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Plant Succession in Native Rain Forest of East Maui following Marijuana Cultivation

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INTRODUCTION

Cultivation of marijuana on public and private conservation lands is an illegal yet relatively widespread practice. The plant succession that follows this type of cultivation has been speculated upon, but, to our knowledge, no data have been published.

Marijuana *(Cannabis sativa)* is a quick-growing, primarily dioecious, annual herb that may reach heights of 12 m (Simmonds 1976). Originally probably a native of central Asia, it has been widely cultivated in both tropical and temperate areas. Though often included in the mulberry or fig family (Moraceae) (St. John 1973), *Cannabis sativa* L. is considered in many modern works as a member of the Cannabaceae or hemp family.

THE STUDY AREA

The rain forest study site, at 1495 m (4900 ft) elevation on the northwest, outer slopes of Haleakala volcano, is located in the Waikamoi Preserve, a private conservation area managed by The Nature Conservancy. The surrounding vegetation is near-pristine koa *(Acacia koa)* and 'ohi'a-lehua *(Metrosideros polymorpha)* forest with tree canopies up to 30 m (100 ft) tall. The native understory vegetation consists of small trees and shrubs, including *Cheirodendron trigynum, Vaccinium calycinum, Broussaisia arguta, Clermontia arborescens, Coprosma stephanocarpa, Styphelia tameiameiae, Pelea clusiaefolia,* and *P. parvifolia*, with a mixed, matted fern understory, primarily *Diplazium sandwichianum* with *Athyrium microphyllum, Coniogramme pilosa, Dryopteris wallichiana, D. hawaiiensis, D. unidentata* var. *ukuleleensis, Sadleria pallida, S. souleytiana, Marattia douglasii, Cibotium glaucum, Elaphoglossum hirtum* var. *micans, E. wawrae*, and *Asplenium* spp.

Native birdlife of the area includes six species of honeycreepers (Drepanidinae). The Common 'Amakihi *(Hemignathus virens)*, 'Apapane *(Himatione sanguinea)*, 'I'iwi *(Vestiaria coccinea)* and Maui Creeper *(Paroreomyza montana)* are all somewhat common. The 'Akohekohe or Crested Honeycreeper *(Palmeria dolei)* and Maui Parrotbill *(Pseudonestor xanthophrys)*, both Federally listed endangered species, occur nearby, and this area is former habitat according to the field notes of R.C.L. Perkins from the 1890's.

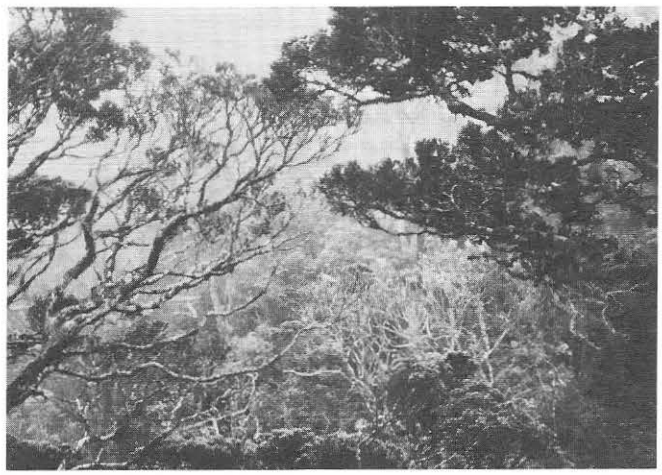
Cultivation of marijuana in forest conditions often includes major site alterations. If the area used is not already a forest clearing, then trees and shrubs are often cut to allow sunlight to reach the forest floor. Natural forest openings are often enlarged by cutting peripheral trees, as has occurred in the cultivated plots in the study area. The creation of an artificial light gap in a montane rain forest ecosystem causes immediate changes in species composition, involving loss of delicate moisture-loving species such as lobelias *(Clermontia arborescens)*, filmy ferns (Hymenophyllaceae) and other ferns *(Ctenitis rubiginosa* and *Dryopteris unidentata* var. *ukuleleensis).*

The plots cultivated in the study area were cleared of koa and 'ohi'a-lehua trees, *Vaccinium* shrubs, native fern ground cover, and leaf litter, and a time-release fertilizer was added to the soil. The marijuana plants were brought into the site in small containers with soils from another area, judging by the diversity and biomass of alien plants found growing only at the cultivation site. Based on the decomposition of the wood of cut trees, the sites were estimated to have been in cultivation for 2-3 years.

The Maui Police Department destroyed the marijuana plants growing in the plots in August 1986. This study was initiated two months later in October 1986.

METHODS

Three cleared, formerly cultivated areas (approximately 200 m^2, 60 m^2, and 40 m^2) were examined to determine trends of successional recovery of native vegetation and the establishment and persistence of alien plant species. A list of alien plant taxa growing within the cleared areas was compiled and presence/absence noted in October 1986 and January 1988 (Table 1). Notes were made on the mode of reproduction for introduced species, that is, whether reproduction was by seed or vegetative. In each of the three plots, cover of each plant species was estimated (Table 2). To supplement the somewhat subjective cover estimates, a 17 m transect was established in the largest cleared area with PVC pins marking the endpoints. Along this transect, a point-intercept frame was used to sample the vegetation cover, with one sampling point every decimeter for a total of 170 sampling points (Table 3). In order to determine changes in a large patch of alien blackberry *(Rubus argutus)*, a 6 m^2 (2 m x 3 m)



Waikamoi Preserve, Maui

Table 1. List of alien plant species found in cultivated plots in Waikamoi. Distributions from St. John (1973).

