

HAKALAU FOREST NATIONAL WILDLIFE REFUGE

Hilo, Hawaii

ANNUAL NARRATIVE REPORT

Calendar Year 1989

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

HAKALAU FOREST NATIONAL WILDLIFE REFUGE
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REVIEW AND APPROVALS

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12/21/90
Date

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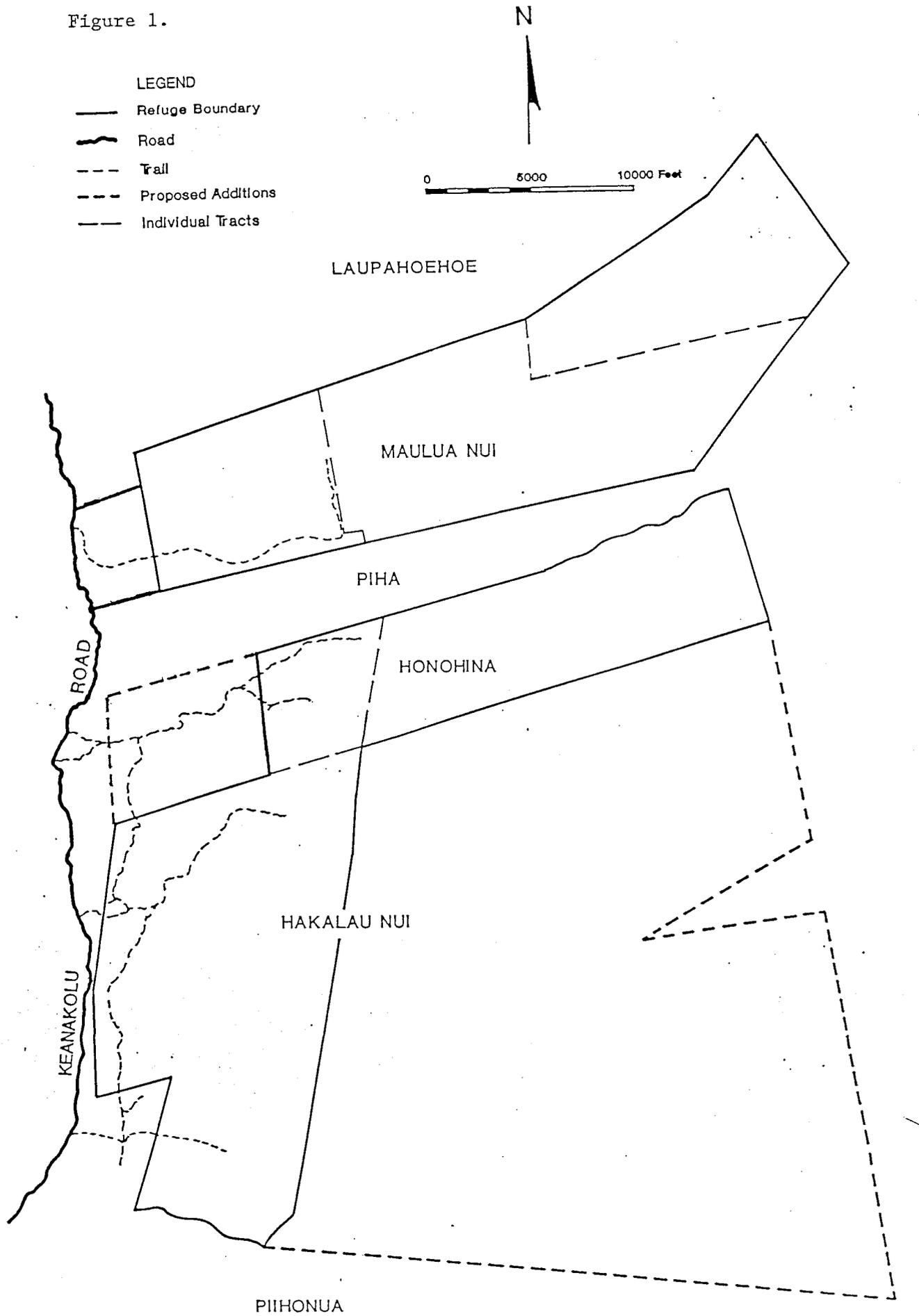
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INTRODUCTION

Hakalau Forest National Wildlife Refuge was established October 29, 1985 with the purchase of two properties totaling 8,313 acres. Four additional parcels were subsequently 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 remaining in Hawaii (and the world). The lower slopes receive very high rainfall and are vegetated with dense forests dominated by ohia and tree ferns and bisected with numerous streams and gullies. 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-six species are found on the refuge including 16 natives (seven of which are endangered) and 20 aliens. Substantial populations of four of the seven endangered forest birds inhabiting the Big Island occur on the refuge. They are the 'akiapola'au, the Hawaii creeper, the Hawaii 'akepa and the 'io (Hawaiian hawk). The other three 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, and the koloa (Hawaiian duck) which inhabits streams and stockponds on the refuge. The endangered Hawaiian hoary bat and a number of candidate endangered plants are also found at Hakalau.

Figure 1.



HAKALAU FOREST NATIONAL WILDLIFE REFUGE

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A. HIGHLIGHTS

1. 1989 was an unusually wet year although drought conditions were experienced during November and December. (Section B.)
2. Dr. Leonard A. Freed, University of Hawaii, continued his forest bird research project on the refuge. His efforts focused on behavioral studies (which included banding as many native birds as possible), genetic studies (which included collecting blood samples), and a study of the evolution of sexual dichromatism and cavity-nesting in the Hawaii 'akepa. Dr. Freed and colleagues (chiefly Jaan Lepson) have banded a total of 1,317 birds at Hakalau during their three-year study including 140 endangered species. Two-hundred and ten birds have been bled. (Section D.5.)
3. The volunteer program was considerably expanded. Ms. Rae Ann Yap was recruited as a Volunteer Coordinator. Volunteer crews assisted with koa seed collecting, three major tree-planting efforts, two major weed control efforts, construction of an outhouse, construction of the garage/workshop, and with both forest bird censuses. (Section E.4.) Two agencies also volunteered a great deal of their time to assist the refuge. The Resources Management Division, Hawaii Volcanoes National Park assisted with feral ungulate eradication (Section G.15.) and the Hawaii State Division of Forestry and Wildlife assisted with the germination and rearing of koa seedlings (Section F.3.b.) and prescribed burning of gorse (Section F.9.).
4. A full-scale reforestation program was initiated with the planting of 11,000 koa seedlings within a 400-acre pasture area. The seedlings were planted by volunteers within corridors that had been disced to reduce grass competition and stimulate germination of the natural koa seedbank.
5. A Special Use Permit issued to Pua Akala Ranch and a Cooperative Agreement with the Alfred Nobriga Ranch permitted 128 and 356 AUY's of grazing on the refuge during 1989. The Pua Akala Ranch sold its cattle in October, thereby ending its grazing relationship with the refuge. (Section F.7.)
6. The gorse control effort was greatly expanded through a contract with Honua Landscaping, Inc. which provided 360 person-hours of effort to spray most of the gorse on the refuge with Tordon 22K. (Section F.10.) The herbicide application was followed with prescribed burning of gorse patches by the refuge staff. (Section F.9.)
7. Biannual bird censuses were conducted during the spring and fall. (Section G.2.)

8. With the help of a team of professional hunters loaned by the National Park Service, the feral ungulate population in the 550 acre Liliuokalani management unit was reduced to near zero. Regular fence maintenance, combined with the use of snares set around the outside perimeter, kept the population from increasing and allowed native vegetation to recover. (Section G.15.)
9. Improvements at Hakalau cabin continued with the installation of a photo-voltaic power generation system, completion of the kitchen, and construction of a cesspool and wastewater disposal system. Also, the foundation was poured and framing completed for the 32' x 28' garage/workshop at the Hakalau cabin site. The driveway leading to the cabin site was graded and graveled.

B. CLIMATIC CONDITIONS

The climate at Hakalau Forest NWR is characterized by moderate temperatures and wet conditions with relatively little seasonal variation. 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 54°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 30°F to 50°F.

Rainfall also shows significant variation with elevations. Approximately 300 inches of rain falls annually at the lowermost elevations of the refuge. Rainfall decreases to about 80 inches at the upper elevations bordering Keanakolu Road. For a 25-year period between 1906 and 1931, rainfall data were recorded at the Pua Akala rain gauge located at 6,200 ft. on property now belonging to the refuge. Annual rainfall ranged between 38.3 and 144.4 inches with a median of 88.2 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 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.

On February 14, 1989 a sophisticated solar-powered meteorological station was installed on the flat immediately below Hakalau cabin (elevation = 6,400 ft). Every 15 minutes, the 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 by the U.S. Forest Service. These data will be correlated with native plant survival, growth rate and life history data collected during the Forest Service's experimental reforestation studies on the refuge.

