

HAKALAU FOREST NATIONAL WILDLIFE REFUGE

Hilo, Hawaii

ANNUAL NARRATIVE REPORT

Calendar Year 1988

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

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REVIEW AND APPROVALS

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1-5-90
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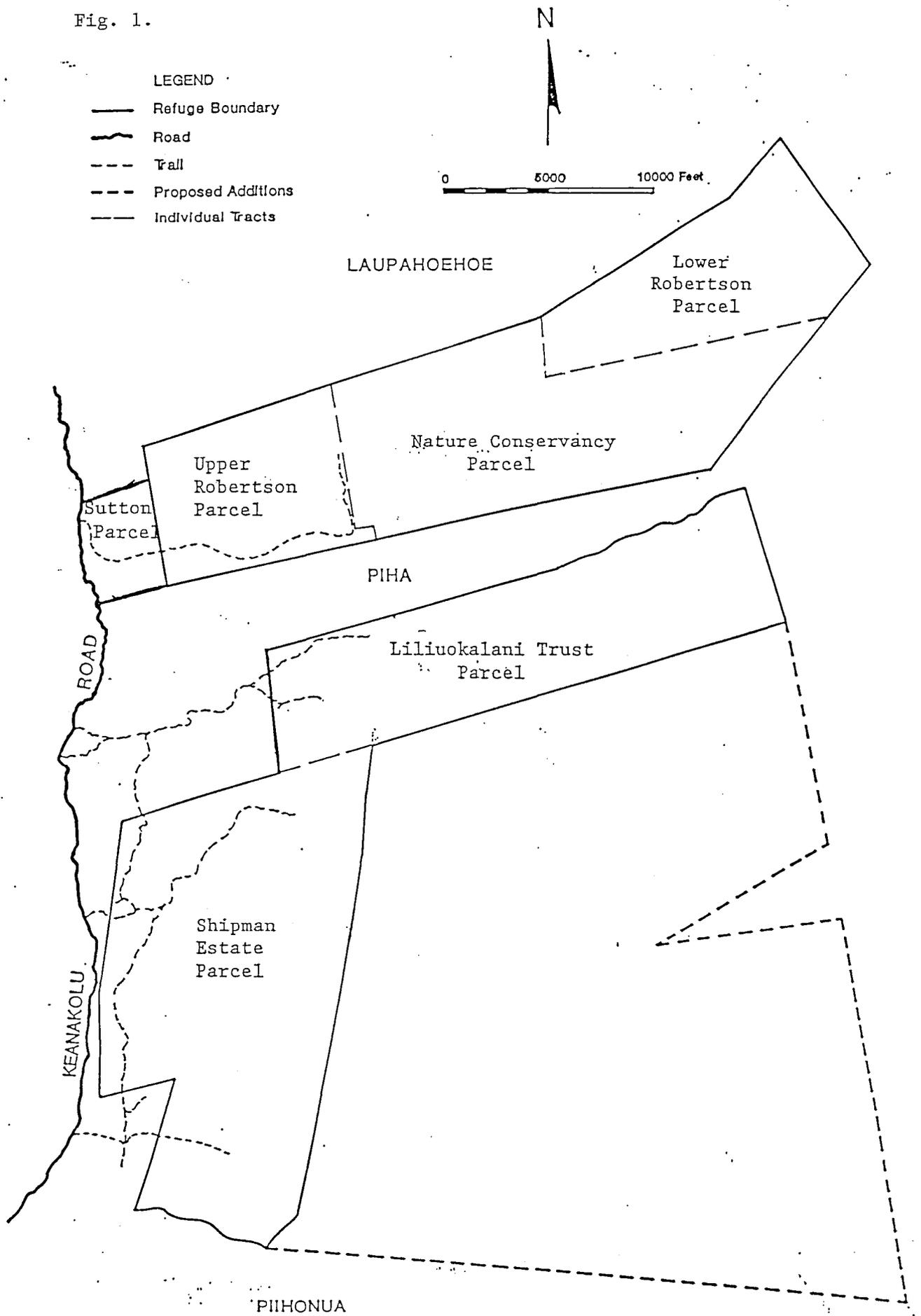
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INTRODUCTION

Hakalau Forest National Wildlife Refuge was established October 29, 1985 with the purchase of two properties totaling 8,313 acres. Four additional parcels were acquired by the close of 1988 bringing the total area to 15,484 acres. Negotiations toward the purchase of an additional property totaling approximately 16,000 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 treeferns and bisected with numerous streams and gullies. Upslope, at elevations above 4,500 ft., koa becomes codominant 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.

Fig. 1.



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A. HIGHLIGHTS

1. A sixth parcel of land (the "Sutton parcel") was added to Hakalau Forest NWR bringing the total size of the refuge to 15,484 acres. The 400 acre addition was purchased for \$360,000 through the Nature Conservancy from Richard Sutton, George Robertson, et. al. (Section C.1.)
2. Management Plans addressing fire and grazing were prepared. (Section D.2.)
3. Dr. Leonard A. Freed, University of Hawaii, continued his forest bird research project on the refuge. His efforts focused on banding as many native birds as possible and a study of the evolution of sexual dichromatism and cavity-nesting in the Hawaii Akepa, an endangered species. (Section D.5).
4. The refuge staff was expanded to two employees in April with the addition of a Maintenance Worker. (Section E.1.)
5. A second Interagency Agreement with the U.S. Forest Service was signed in August. The Forest Service will continue to monitor the experimental reforestation plots established in 1987 and initiate new studies on nutrient requirements, propagation techniques and growth and survival rates for native forest plants. (Section F.3.)
6. Cooperative Agreements with the Pua Akala Ranch and the Alfred Nobriga Ranch permitted 329 and 305 AU's of grazing on the refuge during 1988. (Section F.7.)
7. A gorse control effort with the herbicide Tordon 22K was initiated. (Section F.10.)
8. Bird censuses were conducted during the spring and fall. (Section G.2.)
9. Six and one-half miles of pig/cattle fence were completed along new boundaries and to enclose a 550 acre feral ungulate management unit at a total construction cost of \$57,695. (Section I.1.)
10. A 12' x 18' bunkroom/bathroom/porch was added to Hakalau cabin and a water catchment and distribution system was constructed. (Section I.1.)