MONOCOTS:

1. ***Anthoxanthum odoratum* L.** **Poaceae** Sweet Vernal Grass
   Cult. established, native to Europe. Established in plot by imported seed; disappeared within 15 months.
2. ***Holcus lanatus* L.** **Poaceae** Velvetgrass
   Cult. established, native to Europe. Established in plot by imported seed; persistent after 15 months.
3. ***Ehrharta stipoides* Labill.** **Poaceae** Meadow Ricegrass
   Adventive, native to Australia and Polynesia. Established in plot by imported seed; persistent and apparently established after 15 months.
4. ***Paspalum conjugatum* Berg.** **Poaceae** Hilo Grass
   Adventive, native to tropical America. Established in plot by imported seed; persistent after 15 months.
5. ***Paspalum* cf. *urvillei* Steud.** **Poaceae** Vaseygrass
   Cult. established, New World native. Established in plot by imported seed; persistent after 15 months.
6. ***Setaria palmifolia* (Konig.) Stapf** **Poaceae** Palmgrass
   Cult. established, native to tropical Asia. Established in plot by imported seed; first recorded in study plots on 1/22/88.
7. ***Sporobolus africanus* (Poir.) Robyns & Tourney** **Poaceae** African Dropseed, Rattail Grass
   Cult. established, native to south Africa. Established in plot by imported seed; disappeared after 15 months.

DICOTS:

8. ***Conyza bonariensis* (L.) Cronq.** **Asteraceae** Horseweed
   Adventive, native to the tropics. Established in plot by windblown or imported seed; disappeared after 15 months.
9. ***Epilobium cinereum* A. Rich.** **Onagraceae** Pukamole
   Adventive, native from New Zealand to Java. Established in plot by windblown or imported seed; persistent after 15 months.
10. ***Erechtites valerianaefolia* (Wolf) DC.** **Asteraceae**
    Adventive from tropical America. Established in plot by windblown or imported seed; disappeared after 15 months.
11. ***Gnaphalium japonicum* Thunb.** **Asteraceae**
    Adventive, native to Japan. Established in plot by windblown or imported seed; disappeared after 15 months.
12. ***Hypochoeris radicata* L.** **Asteraceae** Hairy Cats' Ear
    Adventive, native to the Mediterranean region. Established in plot by imported seed or rhizome, persistent after 15 months.
13. ***Rubus argutus* Link** **Rosaceae** Blackberry
    Adventive, native to southeastern United States. Established in plot by imported seed or rhizome; apparently established and spreading after 15 months.
14. ***Rumex crispus* L.** **Polygonaceae** Yellow Dock
    Adventive, native to Eurasia. Established in plot by imported seed; disappeared after 15 months.
15. ***Sonchus oleraceus* L.** **Asteraceae** Sow Thistle
    Adventive, native to Europe. Established in plot by imported seed; persistent after 15 months.

quadrat was marked with PVC corner pins, and cover of plant species within were estimated to the nearest 5% (Table 4).

The first data were collected and the quadrat and transect marked on 8 October 1986. The second data were collected on 22 January 1988, 15½ months later.

RESULTS

At the study onset, 14 species of alien plants had been introduced into the rain forest clearings as a result of marijuana cultivation (Table 1). After 15 months, six species of alien plants had disappeared, due to the death of existing individuals and failure to reseed. Of the eight surviving alien plant species, four species—velvetgrass *(Holcus lanatus),* meadow ricegrass *(Ehrharta stipoides),* Hilo grass *(Paspalum conjugatum),* and blackberry *(Rubus argutus)*—appear capable of persisting and spreading. One species *(Setaria palmifolia),* not noted initially, was first found in January 1988.

Based on the cover estimates in the three plots (Table 2), bare ground has decreased and certain alien species appear to be only maintaining themselves while others are increasing their cover and, in some cases, numbers of individuals. Using cumulative totals of all cover in all three plots (potential overall total of 300%, lumping data from plots of unequal areas), velvetgrass increased from 1% to 10%; blackberry from 4% to 26%; and *Ehrharta* from 82% to 94%. Native ferns and, to a lesser degree, native sedges cover much of the formerly bare ground and overtop open areas. Among the endemic ferns, *Sadleria pallida* and the smaller rhizomatous *Dryopteris hawaiiensis* are the primary colonizers.

Much of the vegetation recovery has been made by native or endemic plant species, which increased in cover from 40% to 78%, based on the point intercept data collected along the 17 m transect (Table 2). Native ferns increased from 20% to 52%; *Sadleria pallida,* an endemic tree fern, tripled its cover (10% to 34%). The native sedge

Table 2 Status of selected plant species and bare ground in plots (* = alien species).

Plot 1. Upper plot (200 m²)

During the 15-month period in plot #1, **Hypochoeris* declined markedly (2% to 0.1%). **Paspalum conjugatum*, **Epilobium*, and **Sonchus* declined slowly (total 4% to 2.4%). Both **Rumex* and **Anthoxanthum* (1.5% and 0.5% respectively in 1986) disappeared. A single plant of **Setaria* was recorded in 1988.

