

STATUS OF MANAGEMENT OF FERAL GOATS IN
HAWAII VOLCANOES NATIONAL PARK

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Goats (*Capra hircus*) were probably introduced to the Island of Hawaii in the winter of 1778-1779 near Kealahou Bay (Tomich 1969). By 1850, they were apparently widely distributed in the wild on the Island. Hawaii Volcanoes National Park (HAVO) personnel have long recognized the destructive effect of feral goats on native vegetation, with control efforts in the Park beginning in the 1920's. Over 70,000 goats were eliminated in the Park from 1927 to 1970 by drives conducted by foresters and rangers, contracts to "goat control companies," Civilian Conservation Corps personnel supervised by rangers, and deputized hunters. However, in 1970 results of an aerial census suggested that about 15,000 goats were present in the Park -- just as many animals as when control efforts began. This unproductive effort to reduce goats was the result of lack of full understanding of goat reproductive potential; shortages of funding; inadequate and unsustained effort; and inadequate fencing.

By late 1970, HAVO personnel had developed a long-term systematic plan for goat reduction. This major step in goat management consisted of plans for: 1) construction and maintenance of goat-proof boundary and internal drift fences, 2) frequent organized goat drives and hunts, and 3) a long-term vegetation monitoring scheme to evaluate results (Baker and Reeser 1972). A citizen hunter program was implemented to allow public participation in the goat management program. Although not stated in the Plan, another goal was to monitor goat population trends during the control effort. Further interest in controlling goats and the funding necessary to do the job occurred after the discovery of an undescribed endemic vine (*Canavalia kauensis*) and rapid establishment of bunchgrass and woody plants during the early monitoring of vegetation recovery in exclosures (Mueller-Dombois and Spatz 1975).

During the five years 1971-1975, 12,976 goats were eliminated, and in June of 1975 the last goat drive was conducted (Table 1). As goats became difficult to locate, interest by the public in the citizen hunter program diminished. From 1976 through 1979, 1,596 goats were eliminated, largely through the efforts of National Park Service riflemen through helicopter searches and horsemen with trained dogs. By 1980, 90 percent of the goat range in HAVO had been fenced and the population estimate within was about 200 goats (Figure 1).

Present Control Methods

Today, the major effort is aimed at eliminating the last few herds within the fenced areas of the Park. Despite intensive helicopter

searches and hunts at 6-8 week intervals, it has been very difficult to remove the last animals. These remnants are wary of humans and helicopters and readily find cover in lava tubes, cracks, and dense vegetation. The efficiency of helicopter hunts has neither increased nor decreased over the past year (Table 2). Only 29.8 percent of our helicopter trips result in elimination of one or more goats, with an average of 1.75 goats per trip. We spend an average of 3.5 hours on a given hunt interval and kill an average of 15 animals every 4-6 weeks. In 1970, the cost per goat taken was \$1 to \$5, while today it ranges from \$100 to \$300 per goat. Part of the increase is inflation, but the bulk of it results from the fact that the remnant animals are more difficult to take. The reproductive potential of the goats remaining is undoubtedly near maximum. This means that if there are now 100 goats in the lowland population, there could be over 4200 goats in 10 years and over 14,000 in 13.5 years (based on Rudge and Smit 1970, intrinsic rate of increase of $r = 0.375$). Obviously, we need to continue to suppress this population.

Alternatives to goat control by helicopter are being tried. We are presently attaching radio collars to "Judas" goats and releasing them. To date, the three released goats joined wild herds, one within a 3-day period. Use of decoy goats in traps and baiting of goats to increase vulnerability to shooting or possibly toxicants will also be attempted. Helicopter searches will continue for the time being to be an essential tool in locating herds and, simultaneously, exotic plants for control purposes.