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 67 degrees F at the lower elevations and 57 degrees F at the higher elevations. Daily temperatures in the vicinity of Hakalau cabin range between highs of 55 degrees F to 80 degrees F and lows of 30 degrees F to 50 degrees 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 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 upper slopes of Mauna Kea. These afternoon low clouds are responsible for the cool and damp climate that generally prevails at Hakalau.

A thermometer and rain gauge were installed on the refuge at Hakalau cabin early in 1987. Data from these instruments are summarized in Table I.

Table I. Meteorological observations at Hakalau cabin during 1988. Data were recorded from a maximum/minimum thermometer and a raingauge at intervals of one day to two weeks with an average interval of about one week. The thermometer was mounted on the exterior wall of the cabin under the porch roof so temperature extremes were constrained by the heat mass of the cabin. Therefore, the actual lows were probably lower and the actual highs, higher.

Month	Lowest Low (degrees F)	Highest High (degrees F)	Rainfall (inches)
January	39	69	2.10
February	38	68	6.45
March	40	66	4.75
April	37	70	3.82
May	42	76	3.45
June	45	78	1.02
July	43	78	3.04
August	42	77	6.39
September	42	76	3.04
October	42	73	2.40
November	41	70	9.67
December	36	70	12.16
		TOTAL	58.29

Rainfall in 1988 was considerably less (58.29") than in 1987 (70.67"). November and December were the wettest months during both years with an average of 12.51"/month.

C. LAND ACQUISITION

1. Fee Title

On December 2, 1988, a sixth parcel of land (the "Sutton parcel") was added to Hakalau Forest NWR. (See Figure 1.) A total of 400 acres was purchased through the Nature Conservancy from Richard Sutton, George Robertson, et. al. at a cost of \$360,000. The parcel is located adjacent to and above the upper Robertson parcel. It is bounded by Piha to the south which is owned and managed by the State of Hawaii as a public hunting area and by state and private lands to the north and west used for grazing cattle. The new parcel lies at elevations between about 5,800 and 6,200 ft. and has a scattered overstory of koa, ohia and kolea trees and an understory of introduced grasses and a few native shrubs. The area is zoned for agriculture and has been grazed by cattle for many years.

The upper boundary of this parcel was surveyed on November 3 by Bill Drummond and Pat Koglin from the Regional Office. The witness posts and monuments they left to mark the boundary were "reinforced" with steel fence posts and piles of rocks as protection from cattle.

The acquisition of the Sutton parcel brings the total acreage of Hakalau Forest NWR to 15,484 acres and the total purchase price to \$6,864,325. Negotiations are ongoing towards the purchase of an additional 16,275 acres owned by World Union Industrial Corporation, Ltd. Acquisition of this property will bring the refuge total to approximately 31,800 acres.

D. PLANNING

2. Management Plan

Management Plans addressing fire and grazing were prepared during 1988.

Herb Troester, Regional Fire Management Coordinator, spent the week of December 7, 1987 with the Refuge Manager to assist with the preparation of a Fire Management Plan. Fire management specialists from Hawaii Volcanoes National Park, the state Division of Forestry and Wildlife and the Hawaii County Fire Department were consulted. The plan was completed the following spring and given final approval on November 18, 1988. It features a Cooperative Agreement with the Hawaii County Fire Department under which that agency provides fire suppression expertise, manpower and equipment on a cost reimbursable basis. Access to fire-fighting assistance from the Hawaii State Division of Forestry and Wildlife is also available under this agreement. The plan addresses prescribed burns as well as wildfires. Because native plants are poorly adapted to fire and tend to be replaced by exotic species in burned areas, and because fire is not a normal component of the rainforest ecosystem, the plan states that immediate and total suppression will be the objective for wildfires occurring on the refuge. Fire severity ratings are deemed "low" for the four fuel types occurring at Hakalau.

Two Cooperative Agreements with cattle ranching operations were in effect during 1988. Because one was expiring at the end of the year and because grazing has significant impacts on native plants, it was appropriate to initiate significant planning effort for grazing and grassland management at Hakalau. Dave Franzen, Range Conservationist from Sheldon-Hart

Mountain Refuges, spent the week of February 29 with the Refuge Manager visiting the refuge, meeting with ranchers, and consulting with local conservationists and resource managers to begin formulating a Grazing/Grassland Management Plan. The initial draft was completed April 13 and it was redrafted in January 1989. The plan concluded that: 1) Pua Akala Ranch cattle would be allowed to graze approximately 1,200 acres in the upper portion of the 4,994 acre Shipman Estate parcel for one additional year under a Special Use Permit. These paddocks are located above the upper edge of the forest and consist of open grassland vegetated almost entirely by alien species. One of the upper paddocks (Triangle Paddock) would be closed to grazing and would be used instead as the site to initiate the refuge's grassland reforestation program.

2) The Alfred Nobriga Ranch cattle would be allowed to continue grazing the entire upper Robertson parcel until the Cooperative Agreement expired at the end of 1989. Thereafter, the parcel would be closed to grazing.

3. Public Participation

An informal advisory group meeting was convened on April 19 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 all-day meeting also served as a forum for disseminating information on refuge activities and eliciting the support of state, private and federal agencies for future management actions. Thirteen individuals were in attendance representing the Hawaii State Division of Forestry and Wildlife, Hawaii Volcanoes National Park, the U.S. Forest Service, the Nature Conservancy and the Fish and Wildlife Service. The attendees were all pleased with the opportunity to provide advice and management input and expressed their desire to participate in similar meetings on an annual basis.