	Oct. 1986	Jan. 1988
**Holcus lanatus*	1%	10%
**Rubus argutus*	2%	12.5%
Uncinia uncinata	15%	5%
Nertera grenadensis	2%	5%
Native ferns	20%	50%
Native sedges	2%	10%
Total for all native species	**39%**	**70%**
Total for all alien species	**12%**	**25%**
Bare ground	50%	5%

Plot 2. West plot (40 m²)

In the 15-month period, **Hypochoeris*, **Erechtites* and **Sporobolus* (together 4%) disappeared, and the native woody species, *Acacia* and *Coprosma*, remained constant at about 1% each. A single plant of **Setaria* was recorded in 1988.

	Oct. 1986	Jan. 1988
**Rubus argutus*	2%	10%
**Ehrharta stipoides*	2%	4%
**Paspalum conjugatum*	14%	14%
**Paspalum* cf. *urvillei*	2%	2%
Native sedges	4%	15%
Native ferns	20%	40%
Total for all native species	**25%**	**56%**
Total for all alien species	**24%**	**30%**
Bare ground	50%	15%

Plot 3. East plot (60 m²)

In the 15-month period, **Hypochoeris*, **Gnaphalium*, **Conyza*, *Vaccinium*, and *Uncinia* (together 3%) disappeared. The native species, *Rubus hawaiiensis*, *Acacia* and *Coprosma*, remained constant throughout at about 3% in total.

	Oct. 1986	Jan. 1988
**Ehrharta stipoides*	80%	90%
**Rubus argutus*	0.5%	3.0%
Native sedges and ferns	5%	4%
Total for all native species	**8%+**	**7%**
Total for all alien species	**83%**	**93%**
Bare ground	7.5%	0%

Table 3. Point-intercept cover results (* = alien species).

	Oct. 1986	Jan. 1988
Athyrium microphyllum	—	0.5%
Dryopteris hawaiiensis	10.0%	14.7%
Dryoperis wallichiana	—	2.9%
Sadleria pallida	10.0%	33.5%
Carex alligata	2.9%	5.9%
Uncinia uncinata	14.1%	12.9%
Alyxia olivaeformis	—	1.2%
**Hypochoeris radicata*	1.2%	1.2%
Nertera grenadensis	1.2%	5.3%
Rubus hawaiiensis	1.8%	0.6%
**Rubus argutus*	0.6%	—
**Sonchus oleracea*	0.6%	1.2%
Styphelia tameiameiae	0.6%	—
Leaf litter	20.6%	11.2%
Bare ground	36.5%	8.8%
Total for all native species	**40.1%**	**77.5%**
Total for all alien species	**2.4%**	**2.4%**
Total for all vegetation	**42.5%**	**79.9%**

Carex alligata doubled its estimated cover value from 3% to 6%, while the native pioneer sedge *Uncinia uncinata* remained stable (14% to 13%).

Within the 2 m x 3 m marked quadrat, four species (including three natives) increased over the 15-month period, accounting for a reduction in bare ground from 50% to 5% (Table 4). The major alien plant species in the quadrat, *Rubus argutus*, expanded its cover from 40% to 65%, spreading beyond the cleared area into the surrounding matted fern understory.

DISCUSSION

From a conservation viewpoint, the worst of the alien plants that invaded the cultivated area are blackberry and the meadow ricegrass. In this area, *Paspalum conjugatum* and *Setaria palmifolia* present lesser apparent threats, but warrant monitoring. Many of the

Table 4. Estimated cover of plant species within marked 2 m x 3 m quadrat (* = alien species; X = less than 2.5% cover).

	Oct. 1986	Jan. 1988
Acacia koa	X	X
Coprosma stephanocarpa	X	X
Dryopteris hawaiiensis	X	X
Metrosideros polymorpha	X	X
Rubus hawaiiensis	X	X
Styphelia tameiameiae	X	X
Uncinia uncinata	X	5%
Carex alligata	X	10%
Sadleria pallida	5%	20%
**Rubus argutus*	40%	65%
**Conyza bonariensis*	X	—
**Sonchus oleraceus*	X	—
Total for all native species	**5%+**	**35%+**
Total for all alien species	**40%+**	**65%+**
Bare ground	50%	5%

other alien plants initially present in the plots were pioneer species, thriving on high levels of light intensity and nutrient availability. As the fertilizer nutrients became depleted and native ferns began to overtop the cleared area, many of these early successional species have disappeared, unable to naturalize locally.

Blackberry is one of the most invasive weeds in Hawaii (Smith 1985), especially in the cooler, upper elevations. It has developed dense, nearly impassable, thickets in native ecosystems on nearly all the main Hawaiian islands. This species is considered one of the most threatening of alien plants in Maui's Haleakala National Park (Loope *et al.* in press). Once established, this thorny shrub develops long leader branches that root where they touch the ground. Blackberry is of particular concern because it does not depend on feral pigs to successfully invade the relatively intact mixed fern understory of native rain forests. This weed spreads vegetatively as well as via the dispersal of seeds by birds that eat its fleshy fruits.

