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Technical Report 52

SOME ASPECTS OF FERAL GOAT DISTRIBUTION IN
HALEAKALA NATIONAL PARK
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August 1984

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NATIONAL PARK SERVICE
Contract Number CA8000 0 0020

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INTRODUCTION

More than 30,000 goats have been killed in Haleakala National Park (HALE) since 1915, yet they still impart a major negative impact upon the native ecosystems. While it may be easy to fault the Park, and indeed mistakes have been made, there is no indication that the National Park Service (NPS) has seriously considered any solution short of eradication as an answer to the problem. While some Park managers have made goat control a higher priority than others, nearly everyone has understood the severity of the problem. The objective of this study was to evaluate the movements, herd ranges, and bedding sites of the feral goat populations in Haleakala National Park and recommend strategies for fencing.

METHODS

Informal discussions were conducted with HALE employees who work in the maintenance, resource management, protection, and interpretive divisions as well as with Park managers to develop a perspective for the past and present concerns of the Park as seen through the eyes of its employees. Additional discussions were held with personnel attached to the Western Region research staff and with scientists who had worked on the Cooperative National Park Resources Studies Unit inventory of the crater as well as the U.S. Fish and Wildlife Service's Maui Forest Bird Survey.

In September 1981, with the assistance of Barry Cooper and Larry Kitahira, four goat management units were established for the Park. These units are topographically distinct zones which could be managed individually.

Diurnal and often nocturnal ground observations of goat movements, habits and traits were conducted in Kaupo Gap, Manawainui Planeze, crater floor, Kalapawili Ridge, the back of Kipahulu Valley, and on the western palis and ridges during September and October 1981. On October 9, 1981 a low level helicopter survey was flown on north Kalapawili Ridge and east Kuiki to determine goat penetration into the rain forest. Other observations were made from fixed wing aircraft on September 12 and from the helicopter while flying the aerial census on September 11.

Much of the work on goat distribution and habits is developed from my personal experience in HALE which began with a Crater trip in 1964. During the next eight years I led or was a member of numerous hiking trips into the Crater. In 1973 I became a deputy ranger and have hunted goats and pigs in the Park ever since. I began working as a park technician (feral animal control) for Haleakala in 1975 and left in 1979 as a Park Ranger (Resource Management Specialist). Since then I have again become a deputy ranger and have continued to assist the Park in its goat

control efforts. Between 1964 and present I have taken over 3000 color photographs of the Park, of which about 10% are airphotos. The comparative analysis of these was most helpful in following vegetation and erosional changes within the Crater during the past 18 years.

PAST AND PRESENT COMPARISONS OF SELECTED AREAS

In the map file at Haleakala National Park (HALE) there is a copy of a map produced sometime in the 1800's which labeled the area between Pu'u O Pili and Kapalaoa Cabin as "SILVERSWORD PLAIN". Though it is anything but that now, humans are probably as guilty as goats for the plant's demise in this area. More recent comparisons in areas less frequented by man give better indications of plant destruction by goats, the resulting erosion and the overall alteration of the landscape.

Yocum took a number of black and white photographs during the summer 1963 (Yocum, HALE library). Photographs #14 and #15 of Kaupo Gap and north Kuiki palis do not show noticeable differences from the present, however photograph #17 of the south Kuiki palis has more Koa trees than now. Photograph #19, taken at approximately 5000 feet in Kaupo Gap and looking southwest shows a density of vegetation that considerably exceeds what is there today. Photographs #21, 22, 25, 26, 29, 30, 31, and 37 depicting the west palis from Kilohana to Halemau show considerably less erosion than is present now. A comparison of the overall vegetation on Kalahaku pali with the present shows more bare ground visible today (photographs #25, 26, 29, 30 and 31). Also very evident are the upward reaching fingers of erosion which appear to be several hundred yards higher than they were in 1963.

