STATUS OF FERAL PIG MANAGEMENT AND RESEARCH IN HAWAI'I VOLCANOES NATIONAL PARK

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INTRODUCTION

Land managers throughout Hawai'i are concerned about damage caused by feral pigs. This animal was introduced into the Hawaiian Islands in the late 18th century by European explorers and has since occupied most wet, mesic, and dry forest and shrubland areas. In some places, native ecosystems have been degraded so severely that recovery is probably no longer possible or extremely long term. In Hawai'i Volcanoes National Park (HAVO) where pigs are fairly recent arrivals, pigs have caused losses of native species in the forest understory, favorable conditions for invasion of alien plants, disruption of soil formation, and creation of pockets of stagnant water in which mosquitoes that carry avian diseases breed.

Clearly there is an urgent need to eliminate feral pigs from National Park forests and shrublands if the Park is to protect and manage native plant and animal communities and if processes such as natural selection and nutrient cycling are to go on without man's influence.

In HAVO, managers and researchers have developed a cooperative approach to solving the feral pig problem. It consists of an integrated program of developing and evaluating control techniques; studying pig population structure, trends, and food habits; determining pig movement patterns; and evaluating vegetation recovery. Additional key features of the program include: fencing of control units and removal of pigs from them, and close cooperation between managers and researchers as the program progresses.

CONTROL METHODS RESEARCH AND DEVELOPMENT

In HAVO, studies of control techniques depend upon research and management input. Most of the testing is conducted within control units that have been fenced to prevent escape and ingress of pigs. Studies have been initiated on trapping, snaring, and hunting with trained dogs. Trapping has been tested with 1 x 1.5 x 2 m drop-door aluminum box traps (constructed by Environmental Technology, Volcano, Hawai'i) with woven wire sides and plywood doors. Traps were baited with cattle and fish remains. Pigs were attracted to the strong odor, fly larvae, and perhaps animal protein. Limited testing showed that papaya was also an

effective bait in mesic and wet forests, but the sources of supply were inconsistent and odor was far less noticeable. Further testing of baits is needed. Each trapping test was conducted for six weeks--three to attract animals and accustom them to traps, and three to trap them.

Snaring has been tested with and without the same bait used in traps. The snares we used were custom-made by Thompson Snare Company (Lynwood, Washington) and were made of reverse-wound 3/16" diameter steel (2xx) cable, 13 feet long with 3/16" swivel (5 ft noose, 8 ft anchor). Snares were usually set with drop logs so that animals would be hanged and die rapidly. In three experiments, a few snares were set strategically near bait piles, and in two, snares were set to cover many of the available trails or movement paths in an area (saturation snaring). Tests with baited snares lasted six weeks each, and those with unbaited snares, three weeks.

Hunting by NPS expert pig removal teams consisting of hunters and trained dogs has been studied continually for eight months. In contrast to the previous Deputy Ranger Program that has operated in the Park since 1972, the pig removal team approach encourages flexibility, innovation, and experimentation. Researchers often accompany hunters, and detailed records are kept of effort expended, hunting routes, sex and age of animals killed, food habits, and other information important in developing control strategy. Teams approach hunts with deliberate strategy, including variations in point of attack, routes hunted, time of day hunted, and intervals between hunts. Scouting for pig sign is done between hunts, and hunters decide when dogs and pigs should be rested.

Results of tests with control methods are shown in Tables 1 and 2. Feral pig removal with dogs is the method of choice to date, based on effort expended, but more data are needed. Only two areas have been hunted so far; both are fairly accessible and have fewer hazards to dogs and hunters than many other areas. All techniques are still being refined. Results of some tests are possibly biased by other tests in the same areas, and removal of pigs from areas with higher population levels will probably require different strategies than removal of pigs from areas with lower levels.

Preliminary data on costs of control, including salaries, supplies and materials, and travel expenses, indicate that pig removal teams with dogs are the most cost effective means of control (Table 3). Costs can probably be lowered as all methods improve over time, but animals in areas with lower population densities may also be more expensive to remove because of increased wariness.

