

HAKALAU FOREST NATIONAL WILDLIFE REFUGE

Hilo, Hawaii

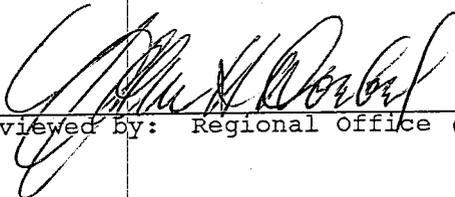
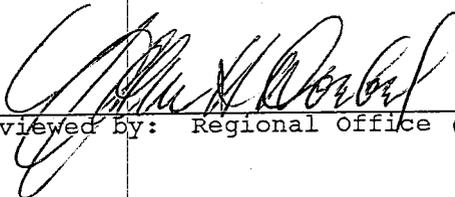
ANNUAL NARRATIVE REPORT

Calendar Year 1990

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

HAKALAU FOREST NATIONAL WILDLIFE REFUGE  
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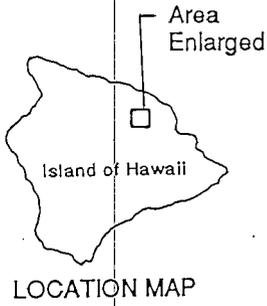
REVIEW AND APPROVALS

	
Submitted by: Refuge Manager	12-18-92
	Date
	
Reviewed by: Project Leader, Hawaii/Pacific Islands NWR Complex	12/22/92
	Date
	
Reviewed by: Regional Office (Region 1)	12/23/92
	Date

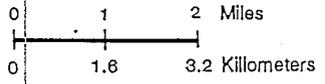
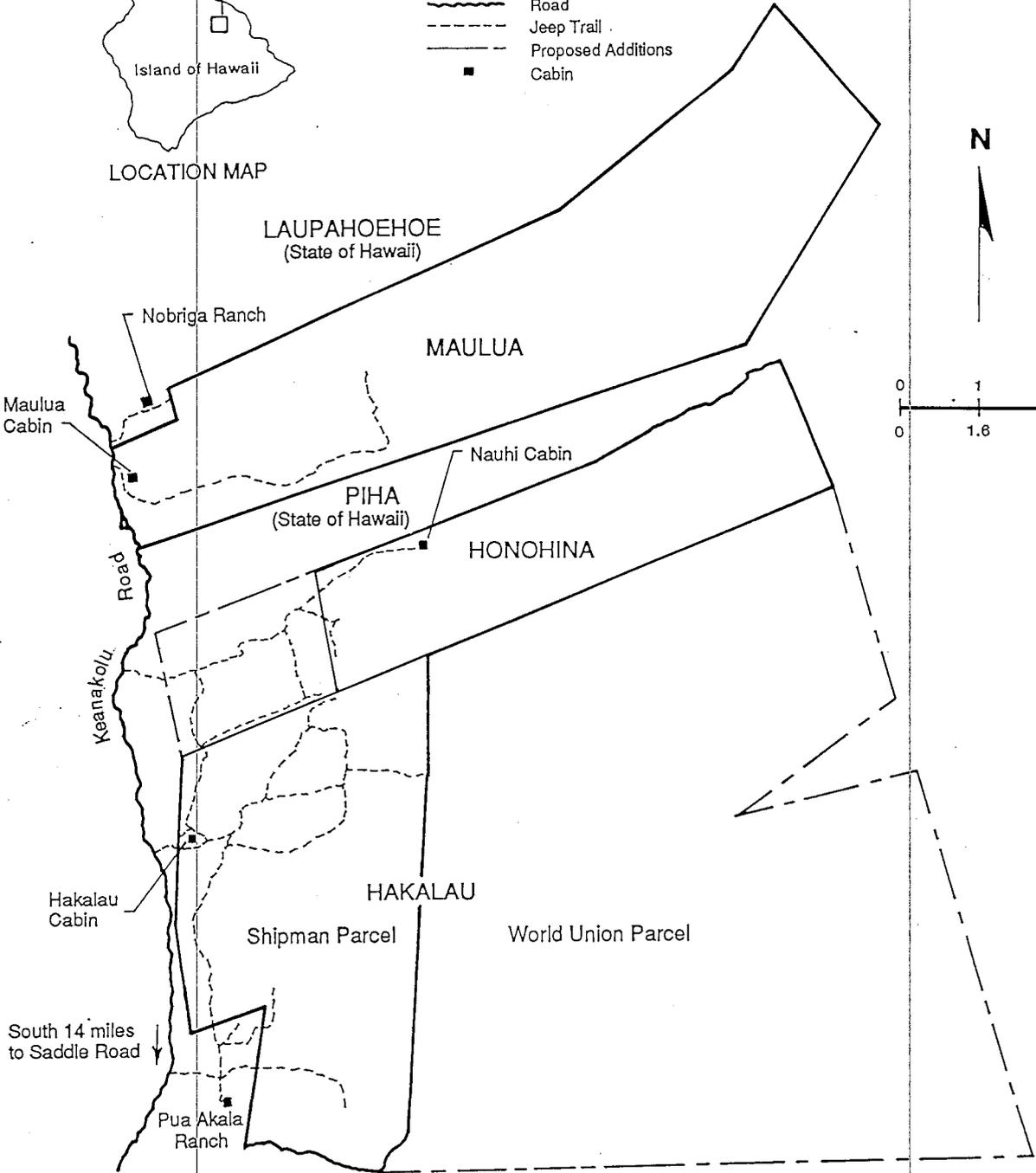
## INTRODUCTION

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

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-seven species are found on the refuge including 18 natives (eight of which are endangered) and 19 aliens. Substantial populations of four endangered forest birds occur on the refuge. They are the 'Akiapola'au, the Hawaii Creeper, the Hawaii 'Akepa and the 'Io (Hawaiian Hawk). The other four endangered birds found at Hakalau include the very rare 'O'u which is reported from the lower elevation ohia forests, the Nene (Hawaiian Goose) which nests in adjoining areas, the Koloa (Hawaiian Duck) which inhabits streams and stockponds on the refuge, and the 'Alae ke 'oke'o (Hawaiian Coot). The endangered Hawaiian Hoary Bat and a number of candidate endangered plants are also found at Hakalau.



- LEGEND**
- Refuge Boundary
  - Road
  - Jeep Trail
  - Proposed Additions
  - Cabin



**HAKALAU FOREST  
NATIONAL WILDLIFE REFUGE**

South 14 miles  
to Saddle Road

HAKALAU FOREST NATIONAL WILDLIFE REFUGE

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*The 'I'iwi is one of the most common birds on the refuge. It feeds on nectar produced by blossoms such as the ohia pictured here. PL*