In October 1981 goats were present in the back of Kipahulu Valley at 7000 feet elevation. Their tracks were observed as low as 6800 feet in an area about 0.25 mile west of Wai Nene Pond but their impact was negligible. Above 7200 feet however they have damaged the ridges extensively. The 1967 Kipahulu Expedition reported them to be on the "rocky headwall ridges above 7500 feet" (Banko and Wilson, 1967). No evidence of goats was found below the elevation of 6700 feet on the north west slopes and 6800 feet on the north slopes of the valley.

A review of my own photographs and reports from many sources indicate that very few parts of the crater have not suffered major vegetational depletion and significant erosion during the past 10 years. Although people, horses, and pigs have undoubtedly had some impact, by far the greatest single factor has been feral goats (Yocum, no date, p. 43-45, HALE library). One of the most striking erosional changes occurred along the Crystal Cave Trail in 1977 when approximately 9000 cu. yds. of cinder eroded in an area 0.4 mi. north east of Honokahua. In the years previous the goat trails had worn down, leaving the soft cinders beneath it exposed. Subsequently heavy rains cut inches

and in some places, several feet into the cinders. This erosion may have happened eventually, but the activity of the goats undoubtedly hastened it, probably by decades if not centuries.

On the opposite side of Kalapawili Ridge the reduction of vegetation has been inversely proportional to the increasing presence of feral goats. In 1973 goats were seldom observed below 8000 feet elevation except above and within 0.6 miles of Waikau Cabin. Today they can be observed as low as 6800 feet, and out to 2.3 miles east of Waikau. As a result, the alpine shrub vegetation native to the area has been thinned, especially the mamane. Many of the vegetated swales of 1973 have become sharply cut creeks flowing muddy water. During a hike through the area in October 1981 topmarked mamane trees and an absence of seedlings were noted. Browse damage was also noticed on 'ohelo, Deschampsia, Geranium, and even pukiaawe. The action of shooting at goats, if it is done with considerable intensity and frequency will cause herds to temporarily relocate until the pressure lets up. Sometimes the goats are so constantly harassed in their original habitat that instead of returning, they remain in the new area. Up until the mid 1970's goats on the east palis of Kaupo stayed in the mid-zones where there was some cover. Since the hunters only traveled on the top and bottom of the cliffs the goats on the cliffs were safe. In 1976 the author and other Park service hunters invaded the palis and for a couple years wreaked havoc with the herds living there. After a while, the goats disappeared, and now the herds which still total hundreds of individuals, have made their way eastward into the koa and 'ohi'a forests of Kuiki. In four years they have moved an average of 0.25 mile back into the trees, where no one hunts them.

MOVEMENT PATTERNS

Goats enter or leave the Park along nearly 12 miles of the boundary (Figure 1). With only one significant exception these crossings are usually routine meanderings of herds within their ranges. Along the south boundary of the Park from Haupa'akea to Haleakala, for example, movements out of the Park are natural rangings of herds T and R (Figures 1,2). The one exception observed on several occasions between 1973 and 1979, appears to occur more than once a year or perhaps there is more than one herd involved. The goats move into the Park on the west slope, descend the Kilohana or Kalahaku palis (sometimes staying a day or two), then cross the crater floor at night and by morning have disappeared over the south rim of the crater. Cross boundary movements between Haleakala peak and the middle of Kaupo Gap are not nearly as common today as in the recent past, probably because there is little to eat along that western boundary. The only place in the area where goats can move out is down from the gulch in the southwest corner of the Gap.

Although a route is indicated between Manawainui and Kaupo this is really only because the park boundary follows the ridgetop and what is seen is a natural cross ridge movement.

There was no evidence of significant movement of goats between Manawainui and the Park. In fact a number of the mauka-makai trails used moderately in past years, are showing disuse and are in some places even becoming overgrown with a'ali'i and pilo. The disuse of these former trails was confirmed during helicopter observations of the area. Cross border movement in that area is currently limited to herd ranging, and even that is minimal.

