

HAKALAU FOREST
NATIONAL WILDLIFE REFUGE

Hilo, Hawaii

ANNUAL NARRATIVE REPORT

Calendar Year 1992

U.S. Department of the Interior
Fish and Wildlife Service
NATIONAL WILDLIFE REFUGE SYSTEM

**HAKALAU FOREST NATIONAL WILDLIFE REFUGE
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Calendar Year 1992**

REVIEW AND APPROVALS

Richard C. Way
Submitted by: Refuge Manager

2/16/94
Date

Tom Panch
Reviewed by: Project Leader, Hawaii/Pacific
Islands NWR Complex

2/18/94
Date

John A. Corbett
Reviewed by: Regional Office (Region 1)

2/25/94
Date

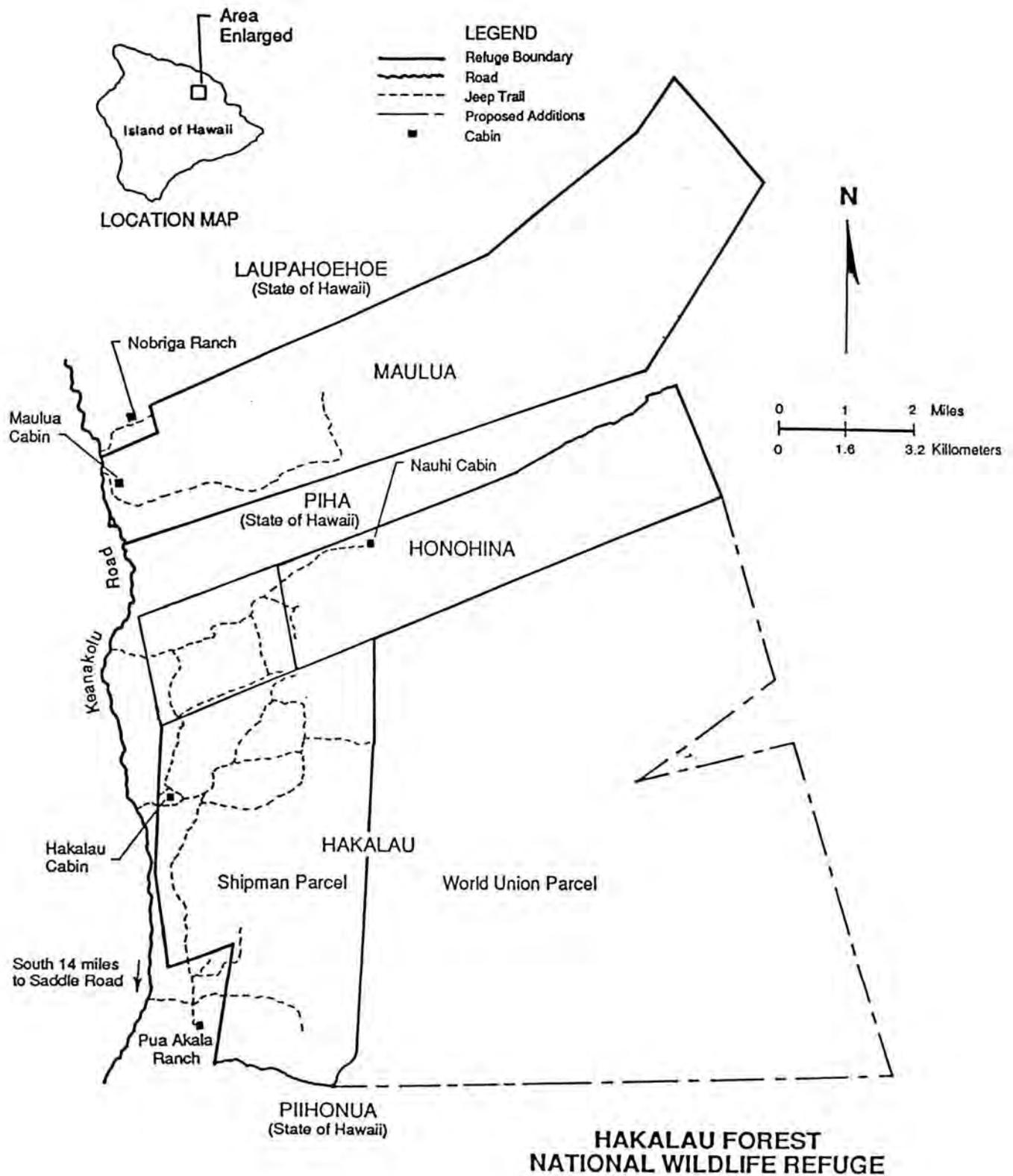
INTRODUCTION

Hakalau Forest National Wildlife Refuge was established October 29, 1985 with the purchase of two properties totaling 8,313 acres. Four additional parcels have subsequently been acquired bringing the current total area to 15,484 acres. Negotiations toward the purchase of two additional parcels totaling approximately 17,000 acres are ongoing. The refuge is located about 14 mi. northwest of Hilo, Hawaii on the windward slope of Mauna Kea. It lies between the elevations of 2,500 and 6,600 ft. and contains some of the finest stands of koa and ohia forest in Hawaii. The lower slopes receive very high rainfall and are vegetated with dense forests dominated by ohia and treeferns and bisected with numerous streams and gulches. Upslope, at elevations above 4,500 ft., koa becomes co-dominant with ohia. The typical structure of this forest is characterized by tall koa and ohia trees forming a closed canopy. Younger ohia trees dominate the mid-story and tree ferns and native shrubs form the understory. Higher elevations (above about 5,400 ft.) experience less rainfall and have been subject to considerable grazing pressure for over 100 years which has eliminated or severely reduced the native understory. A fairly dense canopy of mature koa and ohia trees over a ground cover of exotic grasses characterizes this area. Intensive grazing on the uppermost portion of the refuge (above about 6,000 ft.) has eliminated even the trees except for remnant individuals scattered through the gulches. This area is carpeted with introduced grasses including the noxious weed, gorse.

Hakalau Forest NWR was established to assure the protection, perpetuation and maintenance of five endangered forest bird species and their rain forest habitat. It supports a superb avifauna, rich in species and high in density. Thirty-nine bird species are found on the refuge including 14 endemic (of which 8 are endangered), 5 indigenous and 20 aliens. Substantial populations of four endangered forest birds occur on the refuge. They are the 'Akiapola'au, the Hawaii Creeper, the Hawaii 'Akepa and the 'Io (Hawaiian Hawk). The other four endangered birds found at Hakalau include the very rare 'O'u which is reported from the lower elevation ohia forests, the Nene (Hawaiian Goose) which nests in adjoining areas, the Koloa (Hawaiian Duck) which inhabits streams and stockponds on the refuge, and the 'Alae ke 'Oke'o (Hawaiian Coot). The endangered Hawaiian Hoary Bat and a number of candidate endangered plants are also found at Hakalau.

Figure 1 is a map of the Refuge. The administrative office is located within the Federal Building in downtown Hilo, the largest city on the Island of Hawaii. The address is 154 Waianuenu Ave., Rm. 219, Hilo, HI 96720. The phone number is (808) 969-9909. The FAX number is (808) 934-7473.

Figure 1.



HAKALAU FOREST NATIONAL WILDLIFE REFUGE

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A. HIGHLIGHTS

1. The *El Niño* condition which began in the fall of 1991 persisted throughout 1992 resulting in an unusually dry spring and high mortality amongst planted koa seedlings. (Sections B. and F.3.b.)
2. Dr. Leonard A. Freed, University of Hawaii, and his graduate students, continued their research project on the refuge. Their efforts focused on ornithological studies on behavior, demography, genetics, disease, the evolution of sexual dichromatism and cavity-nesting in the Hawaii 'Akepa, and temporal arthropod abundance in the koa/ohia forest. During their six years of banding at Hakalau, Dr. Freed and colleagues (chiefly Jaan Lepson) have banded a total of 2,328 birds and have taken blood samples from 986. The banded total includes 195 endangered birds. They also documented the presence of avian malaria and avian pox. (Section D.5.)
3. The Hakalau staff increased to eight individuals with the addition of an Office Automation Clerk, a Maintenance Worker Foreman and two Maintenance Workers. (Section E.1.)
4. The volunteer program showed continued growth. Nineteen groups visited the refuge for 1-4 day periods providing 1,652 person-hours of effort to assist the refuge staff picking and shucking koa seed pods, planting koa tree seedlings, fertilizing seedlings and grubbing and removing banana poka, gorse and other alien plants. For the second consecutive year, three Student Conservation Association volunteers spent the summer on the refuge assisting with fence removal, cabin maintenance, habitat monitoring, weed control, tree planting and fertilization, fence inspection and feral ungulate surveys. (Section E.4.)
5. 18,000 koa seedlings were planted during 1992 with the assistance of a grant from the American Forestry Association. 36,000 seedlings have been planted since 1989. The seedlings are doing well though frost, drought and pigs have caused significant mortality. (Section F.3.b.)
6. Twenty-five endangered *Clermontia pyrrularia* plants were outplanted at Hakalau. (Section F.3.d.)
7. Cattle are no longer permitted to graze Hakalau under Cooperative Agreements or Special Use Permits. A few domestic cattle, however, and numerous wild cattle still occur on the refuge. (Sections F.7. and G.15.e.)
8. Orchard Services was contracted to provide 100 hours of effort for foliar spray and basal bark applications of Garlon 4 herbicide on gorse. The original gorse infestation is totally controlled. Continued effort is required to spray or grub young seedlings. (Section F.10.b.)
9. Experimental plots were established in 1991 to test the effectiveness of Roundup for controlling blackberry. The "clip and drip" method was found to be useful, though labor intensive. (Section F.10.c.)
10. A bi-monthly yellowjacket survey was initiated to monitor the population trends of this predaceous insect.
11. The annual spring bird census was conducted. An apparent increase was seen for 10 of 12 forest bird species, but it is not known whether this is the result of management strategies or normal population variability. No consistent population trends are evident for any species during the six-year-period over which the refuge has collected data. (Section G.2.)

12. Feral ungulate control efforts were concentrated in the Shipman Unit during 1992. Feral cattle were eliminated from the unit with the take the final 11 individuals. Sixty-seven pigs were taken through staff hunting and snares. (Section G.15.b.)

13. A public access program was initiated on February 1, 1992 with the opening of the 7,240 acre Maulua Tract to pig hunters during the first three weekends of each month and to non-hunters on the last weekend of each month. (Section H.1.)

14. The hunting public took 38 pigs from the Upper Maulua Tract during 105 hunter-days for an average of 0.36 pigs per hunter-day. (Section H.8.a.)

15. The Fred Smith Construction Company was contracted to construct 33,000 feet of pig/cattle fence around the perimeter of the 1,800 acre Lower Honohina Feral Ungulate Management Unit. Construction will occur in 1993. Since the refuge was established, about 17.2 miles of pig/cattle fence have been constructed and two management units (Middle Honohina Unit and Shipman Unit) have been fenced. (Section I.1.a.)

16. Entrance signs fabricated by the Service's Sign Center were erected on the four roads leading onto the refuge under a contract with Stan's Contracting. (Section I.1.b.)

17. The refuge received a new Caterpillar D4HLGP Crawler Dozer in September which will be used primarily for road maintenance and ground preparation for tree planting. (Section I.4.a.)

B. CLIMATIC CONDITIONS

The climate at Hakalau Forest NWR is characterized by moderate temperatures and generally wet conditions. There is considerable variation within the refuge, however, depending primarily on elevation. Mean annual temperatures vary between about 65°F at the lower elevations and 53°F at the higher elevations. Daily temperatures in the vicinity of Hakalau cabin range between highs of 50°F to 75°F and lows of 32°F to 50°F.

Rainfall also shows significant variation with elevation. Approximately 300 inches of rain falls annually at the lowermost elevations of the refuge. Rainfall decreases to about 90 inches at the upper elevations bordering Keanakolu Road. For a 25-year period between 1906 and 1931, rainfall data were recorded at Pua Akala Ranch (elevation = 6,300 feet) which borders the refuge. Annual rainfall ranged between 38.3 and 144.4 inches with a median of 88.2 inches. During the past six years, rainfall at Hakalau Cabin has varied between 58.29 and 159.56+ inches and averaged 91.07+ inches. At the higher elevations of the refuge, considerable moisture (perhaps as much as an additional 35%) is also received in the form of fog drip from cloud formations that usually gather in the early afternoon on the middle elevation slopes of Mauna Kea. These afternoon low clouds are responsible for the cool and damp climate that generally prevails at Hakalau.

Prevailing winds are from the SSE at about 5 knots. Mean daily humidities range from around 70% in the winter to about 85% in the spring and summer. Typically, humidity is lowest during the mid-morning hours and highest during the late afternoon and early evening.

A standard thermometer and rain gauge were installed on the refuge at Hakalau cabin (elevation = 6,440 ft) early in 1987. Data have been recorded by refuge staff since that date.

In February 1989, a sophisticated solar-powered meteorological station was installed on the flat immediately below Hakalau cabin (elevation = 6,400 ft). Every 15 minutes, the CR 10 data logger records air temperature, humidity, wind speed, wind direction, solar radiation at all wavelengths, solar radiation at photosynthetic wavelengths, and soil moisture and temperature at 10 cm and 50 cm depths. Rainfall is continuously recorded as it occurs in 0.01 inch increments. Seventy-five days of data can be stored in the memory unit which is unplugged every two months and taken to the Hilo office where the data are downloaded into the computer for compilation and analysis. Unfortunately, the battery failed this year in early July (though the failure was not discovered until August 31) so data for the last six months of the year were lost. The failed unit was sent to the manufacturer for battery replacement and servicing. The CR 10 borrowed from the U.S. Forest Service failed a few weeks later and it was early in 1993 before the FWS unit was reinstalled and functional.

In March 1989, a rain gauge was installed on refuge property in the clearing immediately below the Pua Akala Ranch (elevation = 6,200 ft). It is monitored by students and faculty from the University of Hawaii.

Meteorological data from the three locations described above are summarized in Tables I and II.

Table I. Extreme and mean daily air temperatures (°F) recorded at Hakalau cabin and at the flat below the cabin and mean soil temperature (10 cm depth) during 1992.

Month	Cabin		Flat Below Cabin			
	Max.	Min.	Max.	Min.	Mean Daily	Mean Soil Temp.
Jan	-	-	63	40	51	49
Feb	-	-	62	42	51	50
Mar	64	32	59	38	49	52
Apr	77	33	60	41	51	52
May	78	36	63	45	54	54
Jun	-	-	63	46	54	57
Jul	73	44	-	-	-	-
Aug	70	45	-	-	-	-
Sep	74	43	-	-	-	-
Oct	73	42	-	-	-	-
Nov	68	38	-	-	-	-
Dec	68	40	-	-	-	-

Table II. Rainfall (inches) recorded at Hakalau cabin, the flat below the cabin and at the clearing below Pua Akala Ranch during 1992. A "+" after the rainfall figure indicates the rain gauge overflowed before it could be emptied. The true value is, therefore, higher than that listed.

Month	Hakalau Cabin		Flat	Clearing
	87-92 Ave. Rain	92 Rain	92 Rain	92 Rain
Jan	10.34	0.91	0.81	0.65
Feb	6.33	1.07	0.40	0.38
Mar	9.92	0.95	0.71	1.42
Apr	5.01	0.56	0.92	2.26
May	5.18	1.60	1.61	1.99
Jun	3.56	2.69	2.40	4.14
Jul	8.06	8.85	-	12.96
Aug	5.64	9.28	-	8.48
Sep	7.94	12.64	-	16.48

Oct	5.30	3.22	-	4.69
Nov	13.69	12.72	-	13.95
Dec	<u>10.10</u>	<u>10.37</u>	-	<u>15.21</u>
TOTALS	91.07+	64.86		82.61

Unusually dry conditions prevailed at Hakalau throughout the year due largely to the *El Niño* condition which began in the fall of 1991 and persisted through 1992. The weather, and consequently the soil, was particularly dry during the first half of the year. Dry weather is normally appreciated but not during the tree-planting season which extends from April through July. Dry soil conditions resulted in unusually high planting mortality amongst the 18,000 seedlings planted in 1992. (See Section F.3.b.)

Total rainfall for the year was only about 70% of the average for the last six years. Rainfall at Hakalau is highly variable so any month can be unusually wet or unusually dry. In general, however, the wettest months seem to be November through March. The monthly extremes recorded at Hakalau Cabin since 1987 are 0.56 inches for April 1992 and 39.09+ inches for November 1990.

Table II shows that the Pua Akala clearing receives about 25% more rain than Hakalau cabin. The slightly lower elevation (about 200 feet), and the fact that the clearing is surrounded by forest instead of open grassland, probably account for the difference.

C. LAND ACQUISITION

1. Fee Title

Hakalau Forest NWR currently encompasses six parcels totaling 15,484 acres. All of it is owned in Fee Title by the FWS. Acquisition efforts were directed toward three additional parcels during 1992.