Fences

Because of rapid deterioration from sulfur fumes, salt spray, and high humidity, and because of the potential for vandalism, earthquakes, and rock and tree falls, all fences are inspected every three months. One 1.2 km (0.75 mi) section of boundary fence along the coast has been replaced three times since 1975 as a result of corrosion. Within the next 3-15 years, replacement of 64 km (40 mi) of goat-proof boundary fences will be required. Interior drift fences are left in place until they are no longer useful.

Above the drift fence on Mauna Loa at 2042 m (6700 ft) elevation, approximately 100-200 goats roam freely into the Park from adjacent State and private land. This remaining unfenced area, representing 10 percent of HAVO's goat habitat, is a seasonal montane-subalpine habitat used seasonally by nene (*Branta sandvicensis*). Unfortunately, remoteness, the rugged terrain and frequently inclement weather conditions in this 26 km² (10 mi²) area will increase the fencing costs to an expected \$200,000 -- an unfunded project at present.

Population trends

From 1968-1979 a systematic effort to determine population trends of goats in HAVO was made from 113 km (70 mi) of transects flown with the

helicopter semi-annually. Although actual population numbers estimated appear questionable because of techniques and calculations used in a modified King strip census, population trends were obtained. No confidence intervals were applied to the estimates. As goat numbers decreased and animals became more wary and conditioned to helicopters, additional biases entered the method. Even the recovery of vegetation as goats decreased probably changed visibility in some areas to an unknown degree. Aerial surveys were discontinued in 1980 and since then, numbers of goats have been estimated through actual sightings of herds during organized hunts in different areas. Since feral goats maintain discrete herds and traditionally use specific areas (Coblentz 1976, Yocum 1967) and presumably are similarly observable in the same area at different times, comparisons of "total" counts from year to year should provide trend information for low population levels over time. However, attempts to obtain more statistically valid population estimates with confidence intervals from kill figures are also being made at present.

Conclusion

In summary, the goat population within fenced areas of HAVO is at a very low level, but it has become increasingly difficult and costly to eliminate the last few individuals. We intend to maintain the frequent control and monitoring efforts, continue experimenting with "Judas" goats, and look into other possible control methods. We will also continue to monitor population trends so that goat numbers do not increase unexpectedly. Support for long-term management of goats has been sought, and, considering the investment already made and the resources at stake, it is well worth the effort.

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TABLE 1. Numbers of goats eliminated from Hawaii Volcanoes National Park, 1970-1982.

Year	Total Number of Goats Taken	Methods Used
1970	2116	Drives, NPS employees, Deputy rangers
1971	3408	" " "
1972	3623	" " "
1973	3404	" " "
1974	1588	" " "
1975	953	" " "
1976	403	NPS employees, Deputy rangers
1977	276	" "
1978	487	" "
1979 ¹	430	" "
1980	168	" "
1981 ²	149	" "
1982 ³	31	NPS employees

¹ Boundary and drift fences completed to 6700 ft

² Radio-collared "Judas" goat released

³ Jan-June 1982. Estimated population less than 100 goats

TABLE 2. Summary of goat removal by helicopter hunting in Hawaii Volcanoes National Park.

Month and Year	Goats Killed	Hours Flown	Kills/ Hour	Number of Areas Hunted	Percent Areas Hunted Without Kill
March 1981	27	3.4	7.9	6	16.7
April 1981	7	2.3	3.1	7	85.7
May 1981	11	2.4	4.6	8	75.0
July 1981	10	3.6	3.6	9	77.8
Sept 1981	22	6.8	3.2	14	64.3
Nov 1981	31	5.8	5.3	9	66.7
Dec 1981	26	3.0	8.7	9	66.7
Jan 1982	11	2.7	4.0	9	77.8
March 1982	5	3.5	1.4	10	80.0
May 1982	1	2.3	2.3	8	87.5
June 1982	14	3.0	4.7	5	60.0
Total	165	38.8	---	94	---
Mean	15	3.5	4.3	8.5	70.2