On March 1, 1989 a rain gauge was installed in the clearing immediately below the Pua Akala Ranch cabins (elevation = 6,200 ft). It is monitored by students and faculty from the University of Hawaii.

Data from these instruments are summarized in Tables I and II.

Table I. Temperatures (°F) recorded at Hakalau cabin and at the flat below the cabin during 1989.

Month	Cabin		Flat				
	Max.	Min.	Mean Daily	Mean Max.	Mean Min.	Max.	Min.
Jan	66	36	-	-	-	-	-
Feb	70	34	-	-	-	-	-
Mar	68	36	-	-	-	-	-
Apr	68	38	-	-	-	-	-
May	78	39	53	60	46	68	39
Jun	76	42	54	62	46	67	42
Jul	76	44	56	63	49	69	42
Aug	78	40	55	64	46	69	42
Sep	76	40	54	61	46	66	42
Oct	72	40	56	65	49	71	44
Nov	75	41	53	64	44	72	36
Dec	74	35	51	61	41	65	35

Table II. Rainfall (inches) and humidity recorded at Hakalau cabin, the flat below the cabin and at the clearing below Pua Akala Ranch during 1989.

Month	Cabin		Flat		Clearing Rain
	89 Rain	87&88 Avg Rain	Rain	Mean Daily Humid	
Jan	30.75	2.10	-	-	-
Feb	5.06	3.89	-	-	-
Mar	2.49	5.59	-	-	3.10
Apr	14.00	4.49	-	-	15.83
May	9.42	4.87	11.26	89%	14.28
Jun	3.91	3.76	6.10	83%	7.53
Jul	23.43	3.88	22.32	84%	30.51
Aug	3.81	3.56	3.27	78%	4.54
Sep	6.80	3.38	3.86	83%	6.48
Oct	8.07	3.86	7.87	77%	10.13
Nov	0.87	13.04	0.79	71%	0.72
Dec	<u>0.91</u>	<u>11.98</u>	0.75	67%	1.22
TOTALS	109.52	64.40			

The data show that 1989 was a wet year. In spite of the unusual drought conditions that prevailed during the normally wet months of November and December, the 1989 rainfall was about 40% higher than normal.

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.

1989 is the first year since the refuge was established that no additional parcels were acquired. However, negotiations are ongoing toward the purchase of an additional 15,715 acres from the World Union Industrial Corporation, Ltd. A request to initiate condemnation proceedings for this parcel was forwarded to the Attorney General on June 22, 1989. Recently, negotiations were also initiated toward the purchase of an additional 1,042-acre parcel owned by the Liliuokalani Trust. Both properties fall within the approved boundary of the refuge.

D. PLANNING

2. Management Plan

The third draft of the Management Plan was completed and sent out for review by selected agencies and individuals. This draft incorporates comments from the Regional Office in Portland and Fish and Wildlife Enhancement in Honolulu. It contains Part I, Background Information; Part II, Goals, Objectives and Strategies; and two detailed plans in Part III for managing fire and grazing. A general plan for the remaining aspects of refuge management is included within Part II and within a nine-page "Strategy Statement" portraying objectives, rationale and options for near term (2-3 years) management of the refuge.

3. Public Participation

Because an informal advisory group meeting convened in 1988 was so successful, a second meeting of the same group was held June 28, 1989 for the purpose of reviewing the current status, management strategies and accomplishments of the refuge and to discuss and recommend future strategies and plans. The draft Management Plan was sent to all participants beforehand as a basis for the all-day discussion. The meeting also served as a forum for disseminating information on refuge activities and eliciting support for future management actions. Ten individuals were in attendance representing the Hawaii State Division of Forestry and Wildlife, Hawaii Volcanoes National Park, the U.S. Forest Service, and the Fish and Wildlife Service. A number of valuable comments and suggestions were received regarding management priorities and actions. The attendees were pleased with the opportunity to provide input and expressed their desire for continued participation on an annual basis.

4. Compliance with Environmental and Cultural Resource Mandates

On February 8, Paul H. Rosendahl, Ph.D., Inc. conducted an archaeological inventory survey of two proposed fence corridors on the refuge as required by the National Historic Preservation Act. The Maulua Nui portion of the survey consisted of a 6,150-foot corridor located on the boundary of the Upper Robertson-Sutton parcels of the refuge. The other corridor is located within Pedro Paddock of the Shipman Parcel and is approximately 1,207 feet in length. No archaeological remains were found to delay or constrain the fence building projects.

5. Research and Investigations

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 genetical studies." The permit is for a five-year period and is renewable subject to compliance with the Special Conditions. His basic research techniques include capturing birds in mist nets, banding with numbered and colored bands, collecting blood samples for disease and DNA analysis, and behavioral observations of banded individuals. The bulk of his research occurred within an 8 hectare area in the Pua Akala portion of the refuge.

Professors Leonard Freed and Rebecca Cann and graduate students Jaan Lepson and Maile Kjargaard were officially associated with the bird studies during 1989. Mr. Lepson camped below Pua Akala almost continuously, operating mist-nets, banding and bleeding birds, and observing bird behavior. In March, an undergraduate class of six students resided in the tent camp for a week to learn ornithological techniques and to become familiar with native birds. Two biologists from other institutions, Jonathan Roughgarden of Stanford University and Stephen Emlen from Cornell University visited the refuge for two-day periods.

The following species were captured, banded and sampled for blood during 1989 by Dr. Freed and colleagues:

<u>Endangered Species</u>	<u>No. Individuals</u>	<u>No. Bled</u>
Hawaii 'Akepa	31	14
Hawaii Creeper	14	5
'Akiapola'au	<u>4</u>	<u>--</u>
Totals	49	19

<u>Other Native Species</u>	<u>No. Individuals</u>	<u>No. Bled</u>
'Oma'o	10	3
'Elepaio	12	6
Common 'Amakihi	58	13
'Apapane	168	43
'I'iwi	<u>139</u>	<u>25</u>
Totals	387	90

<u>Introduced Species</u>	<u>No. Individuals</u>	<u>No. Bled</u>
Red-Billed Leiothrix	4	--
Japanese White-Eye	22	10
House Finch	10	--
Nutmeg Mannikin	3	--
Totals	39	10
GRAND TOTAL	475	119

During 1987, 381 birds were banded including 57 endangered 'akepa and creeper. During 1988, 461 birds were banded including 34 'akepa, 'akiapola'au, and creeper. Blood samples were taken from 91 birds during 1988 including three 'akepa and one 'akiapola'au.

Dr. Freed and colleagues found nests of all native bird species during 1989 including 14 'akepa nests of which at least 8 fledged young successfully. All 'akepa nests were in ohia and koa tree cavities. The sample of nests will enable study of the extent to which cavities are re-used from one breeding season to the next. Introduced House Finches also nest in cavities. Interspecific competition between 'akepa and House Finches is suggested by observed aggressive interactions between these species over an 'akepa nest-site.



The 'i'iwi is a common bird at Hakalau with a bill adapted to feeding on nectar produced by flowering trees such as the mamane pictured here. JJ

Long-term residency in the tent camp and the banding and bleeding operations appear to have no negative impact on native birds. Throughout one week in which eight people resided in the camp, a female creeper incubated eggs in a nest located directly overhead. During the same week, a pair of 'akepa fledged young from a nest in camp. One of the fledglings remained above the camp refrigerator for two weeks as it was fed by its parents. Also hawks perched in the vicinity of camp, 'akiapola'au family groups resided nearby, and interspecific flocks of 'akepa and creeper freely moved through the camp area with no indication that the camp or human presence had adverse effects.

A total of 210 birds were bled during 1988 and 1989. These birds were recaptured or resighted at least as frequently as those that were only banded indicating that the bleeding procedure and loss of blood had no negative impact. Moreover, survival for banded 'akepa between 1988 and 1989 was 100% for subadult males, 90% for adult males, and 79% for adult females. These rates are the highest known for any passerine bird of equivalent body size in the world and would not be expected if mist-netting or bleeding had a negative effect.

The relationship between the University of Hawaii and the FWS has a great deal of potential for mutual benefit. University personnel have the opportunity to conduct valuable research relative to avian conservation biology and the Service stands to gain a wealth of practical information useful for resource management. Accordingly, Dr. Leonard Freed, Dr. Rebecca Cann and Dr. Sheila Conant submitted a proposal in 1988 to the John D. and Catherine T. MacArthur Foundation to support forest bird research at Hakalau and other areas within the state. In 1989 they received a \$750,000 grant from the MacArthur Foundation to extend over a 3-4 year period. Funding is included for a biological field station to support field research at Hakalau and for ecological and genetic studies of native birds in the Hakalau area.