Until the north boundary of the Park in Management Zone 3 (Figure 3) is fenced the area north of it must be managed as if it were one with the Park for existing herds frequent the entire area and can be found in the Park one day and outside it on the next. Generally speaking they do not tie into any other goat populations, however if they continue their eastward spread through the grasslands they could reach Kuiki via the top of Kipahulu Valley.

Goats cross the barbed wire fenced western boundary in several locations. At least two herds occupy range A (Figure 2), one of which can often be seen in the mamane and sandalwood groves makai of the 8500 foot elevation stand of Eucalyptus. Another occupies a higher level and occasionally even crosses to the rim between Kalahaku and Leleiwi.

HOME RANGES AND BEDDING AREAS

The 21 herd ranges (Figure 2) overlap each other slightly but for clarity the overlap is not shown. Herd ranges are those areas that herds cover in search of food and shelter and should not be confused with areas that the goats can be driven to when chased or hunted, which may or may not be within their natural range. As previously mentioned range A contains at least 2 herds but occasionally a third can be found in the low mamane and pilo thickets just mauka of Pu'u o Ili. A number of excellent bedding sites (Figure 4) can be found over a large area outside and just within the Park. Most of these are west facing overhangs or shallow caves, although as one travels westward toward the power lines there is an increase in the number of large caves used by goats.

The number of herds in range area B seems to increase in the winter months. There is movement between B and T, though if unharassed, one herd centers over and north of Holua, one over Leleiwi up to Kalahaku, and a third over Kilohana and Kalahaku. There are a number of excellent bedding areas in this zone. In fact the largest goat cave in the crater is located here on the Kalahaku pali at 9100 feet elevation, just south of the prominent head. Here, as throughout the crater, overhanging rocks and inward swept cliffs serve as bedding sites provided they face away from the prevailing north east trades. On windward facing palis only caves and large overhangs provide adequate bedding areas. Although the central and northern crater floor is traversed by goats from several herds, their normal diurnal range does not include this barren area.

Area C is heavily overlapped by herds from D and E but contains at least two distinct herds of its own which bed down in the 'a'a flows known as Devil's Kitchen, north west of Pu'u Kumu. Bedding areas on the Waikau palis are used primarily by more westerly situated herds in range D. The F area herds are frequently not distinct from E and G, however at night they will usually return to the shallow overhangs at the base of tall basalt cliffs between Lau'ulu and Crystal Cave Trails. Nocturnal observations along Kalapawili Ridge in September of 1981 indicated the presence of 3 herds totaling 78 goats in range C, 2 herds exceeding 60 individuals in F, and only one herd of less than 20 goats in G. However C and D were not covered and difficult spotting conditions prevented observation more than 50 meters down slope in G. There appears to be only one or two herds in range H. A few individuals have been observed bedding in caves near the top of the eastern ridge of Kuiki where they are hard to see because of the 'ohi'a trees, but the majority overnight on the west facing palis, both high up at the base of cliffs and midway down under small overhangs in more vegetated areas. Caves are rare throughout ranges H, I, and J. In J goats appear to be sleeping in the vegetation, sometimes on leeward sides of large trees. Determining exactly what the herds in range J are doing is difficult due to the dense forest. In 1979 three herds were observed in the upper third. Two were located side by side (one further in the forest than the other) and one was above. There are at least five herds there now, only two of which show any real overlap into range I. Bedding in I has been observed at the base of cliffs high above the dry forest enclosure, under 'ama'uma'u ferns in the wetter areas, and in the thick grass, pukiaue and bramble under koa trees near the Park boundary. Several small herds can be seen in regular diurnal movement across the slopes with only occasional forays into the forest at the cliff base. The herd structure and locations throughout all of management zone 4, of which H, I, and J are a part have changed considerably in the past five years.