The shade-tolerant meadow ricegrass *(Ehrharta stipoides)* forms dense green mats in pig diggings in rain forests on Hawaii Island. The seeds are "hitchhikers", dispersing themselves by clinging to pig manes and hikers' socks. Still not common in most montane rain forest areas of Maui, this species is a noxious pest and should be prevented from gaining a foothold on the island, if possible.

The potential for negative impact of marijuana cultivation on native rain forests is substantial. In many respects, its effects are similar to those of pig digging. In both types of disturbance, there is removal of much of the herbaceous understory, upturning of the uppermost soil layers, and importation of foreign plant seeds. Some of the weed species that invaded cultivated plots are also characteristic pioneer species of pig diggings on upper Haleakala, e.g. *Holcus lanatus* and *Hypochoeris radicata* (pers. observ.).

Though both activities may be superficially similar, certain detrimental effects are exclusive to marijuana cultivation. First, there is the distinct possibility of long-distance importation of noxious alien plant species. Feral pigs may move propagules around within a given area of home range; however, the distances that seeds are dispersed appear to be limited (pers. observ.). In marijuana cultivation, soil (including hitchhiking seeds) may be transported many miles into remote sites within pristine native forests.

Many noxious weeds have restricted distributions in the Hawaiian Islands, and their spread between islands is highly detrimental. The potential cost of eliminating such weeds once established in a natural area may be prohibitive. Federal and State agencies and private landowners are currently exerting much effort to prevent the spread of noxious weeds such as *Clidemia hirta,* other melastomes, banana poka *(Passiflora mollissima),* fountain grass *(Pennisetum setaceum),* and mullein *(Verbascum thapsus)* that threaten native ecosystems. Site alterations in rain forest to support marijuana cultivation may not only degrade the existing native vegetation but also produce ideal conditions for alien species. In addition, the clandestine nature of marijuana cultivation places potentially noxious alien weeds in remote, rarely visited areas. This prevents the early detection and control of alien species, which is critical if management is to be effective in dealing with invading species.

The establishment and spread of blackberry and meadow ricegrass in the plots studied provide examples of long distance dispersal of noxious plant pests. Yellow dock *(Rumex crispus),* a somewhat rare weed on Maui, is mostly found in disturbed areas at middle elevation on the island. Dispersal of this species over several kilometers from the nearest natural population to a site within relatively pristine forest is consistent with expected consequences of marijuana cultivation. The Ola'a district of Hawaii island is an area used for marijuana cultivation where *Torenia fournieri,* a rare alien species otherwise not naturalized in Hawaii, has been collected (L. Cuddihy, pers. comm.). In the Puna district of Hawaii island, the weed *Impatiens sultani* is often an indicator of sites formerly used for marijuana cultivation (L. Cuddihy, L. Stemmermann, pers. comm.). In the Waikamoi Preserve, staffs of white ginger *(Hedychium coronarium)* are sometimes used by marijuana growers to mark the location of cultivation areas. These plants slowly spread vegetatively, becoming small clumps that must be removed by managers to prevent further invasion. Sites of marijuana cultivation, used perhaps as long ago as a decade, are identifiable by their still-open understories as well as the presence of characteristic alien plant species.

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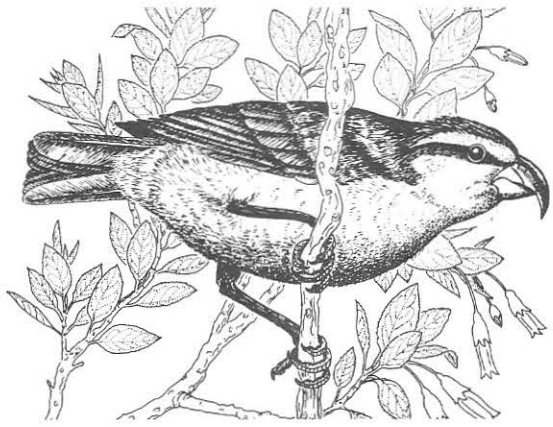


Maui Parrotbill (*Pseudonestor xanthophrys*), one of Maui's rarest endangered birds.

Drawing by Nanci Sidaras

Factors Affecting Groundings of the Endangered Dark-rumped Petrel on Maui in 1987

Renate Gassmann-Duvall[1], Lloyd L. Loope[2], and Fern Duvall II[3]

The largest known surviving nesting colony of the Hawaiian Dark-rumped Petrel or 'Ua'u *(Pterodroma phaeopygia sandwichensis)* is in Haleakala National Park on the island of Maui (Conant 1979, 1980, 1981; Simons 1983, 1984, 1985). Other possible remnant 'Ua'u populations have been reported from Kauai (Telfer *et al.* 1987), Lanai (Shallenberger 1974; Hirai 1978), and from Hawaii (van Riper 1978, Banko 1980). Although the future of the Hawaiian 'Ua'u subspecies is believed to depend largely on the survival of the Haleakala breeding colony (Simons 1983, U.S. Fish and Wildlife Service 1983), the large numbers of grounded juvenile petrels on Kauai over the past ten years could indicate the presence of a breeding colony there (Telfer, pers. comm., 1988).

The 'Ua'u, like the Nene *(Nesochen sandvicensis)*, appears to benefit from localized control of predators (Conant 1981, Simons 1983). Simons (1983, 1984, 1985) investigated 'Ua'u biology and conservation status and found that reproductive success of the birds increased dramatically following the start in 1980 of a program by Haleakala National Park to control mongooses and feral cats.