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. The bulk of his research occurred within an 8 hectare area in the Pua Akala portion of the refuge. One of Dr. Freed's students (Jaan Lepson) camped below Pua Akala almost continuously between late May and December, operating mist-nets, banding birds, and observing bird behavior. In March, a Graduate Seminar Class of 7 students visited the refuge for a week to learn ornithological techniques and to become familiar with native birds.

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

<u>Endangered Species</u>	<u>No. Individuals</u>	<u>No. Bled</u>
Hawaii 'Akepa	23	3
Hawaii Creeper	10	
'Akiapola'au	1	1
Totals	<u>34</u>	<u>4</u>

<u>Other Native Species</u>	<u>No. Individuals</u>	<u>No. Bled</u>
'Oma'o	21	5
'Elepaio	16	4
Common 'Amakihi	58	9
'Apapane	199	25
'I'iwi	96	28
Totals	<u>390</u>	<u>71</u>
<u>Introduced Species</u>	<u>No. Individuals</u>	<u>No. Bled</u>
Red-Billed Leiothrix	3	1
Northern Cardinal	1	
Japanese White-Eye	13	10
House Finch	16	5
Nutmeg Mannikin	4	
Totals	<u>37</u>	<u>16</u>
GRAND TOTAL	461	91

During 1987, 381 birds were banded including 57 endangered 'Akepa and Creeper.



The 'Amakihi is a native honeycreeper commonly found on the refuge. Note the band on its left leg.

During 1988, one 'Akepa nest, one 'Elepaio nest, one 'Oma'o nest and numerous 'I'iwi and 'Apapane nests were discovered. There was no mortality associated with the banding operations, and no nest desertion

associated with capture of parents in mist-nets or inspection of nest contents. Numerous recaptures of individual birds within the system of mist-nets indicate that birds neither learn to avoid nets nor leave the study area because they are captured.

Insectivorous honeycreepers (including the endangered 'Akepa and Creeper) had much poorer reproductive success during 1988 than during 1987. No such difference occurred in the nectarivorous honeycreepers. Casual observations indicated that introduced yellow-jacket wasps (*Vespula* sp.) were more numerous in 1988. Perhaps the wasps are food competitors with insectivorous honey creepers under certain conditions.

Most significantly, birds were discovered with symptoms suggestive of avian pox virus. Two 'I'iwis, one 'Apapane, and two 'Amakihis were captured with missing upper or lower mandibles, missing toes, and/or lesions on the legs and toes. Blood collected from one of the 'Amakihis will be tested for pox virus.

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, the University submitted a proposal to the MacArthur Foundation for funds to construct a field station at Hakalau and to initiate a rigorous research effort to document the genetic and demographic population structure of forest birds. That proposal is pending.

E. ADMINISTRATION

1. Personnel



The 1988 Hakalau Forest NWR staff consisted of Maintenance Worker Jon R. Emig (left) and Refuge Manager Richard C. Wass (right).

Prior to 1987, the administrative, management and planning duties for Hakalau Forest NWR were shared by the Hawaiian and Pacific Islands NWR Complex Manager and the Endangered Species Coordinator in Honolulu. Early in 1987, the position of Refuge Manager (GS-485-11 PFT) was established for Hakalau. Richard C. Wass was assigned the position and based within the Hawaii and Pacific Islands NWR 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. During 1988 a second position was added to the refuge staff. On April 20, 1988, Jon R. Emig was hired as a Maintenance Worker (WG-4749-7 TFT). His duties during the year included design and construction of an addition to Hakalau cabin, design of a garage/workshop, installation of a water catchment and distribution system for Hakalau cabin, application of herbicide for gorse control, fence maintenance and surveys, maintenance of Nauhi cabin and general maintenance of vehicles and equipment.

4. Volunteer Program



A group of eight volunteers including John Kahiapo assisted with the Federal Lands Day/Public Lands Day effort to rehabilitate Nauhi cabin.

The major volunteer effort of the year occurred during September 10 and 11 as an observance of Federal Lands Day/Public Lands Day. Eight volunteers (Bob Bemm, Jon Emig, Buster Kahakua, John Kahiapo, Aaron Morita, Tom Seabury, Richard Wass and Ed Yamamoto) spent the weekend on the refuge rehabilitating Nauhi cabin as a base for biological surveys, feral ungulate control, fence construction and reforestation projects. The cabin was constructed about 1920 and was acquired by FWS with the purchase of the Liliuokalani Trust Estate parcel in 1986. Accomplishments for the weekend included 1) the cabin was thoroughly cleaned of cobwebs and debris; 2) about 85% of the interior (walls, ceilings, cabinets) was repainted with an oil-base primer; 3) about 75% of the interior was painted with an oil-base finish coat; 4) the front steps were repaired; 5) a free-standing fireplace and stovepipe were installed; 6) broken windowpanes were replaced and windows were reinstalled in their frames; 7) the roof on the storage shed was cleaned and repaired; and 8) the outhouse was cleaned and its door repaired. A month later, volunteers Carol and Richard Wass completed the painting.

Maile Kjargaard and Reggie Davis were volunteer participants in the June 13-17 forest bird census. Volunteer Marie Morin assisted with the October 17-21 census.

During June 7 and 8, Pam Warren provided volunteer assistance with the construction of the addition to Hakalau cabin.

A major hindrance to the volunteer program 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 late in the year for a "Volunteer Coordinator" to assist the Refuge Manager with the volunteer program. The volunteer position was widely advertised in local newsletters of the Sierra Club and the Hawaii Audubon Society, through the Regional Office of the FWS, by word-of-mouth, etc.

5. Funding

Almost \$130,000 was expended for special projects at Hakalau in FY86 and all of the money was provided through Fish and Wildlife Enhancement. Major items were Interagency Agreements to survey pigs and vegetation, to conduct reforestation studies and to recommend gorse control measures; a Research Work Order to design and conduct a forest bird census; the construction of a cabin; the purchase of materials for six miles of fence; and a contract to erect the fence.