Range K, Manawainui Valley and planeze, are becoming a goat-induced disaster area due in large part to extremely high population densities. There is no shortage of bedding areas on leeward facing slopes and in the rain shadow of trees in Manawainui. When disturbed, herds join in long trains, running off the high ridge tops and out toward the steep palis of the central valley. The goats in this area are so plentiful and their trails so profuse that viewed from a distance they resemble swarming ants. Goats on the upper planeze above 4600 feet have worked their way eastward under the 'ohi'a trees and through the maile patches along a front extending about 0.35 miles beyond Healani stream, an increase of about 0.15 miles since 1976 (Gon, 1976).

Range L usually has only one herd in it, if that, due primarily to its proximity to the Koa Tree, a favorite hunters' camp site which is reachable by jeep via the Kaupo Ranch. At present M contains a few small herds which when fired upon no

longer move into N but rather go to ground there or in range O). There is really very little movement between M and N because the western side of M, like upper Kahikinui, has become depleted of vegetation. In L and O goats rely more on the cover provided by shrubs and small trees than on overhangs and caves for bedding. There is extensive overlap between areas L, M and O.

Range N which includes devastated parts of Kahikinui as well as the Park has its population center in its more southern areas (outside the Park) and many of the excellent bedding sites along the stream channel at the pali base are falling into disuse. At the top of the pali many goats can still be observed though their ranges do not extend very far westward since there is nothing growing there but bracken ferns which goats refuse to eat. Several south facing caves appear to be used for bedding (pers. comm. T. Rodrigues 1980). It is goats from range P that are occasionally seen in Paliku and more commonly around 'O'ili Pu'u. Two herds were seen in P in September 1981 and there is extensive overlap between ranges P, M, and Q. Heavy stands of a'ali'i provide good cover and some shelter in area P, though bedding sites in Q are primarily rock overhangs paralleling a little ridge that runs along side the trail to Waikane. Q, like P and U are generally low density areas, encompassing at most 3 herds each. There is considerable overlap between Q and U, U and T, and N and T. Vegetation cover is virtually nonexistent in all four areas and shelter provided by topographic features is utilized for most bedding. When there has been no hunting in the south eastern end of the crater it is not unusual to observe a small scattered herd of goats in area R. These animals bed in the jumble of rocks along and adjacent to a stream channel, parallel with the trail to Waikane spring. When disturbed these animals flee southward up the palis to Haleakala peak. Herds in area T are a lot scarcer recently than in the past, possibly due to lack of food, although this may change with an increase in rainfall.

Range S (Kahikinui), has more goats than I have seen anywhere in Hawaii. It is separated from the Park by more than a mile of utterly barren alpine rock and sand desert and it is unlikely that there is any interaction between S and either T or R and fairly unlikely even that there is much traffic between S and N, (due to severely dissected terrain) except perhaps below 4000 feet elevation.

PRESENT MANAGEMENT TECHNIQUES AND POTENTIAL POPULATION DYNAMICS

The record of goat kills at Haleakala is sporadic (Figure 5). Unfortunately without dependable population counts or man-days expended on control, very little information can be extracted on the actual size of the goat population in years past. With the exception of Yocum's estimate of 600 in 1963 other estimates fail to show how they were derived. The Goat Movement Study (on file HALE library), for instance gives the following estimates:

1949 - less than 500	1962 - 1000
1955 - 1000	1963 - 1000
1957 - 1500	1964 - 1000
1958 - 1000	1965 - 600
1959 - 1000	

It cannot be determined from the report whether these estimates are for the entire crater or for just the western palis which were the subject of the study.

Large goat hunts led by Park Ranger McCall in 1948 averaged 2.2 goats per man day but this is not always the case. Several Park hunts between 1976 and 1978 averaged less than 1.5 goats per man day. A pair of hunters working in the spring of 1950 maintained a very high level of 3.4 goats per man day. Current estimates by the Park for their personnel are 2.2 goats per man day (pers. comm. B. Cooper, 1981) while actual figures for the deputy rangers show only 0.38 goats per man day (Feral Animal Control Log, HALE). Over the last forty years somewhere around ten thousand man days have been spent at Haleakala hunting feral goats.