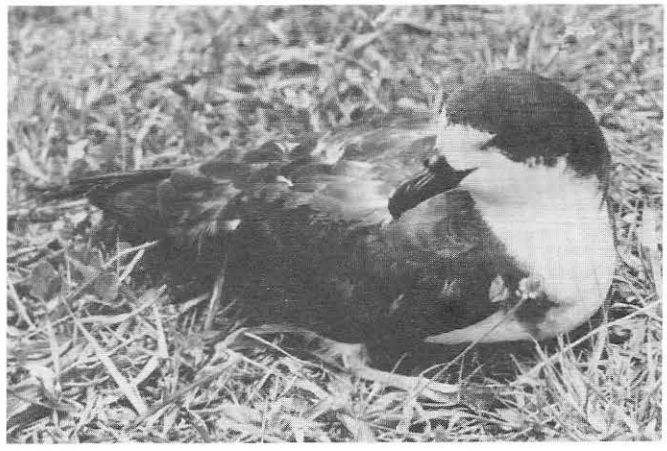
Fledgling petrels, like fledglings of the more-studied Newell's Shearwater or 'A'o *(Puffinus auricularis newelli)*, are sometimes attracted to and disoriented by the bright lights of urban areas while heading for the sea on their first flight. In contrast to the importance of light-related groundings of the Newell's Shearwater on Kauai (Telfer *et al.* 1987), light related groundings of petrels on Maui have not been considered a serious threat at present (Simons 1983, 1984). Simons (1984) stated, however, based on a computer model, that "the problem can be expected to increase with growing urbanization on Maui and should be monitored closely because the loss of only 15 chicks a season could tip the balance between a constant or increasing population or a declining one." According to the same model, a loss of 20 chicks would cause an annual population decline of 1.5%. Speculations as to why petrels suffer less light related fallout than shearwaters have suggested that (1) petrels on Maui, due to the high-elevation (2500-3000 m) nesting grounds, fly higher than birds on Kauai and therefore might experience less disorientation from urban lights (Simons 1983), (2) petrels use routes to the ocean which are less influenced by urban lights, or (3) that petrels may not be as susceptible to light attraction as are shearwaters (U.S. Fish and Wildlife Service 1983). The effects of moon phases on petrel fallout on Maui have not been previously explored.

Little is known for such species about specific diseases or parasites and their role as limiting factors. Avian pox has been recorded recently in a few cases in Newell's Shearwater on Kauai (T. Telfer, pers. comm., 1988); it has never been reported for Dark-rumped Petrels. Simons (1985) postulated that the death of five petrel fledglings in 1979-1980 might have been caused by starvation; there was no definitive explanation in that study for the relatively large number of eggs (ca. 20-30%) which did not hatch in 1979-81. Levels of organochlorine compounds that would lower reproductive success were in a range generally considered "normal," although nothing is known regarding the specific susceptibility of petrels to organochlorine. Since petrel egg shells are exceptionally thin, levels of organochlorine necessary to reduce hatchability might be much lower than for other birds (Simons 1985).

Fledgling petrels on their first flight from their nest may, like shearwaters, be attracted to and blinded by artificial lights, often with the result that birds crash into obstacles and fall. Such fallen birds, which are found between 8-30 October (Simons 1985), are generally unable to take off from the ground even if not injured and will perish. Even after they have reached the ocean successfully, fledglings may be attracted back to land by bright lights of urban areas and suffer grounding. That the light attraction problem is most relevant for fledglings and not for adults was described by Telfer *et al.* (1987). Petrel grounding has been noted on Maui since the early 1970s. Simons (1983) included a report by C.B. Kepler (pers. comm.) of an otherwise undocumented large grounding of 20-30 petrels in the early 1970s in Lahaina, Maui. Berger (1981) described the grounding of 8 birds in 1976. Simons and Haleakala National Park, with cooperation of the Hawaii State Division of Forestry and Wildlife, initiated a major publicity campaign to educate the Maui public in 1980, through newspaper articles, radio spots, and distribution of "wanted" posters. Two "petrel aid stations" were set up to receive the grounded birds. Response was minimal (Table 1), indicating that few groundings occurred, and the publicity program decreased in intensity. In contrast to the low number of petrels turned in to the aid stations on Maui, the shearwater aid program on Kauai, established in 1978, has salvaged 15,143 birds, mostly shearwaters, over nine years.

The "petrel aid program" was revived on Maui in mid-October 1987, through the initiative of Haleakala National Park and Olinda Endangered Species Facility personnel after a grounded petrel was found near Makawao, Maui. Ten groundings from which seven birds could be successfully released were registered between 14-24 October 1987 (Table 2). All birds were juveniles.

Of the three birds which could not be salvaged, one bird had been found dead and two birds died soon after they were found. All three dead petrels were sent to the National Wildlife Health Center in Madison, Wisconsin, for necropsy and ancillary tests. The diagnoses of the three dead petrels were as follows: 1) trauma caused by a perforatic wound in the thorax, probably due to a bite by a predator; 2) trauma, internal bleeding; and 3) multifocal pneumonia, caused by an undetermined fungus (N. Thomas, pers. comm., 1987).