Condemnation proceedings were initiated by the Regional Director in 1989 for a 15,715 acre parcel owned by the World Union Industrial Corporation. An out-of-court settlement between the Service and World Union was reached on April 30, 1992 when the parties agreed on a total value of \$10 million. Funds are on hand to purchase 11,236.36 acres. Funding for the remaining acreage has been requested from Congress. World Union has agreed to give the Service two years to secure the additional funding before pursuing other options to sell the property. The northern portion will be purchased first because it includes the best forest bird habitat.

Negotiations were also ongoing toward the purchase of a 1,034 acre parcel (Upper Honohina) owned by the Liliuokalani Trust. During 1992, the refuge assisted with appraisals and inspections of this property through provision of information and guided tours for appraisers and FWS personnel. Both the World Union and the Liliuokalani Trust properties are within the approved boundary of the refuge.

In 1990, the Service learned that the W.H. Shipman Corporation was for sale and expressed interest in acquiring the 500 acres retained by the W.H. Shipman Estate (borders the southwest corner of the refuge) when the 4,994 acre Shipman Parcel was sold to the FWS in 1985. Initially, the owners were reluctant to break the property away from the corporation and sell it as an individual parcel. During 1992, however, the owners indicated their willingness to sell the 500 acres to the Service. The property is currently leased for grazing and encompasses about 200 acres of forest and 300 acres of grassland heavily infested with gorse. Before the refuge was established, this parcel was included

within the proposed boundary. It was removed before Congress gave final approval, however, so that step must be taken before proceeding with the acquisition.

D. PLANNING

2. Management Plan

Pete Weher and Mike Poe from the Regional Engineer's Office and Deputy Project Leader Leinecke traveled to Hakalau in October to meet with staff and initiate a site planning effort for the refuge. Future needs, general specifications and the best locations for structures and roads were discussed. Poe and Weher took survey data to enable them to map elevations in the general area of the Hakalau Cabin Complex. Weher will draft a site plan sketch for the area to include a new staff residence, garage/maintenance shed, fuel dispensing/flammables storage area, helicopter pad, tree nursery, dog kennel, field research station for the University of Hawaii and access roads.

4. Compliance with Environmental and Cultural Resource Mandates

In 1991 The R.M. Towill Corporation was contracted to prepare a Conservation District Use Application for the construction of approximately 63.8 miles of pig\cattle fence and the eradication of pigs and cattle within the lower elevations of the refuge which are zoned "Conservation". The areas covered by the application include the lower portions of the Maulua and Honohina tracts as well as the World Union property which is planned for acquisition in the near future. The application was completed in February 1992 and State of Hawaii approval was obtained in July subject to 11 conditions. The construction of six miles of fence within the lower Honohina tract during 1993 can proceed on schedule as the result of this approval.

5. Research and Investigations

a. Forest Bird Research

Forest bird research was initiated in 1987 at Hakalau by Dr. Leonard A. Freed, Professor of Zoology, University of Hawaii. In 1988 he was issued a Special Use Permit (HAK-1-88) to "conduct ornithological research within Hakalau Forest NWR to include observational, demographic, behavioral and genetic studies." The permit is for a five-year period and is renewable subject to compliance with the Special Conditions. Freed and his students are using basic research techniques including mist netting, banding, collecting blood samples for disease and DNA analysis, and behavioral observations. The bulk of this research occurred within a 20 hectare area centered around an open meadow at the top of the Pua Akala Tract. A second study area was located a few hundred meters northwest of Spring Water Camp within the Maulua Tract.

Several distinguished scientists were included in short term activities and one-day field trips. In association with the August AIBS meeting in Honolulu, L. Freed conducted a short field trip for 15 scientists. In May, Dr. Gell-Mann, Nobel Laureate on the board of the World Environment and Resources Program of the MacArthur Foundation, visited the camp for two days. Also, Drs. Fran James, John Fitzpatrick and Stuart Pimm, associated with the Alala Commission of the National Academy of Sciences were at the camp for several days. In August Dr. Gordon Orians, President of the Organization for Tropical Studies for the National Academy of Sciences visited the field camp.

Ten University of Hawaii personnel were officially associated with the field studies at Hakalau during 1992. Drs. Leonard Freed and Rebecca Cann (Chief Investigators) were assisted by graduate students Robert Feldman, Scott Fretz, Patrick Hart, David Hopper, Jaan Lepson, Sylvia Leupp, Robert Peck and Joby Rohrer.

Mr. Lepson camped in the Pua Akala meadow almost continuously, operating mist-nets, banding and bleeding birds, and observing bird behavior to obtain information for his PhD dissertation on temporal plumage maturation of the endangered 'Akepa. Robert Peck stayed intermittently at the camp while collecting insects for his research comparing arthropod abundance in open- versus closed-forest areas. Sylvia Leupp resided almost continuously at the camp during the first half of the year in association with a study of artificial nest cavities for the Hawaii 'Akepa. Other students assisted Freed in netting and banding activities.

Drs. Leonard Freed and Stuart Pimm (University of Tennessee) conducted two sessions of the School For Field Studies course entitled "Conservation of Endangered Species" during late spring and early summer of 1992. The June 22 - July 5 session led by Freed involved 10 students and 3 faculty. The August 8-19 session conducted by Pimm involved 14 students and 3 faculty. Students and instructors camped at Maulua Cabin and used the cabin facilities for cooking, eating, discussion and data analysis. The research was conducted in the Maulua Tract northwest of Springwater Camp. Ten aerial mist-nets were used to capture birds frequenting the area. Students conducted individual research projects on forest structure, plant phenology and demography of various bird populations. A summary of the birds captured during these sessions and during other banding efforts are included in the table below.

The following species were captured, banded and bled during 1992 by Dr. Freed and colleagues:

<u>Endangered Species</u>	<u>Newly Banded</u>		<u>Recaptures</u>	<u>No. Bled</u>	
	<u>Individuals</u>				
	Pua Akala/Maulua		Pua Akala	Pua Akala/Maulua	
Hawaii 'Akepa	3	0	4	3	0
Hawaii Creeper	2	3	0	2	1
'Akiapola'au	1	0	1	1	0
Total	6	3	5	6	1
<u>Other Native Species</u>					
'Oma'o	3	5	1	3	3
'Elepaio	2	1	4	3	1
Common 'Amakihi	35	27	11	32	15
'Apapane	64	29	3	44	16
'I'iwi	64	36	26	39	20
Total	168	98	45	121	55
<u>Introduced Species</u>					
Red-Billed Leiothrix	6	0	1	7	0
Japanese White-Eye	23	8	2	10	0
House Finch	6	0	0	5	0
Northern Cardinal	0	1	0	0	0
Nutmeg Mannikin	1	0	0	1	0
Total	36	9	3	23	0
GRAND TOTAL	210	/110	53	150	/ 56

Six-Year Summary of Bird Banding By University of Hawaii
Research Team

	Banded All Species	Banded Endangered	Bled All Species
1987	381	57	0
1988	461	34	91
1989	475	49	119
1990	325	23	232
1991	366	23	258
1992	<u>320</u>	<u>9</u>	<u>206</u>
TOTAL	2328	195	986

Dr. Freed and colleagues found nests of all native bird species except Hawaiian Hawk during 1992, including 9 endangered 'Akepa nests of which at least 4 fledged young successfully. Three failed and the fate of the 2 other nests is unknown. One Hawaii creeper nest, successful, was also found. All 'Akepa nests were in ohia and koa tree cavities and in the same trees used in previous years for nesting or in another tree in close proximity. The nest trees were the largest (diameter) in the area. This sample of nests will enable a study of the extent to which cavities are re-used from one breeding season to the next. Introduced House Finches also nest in cavities, allowing for possible interspecific competition for nest sites with 'Akepa.

In addition to the natural nest studies, the researchers designed and mounted 61 artificial cavities on large ohia and koa trees that had been previously used by Akepa for nesting in the past. These artificial cavities were constructed of six-inch black ABS pipe with a rubber cap, wooden bottom and tree bark glued to the outside as camouflage and to the inside walls to provide a rough surface to assist the birds in exiting the cavity. No active nests were located in the artificial cavities at the end of the nesting season, but small amounts of nesting material was deposited in 3 of the cavities. No other species such as rats or House Finches were found to use the cavities. Funding for this study during 1992 was obtained from the U.S. Forest Service and Ecological Services, U.S. Fish and Wildlife Service.

The presence of avian malaria and pox at Hakalau was confirmed. A molecular probe used in detecting subclinical malarial infections was developed by Dr. Rebecca Cann and associates. The discovery of malaria at this elevation opens the question of whether the disease was contracted by birds on the refuge or at lower elevations with subsequent dispersal to the refuge. If the disease was contracted on the refuge, then the potential vector needs to be identified. The UH staff will attempt to use the molecular probe to identify malarial DNA in the hemolymph of mosquitoes and other biting insects found at Hakalau.

Pox-like lesions were found in all species of native birds on the refuge, although rarely on the endangered species. The survival and reproductive success of birds with lesions are being monitored to determine demographic effects. Dr. Rebecca Cann is attempting to design a molecular probe for pox virus similar to the one she designed for malaria.

Pox-like lesions were found on birds in the following proportions within the Pua Akala and Maulua study sites:

<u>Species</u>	<u>Pua Akala</u>	<u>Maulua</u>
Apapane	9 (13%)	2 (7%)
Iiwi	2 (2%)	1 (3%)
Amakihi	7 (15%)	2 (7%)
Elepaio	1 (17%)	0
Japanese White-eye	3 (12%)	0

In October, Refuge Manager Wass and Biologist Jeffrey attended a two-day workshop convened in Honolulu by The Nature Conservancy. Over fifty people from Federal and State Government agencies and the private sector were in attendance. The purpose of the workshop was to determine the highest priority research projects needed to help save Hawaii's forest birds.

b. Soils Research

Dr. Haruyoshi Ikawa, Department of Agronomy and Soil Science, University of Hawaii was awarded a \$10,000 contract to conduct a study of the physical, chemical, mineralogical and mycorrhizal properties of the soils at Hakalau relative to problems with koa seedling establishment and growth. The study will continue at least through 1993. During 1992, 36 soil samples were collected from three sites at Hakalau where there were problems establishing koa seedlings and three sites where there were no problems. Analysis of these samples is underway. Also, approximately 1/2 ton of soil was collected from the same sites for use in the study to determine the response of koa seedlings to mycorrhizal inoculation.

E. ADMINISTRATION

1. Personnel

Hakalau Forest NWR is part of the Hawaii/Pacific Islands NWR Complex. The 1992 Complex staff was comprised of 38.7 FTE's broken down as follows:

Refuge Complex Administration	4.5 FTE
Remote Island Refuges	14.5 FTE
Oahu Refuges	4.5 FTE
Kauai Refuges	8.9 FTE
Hakalau Forest NWR	<u>6.3 FTE</u>
TOTAL	38.7 FTE



The 1992 Hakalau Forest NWR staff. Front row, left to right: Andrew Kikuta (Maint Wkr Foreman), Victor Souza (Maint Wkr), Jack Jeffrey (Wildlife Biologist), Jon Emig (Maint Wkr). Back row, left to right: Terence Takiue (Maint Wkr), Lynne Hanzawa (Office Automation Clerk), Anthony Texeira (Maint Wkr), Dick Wass (Refuge Manager).

The Hakalau staff experienced significant growth during 1992 with the addition of four new positions. Lynne Hanzawa was hired on January 14 as an Office Automation Clerk GS-326-4, permanent full time. All clerical support was previously provided by the Hawaii/Pacific Islands Complex staff in Honolulu. Lynne was "lateraled" from a similar position with the Farmers Home Administration located in the same building as the refuge office.

Andrew Kikuta was hired on June 14 as a Maintenance Worker Foreman WS-4749-4, permanent full time. He supervises three positions and leads the Habitat Management crew which is responsible for fence construction and maintenance, feral ungulate and predator control, and weed control. Andy was previously employed with the Resource Management Division at Hawaii Volcanoes National Park.

Victor Souza and Terence Takiue were both hired on August 3 as Maintenance Workers WG-4749-5, temporary full-time. They, along with Andy Kikuta and Tony Texeira, comprise the Habitat Management crew. Victor was previously employed as a General Laborer with the State Division of Forestry and Wildlife. Terry worked as Operations Manager for the Hawaii Tropical Botanical Gardens.

At the end of 1992, the Hakalau staff was comprised of the following individuals:

- a. Richard C. (Dick) Wass, Refuge Manager, GS-485-11, Permanent Full Time, entered on duty January 1, 1987.
- b. John J. (Jack) Jeffrey, Wildlife Biologist, GS-486-9, Permanent Full Time, entered on duty September 9, 1990.
- c. Jon R. Emig, Maintenance Worker, WG-4749-7, Permanent Full Time, entered on duty April 20, 1988 as Temporary Full Time, converted to Permanent Full Time May 5, 1991.
- d. Lynne H. Hanzawa, Office Automation Clerk, GS-326-4, Permanent Full Time, entered on duty January 12, 1992.
- e. Andrew (Andy) H. Kikuta, Maintenance Worker Foreman WS-4749-4, Permanent Full Time, entered on duty June 14, 1992.
- f. Anthony C. (Tony) Texeira, Maintenance Worker, WG-4749-6, Temporary Full Time, entered on duty April 15, 1990.
- g. Victor B. Souza, Jr., Maintenance Worker, WG-4749-5, Temporary Full Time, entered on duty August 3, 1992.
- i. Terence (Terry) M. Takiue, Maintenance Worker, WG-4749-5, Temporary Full Time, entered on duty August 3, 1992.

An organizational chart for the Hakalau staff is depicted in Figure 2.

The history of employee strength for Hakalau Forest NWR since the refuge was established is summarized as follows:

Calendar Year	Permanent		Temporary	Total FTE
	Full-Time	Part Time		
1985	-	-	-	0
1986	-	-	-	0
1987	1.0	-	-	1.0
1988	1.0	-	0.7	1.7
1989	1.0	-	1.0	2.0
1990	1.3	-	1.7	3.0
1991	2.7	-	1.3	4.0
1992	4.0	-	2.3	6.3

HAKALAU FOREST NATIONAL WILDLIFE REFUGE - 1992
(12516)

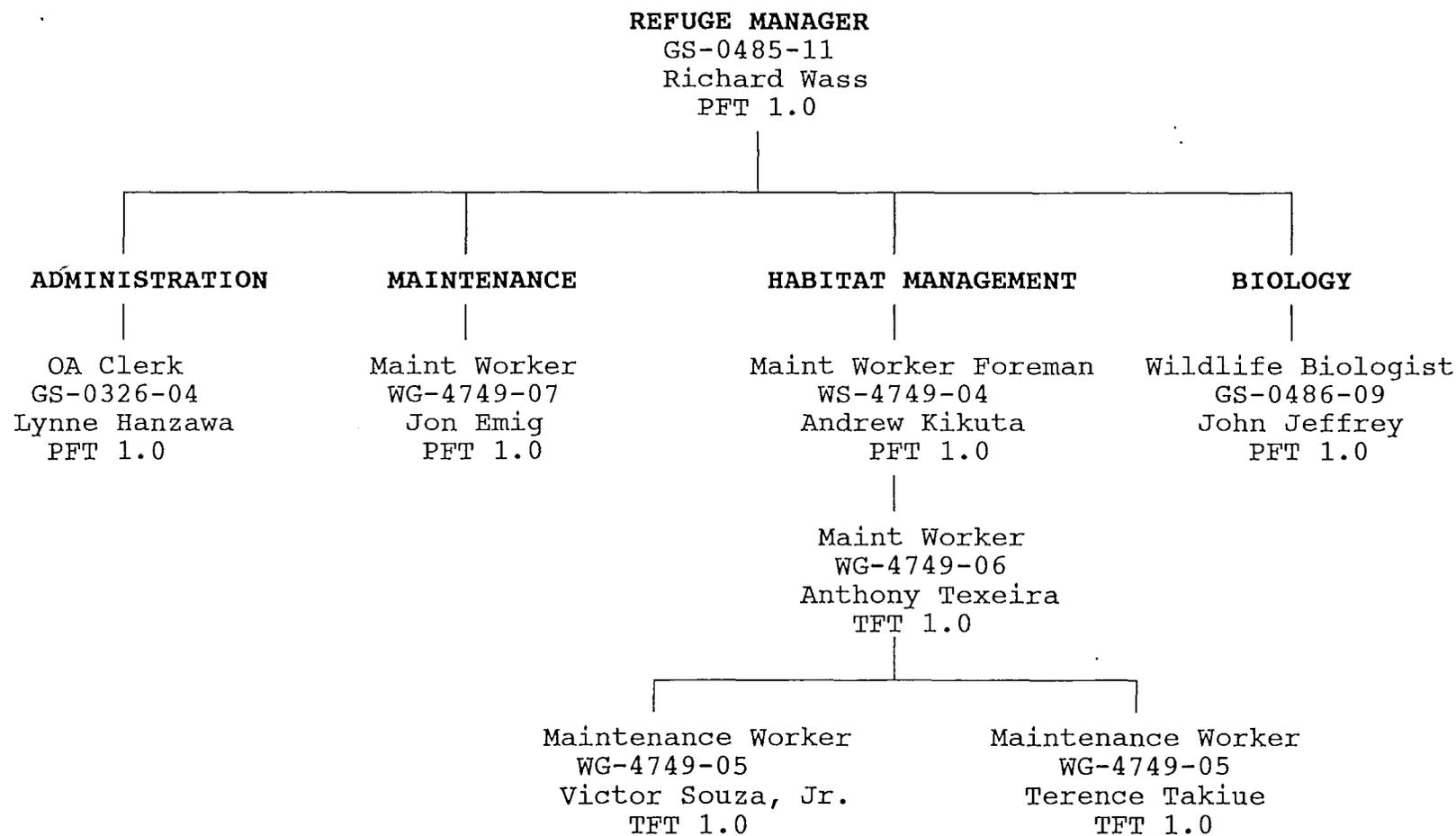


Figure 2.