A. HIGHLIGHTS

1. A total of 159.56 inches of rain fell at Hakalau Cabin during 1990 making it the wettest year since records have been kept by refuge staff. Hilo experienced record rainfall during the same period. (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. During their four year study at Hakalau Dr. Leonard Freed and colleagues (chiefly Jaan Lepson) have banded a total of 1,642 birds of which 442 have been bled. This total includes 163 endangered birds banded. (Section D.5.)
3. The refuge staff doubled in size during 1990, going from two to four positions. The Maintenance Worker position (WG-6 TFT) was filled on April 15 and the Wildlife Biologist position (GS-9 PFT) was filled on September 9. (Section E.1.)
4. Volunteer work crews assisted the refuge staff with planting koa tree seedlings, pulling and cutting banana poka vines, pulling and grubbing gorse, painting the garage, and picking and shucking koa seed pods. (Section E.4.)
5. Only 327 koa seedlings were planted in 1990 due to the lack of seed production by mature trees on the refuge. 180 seedlings and rooted cuttings from six other native plants were established within the Liliuokalani Trust Management Unit. They will be monitored for growth and survival. 79% of the koa seedlings planted in 1989 survived their first year. Average height increased from 12 inches to 27.7 inches. (Section F.3.b.)
6. A Special Use Permit was issued to the Alfred Nobriga Ranch which allowed grazing to continue through 1990 within the Upper Maulua Tract. Grazing amounted to 324 AUY during the year for which \$8,652.90 in grazing fees were collected. (Section F.7.)
7. Honua Landscaping, Inc. was contracted to provide 317 hours of effort uprooting and cutting banana poka vines within the Maulua Tract. (Section F.10.)
8. Honua Landscaping, Inc. was contracted to provide 283 hours of effort for the spray application of Garlon 4 and Escort on gorse. Excepting the interior of the largest patch (about 10 acres), all gorse on the refuge was sprayed during 1989 (with Tordon 22K) or 1990. (Section F.10.) The herbicide application was followed with prescribed burning of gorse patches by the refuge staff. (Section F.9.)
9. Biannual bird censuses were conducted during the spring and fall. The 1987 data were used to compile population estimates for each species. (Section G.2.)
10. The endangered 'Alae ke 'oke'o (Hawaiian Coot) was observed on the refuge for the first time ever. (Section G.2.)
11. The Hawaii Volcanoes National Park was contracted late in the year to assist the Refuge with feral cattle eradication in the 5,000 acre Shipman Parcel. During the initial two hour helicopter charter, 53

cattle were shot by the aerial gunner. Fourteen additional cattle were taken by ground hunters during the remainder of the year. Incidental shooting by Refuge and Park Service staff accounted for 44 pigs during the year. (Section G.15.)

12. Hakalau Cabin was improved by a solar power system upgrade, the installation of a cabin-wide propane gas plumbing system and construction of a concrete walkway. The 32' x 28' garage/workshop was completed. (Section I.1.)

13. A 32,700 foot fence corridor was cleared and smoothed by bulldozer along the southern and eastern boundaries of the Shipman Parcel. A pig/cattle fence will be constructed around the entire perimeter of this parcel in 1991. (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 65°F at the lower elevations and 53°F at the higher elevations. Daily temperatures in the vicinity of Hakalau cabin range between highs of 50°F to 75°F and lows of 30°F to 50°F.

Rainfall also shows significant variation with elevation. Approximately 300 inches of rain falls annually at the lowermost elevations of the refuge. Rainfall decreases to about 80 inches at the upper elevations bordering Keanakolu Road. For a 25-year period between 1906 and 1931, rainfall data were recorded at Pua Akala Ranch (elevation = 6,300 feet) which borders the refuge. Annual rainfall ranged between 38.3 and 144.4 inches with a median of 88.2 inches. 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 thermometer and a rain gauge were installed on the refuge at Hakalau cabin (elevation = 6,440 ft) early in 1987. Data have been recorded by refuge staff since that date.

In February 1989, a sophisticated solar-powered meteorological station was installed on the flat immediately below Hakalau cabin (elevation = 6,400 ft). Every 15 minutes, the 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.

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

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

Table I. Temperatures (degrees Fahrenheit) recorded at Hakalau cabin and at the flat below the cabin during 1990.

Month	Cabin		Flat Below Cabin		
	Max.	Min.	Mean	Max.	Min.
Jan	72°	35°	59°	45°	52°
Feb	68°	34°	55°	41°	48°
Mar	77°	37°	58°	41°	50°
Apr	73°	37°	62°	44°	52°
May	72°	34°	60°	43°	52°
Jun	76°	43°	62°	46°	54°
Jul	72°	41°	64°	47°	56°
Aug	78°	42°	65°	47°	56°
Sep	77°	43°	64°	48°	56°
Oct	77°	42°	62°	47°	54°
Nov	70°	39°	62°	49°	55°
Dec	78°	38°	58°	43°	51°

Table II. Rainfall (inches) recorded at Hakalau cabin, the flat below the cabin and at the clearing below Pua Akala Ranch during 1990. A "+" after the rainfall figure indicates the rain gauge overflowed before it could be emptied. The true value is, therefore, higher than that listed.

Month	Hakalau Cabin		Flat	Clearing
	87-90 Ave. Rain	90 Rain	90 Rain	90 Rain
Jan	20.09	27.42+	21.50	26.81
Feb	7.92	18.85	17.43	21.64
Mar	5.41	7.96	8.83	12.77
Apr	6.14	1.56	1.24	2.48
May	5.88	4.33	4.60	6.03
Jun	3.84	3.95	3.69	6.57
Jul	9.16	5.42	4.78	6.97
Aug	3.90	4.69	4.09	6.50
Sep	7.75	17.44	12.11	16.78
Oct	6.69	10.98	10.38	13.06
Nov	16.51	39.09+	32.28	43.37
Dec	10.68	17.87	16.93	20.97
TOTALS	103.97	159.56+	137.86	183.95

The data show that 1990 was an extremely wet year. Though records for the Hakalau area are very incomplete, the 159.56+ inch total is probably close to the record. Rainfall records for Hilo are much more complete

and Hilo experienced record rainfall during 1990 (over 250 inches). The 1989 rainfall, which totaled 109.52 inches, was also somewhat higher than normal. Almost 30 inches of rain fell during a 72-hour period in mid-November. Refuge roads and fences received considerable damage but the volcanic soil is relatively porous and the run-off was quickly carried away by numerous streams.

Table II also shows that the Pua Akala clearing receives about 15% more rain than Hakalau cabin. The slightly lower elevation (about 200 feet), and the fact that the clearing is surrounded by forest instead of open grassland, probably account for the difference.

### C. LAND ACQUISITION

#### 1. Fee Title

Hakalau Forest NWR currently encompasses six parcels totaling 15,484 acres. All of it is owned in Fee Title by the FWS.

During 1990, negotiations were 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. Negotiations were also ongoing toward the purchase of an additional 1,034 acre parcel owned by the Liliuokalani Trust. The refuge assisted with the appraisal and inspection of this property through provision of information and guided tours for appraisers and FWS personnel. Both properties fall within the approved boundary of the refuge.

In August, the Refuge Manager and other FWS officials met with Roy Blackshear and Fred Koehnen of the W.H. Shipman Estate to reiterate the Service's interest in acquiring the 500 acres retained by the Estate when the 4,994 acre Shipman Parcel was sold to the FWS. The remaining 500 acres borders the southwest corner of the refuge and may become available in the near future because the W.H. Shipman Corporation is currently "for sale".

### D. PLANNING

#### 2. Management Plan

The refuge is managed in conformance with strategies and objectives detailed within the draft Management Plan which has been reviewed by numerous agencies, groups and individuals. 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.

During 1990, work began on a management plan to allow public hunting on the refuge to assist with feral pig control.

#### 4. Compliance with Environmental and Cultural Resource Mandates

On May 8, Paul H. Rosendahl, Ph.D., Inc. conducted an archaeological inventory survey of the 7,150 foot fence corridor to be re-cleared along the south boundary (Nukupahu Gulch) of the Shipman Parcel. Such a

survey is required by the National Historic Preservation Act. No archaeological remains were found to delay or constrain the fence clearing and construction project.

On November 29 a similar survey was done at sites likely to be impacted by road maintenance on the Pua Akala Road and Pedro Road. The sites included potential gravel quarries and a 50 foot section of new road below the Pua Akala clearing. The site for the University of Hawaii's temporary rain shelter and field camp was also examined. This survey was conducted by Laura Carter, a National Park Service Archaeologist. Again no archeological features or artifacts were discovered.

#### 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 genetic 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 a 20 acre area surrounding the Pua Akala clearing.