Dark-rumped Petrel

Photo by Larry Hirai

Table 1. Known groundings of Dark-rumped Petrels on Maui through 1987. Data for 1982-1986 from records of Meyer Ueoka, Hawaii Division of Forestry and Wildlife, Wailuku, Maui.

Year	Known Groundings	Known Deaths	Source
early 1970s	20-30		Simons 1983
1976	8	3	Berger 1981
1979	0	0	Simons 1983
1980	0	0	Simons 1983
1981	3	1	Simons 1983
1982	0	0	M. Ueoka
1983	0	0	M. Ueoka
1984	5	0	M. Ueoka
1985	2	0	M. Ueoka
1986	0	0	M. Ueoka
1987	10	3	(our data)

All but one of the other birds received a physical examination, were fed with squid and a dietary supplement (Nutrical), and were subsequently released within 24 hours. One petrel which was found near the crater rim in Haleakala National Park was hospitalized, due to a wing abnormality, for three weeks. During this time, the bird was fed every other day with squid and crab meat soaked in saltwater and Nutrical. An intramuscular injection with multivitamins, calcium, and amino acids was given twice a week, and the bird received physical therapy on the ground and in water to help it regain flight ability. The bird was released successfully.

Moon phase and weather conditions on Maui during middle to late-October 1987 may have been particularly conducive to petrel grounding. All groundings occurred during the last quarter of the waning moon and the first quarter of the new moon; peak fallout occurred in the dark period preceding the new moon. Cloud cover varied between scattered clouds and dense overcast; winds remained mostly moderate.

Table 2. Data for Dark-rumped Petrel groundings on Maui in October 1987.

Date of Grounding	Location, Elevation	Fate of Bird
Oct. 14	Makawao Maliko Nursery, 390 m	Died soon after found
Oct. 16	Kahului 10 m	Released on Oct. 16 Kahului Harbor
Oct. 16	Wailuku Football Stadium, 10 m	Released on Oct. 17 Hookipa
Oct. 19	Kahului Molokai Hema St., 10 m	Released on Oct. 19 Kahului Harbor
Oct. 20	Keokea Lower Kula Highway, 880 m	Released on Oct. 20 Keokea
Oct. 21	Kihei Kamaole II Park, sea level	Died Oct. 21 while in transport to Olinda
Oct. 21	Haleakala Milepost 8, 1800 m	Released on Oct. 22 Hookipa
Oct. 22	Kihei Kihei Surf Hotel, sea level	Dead when found
Oct. 24	Lahaina Launiupoku Park, sea level	Released on Oct. 24 Hookipa
Oct. 24	Haleakala near Visitor Center, 2990 m	Released on Nov. 13 Spreckelsville (USFWS #784-30001)

Elevation of grounded birds ranged from sea level to 2990 m. Kihei, upper Haleakala volcano, and Kahului were the sites of the majority of groundings, but the number of groundings was too small to draw firm conclusions about patterns of groundings. Electrical use on Maui has increased 68% over the past nine years, from 373 gigawatt-hours in 1978 to 626 gigawatt-hours in 1987 (T. Hoshino, Maui Electric Co., pers. comm., 1988). Urban lighting has increased similarly.

Last year (1987) was the year with the second highest number of groundings of juvenile petrels ever recorded on Maui. It was also the year with the highest number of recorded groundings of shearwaters and petrels on Kauai (T. Telfer, pers. comm., 1987). Although this could indicate that absolute numbers of birds being produced is increasing, the correlations between the dark phase of the moon and grounding is clear. On the other hand, effects of a public awareness campaign are important in influencing the number of birds found and reported. Also, the grounding of birds in Kihei, where lighting has increased dramatically due to expanding development, suggests a growing threat from urban lighting—a factor which has already been well documented as important in seabird grounding (Telfer *et al.* 1987).

The recovery of two petrels with medical problems other than injuries—one bird with a fungal respiratory disease, a not uncommon finding with seabirds as a group (Pokras 1988), and the other bird with a wing abnormality—raises the question of how much of a role avian diseases play in grounding of petrels. Two juvenile shearwaters with extensive and debilitating physical deformities, probably caused by toxic agents or disease, were turned in to authorities during 1987 (one bird from Kauai, one from Maui). The possibility remains that the dead fledglings described by Simons (1985) as dying from starvation may have been disease casualties. Such questions will only be resolved through the careful search for avian diseases, fungal agents, parasites, and toxic pollutants in grounded birds, chicks, and failed eggs, as well as at active burrows.

The newly revived program for public awareness of petrels on Maui should be continued and promoted with additional zeal whenever the peak of the petrel fledging corresponds with the dark phase of the moon (a highly predictable phenomenon). The correlation of light intensity for urbanized localities and the number of birds being grounded in such areas should be monitored carefully on a continuing basis.

ACKNOWLEDGMENTS

Meyer Ueoka provided data on petrel groundings during 1982-87. Tom Telfer assisted in many ways, including giving very helpful comments on the manuscript. The Federal Aviation Administration at Kahului Airport supplied data on meteorological conditions during the 1987 petrel grounding season.