E. ADMINISTRATION

1. Personnel

Hakalau Forest NWR is part of the Hawaii/Pacific Islands Refuge Complex. The 1989 Complex staff was comprised of 22.5 FTE's broken down as follows:

Refuge Complex Administration	4.0 FTE
Remote Island Refuges	6.5 FTE
Wetland Refuges	5.0 FTE
Kilauea Point NWR	5.0 FTE
Hakalau Forest NWR	<u>2.0 FTE</u>
TOTAL	22.5 FTE



The 1989 Hakalau Forest NWR staff consisted of Maintenance Worker Jon R. Emig, WG-7, Temporary Full Time (left); and Refuge Manager Richard C. Wass, GS-11, Permanent Full Time (right). RAY

The position of Refuge Manager was established for Hakalau early in 1987. Mr. Wass was assigned the position and initially based within the Complex office in Honolulu on the island of Oahu. In August 1987, he moved to Hilo on the island of Hawaii to establish the permanent administrative headquarters and provide on-site management.

The position of Maintenance Worker was established the following year and Mr. Emig was hired April 20, 1988. During 1989, his main duties were the construction and maintenance of Hakalau cabin and an adjoining garage/workshop, fence maintenance, feral pig control and banana poka and gorse eradication.

3. Other Manpower Programs

In early May, two individuals were hired through "Alu Like" to hand-shuck koa seed from 12 lb, 12 oz of seed pods. "Alu Like" is a federal and state-funded program to assist people with Hawaiian ancestry in finding jobs. The minimum wage (\$3.85/hr) was paid for 33.5 hours of work which resulted in 1,358 grams of seeds estimated to number 12,000.

4. Volunteer Program

A major hindrance to the volunteer program prior to 1989 was the lack of time on the part of the Refuge Manager for organization and coordination. Even the most accessible areas of the refuge are a two-hour drive from the nearest town and 4x4 vehicles are required so the refuge must usually provide transportation, food and housing. Accordingly, a search was initiated for a "Volunteer Coordinator" to assist the Refuge Manager with the volunteer program. Ms. Rae Ann Yap was recruited for the position and was given an extensive orientation by the Refuge Manager. Her assistance is gratefully acknowledged. During the year she helped drive vehicles, coordinate logistics, plan meals, purchase supplies and lead work crews.

Volunteers provided a tremendous amount of help to the refuge during 1989. The bulk of their effort was directed toward planting koa tree seedlings. On three overnight trips during July, October and November, approximately 9,000 koa seedlings were planted by 25 volunteers. About half of the people flew over from Oahu at their own expense. They were met at the Hilo airport, driven up to Hakalau, and provided food and housing at the refuge cabin during their stay. In most cases they were also given time to hike and observe birds. This is a major incentive as the refuge is closed to the general public.

Two major weed control efforts were also conducted during the year with the help of volunteers. On a Saturday in February, six volunteers belonging to the local chapter (Moku Loa Group) of the Sierra Club assisted the refuge staff with hoeing, chopping and grubbing out gorse and blackberry bushes in the forest below Pua Akala. During the Labor Day weekend, a group of ten volunteers flew over from Oahu to pull up banana poka vines invading the Liliuokalani Trust feral ungulate management unit.

Three additional tasks were accomplished by volunteers. Using materials provided by the refuge, John Kahiapo and friends constructed and installed an outhouse adjacent to Hakalau cabin. (The cabin has an indoor toilet but the outhouse is also needed when a large group is staying in the cabin.) Mike Fedorko spent a week in February harvesting seed pods from koa trees. Vanessa Gauger assisted with construction of the walls and roof of the garage/workshop for two weeks in December.

Finally, Maile Kjargaard, Jaan Lepson and Marie Morin volunteered their assistance during the March 27-29 biannual forest bird census. Reggie David and Jaan Lepson assisted with the October 23-27 census.

5. Funding

Hakalau Forest NWR receives its funding through the Hawaii/Pacific Islands Refuge Complex. The 1989 funding for the Complex was broken down as follows:

Refuge Complex Administration	\$ 188,800
Remote Island Refuges	473,881
Wetland Refuges	302,677
Kilauea Point NWR	216,800
Hakalau Forest NWR	<u>161,500</u>
TOTAL	\$1,343,658

Since its establishment, Hakalau Forest NWR has received operational and special project funding from Refuges and Wildlife Resources (RW) and Fish and Wildlife Enhancement (FWE). The following table lists funding by source:

	RW	FWE	TOTAL
FY 86	\$ -	\$130,000	\$130,000
FY 87	23,000	75,000	98,000
FY 88	180,000	-	180,000
FY 89	161,500	-	161,500

Besides personnel costs, major expenditures for Hakalau during FY 89 included \$16,680 for a contract to spray herbicide on gorse, \$16,500 for materials and expenses associated with construction of the garage/workshop, and \$6,700 for office rent.

6. Safety

Maintenance Worker Emig and Refuge Manager Wass both received Defensive Drivers Training with nine members of the U.S. Forest Service Staff in March.

No accidents or reportable injuries occurred on the refuge during the year.

7. Technical Assistance

The Refuge Manager actively participated on the State of Hawaii's Animal Species Advisory Commission and the multi-agency Gorse Steering Committee.

8. Other

A programmatic review was conducted in conjunction with a visit to the refuge by RD Marv Plenert, ARW John Doebel, PIA Al Marmelstein and District Supervisor Jerry Leinecke. The team visited the Hilo office on the afternoon of October 17 and toured the refuge on October 18. The team recommended that additional thought and study be given toward siting the University of Hawaii field station and formulating a Cooperative Agreement covering the station's operation and research. Their comments on refuge operations were favorable.

Hakalau Forest NWR 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 required 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. About two hours are usually spent walking through the forest observing native birds and plants. If time permits, the visitors are also shown the experimental reforestation plots, tree-planting efforts, feral ungulate control programs, and the Hakalau cabin. Management objectives and strategies, funding and staffing needs and a wide variety of other subjects are discussed by the Refuge Manager.

Noteworthy visitors to Hakalau during 1989 included:

- Jan 5. Amos Eno, Fish and Wildlife Foundation; Tim Shea, Staff for Congressman Conte who is Chairman of the House Appropriations Committee; Tim Johns, The Nature Conservancy; and Al Marmelstein, PIA.
- Jan 18. Calvin Lum, Administrator, State Division of Forestry and Wildlife; Charlie Wakida; Ed Pettys; Gene Conrad, Director, Institute of Pacific Islands Forestry, U.S. Forest Service; Paul Scowcroft and Don Goo. This trip emphasized the cooperative effort between the FWS and the Forest Service to reforest Hakalau.
- Jan 31. Ike Ikawa, Soils Scientist, U. of Hawaii; Gene Conrad and Paul Scowcroft, U.S. Forest Service. Discussions centered on soils and many samples were taken from various sites on the refuge.
- Mar 1. Dana Kokobun, Hawaii State Director, National Audubon Society.
- Mar 9. Ed Collins, Ducks Unlimited; Don Weathers, ARD-Budget and Administration; Bill Striplin, Regional Engineer; and Scott Wise, Georgia Shirilla and Jack Helvie from the Realty Division.

- Mar 22. Dan Taylor, Larry Katahira and Andy Kikuta of the Resources Management Division, Hawaii Volcanoes National Park. The primary purpose for this visit was to plan and discuss the upcoming cooperative effort to eradicate pigs and cattle from the Liliuokalani Feral Ungulate Management Unit.
- May 11. Arnold Lum, Mike Sherwood, Kathy Sherwood and Marjorie Ziegler of the Sierra Club Legal Defense Fund.
- May 16. Deanne Kloepfer, Wilderness Society.
- May 29. Ralph Morganwick, Assistant Director for Fish and Wildlife Enhancement and Al Marmelstein, PIA.
- July 25. Robert Smith, ARD-Fish and Wildlife Enhancement and Laura King, Natural Resources Defense Council.
- Sept 28. Bill McCowatt, Waimea Gazette and Dave Fisher, Soil Conservation Service. Bill was collecting information for a feature article on Hakalau.
- Oct 18. Marv Plenert, Regional Director; John Doebel, ARD-Refuges and Wildlife; Al Marmelstein, PIA; and Jerry Leinecke, District Supervisor. This visit was in conjunction with a programmatic review.



District Supervisor Jerry Leinecke, Regional Director Marv Plenert, Assistant Regional Director for Refuges and Wildlife John Doebel and Pacific Islands Administrator Al Marmelstein ogle an 'akiapola'au. RW

- Nov 13. Allan Weeden and Audrey Newman, The Nature Conservancy and Maile Kjargaard. The Weeden Foundation gives major support to TNC, Hawaii.
- Nov 21. Seventeen members of the Forestry Committee, Big Island Resource Conservation and Development Council.
- Dec 13. Pat Gorman, Director, Hawaii Island Humane Society; and Lowell Hicks, President of the Big Island Chapter, Animal Rights Hawaii. Their organizations are concerned about the refuge's use of snares for controlling pig populations.