Professors Leonard Freed and Rebecca Cann and graduate student Jaan Lepson were officially associated with the bird studies during 1990. Mr. Lepson camped at the edge of the Pua Akala clearing almost continuously, operating mist-nets, banding and bleeding birds, and observing bird behavior. In March, an undergraduate class of seven students resided in the tent camp for a week to learn ornithological techniques and to become familiar with native birds. Two world renowned ornithologists, Amotz Zahavi from Tel Aviv University and Christopher Perrins from Oxford University each visited the refuge for a day. Three U.S. biologists, Tom Quinn and Tom Smith, University of California at Berkeley and Hugh Dingle from the University of California at Davis, visited the refuge for 2-3 day periods. Mike Hadfield and Ken Kaneshiro from the University of Hawaii studied snails and insects for a short period of time.

The following species were captured, banded and sampled for blood during 1990 by Dr. Freed and colleagues:

<u>Endangered Species</u>	<u>Newly Banded Individuals</u>	<u>No. Bled</u> (Includes birds previously captured)
Hawaii 'Akepa	10	28
Hawaii Creeper	13	18
'Akiapola'au	0	1
Total	23	47
<u>Other Native Species</u>		
'Oma'o	9	9
'Elepaio	7	6
Common 'Amakihi	33	24
'Apapane	123	28
'I'iwi	94	118
Total	266	185

Introduced Species

Red-Billed Leiothrix	9	0
Japanese White-Eye	20	0
House Finch	5	0
Nutmeg Mannikin	2	--
Total	36	0
GRAND TOTAL	325	232

Four Year Summary of Bird Banding By University of Hawaii  
Research Team

	Banded All Species	Banded Endangered	Bled All Species
1987	381	57	0
1988	461	34	91
1989	475	49	119
1990	325	23	232
Total	1642	163	442

Dr. Freed and colleagues found nests of all native bird species except the Hawaiian Hawk during 1990, including 16 'Akepa nests of which at least 13 fledged young successfully. All 'Akepa nests found were in ohia and koa tree cavities. All nests found this year were in the same trees as used in previous years for nesting or in another tree in close proximity. Measurements indicate that the trees used for nesting were the largest in the area. This sample of nests will enable a study of the extent to which cavities are re-used from one breeding season to the next. Introduced House Finches also nest in cavities allowing for interspecific competition for nest sites between 'Akepa and House Finches. At least one observed aggressive interaction between these species over an 'Akepa nest-site has been noted.

Three Hawaii Creeper nests were also found in the area of which 2 were known to fledge young. Only one 'Akiapola'au nest was found and it was abandoned during the construction stage.

Five amendments to Special Use Permit HAK-1-88 were issued to Dr. Freed during 1990. Amendment 2 permits the collection of blood from endangered, native and introduced birds for DNA analysis to determine genetic variability within the refuge and between other geographically isolated populations at Kilauea, Mauna Loa and Hualalai. Amendment 3 permits up to 50 laparotomies on introduced birds for the purpose of determining sex and breeding status. The results of this effort may be used as justification for a possible request to laparotomize endangered species in the future.

Amendment 5 supersedes and voids Amendment 4 and permits the construction of a temporary 12' x 16' rain shelter in the middle of the Pua Akala clearing. The structure will be used by researchers, camera crews, birders, students and other refuge visitors as a dry place to eat, work and store gear. Its construction will also serve as the stimulus for moving the four tents and the food preparation/dining area previously situated under the forest canopy into the Pua Akala clearing. The shelter was constructed and the tents moved early in 1991.

Amendment 6 was issued to enable graduate student Robert Peck to collect and identify arthropods occurring in the Pua Akala area and to assess temporal and spatial changes in their density which may affect feeding

and abundance of native forest birds. Sampling methods will include light traps for nocturnal flying insects, sweep netting within the grassy understory, malaise traps for nocturnal and diurnal flying insects, bark or intercept traps for climbing arthropods and terminal branch clipping for specific and microhabitat use determination.

#### E. ADMINISTRATION

##### 1. Personnel

Hakalau Forest NWR is part of the Hawaii/Pacific Islands Refuge Complex. The 1990 Complex staff was comprised of 29.0 FTEs broken down as follows:

Refuge Complex Administration	5.0 FTE
Remote Island Refuges	9.0 FTE
Wetland Refuges	5.0 FTE
Kilauea Point NWR	7.0 FTE
Hakalau Forest NWR	<u>3.0 FTE</u>
TOTAL	29.0 FTE

The staff at Hakalau Forest NWR doubled in size during 1990. Anthony Texeira assumed the newly created Maintenance Worker, WG-4749-6 position on April 15. He transferred from a similar position at Hanalei NWR, Island of Kauai. John Jeffrey assumed the newly created Wildlife Biologist GS-9 position on September 9. He transferred from a Wildlife Biologist GS-7 position with the Service's Hawaii Research Station, Island of Hawaii. The following individuals were on the Hakalau staff at the end of 1990:

Richard C. (Dick) Wass, Refuge Manager, GS-11, Permanent Full Time.  
 John J. (Jack) Jeffrey, Wildlife Biologist, GS-9, Permanent Full Time.  
 Jon R. Emig, Maintenance Worker, WG-7, Temporary Full Time.  
 Anthony C. (Tony) Texeira, Maintenance Worker, WG-6, Temporary Full Time.



The 1990 Hakalau staff. Tony Texeira (Maintenance Worker), Jon Emig (Maintenance Worker), Dick Wass (Refuge Manager), and Jack Jeffrey (Wildlife Biologist), left to right. DW

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

Calendar Year	Full-Time	Permanent		Temporary	Total FTE
		Part Time			
1985	-	-		-	0
1986	-	-		-	0
1987	1.0	-		-	1.0
1988	1.0	-		0.7	1.7
1989	1.0	-		1.0	2.0
1990	1.3	-		1.7	3.0

#### 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 in 1989 and was given an extensive orientation by the Refuge Manager. Her assistance is gratefully acknowledged. During 1990 she helped drive vehicles, coordinate logistics, plan meals, purchase supplies and lead work crews.

Five volunteer crews assisted the refuge during 1990. Ms. Yap organized and led the first group of five volunteers which spent 10 person-hours in February planting koa tree seedlings. She also organized the second group which was affiliated with the Maui Sierra Club. Over the Memorial Day weekend, eight volunteers plus two staff provided 60 person-hours of effort pulling and cutting banana poka vines within the Maulua Tract. The third group was affiliated with the Hawaii Island Sierra Club (Moku Loa Group). Thirteen people plus two refuge staff provided 90 hours of effort in July pulling and grubbing gorse, holly, German ivy and fushia in the Pua Akala area. In August, a group of four volunteers plus one staff expended 10 hours of effort painting the Hakalau garage exterior. On a Saturday in October, eight volunteers and two refuge staff picked 8 bags of koa seed pods in the Maulua area. Volunteers from the Moku Loa Group also assisted shucking seeds from those pods.

The group from Maui flew over 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. All of the volunteer crews were also given time to hike and observe birds. This is a major incentive because the refuge is closed to the general public.

#### 5. Funding

Hakalau Forest NWR receives its funding through the Hawaii/Pacific Islands Refuge Complex. The FY 1990 funding for the Complex is broken down as follows:

Refuge Complex Administration	\$320,100
Remote Island Refuges	471,300
Wetland Refuges	237,000
Kilauea Point NWR	439,200
Hakalau Forest NWR	466,600
TOTAL	\$1,934,200

The refuge received \$466,600 in funding for FY 1990 which included a special congressional appropriation in the amount of \$237,500 for the construction of pig\cattle fence and a donation of \$3,000 through the Fish and Wildlife Foundation by Mr. Kurt Schwarz in memory of his mother to be used for planting koa trees.