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AUGUST FIELD TRIP REPORT KOKO HEAD REEF WALK

The 27 August nighttime reef walk along a Koko Head lava bench was attended by 34 participants. The search for Hawaii's nocturnal marine creatures was a great success. Some of the unusual animals that the group discovered included: "7-11" crabs, hermit crabs, white eels, moray eels, sea hares, squirrel fish, damselfish, surgeon fish, hawk fish, ahole'hole, mullet, rock skippers, lizard fish, sea cucumbers, sea squirts, spiny sea urchins, brittle starfish, an octopus, and various kinds of shrimps and crabs. Some of the sea shells were hump-back, reticulated, and snakehead cowries, cone shells, bubble shells, stromb shells, and auger shells. All of the marine life we encountered was left behind, alive and well, for the enjoyment of future visitors and generations. The walk began around 8:00 PM and ended around 10:00 PM. All who attended were treated to good weather and an experience that was out of the ordinary.

Bruce Eilerts

JULY PROGRAM: A RAINBOW OF BIRDS

Hawaii Audubon President, Bruce Eilerts, narrated "A Rainbow of Birds" at our July membership meeting. This educational slide program was developed by the Hawaii chapter of the Wildlife Society.

In addition to seeing slides of native, introduced and migratory birds, we learned about bird behavior, how different species feed, and how man, beginning with the early Polynesian settlers, extirpated some species. The slides also showed Hawaii's counterparts to Darwin's Finches, the various species of honeycreepers which developed from a single species of finch.

Some of the most ineresting slides were of the endangered water birds, the 'Io, and the 'Alala.

Betty Johnson

IT'S FALL AGAIN: TIME TO SAVE OUR SHEARWATERS!

Every year from October through December, thousands of fledgling shearwaters and hundreds of petrels leave their burrows in Hawaii's mountains and along her coasts. They fly at night, a safe time to go were it not for the bright lights of street lamps and towns. Drawn to the lights, the birds crash into powerlines and other structures. Last year more than 2,000 fledglings were rescued by the caring public.

To save a shearwater, place the bird you've found in a box and, if you're on Kauai, take it to the nearest fire station, or, on the other islands, contact the Hawaii Division of Forestry & Wildlife, Department of Land & Natural Resources. Wildlife biologists will receive the bird, treat its injuries if it has any, and release it when the bird is ready.

Thank's for your,Kokua!

VOLUNTEER COORDINATOR NEEDED FOR BIG ISLAND REFUGE

The U.S. Fish & Wildlife Service is looking for a Volunteer Program Coordinator at the Hakalau Forest National Wildlife Refuge on Hawaii Island. Duties include recruiting volunteers and supervising volunteer groups engaged in alien plant control, tree planting and fence maintenance. The coordinator must be independent, physically fit, and willing to work in remote and isolated locations. A 4X4 government vehicle will be available for the 2-hour drive between Hilo and the refuge. A per diem of $23 per 24 hours will be given for nights spent on the refuge. For more information, contact Richard C. Wass, Refuge Manager, Hakalau Forest National Wildlife Refuge, 154 Waianuenue Ave., Rm. 219, Hilo, HI 96720. Or phone 1-969-9909.

PACIFIC GOLDEN PLOVER ALERT

Golden Plovers have been banded on Oahu, Hawaii, and near Nome, Alaska. Each bird wears a U.S. Fish and Wildlife Service band on one leg (some individuals also have a single color band on that leg) and one or more color bands on the other leg. If a bird wears more than one color band, combinations are two of the same

color, two of different colors, three of two colors, or three of three colors. Observers are asked to note the colors and exact sequences of all bands on the bird. It is very important that we know which leg carries the particular color (or colors) and, where used on the same leg, whether the color band is above or below the metal FWS band. Please send observations to Phil Bruner, Box 1775, Biology Dept., BYU-Hawaii, Laie, Hawaii 96762, or call (808) 293-3820 or 3816.

HAS WILDLIFE PHOTO/ART EXHIBIT AND CONTEST

The Third Annual HAS Wildlife Photo/Art Exhibit and Contest will be hosted by the Pacific Island Art Gallery at the North Shore Marketplace in Haleiwa during March 1989. The gallery generously offered their premises to HAS, and thousands of people are expected to visit the show. The exhibit will feature photographs and other art works depicting the natural environments of Hawaii and other islands of the Pacific and will coincide with National Wildlife Week. Tourists and local residents will be exposed to the natural wonders of Hawaii and the Pacific through the eyes of photographers and other artists. Call Dan Van Zyle at 595-4522 or Bruce Eilerts at 599-4795 for further information.

BEQUESTS

Do you know it's possible to leave money to Hawaii Audubon Society? George C. Munro, tireless and enthusiastic field ornithologist and naturalist and a major force in founding HAS, did more than 20 years ago. Today the George C. Munro Fund provides monies for research projects on the conservation of dryland forests.

A bequest to HAS is an excellent way to help us in our conservation efforts. Although an attorney should be consulted in the drafting of your will, a model clause for bequests is set forth below.

"I hereby give, devise and bequeath to the Hawaii Audubon Society, Honolulu, HI, the sum of _____ dollars (or set forth a description of the property) to be used for the general purposes of said organization."