F. HABITAT MANAGEMENT

3. Forests

One of the primary management objectives for Hakalau Forest NWR is restoration of the native forest. The entire refuge has experienced considerable degradation from feral pigs and the introduction of alien plants, and large areas at the upper elevations have been nearly denuded of native plants by grazing cattle.

a. Interagency Agreements and Studies

On September 11, 1986 an Interagency Agreement between the FWS and the U.S. Forest Service's Pacific Southwest Forest and Range Experiment Station was signed. The agreement transferred \$15,000 to the Forest Service "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 methods for regeneration of the native forest are most efficient and cost effective and to provide management prescriptions for future large-scale reforestation effort.

A second Interagency Agreement was signed with the U.S. Forest Service in August 1988 to continue and expand the original studies. The agreement transferred \$15,000 to the Institute of Pacific Islands Forestry to accomplish the following: 1) Determine if fertilizing enhances establishment and early growth of koa and other native seedlings; 2) Test the extent of koa seedling production from the soil seed bank along a gradient of decreasing koa tree cover; 3) Continue research on techniques for propagating seedlings and vegetatively propagated plantlets for various native forest trees and shrubs; 4) Evaluate survival of planted native understory species; 5) Plant rooted ohia cuttings in the Magnetic Hill enclosure to test the effect of established koa seedlings on rates of growth and survival for the cuttings; 6) Continue measurements of growth and survival on seedlings established within the Magnetic

Hill and woodland exclosures; 7) Document baseline forest cover within the 40 acre woodland exclosure; and 8) Assist with the preparation of a reforestation management plan for the refuge. This agreement extends through March 1991. Accomplishments through 1989 under both agreements are summarized in the following paragraphs.

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-foot elevation. The area was fenced to exclude cattle and pigs. Koa seedlings, mamane seedlings and rooted ohia cuttings were planted in pure stands and in combination with each other. No weed control or fertilization was done. The koa seedlings were doing very well by the end of 1989. Almost all were thriving and some were as tall as 8 feet. The vast majority of mamane and ohia seedlings, however, were dead.

A second experimental reforestation plot (termed the Woodland Exclosure) was established in July 1987. It is located at about 5,500 feet in the SW corner of the Liliuokalani Trust parcel. The understory has been heavily impacted by cattle and pigs and consists mostly of introduced grasses. There is a scattered overstory of koa, ohia, and other species, however, to produce seeds and root-sprouts. This plot was established to determine the efficacy of soil scarification for producing koa forest regeneration from the residual soil seed bank. A disk plow was used to turn over the sod to a depth of about 5 inches, thereby exposing the soil surface and allowing sunlight to penetrate and warm the soil to stimulate seed sprouting.

Areas beneath five live koa trees, four clusters of live koa trees, five dead and down koa trees and five open areas were selected at random for scarifying by discing. The open spots were at least 30 meters from a live or dead koa and were marked to be about 30 meters across after discing. The seedlings established as of January 1988 were counted and flagged as a baseline study. Each of the scarified areas associated with live trees contained at least 29 seedlings and some contained hundreds. Seedling counts associated with dead trees ranged between 1 and 660. The range of 0 to 17 seedlings in the five open areas suggests that at least some seeds are spread far from the existing mature trees. Overall seedling condition was good. Their foliage was darker green and thicker than that of the seedlings at Magnetic Hill. They also grow faster in the Woodland Exclosure as some trees were more than 10 feet tall by the end of 1989.

Conclusions drawn thus far from the two experimental plots include the following: Mamane seedlings and ohia cuttings do not do well at the higher elevation plot. Koa seedlings do well in both plots but grow more rapidly at the lower site, perhaps because of the warmer temperature and moister conditions. Scarifying the soil in woodland areas results in significant numbers of koa seedlings.

Competition from grasses such as *kikuyu* is severe but, once established, koa seedling growth is vigorous. Most koa seed is not far from the seed source. Beyond about 80 feet, the number of seedlings drops dramatically. Prevailing wind does not appear to have much impact on seed distribution. Existing data do not allow a determination of how long koa seeds remain viable in the soil but dead tree skeletons remain after most of the seeds have lost viability.

As part of the Interagency Agreement, the Forest Service has also attempted to propagate a number of native trees and shrubs in addition to koa, ohia and mamane. Germination and grow-out conditions have been established for 11 species thus far. Seedlings and rooted cuttings from these species will be planted at Hakalau in 1990.

A number of general conclusions can be drawn from observations and studies by the Forest Service at Hakalau and elsewhere within the state:

- 1) Koa seedling survival and growth rate can be increased by application of herbicide to reduce competition from pasture grasses and weeds. The negative effects of competition and the positive effects of fertilizer will be further studied in an experimental plot established at Hakalau in 1989. The response of 900 koa seedlings to three levels of competition from pasture grasses and three levels of nutrient enrichment will be documented.
- 2) Koa stands increase soil acidity, increase soil nitrates and increase soil water content. These soil conditions are favored by other species of native trees and shrubs. It, therefore, appears that a healthy stand of koa may be needed to prepare pastureland for the reintroduction of other native plants.
- 3) An organic seedbed such as decaying wood or the trunk of a tree fern is required for natural reproduction of native plants. Only a few individuals of some species will germinate and grow in mineral soil. It may, therefore, be necessary to create organic seedbeds in the pasture areas to establish a diverse community of native plants.
- 4) Growth rate and survival of koa seedlings is far greater within enclosures which have been fenced to exclude feral pigs.

b. Reforestation Program

Reforestation studies at Hakalau will continue for many years. By 1989, however, enough was known about koa trees to go beyond the

experimental stage and initiate a full-scale reforestation program. Accordingly, the 340-acre Triangle Paddock located in the northwest corner of the Shipman Parcel, the 30-acre "toe" of Hakalau 4 Paddock located immediately east of Triangle Paddock and a 30 acre piece of Pedro Paddock immediately east of the "toe" of Hakalau 4 were designated for the initial reforestation effort.

During a three-week period in February, seed pods were collected from koa trees in and adjacent to Triangle Paddock. Seeds were shucked mechanically and by hand and passed to Waimea Tree Nursery operated by the Hawaii State Division of Forestry and Wildlife. At no cost to the Refuge, the seeds were scarified in a hot water bath, germinated in a bed of moss and cinders, planted in dibble tubes and grown to a height of 12-18 inches. Germination and growth to plantable size takes approximately four months. About 11,000 koa seedlings were produced by the nursery and passed back to the Refuge for planting which began in July 1989 and extended through March 1990.

Prior to planting, the surrounding fences were inspected and repaired and the 400-acre area was intensively grazed by cattle to reduce grass competition. Cattle were permanently excluded the week before planting began because of their predilection for koa seedlings.



Prior to planting koa tree seedlings, a disc-plow was used to reduce grass competition and to stimulate germination of the natural koa seedbank. RW

The seedlings were planted in corridors that had been scarified with a disc-plow dragged behind a bulldozer. The discing accomplished two objectives: 1) It reduced competition by temporarily burying the exotic grasses forming the ground cover; and 2) it facilitated the germination and sprouting of the natural koa-seed bank through mechanical roughing and exposing seeds to the light and warmth of the sun. The corridors were usually comprised of three parallel disced tracks, each about eight feet wide with the centers about twelve feet apart. Each track was double-disced to further break up the clods. The corridors were generally oriented parallel to the slope and configured to link mature koa trees. Trees in the pasture area are widely scattered and often associated with gulches because of the protection afforded from grazing cattle (and pigs) by the steep sides and irregular terrain. The location of the planted corridors and trees is shown in Figure 2.

This planting scheme was selected for two reasons: 1) Planting trees in lines maximizes the edge area. A high proportion of seeds from these trees will fall in and beyond the unforested edges, thereby maximizing the rate of reforestation by natural means throughout the remainder of the area. 2) Native birds will move up from the forest through these corridors and colonize the upper elevations as the forest is restored. Even now birds are often observed in tree-lined gulches a few thousand yards upslope from the forest.

Most of the koa seedlings were planted by three crews of volunteers as noted above under Section D.4. The seedlings were planted at 12-foot spacings (12 feet between each track and 12 feet apart within each track). Even with the anticipated mortality of about 50%, this density will create shaded habitat between the rows where other native species can be planted or can establish naturally. The long term objective is a diverse forest with many species of native plants in the overstory, mid-story and understory--not a monoculture of koa trees. It is likely that a koa overstory will favorably modify the existing grassland habitat and improve the conditions for establishing additional species of native plants.