Funding for FY87 totaled about \$98,000. Of that total, \$23,000 came to Hakalau through Refuges and Wildlife and \$75,000 through Fish and Wildlife Enhancement. Major expenditures included the refuge manager's salary, travel between Hilo and Honolulu, equipment for the new office in Hilo, fence materials, and an ATV motorcycle.

FY88 funding increased to \$180,000 and all of it was provided through the Hawaii/Pacific Islands Refuge Complex (i.e. Refuges and Wildlife). Major expenditures included \$36,667 for a contract to complete 6-1/2 miles of pig/cattle fence, \$15,000 to fund an Interagency Agreement for experimental studies and assistance with reforestation, \$12,000 for the purchase of fence materials, \$10,700 for the purchase of materials for the cabin addition and provision of water and power, \$6,700 for office rent and \$5,000 for the purchase of a remote recording weather station.

6. Safety

Because of the danger involved with the operation of a 4-wheel-drive ATV motorcycle, both the Refuge Manager and the Maintenance Worker received a full day of training on the refuge in the safe use and operation of the Honda ATV's.

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

7. Technical Assistance

Refuge Manager Wass served as the local contact for the Western Section of the Wildlife Society in setting up their annual meeting on February 11-13 at the Naniloa Hotel in Hilo. Major responsibilities including meeting with hotel staff to coordinate the reservation and set up of meeting rooms, facilities and meals. Almost 300 people attended the conference.

The Refuge Manager provided comments to the Hawaii Volcanoes National Park regarding Environmental Assessments of proposals to control noxious weeds with the use of biocontrol agents (insects) and herbicides, construct firebreaks and widen roads. The Manager also participated on the State of Hawaii's Animal Species Advisory Commission and the Gorse Steering Committee.

8. Other

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.

Noteworthy visitors to Hakalau during 1988 included:

- Jan 28. Bill Rosehill, Hawaii Island Land Manager, Bishop Estate
Ernest Pung, State Division of Forestry & Wildlife, Retired
Howard Horiuchi, State Division of Forestry & Wildlife
- Feb 13. 45 people attending the annual meeting of the Western Section of
The Wildlife Society toured Hakalau as one of three field trips
offered the participants
- Feb 15. Tim Ohashi, Animal Damage Control, APHIS, USDA
Larry Hirata, USDA
- Mar 7. Sam Buzbee, Budget and Finance Manager, Region 1, FWS
- Apr 12. Wally Steucke, Deputy Regional Director, FWS
Mrs. Steucke
Al Marmelstein, PIA
- Jun 29. NOVA film crew, Public Television.
- Aug 18. Jim McCollum, Staff for House Merchant Marine and Fisheries
Committee
Lurline McCollum, Staff for Senator Inouye
Al Marmelstein, PIA

- Nov 14. Rob Shallenberger, Acting Assistant Regional Director, Refuges & Wildlife, FWS
Jerry Leinecke, District Supervisor
- Nov 28. Steve Robinson, Deputy Director, FWS
Mrs. Robinson, Staff for Congresswoman Vucanovich
Al Marmelstein, PIA
- Nov 29. Dick Smyth, Director of Environmental Research, U.S. Forest Service
Enoch Bell, U.S. Forest Service
Gene Conrad, Director, Institute of Pacific Islands Forestry
Jerry Leinecke, District Supervisor, FWS
- Dec 6. Jan TenBruggencate, Environmental Writer, Honolulu Advertiser and Star-Bulletin.
- Dec 19. Congresswoman Beverly Vucanovich
George Vucanovich, husband
Al Marmelstein, PIA

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.

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.

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. 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 at 2-meter and 2.5-meter spacings in seven- by seven-tree matrices. Site preparation prior to planting was minimal and consisted of scalping the vegetation (mostly kikuyugrass) from a circular area about 1/3 m across at each planting spot. No subsequent weed control was conducted.

Observations made near the end of 1988 indicated that growth of the koa seedlings was slow compared to a second plot established at a lower elevation. Vigor was rated average for koa and below average for ohia and mamane. The ohia that looked best were those under some cover of surrounding plants. Frost damage may be the cause of the relatively poor vigor. The plot is located at the upper limit of the elevational range of ohia.

A second experimental reforestation plot (termed the Woodland Exclosure) was established and disked in July 1987. It is located at about 5,500 ft 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.

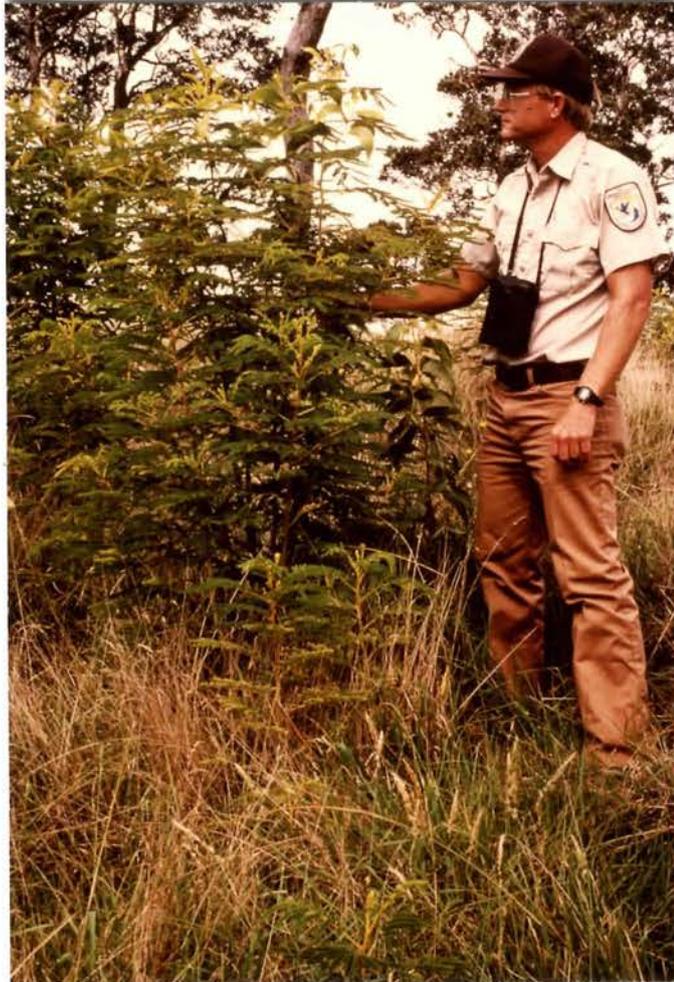
Areas beneath five live koa trees, four clusters of live koa trees, five dead and down koa trees and five open areas were selected at random for scarifying by disking. The open spots were at least 30 m from a live or dead koa and were marked to be about 30 m across after disking. The seedlings established 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 away 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. Some trees were more than five feet tall by the end of 1988.