We are also evaluating rates of removal from control units. From 36-40 percent of adult animals must be taken from

an area in a 6-month period if elimination in a 3-5 year period is to be obtained (Barrett and Stone 1983). We have based our estimates of pig densities on data obtained by Giffin (1982) in similar vegetation types. If these estimates are correct, none of the control methods tested to date are removing animals at a rapid enough rate from rain forest to effect total elimination. The rate of removal in the Puhimau rain forest unit is now 25 percent. However, the rate in mesic forest (Kipuka Ki) may be over 50 percent.

Part of the integrated process of evaluating control methods is estimating trends in pig populations before, after, and during control. For this purpose, permanent pig activity transects have been established in the Puhimau, Kipuka Ki, and Ola'a Tract control units. Pig digging, tracks, scats, trails, and plant feeding are categorized into fresh, old, and sometimes intermediate categories, through use of standard criteria developed in HAVO. Transects are read approximately every three months in 10-meter increments and are being analyzed at present.

Optimum sizes of fenced control units depend upon density and distribution of pigs and vegetation, topography and hazards (such as cracks) within the area, and accessibility of the area to control. Units are enclosed with 32-inch woven wire fences with barbed wire at top and sometimes bottom; and topographic barriers such as cracks and escarpments are used where feasible. The enclosed Puhimau Unit contains rain forest with tree ferns (Cibotium spp.) and uluhe fern (Dicranopteris emarginata), with mesic and dry forest and shrubland, and encompasses 5500 acres. The enclosed Kipuka Ki area is mesic forest and about 4000 acres in extent. We plan to fence a 640-acre area in Ola'a Tract in the near future and subdivide the Puhimau Unit into 1000- and 4500-acre areas this summer. A 320-acre section of Ola'a Tract is now fenced on three sides, and the fourth side will be fenced this summer. The optimum sizes and configurations for control units in different situations will be determined from experience with these and other units.

MOVEMENTS AND RESPONSES TO CONTROL

We are using radio transmitters from Telonics (Mesa, Arizona) and Custom Telemetry and Consulting (Athens, Georgia) to determine movements of feral pigs in response to control. Movements of three pigs followed for 4-4.5 months until taken by hunters and three pigs tracked more intensively for 1-1.5 months are summarized in Table 4. Nocturnal, diurnal, and crepuscular ranges sometimes varied in size and location for individual pigs and may or may not have been in response to hunting. We do not have information on pig movements prior to our control program in the Puhimau Unit but hope to obtain data prior to intensive hunting at Napau this summer.

The influence of hunters and dogs on individual pig movements was variable. One female pig seemed especially sensitive to control teams and showed movements of 1.8 and 3.2 km on two occasions, probably related to dogs. On two other occasions, her usual escape routes were blocked by fences on two sides and by dogs on a third side, and her movements were short. In other cases, pigs near dogs showed movements that were similar to those when no dogs were present. Two radioed pigs (a sow and a boar) that were within hearing range of two loose dogs far from hunters showed little departure from normal movements despite considerable barking by the dogs.

POPULATION CHARACTERISTICS

Data from animals taken by pig removal teams are recorded on field forms and transferred to an IBM-PC computer program called PC-FILE for ease of retrieval and sorting. Information on sex, age, weight, reproduction, color, parasites, fat, and food habits are gathered, and may readily be sorted and summarized by area taken, sex, age, method taken, or any other characteristic. An overall summary of the 161 pigs taken to date shows that the average pig taken in HAVO (mostly Kipuka Ki and Puhimau Units) is 18 months old, weighs 66.5 pounds, and eats largely tree ferns (hapu'u) (20%) and grass (31%), with lesser amounts of Lycopodium (5%), Myrica (5%), and earthworms (3%). (Offal was found as 14% volume but originated largely from baits used in trapping and snaring tests in one unit.)

Some characteristics of pigs taken in four control units (including the unfenced Napau area) are shown in Table 5. Contrasts in food use between rain forest (Puhimau) and mesic forest (Kipuka Ki) pigs are readily seen in greater use of hapu'u, Myrica faya, earthworms, and Lycopodium by pigs from the wet area, and greater use of grass and Acacia koa by pigs from the mesic forest. Such information, coupled with vegetation maps of control units and movement data, can facilitate more effective control by allowing hunters to concentrate in important food areas where these are concentrated; managers may also wish to separate important food areas from escape cover through strategic fencing. Rain forest pigs also appear to contain more young individuals, but this may be related to sample size, method by which pigs were taken (see below), and/or greater intensity of hunting in the Puhimau area, resulting in increased reproduction.