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

<u>Year</u>	<u>Establishment (FWE)</u>	<u>Operations &amp; Maintenance (RW)</u>	<u>Special Appropriation</u>	<u>Other Contributions</u>	<u>Total</u>
FY86	\$130,000	-	-	-	\$130,000
FY87	\$ 75,000	\$ 23,000	-	-	\$ 98,000
FY88	-	\$180,000	-	-	\$180,000
FY89	-	\$161,500	-	-	\$161,500
FY90	-	\$226,100	\$237,500	\$3,000	\$466,600

#### 6. Safety

One reportable accident occurred on the refuge during 1990. A "weed wrench", used to uproot gorse and other alien plants, was thrown by a volunteer across a gorse patch. It accidentally struck the Refuge Manager who was hidden from view by a gorse bush. The ensuing head laceration required three stitches to close.

In March, potable water from the Hakalau cabin catchment system was retested to see if it remained safe to drink. Test results indicated the water was within the safe levels for coliform bacteria and lead.

On March 6, Jim McNulty, Regional Safety Manager, conducted a hazard analysis for Hakalau as well as an administrative review of safety procedures and policy.

#### 7. Technical Assistance

The Refuge Manager actively participated on the State of Hawaii's Animal Species Advisory Commission, the multi-agency Gorse Steering Committee, and the Forestry Subcommittee of the Resource Conservation and Development Council.

The Manager also reviewed an environmental assessment for the release of a banana poka control insect at Hawaii Volcanoes National Park, reviewed the State Division of Forestry and Wildlife's draft Management Plan for Laupahoehoe Natural Area Reserve, and reviewed a National Park Service manuscript addressing the subject of feral pig management.

The Manager visited the Alf Seabury farm above Mountain View in the company of U.S. Soil Conservation Service staff to advise the owner regarding measures that could be taken to improve wildlife habitat with funding assistance from the SCS.

The Manager traveled to Kilauea Point NWR to advise and assist the staff with a prescribed burn planned for Crater Hill. It was too windy to conduct the burn.

The Biologist and Manager participated in the State's Native Ecosystems and Endangered Species Planning Workshop to assist in the identification and listing of areas on the Big Island known to contain important biological resources.

## 8. Other

On March 6 and 8, an administrative review of the refuge was conducted by personnel from the Regional Office including Sam Buzbee, Budget and Finance Manager; Gloria Parrish, Chief of Contracting and General Services; Mike Bowen, Senior Contract Specialist; Jim McNulty, Safety Officer; and Bill Striplin, Regional Engineer. Buzbee recommended the imprest fund be increased from \$400 to \$600.

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. A few hours are usually spent walking through the forest observing native birds and plants. If time permits, the visitors are also generally shown the experimental reforestation plots, tree-planting efforts, feral ungulate control programs, weed control projects and the Hakalau cabin and associated facilities. Management objectives and strategies, funding and staffing needs and a wide variety of other subjects are discussed by the Refuge Manager and staff.

Noteworthy visitors to Hakalau during 1990 included:

Jan. 9. Dr. Greg Liu, author of travel books.

Jan. 30. Bill Martin, Deputy Regional Director; Robert Smith, ARD Fish and Wildlife Enhancement; Carroll Cox, Special Agent; and Al Marmelstein, PIA.

Feb. 14. A group of VIP's from the U.S. Forest Service's Washington Office overflew the refuge in a helicopter for a briefing which emphasized reforestation efforts and assistance from the Forest Service.

March 6. Sam Buzbee, Budget and Finance Manager; Gloria Parrish, Chief of Contracting and General Services; Mike Bowen, Senior Contract Specialist; and Jim McNulty, Safety Officer, all from the Regional Office, visited the refuge during the conduct of their Administrative Review.

March 20. Drs. Paul Erlich and Peter Vitousek of Stanford University and an NBC news team spent three hours filming the refuge and interviewing the staff for a sequence to be aired on the "Today Show" during the week of Earth Day.

April 2. Mike Phillips, Regional Fire Management Officer toured the refuge to discuss fire management and view areas where prescribed burning is conducted to control gorse.

May 4. John Holod, J.H. Travel Adventure Productions, visited Hakalau in the company of the Refuge Manager to film forest birds for his travelogue on Hawaiian natural history.

May 17. Doug McConnel, Host and Larry Warner, Cameraman of CBS News filmed the refuge and interviewed the manager. They were gathering material for a five-minute short highlighting management and research for Hawaiian forest birds to be aired on "CBS This Morning" the week of June 11.

May 19. Rod Morris of Television New Zealand spent the day on the refuge attempting to film 'akiapola'au for his three hour special on "Islands".

June 6-8. Paul and Grace Atkins, Moana Productions filmed birds and habitat on the refuge for their National Geographic Special titled "Hawaii: Strangers in Paradise".

August 28. Rick Scudder, Quentin Tomich and Doug Blake of the Hawaii Conservation Council toured the refuge with the manager and Dave Woodside of the Oahu Refuge Complex.

September 15. Mike Buck, Administrator, State Division of Forestry and Wildlife; and Gene Conrad, Director, Institute of Pacific Islands Forestry visited the refuge in the company of the Refuge Manager to review reforestation efforts and discuss future plans including the possibility of acquiring the state-owned property known as Piha in exchange for another property.

October 24. Lola Gannon, Contract Specialist; Gus Williams, Civil Engineer; and Steve Baczkiewicz, Road Maintenance Contractor; inspected refuge roads and discussed road maintenance priorities prior to initiation of the road maintenance contract.

October 26. Elliot Black, Realty Appraiser viewed the proposed Liliuokalani Trust acquisition and inspected the access easement.

December 11. Brooks Harper, Fish and Wildlife Enhancement, Southern California, toured the refuge and was briefed on management issues and strategies.

#### F. HABITAT MANAGEMENT

##### 3. Forests

One of the primary management objectives for Hakalau Forest NWR is restoration of 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. \$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. This agreement extends through March 1991. Accomplishments through 1990 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 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. No weed control or fertilization was done. The koa seedlings were doing very well by the end of 1990. Almost all were thriving and many were eight feet or more in height. The vast majority of mamane seedlings and ohia cuttings, however, were dead. The ohia was probably killed by frost.

A second experimental reforestation plot (a 40-acre area termed the Woodland Exclosure) was established in July 1987. It is located at about 5,500 ft in the SW corner of the 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 disc-harrow 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.

The early results from the soil scarification study were detailed in the 1989 narrative. The study showed that scarification will produce numerous seedlings in the vicinity of live and dead koas (if they have been dead for less than about 10 or 15 years). The seedlings in the Woodland Exclosure are growing faster than those at Magnetic Hill. Some were almost twelve feet tall by the end of 1990.

Conclusions that can be drawn thus far from the two experimental plots include the following: Mamane seedlings and ohia cuttings have not done 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 seeds are 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 the seeds have lost viability.

As part of the Interagency Agreement, the Forest Service has also been working on the propagation of a number of native trees and shrubs in addition to koa, ohia and mamane. Germination and grow-out conditions have been established for a total of 11 species thus far.



*Gene Conrad, Director, Institute of Pacific Islands Forestry, with a three-year koa seedling in the woodland enclosure. DW*

180 seedlings and rooted cuttings from six of these species (Kolea, Kawau, Olapa, Ohia, Lobelia and Pilo) were planted at Hakalau during May and June of 1990. They were planted at five partially shaded sites within the 40 acre Woodland Enclosure for protection from feral pigs and cattle. Growth and survival will be monitored.

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.
- 2) Koa stands are found to 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 treefern is required for natural reproduction of many native plant species. 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 to go beyond the experimental stage and initiate a full-scale reforestation program. Koa was chosen because the propagation methodology is best known for this species. Additional species will be planted in the future as techniques for their propagation become known. In the meantime, the establishment of koa stands in open pasture will improve the chances for later success with other species because koa will add nitrogen to the soil, acidify the soil, add organic matter to the soil and provide shade.