Conclusions that can be drawn thus far from the two experimental plots include the following: Seedlings and rooted cuttings of koa, ohia and mamane survive at both sites but the lower site is better for koa and probably for ohia because of the warmer temperature. 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 ft, the number of seedlings drops dramatically. Prevailing wind does not appear to have much impact on seedling distribution. Existing data do not allow a determination of how long koa seeds remain viable in the soil but it appears that dead tree skeletons remain after most of the seeds have lost viability.

The first year of results from the reforestation study are described in the following paper which was presented during the February 10-13, 1988 meeting of the Western Section of The Wildlife Society held in Hilo: Conrad, C.E, P.G. Scowcroft, R.C. Wass and D.S. Goo. 1988. Reforestation research in Hakalau Forest National Wildlife Refuge. Transactions of the Western Section of The Wildlife Society 24:80-86.

A second Interagency Agreement was signed with the U.S. Forest Service in August 1988 to continue and expand the original studies. \$15,000 was transferred 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 exclosure 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. 8) Assist with the preparation of a reforestation management plan for the refuge. The agreement extends through March 1991.



Refuge Manager Wass admires a 1-1/2 year old koa tree which sprouted in the woodland experimental reforestation exclosure following scarification with a disk/plow.

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.

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 a minimum of 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 to permit grazing on the upper portions of the Shipman Estate parcel from January 1, 1986 to December 31, 1988. Grazing privileges were provided in exchange for equivalent value services from Pua Akala Ranch relating to grazing and land management such as fence and trail construction and maintenance, boundary posting, exotic vegetation control, tractor scarification to stimulate reforestation, and removal of feral cattle from adjoining refuge property. 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).

During the first two years of the agreement, the Pua Akala Ranch was allowed to graze cattle on approximately 3,794 acres of the 4,994 acre Shipman Estate parcel. Three of the lowermost 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. In January of 1988, Pedro Paddock (910 acres) was also closed. Much of this paddock has a good canopy of native trees so, even if no active management action is taken, some reforestation will occur naturally if cattle are excluded.

Grazing by Pua Akala Ranch cattle amounted to 447 Animal Unit Years (AUY) in 1986, 355 AUY in 1987 and 320 AUY in 1988 for a total of \$24,950 in equivalent value services. The grazing fee was adjusted upward to \$22.97 per AUY for 1988. By the end of 1988, the Pua Akala Ranch had provided services to the refuge valued at \$5,395 in the form of tractor scarification, boundary posting, fence construction and cabin maintenance. The remaining \$19,555 of services are on account to be utilized in 1989 during which Pua Akala Ranch was issued a Special Use Permit to allow continued grazing.

On April 11, 1987, a Cooperative Agreement was signed with the Alfred Nobriga Ranch which permits grazing on the entire 1,542 acres of the upper Robertson parcel through the end of 1989. The terms are generally similar to the Pua Akala Ranch agreement described above in that grazing privileges are provided in exchange for equivalent value services at the base rate of \$22.00 per AUY subject to annual adjustment. The maximum stocking rate again is one animal unit per five acres (308 AUY's).

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.) Services (use of bulldozer and backhoe) valued at \$1,159 were provided by the Alfred Nobriga Ranch through the end of 1988. The remaining \$10,619 has been placed on account and will be provided during 1989.

Prior to acquisition of the upper Robertson parcel, the FWS agreed to allow the Alfred Nobriga Ranch to take water from the refuge during periods of drought. In 1987, the Nobriga Ranch was issued a Special Use Permit for the construction of a four million gallon water catchment pond on the upper Robertson parcel. That permit was renewed in 1988 (HAK-3-88, #52176)) when a 1-1/2 mile pipeline was laid to connect with holding tanks and ponds above the refuge and then to a series of troughs to provide

water for the permittee's cattle. During the summer of 1988, approximately 1.5 million gallons of water were pumped from the collecting pond during 750 hours of pump operation. On October 12, a member of The Nature Conservancy called to complain about the lack of a muffler on the pump engine and about oil spilled in the vicinity of the pump. The Refuge Manager visited the site on the following day. The pump was not running so it was not possible to determine if the noise level was a significant disturbance. It was estimated that one gallon of diesel fuel and/or motor oil had been spilled on the ground within six feet of the pump. Mr. Nobriga was immediately instructed to cease pumping and directed to construct a shed over the pump before he could resume operation.

9. Fire Management

As mentioned above under D.2., a Fire Management Plan was completed for Hakalau Forest NWR during 1988. No wildfires occurred on the refuge during the year and no prescribed burning was conducted.

Refuge Manager Richard Wass received training in Basic Firefighting (S-130) and Basic Fire Behavior (S-190) from the staff at Hawaii Volcanoes National Park. During June he traveled to Boise, Idaho for a week of training in Intermediate Fire Behavior (S-390) led by the Regional Fire Management Coordinator. This training will allow the Manager to conduct prescribed burns of gorse during 1989 and beyond.

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. At present, the banana poka vine is kept in check by cattle. As grazing is phased out, however, it will likely become a problem.