4. Volunteer Program

Volunteer assistance is generally provided by groups from Oahu, Maui and the Big Island which travel to the refuge for a 2- or 3-day weekend. The groups of 6-12 individuals provide their own transportation to the Big Island and their own food. The refuge usually provides transportation from Hilo, the facilities at Hakalau Cabin, and tools to accomplish the job. A member of the refuge staff generally accompanies the group to direct their efforts. For three-day trips, the group is usually given the last day to hike and observe birds with the refuge biologist as a guide. The bird hike is a major incentive because most of the refuge is closed to the general public. Each volunteer who provides two or more days of effort is also given a "Hakalau T-shirt" or a FWS volunteer cap as an expression of thanks.

The volunteer program showed continued growth during 1992. Nineteen volunteer groups (five more than in 1991) visited Hakalau for periods of 1-4 days. They donated 1,652 person-hours (compared to 1,418 hours in 1991) of much-appreciated effort to pick and shuck koa seed pods, plant koa seedlings and control banana poka, gorse and holly.

The main factor which has limited growth of the program is the lack of a volunteer coordinator who has the necessary time (mostly on weekends and holidays) to organize and coordinate groups and to direct and supervise their efforts while on the refuge. This need was partially alleviated in 1992 by the reforestation grant from American Forestry Association (see Section F.3) which paid Barry Orlando, Pat Bryan and Mike Robinson to lead tree planting and seed picking efforts. A brief description of each volunteer group visit follows:

a. January 18-20. Five volunteers from the Hawaii/Pacific Islands NWR Complex office and The Nature Conservancy spent 37 person-hours shucking two bags (about 30 lbs) of koa seed pods.

b. February 18-22. Marianne Gaglia and Randall Hetzel spent about 60 person-hours grubbing banana poka and 16 person-hours grubbing gorse.

c. April 17-19. Eight volunteers from the Honolulu Sierra Club led by Ron Chock spent 40 person-hours grubbing and cutting holly and 72 person-hours grubbing gorse in the Pua Akala tract.

d. May 1-3. Eleven volunteers representing the West Hawaii Sierra Club planted 3,000 koa seedlings during 80 person-hours of effort. The effort was coordinated and led by Barry Orlando and Mike Robinson as well as the refuge staff.

e. May 13-15. Seven students and two instructors from Parker School planted 5,000 koa seedlings during 140 person-hours. Barry Orlando and the refuge staff directed the effort.

f. May 23-25. Ten volunteers from the Honolulu Sierra Club expended 120 person-hours planting 3,000 koa seedlings under the direction of Barry Orlando and the refuge staff.

g. June 11-14. Five volunteers from the Maui Sierra Club (Anna Mae Shishido's group) and two Student Conservation Association volunteers planted 4,000 koa seedlings during 125 person-hours. Barry Orlando and the refuge staff coordinated and led the effort.

h. July 3-5. The Moku Loa Group, Hawaii Island Sierra Club planted 3,000 koa seedlings during 126 hours of effort under the direction of Barry Orlando and the refuge staff.

i. August 21-23. Nine volunteers from the Honolulu Sierra Club and two Student Conservation Association volunteers expended 70 person-hours grubbing Holly at Pua Akala and 72 person-hours grubbing banana poka at Maulua.

j. September 5-7. Nora Furuno's group of nine volunteers from Honolulu plus two Student Conservation Association volunteers donated 144 person-hours of effort grubbing banana poka in the Maulua tract.

k. October 10-12. Steve Kim's group of nine volunteers from Honolulu provided 113 person-hours of effort to pick 7 bags of koa seed pods. Mike Robinson and the refuge staff directed the effort.

l. October 24-25. A group of eight FWS volunteers from the complex office picked 5 bags of seed pods during 56 person-hours of effort. The group was directed by Pat Bryan and the refuge staff.

m. November 7-8. A 4-H Club group of nine volunteers led by Debbie Ward expended 95 person-hours picking 4 bags of seed pods. Pat Bryan directed the effort.

n. November 14-15. Eleven volunteers from the Hilo Rotary Club and the Waieka High School Interact Club spent 94 person-hours picking 3-1/2 bags of seed pods under the direction of Pat Bryan.

o. November 29-30. Jan Moon's group of five volunteers expended 18 hours of effort to pick 1 bag of pods under Pat Bryan's supervision. Their vehicle got stuck as the result of heavy rains and the group was forced to spend an unplanned night in the refuge cabin.

p. December 5. Nine volunteers from the Hilo High School Hiker's Club led by Julie Williams provided 54 person-hours to pick 4 bags of seed pods supervised by refuge staff.

q. December 7-8. Four volunteers from the Puna Outdoor Circle expended 60 hours of effort to pick 4 bags of pods under direction from Pat Bryan.

r. December 11-13. Seven volunteers from the Maui Sierra Club donated 92 person-hours to pick 7 bags of seed pods. The group was coordinated and supervised by Pat Bryan.

s. December 23. Twelve volunteers and six members of the Hakalau staff provided 54 volunteer hours to pick 11-1/2 bags of seed pods.

For the second consecutive year, three volunteer college students associated with the Student Conservation Association also provided a great deal of assistance to the refuge for a three-month period during the summer. Matthew Getz, Martin Jones and Jared Gerstein resided at Hakalau Cabin while assisting with the removal of old fences, banana poka control, tree planting and fertilization, monitoring growth and survival of koa seedlings, weed surveys, gorse control, native plant surveys, fence inspection and feral ungulate surveys. In return they received roundtrip air tickets between their mainland residences and Hilo, \$15 per day to cover living expenses and a very thorough orientation to Hakalau Forest NWR and its resources. All parties were pleased with the program.

5. Funding

Hakalau Forest NWR receives its funding through the Hawaii/Pacific Islands NWR Complex. The FY 1992 funding for the Complex follows:

Refuge Complex Administration	\$315,000
Remote Island Refuges	961,500
Oahu Refuges	400,200
Kauai Refuges	908,900
Hakalau Forest NWR	<u>775,000</u>

TOTAL \$3,360,600

Hakalau received \$775,000 in funding for FY 1992 which included operations and maintenance funding totaling \$483,700, a special congressional appropriation in the amount of \$289,300 for the construction of pig\cattle fence, and two donations of \$1,000 each. \$1,000 was donated by the Natural Resources Defense Council staff as a Christmas present to their major donors. NRDC members and staff have given a total of \$4,507 during 1991 and 1992 for koa tree planting at Hakalau. \$1,000 was also received from the Hilo Rotary Club and designated for tree planting. This money went toward the fabrication of two "blade rakes" used to prepare planting sites for koa seedlings.

The history of funding for Hakalau Forest NWR since the refuge was established is summarized as follows:

<u>Year</u>	<u>Establishment (FWE)</u>	<u>Operations & Maintenance (RW)</u>	<u>Special Appropriation</u>	<u>Other Contributions</u>	<u>Total</u>
FY86	\$130,000	-	-	-	\$130,000
FY87	\$75,000	\$23,000	-	-	\$98,000
FY88	-	\$180,000	-	-	\$180,000
FY89	-	\$161,500	-	-	\$161,500
FY90	-	\$226,100	\$237,500	\$3,000	\$466,600
FY91	-	\$271,300	\$251,000	\$3,500	\$525,800
FY92	-	\$483,700	\$289,300	\$2,000	\$775,000

6. Safety

One serious accident occurred in 1992. Matthew Getz, Student Conservation Association volunteer, was driving alone in the GSA-owned 1991 Chevrolet Blazer assigned to Hakalau Forest NWR. While proceeding down the Saddle Road on a wet and foggy day to pick up another volunteer at the airport, the vehicle ran off the road near the 21 mile marker and over-turned. Fortunately, Mathew was wearing his seatbelt and was not injured. The accident was attributed to driver error. Mathew had previously received instruction regarding Hakalau's vehicle use policy which included safe and defensive driving practices and had even signed a statement that he read and understood the policy and instructions. Subsequent to this accident, even more emphasis has been placed on instructing volunteers and employees on the safe use of refuge vehicles and the hazards of driving on the Saddle Road and the rough roads of the refuge.

Hanzawa, Jeffrey, Texeira and Wass attended eight hours of CPR and First Aid training at the Community College. All four received Red Cross Certification.

7. Technical Assistance

Refuge Manager Wass accepted an invitation to participate as a technical advisor to the Pacific Sea Turtle Recovery Team. He had previously served as a team member on the Hawaii Sea Turtle Recovery Team.

The Refuge Manager actively participated on the multi-agency Gorse Steering Committee and the Forestry Subcommittee of the Resource Conservation and Development Council. The Forestry Subcommittee is considering a project to solicit funds from the public for a reforestation project on the Big Island. Hakalau Forest NWR will likely be the first recipient of these funds. The same committee also worked with the Refuge Manager on a proposal to secure funding from the American Forestry Association for tree-planting efforts at Hakalau.

The manager was invited to participate on a committee convened by the Nature Conservancy of Hawaii. The 10-member committee met for the first time in August and was charged with the responsibility for compiling a prioritized list of research needs relative to native terrestrial communities throughout the state.

The Refuge Manager spent March 11 at the Career Fair held at the University of Hawaii. He discussed job opportunities within the Service and other federal agencies with students and passed out pertinent literature.

During a week in June, Wass traveled to Tau Island, American Samoa with Mike Molina, Fish & Wildlife Enhancement, to assess the potential impact of a new boat harbor on the fishes and reef fronting Faleasao Village. The trip was funded by the Army Corps of Engineers. Wass was tapped for the job because of the expertise gained during his ten-year stint in American Samoa as a Fishery Biologist.

Wildlife Biologist Jeffrey assisted with the planning of the Native Ecosystem Management Workshop held February 25-28 at Hawaii Volcanoes National Park. The workshop focused on management of feral ungulates and alien plants. Jeffrey and Wass attended the workshop. Wass presented a slide talk on the refuge with emphasis on alien species management.

An intensive three day training session in bird identification and survey methodology was conducted in late September to assist other agency personnel in increasing skill levels. Refuge Biologist Jack Jeffrey and Jim Jacobi (USFWS, Hawaii Research Station) trained 25 people from various agencies including USFWS (Enhancement, Refuges, and Research), NPS (Volcanos and Haleakala), TNCH (Maui and Oahu), DLNR/DOFAW (Hawaii and Oahu) and Maui Land and Pine. Training of this type is needed to assist groups in developing the necessary skills to begin regular detailed forest bird monitoring on each of the other islands.

In December, Maintenance Worker Foreman Kikuta participated in the annual albatross census at Midway Atoll. Biologist Jeffrey attended a Population and Habitat Viability Analysis Workshop which discussed and modeled risk assessments for a number of Hawaiian endangered forest birds. Factors with the potential to cause extinctions were identified.

F. HABITAT MANAGEMENT

3. Forests

Formerly, koa and ohia forests extended to the upper reaches of the Refuge. One hundred and fifty years of logging, burning and cattle grazing, however, have reduced the upper elevation forests to exotic grassland pastures with scattered native trees. Current management plans call for reforestation of these treeless areas. Below the pastures are forests with a complete canopy but with incomplete understory due to the devastating effects of feral cattle and pigs.

Management, in the form of feral ungulate removal, will promote natural understory regeneration in these areas.

a. Interagency Agreements and Studies

Two Interagency Agreements (1986 and 1988) between the FWS and the U.S. Forest Service's Pacific Southwest Forest and Range Experiment Station were signed "for the purpose of developing guides for re-establishing the native forest on pasture areas of the Hakalau Forest NWR...." The objectives were to conduct the necessary field trials to determine what native forest regeneration methods are most efficient and cost effective and to provide management prescriptions for future large-scale reforestation effort. Accomplishments through 1991 under both agreements were summarized in the 1991 Annual Narrative.

In May 1987, an experimental reforestation plot (termed the Magnetic Hill Exclosure) of about 6 acres was established in open grassland below Magnetic Hill at the 6,500 ft elevation. A second experimental reforestation plot (a 40-acre area termed the Woodland Exclosure) was established in July 1987. It is located at about 5,500 ft in the SW corner of the Middle Honohina Feral Ungulate Management Unit.

1) The Magnetic Hill Exclosure Study

The objectives of this study were to evaluate survival and growth of koa plantings at two spacing distances, as well as growth and survival of mamane, sandalwood and ohia plantings. Because of site planting flaws, effects of microsite rather than spacing, have been observed. Survival rates of koa within this site were high averaging 84% for the 2 meter spacing and 74% for the 2.5 meter spacing after three years. The high survival rate at Magnetic Hill appears to be an anomaly, however, rather than the norm. Subsequent koa plantings at similar elevations elsewhere on the refuge have shown significantly higher mortalities. Perhaps rainfall and temperature were particularly conducive to survival during the winter of 1987. After three years, tree heights averaged 3.2 meters in the higher, sloping portions of the study site and 3.9 meters in the lower, flatter portions. By 1992, some of the koa trees were taller than 18 feet. A few were already blooming though no seed production was observed. Numerous root sprouts were found around the edge of the plantings so the trees are already actively reproducing.

Sandalwood survival was generally high though all seedlings suffered dieback and little subsequent growth. The data suggest there is little benefit to planting sandalwood with either a koa or mamane host as those planted without a host plant did equally well. As for the host plants themselves, almost half of the mamane died, while only 15% of the koa died. All of the ohia planted in 1987 died.

2) Woodland Exclosure Understory Species Out-planting Trials

The objectives of the Woodland Exclosure study were: 1) Determine the patterns of and requirements for natural regeneration of native plant species after cattle removal; and 2) Test out-planting methods for eight understory species (ohia, olomea, olapa, kolea, kawau, pilo, and two *Clermontias*). All species showed reasonably high survival despite the lack of rainfall due to an *El Niño*-induced drought. During the height of the drought, plants under less than 25% tree canopy were severely stressed while those with greater canopy cover looked more vigorous. A post-drought inspection showed relatively high survival. *Clermontia* had the highest (100%), with pilo (65%), olomea (50%), kawau (50%), ohia (46%) and kolea (35%) having less. Olapa had the poorest survival (13%).

3) Triangle Paddock Seed Source Study

The objectives of this study were to test survival and growth rates for koa seedlings of known parentage. Data analysis indicates that parentage had little effect on seedling survival or growth along any of the tested elevational gradients. All trees had poor survivorship and growth at high elevations but most did well at lower elevations. Variation in growth and survival occurred at all elevations and was likely due to microsite differences. This variation was as great between seedlings from a single parent as it was between seedlings from all parents. Interestingly, different parents produced different size seeds.

4) Hakalau and Pedro Fertilizer Studies

A study was begun to determine whether fertilizer (10-30-10) will significantly increase the survival and/or growth rate of koa seedlings. Five study plots were established ranging from the highest to the lowest elevations of the 1992 planting. Fertilized and unfertilized seedlings were staked and flagged for identification and will be monitored for growth rates and survival.

b. Reforestation Program

By 1989, enough was known to go beyond the experimental stage and initiate a full-scale reforestation program on the refuge. Koa was chosen because the propagation methods are best known for this species. Additional species will be planted in the future as techniques for their propagation are better defined. The current establishment of koa stands in open pasture areas will improve the chances for later success with other species. These newly planted koa trees will add organic matter and nitrogen, acidify the soil, and provide shade for future plantings of ohia and understory species.