When assessing a program designated as a "control" (originally a Park service euphemism for eradication) it has come to mean holding the population in check, as opposed to a "sustained yield" policy. The only animals that really matter are the females, for whether the population is 50% males or 1% males it will still grow exponentially. The other important concept is that the success (or failure) of eradication efforts must be determined by the number of goats remaining in the park, not simply by counting those which have been killed.

In recent years Park personnel and deputies have generally hunted wherever they pleased. Inevitably these areas are where the greatest number of kills can be made for the least effort expended. Few attempts have been made to rid an area of goats or even to seriously check their spread into previously undisturbed territory.

In the summer of 1973 most herds could be openly approached on foot to within at least 200 yards since they had become conditioned to being shot at predominately by mounted hunters. This is no longer the case as the goats have now adjusted to being shot at by virtually anyone.

Reduction of goat populations by shooting or capture tends to set up artificial selection patterns which favor the survival of females, dark colored individuals and strong goats. As it is natural for nannies with kids to break away from the parent herd for several weeks after birth to seek a more sheltered and restricted range (Mackenzie, 1975, p. 110), there are corresponding periods when the large herds are predominately male and relatively more visible than the females. Most hunting during this period will actually increase the percentage of

females in the population. There is also an instinctive tendency among hunters to shoot at the best target or to try to disrupt the herd by shooting the king billy first. Often enough this is the only goat hit. Analysis of goat kills in the park during the first nine months of 1981 indicates that the ratio of males to females killed is 1.7 to 1, however in cases where only one goat was shot the ration increases to 3.8 to 1 (Feral Animal Control Records, HALE). This increase is most likely the result of a first shot preference for a larger goat (usually male) since even at close ranges it can be difficult to differentiate the sexes of mature goats (Mosby, 1963). Most hunters will not fire at goats in running herds after the range exceeds 200 yards (which can happen very quickly) unless an animal stops, thereby presenting a motionless target. Weaker goats and kids are more likely to stop to rest, though the latter make very small, and unpredictable targets. Brown and black goats (except on Mauna Hina) are more difficult to see and have an easier time escaping detection than light colored individuals. These darker goats comprised 94.3% of the 557 goats spotted by Yocum in 1963 (Yocum 1963). Mostly or completely tan or white goats are still few in number, though numerous reports indicate that they are somewhat more common than in 1963.

A detailed analysis of population structure within Haleakala herds was not undertaken due to lack of data. However, using a high (15%) juvenile mortality rate as reported by Rudge and Smit (1970) in New Zealand and considering the increased death risks of adult goats as a result of hunting, the population is probably biased to the young (less than 5 years old) individuals. This juvenility of the herds, plus the high turnover of lead billies (Mackenzie 1975), helps keep a more fertile breeding population than might occur naturally.

More than 65 years of goat hunting in Haleakala has had a number of impacts upon the Park, many of which are taken for granted because they have become a way of life. The crash of gunfire and the wails and groans of wounded goats are everyday occurrences for those who hunt there, but for visitors, many of whom have no idea what is going on, the experience is unnerving and in no way leads to a pleasant "wilderness experience." Hikers, cautioned to stay on trails, frequently wonder why hunters, both on foot and on horseback, Rangers and Deputies alike, are not bound by these rules.