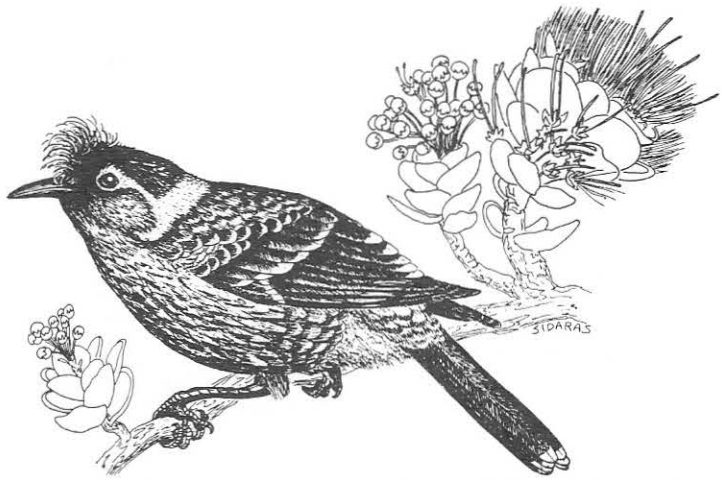
For more information and assistance in the specifics of the manner and form of gifts and bequests contact HAS, P.O. Box 22832, Honolulu, HI 96822.

FUND RAISING COMMITTEE MEETS 13 OCTOBER

Hawaii Audubon needs dedicated volunteers to help with mailings, write grant requests, work on a "phonathon," and generate new fund raising ideas. The Fund Raising Committee will meet on 13 October at 7 PM at Lynne Matusow's house. If you would like to join this committee, or share some ideas, call Lynne Matusow at 531-4260.

OCTOBER 16 FIELD TRIP: JAMES CAMPBELL N.W.R.

The next HAS field trip will be a visit to the James Campbell National Wildlife Refuge. The outing is scheduled for Sunday, 16 October and will be followed by a second trip to the same refuge in November. The October visit will allow participants to observe migratory shorebirds as they pass from their summer breeding



'Akohekohe (Crested Honeycreeper, *Palmeria dolei*), an endangered bird found in the Waikamoi Preserve, site of study.

Drawing by Nanci Sidaras

grounds in North America and Asia south through the Hawaiian Islands. The possibility of seeing Bristle-thighed Curlews, Dowitchers, Sharp-tailed and Pectoral Sandpipers, Dunlins, and who knows what other species, is very good. The resident endangered Hawaiian waterbirds, along with the four species of migratory shorebirds that regularly winter in Hawaii, are sure to be encountered. Bring along lunch, binoculars, field guides, and sunscreen. Meet in front of the State Library on Punchbowl St. at 7:30 AM or at the Kahuku Sugar Mill between 8:45 AM and 9:00 AM. The 20 November visit to James Campbell NWR will coincide with the arrival of migratory waterfowl in the islands. Contact Bruce Eilerts at 599-4795 for further information.

OCTOBER PROGRAM: THE NENE -- BIRD WITHOUT A HOME?

The Nene, State Bird of Hawaii, has been the focus of the State's endangered species program for 40 years. More than 2,000 captive-bred birds have been released on Hawaii and Maui islands. Yet only three self-sustaining populations, perhaps totaling fewer than 200 birds, survive in the wild. Given this grim record, what future lies ahead for the Nene? At the 17 October general meeting of HAS, Thane K. Pratt, nongame wildlife biologist with the Hawaii Division of Forestry & Wildlife, will speak on new developments in restoration of the Nene -- a bird which may yet find its place in 20th Century Hawaii. The meeting place will be the Atherton Halau, B.P. Bishop Museum, at 7:30 PM. Refreshments will be served.

HAWAII AUDUBON SOCIETY

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----------*'ELEPAIO*----------

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EDITOR NEEDED FOR *'ELEPAIO*

After three years as managing editor of the *'Elepaio*, I now wish to move on to other projects. Sheila Conant will be staying as Scientific Editor, but we need someone to take responsibility for production of the journal. Thus, we are now searching for a new Managing Editor. The job entails a wide range of responsibilities: interacting with the printers, editing and laying out the journal, organizing and working with volunteers who enter text on a computer and assist in proof reading and paste up, and coordinating various aspects of production. The only skills the applicant must possess are an ability to write clearly (and therefore edit), meet deadlines, and be successful at working with people. The rest is easy enough to learn. Those interested should call me at 548-8850.

Thane K. Pratt

by Fern Duvall

FREE ICE CREAM!

Ice cream will again be served to those volunteering for paste up of the *'Elepaio* at Thane Pratt's house on Saturday, 22 October, beginning at 1:00 PM. Thanks to Lynne Matusow for helping with the paste up of the current issue! For more information, call me at 524-8464.

TKP

CALENDAR OF EVENTS

Oct. 10 (Mon., Discoverer's Day) Board Meeting at Bishop Museum at 7:00 PM. Call Bruce Eilerts for details.

Oct. 13 (Thurs.) Meeting of Fund Raising Committee. Call 531-4260.

Oct. 16 (Sun.) Field trip to James Campbell Nat. Wildl. Refuge. Meet next to State Library on Punchbowl St. at 7:30 AM. Announcement on page 88.

Oct. 17 (Mon.) General Meeting at Atherton Halau, Bishop Museum at 7:30 PM. Program: Nene, by Thane Pratt. Announcement on page 88.

Oct. 22 (Sat.) *'Elepaio* Paste-up at Thane Pratt's house, 1:00 PM. Call 524-8464.

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