1) Koa Planting - 1989

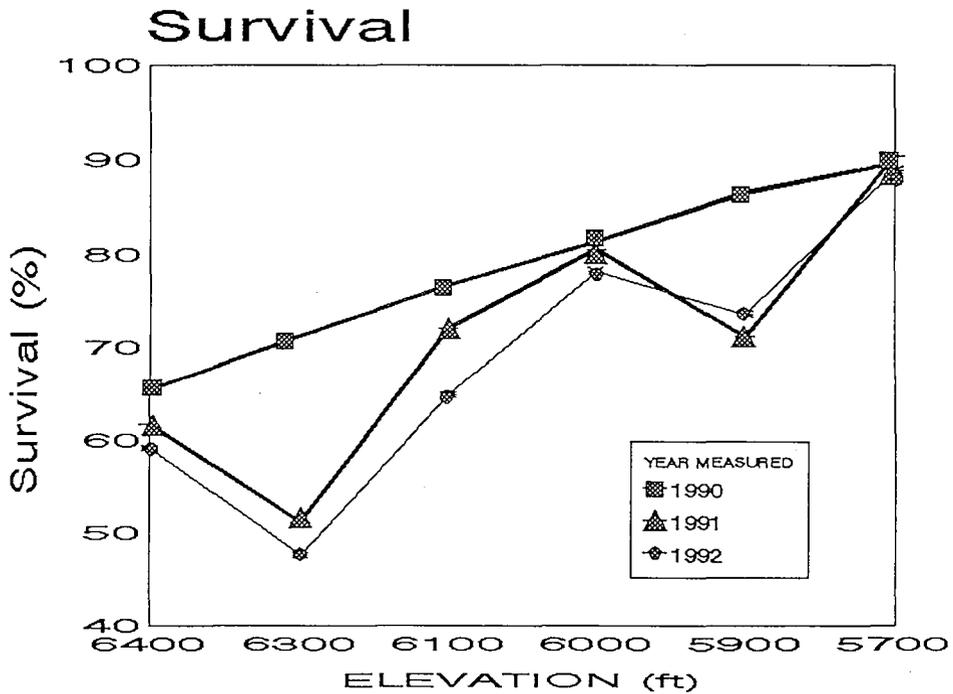
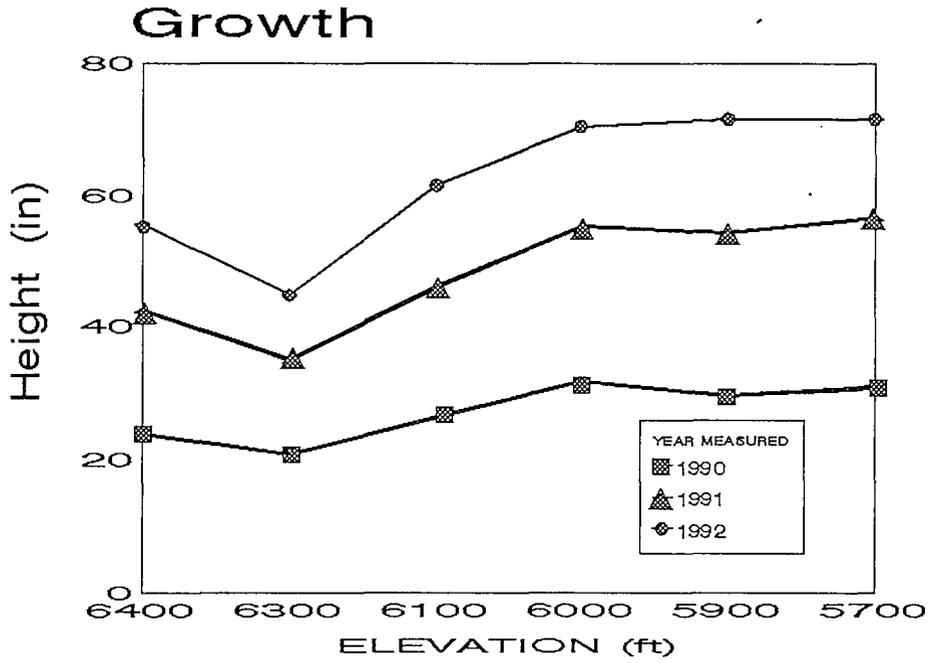
During 1989, 11,000 koa tree seedlings were planted in the 400 acre Triangle Paddock area of the refuge. Planting sites were prepared with a disc-harrow to reduce competition from exotic pasture grasses. Koa seedlings (10" to 18" tall) were then planted in the exposed soil.

Survival and growth rates for approximately 2,500 seedlings in fifteen plots, at elevations between 6,400 and 5,600 feet within the Triangle Paddock were re-measured in August 1992. Mean survival from the time of planting to the present (1989 to 1992) was found to be 68.7%. Survival varied from 42% at the higher elevations to 100% at the lower elevations. Much of the mortality at higher elevations resulted from frost during the winter months. During 1992, an *El Niño* event generated drought conditions over the Hawaiian Islands and caused a dramatic decrease in rainfall at Hakalau. Although the drought did not seriously affect total survival of these three-year-old trees, its effects could be discerned. Some of the large (3 meter tall) trees died and others were stressed. A 2-3% mortality detected across all elevational gradients is most likely a result of this drought. The mean sapling height in 1992 was 64.4 inches, an increase of 23% over last year. This is a decrease in the expected growth rate as compared to the 44% growth rate from 1990-91 and is probably drought related. Height averaged 50 inches at the highest elevation and 69 inches at the lowest elevation. Warmer temperatures, fewer heavy frosts, and greater moisture enhanced the survival and growth at lower elevations. Growth and survival data for 1990 through 1992 are summarized in Figure 3.

The confounding effects of tall grass, multiple root sprouts from pre-existing and planted trees and trees with dead tops but live root

1990-1992 Koa Growth and Survival Summary

Triangle Paddock



sprouts, are limiting the collection of accurate data on survival and growth.

2) Koa Planting - 1991

In 1991, 5,000 seedlings were planted below Hakalau Cabin and along the north side of Kolekole Stream above Middle Road. Six parallel continuous strips were laid out 12 feet apart from 6,400 ft to 5,500 ft elevation. The following site preparations, one on each strip, to test six different methods of reducing grass competition, were made: 1) Discing; a continuous strip about two meters wide was disced. 2) Burning; a patch of grass about one meter in diameter was burned away with a propane torch. 3) Scalping; a mattock was used to clear the vegetation within a one meter circle. 4) Weed-wacking; a gas-powered weedwacker was used to clear the grass from a one meter circle. 5) No preparation; nothing was done to remove or kill the grass. 6) Herbicide; Roundup was sprayed a few weeks before planting to kill the vegetation in a one meter diameter area.

Preliminary analysis (data collected February 1992) shows that discing was the most effective method of planting site preparation. Koa seedling survival rate at the highest disced plot averaged 79%. Other treatment plots had significantly lower survival (range 30%-39%) at this same elevation. Although the vigor class was rated highest in the disced treatment, growth was less than some of the other treatments. At lower elevations, the disced plots had higher rates of survival and higher rates of vigor but similar growth rates to the other treatments. The herbicide treated plots were notable in that they had consistently higher growth rates but with average vigor and survivorship.

All seedlings in the subplots were remeasured in August 1992. The drought and winter frosts had taken a great toll. Mean survivorship for all elevations was only 36%. The highest elevation had the highest mortality (84%) within all treatments. Discing had the highest rate of survival and was slightly behind herbicide in growth rate, as compared to all other treatments, after one year. Survival rates for discing averaged 61% for all elevations versus 31% for all other treatments. The greatest growth occurred in the herbicide treatment which averaged 22.0 inches. The disced treatment was second in growth rate averaging 19.1 inches.

Discing is the most cost effective pre-planting treatment for planting koa in the upper grasslands on the refuge. Slightly slower growth rates may be the result of removal of the rich organic top soil during discing and planting the seedlings in a less friable substrate. The use of a rake or other device that removes the grasses but leaves the top soil is being investigated. A disadvantage of discing is that the large amount of exposed soil attracts feral pigs which often damage or kill koa seedlings.

A study to determine if fertilizer would increase growth and survival of koa seedlings was initiated in 1991 in the six-treatment planting corridor. Three plots made up of 120 rows at three different elevations were established and fertilized on December 7. Each plot was defined as six strips wide and 120 rows long and each contained 720 plants. Two ounces (60 grams) of 10-30-10 granular fertilizer were placed in each of two holes made with a dibble stick at each test plant. Fertilizer placed in dibble holes is thought to leach out slower than broadcast applications and is less likely to burn the plants. It is also available sooner because it is closer to the roots. An earlier test using 20, 40, and 60 grams of 10-30-10 fertilizer on a small sample of seedlings showed that no burning of the young trees occurred at the 60 gram fertilizer level.

Growth and survival were compared for the fertilized and unfertilized trees two months after treatment. The results were inconclusive because drought and heavy frosts killed a large number of the trees in the study plots. The experiment should be repeated.

3) Koa Planting - 1992

Early in 1992, a partnership was created to help meet Hakalau's goal of reforesting the higher elevation, open grassland portions of the refuge. Although sufficient volunteer labor was available to help with the seed picking and planting, supervision of volunteer crews was needed to relieve the refuge staff on weekends. The Big Island Resource Development Council (RC&D) helped to form the partnership of sponsoring entities to conduct a five year reforestation project. Under this partnership, the refuge manages the project, prepares the planting sites, and provides volunteer transportation and lodging, plantation maintenance and protection, technical support and overall supervision and direction. The RC&D manages a \$31,300 grant from the American Forestry Association to plant 126,000 koa seedlings at Hakalau. As a condition of the grant, the plantings will be designated a Global ReLeaf Heritage Forest. The funds are used primarily to pay a Crew Leader to organize and supervise volunteer crews of seed pickers and tree planters. The RC&D has contracted a forestry consulting firm, Resource Management, to administer the grant, provide technical assistance and to coordinate the recruitment and supervision of paid Crew Leaders. The State Division of Forestry and Wildlife (DOFAW) germinates and grows the seedlings from seed provided by the refuge.

Under this partnership, 18,000 koa seedlings were planted on the refuge during 1992. Approximately 36,000 koas have been planted since 1987. The 1992 trees were planted in Hakalau 2 (130 acres) and Hakalau 4 (490 acres) paddocks which are largely open grassland and in the upper portion (100 acres) of Pedro paddock which is also largely unforested. Again the trees were planted in three-row-wide corridors oriented in the mauka-makai (uphill-downhill) direction between the upper boundary and the top of the forest. The rows were spaced about 12 feet apart and the seedlings within each row were spaced about 12 feet apart. Planting sites were created by a contractor using a five-tined ripper mounted behind a Case 450 caterpillar tractor. A strip of turf approximately four feet by four feet was peeled back to expose mineral soil.

Ten three-row-wide planting corridors were created in Hakalau 2, Hakalau 4 and Pedro Paddocks in April by the contractor (Steve's Ag Services). Between May 1 and July 5, five groups of volunteers planted the 18,000 seedlings. Barry Orlando was contracted by Resources Management to help organize and to lead the planting crews and he did an excellent job. Unfortunately, April, May and early June were extremely dry so many of the seedlings died and the rest got off to a slow start. Mortality was greatest in Hakalau 2 paddock located at the highest end of the planting.

4) Seed Collection

All koa seedlings planted at Hakalau are germinated from seeds picked from trees growing on or adjacent to the refuge to ensure that the seedlings are adapted to local conditions.

For unknown reasons, 1992 was the best year for seed production seen at the refuge since the staff began collecting seed (1987). Perhaps the high production resulted from the dry conditions caused by the *El Niño* event. Volunteers and staff picked 47 plastic trash bags of seed pods late in the year. The pods were mechanically shucked to yield 120 lbs of seed plus debris. Some of the seed was immediately germinated for

planting in 1993. The remainder will be stored in a refrigerator and germinated for planting in 1994.

c. Vegetation Plot Surveys

In 1987, C. P. Stone and assistants (NPS Technical Report 63) began the collection of detailed vegetation data at Hakalau to monitor forest recovery as intensive forest management progresses. Stone established six 20 x 20 meter semi-permanent plots and six 50 meter line-intercept transects at six locations on the refuge. Three heavily grazed areas and three less grazed areas were selected for sampling at different elevations and in different parcels of the refuge.

In March of 1992, with the help of Dr. Lani Stemmermann, University of Hawaii and several volunteers, two of Stone's plots on transect 10 in the Honohina Tract area were resurveyed with the same methodology. Vegetation resurveys were completed for the four other plots in 1991. All plots will be monitored every five years to assess vegetation response to management efforts such as feral ungulate removal and weed control.

The 1992 results from Plot 3 within the middle Honohina Tract, where feral ungulates were removed in 1987, showed an increase of three native plant species and an increase in native cover from 6% to 19%. Alien plant cover decreased 13% but four new alien plants were found. A notable and expected exception to the decrease in alien plant cover was a four-fold increase in blackberry cover.

Plot 4, within the same area but still under the influence of feral ungulates, had a slight increase in native plant cover (16% to 19%) while the number of native species was unchanged. Alien plant species decreased by two and alien plant cover decreased from 68% to 54%.

Plots 5 and 6, located in the Hakalau Tract two kilometers south of plots 3 and 4, are still experiencing pig and cattle disturbance but to a lesser extent than in 1987 because control measures are underway. Slight increases in native plant cover and alien plant cover were noted.

The native vegetation is responding positively to the removal of feral ungulates as shown by the analysis of Plot 3 data. It appears, however, that both alien plants and native plants are inhibited by grazing and rooting of feral animals because the number of species in both groups increased in Plot 3.

d. Rare Plants

In 1991, several ripe fruits of the endangered *Clermontia pyrularia* were collected by refuge staff from the only known plant (located in the Piha area). These were sent to Fern Duvall (DLNR) for seed extraction and germination. Failing to germinate seeds on the first try, Duvall fed the fruits to captive reared, endangered Alala (Hawaiian Crow) after which they sprouted readily. When the plants were a few inches tall, they were hand carried from Maui to the Hawaii Volcanoes National Park greenhouse. In June 1992, 25 *Clermontia pyrularia* 6-8" tall were planted at Hakalau in the Pua Akala and Honohina Tracts on rotted log and soil substrates. The Pua Akala plants were fertilized with a small amount of 10-30-10 granular fertilizer in October. All will be monitored periodically to measure vigor, growth rates and first flowering dates.

During 1992, two common myna birds were fed fruit from *C. pyrularia*. The scarified seeds from the myna feces and fresh fruits were sent to Peter Van Dyke at Amy Greenwell Botanical Gardens in Kona who was unable

to obtain germination. The relatively low elevation of this garden and its warm temperatures may be responsible for the failure.



Student Conservation Association Volunteers (Jared Gerstein, Martin Jones and Matthew Getz) planted 25 rare 'Oha wai (Clermontia pyrularia) within the Pua Akala and Honohina Tracts. (JJ)

7. Grazing

Native Hawaiian plants are ill-adapted to withstand grazing pressure. Consequently, the 100-year period of grazing has had a devastating impact on the upper-elevation forests of the refuge. The elimination of grazing, therefore, is a primary refuge management objective.

Four of the six parcels currently comprising the refuge were leased for grazing at the time of their acquisition by the FWS. As conditions of sale, the Service consented to continued grazing by the lessees on two of the parcels for at least three years to allow time for the ranches to phase out their operations and to allow the Service time to determine if the benefits of a limited grazing program might outweigh the adverse impacts.

Under Cooperative Agreement and Special Use Permit, the Pua Akala Ranch was allowed to graze portions of the Shipman Parcel from October 1985 to October 1989. Pua Akala Ranch, presently owned and managed by Willie Andrade, currently grazes cattle on a 500 acre parcel adjoining the southwest corner of the refuge which is still owned by the W.H. Shipman Estate. Pua Akala Ranch cattle, however, no longer graze any portion of the refuge.

Grazing by the Alfred Nobriga Ranch on the 1,942 acre upper Maulua Parcel occurred from 1987 through 1991. The first three years were covered by a Cooperative Agreement under which grazing privileges were provided in exchange for equivalent value services relating to grazing

and management. Grazing during the remainder of the five-year period was covered by Special Use Permits (HAK-1-90 and HAK-4-91) under which the Nobriga Ranch paid \$26.72 per Animal Unit Year. Grazing during those two years amounted to 540 AU for which \$14,426 in grazing fees were collected.

During January and February of 1992, the bulk of Mr. Nobriga's herd was removed from the upper Maulua Parcel. Twenty more head were removed during the remainder of 1992, but about a dozen domestic and feral cattle remained on the property at year's end. The perimeter fence has numerous holes so wild cattle from lower Maulua and the adjacent state-owned parcels of Piha and Laupahoehoe keep trickling in. The problem will not be solved until a new perimeter fence is constructed.

Mr. Nobriga was issued a Special Use Permit (HAK-9-92) to allow him to pump water from his rubber-lined catchment pond on the refuge up to his grazing area above Keanakolu Road.

9. Fire Management

A Fire Management Plan was completed for Hakalau in 1988. It includes a section on prescribed burning which discusses the use of fire to burn patches of gorse killed by earlier applications of herbicide. Five prescribed burns were conducted in 1989, 1990 and 1991 which eliminated 99% of the larger gorse patches. No prescribed burns were conducted during 1992 and it appears there will be no further need for gorse control burns on the refuge as long as the young plants are regularly controlled with herbicide and no new gorse-infested property is acquired.