Characteristics of animals taken by three control methods suggest that pigs vulnerable to snaring and hunting are more alike than those vulnerable to trapping (Table 6). Trapped animals were younger and had less fat, and apparently used less hapu'u and Lycopodium than snared or hunted animals. Food habits of snared and hunted animals were less masked by taking of offal in baited areas and showed more use of hapu'u, Lycopodium, Myrica and earthworms. J. Hone (personal

communication) and R. Barrett (personal communication) stated that some feral pigs may not be readily vulnerable to baiting, and this may also be the case at HAVO, judging from different characteristics of animals taken by different methods and by field observations. This has important implications for development of techniques such as toxicants. Other computer sorts by age, sex, etc. are also of interest but cannot be covered here.

VEGETATION RECOVERY

The goal of the feral pig control program at HAVO is to completely remove pigs from control units. However, achieving that goal may be impossible in some areas because of manpower and money constraints and other priorities, or may be extremely long term. Because we need to know the negative effects of feral pigs on different ecosystems at different pig densities (including zero), we are establishing a system of exclosures and vegetation plots in important areas of the Park. Continuing research and monitoring of vegetation recovery will also help us to determine what other management measures are necessary to restore native ecosystems and which areas are most manageable for this end. We have established 30 x 30 m exclosures in the pig-free Thurston area, and in an adjacent area where pigs are present. A 14-year old exclosure near the Puhimau area and another 9-year old one near Napau Crater have given us some indication of vegetation recovery where pigs are absent (Higashino and Stone 1982, Katahira 1980). Groups of four contiguous 3 x 5 m vegetation plots have been established in the Ola'a Tract. Construction of exclosures in the Ola'a and Puhimau areas is planned for this summer, as are additional vegetation plots in both areas. We are in the process of comparing methodologies from monitoring and research efforts on vegetation from studies on fire ecology, forest baseline data collection for energy development, goat damage, rare plant and other studies (Tunison, Cuddihy, Higashino, personal communication).

PLANS FOR THE FUTURE

A coordinated research and management program on feral pigs in HAVO is expected to continue until October of 1986. Subsequent to that, Resources Management now appears to have additional funding for continual pig removal. Research efforts to study feral pig control in upper Kipahulu Valley may begin this summer and a feral pig management plan for the Valley has been formulated. In addition to the fencing of Ola'a and Puhimau and the exclosures and vegetation plots in the units mentioned above, we are planning a 3-week test with pig hunters and dogs near Napau Crater and an intensive snaring test in the Puhimau area at the same time. Instrumentation of animals and telemetry studies at Napau and Ola'a prior to control or fencing efforts is also planned. Continued emphasis on Puhimau and Kipuka Ki control units to

refine control methods and increase removal rates is needed, and further development of monitoring methods will be emphasized. We need to learn more about appropriate intervals and sequences for each control method.

Controlled studies of bait preferences, of pig responses to control techniques, of nutritional needs, and studies related to chemical development as a pig control method, are critical at this point. Construction of a pig-holding facility is essential in this regard. We also intend to acquire additional dogs so that more packs will be available for continuous and simultaneous use in several control units. Long-term plans of the feral pig project are to continue to learn, innovate, and remove feral pigs from as many control units in HAVO as possible so that ecosystems may be restored to native species and natural processes wherever possible.

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TABLE 1. FERAL PIG CONTROL EFFORT IN HAWAI'I VOLCANOES NATIONAL PARK BY METHOD, 1983 - 84.

CONTROL METHOD	TOTAL EFFORT*	ADULTS TAKEN	PIGS/ EFFORT	AREA	MONTHS
TRAPPING	792 TN	16	1/50 TN	PUHIMAU	4 - 8
TRAPPING	420 TN	4	1/105 TN	MAUNA LOA	5 - 8
SNARING	3819 SN	15	1/255 SN	PUHIMAU	6 - 12
SNARING	2247 SN	6	1/375 SN	NAPAU	1
HUNTING	181 PH	22	1/8 PH	PUHIMAU	9 - 11
HUNTING	218 PH	29	1/8 PH	KIPUKA KI	11 - 4
HUNTING	78 PH	9	1/9 PH	PUHIMAU	1 - 3

* TRAP NIGHTS, SNARE NIGHTS, PARTY HOURS

TABLE 2. PRELIMINARY FERAL PIG CONTROL EFFORT IN HAWAI'I VOLCANOES NATIONAL PARK, STANDARDIZED TO ADULT PIGS TAKEN PER WEEK, 1983 - 1984.

