hawaiian Hawk

Endemic to Hawai'i Island; endangered species.

Uncommon (< 1 bird/40 ha) but recorded in all habitat types except rockland communities. Individuals observed regularly at Pua'i'ālua Crater and in closed 'ohi'a forest or eastern boundary of Kalapana Extension.

FAMILY PHASIANIDAE (QUAILS, PHEASANTS, FRANCOLINS)

Lophortyx californicus
 Fl California Quail

Foreign species; established and breeding more than 25 years.

Regularly observed but uncommon, in scrub 'ōhi'a forests, scrub and grassland communities adjacent to upper portions of 'Āinahou Ranch (J. & Z. Jacobi, pers. comm.; pers. obs.).

Francolinus erckelii

Fn

Erckel Francolin

Foreign species; introduced to Hawai'i in 1957; presumed to be breeding on Hawai'i Island.

Regularly observed but uncommon, in scrub 'ōhi'a forests, scrub and grasslands communities adjacent to upper portions of 'Āinahou Ranch (J. & Z. Jacobi, pers. comm.).

Francolinus adspersus

Fn

Closebarred Francolin

Foreign species; introduced to Hawai'i Island in 1957; presumed to be breeding.

Regularly observed but uncommon, in scrub 'ōhi'a forests, scrub and grassland communities adjacent to upper portions of 'Āinahou Ranch (J. & Z. Jacobi, pers. comm.).

Phasianus versicolor

Fl

Green Pheasant

Foreign species; established and breeding more than 25 years.

Regularly observed but uncommon, in scrub 'ōhi'a forests, scrub and grassland communities adjacent to upper portions of 'Āinahou Ranch (J. & Z. Jacobi, pers. comm.).

Phasianus colchicus

Fl

Ring-necked Pheasant

Foreign species; established and breeding more than 25 years.

Uncommon (1-3 birds/40 ha) in lowland scrub and grassland communities.

FAMILY CHARIDRIIDAE (PLOVERS)

Pluvialis dominica

Vr

Kōlea

Golden Plover

Visitor species; resident during non-breeding season (approx. September through March).

Uncommon (1-3 birds/40 ha), widely distributed throughout rockland scrub and grassland communities.

FAMILY LARIDAE (GULLS, TERNS, NODDIES)

Anous tenuirostris melanogenys
RiNoio
Hawaiian Noddy
(White-capped Noddy)

Indigenous breeding species; Hawaiian form not endemic.

Frequently observed in flocks of 2-20 birds along rocky shoreline. Birds frequently come to rest on rock ledges.

FAMILY COLUMBIDAE (DOVES)

Streptopelia chinensis
FlSpotted Dove
(Chinese Dove,
Lace-necked Dove)

Foreign species; established and breeding more than 25 years.

Uncommon (1-3 birds/40 ha) in 'ōhi'a-lama forests, scrub communities, and grasslands. Common (15 birds/ 40 ha) in open, mixed lowland forests. Also recorded from scrub 'ōhi'a forests near 'Āinahou Ranch.

Geopelia striata
Fl

Barred Dove

Foreign species; established and breeding more than 25 years.

Uncommon (1-3 birds/40 ha) in open, mixed lowland forests. Observed very infrequently in scrub 'ōhi'a forests west of Mauna Ulu flows.

FAMILY STRIGIDAE (TYPICAL OWLS)

Asio flammeus sandwichensis
RisPueo
Hawaiian Owl

Indigenous breeding species; Hawaiian subspecies endemic.

Rare; observed infrequently: in open 'ōhi'a forests near Poliokeawe Pali (J. Jacobi & F. R. Warshauer, pers. comm.) and over scrub communities at 1200 feet on the Kalapana Trail (pers. obs.).

FAMILY ALAUDIDAE (LARKS)

Alauda arvensis

Fl

Skylark

Foreign species; established and breeding more than 25 years; has been recorded as a straggler in the State.

Uncommon (1-3 birds/40 ha), but widely distributed primarily in grasslands, occasionally in scrub communities, primarily in lowland areas (i.e., below pali's).

FAMILY TIMALIIDAE (BABBLERS)

Garrulax canorus

Fl

Melodious Laughing-thrush
(Chinese Thrush, Hwa-mei)

Foreign species; established and breeding more than 25 years.

Uncommon (1-3 birds/40 ha) in open and closed 'ōhi'a forests and 'ōhi'a-lama forests. May be more abundant in some localities.

FAMILY TURDIDAE (THRUSHES)

Phaeornis obscurus obscurus

Re

'Ōma'o
Hawai'i Thrush

Endemic species; this subspecies endemic to Hawai'i Island.

Fairly common in closed (14-28 birds/40 ha) and open (4-11 birds/40 ha) 'ōhi'a forests. Uncommon (1-3 birds/40 ha) in 'ōhi'a-lama forests. Not observed below 1600 feet.