10. Pest Control

A major management concern is the establishment and spread of alien plants which crowd out and compete with native species and provide little or no habitat for the endangered birds the refuge is mandated to protect. Banana poka (*Passiflora mollissima*), gorse (*Ulex europaeus*), and prickly Florida blackberry (*Rubus argutus*) are invading species that require control measures.

a. Banana poka

On the Refuge, only the Maulua tract (bounded by Laupahoehoe and Piha) and the northern edge of the Honohina tract (bounded by Piha) are presently infested with banana poka. Cattle grazing has helped to control this weed in the past but active effort is now required because the cattle have been removed. Currently-used control methods include severing large stems and uprooting small plants. Roots and cut ends are suspended in the air because they will re-root if touching the ground or in contact with wet vegetation. Both methods are labor intensive.

In 1990 and 1991, Honua Landscaping was contracted to conduct 317 hours and 240 hours of manual poka control effort within the upper Maulua tract. Volunteer groups led by refuge staff expended a great deal of additional control effort in upper Maulua and middle Honohina to the point where it was estimated that over 90% of the mature (fruiting) vines had been removed. No poka control was contracted during 1992 due to funding limitations. However, four groups of volunteers spent 262 person-hours severing stems and pulling vines in upper Maulua so the area remains relatively free of poka.



Banana Poka vines were removed from Maulua Tract with the assistance of volunteers. (JJ)

b. Gorse

Gorse is a noxious weed that formerly occurred in large patches on the upper-elevation grasslands in the southwestern corner of the refuge. It provides no habitat for native wildlife, grows in impenetrable thickets in which no native plants can establish, and poses a fire hazard.

Gorse control through use of herbicide, fire and manual removal was initiated at Hakalau in 1988 and has resulted in the eradication of almost all plants except for young seedlings. Since 1989, contractors have provided manpower to chemically control gorse. Each successive year has seen a reduction in man-hours needed to do the job. Although the infestation has been greatly reduced, the 30 year seed viability results in a continual problem with new sprouts. Also, heavy rains and feral pigs carry the seeds into the forest and downstream requiring geographical expansion of efforts.

Gorse prefers the open sunlit pasture areas but it does occur within the forest, particularly in sunny areas and at wide openings in streambeds. A considerable amount of staff and volunteer effort was expended manually removing gorse from streambeds within the forest. Herbicide is not used to control gorse in or near the forest because of the potential adverse impacts on native plants.

The chemical control of gorse has evolved since the Service prohibited the use of Tordon 22K which bears the label "restricted use". Escort was applied as a foliar spray in 1990 but was less effective than Tordon. Also in 1990, Garlon 4 was mixed with diesel and applied as a basal bark treatment to root crowns and stumps of burned plants which proved very effective. In 1991, Garlon 4 mixed with water was applied as a foliar spray. It proved to be almost as effective as Tordon so was also used in 1992.

Honua Landscaping was contracted by the refuge in 1989 and 1990 to provide 360 man-hours and 283 man-hours respectively of herbicide application effort toward gorse control. A 258 hour contract was let to Orchard Services in 1991 for herbicide control of gorse.

In 1992, Orchard Services was contracted again to provide 100 hours of chemical control effort. This effort focused on the largest gorse patch which had also been sprayed and burned the previous year. As before, the refuge provided herbicide, surfactant (Silwet), and water, while the contractor provided equipment and manpower. Garlon 4 was used in a 2% formulation in water as a foliar spray, while a 4% formulation in diesel was applied as a basal bark treatment. The refuge staff provided another 56 hours of chemical control during the year. Additionally, three Student Conservation Association volunteers provided 211 hours, two volunteer groups provided 88 hours and the Hakalau staff provided 115 hours of manual control in forested areas.



A 4 percent solution of Garlon 3A and diesel was applied to the burnt stumps and root crowns of gorse to kill the roots. (DW)

The considerable effort described above has resulted in good control of the original infestation. Few mature (seed producing) plants remain on the refuge. Continued effort, however, is required for several more years to kill the young plants which sprout from the remaining seedbank and seeds washed onto the refuge from above by heavy rains.

c. Blackberry

Florida Blackberry (*Rubus argutus*) has been categorized as one of the most habitat disruptive alien plants in Hawaii. Years of grazing by cattle and rooting by pigs have created unnatural openings and soil disturbances in the native forest allowing blackberry to gain a foothold, competing with native plants for space and nutrients.

An alien plant survey conducted in 1992 within the 550 acre Middle Honohina feral ungulate management unit showed that blackberry has exploded since cattle were removed from the area in 1989. (See Figure 4, upper chart.) Most of the surveyed plots within the cattle-free area had blackberry densities in cover classes 2 (6-24%) and 3 (25-50%). This is a dramatic increase over the 1987 survey which had only 8% of the plots in these same high density cover classes. In contrast, Figure 4, lower chart shows a much smaller increase in blackberry cover during the same period in an adjacent area where domestic cattle were removed in 1989 but which is still frequented by feral cattle. Obviously, blackberry control measures must be implemented in areas where cattle have been removed.

In June 1991, five 10 X 10 meter plots were established in the exotic grass/blackberry area of the fenced 550 acre Middle Honohina feral ungulate management unit to test the effectiveness of the "clip and drip" method for controlling blackberry. Two plots were set up in blackberry with exotic grass ground cover and three in blackberry with exotic grass/native fern ground cover. Two plots of each ground cover type were used to test different concentrations (50% and 100%) of Roundup herbicide. All blackberry stems were cut as close to the ground as possible and a drop of Roundup was dripped, using a small (250 ml) laboratory drip bottle, onto the stump end. The fifth plot (exotic grass/native ferns) was used as a control. Stems were cut, but the stump end was not treated with roundup. One month and one year later, all plots were monitored for regrowth of the cut stumps.

The following table summarizes the results:

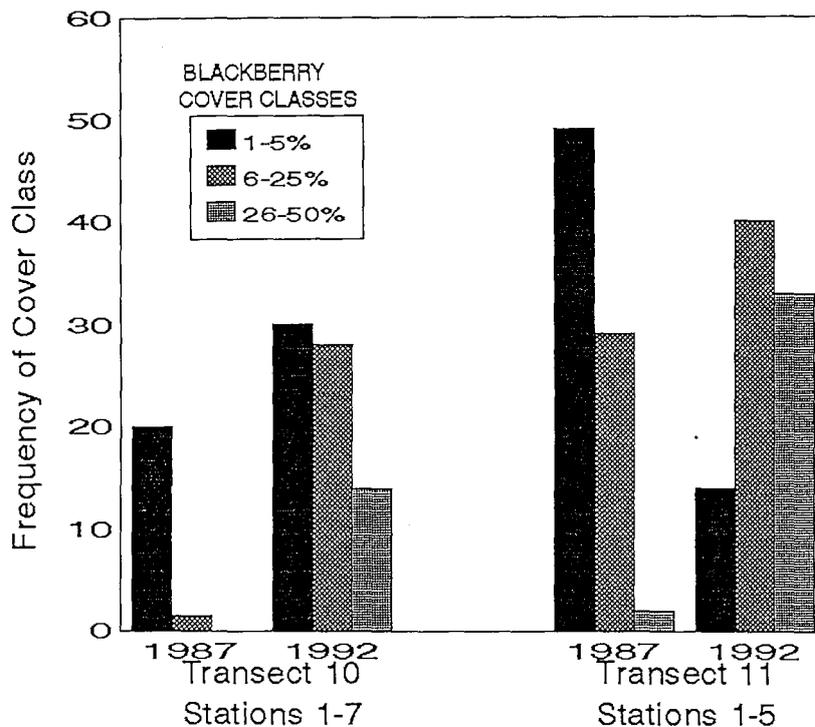
Ground Cover	Roundup Concen.	Stems	Stems	Stems	Percent
		Cut	Regrowth	Regrowth	Regrowth
		Initial	1 Month	1 Year	1 Year
Grass/Fern	None	310	193	249	80%
Grass	50%	180	23	54	30%
Grass/Fern	50%	167	24	34	20%
Grass	100%	175	11	38	22%
Grass/Fern	100%	336	19	37	11%

No buffer zones were treated around the study plots so much of the regrowth noted in the above table probably emanates from the roots of plants located just outside of the 10 x 10 meter plot. Although labor intensive, the clip and drip method is useful for controlling blackberry in situations where a foliar spray application has the potential for damaging nearby native vegetation.

d. Other Plant Pests

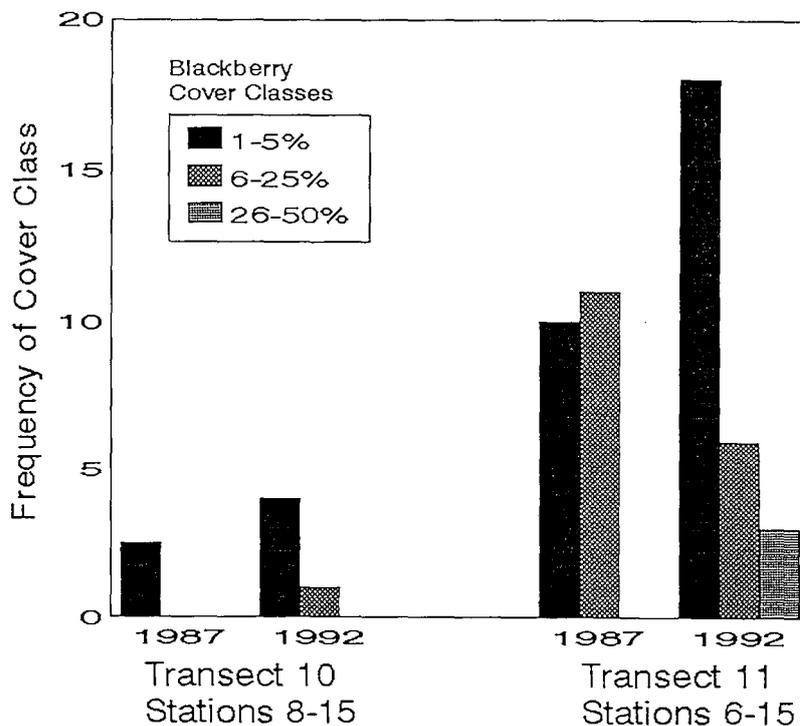
During a June weed inspection of the Shipman Unit fence corridor, six *Tibouchina herbacea* plants were found along the bottom fence one half

Blackberry Cover in Middle Honohina Unit*



*Feral cattle removed from area in 1989.

Blackberry Cover in Lower Honohina Unit**



**Area continuously grazed by feral cattle.

mile south of the Pedro corral. This is the first record of this weed on the refuge. All plants were pulled. Several more small individuals were pulled during a subsequent inspection in the same area. These plants were probably introduced during bulldozer fence-line clearing operations in 1988. This series of events underlines the importance of regular inspections of fence corridors and other areas where new weeds can become established.

Many years ago, holly was planted as an ornamental around Pua Akala Cabin and elsewhere within the 500 acre parcel still owned by the W.H. Shipman Estate. Holly is now well established on nearby portions of the refuge because the berries are readily eaten by the 'Oma'o. Forty person-hours of volunteer effort were expended during 1992 removing holly trees from the Pua Akala tract of the refuge.

e. Rat Control

One of the conditions associated with the issue of the Special Use Permit (HAK-1-88, Amendment 5) that allowed construction of the rain shelter in Pua Akala Meadow was that a rat control program would be initiated in the shelter area by the Permittee. Food storage and preparation at the shelter could cause an increase in the local rat population by providing a previously unavailable food source. Rats are known nest predators and an increase in their numbers might result in increased predation on eggs and nestlings of native birds. Resident graduate students trapped rats in the shelter area from January through December 1992. The catch during 233 trap nights was four Black rats (*Rattus*), and 17 house mice (*Mus domesticus*).

f. Yellowjacket Wasps

Over the past few years exotic yellowjacket wasps (*Paravespula pensylvanica*) have been seen in low numbers on the refuge. During the 1991-1992 *El Niño* event, drier conditions in the upper forests have led to an increase in wasp numbers. Several nests of this ground nesting species were found in the Honohina and Pua Akala Tracts. The highest elevation nest was found in the Pua Akala Tract along Nukupahu Gulch at 6,000 feet elevation. A large nest, with a 6 inch opening, was found in the Honohina Tract at 5,300 feet at the lower edge of the alley-way. This nest was destroyed in mid-July by injecting the powdered insecticide, Ficam.

A Yellowjacket monitoring program was initiated in August 1992 and will continue year round on a bi-monthly basis. Small plastic wasp traps baited with heptyl-butyrate, an aromatic attractant, were placed at 100 foot elevational gradients, along the Maulua, Honohina, Pedro, and Pua Akala roads. Yellowjacket numbers were consistently low in all of the Maulua traps. Relatively high numbers of the wasps were trapped in the other three areas in late September through December.

G. WILDLIFE

2. Endangered and Threatened Species

Hakalau Forest NWR was established for the purpose of protecting and restoring endangered forest bird populations and their habitat. The Hawaii 'Akepa, the Hawaii Creeper, the 'Akiapola'au, the 'Io (Hawaiian Hawk) and Koloa (Hawaiian Duck) are relatively common endangered birds at Hakalau. Three other endangered birds, the 'O'u, the Nene (Hawaiian goose) and the 'Alae ke 'Oke'o (Hawaiian Coot) are very rare. The endangered Hawaiian Hoary Bat, Hawaii's only land mammal, also occurs on the refuge but is rare.



The 'I'iwi is one of the most abundant birds on the Refuge. It feeds on nectar produced by Ohia blossoms such as those shown here. (JJ)

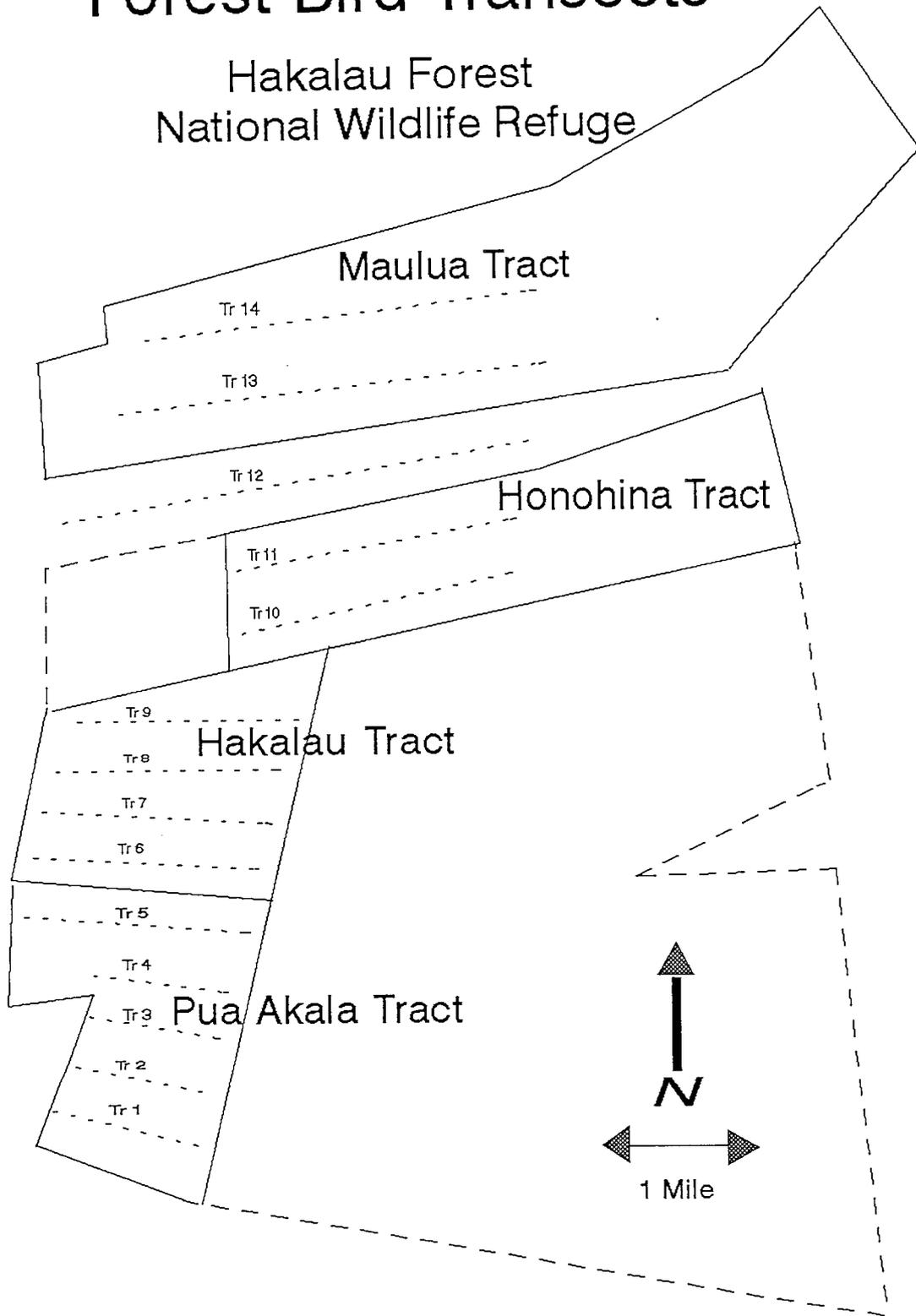
Systematic bird population surveys are required to ascertain the status of all bird species, to track their population trends and to measure their response to management efforts. Surveys have been conducted twice annually since 1987 by inter-agency teams from the Fish and Wildlife Service, National Park Service, Hawaii State Department of Land and Natural Resources the University of Hawaii and volunteers from the private sector.