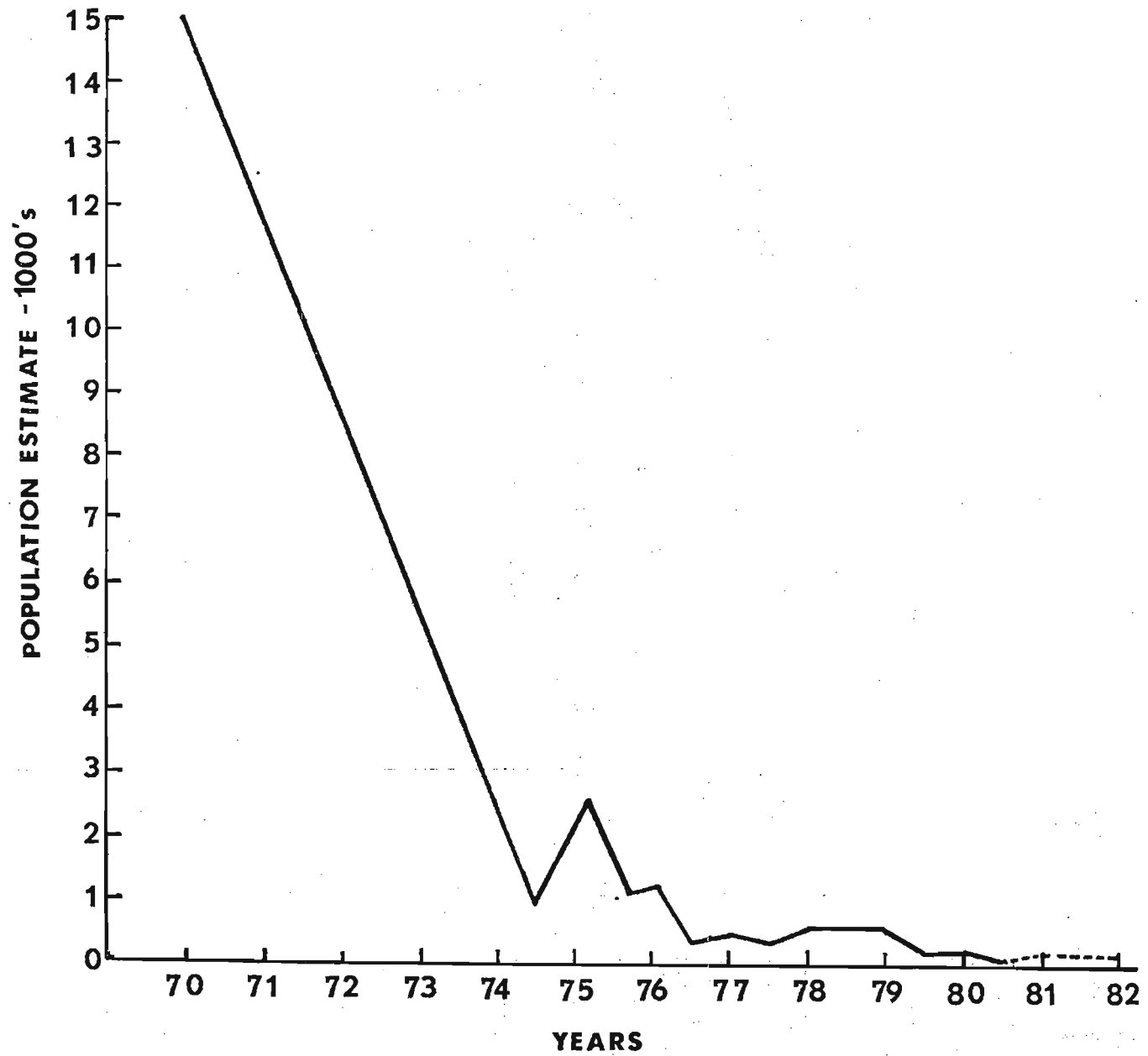


FIGURE 1. Feral goat population estimates, Hawaii Volcanoes National Park.