Dogs, even more so than cats and mongoose, are probably the most illusive feral mammals in the crater. In the last 12 years 14 dogs and 23 cats have been shot in the Park (Feral Animal Control Records, HALE). Goat carcasses are suspected to be a major food source for both species (aside from Hosmer Grove garbage cans) and on three occasions I have observed such feeding. It is reasonable to believe that in the lowest goat kill months of December, January, and February (NPS records averaged from 1967-1981) which are preceded by the highest months of September, October, and November, that hungry dogs may look to

the ground nesting nene as a supplemental food source. Another problem aggravated by present control measures involves the potential health hazards to crater visitors presented by the flies that breed in goat carcasses (CPSU Technical Report #9, p. 149) and the wasps that feed there.

A major impact of goat management has been the soil destabilization and introduction of exotic plants brought about by the presence of hunters and livestock in unique ecosystems. The most striking example of this is in the Deschampsia grasslands of Kalapawili Ridge. The vast majority of the hunting done on this ridge is with the aid of horses and although there is a major east-west trail along the ridgetop from Hanakauhi to Flat Top Bog, hunters frequently lead their horses deep into the grasslands and occasionally even down to Lake Wai Anapanapa. Introduced herbs and pasture grasses, arriving in feces and on coats can be found all along the trail and here and there throughout the rest of the area. Sheet erosion along the ridgetop west of Pohaku Palaha begins where runoff from the trail descends a small slope. Browsing by stock along this as well as the Lau'ulu Trail is less subtle than by goats since horses take bigger, deeper bites and can uproot entire Deschampsia tussocks.

CONTROL MEASURES WITH FENCING

Whether fencing is done piecemeal or in one fell swoop I would recommend that section 1 on Kuiki (Figure 5) be completed first to stop the movement of goats back into the forest. The choice of completing the west boundary second is not so much the result of its importance but rather because a small investment will pay large dividends. The completion of unit 3 in Kaupo will serve to block the largest goat highway in the park. The goats will probably stay their invasion of the lower flanks of Kuiki from Manawainui for a couple years more so that it can be ranked fourth in priority. If permission can be obtained to follow the 5000 foot contour all the way across to Kipahulu it would at least be shorter and probably easier as well. Since there are now goats in the forest east of Manawainui I can't think of any other way to run the fence which would be either easier or more effective. By fencing zone 5 last there is always the hope that some animals will voluntarily leave through that route. No fence is proposed for the north boundary because it is imperative that the goats be removed from all of unit 3. If this is not done and a fence is put on the boundary the isolated goats will be a nuisance for a long time to come. If a fence is desired to keep pigs out of the Park then permission should be obtained to run it along the top of the forest.

Until fence number one is completed it may be better not to hunt in the area because shooting may actually drive the goats further into the forest. However, on completion, an intensified eradication program for the eastern third of unit 4 should be initiated. With the completion of fence number two a hundred percent increase in hunting in that unit should reduce the population considerably within a short period of time.

After fence 3 is completed the unit 4 eradication can be finished up as well, a task to which all available energies should be directed. An internal fence (#3) across the top of Kaupo Gap (Figure 7) would be helpful in keeping the area goat free. To assume that eradication can be achieved without the use of internal fences is to assume that one has a high tolerance to frustration or an unlimited helicopter budget. Internal fence number 1 was designed and built by the park in 1981 and if extended by the addition of number 2 it should adequately disrupt east west movement. Fence four will probably be necessary, not only to discourage exodus during control but also to prevent reinfestation. Fence number five descends, for the most part, a sand slope and should significantly raise the efficiency of all hunting done on the western palis by preventing north-south movement. Fencing the Park boundary is not going to eradicate goats. To control goats in a reasonable period of time Kaupo and Kalapawili Ridge are going to have to be isolated. If these fences were built before the boundary fences they could be utilized right away and control could probably be effected sooner. If funds were cut the Park would at least be left with some usefully placed fencing. By the time all fences are in place significant inroads should already have been made against the trapped populations. A reassessment of the situation as it looks at that time will be necessary to develop the best strategy for the final eradication.