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 1989, 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 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 about 15 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 because of their predilection for koa seedlings.

The seedlings were planted in corridors that had been scarified with a disc-harrow 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 positioned 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.

This planting scheme was selected for two reasons: 1) Planting trees in lines maximizes the edge area where natural establishment of new trees from seeds or root sprouts is most likely. 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 crews of volunteers. The seedlings were planted at twelve foot spacings (twelve feet between each track and twelve 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.

Growth and survival data for the planted koa seedlings were collected during September 1990. Analysis of these data indicated that 79% of the seedlings were still alive and that average height of the live seedlings had increased from about 12 inches at planting to 27.7 inches. Survival and growth was much better at lower elevations. At elevations between 5,600 and 6,000 feet, about 86% of the seedlings were still alive and their height averaged almost 30 inches. At elevations between 6,100 and 6,400 feet, survival was about 71% and average height was about 24 inches. Cooler and drier conditions at the higher elevations probably account for the differences in growth and survival.

Tree-planting efforts during 1990 were halted by the almost total lack of koa seed production during the 1989-90 season. 327 koa seedlings left over from 1989 were planted in Triangle Paddock during February. Fortunately there was some seed production late in 1990. Eight bags of pods were picked by a crew of eight volunteers and two refuge staff on October 20 at the top of the Maulua Parcel. These seeds will ensure a tree planting effort in 1991.



*Koa Seed Pods are picked by volunteers. DW*

Planting corridors were not the only areas scarified with the disc-plow during 1989. As an experiment, twelve areas (approximately 50 yards in diameter) located in open areas far from live or dead koa trees were thoroughly scarified to determine if viable seeds were present. No koa seedlings were discovered within these disced circles during 1990. It, therefore, appears that a seedbank no longer exists and that discing alone is not a useful technique for re-establishing koa stands in the open areas of the refuge.

c. *Clermontia pyruloria*

In 1989, a single *Clermontia pyruloria* plant was discovered within the neighboring Piha tract managed by the State Division of Forestry and Wildlife. This plant is extremely valuable because it is the only known mature specimen of the species which will soon be formally listed as endangered. With permission from the Division of Forestry and Wildlife, the refuge staff erected a pig/cattle fence around the plant and cleared banana poka vines which were draped over it. This plant will be used as a seed source for re-establishing the species on refuge property.



*Clermontia pyruloria*, known by the Hawaiians as "oha wai" will soon be formally listed as endangered. DW

On September 26, a few ripe fruits were collected and passed to the U.S. Forest Service, the National Park Service and to Fern Duvall, Manager for the Endangered Species Propagation Facility, Olinda Maui. Mr. Duvall successfully germinated several seedlings which were returned to the refuge in 1991 for outplanting.

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 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.

a. Grazing by Pua Akala Ranch

A Cooperative Agreement was signed with the Pua Akala Ranch for the period January 1, 1986 to December 31, 1988 to permit grazing on the upper (unforested and less forested) portions of the 4,994 acre Shipman Estate parcel. 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 were provided during 1990 in the form of bulldozer time (@ \$75/hr) for road maintenance (109 hours) and tractor scarification (29.2 hours).

A Special Use Permit was issued to the Pua Akala Ranch to allow continued grazing during 1989. By October of that year, all Pua Akala ranch cattle were removed from the refuge. The Pua Akala Ranch assets were subsequently purchased by William Andrade who plans to continue grazing the 500 acre parcel adjacent to the refuge which is still owned by the W.H. Shipman Estate. With permission from the Refuge Manager, Pua Akala ranch hands made periodic forays onto the refuge throughout 1990 to round up wild cattle and domestic cattle which had broken through the fence.

b. Grazing by Alfred Nobriga Ranch

On April 11, 1987, a Cooperative Agreement was signed with the Alfred Nobriga Ranch which permitted grazing on the entire 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. Grazing during the three-year period covered by the Cooperative Agreement amounted to 879 AUY valued at \$21,290. Services valued at \$13,824 were provided by the Alfred Nobriga Ranch through the end of 1989. The remaining \$7,466 worth of services were provided during 1990 in the form of labor for fence construction. On May 2, 1990, Mr. Nobriga completed the construction of 5,000 feet of pig/cattle fence in the northwest corner of the Upper Maulua Parcel on the boundary between the refuge and the 120 acres retained by George Robertson. All of the labor for this job was provided by Mr. Nobriga. The refuge provided the materials.

A Special Use Permit (HAK-1-90) was issued to the Alfred Nobriga Ranch to allow continued grazing on the 1,942 acre Upper Maulua Parcel during 1990. The SUP was issued because Mr. Nobriga felt the Service had verbally agreed to allow him to graze for a five year period after the property was purchased and because the cattle would help to control banana poka until adequate funding and staff became available to fully address the problem.

Grazing was permitted on the entire 1,942 acres for the first half of the year. Beginning July 1, grazing was permitted only on the upper 1,000 acres (above the "halfway fence"). The grazing fee was set at \$26.72 per AUW and maximum stocking density was set at one head per five acres. Grazing during 1990 amounted to 324 AUW for which \$8,652.90 in grazing fees were collected.

Cattle were removed from the lower half of the property by July 1 as required by the permit. However, on December 13, the Hakalau staff discovered a hole in the "halfway fence" and reported that at least 50 head of cattle belonging to the Nobriga Ranch were grazing in the lower half. Mr. Nobriga was notified immediately but the trespassing cattle had not been removed by the end of the year.

#### 9. Fire Management

A Fire Management Plan was completed for Hakalau in 1988. It includes a section on prescribed burning which discusses the use of fire to burn patches of gorse killed by application of herbicide a few months earlier. The objective is to achieve the hottest possible fire to maximize consumption of the gorse biomass 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 of gorse were conducted on October 29 and December 5, 1989 and again on March 27, 1990. Burning occurred between 0900 - 1400 hrs during mostly sunny conditions. Temperatures ranged between 59° and 69° F., relative humidity between 56% and 88% and wind speed between 0 and 10 knots. A propane torch with the tank mounted on a backpack was used to ignite individual weed patches. The torch worked well enabling rapid ignition at several points along the upwind side of the patch perimeter. The dead gorse patches averaged about 20 ft in diameter and burned almost explosively, being fully engulfed in flames 40-50 feet long within about 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 treated with herbicide. Areas between gorse patches consisted of kikuyugrass pasture which had been recently grazed. Occasionally the grass duff would catch fire and smolder but it was relatively easy to confine the fire to the gorse patches. Two fire trucks and four fire fighters were provided by the Hawaii State Division of Forestry and Wildlife to assist with the burns on the first day of the 1989 effort but it soon became obvious they were not needed. During subsequent burns, only the Refuge Manager and the Maintenance Worker comprised the burn team.

#### 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.

##### a. Banana Poka

On the refuge, only the Maulua area (which is bounded by Laupahoehoe and Piha) and the northern edge of the Liliuokalani Trust parcel (which is bounded by Piha) are presently infested with banana poka. Cattle

grazing has helped to control this weed but, as grazing is eliminated, other means for control must be utilized. An experimental study conducted by refuge personnel indicated that most of the large vines (stem diameter greater than about one inch) were killed by severing the stem near its base with a machete or pruning shears. In most cases the root did not re-sprout and the distal end died if it was not allowed to make contact with the wet ground. Smaller vines could be uprooted by hand as long as the root end was hung from a tree or otherwise positioned so as not to make contact with the ground or wet vegetation.