Fourteen downslope transects, 500 or 1,000 meters apart and two to five kilometers long, were established to cover the entire refuge as well as the Piha tract managed by the State Division of Forestry and Wildlife. (See Figure 5 for transect locations.) Count stations (239 total) were established on each transect at 200 meter intervals. During a standard survey, all birds seen and heard at each station during an eight-minute count period are identified and distances to each are estimated.

The 1992 spring census was conducted from March 16-20. Principal observers included Jack Jeffrey (HFNWR), Jim Jacobi (Hawaii Research Station), Zee Sarr, (Hawaii Volcano National Park), and Jaan Lepson, (University of Hawaii).

Forest Bird Transects

Hakalau Forest
National Wildlife Refuge



Beginning in 1992, the survey was conducted in the spring only, not spring and fall as in past surveys. Also, the pasture or open grassland stations are now censused only once every three years until reforestation efforts in the pastures establish some forest canopy in these treeless areas.

The data for the 1988-1992 spring forest bird surveys have been compiled and analyzed. Annual population estimates are summarized for each species in the following table:

Species	1988	1989	1990	1991	1992
'Akiapola'au	279	537	157	206	147
'Apapane	19,237	42,483	26,632	26,471	49,776
Common 'Amakihi	24,279	28,212	36,383	26,000	39,027
'Elepaio	9,007	5,806	8,246	3,404	7,139
Hawaii 'Akepa	3,218	4,366	2,297	2,227	4,385
Hawaii Creeper	1,704	1,419	4,400	3,477	4,930
'I'iwi	57,765	78,545	53,308	36,673	56,609
'Oma'ο	7,154	6,412	5,839	2,939	5,815
House Finch	4,552	1,975	1,717	1,515	1,904
Japanese White-eye	8,815	10,546	14,044	5,777	11,132
Northern Cardinal	401	366	605	571	420
Redbilled Leiothrix	7,799	11,052	10,703	4,681	7,211

The population estimates for each species are graphically depicted in Figure 6.

Data for 12 forest bird species shows an increase in mean population size for 10 of the species between 1991 and 1992. Although this upturn might be interpreted as the result of management actions taken on the refuge, it is doubtful that this is the case. Normal population swings due to weather effects on breeding success and food availability, as well as observer variability, can cause yearly variations in population estimates of similar magnitude. Population trends documented through long term monitoring will more accurately portray the response to management actions.

6. Raptors

The Pua Akala Tract, transect 7 Hawaiian Hawk nest was again active this year. Two dark phase young fledged in early August. The adults at this nest are each of different color phases with the male being light and the female dark. A dark phase second year Hawaiian Hawk was seen and heard calling around this nest site until late September and is thought to be the young bird from last years nesting.

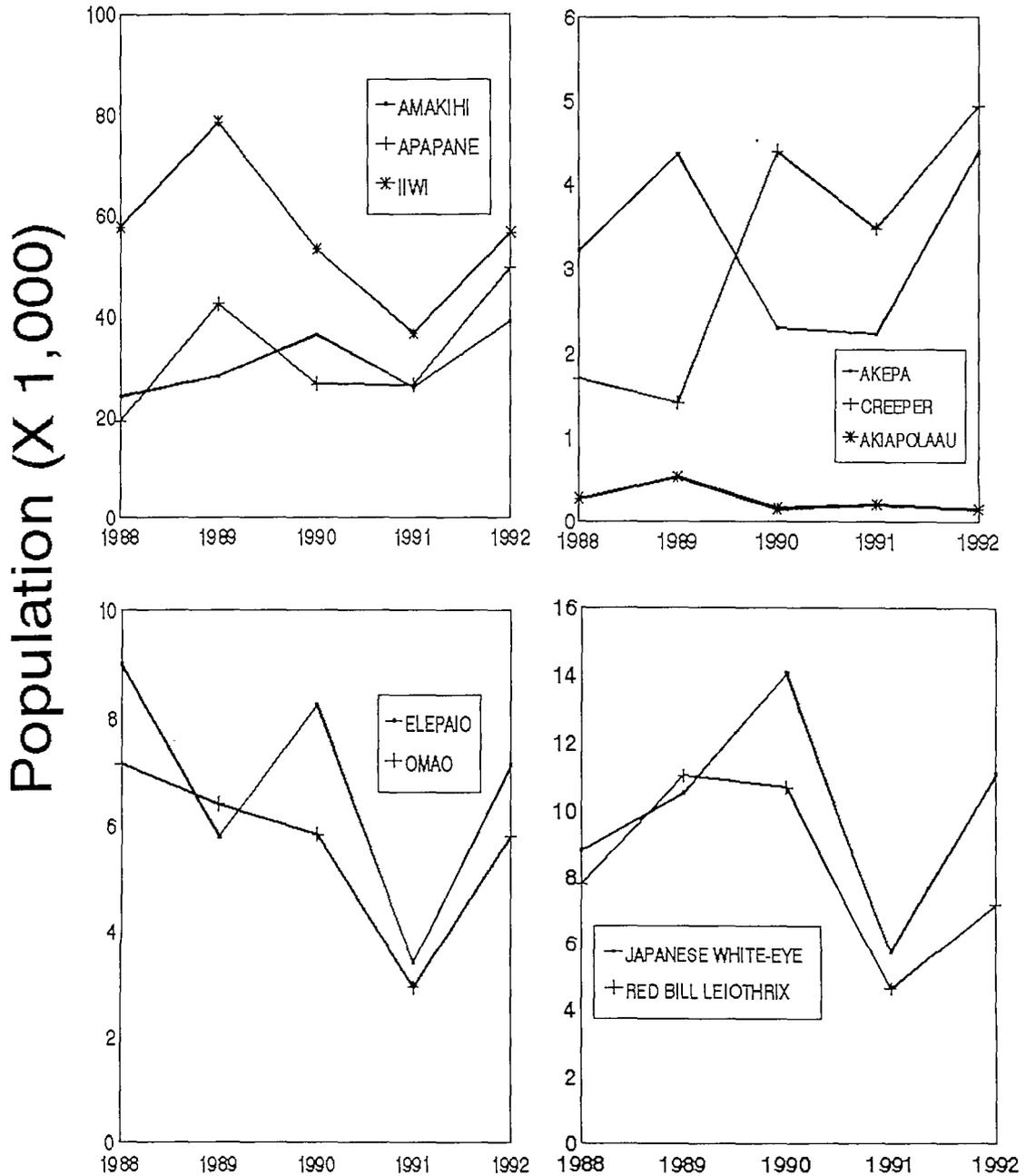
A second hawk nest found last year in the Maulua Tract near station 6 of transect 14, was not active this year.

14. Scientific Collections

The refuge was selected as a collection site by the Hawaii State Department of Land and Natural Resources for their survey of disease and parasites in exotic game birds. In December, Paul Conry and assistants from the Division of Forestry and Wildlife collected and necropsied (under Special Use Permit SUP-14-92) 3 Erckel's Francolin, 10 Ring Neck Pheasant, 3 Wild Turkey, 1 Japanese Quail and 1 Kalij Pheasant. The necropsy results will be reported when received.

A Special Use Permit (SUP-15-92) was issued to Dr. Peter Vitousek of Stanford University for the collection of ohia leaves along Pua Akala Road. He is investigating productivity, nutrient cycling and plant-soil

Estimates of Forest Bird Populations at Hakalau Forest NWR 1988-1992



interaction along elevational gradients in a variety of habitats throughout the state.

15. Animal Control

Feral pig and cattle control continues to be a high priority management objective at Hakalau. Hawaiian plants are not adapted to the grazing pressure of these introduced ungulates and are easily suppressed by them. Pigs find several species of native plants particularly delectable and have the destructive habit of rooting up vegetation and the top layer of soil in search of earthworms and edible roots. Cattle graze on native plants, especially tender young shoots and trample small trees, ferns, and roots. Both animals also heighten soil erosion and contribute to weed dispersal.

The need for fences to exclude feral ungulates has been well documented by other agencies such as Hawaii Volcanoes National Park. The fences are constructed of triple-galvanized posts and wire. T-posts are spaced at 10-foot intervals. The hogwire is further anchored to the substrate by anchor posts inserted between each pair of T-posts. Barbwire is attached to the bottom of the hogwire to prevent pigs from squeezing under and 8" above the hogwire to prevent cattle from going over.

Two fenced units have been created at Hakalau thus far: the 550 acre Middle Honohina Unit and the 5,000 acre Shipman Unit. (See Figure 7.) At the end of 1992, a contract was let for the fencing of a third unit to be completed in 1993: the 1,800 acre Lower Honohina Unit. Plans have also been made to fence the upper portion of the public hunting area: the 1,942 acre Upper Maulua Unit.

a. Middle Honohina Unit

The 550 acre Middle Honohina unit was fenced in 1988. By the end of 1989, all feral cattle and all but a few pigs were removed with assistance from the Resources Management Division, Hawaii Volcanoes National Park. Fence inspections were conducted periodically thereafter. No major fence damage was discovered, there has been no evidence of pig ingress and only a small amount of pig sign was located.

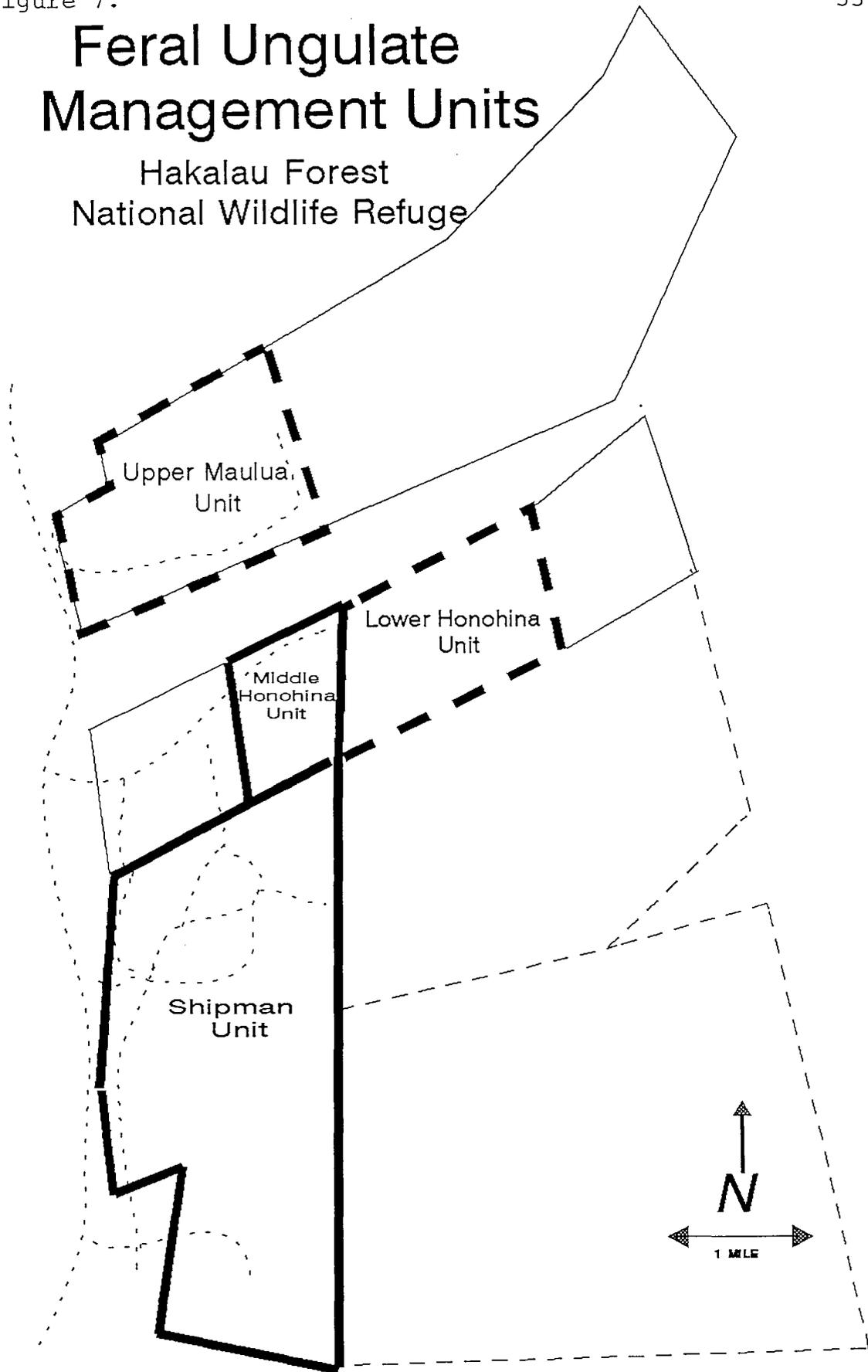
b. Shipman Unit

The perimeter fence around the Shipman unit was completed in 1991. Feral cattle eradication began in 1990. Cattle were targeted before pigs because: 1) cattle suppress natural reforestation to a greater degree than pigs; 2) cattle are easier to remove because they offer more obvious targets and occur in lower numbers; and 3) cattle have the potential for breaking through the new fence when frightened. During 1990-92, 171 feral cattle were removed from the Shipman unit under an aerial and ground hunting contract with the Resources Management Division, Hawaii Volcanoes National Park, by staff hunting, and under a contract with Ernest Pung.

Ground hunting by refuge staff and aerial hunting from a helicopter proved very effective when the population was high. These methods resulted in a take of 149 cattle by the end of 1991. After four helicopter hunts, however, the remaining cattle learned to hide in the thick brush when they heard the helicopter so a different approach was needed. Ernest Pung, a retired State forester and experienced cattleman was contracted to use his trained catahoula hounds to conduct ground hunts. He was able to shoot 11 cattle in late 1991 and 11 more during 1992. After three or four hunts with no captures, his contract was terminated. No cattle sign has subsequently been seen in the unit so it appears that eradication has been successful. These experiences indicate that feral animals can adapt to and elude control efforts, and

Feral Ungulate Management Units

Hakalau Forest
National Wildlife Refuge



that a variety of control methods are required to achieve eradication.

During 1992, 31 pigs were removed from the Shipman unit through staff hunting and 36 were taken in snares. Most of the effort began in the last quarter of 1992 when the Habitat Management Supervisor and two additional workers were hired. By the end of the year, about 100 snares were set in the Pedro Road area. The snares were checked at least once a week to satisfy animal rights activists. Check dates, snare locations and catches are logged on a form to document the effort.

Monthly inspections of the feral ungulate unit fences were implemented in November 1992. The length of these fences totals 17.2 miles.

c. Lower Honohina Unit

The Lower Honohina fence contract was awarded to the Fred Smith Construction Co. in late 1992 for \$189,000. Approximately 33,000 feet of fence will be installed to enclose about 1,800 acres at elevations between about 5,200 and 4,200 feet. The makai (east) boundary fence of the Middle Honohina unit will serve as the mauka (west) boundary of the Lower unit. The upper portions of the fence will be constructed to specifications which exclude cattle (47 inch hogwire). Since cattle occur only down to about 4,600 feet elevation, the lower portion of the fence will only be constructed to exclude pigs, thereby enabling the use of the cheaper 39 inch hogwire.

The refuge staff (Habitat Management Section) was to have cleared the fence corridor to keep costs down and to control the quality of the clearing process. The corridor-clearing effort began in October along the Piha-Honohina boundary to assist survey crews from the R.M. Towill Corporation which was contracted to stake the boundary. Wet weather and the rugged terrain retarded the effort and only about 8,000 feet of the corridor was flagged and cleared by year-end. After discussion with the contractor, the contract was amended to allow the contractor to complete most of the remaining clearing. The contractor will commence work in January.

d. Maulua Unit

Future plans call for construction of a fence around the 1,942 acre Upper Maulua unit and, perhaps, the lower units as well. In the meantime, the entire 7,240 acre Maulua Tract was opened to public hunting in February 1992 as mentioned in Section H.8. Hunters removed 38 pigs during 1992.