Gorse is a noxious weed that was introduced to Hawaii over 100 years ago, either to create hedgerows 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 presently 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. The use of herbicide, fire, and bulldozers may only provide short-term control because the millions of seeds in the ground are often stimulated to sprout by these procedures. Biocontrol through the introduction of insects and pathogens which naturally prey on gorse appears to be a viable long-term solution.

The U.S. Soil Conservation Service, the U.S. Forest Service, and the Hawaii State Department of Agriculture are currently studying and testing various gorse control measures. The FWS funded a portion of this work through an Interagency Agreement with the U.S. Soil Conservation Service (SCS) signed September 15, 1986. This agreement transferred \$10,000 to the SCS "to coordinate the development of techniques to control/eradicate the plant pest, gorse (Ulex europaeus) on the Island of Hawaii".

The agreement was completed at the end of 1987 and the results submitted to the FWS in a report dated April 4, 1988 which was summarized in the 1987 narrative. The report contained specific recommendations for short term control of gorse at Hakalau. They included application of the restricted use herbicide, Tordon 22K, at a rate of two pounds acid equivalent per acre followed by burning and repeated applications 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 obtained certification as a commercial applicator of restricted pesticides for Category 2 - Forest Pest Control from the State of Hawaii as well as a state permit to purchase and use Tordon. The Refuge Manager and Maintenance Worker then spent a total of 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 ft. hose and a 15 gal. tank mounted on the rear rack of a 4-wheel-drive ATV motorcycle. The equipment functioned exceptionally well and allowed us to reach gorse patches inaccessible to a larger vehicle.



Maintenance Worker Emig uses an ATV to spray herbicide on gorse.

The response of gorse to the Tordon 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, indicates that a long term program of prescribed burning and repeated spray application will be required to control the gorse infestation at Hakalau. Three photo points were set up near Hakalau Cabin to document the response of three gorse patches to this and future treatments.

G. WILDLIFE

2. Endangered and Threatened Species

As was mentioned in the introduction, Hakalau Forest NWR was established primarily to protect and restore 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.

A native bird population monitoring effort is 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 by Research Work Order in 1986 to 1) Develop a permanent monitoring program for the forest bird populations of Hakalau Forest NWR; 2) Select and permanently mark the locations of transects and plots for the forest bird monitoring program; 3) Determine what frequency of monitoring is necessary to measure seasonal, annual and long-term population trends; and 4) Conduct two initial surveys during the period of this Research Work Order and train refuge personnel to continue the monitoring program upon completion of the contract.

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 m 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 m 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. Additional censuses were conducted along the 14 transects by Dr. Scott and crew during late May-early June and again in October 1987. Data from the two 1987 censuses were computerized and densities (birds per square kilometer) were calculated for each species at each station using the variable circular plot method. These densities were then used to estimate total refuge populations for each species. Because the population estimates were unavailable for the 1987 narrative, they are included herein as Table II.

Table II. 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
Other Native Species		
'Apapane	96,341	17,909
Common 'Amakihi	50,596	22,683
'Elepaio	9,377	4,751
Hawaiian Hawk	present	present
Hawaiian Thrush	11,808	4,242
'I'iwi	114,251	36,734
Pueo	present	present
Exotic Species		
Chukar	present	present
Common Mynah	279	467
Erkel'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

Dr. Scott and others have recommended that the 14 transects be censused every spring and fall for the foreseeable future. Because the refuge did not have the staff to continue this effort, \$3,000 was transferred to the Hawaii Research Station (HRS), Fish and Wildlife service in 1988 for this purpose. HRS agreed to provide the personnel to count birds, to input data and to perform the computer analysis.

Censuses were conducted June 13-17 and October 17-21, 1988 using the standard methodology established by Dr. Scott. The analysis of these data is incomplete and will be presented in the 1989 narrative.

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 National Park Resources Studies Unit, National Park Service, University of Hawaii was signed September 26, 1986 to document the extent of the problem and recommend measures for reducing the 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.

Tim Ohashi and David Hirata (Animal Damage Control, U.S. Dept. of Agriculture) spent a day (February 15) at Hakalau with the Refuge Manager to assess the feral pig problem and to provide assistance with pig control. The three-member party walked parallel through the forest shooting pigs whenever they were encountered. The hunt lasted for seven hours and no dogs were used. Six pigs were killed -- 2 boars (ages 12 mo and 24 mo) 2 sows (ages 36 mo and 15 mo) and two young (ages 2 mo and 4 mo). All were judged to be in good condition based on a subjective assessment of subcutaneous fat and musculature.

Special Use Permits (HAK-4-88, #52177 and HAK-5-88, #52179) were issued to the Pua Akala Ranch and the Alfred Nobriga Ranch to allow their employees to take feral pigs for their personal use incidental to other ranching activities. No estimate is available for the number of pigs taken by Pua Akala Ranch employees but the total was probably very low (i.e. less than 10). Freddie Nobriga gave estimates of 30 hunters and 500 pig kills within the Maulua sector of Hakalau Forest NWR during the ten months his permit was effective. He further estimated that three hunters hunted for two days during an average week. His permit was terminated on October 23 when the Refuge Manager determined that pigs were being taken by individuals who were not employees of the Nobriga Ranch, thereby violating a special condition of the permit.

16. Marking and Banding

As listed under Section D.5, Dr. Leonard Freed and colleagues banded 461 birds during the year including 34 endangered 'Akepa, Hawaii Creeper and 'Akiapola'au.

H. PUBLIC USE

1. General

Public entry was not permitted on the refuge during 1987. There are no facilities for self-guided tours and no staff to act as guides. Also, the more accessible portions of the refuge are grazed by cattle which require locked gates and lots of barbwire fences. 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 such tour was held during the year. It was organized by the Western Section of The Wildlife Society which held their annual meeting in Hilo during February. Forty-five of the attendees visited the Magnetic Hill reforestation plot and the Pua Akala sector of the refuge on February 13 for a briefing on refuge objectives and

management strategies and to observe forest birds and Hawaiian rainforest habitat.