A contract was let to Honua Landscaping, Inc. for banana poka control at Maulua during 1990. They spent 317 hours severing stems and uprooting vines at a total cost of \$10,312 (\$32.50 per man-hour). Their effort was focussed in lower Maulua because grazing was phased out of that area during the middle of the year. Eight volunteers and two refuge staff also provided 60 person-hours of effort over the Memorial Day weekend pulling and cutting poka in Maulua. Several additional days of staff time were directed towards banana poka control during the year. By December, approximately 90% of the larger vines in lower Maulua were eradicated.

In order to evaluate the removal of Banana poka from the lower Maulua Parcel, four 1000 meter transects were set up in the area and surveyed. The results show that 79% of the banana poka plants which remained were growing on very steep hillsides and on brush piles and downed trees where cattle were less likely to feed. Few plants were found in flat accessible areas. Plants were missed by contract cutters and volunteers for the same reason that cattle do not graze these areas, i.e. steep slope and thick brush.

b. Goose

Goose 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.

Goose 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.

A goose control effort was initiated at Hakalau during the summer of 1988 by the refuge staff. In pasture areas, Tordon 22K concentrate (diluted with water at the rate of 1:200) was sprayed on goose plants located around the perimeter of the goose infestation. 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 response of goose to the Tordon spray was variable. In most cases (about 95%), the plants were obviously sickened but not killed. The 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 goose 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 will be required to control the goose 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.

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 refuge provided 20 gal 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 ft 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) the vast majority of all patches on the refuge (80-90%) were sprayed.

A few months later, the dead and partially dead gorse patches were burned. Burning is necessary to remove the dead plants and kill seeds on the surface of the ground, and to scarify remaining viable seeds in order to cause their immediate and simultaneous germination. If simultaneous and complete germination does not occur, some seeds will continue to sprout each year for the next 30 years resulting in the need for a long term control effort.

Honua Landscaping was contracted again in 1990 to spray gorse during August and September. The company provided the equipment and 283 hours of effort for \$15,848 (\$56.00 per hour). The refuge provided the herbicide which consisted of 2 gal of Garlon 4 and 620 grams of Escort.

The FWS would no longer permit the use of the "restricted use" herbicide, Tordon so Escort mixed with water (3/4 oz. Escort per 100 gal water) and applied at a rate of 3/4 oz. per acre was used as a foliar spray. Garlon 4 mixed with diesel (4% solution) was applied as a basal bark treatment to the stumps of burned gorse bushes. The roots have a tendency to re-sprout after being burned if they are not completely killed by herbicide prior to burning.

With the exception of the interior of the largest gorse patch (approximately 10 acres in size), all live gorse plants in the pasture areas, including the seedlings which had sprouted as the result of the prescribed burning, were treated with a foliar application of Escort.

Escort was not found to be as effective as Tordon. Most of the plants that were drenched with Escort eventually died but many were only weakened to the point where they did not bloom and produce seed the following year.

Garlon in diesel was applied to the stumps of all large gorse plants which had been burned a year earlier. Most of these plants were at least partially killed by herbicide before burning but some were not sprayed before burning. The basal bark application worked very well, killing the roots of 95% of the plants to which it was applied.

The 1990 spray effort was again followed with prescribed burning to kill and germinate seeds and to remove brush, thereby increasing accessibility for future basal bark treatment. The prescribed burns are described above in Section F.9.

Gorse prefers the open, sunlit pasture areas but it does occur within the forest, particularly in sunny openings and at wide spots in

streambeds. A considerable amount of staff time was spent manually removing gorse in these areas with a weed wrench and other hand tools. Thirteen volunteers from the Hawaii Island Sierra Club plus two refuge staff provided 90 hours of effort in July removing gorse and other alien plants such as holly, German ivy and fuchsia from the forest in the Pua Akala area.

#### 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. Three endangered forest birds are relatively common on the refuge. They include the Hawaii 'Akepa, the Hawaii Creeper and the 'Io (Hawaiian Hawk). The other two endangered forest birds at Hakalau include the rarely seen 'Akiapola'au and the 'O'u which has not been sighted in the refuge area for the past 15 years. Additional endangered species at Hakalau include the Koloa (Hawaiian Duck), which is occasionally seen on refuge streams and stockponds; the Nene (Hawaiian Goose) and 'Alae ke 'oke'o (Hawaiian Coot) which have been sighted on the refuge one or two times since it was established; and the endangered Hawaiian Hoary Bat, Hawaii's only native land mammal.



*The Hawaii Creeper is one of three relatively common endangered forest birds occurring at Hakalau. PL*

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. Since that time, annual

spring and fall surveys have been conducted by inter-agency teams from the Fish and Wildlife Service, National Park Service, Hawaii State Division of Forestry and Wildlife, University of Hawaii, and trained volunteers.

Fourteen downslope transects, 500 and 1,000 meters apart and 2 to 5 kilometers long, were established to cover the entire refuge above 4,800 ft elevation 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 covering all vegetation types. During a typical survey, all birds seen and heard at each station during an eight-minute period are identified and distances are estimated to each.

The 1990 spring census was conducted during the period of March 5th through 17th. Principal observers included J. Jeffrey, J. Jacobi, P. Banko and T. Pratt of USFWS; L. Katahira, H. Hoshide and L. Cuddihy of NPS and R. David, a volunteer. Others included in the training and orientation were P. Chang, D. Hu and C. Rowland of USFWS; J. Yoshioka of NPS; P. Conry and C. Terry of State Division of Forestry and Wildlife; and R. Ferguson, K. Brust, M. McClure and D. Ball. The fall census was conducted November 4-6 by J. Jeffrey, L. Cuddihy, T. Pratt, L. Katahira, H. Hoshide, R. David, and P. Banko.

The 1987 data were analyzed by Dr. Scott and populations sizes were estimated (Table III). Analysis of the 1988-90 data is still incomplete.

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

Species	Spring Census	Fall Census
<u>Endangered Species</u>		
'Akiapola'au	1,285	421
Hawaii 'Akepa	4,971	3,874
Hawaii Creeper	4,005	2,096
Hawaiian Hawk	present	present
<u>Other Native Species</u>		
'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
<u>Exotic Species</u>		
Chukar	present	present
Common Myna	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

On July 12, seven endangered Koloa ducklings and a parent were observed along the edge of the large stockpond in upper Maulua. This is the first record of duck production on the refuge. As cattle are removed and vegetation grows up around the edges of the ponds, ducklings will likely be produced with increasing frequency.

On September 11, 16 and 19, an endangered 'Alae ke 'oke'oke (Hawaiian Coot) was observed on "Frog Pond", Honohina Tract by the Wildlife Biologist and the Refuge Manger. This was the first record of this endangered species occurring at Hakalau.

#### 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. Cattle graze on native plants, especially tender seedlings, and trample small trees, ferns and roots. Hawaiian plants are not adapted to trampling, rooting and grazing pressure (the only native mammals are a bat and a seal) so they are easily suppressed by cattle and pigs.

An Interagency Agreement with the Cooperative Park Studies Unit, National Park Service, University of Hawaii was signed September 26, 1986 to document the extent of the feral ungulate problem at Hakalau to 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 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.

Progress has been made toward implementing these recommendations. By the end of 1990, grazing of domestic cattle was limited to the 2,000 acres comprising the Maulua 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. All of the cattle and all but about two pigs were eradicated from this unit in 1989 by teams of hunters and dogs loaned to the refuge by Hawaii Volcanoes National Park.

##### a. Feral Ungulate Survey

The 5,000 acre Shipman Estate Parcel of the refuge will be fenced during 1991 so the effort to remove feral pigs and cattle from this parcel began in 1990. As the first step in this process, a feral ungulate activity survey was conducted in November of 1990 to determine relative abundance of pigs and cattle. We sampled 2,840 plots, each 5m x 10m,

along the established transects, recording pig and cattle spoor for each of three age categories: fresh, intermediate and old.