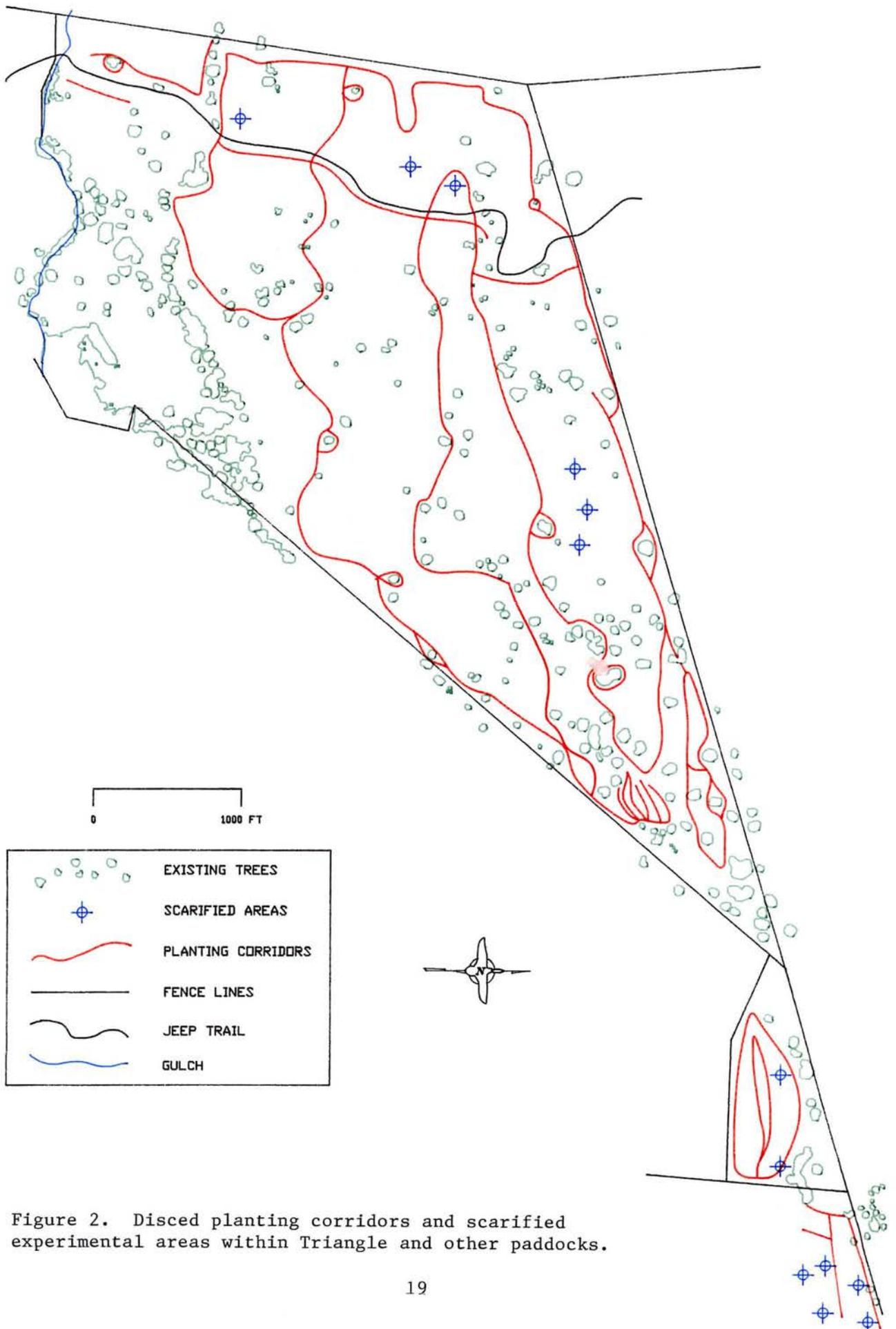


Figure 2. Disced planting corridors and scarified experimental areas within Triangle and other paddocks.



A large cadre of volunteers was recruited to plant koa seedlings within corridors that usually consisted of three disced tracks with the centers about 12 feet apart.
RW

Planting corridors were not the only areas scarified with the disc-plow. Considerable discing was also done beneath standing trees and around toppled logs where naturally occurring seeds are likely to be most numerous. As an experiment, 13 circles 50 yards in diameter and located in open areas far from live or dead koa trees were also thoroughly scarified. The number of seedlings that sprout in these areas will measure the extent of the seedbank far from apparent seed sources and will indicate whether further scarification in open areas is worthwhile.



An aerial view of Triangle Paddock. The three disced circles in the foreground are part of a study to determine the extent of the natural seedbank. Tree-planting corridors and disced areas around mature koa trees are also evident in the photo.
RW

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. Another primary management objective at Hakalau, therefore, is the elimination of grazing by domestic and feral cattle.

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.

Early in 1986, a Cooperative Agreement was signed with the Pua Akala Ranch for the period January 1, 1986 to December 31, 1988 to initially permit grazing on the upper 3,794 acres of the 4,994-acre Shipman Estate parcel. In 1988 the grazing area was further reduced to 2,884 acres. The lower elevation paddocks were closed to grazing because they had a fairly good canopy of native trees which could lead to a relatively high rate of natural reforestation upon the exclusion of cattle.

Grazing privileges were provided in exchange for equivalent value services relating to grazing and management. Grazing by Pua Akala Ranch cattle during the three-year period amounted to 1,122 Animal Unit Years (AUY) valued at \$24,950 in equivalent value services. By the end of 1989, the Pua Akala Ranch had provided \$14,584 in services to the refuge in the form of tractor scarification, boundary posting, fence construction and cabin maintenance. The remaining \$10,366 of services are on account to be utilized in 1990 for road maintenance and additional scarification.

A Special Use Permit (HAK-1-89) was issued to the Pua Akala Ranch to allow continued grazing during 1989. The grazing area was further restricted to the upper 1,200 acres of open grassland. One of the upper grassland paddocks (Triangle) was closed to provide an area for the tree-planting effort. Unlike the earlier Cooperative Agreement, grazing fees were paid in cash at the rate of \$22.97 per AUY. A total of \$2,949 was received during the year for approximately 128 AUY of grazing. In October 1989 the Pua Akala Ranch cattle were sold and removed from the refuge. Willie Andrade, the former manager of Pua Akala Ranch, purchased some of the Ranch's cattle and assumed the lease on the 500-acre parcel that was retained by the W.H. Shipman Estate when they sold the rest of their property to the FWS. He plans to continue grazing cattle on that parcel and has assumed the debt of equivalent value services the Pua Akala Ranch still owes the refuge.

On April 11, 1987, a Cooperative Agreement was signed with the Alfred Nobriga Ranch which permitted grazing on the 1,542 acres of the upper Robertson parcel through the end of 1989. Grazing privileges were provided in exchange for equivalent value services relating to grazing and management. The agreement specifies a maximum stocking rate of one animal unit per five acres and sets the value of one animal unit year (AUY) of grazing at \$22.00 based on a rate survey conducted by the Service. That figure is adjusted annually to account for increases or decreases in the price of beef through use of the formula listed in the Refuge Manual (6 RM 9).

A total of 218 AUY of grazing valued at \$4,787 in services occurred on the upper Robertson parcel during 1987. Grazing during 1988 amounted to 305 AUY valued at \$6,991. The grazing rate was adjusted upward to \$22.97 per AUY for 1988. Grazing during 1989 amounted to 356 AUY valued at \$9,512. The 400-acre Sutton Parcel, acquired by the refuge in December of 1988, was also grazed this year. The grazing rate was adjusted upward to \$26.72 per AUY for 1989. Services valued at \$13,824 were provided by the Alfred Nobriga Ranch through the end of 1989. They included the use of a bulldozer, backhoe, dumptruck and loader to construct a cesspool, provide a base for the garage slab, and grading and surfacing the road between Keanakolu Road and Hakalau cabin. The remaining \$7,466 has been placed on account and will be zeroed

out during 1990 by the construction of a new fence along the refuge boundary where it abuts property retained by George Robertson, et. al. and Alfred Nobriga. The Cooperative Agreement terminated in 1989 but grazing on at least a portion of the upper Robertson and Sutton parcels will continue through 1990 by Special Use Permit.

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 control gorse. A Prescribed Burning Plan for the refuge was approved by the Regional Fire Management Coordinator on May 8, 1989. It calls for the use of fire to burn patches of gorse that had been killed by application of herbicide a few months earlier. The objective was to achieve the hottest possible fire to maximize consumption of the gorse patch and gorse seeds and to scarify as many of the remaining seeds as possible to cause early germination. The plan also called for the collection of data on a specially designed form to document fuel conditions, climatic conditions and fire behavior because there is no fuel model for gorse and there is little information on prescribed gorse burns.