A group of people attending the annual meeting of the Western Section of The Wildlife Society toured the refuge to view native birds and plants and gain first-hand knowledge of management strategies.

6. Interpretive Exhibits/Demonstrations

A poster depicting the refuge and management strategies was presented during the poster session of the meeting of the Western Section of The Wildlife Society. The poster won second prize in the competition. It was subsequently used by the Refuge Manager for general orientation including a slide talk given to the Sierra Club and during an interview for a local television station.

7. Other Interpretive Programs

On March 9, the Refuge Manager was interviewed by the host of a local television (KHBC-TV) talk show ("Night Moves"). During a 15 minute filming session in the studio, the refuge was described and management objectives and strategies were discussed. A few days later, the host and a cameraman visited the refuge to film birds and habitat as well as further statements by the Refuge Manager relative to management problems and priorities.

On April 28, the Manager was interviewed by Jack Hughes of radio station KIPA. The interview was edited to prepare several 3-minute shorts to be aired during the following week. This interview was the result of a Press

Release publicizing the presentation of the 1988 Revenue Sharing Check in the amount of \$28,718 to Hawaii County Mayor Dante Carpenter.

On July 26, the Manger gave a slide talk on the refuge to the local chapter of the Sierra Club. Potential volunteers were also recruited.

On December 6, Jan TenBruggencate, Environmental Writer for the Honolulu Advertiser and Star-Bulletin toured Hakalau in the company of the Manager. The result was a feature article in the Sunday Star-Bulletin and Advertiser published December 25. The article described the refuge and discussed management objectives.

A Special Use Permit (Hak-6-88, #52180) was issued to Mr. Larry Engel, Cineworks Inc., to allow videotaping of native forest birds for the purpose of illustrating adaptive radiation in beak morphology, color patterns and behavior. A three-person film crew visited the refuge on June 29 in the company of the Refuge Manager to film birds and tape their vocalizations. Their film will be used on the educational TV series "NOVA" of the Public Broadcasting System.

11. Wildlife Observation

For the second consecutive year, a Special Use Permit (HAK-2-88) 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 1988 Mr. Collins conducted 3 tours (averaging about 3-1/2 hours of observation time) with a total of 15 participants. He reported a total of 6 'Akepa, 3 Hawaii Creeper, 2 'Akiapola'au and 6 'Io (Hawaiian Hawk). At least three endangered birds were seen on each trip.

I. EQUIPMENT AND FACILITIES

1. New Construction

Fencing

In September of 1986, a contract in the amount of \$24,535.50 was let to Kama'aina Fence Builders, the low bidder, for the construction of approximately six and one-half miles of boundary and internal fence. Two and one-half miles of the fence would form the boundary between the refuge and the 500 acres of property retained by the W.H. Shipman Estate. The remaining four miles would be erected on the Liliuokalani Trust parcel. About half of it would bound the property retained by the Liliuokalani Trust to the west and the Piha state game management area to the north. The remainder would extend from the ends of these two fencelines to enclose approximately 550 acres as a pig management unit.

All fence materials were supplied by the refuge. The fence is designed to exclude both feral pigs and cattle and is constructed of triple-galvanized 47 inch square mesh wire with a strand of barbwire running along both the top and the bottom. The bottom of the fence is no more than two inches above the ground to prevent pigs from squeezing underneath. Gaps greater than two inches are closed by pulling the fence down with anchors, filling in the holes with large rocks or splicing in additional fence material.

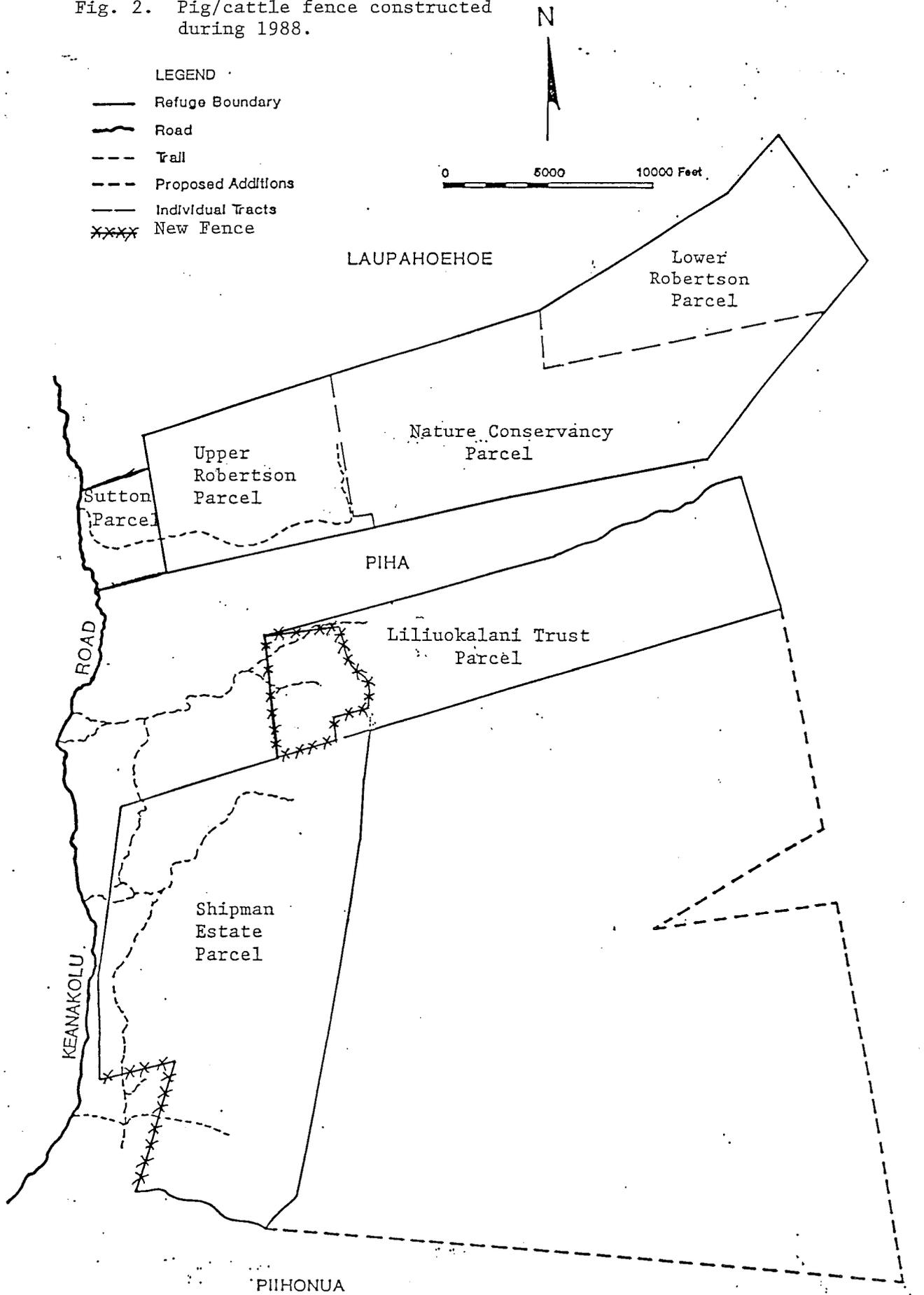
The onset of the project was delayed until January 1987 due to problems encountered in procuring and shipping the materials. Bad weather, further shipping delays, equipment breakdowns and the snail-like pace of the contractor all contributed toward additional delays and the contract was still unfinished by the end of 1987. The situation went from bad to worse in 1988 and on July 20, Kama'aina Fence Builders was issued a Notice of Termination for Default with about one-third of the job remaining and \$3,507.75 of the contracted amount unpaid. A major factor contributing to the default was that the \$24,535.50 bid was too low to allow an adequate profit given the inaccessibility of the job site and the prevailing wet weather.