A 40% increase in fresh and intermediate pig activity was noted since the 1987 survey completed on contract by the Cooperative Park Studies Unit (Technical Report No. 63). This increase was expected because hunting pressure within the parcel has markedly declined since the parcel was purchased by the FWS in 1985.

Cattle activity was noted on 33% of the plots in 1987, but on only 15% of the plots in 1990. This is because domestic cattle grazing was terminated on the Shipman Parcel in 1989. Feral cattle continue to graze the forested, lower elevation portions of the parcel.

#### b. Feral Cattle Eradication

The feral cattle eradication program for the Shipman Parcel began in December 1990. Cattle were targeted before pigs because: 1) cattle suppress natural reforestation to a greater degree than pigs; 2) cattle would be easier to remove because they offer more obvious targets and there were fewer of them (we estimated about 200 head); and 3) cattle had the potential for seriously damaging the new fence if not removed beforehand because they routinely crash through fences when frightened by gunshots or the sight and smell of humans.

Professional hunting expertise and manpower from the Resources Management Branch, Hawaii Volcanoes National Park was contracted for \$12,000.00 through the Cooperative Park Studies Unit, University of Hawaii. They agreed to test the effectiveness of aerial hunting versus ground hunting.

Aerial hunting was conducted from a Hughes 500D helicopter with the doors removed. The OAS-trained rifleman was strapped and seated in the rear of the aircraft on the pilot's side to give the pilot and him the same field of view. A spotter/recorder sat forward next to the pilot to assist with the search and to record the number and location of kills. Aircraft crew members were in continuous communication with each other and with ground crews who also helped locate target animals. From 200-400 feet above the forest, the helicopter would systematically search an area. Upon sighting cattle, the aircraft would descend to a level just above the canopy or even into holes within the canopy to give the best vantage point for shooting. Usually the animals were shot in the forest but in some instances they could be driven into more open areas for easier shooting.

A single aerial hunt was conducted on December 4. During the two-hour helicopter charter, 53 cattle were shot by the aerial gunner. The ten-person ground crew killed six additional cattle during their six-hour hunt. Eight more cattle were shot incidental to other refuge operations during the latter part of December so a total of 67 feral cattle were removed from the Shipman Parcel by contract hunters and refuge staff during 1990.

The cattle eradication effort continued in 1991. Shooting from the helicopter proved to be an effective method for killing cattle when numbers were high. A large area can be searched quickly and efficiently from the air (the Shipman Parcel contains approximately 3,000 forested acres) and animals seen can often be followed and shot. In one hour a helicopter can cover more area (though sometimes less thoroughly) than a ten-person ground crew can search in two days. If a herd is found by ground hunters, some animals can be shot and some usually escape by running away. Fewer animals in a herd escape the helicopter. When

cattle numbers were reduced, a coordinated effort between helicopter and ground crews proved most effective. After the first aerial hunt, the cattle became wary and learned to hide in thick vegetation at the sound of the helicopter. Ground crews were able to see or hear cattle in thick vegetation and call in the helicopter for assistance in shooting or following the animals.

#### c. Pig Control

No organized pig hunts occurred during 1990, but incidental shooting by refuge and National Park Service staff during cattle hunts, fence maintenance and other operations accounted for 44 feral pigs during the year.

#### 16. Marking and Banding

As noted under Section D.5, Dr. Leonard Freed and colleagues banded 325 birds during the year including 23 endangered 'Akepa, Hawaii Creeper and 'Akiapola'au. The totals for his four years of study are 1,642 birds of which 163 were endangered. This banded population is an extremely valuable study resource.

#### 17. Disease Prevention and Control

Disease has been implicated as one of the main factors in the continued decline and extinction of the Hawaiian avifauna. Avian malaria and avian pox are two diseases known to infect native bird populations. Avian malaria is transmitted by mosquitos found at elevations below 4,000 feet and at this time is not considered a threat to native birds living in the upper reaches of the refuge. Suspected avian pox lesions have been found on birds captured in mistnets at 6,300 feet elevation near the Pua Akala clearing. Avian pox is spread through contact with contaminated surfaces and is easily passed from one bird to another through direct or secondary contact. Open lesions on the feet may contaminate branch and leaf surfaces giving rise to pox infections in birds landing on these contaminated substrates. Researchers handling birds in mistnetting operations must be especially careful. Diseases may be spread to subsequent captures if an infected bird is caught and persons handling the bird do not disinfect hands, banding tools, holding bags and mistnets. Dr. Freed and associates have agreed to follow a disinfection protocol suggested by refuge staff to prevent the spread of diseases in native and exotic birds captured at their study site.

Currently, a fine resolution molecular probe is being developed for avian malaria by Dr. Rebecca Cann, a colleague of Dr. L. Freed. This probe should give 100,000 times greater detection rates than traditional staining techniques. Blood from current bird captures is preserved cryogenically and will be tested in the future when the molecular probe is developed.

### 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.

## 7. Other Interpretive Programs

On May 7 the Refuge Manager met with Hawaii County Mayor Larry Tanimoto to present the 1990 Revenue Sharing Check in the amount of \$33,472 from the FWS and to brief him on objectives and activities at Hakalau. A Press Release was also distributed at this time which was subsequently published in the Hilo Tribune Herald.

Because Hakalau Forest NWR is closed to the general public, film-makers, photographers, and journalists are encouraged to visit the refuge and then "interpret" the resources and management efforts through their media to the public. The following such activities occurred during 1990:

A Special Use Permit (HAK-3-90) 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 resulting from their effort.

Under Special Use Permit HAK-4-90, John Holod, J.H. Travel Adventure Productions, visited Hakalau in the company of the Refuge Manager to film forest birds for his travelogue on Hawaiian natural history.

Rod Morris of Television New Zealand was issued a Special Use Permit (HAK-5-90) to film 'Akiapola'au for his three hour special on "Islands".

A Special Use Permit (HAK-6-90) was issued to Paul and Grace Atkins, Moana Productions. They filmed birds and habitat on the refuge for their National Geographic Special titled "Hawaii: Strangers in Paradise".

A Special Use Permit (HAK-7-90) was issued to Peter LaTourrette to permit still photography of birds and scenery. Mr. LaTourrette has provided the refuge with a number of nice bird photos.

Drs. Paul Erlich and Peter Vitousek of Stanford University and an NBC news team spent three hours on March 20 filming the refuge and interviewing the staff for a sequence to be aired on the "Today Show" during the week of Earth Day. Dr. Erlich was filmed walking through the forest observing birds and plants; chatting with and assisting Graduate Student Jaan Lepson with netting and banding birds; and discussing management objectives and strategies with the Refuge Manager.

Doug McConnel, Host and Larry Warner, Cameraman of CBS News filmed the refuge and interviewed scientists and the Refuge Manager on May 17. The news team was gathering material for a five-minute sequence highlighting Hawaiian forest bird management and research that was aired on "CBS This Morning" the week of June 11. They spent about five hours filming the mist-netting and bird-banding operations of Dr. Leonard Freed and Jaan Lepson. The forest bird research at Hakalau and the general plight of Hawaiian forest birds were discussed at length during a filmed interview with Dr. Freed. The Refuge Manager was interviewed regarding refuge objectives and management strategies.



*CBS News filming Dr. Freed's and Jaan Lepson's forest bird research effort at Hakalau. DW*

Each year refuge personnel spend some time "off-refuge" making presentations to conservation, student and special interest groups. Following is a summary of presentations made during 1990:

Feb. 21. The Refuge Manager traveled to Kauai to present a slide talk on Hawaii forest birds and the refuge at a volunteer training session at Kilauea Point NWR.