An old cattle fence presently surrounds the Upper Maulua unit but numerous holes allow feral cattle easy access. The Nobriga Ranch trapped a few dozen cattle in upper Maulua during 1992. Feral cattle also occur within lower Maulua.

e. Feral Ungulate Surveys

As mentioned above, Maulua Tract was opened to public hunting February 1, 1992. Transects 13 and 14 in the Maulua Tract were surveyed for feral ungulate activity in January and July to determine if public hunting can significantly reduce feral pig populations. The following table summarizes pig and cattle activity in Maulua before public hunting was initiated and six months after hunting began:

Transect	No. plots	Jan.	July	Jan.	July
		Pig Act.	Pig Act.	Cattle Act.	Cattle Act.
13 Top	299	25%	3%	31%	0
13 Bot	201	97%	68%	0	<1%
14 Top	298	52%	31%	66%	29%
14 Bot	200	90%	65%	0	0

Before hunting began, feral pig activity in the area below the bottom fence at Maulua averaged 94%. After hunting, the average dropped to 67%. Above the bottom fence, pre-hunting activity levels averaged 39% and post-hunting levels averaged 17%.

The greatest drop in activity was in the transect 13 top area where activity dropped from 25% to 3%. This was probably caused by greater human activity and higher hunting pressure along the Maulua Road which parallels the transect. A 30% drop in activity was noted in the lower reaches of this transect, again probably the result of easy access. Transect 14 had less reduction in pig activity. The long distance from the road and parking area may account for the smaller reduction.

A few cattle remain in the upper Maulua area in the vicinity of transect 14. None were seen in the upper portions of transect 13 but a single cow was seen below the bottom fence on transect 13.

Feral ungulate activity surveys were also conducted in the Pua Akala, Hakalau and Honohina Tracts of the refuge. No public hunting occurred in these areas but the refuge staff exerted considerable effort during 1991 and 1992. The survey results are summarized in the following table:

Transect	PIG		CATTLE	
	1990	1992	1990	1992
1	37%	12%	30%	0
2	39%	22%	6%	0
3	76%	9%	25%	0
4	76%	16%	41%	0
5	47%	7%	11%	0
6	40%	19%	12%	0
7	83%	57%	16%	0
7A	42%	51%	8%	0
8	10%	6%	0	0
8A	32%	3%	2%	0
9	15%	31%	35%	0

Pig activity in July 1992 averaged only 20% for the forested stations, three times less than in comparable areas of Maulua. No fresh cattle sign was found in the Shipman Feral Ungulate Management Unit during the 1992 survey so it appears cattle have been totally eradicated within the Shipman unit.

16. Marking and Banding

As noted above under Section D.5., Dr. Leonard Freed and colleagues banded 320 birds during the year including 7 endangered species: 3 'Akepa, 5 Hawaii Creeper and 1 'Akiapola'au. The totals for his five-year study are 2,328 banded birds of which 195 are endangered. This banded population is an extremely valuable study resource.

17. Disease Prevention and Control

Disease has been implicated as one of the main factors in the continued decline and extinction of the Hawaiian avifauna. Avian malaria and

avian pox are two diseases known to infect native bird populations. Avian malaria is probably transmitted by mosquitos and is generally found at elevations below 4,000 feet. The recent discovery of this disease on the refuge in both forest birds and game birds captured above 6,000 feet is discouraging though they may have been infected during flights to lower elevations in search of food. Identification of the vectors is urgently needed.

Avian pox lesions have also been found on forest birds captured above 6,000 feet on the refuge. Pox virus is spread by mosquitos, through contact with contaminated surfaces, and from one bird to another through direct or secondary contact. Open lesions on the feet may contaminate branch and leaf surfaces, giving rise to pox infections in birds landing on these substrates. Researchers handling birds in mistnetting operations must be especially careful. Diseases may be spread to subsequent captures if an infected bird is caught and persons handling the bird do not disinfect hands, banding tools, holding bags and mistnets. Dr. Freed and associates are following a disinfection protocol suggested by refuge staff to prevent the spread of diseases in native and exotic birds captured at their study site.



Populations of native forest birds like the 'Apapane may be limited by avian pox and avian malaria which are transmitted by mosquitoes. (JJ)

A fine resolution molecular probe is currently being developed for avian pox by Dr. Rebecca Cann. This probe should give greater detection rates than present methods. Blood from birds captured during ongoing mistnetting operations will be cryogenically preserved for later testing once the molecular probe is developed.

H. PUBLIC USE1. General

Public access to the refuge was initiated on February 1, 1992 with the opening of the 7,240 acre Maulua Tract to pig hunters during state holidays and the first three weekends of each month and to non-hunters on the last weekend of each month. Reservations are required for all visitors. Access is through Maulua Gate and includes the use of Maulua Road which extends two miles to the bottom of the upper Maulua Parcel. The response of hunters and non-hunters to the opening is summarized in the following table:

MONTH	NUMBER OF HUNTER RESERVATIONS*	NUMBER OF NON- HUNTER RESERVATIONS*
FEBRUARY	105	2
MARCH	20	8
APRIL	6	0
MAY	24	7
JUNE	5	14
JULY	4	16
AUGUST	10	11
SEPTEMBER	0	0
OCTOBER	19	0
NOVEMBER	6	6
DECEMBER	13	0
1992 TOTALS	212	64

*Reservations are used to estimate visitor use because the number of actual visits is unavailable.

Public hunting is described below under Section H.8. The response of non-hunters (i.e. birders, hikers, photographers, etc.) to the opening has been slow. This is attributed to a number of factors including the long bumpy drive (2 hours each way) from the population centers, the need for a four-wheel-drive vehicle, the fact that endangered bird populations are relatively low in the Maulua area, and the fact that access is limited to only two days each month.

A four-panel leaflet titled "Hunting and Public Access" was printed for distribution to visitors and those seeking information about the visitation program. The leaflet includes a map of the area open to visitation and describes the reservation procedure, rules and management objectives of the hunting and visitation program. Publication of the general refuge brochure, which was also to have occurred before the refuge was opened to the public, was delayed at least until the end of 1993.

Hakalau is a relatively new refuge and is the only refuge in the national system established primarily for the conservation of forest birds and their habitat. Consequently, considerable effort is expended to familiarize organizations and off-island decision-makers with the refuge and its unique problems and needs. Refuge tours, which often include helicopter overflights, are the usual means for accomplishing this objective. A few hours are often spent walking through the forest observing native birds and plants. If time permits, the visitors may also be shown the experimental reforestation plots, tree-planting efforts, feral ungulate control programs, weed control projects and the Hakalau cabin and associated facilities. Management objectives and strategies, funding and staffing needs and a wide variety of other subjects are discussed by the Refuge Manager and refuge staff who accompany the visitors.

Noteworthy visitors to Hakalau during 1992 included:

Jan. 10. Debbie Weatherly, Administrative Assistant to Rep. Joseph McDade (ranking minority member of the House Interior Appropriations Committee), Tia Nelson, Washington Office of The Nature Conservancy and Project Leader Jerry Leinecke helicoptered in to the refuge to participate in a ground tour and a briefing on management strategies and funding needs.

Jan. 16. Charles Smith and John Smith of the American Forestry Association visited the refuge to inspect and discuss the koa planting program which is partially funded by their organization. Rod King, a Service biologist from Alaska accompanied the tour.

Feb. 24. John Grandy, Vice President for Wildlife and Habitat Protection, The Humane Society of the United States, his wife Sheryl and Jerry Leinecke toured the refuge by helicopter and 4x4 vehicle to discuss the feral pig and cattle control program and to inspect habitat damaged by pigs.

Mar. 18. Mike Kitamura, Chief of Staff for Senator Daniel Akaka's Hawaii Office and Jerry Leinecke toured the refuge by helicopter and 4x4 for observation and briefing. All agreed we should arrange for Senator Akaka to visit Hakalau in the near future.

May 11. Ray Rauch, the new Project Leader for the Hawaii/Pacific Islands NWR Complex and Jerry Leinecke received a helicopter and ground tour of the refuge plus a thorough orientation and briefing.

July 16. Dale Hall, Asst. Regional Director for Fish and Wildlife Enhancement and Brooks Harper, Ecological Services overflew Hakalau by helicopter and toured the refuge by 4x4 along with Robert Smith, Enhancement.

Aug. 3. Judith Henry, Office of State Planning overflew the refuge and adjoining property and received a ground tour of the refuge. The primary issue for discussion was the State's proposal to rezone certain adjacent properties and some owned by the refuge from "Agriculture" to "Conservation".

Aug. 5-6. George Steuer, environmental staffer from Senator Daniel Inouye's office toured the refuge by vehicle and on foot for a general orientation that covered issues, management strategies, funding needs and accomplishments.

Aug. 10. Lynne Corn, Congressional Research Service drove and hiked the refuge discussing management concerns and strategies.

Dec. 13. Cyndy Kuehler, San Diego Zoological Society; Sue Ellis-Joseph, Captive Breeding Specialist Group; Bill Burnham, The Peregrine Fund; Peter Luscomb, Honolulu Zoo; and Chris Ekert, Olinda Captive Propagation Facility visited Hakalau primarily to view birds. They were part of the group assembled on the Big Island to conduct population viability analyses for Hawaiian forest birds.

2. outdoor Classrooms - students

A Special Use Permit (HAK-11-92) was issued to allow Drs. Leonard Freed and Stuart Pimm to conduct a college level School For Field Studies summer course titled "Conservation of Endangered Species" at the Maulua Tract and Cabin. Objectives of the course were to engage in group-structured research, to learn techniques of mist-netting and banding in order to monitor the population and community structure of endangered and common species of birds and to conduct student research projects

that focused on conservation-related problems involving single species, communities and habitats. Two sessions of the course were taught for a total of 16 students. The course was conducted at Maulua where few endangered birds occur to minimize the potential for adverse impacts.

7. Other Interpretive Programs

Because Hakalau Forest NWR is closed to the general public, film-makers, photographers, and journalists are encouraged to visit the refuge and then "interpret" the resources and management efforts through their media to the public. The following such activities occurred during 1992:

Stefan and Claire Dobert spent a February weekend on the refuge in the company of Jerry Leinecke and the Refuge Manager videotaping habitat and management efforts. They filmed about 1-1/2 hours of stock footage on the ground and from a helicopter to be used as the basis for a videotape library for the refuge. Their work was funded by the Regional Office.

Franz Lanting spent a day in March at Hakalau in the company of Biologist Jack Jeffrey photographing birds.

Cynthia Ramsey spent a day on the Pua Akala Tract viewing birds and plants and interviewing the refuge staff to gather material for her book titled "Hawaii's Hidden Treasures" to be published by the National Geographic Society.

For the fourth year in a row, a Special Use Permit (Hak-2-92) was issued to Jack Jeffrey to allow photography of birds, plants and Hakalau scenery for possible publication and sale. Jack allows the refuge and other federal and state agencies to use his photos at no cost. Several of his photos have also been used in widely-circulated publications.

Peter La Tourrette was again issued a Special Use Permit (HAK-4-92) to take 35mm photographs of birds and scenery for possible publication and sale. He donated several slides to the refuge which resulted from his efforts.

Mark Jacobs, The Producers' Group, was issued a permit (HAK-10-92) to film birds and plants at Hakalau. The film will be used by the BBC Natural History Unit in a four part series on the natural history of Polynesia titled "Nomads of the Winds". Mr. Jacobs is producing the fourth episode titled "The Last Horizon".

Each year refuge personnel spend some time "off-refuge" making presentations to conservation, student and special interest groups. Following is a summary of presentations made during 1992:

Refuge Manager Wass gave two 45-minute slide talks about the refuge and Hawaiian forest birds to four sixth-grade science classes at Waikea Intermediate School.

Wass gave a slide talk on the Hakalau reforestation effort at the Cooperative Extension Service Workshop on the Renewable Resource Extension Act.

Wass presented a slide talk with emphasis on alien species management at the Native Ecosystem Management Workshop at Hawaii Volcanoes National Park.

8. Hunting

a. Public Hunting

A Sport Hunting Plan for Hakalau was approved by the Regional Director in 1991 which opened the 7,240 acre Maulua Tract to public use beginning February 1, 1992. The hunting program has three objectives: 1) Employ public hunting as a low-cost management tool to reduce feral pig populations. 2) Gain public relations benefits by opening an area that has never been open to hunting before. 3) Provide the public with a quality and safe hunting experience in accordance with State and Federal laws. Hunters are allowed to hunt pigs on state holidays and during the first three weekends of each month. The first Saturday of each month is designated for bow-hunting only unless no bow-hunters make reservations. Reservations are required for all visitors and are limited to a maximum of 12 during hunting days for safety reasons. State hunting regulations apply except there is no limit to the number, size or sex of pigs taken because one of the program objectives is to maximize the control effort.



*The Maulua Tract was opened to public hunting and birding in February.
(DW)*

Hunter participation and take during 1992 is summarized in the following table:

MONTH	NUMBER OF RESERVATIONS	NUMBER OF HUNTERS	NUMBER OF PIGS TAKEN	PIGS/HUNTER
FEBRUARY	105	58	20	0.345
MARCH	20	10	1	0.100
APRIL	6	3	0	0.000
MAY	24	8	2	0.250
JUNE	5	3	1	0.333
JULY	4	2	3	1.500
AUGUST	10	6	1	0.167
SEPTEMBER	0	0	0	0.000
OCTOBER	19	8	3	0.375
NOVEMBER	6	2	4	2.000
DECEMBER	13	5	3	0.600
TOTALS	212	105	38	0.362

The initial response to the opening of Maulua for pig hunting was good. Hunters soon realized, however, that hunting on the refuge was no better than in the adjoining state-managed areas of Piha and Laupahoehoe so their numbers declined markedly after the first few weekends to relatively low numbers. Hunter success held steady at about one pig per three hunter-days which is slightly less than reported by the state for Piha and Laupahoehoe where food (banana poka fruit) is more abundant. Feral ungulate activity surveys planned for 1993 will show whether or not the low level of public hunting pressure in Maulua is sufficient to reduce pig activity.

b. Hunter Meetings

At the invitation of State Representative Dwight Takamine, the Refuge Manager attended two meetings with State Division of Forestry and Wildlife Officials and about 25 local pig hunters to discuss state and federal programs for public hunting, and resource management objectives that impact pig populations. Hunters expressed the belief that the refuge is not responsive to their position. Some of their major points and opinions were: 1) Increasingly, land within the state is managed with the objective of pig eradication and control which, coupled with reductions in forested areas due to logging and ranching, and increased closures of private property, results in continued compression of public hunting areas. 2) Pigs are beneficial to the native forest at low to medium population levels. 3) Data which implicate ungulates as responsible for significant forest degradation are fabricated by scientists and government officials to support control programs. 4) "Outsiders" ("mainland haoles") want to preserve native birds and plants for their own enjoyment. "Locals" appreciate native birds and plants too, but as an integral part of the hunting experience. 5) Scientists, which net, study and take blood samples from birds cause birds more harm than do pigs. 6) The mountain is the hunter's "meat locker". Hunters depend on hunting as a significant food source for their families and abhor the waste of meat resulting from some government control programs. The meetings did much to facilitate communication between hunters and managers. They also caused the Refuge Manager to begin thinking about permitting hunters to access the Maulua Tract from the lower end and to allow them to use dogs.

11. Wildlife Observation

The Special Use Permit issued last year to H. Douglas Pratt (HAK-3-91) was amended to allow him to conduct additional guided bird-observation tours to the Pua Akala Tract during 1992. On August 11, he led a small group from Four Points Nature Tours and on October 16 he led a group

sponsored by the American Birding Association. They observed endangered Creeper and 'Akepa on both occasions and a family of 'Akiapola'au the second time.

Peter La Tourrette was issued a permit (HAK-5-92) to lead a photo safari of about 10 people to Hakalau under the auspices of Cheesemans' Ecology Safaris.

Mark Collins was again issued a permit (HAK-6-92) to lead small groups of birders on day visits to the refuge.

Casey Jarman was issued a permit (HAK-7-92) to conduct a Hawaii Audubon Society field trip to Hakalau. Their trip was canceled when Hurricane Iniki hit Kauai.

Pacific Quest - Outdoor Adventures was issued a Special Use Permit (HAK-8-92) to conduct a guided tour of the refuge for a group associated with the Natural Resources Defense Council. The Refuge Manager accompanied the group which spent most of their time viewing birds and habitat in the Pua Akala area. About half of the group spent the afternoon touring the tree planting area.

Robert Sundstrom of Victor Emanuel Nature Tours conducted a guided bird observation tour at Pua Akala on November 1 for 20 visitors under HAK-13-92.

17. Law Enforcement

Late in 1991, Maintenance Worker Jon Emig attended Federal Law Enforcement Training School in Georgia. He graduated with honors at the head of his class. Emig continued law enforcement training in 1992, earning firearms instructor and armorer certifications and completing Refuge Officer Basic School.