Prescribed burns were conducted on October 29 and December 5. Conditions were extremely dry for Hakalau as more than 30 days had elapsed since a significant amount of rainfall (more than 0.5 inches within a 24 hour period) had fallen. Burning occurred between 0900 - 1400 hrs during mostly sunny conditions. Temperatures ranged between 61 and 69°F, relative humidity between 56 and 88% and wind speed between 2 and 10 knots. A propane torch with the fuel tank mounted on a backpack was used to ignite the individual patches. It worked well, enabling near simultaneous ignitions at several points along the upwind side of the patch perimeter.

The dead gorse patches averaged about 20 feet in diameter and burned almost explosively, being fully engulfed in flames 40-50 feet long within one minute of ignition. Two minutes later, only the smoking stems remained. Live patches of gorse also burned fairly well, especially if the perimeter had been killed by herbicide. Areas between the gorse patches consisted of kikuyu grass pasture which had been recently grazed. Occasionally the grass duff would catch fire and smolder but it was easy to confine the fire to the gorse patches. Two fire trucks and four firefighters were provided by the Hawaii State Division of Forestry and Wildlife to assist with the burns on the first day of the effort but it soon became obvious they were not needed. On the second day, only the Refuge Manager and the Maintenance Worker comprised the burn team.

The usual wet weather returned before the prescribed burning was completed but about half of the gorse on the refuge was burned and the objective of producing the hottest possible fires was achieved.



Gorse patches, which had been sprayed three months earlier with herbicide, were burned in the effort to rid the grassland areas of this noxious weed prior to the planting of koa seedlings. JE

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 penetrans) are invading species that require control measures.

Banana poka is not particularly abundant on the refuge at present. It is readily grazed by cattle and areas where it would be expected are either still being grazed or have recently been grazed. It will likely become a serious problem, however, in the upper Robertson and Sutton parcels as grazing is phased out of these areas in 1990 and 1991. Its status is also being monitored within the 550-acre feral ungulate enclosure established in 1989 on the Liliuokalani Trust parcel. Increasing numbers of young plants have already been noted. Twelve volunteers from Oahu and the Big Island spent two days of the Labor Day weekend searching for and removing banana poka vines from this enclosure. Forty-eight poka plants, some of them very large, were found and rooted out. Ripe fruit was bagged and transported off-refuge to prevent germination of the seeds they contained. Labor-intensive mechanical removal is the method of choice for controlling banana poka. Selective use of herbicides may also be employed in the future.

Gorse is a noxious weed that was introduced to Hawaii over 100 years ago, either to create hedge-rows for penning sheep or accidentally from seeds tangled in sheep wool. Sheep are no longer ranched on a large scale and the plant, which was grazed by sheep (but not cattle), is now rapidly invading grassland areas on the slopes of Mauna Kea.

Gorse occurs 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.

An Interagency Agreement with the U.S. Soil Conservation Service was established in 1987 to coordinate the development of techniques to control/eradicate gorse at Hakalau. The final report recommended application of the restricted use herbicide, Tordon 22K, at a rate of two pounds acid equivalent per acre followed by burning and repeated application of herbicide to kill new sprouts and plants that were only weakened initially.

A gorse control effort based on the above recommendations was initiated at Hakalau during the summer of 1988. The Refuge Manager and Maintenance Worker spent five days applying Tordon 22K concentrate (diluted with water at the rate of 1:200) to gorse plants located around the perimeter of the gorse infestation in open pasture. Manpower and equipment resources were insufficient to spray herbicide within the core area of the infestation. Spraying was done through the use of a 12-volt pump connected to a 40-foot. hose and a 15-gallon tank mounted on the rear rack of a 4-wheel-drive ATV motorcycle.

The response of gorse to the Tordon 22K spray was variable. In most cases (about 95%), the plants were obviously sickened but not killed. The branching tips died and the plants turned yellow and failed to bloom and produce seeds the following spring. At least some new growth was observed on most plants 6-8 months after they had been sprayed. This response, coupled with the fact that the gorse patches were often so large that the interior could not be reached with the spray, showed that a long-term program of prescribed burning and repeated spray application is required. Photo points were set up near Hakalau cabin to document the response of three gorse patches to this and future treatments.

In 1989, Honua Landscaping, Inc. was contracted for the spray application of herbicide on gorse. The company agreed to provide the equipment and 360 man-hours of effort for \$16,680. The major items of equipment were a 4x4 pickup in which was mounted a 100-gallon tank, a gas-powered pump and 200 feet of hose; and a 4x4 ATV on which was mounted a 15-gallon tank, an electric pump and 20 feet of hose. The application team consisted of 1-3 individuals. The refuge provided 20 gallons of Tordon 22K and surfactant (non-ionic and Silwet). The spray operation was conducted between August 15 and September 19. This is a relatively dry time of the year and a period when gorse is actively growing.

Most of the gorse patches were small enough to be completely drenched by the hand-held spray wand. The interiors of patches larger than about 25 feet in diameter were not sprayed. With the exception of the core area of the gorse distribution at Hakalau (primarily a huge patch below Magnetic Hill which covers a few acres) most of the patches on the refuge (80-90%) were sprayed.

Three months after herbicidal application, the gorse was dead and ready for burning. Burning removes the dead biomass, kills seeds on the surface of the ground, and stimulates the immediate germination of most of the viable seeds that remain. If complete germination does not occur in response to the heat, seeds will continue to sprout every year for the next 30 years resulting in the need for a long term control effort. A follow-up program of herbicidal application during 1990 is critical because millions of gorse plants will sprout in the vicinity of burned patches after a good rain.

The gorse burns are described above in Section F.9. They were very successful and resulted in the combustion of about half the gorse on the refuge.

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. Four endangered forest birds are relatively common on the refuge. They are the Hawaii 'akepa, the Hawaii creeper, the 'akiapola'au and the 'io (Hawaiian Hawk). Three other endangered birds, the 'o'u, the nene (Hawaiian goose) and the koloa (Hawaiian duck), and the endangered Hawaiian hoary bat also occur on the refuge.

Systematic bird population surveys are required to ascertain the general health of the various species, to track their population trends and to measure their response to management efforts. Accordingly, Dr. J. Michael Scott of the Cooperative Fish and Wildlife Research Unit, University of Idaho was contracted to develop a permanent monitoring program and to conduct the first three surveys.

Dr. Scott and his crew of census takers and trainees made their first trip to the refuge during the last two weeks of November, 1986. They set up fourteen downslope transects 500 and 1,000 meters apart to cover the entire refuge as well as the Piha area managed by the State Division of Forestry and Wildlife. Count stations (239 total) were established on each transect at 200 meter intervals. All birds seen and heard at each station during eight-minute observation periods were identified and counted. Distances to each bird were also estimated.

Biannual censuses have been conducted each spring and fall since 1987 using the standard methodology developed by Dr. Scott. Because the refuge did not have the staff to continue Dr. Scott's effort, \$3,000 was transferred to the Hawaii Research Station (HRS), Fish and Wildlife service in 1988 and 1989 for this purpose. HRS agreed to provide the personnel to count birds, input data and perform the computer analysis.

The 1989 spring census was conducted March 27-29 by Jack Jeffrey, Paul Banko, Thane Pratt, Marie Morin, Jaan Lepson and Maile Kjargaard. The fall census was conducted October 23-27 by Jack Jeffrey, Paul Banko, Thane Pratt, Reggie David and Jaan Lepson.

The 1987 data were analyzed by Dr. Scott and populations sizes were estimated (Table III). Analysis of the 1988 and 1989 data is incomplete at present.

Table III. Bird population estimates for the 13,106 acres comprising Hakalau Forest NWR in 1987.

Species	Spring Census	Fall Census
Endangered Species		
'Akiapola'au	1,285	421
Hawaii 'Akepa	4,971	3,874
Hawaii Creeper	4,005	2,096
Hawaiian Hawk	present	present
Other Native Species		
'Apapane	96,341	17,909
Common 'Amakihi	50,596	22,683
'Elepaio	9,377	4,751
Hawaiian Thrush	11,808	4,242
'I'iwi	114,251	36,734
Pueo	present	present
Exotic Species		
Chukar	present	present
Common Mynah	279	467
Erckel's Francolin	present	present
Eurasian Skylark	1,084	2,094
House Finch	2,626	1,513
Japanese White-eye	27,698	13,220
Kalij Pheasant	738	104
Northern Cardinal	1,900	496
Red-billed Leiothrix	24,884	2,286
Ring-necked Pheasant	30	20
Wild Turkey	68	1,110

15. Animal Control

Feral pig and cattle control is a major management concern. 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. Hawaiian plants are not adapted to grazing pressure (the only native mammals are a bat and a seal) so they are easily suppressed by grazing cattle.