Feb. 26. The Refuge Manager gave a slide talk on forest birds and the refuge to approximately 150 high school students, teachers and visitors at Parker School, Waimea during their monthly "Family Meeting".

Oct. 11. The Refuge Manager presented a slide talk about the refuge at the "After Dark in the Park" series at Hawaii Volcanoes National Park. Approximately 80 people attended. Twelve of them signed a list volunteering their services at the refuge.

#### 8. Hunting

At the request of Mike Kitamura of Senator Akaka's staff, the Refuge Manager met with Stanley Yasuda, President; Wayne Mathews, East Hawaii Representative; and Clyde Beaudet, all of the Hawaii Bowhunters Association, in the Senator's Hilo office. Tentative plans for opening the refuge to public hunting by 1992 were discussed and HBA's input to the Hunt Plan was solicited.

## 11. Wildlife Observation

A Special Use Permit (HAK-2-90) was issued to H. Douglas Pratt to allow him to conduct guided bird-observation tours at Hakalau Forest NWR. On April 19, he led a party of four representing Four Points Nature Tours on a four-hour visit. The endangered birds they saw were 'Akepa, Hawaii Creeper and 'Io. On October 13, he led a party of 18 representing the American Birding Association. They observed all the endangered except for 'Akiapola'au.

The Refuge Manager met with Rick Soren to provide material relative to birding at Hakalau for a book he is writing for birdwatchers in Hawaii. Mr. Soren toured the refuge a few days later in the company of the Refuge Manager.

### I. EQUIPMENT AND FACILITIES

#### 1. New Construction

##### a. Hakalau Cabin

A "no frills" 12' x 24' wood frame cabin (Hakalau Cabin) was constructed on the refuge in 1986 to serve as a base of operations. 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 constructed and the cabin was plumbed with running water (including a hot-water shower). 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. Ten bunk beds were constructed. Linoleum was laid on the floor and the interior was painted. Outside work included digging, plumbing and capping a cesspool.

Hakalau Cabin improvements in 1990 included a solar power system upgrade which doubled both collection and storage capability. The additional storage battery capacity makes conservation less critical when large groups are boarded for several days. The improved solar system was further augmented with a 117 volt inverter which provides ordinary household current for the use of tape recorders, computers and other technical equipment for data analysis and storage. A blender and coffee maker have improved cabin cuisine.

A cabin-wide propane gas plumbing system was also installed in 1990 which permits the use of small radiant heaters at various locations throughout the building. These low fuel consumption, semi-portable units have increased cabin comfort on chilly mornings and evenings. A concrete walkway connecting the cabin and garage building is appreciated by volunteers and staff. The walkway spans a muddy area between the buildings.

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

b. 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 also serves as overflow housing for large work crews. Construction of the foundation and slab for this 32' x 28' wood frame structure was initiated in 1988. By the end of 1989, the walls were framed and the roof trusses were in place.

The structure was completed in 1990. The painted steel roof includes a generous skylight area allowing good interior light without power consumption. Interior additions include a tool/storage closet with paint and herbicide storage areas; a fire cache with tools and protective equipment for each refuge staff member; and a large work bench with storage bins and cabinets. Gutters have been installed to direct rain falling on the garage roof to the cabin water catchment tank.



*The garage\workshop under construction at the Hakalau Cabin complex. DW*

c. Cattle\Pig Fence

The construction of 5,000 feet of pig/cattle fence in the northwest corner of the Upper Maulua Parcel on the boundary between the refuge and the 120 acres retained by George Robertson was completed on May 2, 1990. The refuge provided the materials while the labor was provided by the Alfred Nobriga Ranch as described above under Section F.9. Grazing. This fence will allow Nobriga Ranch cattle to graze the 120 acre area around Mr. Nobriga's cabin without straying onto refuge property. In the future, it will be linked with a fence to be constructed around the

remainder of the perimeter of the Upper Maulua Parcel to prevent pig ingress.

A pig\cattle fence will be constructed around the perimeter of the 5,000 acre Shipman Parcel in 1991. About half of this fence will be erected through forested habitat within a wide corridor cleared by a bulldozer during the mid 1970's. In preparation for this construction, a contract was let to M. Sonomura Contracting Co., Inc. to re-clear and re-smooth a 12 foot wide corridor approximately 32,700 feet in length. The objective was to provide a corridor within which the new fence could be constructed, accessed and maintained. The corridor was cleared of brush, logs, dead trees and live trees of less than 18 inches diameter at breast height (DBH). Where the ground surface was already relatively smooth and even, it was merely compacted by the weight of the bulldozer. The blade was used when necessary to clear brush and trees and to smooth the substrate surface to eliminate holes through which pigs could get under the fence. The corridor was cleared between August 20 and September 6 at a total cost of \$39,700 or \$1.21 per foot. Only 15 live trees with a DBH greater than 4 inches were knocked down. A 900 foot length near the middle of the eastern boundary of the Shipman Parcel (the Kolekole Stream valley) was not cleared because the bulldozer was unable to access the area.

In August, a contract to provide materials and construct approximately 34,000 feet of pig/cattle fence around the perimeter of the Shipman Parcel was awarded to the Kershaw Construction Company of Oakland California. The successful bid totaled \$169,652 for all four sections and averaged about \$5.00 per foot. In September, a second contract was awarded to the Kershaw Construction Company for an additional 8,000 feet of perimeter fence at a cost of \$23,600. Construction for both contracts began in January 1991.

#### 4. Equipment Utilization and Replacement

The refuge received a new (GSA leased) Ford Bronco in 1990 in exchange for the 1985 Bronco which was acquired as a used vehicle in 1988. The new Bronco is equipped with a 5-speed transmission and limited-slip rear differential. A bumper-mounted heavy duty winch and oversize all-terrain tires were added locally. This vehicle has proven to be reliable and a good off-road performer.

The refuge Chevrolet diesel pick-up was in the shop twice in 1990 for repairs to the four-wheel-drive. The 8,000 lb. winch installed by GSA required rebuilding. This winch seems inadequate for the heavy-weight pick-up truck. With a little over 10,000 miles on the odometer, the pickup is beginning to show signs of damage from vibration. A lost bumper mount, body panel cracks in the corners of the bed, and loose body screws with attendant squeaks are notable.

A 4 ft. x 6 ft. steel trailer was fabricated by a local welder for use with the refuge's 4 x 4 Honda all-terrain-vehicle. A special hitch was fabricated and mounted on the older ATV. The trailer has removable metal "stake" sides, low pressure all-terrain tires, and a capacity in excess of 500 lbs. It has proven useful for delivering fence materials, herbicide, and weed control tools in difficult-to-reach areas.

#### 5. Communications Systems

A series of tests conducted by refuge staff over a period of several months led to the purchase of a 0.6 watt portable, rechargeable cellular phone. Limited battery life makes the unit impractical for full time field use, but the unit's ability to function reliably at any location

makes it extremely valuable when used in conjunction with a four-wheel-drive vehicle. The new cellular phone has taken over mobile communications and is moved from vehicle to vehicle as needed. A cigarette lighter plug provides power for continuous use and battery recharging for short use away from the vehicle.

The high power consumption, AM band radio telephone was removed from the Chevrolet pickup and permanently installed at Hakalau Cabin. This convenience for staff communication allows closer monitoring of activities at the refuge when management cannot be present and is used for emergency and priority communication for staff and volunteers.

Two hand-held, five-watt VHF radios 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 continuously monitored 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). In 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.

A new phone line was installed in the office (934-7473) which will be dedicated to the FAX machine.

#### J. OTHER ITEMS

##### 4. Credits

This narrative was written by Dick Wass, Refuge Manager, Jack Jeffrey, Wildlife Biologist and Jon Emig, Maintenance Worker. The photographs were taken by Peter La Tourette (PL) and Dick Wass (DW).