CONTROL METHOD	ADULT PIGS PER WEEK	NUMBER OF TEST WEEKS
TRAPPING (BAITED)	0.55	36
SNARING (BAITED)	0.67	18
SNARING	1.50	6
HUNTING	2.07	28

TABLE 3. PRELIMINARY FERAL PIG CONTROL ECONOMICS, HAWAI'I VOLCANOES NATIONAL PARK, 1983 - 1984.

CONTROL METHOD	COSTS PER ADULT PIG	
	INITIAL AND CONTINUAL	CONTINUAL ONLY
TRAPPING (BAITED)	$ 1013	$ 637
SNARING (BAITED)	$ 727	$ 510
SNARING	$ 678	$ 344
HUNTING	$ 401	$ 237

TABLE 4. SUMMARY OF DATA FOR 6 RADIOED PIGS, PUHIMAU UNIT, HAWAI'I VOLCANOES NATIONAL PARK, 1983 - 1984.

	AGE (YR), SEX, WEIGHT (LBS)	RADIO FREQUENCY	PERIOD TRACKED (MOS)	HOME RANGE (KM^2) DIURNAL (NO. FIXES)	NOCTURNAL (NO. FIXES)	CREPUSCULAR (NO. FIXES)
1.	3.5, F, 200	1/9	11/22-04/06 (4.5)	2.4 (70)	2.5 (18)	1.2 (14)
2.	3, F, 150	2/6	10/10-02/14 (4.0)	2.3 (68)	1.6 (37)	0.9 (13)
3.	2.5, M, 93	2/5	09/08-01/24 (4.5)	3.1 (82)	5.1 (39)	2.0 (16)
4.	?, F, 52	1/6	04/10-05/25 (1.5)	5.0 (81)	5.4 (45)	4.2 (25)
5.	?, F, 74	1/8	04/13-05/25 (1.5)	3.2 (58)	1.3 (32)	1.1 (19)
6.	3, M, 200	1/3	04/16-05/25 (1.5)	5.4 (50)	2.5 (33)	5.1 (27)

TABLE 5. SOME CHARACTERISTICS OF FERAL PIGS TAKEN IN FOUR FERAL ANIMAL UNITS, HAWAI'I VOLCANOES NATIONAL PARK

	Feral Animal Unit			
	Puhimau	Napau	Mauna Loa	Kipuka Ki
$\bar{x}$ Weight	15.3	33.5	20.7	21.8
$\bar{x}$ Age	57.8	80.5	70.5	79.4
$\bar{x}$ Fat	1.9	1.7	2.6	0.8
% Offal	18.0	0.3	60.0	1.0
% Earthworms	4.3	0.0	0	1.3
% Hapu'u	23.6	83.3	0	0.0
% Grass	18.5	15.8	28.0	68.4
% Lycopodium	8.0	0.0	0	0.0
% Koa	0.0	0.0	2.0	14.8
% Myrica	7.5	0.0	0.0	0.0
N	107	6	5	40
Period	4/83-5/84	1/84	5/83-8/83	11/83-5/84
Methods	T,H,S	S	T,S	H

TABLE 6. SOME CHARACTERISTICS OF FERAL PIGS TAKEN WITH TRAPS, SNARES, AND DOGS IN PUHIMAU FERAL ANIMAL UNIT, HAWAI'I VOLCANOES NATIONAL PARK.

	TRAP	SNARE	HUNT
$\bar{x}$ AGE (MO)	8.1	20.3	16.9
$\bar{x}$ WEIGHT (#)	20.1	88.9	63.3
$\bar{x}$ FAT (MM)	0.7	3.7	1.9
% OFFAL	56.8	20.7	3.8
% EARTHWORMS	0.0	0.0	7.5
% HAPU'U	16.1	29.0	24.9
% LYCOPODIUM	2.7	8.3	10.2
% MYRICA	0.0	7.5	10.5
% GRASS	9.3	15.9	23.0
N	22	20	62
PERIOD	4/83-8/83	6/83-12/83	9/83-5/84