An Interagency Agreement with the Cooperative Park Studies Unit, National Park Service, University of Hawaii was signed on September 26, 1986 to document the extent of the feral ungulate problem at Hakalau and to recommend measures for reducing damage. The resulting report recommended that: 1) Cattle should be removed as soon as possible with priority given to the lower elevations and northern portions of the refuge which are not as dominated by alien plants in the understory. 2) Feral pigs should be controlled through establishment of 11 fenced units ranging in size from about 700 to 2,100 acres. Priority should be given to the lower units where forest integrity and reclamation potential are highest. 3) Pigs should be eradicated from each unit by systematic hunting with dogs where hunters are required to return to hard-to-hunt areas. Public hunting reduces pig populations in accessible areas and is a good public relations tool but is no substitute for a systematic program where hunters are paid and a variety of innovative methods such as snaring, trapping, baiting, use of exit gates and ramps, and wing fences are utilized to reduce pig populations to near zero. 4) Transects should be systematically surveyed to monitor abundance and distribution of feral ungulates and alien plants.

Some progress has been made toward implementing these recommendations. By the end of 1989, grazing of domestic cattle was limited to the 2,000 acres comprising the Upper Robertson parcel and the Sutton parcel. However, relatively large numbers of feral cattle (perhaps 200 head) still occur within the forested areas of the Shipman parcel, the lower reaches of the Liliuokalani Trust parcel and the lower elevations of Maulua.

The fence surrounding the first feral ungulate management unit (550 acres at the upper end of the Liliuokalani Trust parcel) was completed in December 1988. Additional fencing is scheduled for 1990.

Eight professional hunters and 13 dogs from Hawaii Volcanoes National Park and a hunter from the State Division of Forestry and Wildlife assisted with the attempt to eradicate pigs and cattle from the 550-acre feral ungulate management unit during six days of effort in May and July. Hunters and dogs were divided into as many as six teams which coordinated their movement with portable radios while sweeping across the unit in a line. Cattle were shot with rifles. Pigs were usually bayed by the dogs, then knifed by the hunters. Five pigs, two cows and

four calves were exterminated within the unit. Another pig was shot just outside. At the end of our effort, we "guesstimated" that about two pigs and no cattle remained. Subsequent observations supported the accuracy of this "guesstimate".

Ninety snares were set inside the unit in the attempt to eliminate the last few pigs. Fifty more snares were set just outside to reduce pressure from animals trying to dig under or break through the fence. By the end of December, no animals had been snared inside the unit though two snares had been disrupted. Eleven pigs, two feral cows and two feral dogs were captured in the outside snares.

The day before hunting began in the unit, the National Park Service personnel assisted with the set-up of four transects and the collection of baseline data on pig activity and alien plant abundance. Plans were also made to establish a number of study plots inside and outside the unit in which detailed vegetation surveys would be made at regular intervals to document the response of native and alien plants to ungulate removal. Unfortunately, a lack of manpower has precluded this action to date. Resurveys of the four transects subsequent to their initial establishment has not been repeated for the same reason.

Late in the year a letter was received from the Hawaii Island Humane Society expressing their concern about the use of snares and other feral animal control methods at Hakalau. It was agreed that the snares would be monitored by refuge personnel at intervals of one week or less to reduce the period of time live animals might be held by the snares. The Society was also invited to visit the refuge to see why feral animal control is necessary. On December 13, Pat Gorman, Director, Hawaii Island Humane Society; Dave, his assistant; and Lowell Hicks, President of the Big Island Chapter of Animal Rights Hawaii toured the refuge in the company of the Refuge Manager. We hiked about half the perimeter of the 550-acre feral ungulate management unit viewing pig damage and inspecting snare sets and the remains of pigs captured during the past few months. They came away agreeing that feral ungulate control is necessary and with a good understanding of the techniques we have used to achieve control. They would prefer that snares not be used but were unable to suggest feasible alternatives, given the isolated and rugged terrain and the limited resources.

16. Marking and Banding

As noted under Section D.5, Dr. Leonard Freed and colleagues banded 475 birds during the year including 49 endangered 'akepa, Hawaii creeper and 'akiapola'au. The totals for his three years of study are 1,317 birds of which 140 were endangered. This banded population is an extremely valuable study resource.

17. Disease Prevention and Control

A Special Use Permit (HAK-3-89, #52184) was issued to Dr. Charles T. Campbell, D.V.M. to allow him to collect blood samples from feral pigs as part of his continuing research on the occurrence of brucellosis and pseudorabies amongst the pig population on the windward slope of Mauna Kea. The Refuge Manager accompanied Dr. Campbell and his party of four hunters who spent February 24 and 25 in the vicinity of Nauhi Camp hunting pigs with dogs and rifles. It rained most of both days and only a single pig was taken, a pregnant sow with three piglets in her uteri. A blood sample tested negative for brucellosis and pseudorabies.

Blood samples were also taken from three pigs killed during the effort to eradicate feral ungulates from the 550-acre management unit in the Liliuokalani Trust parcel. The large boar tested positive for pseudorabies. The two sows were negative for both brucellosis and pseudorabies. In addition, cysts removed from the liver and spleen of one of the sows were identified as the immature stage of the pig tapeworm (Taenia solium). Man is the final host for this parasite.

Blood samples were taken from two of the cattle killed within the management unit. They tested negative for both brucellosis and anaplasmosis.

H. PUBLIC USE

1. General

Public entry is not permitted on the refuge. There are no facilities for self-guided tours and no staff to act as guides. Also, the best and most accessible area for viewing birds and native plants requires the transit of four gates and a privately owned parcel leased for cattle ranching. Visitors gained access only through Special Use Permit, in the company of the Refuge Manager or FWS staff, through the volunteer process or during guided tours conducted by the Refuge Manager.

One guided tour was held during the year. It was organized by the Forestry Committee of the Resource Conservation and Development Council. The group of 18 toured the refuge in the company of the Refuge Manager. They visited the Magnetic Hill reforestation plot and Triangle Paddock and received a briefing on refuge objectives and management strategies with emphasis on reforestation studies by the U.S. Forest Service and the effort to restore native vegetation in the pasture areas.

The Refuge Manager presented a slide talk to the 6th grade class at DeSilva Elementary School. The class was studying natural history of the Hawaiian Islands.

The Manager also participated in a symposium and panel discussion held at the University of Hawaii at Hilo titled "Environment in Crisis - A Look at Solutions". He gave a ten-minute talk on the conservation effort at Hakalau.

As mentioned above under Section D.5., Drs. Leonard Freed, Rebecca Cann and Sheila Conant of the University of Hawaii received a \$750,000 grant in 1989 from the MacArthur Foundation which included funds for ecological and genetic studies of native birds at Hakalau and for the construction of a biological field station to support this research. A draft Cooperative Agreement between the University of Hawaii and the Fish and Wildlife Service covering the proposed research as well as the construction and operation of the field station was prepared and is currently under review. A draft Environmental Assessment for the construction and operation of a field station sited on the refuge in the clearing below Pua Akala Ranch was also prepared. Considerable opposition to this site soon developed. Several people felt that a facility constructed in this area would have too much potential for adverse impacts on native birds because it was surrounded by forest. In November, a siting study for the field station was conducted by Peter Weher, Landscape Architect, Region 1. His study concluded that the best site for the station is on a ten-acre parcel in the Pua Akala area immediately above the refuge and owned by the W.H. Shipman Estate. A site on the refuge and adjacent to Hakalau cabin ranked second. Both sites are in pasture areas above the forest. The University of Hawaii is currently negotiating for the Shipman site.

3. Outdoor Classrooms - Teachers

Lorin T. Gill and the Moanalua Gardens Foundation were issued a Special Use Permit (HAK-9-89, #52191) to allow Mr. Gill and five members of the Foundation teaching staff to visit Hakalau. They spent five hours in the Pua Akala sector of the refuge viewing and learning about native birds and plants.

7. Other Interpretive Programs

On May 30 the Manager met with Hawaii County Mayor Bernard Akana to present the 1989 Revenue Sharing Check in the amount of \$28,642 from the FWS and to brief him on objectives and activities at Hakalau. A Press Release was also distributed at this time.

On September 28, Bill McCowatt toured the refuge in the company of the Refuge Manager. Bill is a feature writer for the WAIMEA GAZETTE, a "coffee table" magazine that targets the upscale professionals of the Big Island. The result was a feature article published in the December-January issue that described the refuge and discussed management objectives and strategies.

A Special Use Permit (HAK-5-89, #52186) was issued to Paul Atkins, Moana Productions for the purpose of filming forest birds and recording their vocalizations. Other commitments, however, prevented him from working on the refuge during 1989.

A Special Use Permit (HAK-7-89, #52188) was issued to videographer John I. Kjargaard, Ka'io Productions for the purpose of filming birds, native vegetation, and research and management activities on the refuge. His film will be used to produce documentaries for non-profit and commercial use. He also agreed to produce a short film for the refuge to use in publicizing management objectives and actions and for orienting volunteers and visitors. He visited the refuge once during the year to photograph a volunteer tree-planting effort and reforestation study plots. By the end of the year, plans were being made for the U.S. Forest Service and the Fish and the Fish and Wildlife Service to collaborate with Mr. Kjargaard in the production of a high-quality, 20-minute feature film depicting the refuge resources and management needs and activities.