On September 12, an Invitation for Bids to complete the construction of 6-1/2 miles of fence was issued. The winning bid was \$36,667.00 submitted by the Scott Lynch Fence Co. of Ronan, Montana. This company was issued a Notice to Proceed on October 28 and the job was completed on December 14. At last we had our fence. The total construction cost was \$57,694.75. The location is mapped in Figure 2.



District Supervisor Jerry Leinecke examines a pig trail going under a section of the new fence. Pig hair is entangled on the bottom strand of barb wire.

Fig. 2. Pig/cattle fence constructed during 1988.



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 it lacked the basic amenities such as water, electricity, and an indoor toilet. It was also too small to comfortably 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 late April. By the end of May, plans were drafted for a 12' x 12' addition to include a bunkroom and bathroom as well as a 12' extension of the 6' wide porch. The framing, walls and roof were completed in July. A 10,000 gallon rainwater catchment system was completed in August and the cabin was plumbed with running water (including a hot-water shower) in September. By the end of the year, the interior was nearly finished and the new room was being utilized for storage and sleeping quarters.



Maintenance Worker Emig takes a break from his effort to construct a 12' x 12' addition and adjoining porch at Hakalau cabin.

Garage/Workshop

A garage/workshop is required 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. Plans for this 32' x 28' wood frame structure and concrete slab were drafted in May. Pat Koglin (Engineering, Regional

Office) spent about a week and a half on the refuge in November with the intent of supervising construction of the foundation slab. His efforts to dig the footings and construct the formwork, as well as the efforts of our Cooperator (Freddie Nobriga) to provide a gravel base course and to construct a road to the worksite to accommodate a ready-mix concrete truck, were continually frustrated by heavy rains. Consequently, construction was postponed until the middle of 1988 when drier conditions could be expected.

2. Rehabilitation

Nauhi cabin, located on the Liliuokalani Trust Estate parcel of the refuge, was rehabilitated during the Federal Lands Day weekend in September by a group of volunteers and the refuge staff. Details of this effort are described above under E.4. The cabin is approximately 70 years old and needs much more work, particularly on the roof and exterior.

4. Equipment Utilization and Replacement

The refuge's 1983 Dodge pickup (leased from GSA) experienced major mechanical problems throughout the second half of the year. It was laid up in the repair shop approximately 25% of the time. Even when it was out of the shop, major amounts of the Maintenance Worker's time were spent tinkering with the mechanical components to keep it running. A vaporlock problem was the most exasperating. It remained unsolved despite the installation of an electrical fuel pump, a new carburetor and the work of six different mechanics.

5. Communications Systems

A mobile telephone was installed in the Dodge pickup in April. This 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. The phone also allows the conduct of business via telephone directly from the refuge.

Two hand-held, five-watt VHF radios were purchased in September. They are manufactured by Bendix/King (Model MPH5142A-02), are programmable for frequencies between 148-174 MHz, and meet military specifications for environmental stress. They are carried by personnel working in the forest for routine communications and to provide an added measure of safety when alone. Routine business is 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) and which are monitored almost continuously.

J. OTHER ITEMS

1. Cooperative Programs

A Special Use Permit (HAK-7-88, #52182) was issued to Dr. James Juvik, Department of Geography, University of Hawaii to allow a December visit to the refuge for the purpose of evaluating potential sites for the installation of meteorological instrumentation for a climatic monitoring program. Data from such a station will be of value for management purposes and provided at no cost.

3. Items of Interest

A set of color aerial photos of the refuge was taken February 24, 1988. The scale is 1:36,000. Total cost was \$3,542.00 and the contractor was R.M. Towill Corporation. The negatives are being stored by the contractor under optimal conditions for safekeeping. Boundary corners and bird transects were marked with 3 ft x 20 ft sheets of white plastic prior to the flight to facilitate their location on the photographic prints.

4. Credits

This narrative was written and the photographs were taken by Richard C. Wass, Refuge Manager.