FAMILY MUSCICAPIDAE (OLD WORLD FLYCATCHERS)

Chasiempis sandwichensissandwichensis

Re

'Elepaio
Hawai'i 'Elepaio

Endemic species; this subspecies endemic to Hawai'i Island.

Uncommon (2-4 birds/40 ha) in open and closed 'ōhi'a forests. Somewhat more common (13 birds/40 ha) in 'ōhi'a-lama forests. Not observed below 400 feet.

FAMILY ZOSTEROPIDAE (WHITE-EYES)

Zosterops japonicus

Fl

Japanese White-eye
(White-eye, Mejiro)

Foreign species; established and breeding more than 25 years.

By far the most abundant and widely distributed bird species in the Kalapana Extension. Occurs in all but rockland communities: open 'ōhi'a forests (193-266 birds/40 ha); closed 'ōhi'a forests (78-156 birds/40 ha); 'ōhi'a-lama forests (149 birds/40 ha); open, mixed lowland forests (213 birds/40 ha); scrub communities (80 birds/40 ha); and grasslands (64 birds/40 ha).

FAMILY STURNIDAE (MYNAS)

Acridotheres tristis

Fl

Common Myna

Foreign species; established and breeding more than 25 years.

Uncommon except near picnic areas, campgrounds, and buildings. Regularly observed, but very uncommon in open, mixed lowland forest, scrub communities, and grasslands.

FAMILY DREPANIDIDAE (HAWAIIAN HONEYCREEPERS)

SUBFAMILY PSITTIROSTRINAE (GREEN AND YELLOW HONEYCREEPERS)

Loxops virens virens

Re

'Amakihi
Hawai'i 'Amakihi

Endemic species; this subspecies endemic to Hawai'i Island.

Patchily distributed. East of Mauna Ulu flows: primarily limited to open 'ōhi'a forests (5 birds/40 ha) and 'ōhi'a-lama forests (47 birds/40 ha) between 400 and 1600 feet. West of Mauna Ulu flows: in open and scrub 'ōhi'a forests (30-50 birds/40 ha) and 'ōhi'a-lama forests (20-40 birds/40 ha) from about 1200 feet and upwards. Has been observed in edges of closed 'ōhi'a forests in northeastern portion of Kalapana Extension (J. Jacobi, pers. comm.).

*Psittirostra psittacea

Re

'Ō'ū

Endemic species.

Extremely rare. Sighted near northeastern border of Kalapana Extension by Scott (pers. comm.) and Reeser (pers. comm.). Also occurs in 'Ōla'a Tract.

SUBFAMILY DREPANIDINAE (RED AND BLACK HONEYCREEPERS)

Himatione sanguinea sanguinea 'Apapane
Re

Endemic species; this subspecies endemic to main Hawaiian Islands.

Abundant above 400 feet in open (42-106 birds/40 ha) and closed (102 birds/40 ha) 'ōhi'a forests and 'ōhi'a-lama forests (65 birds/40 ha). Very sparse (< 1 bird/40 ha) in open and scrub 'ōhi'a forests within and west of Mauna Ulu flows (J. Jacobi, pers. comm.; pers. obs.).

FAMILY PLOCEIDAE (WAXBILLS, MUNIAS, WEAVER FINCHES)

Lonchura punctulata
Fl Spotted Munia
(Ricebird)

Foreign species; established and breeding more than 25 years.

Sparsely but widely distributed in flocks of 4-16 birds in open, mixed lowland forests, scrub and grassland communities.

Passer domesticus
Fl House Sparrow

Foreign species; established and breeding more than 25 years.

Observed infrequently near picnic areas, campgrounds, and buildings.

FAMILY FRINGILLIDAE (CARDINALS, FINCHES)

Cardinalis cardinalis
Fl Cardinal
(Northern Cardinal,
North American Cardinal,
Kentucky Cardinal)

Foreign species; established and breeding more than 25 years.

Widely distributed: closed 'ōhi'a forests (1-3 birds/40 ha); open 'ōhi'a forests (1-6 birds/40 ha); 'ōhi'a-lama forests (22 birds/40 ha); open, mixed lowland forests (7 birds/40 ha); scrub and grassland communities (1-3 birds/40 ha).

Carpodacus mexicanus
Fl

House Finch
(Linnet, Papayabird)

Foreign species; established and breeding more than 25 years.

Infrequently observed in open and closed 'ōhi'a forests; uncommon (1-3 birds/40 ha) in 'ōhi'a-lama forests; common in scrub 'ōhi'a and open, mixed lowland forests (15 birds/40 ha), scrub communities (27 birds/40 ha), and grasslands (14 birds/40 ha). Most frequently observed in flocks of highly variable size.