The Natural History Department of Television New Zealand was also given a Special Use Permit (HAK-8-89, #52189) to film forest birds. Their footage will be used in the production of a three-part documentary series on "Islands", depicting island formation and evolution, the dispersal of plants and animals to islands and the fragility of island ecosystems.

A Special Use Permit (HAK-10-89, #52192) was issued to Jack Jeffrey to allow him to take 35mm photographs of birds, plants and Hakalau scenery for possible publication and sale. Jack and his companion Peter LaTourrette gave the refuge some nice bird photos which resulted from their effort.

11. Wildlife Observation

For the third consecutive year, a Special Use Permit (HAK-2-89, #52183)) was issued to Mark S. Collins, Hawaiian Sunrise Excursions, permitting him to conduct guided bird observation tours on the Shipman parcel of Hakalau Forest NWR. Most of the public's requests to visit the refuge were directed to Mr. Collins. He is familiar with the area having participated in the Service's forest bird surveys throughout the island in years past. A Special Condition of his permit requires that he report all visits to the refuge as well as a list of the endangered birds the group observes. During 1989 Mr. Collins conducted only one tour of the refuge. The group of two people observed three Hawaii creeper, nine 'akepa, and one 'io during four hours of observation.

A Special Use Permit (HAK-4-89, #52185) was also issued to H. Douglas Pratt to allow Robert Pyle and him to lead two tour groups sponsored by the American Birding Association for the purpose of observing endangered

birds. The Refuge Manager accompanied the first tour to orient the leaders and the group to the Pua Akala area and to describe management strategies. Both groups observed creeper, 'akepa and 'akiapola'au and were very pleased with their experience.

Mr. Reginald E. David and the National Audubon Society were given a Special Use Permit (HAK-6-89, #52187) to hold a portion of the Society's "Birdathon" at Hakalau on April 29. The "Birdathon" is a nation-wide effort to raise funds for the Audubon Society by attempting to observe as many different bird species as possible during a 24-hour period. The Refuge Manager accompanied the group of 12 participants. The common forest birds were observed plus all three of the endangered forest birds which made for a very successful trip.

I. EQUIPMENT AND FACILITIES

1. New Construction

Hakalau Cabin

A 12' x 24' wood frame cabin (Hakalau Cabin) was constructed on the refuge during 1986 to serve as a base of operations. It was relatively dry and warm inside but lacked the basic amenities such as water, electricity, and an indoor toilet. It was also too small to house more than six people. A larger and more comfortable facility was needed to attract and accommodate biological survey and work crews which consist of up to a dozen people, many of which are volunteers.

The manpower and expertise to enlarge and improve the basic cabin was provided with the addition of Jon Emig to the refuge staff in 1988. By the end of that year a 12' x 12' addition including a bunkroom and bathroom was nearly complete. A 10,000-gallon rainwater catchment system was also constructed and the cabin was plumbed with running water (including a hot-water shower).

Improvements continued in 1989. A photo-voltaic power generation, distribution, lighting and storage system was added. A kitchen including counters, sink, cabinets, stove and refrigerator was installed. Five double-decker bunk beds were constructed. Linoleum was laid on the floor and the interior was painted. Outside work included digging, plumbing and capping a cesspool.

The comfortable cabin has proven to be a real asset in attracting volunteers to assist with refuge projects. Most volunteer crews prefer to spend one or two nights on the refuge because of the difficulty in getting there. Overnight stays allow more time for work and for wildlife observation.

Garage/Workshop

A garage/workshop is required at the Hakalau cabin site for parking refuge vehicles (including two 4-wheel-drive motorcycles); for storage of tools, fire-fighting equipment, construction materials, etc.; and as shelter for small construction and repair projects. In a pinch, it can also serve as overflow housing for large work crews. Plans for this 32' x 28' wood frame structure and concrete slab were drafted in 1988. Construction of the forms and base was initiated late that year but heavy rains and the lack of a good driveway between the construction site and Keanakolu Road precluded their completion and any thought of pouring concrete that winter.

Driveway construction was further delayed during the first half of 1989 but was finally completed in September. With assistance from refuge staff, two workers from James W. Glover, Ltd. spent two days at the site leveling and compacting the base course and finishing the fourth side of the form. They also assisted with pouring and finishing the 27-cubic yard concrete foundation in October. By the end of the year, the walls were framed and the roof trusses were in place.



Twenty-seven cubic yards of concrete were poured to construct the foundation for the garage/workshop at Hakalau. RW

Hakalau Cabin Driveway

The half-mile long driveway between Keanakolu Road and the garage construction site adjacent to Hakalau cabin required considerable work to bring it up to the point where it could handle heavy trucks hauling ready-mix concrete. Accordingly, permission was received from the State Division of Hawaiian Homelands to mine gravel from their property. Approximately 30 dumptruck loads of gravel were placed on the existing driveway and graded with a bulldozer during early September. The result was a very nice road, easily negotiated by the concrete trucks and suitable even for two-wheel drive vehicles. The labor and equipment were provided under the Cooperative Agreement with the Alfred Nobriga Ranch.

2. Rehabilitation

Mike Poe, from the Regional Engineer's Office, spent a week on the refuge in May surveying the Pua Akala Road easement where it crosses the 500 acres owned by the Shipman Estate. He also prepared drawings and specifications for improving this road which leads to the site originally considered for construction of the University of Hawaii's field station. The improvements, to be funded by the University, are currently on "hold" until the field station site is formally designated.

4. Equipment Utilization and Replacement

The refuge's 1983 Dodge pickup (leased from GSA) continued to experience major mechanical problems during 1989. An apparently unsolvable vaporlock and corroded body and motor mounts were the most exasperating problems. In July, GSA exchanged the old Dodge for a new Chevrolet diesel 4x4 pickup which is a real improvement. Dependable vehicles are a "must" in an isolated location like Hakalau. The refuge's other vehicle, a 1985 Ford Bronco 4x4 (also leased from GSA), continues to run well.

5. Communications Systems

The mobile telephone was taken from the Dodge and re-installed in the new Chevrolet pickup. This phone has considerably reduced the work hazards for the Maintenance Worker who generally spends most of the week alone on the refuge. It has also greatly facilitated communication between the refuge and the administrative headquarters in Hilo as well as with vendors and neighboring ranchers.

Two hand-held, five-watt VHF radios (Bendix/King Model MPH5142A-02) were purchased in 1988. They are carried by personnel working in the forest for routine communications and to provide an added measure of safety when alone. Business is normally conducted on the frequency of 164.625

MHz. For emergency use only, the Hawaii State Department of Land and Natural Resources has authorized the refuge to use their frequencies which consist of a simplex channel (154.995 MHz) and a duplex channel (154.085 MHz Transmit and 154.995 MHz Receive) which goes through a repeater atop Mauna Kea. These frequencies are monitored almost continuously. During 1989, a whip antenna was erected on the roof of Hakalau cabin. A hand-held radio can be plugged into this antenna to improve its range and facilitate communication with a party deep inside the forest or behind a ridge.

J. OTHER ITEMS

1. Cooperative Programs

Because the refuge shares approximately 20 miles of boundary with the Piha and Laupahoehoe parcels managed by the State Division of Forestry and Wildlife (DOFAW) and because many of the DOFAW's management objectives parallel those for the refuge, numerous opportunities exist for cooperation between the two agencies. A June 19 meeting with Charlie Wakida, Ron Bachman and Howard Horiuchi (DOFAW) identified the following areas as having potential for cooperation: public hunting, land exchanges, fire suppression, reforestation, fence maintenance, prevention of cattle trespass, feral cattle eradication, and bird and pig surveys. Cooperative efforts have already been initiated in some of these areas and more will certainly follow.

3. Items of Interest

A great deal was accomplished on the refuge during 1989 in spite of the small staff (2 individuals) and budget (\$150,000). Much of the credit goes to outside agencies and individuals who provided a great deal of encouragement as well as tangible support at no cost to the refuge. Those deserving particular recognition for their generous efforts and cooperation include:

- 1) Resources Management Division, Hawaii Volcanoes National Park. Larry Katahira, Dan Taylor, Andy Kikuta and several others provided a tremendous amount of advice and help relative to fencing and feral ungulate control as outlined in Section G.15.
- 2) Hawaii State Division of Forestry and Wildlife. Charlie Wakida, Jeanine Branham and the staff of the Waimea Tree Nursery germinated and reared 12,000 koa seedlings for the refuge. Bill Stormont led a crew of four firefighters and two firetrucks to the refuge to act as emergency standby during the first prescribed burn of gorse. Jon Giffin assisted with the feral ungulate control effort.