CONTROL WITHOUT FENCING

While it is possible to control goats at Haleakala (as is being done now) without fencing it is an unending job. Moreover, this type of control more closely approximates sustained harvesting than it does eradication. In the past 40 years more than 20,000 goats are reported to have been killed or removed from the park and yet there are still enough left to be more than just a nuisance. Direct control is attractive primarily because it requires no major annual expenditures. In the long run of course, it is only a delaying action, and though it could be justified as valuable in conjunction with a fencing program, by itself it is not particularly effective.

The only possible alternative to fencing to achieve goat eradication at Haleakala would be the institution of a major (and continuous) poisoning program. The likelihood of this option being approved is exceedingly low.

CONCLUSIONS

That feral goats create a serious destabilizing influence upon native ecosystems at HALE is certainly not new to anyone at all familiar with the situation. It can also be seen that although NPS has spent a significant amount of time, effort and money killing goats, they certainly have come nowhere close to eradicating them. What is yet to be fully realized is that only a dedicated effort, adequately funded, wholeheartedly supported and logically planned will achieve the desired results.

Fencing is mandatory, both to prevent goats in adjacent land from entering the Park as well as to limit the movement of those that are inside. An intensive hunting or removal program must be instigated simultaneously and a fence maintenance crew organized before, and kept long after the last goat in the park has been killed. Additionally, efforts must be made to monitor the goat population within and adjacent to the Park until eradication is achieved.

Perhaps most important to success is the realization, not only of the seriousness of the goat problem and the need for immediate action, but also that the proposed course of action is justifiable and prudent. To this end the Park will need to admit that eradication is its goal and be prepared to inform and educate the public. The tasks ahead are difficult, perhaps the most difficult that the Park has faced. But it can be done; indeed it must be done to prevent the permanent and irreversible destruction of Haleakala's native ecosystems.

Several potential problems associated with a goat control program must be evaluated and countermeasures adopted before any plan is implemented. First, the dead carcasses will be breeding grounds for very large numbers of flies. Food in cabins and elsewhere should be specially protected. Feral dogs will feed on the carcasses, thus the population will increase due to breeding and immigration of animals into to area. As the carcasses become scarcer, there will be dogs lurking around other sources of food, particularly nene and perhaps people. A dog control is essential. Finally, great care needs to be taken to ensure that goats are killed and not left maimed in the backcountry.

ACKNOWLEDGEMENTS

Many people have been very helpful to me during the preparation of this report and I would especially like to thank Carmelle Crivellone for her assistance with logistics and field work. I also owe considerable thanks to Larry Katahira for his help with the aerial census. I would like to thank Robert and Rosemary Howell for their field assistance and Barry Cooper for going out of his way to coordinate NPS assistance.

The helicopter was superbly piloted by Tom Hauptman of Sun Air Copters who donated several hours of flight time to the project. The fixed wing aircraft was flown by Col. Herb H. Hardin (CAP) who donated the better part of a Saturday to flying me around the crater, for which I am very grateful. I would like to thank the Cooperative Parks Study Unit, HALE and The Nature Conservancy for sharing the cost of aircraft.

Thanks are also due Carol Beadle for her assistance in finding reference materials in the Park's library and Dr. Stone and Rick Warshauer who loaned numerous references to me. I would also like to thank all the staff at Haleakala and especially Ted Rodrigues, Adele Fevella, Ron Nagata, Clifford McCall,

Superintendent Huntzinger, Eddie Grasa and Dr. Lloyd Loope for their help during the course of this project. Also of considerable assistance were Jim Jacobi, Lani Stemmermann, Peter Connally, Sam Kalalau Jr., and Ted Rodrigues Sr. to all of whom I owe a big mahalo.

Finally I would like to thank the U.S. Fish and Wildlife Service for use of their planimeter, Kaupo Ranch for permission to cross their property and Dr. C. W. Smith for considerable assistance in the preparation of this report.