Enforcement of Hakalau's public hunting program began in February, 1992, with the opening of Maulua Tract to pig hunting. The hunting program was monitored closely during the first few months. Most hunters were greeted upon arrival and licenses, reservations and equipment were checked. Take was inspected upon departure. Random patrols were conducted on hunting and non-hunting days. Decreasing hunter participation and excellent compliance (no citations and few warnings were issued) led management to reduce law enforcement activity to occasional patrols by June, 1992.

Officers from the State Department of Conservation and Resources Enforcement visited Hakalau in March. A cooperative relationship was established that includes sharing information and access to adjacent State and Federal areas for official purposes.

I. EQUIPMENT AND FACILITIES

1. New Construction

a. Fence

Since the refuge was established, 90,741 feet (17.2 miles) of pig/cattle fence have been constructed at a total cost of \$421,114 (\$4.64/foot or \$24,484/mile). Two feral ungulate management units (the 5,000 acre Shipman Unit and the 550 acre Middle Honohina Unit) have been enclosed. (See Figure 7.)

On September 28, 1992, a contract for \$189,000 was awarded to Smith Construction Company for 33,000 feet of pig/cattle fence to enclose a

third feral ungulate management unit (Lower Honohina Unit) encompassing about 1,800 acres. The contract calls for materials and construction of three sections of fence in the Honohina Tract area at elevations between 4,200 and 5,200 feet. In December, a contract modification added \$25,000 to cover hand-clearing portions of the fence corridor. Construction is scheduled to begin early in 1993.

The fence will be constructed of woven wire mesh and barbed wire with steel T-posts at 10-foot intervals and stress panels utilizing galvanized posts at corners and elevation changes. The fence is designed to be cattle and/or pig proof for its full length. Two construction specifications will be used. One specification is designed to exclude both cattle and pigs and will be used in upper elevation areas where cattle are present (about 70% of the total length). This specification requires using 7' T-posts and 47" woven wire with a barbed wire strand at ground level and another strand 8" above the woven wire. The other specification is designed to exclude pigs only and will reduce costs at lower elevations where cattle do not occur. This design uses 6' T-posts and 39" woven wire with barbed wire only on the bottom. Both specifications call for anchoring the bottom of the fence between the regular fence posts by attaching the woven wire and the barbed wire to specially prepared 26" T-post sections, which are driven into the ground so that no gap greater than 2" exists under the completed fence.

b. Entrance Signs

Early in 1992, Hakalau received four sets of refuge entrance signs ordered from Region 3's Sign Center in Winona, Minnesota. Each set consists of a 34" x 66" Refuge Entrance sign, with vinyl Service logo, and an 18" x 66" tract name and public access information sign. One set was purchased for the main entrance to each tract (Pua Akala, Hakalau, Honohina and Maulua).

Stan's Contracting was awarded the contract for framing and installation of the entrance and information signs. Stan's bid of \$8,800 included materials, assembly and installation of frames for the signs and construction and installation of a brochure rack in each frame. The frames were constructed of 4" x 6" and 6" x 6" treated lumber, providing a solid mount for the two signs installed in each frame. The brochure racks were constructed of treated lumber with plexiglass windows that make the brochures visible and protect them from the weather. The frames, with brochure racks and sign panels were set in concrete at the four tract entrances in July.

2. Rehabilitation

Steve's Ag Services was contracted in 1990, with provision for extension through 1992, to provide maintenance and rehabilitation of roads at Hakalau. The first increment of the contract called for rehabilitation of the access to the Pua Akala tract. The job was completed in 1991 at a cost of \$17,930 for 120 machine hours of work. A second increment called for the rehabilitation of about one mile of the Honohina Tract access to Nauhi Cabin and rehabilitation of the Alleyway access to the lower boundary of the Shipman Parcel. About 130 machine hours were expended by completion of this increment in December, 1991 at a cost of \$18,058.

An additional increment to the contract with Steve's Ag Services was ordered in April, 1992 which required scarifying a 43-mile-long, 19,000 site, Koa Tree planting strip. Steve used his Case 450 tractor with a 40" wide, five shank ripper attachment to finish the job in 71 machine hours at a cost of \$5,958.

On July 31, 1992, the refuge elected to exercise its option to continue the contract with Steve's Ag Services for road rehabilitation at Hakalau, allocating \$35,000 for continued grading and graveling of Nauhi Road and additional work on other roads. Steve constructed a custom all-wheel-drive dump truck especially for this project. Difficulty in procurement of parts for the truck delayed mobilization of his other equipment until 1993.

During November and December, 1992, the staff spent fifty hours using the refuge's new D4HLGP crawler dozer to stockpile gravel in the Honohina Tract area for use on Nauhi Road.

4. Equipment Utilization and Replacement

a. Heavy Equipment

Hakalau received a new Caterpillar D4HLGP Crawler Dozer in September of 1992. This tractor is equipped with automatic transmission, 60,000 lb. winch and articulating dozer blade. It will be used primarily for road maintenance and ground preparation for tree planting.



The Refuge acquired a D4H LGP Crawler Dozer to assist with road maintenance and tree planting. (DW)

b. Vehicles

A new Chevrolet 2500, 4X4 pick-up, was leased from GSA in 1992. This is a 3/4 ton model, equipped with V-8, standard transmission and a very stout suspension. Oversize all terrain tires, heavy duty bumper winch and double storage boxes were installed locally. This vehicle will be used by the habitat management crew and brings the refuge's fleet to two pickups, three sport-utility vehicles and two 4x4 ATV's.

5. Communications Systems

A two line telephone system with five phones was installed at the refuge office in Hilo in March. The new system and phones have eased the communications crunch caused by added staff and the opening of the Refuge to public use.

In December a new Bendix King LFH 3142A, 30 watt base station VHF radio for Hakalau Cabin and two Bendix King EPH 5142 M-04 hand-held radios with leather cases and whip antennas were purchased. New, heavy duty battery packs and a charger were also purchased. These battery packs will provide increased field use time with Hakalau's two existing hand-held radios as well as the new ones. The radios are used primarily by the habitat management crew to coordinate hunting and weed control efforts.

6. Computer Systems

A third computer and printer were added to the Hakalau inventory in 1992. The new computer is a CompuAdd 386 and the printer is a Toshiba P351 which was transferred from the Complex office. The new system is used by the OM Clerk for budget tracking and other administrative purposes.

8. Other

Transfer of excess property from U. S. Coast Guard Loran Station Upolu Point began in December, 1992. Two large storage racks of drawers containing a nuts and bolts assortment and pipe fittings were picked up by refuge staff. Other equipment and supplies planned for transfer include power tools, furniture, safety equipment, hardware and a flammables storage locker.

J. OTHER ITEMS

4. Credits

This narrative was written by Dick Wass, Refuge Manager, Jack Jeffrey, Wildlife Biologist, Andy Kikuta, Maintenance Worker Foreman and Jon Emig, Maintenance Worker. The photographs were taken by Jack Jeffrey (JJ) and Dick Wass (DW).

L. INFORMATION PACKET

Hunting and Public Access leaflet attached to the back cover.



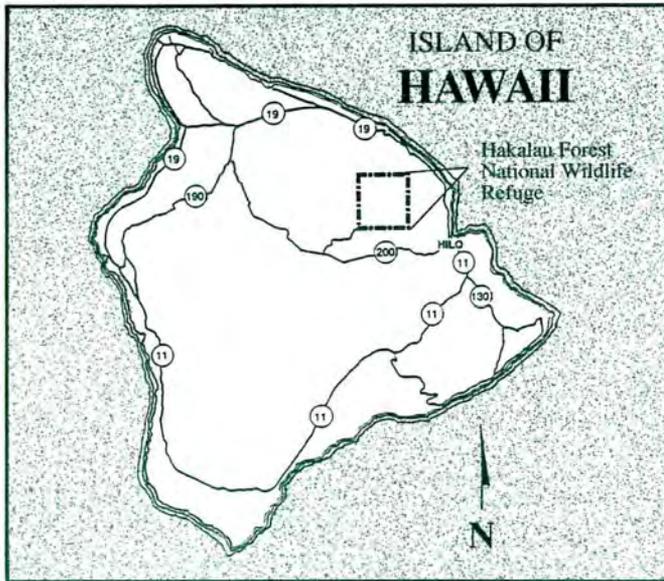
This sign designates the no hunting zone in the northwest corner of Maulua Tract. No shooting is permitted between this sign and the boundary fence.



This sign is posted along Maulua Road which is the only access for four-wheel-drive vehicles.



Motor vehicles are not allowed beyond this sign. Do not block access.



For More Information Contact:

Refuge Manager
Hakalau Forest National Wildlife Refuge
154 Waiuanue Avenue, Room 219
Hilo, Hawaii 96720
Telephone: (808) 969-9909



DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE



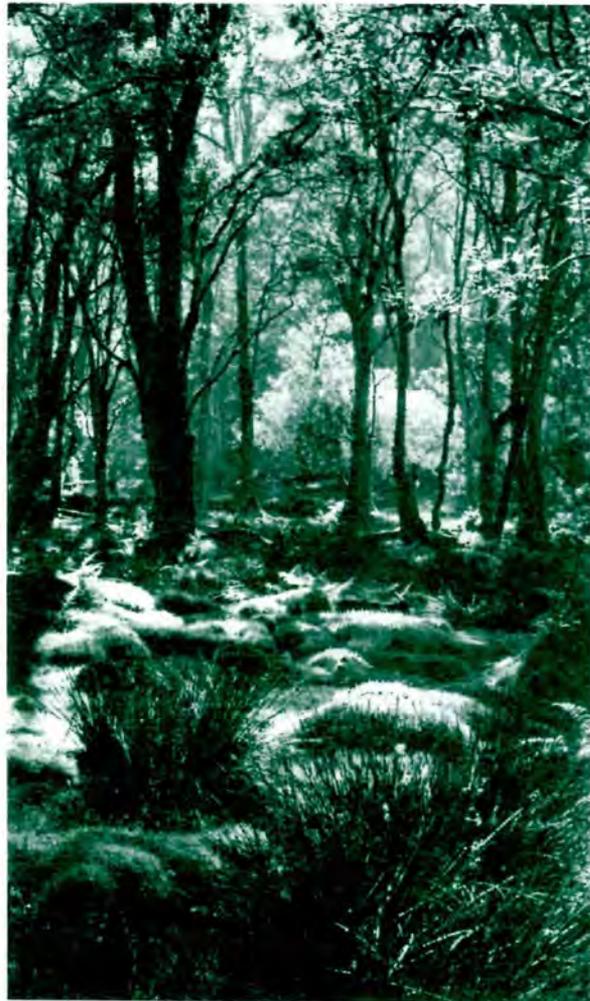
RF 12516 January 1992

No person shall, on the basis of race, color, sex, age, national origin, religion, physical or mental restrictions, be excluded from participation in, denied the benefits of, or be otherwise subjected to discrimination in any program or activity of the Department of the Interior.

HAKALAU FOREST

NATIONAL WILDLIFE REFUGE
HAWAII

HUNTING and PUBLIC ACCESS



Public Access

Only the Maulua Tract of Hakalau Forest National Wildlife Refuge(NWR) is currently open to the public. All other portions of the refuge are closed. Access to Maulua Tract is permitted on Saturdays, Sundays, and state holidays between sunrise and sunset. Hunting is permitted on state holidays and the first three (or four) weekends of each month. The last weekend of each month is reserved for non-hunting activities such as hiking, birdwatching, and photography.

Reservations

Every visitor including hunters, birders, hikers, and photographers requires a reservation. A hunting or visitation day may be reserved by calling the Hakalau Forest NWR office at (808)969-9909, between 8:00 a.m. and 4:00 p.m., three Wednesdays before the activity day desired. Hunters calling for reservations will be asked to provide (1) caller's telephone number; (2) current Hawaii hunting license number for each person in the group; (3) license plate number(s) of vehicle(s) to be used; and (4) description of vehicle(s) to be used. Group hunting reservations are limited to four persons per group. Other visitors will be asked to provide (1) caller's telephone number; (2) the number of people in their group; (3) license plate number(s) of vehicle(s) to be used; and (4) description of vehicle(s) to be used.

Limited Number of Reservations

For safety reasons, the maximum number of reservations accepted for any hunting day is twelve. All visitors on hunting days must be hunters and must possess a hunting license. A hunter is allowed only one day per month unless there are vacancies. Inquiries regarding vacancies may be made by calling on the Wednesday prior to the hunting day between 8:00 a.m. and 4:00 p.m. The number of reservations accepted for a non-hunting day is not limited.

Huntable Species and Bag Limits

Only pigs may be hunted on the refuge. There is no limit on the number or size of pigs that may be taken. All other wildlife and domestic animals are protected.



Feral (wild) Pigs

Use of Dogs

Dogs are not permitted within Maulua Tract.

State Regulations Apply

State of Hawaii hunting regulations as set forth under Title 13, Chapter 123, Rules Regulating Game Mammal Hunting, are applicable. Highlights include:

- It is unlawful to hunt or possess game mammals without a valid hunting license issued by the State of Hawaii
- A bright orange exterior garment at least 12 inches square on chest and back must be worn by all hunters and assistants in hunting areas.
- It is prohibited to have a loaded hunting arm on horseback, in any vehicle, or any other carrier, or to discharge a hunting arm from any carrier.

— Permitted Hunting Arms

Bows and arrows: Bows having at least 45 pounds of drawing tension for straight bows, 30 pounds for compound bows, and 35 pounds for full-recurved bows.

Firearms: Rifles of 1,200 foot pounds muzzle energy or more; shotguns of 20 gauge or larger loaded with 00 buckshot or rifled slugs; or muzzle loading rifles with a minimum of .45 calibre bore size.

Hunter Checkout

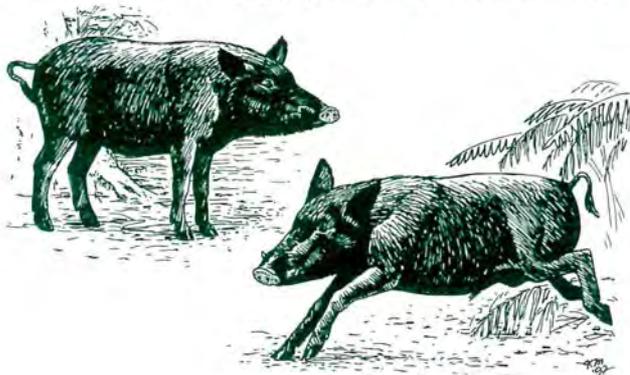
At the Maulua gate exit, hunters are asked to deposit a form which records take and effort. Game may be inspected by enforcement officers or refuge personnel.

No-Hunting Zone

The area within 100 yards of the hogwire fence in the northwest corner of Maulua Tract is designated as a no-hunting zone. No shooting is permitted within this area.

Pig Hunting is a Management Strategy

The refuge was established to protect endangered Hawaiian birds and their rain-forest habitat. Because pigs eat native plants and damage the forest floor by their rooting and trampling actions, the population of this non-native animal must be greatly reduced or eliminated on the refuge. The hunting public is invited to assist with this action. Maulua Tract will be closed to hunting when the pig population is under control.



Alien Plants

Relatively few non-native plant species occur on the refuge. Prevent the introduction of weed species such as firetree and gorse by cleaning mud and plant material from boots, gear and vehicles before entering Maulua Tract.



L'iwi, Hakalau Forest Bird

Prohibited Activities

- Use or possession of alcoholic beverages or other drugs while hunting
- Removal of any plant or plant material
- Littering and dumping of trash
- Removal or damage to numbered tags and colored flagging tape
- Disposal of lighted smoking materials
- Open fires
- Overnight parking and camping

Vehicle Entry

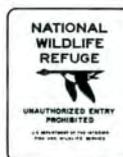
All access to the Maulua Tract of Hakalau Forest NWR is via Maulua Road which intersects with Keanakolu Road at the upper end of the tract. The main gate must be closed after entry or exit. Vehicles must be four-wheel-drive and must remain on Maulua Road or parked on the shoulder. Vehicles may be driven to the gate at the bottom of Maulua Road.

No Access to Piha or Laupahoehoe

The adjacent tracts of Piha and Laupahoehoe are managed for public hunting by the State of Hawaii and require reservations obtained through the State Division of Forestry and Wildlife. No person may enter Piha or Laupahoehoe from Maulua even if he or she is holding a valid reservation to hunt in Piha or Laupahoehoe.

Signs and Boundaries

These signs designate zones, boundaries, and regulations. The wording applies to the area behind the signs. They will help locate your position on the map.



This sign is posted along the refuge boundary. Only the Maulua Tract is open for public hunting and visitation.



Used alone or beneath a refuge boundary sign. The area behind this sign may be hunted and visited as permitted by refuge regulations.



The area beyond this sign is owned and managed by the State of Hawaii. No person may enter the area from the refuge.