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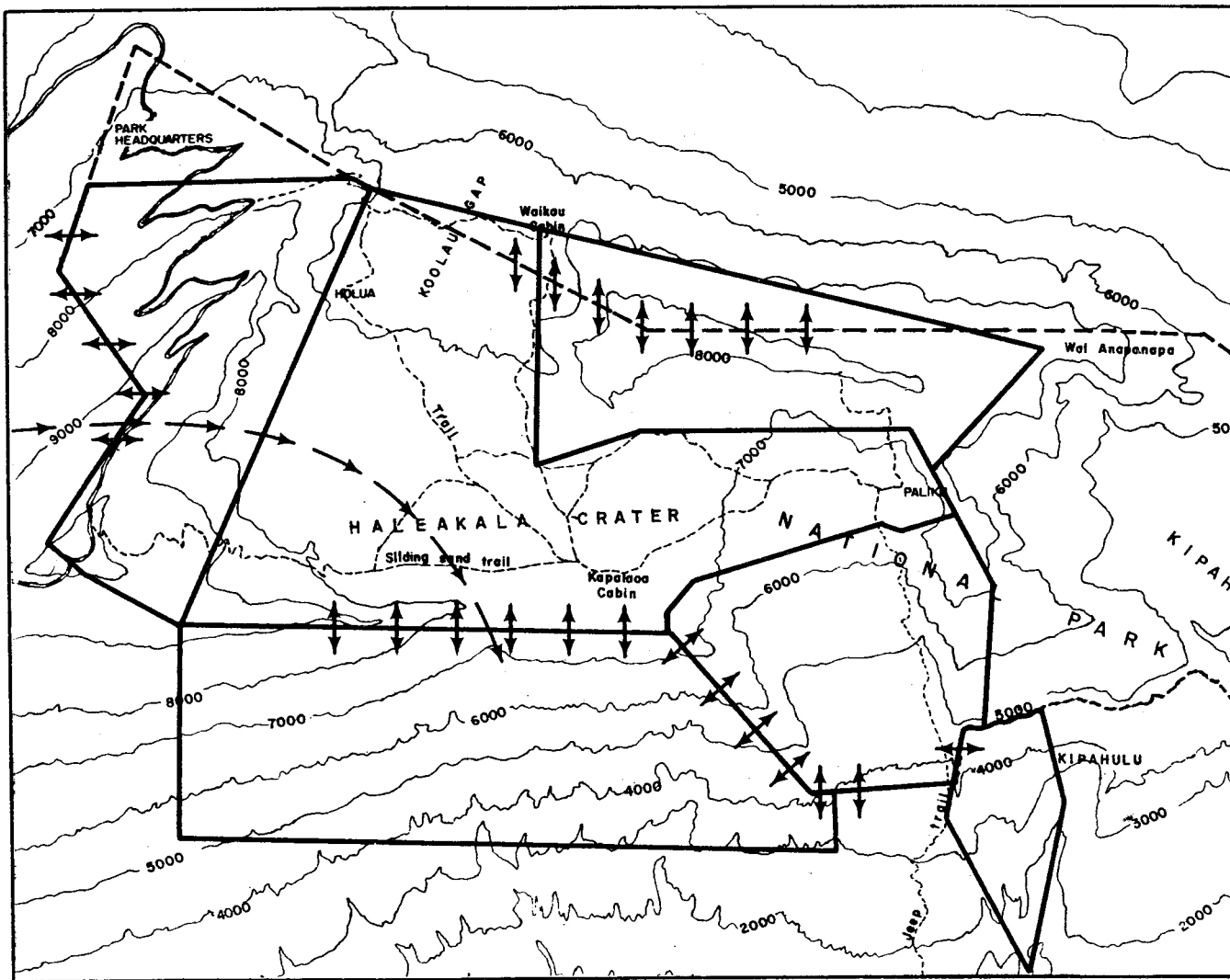


Figure 1. Map of the Crater District, Haleakala National Park showing the principal routes of feral goat entry and exit.

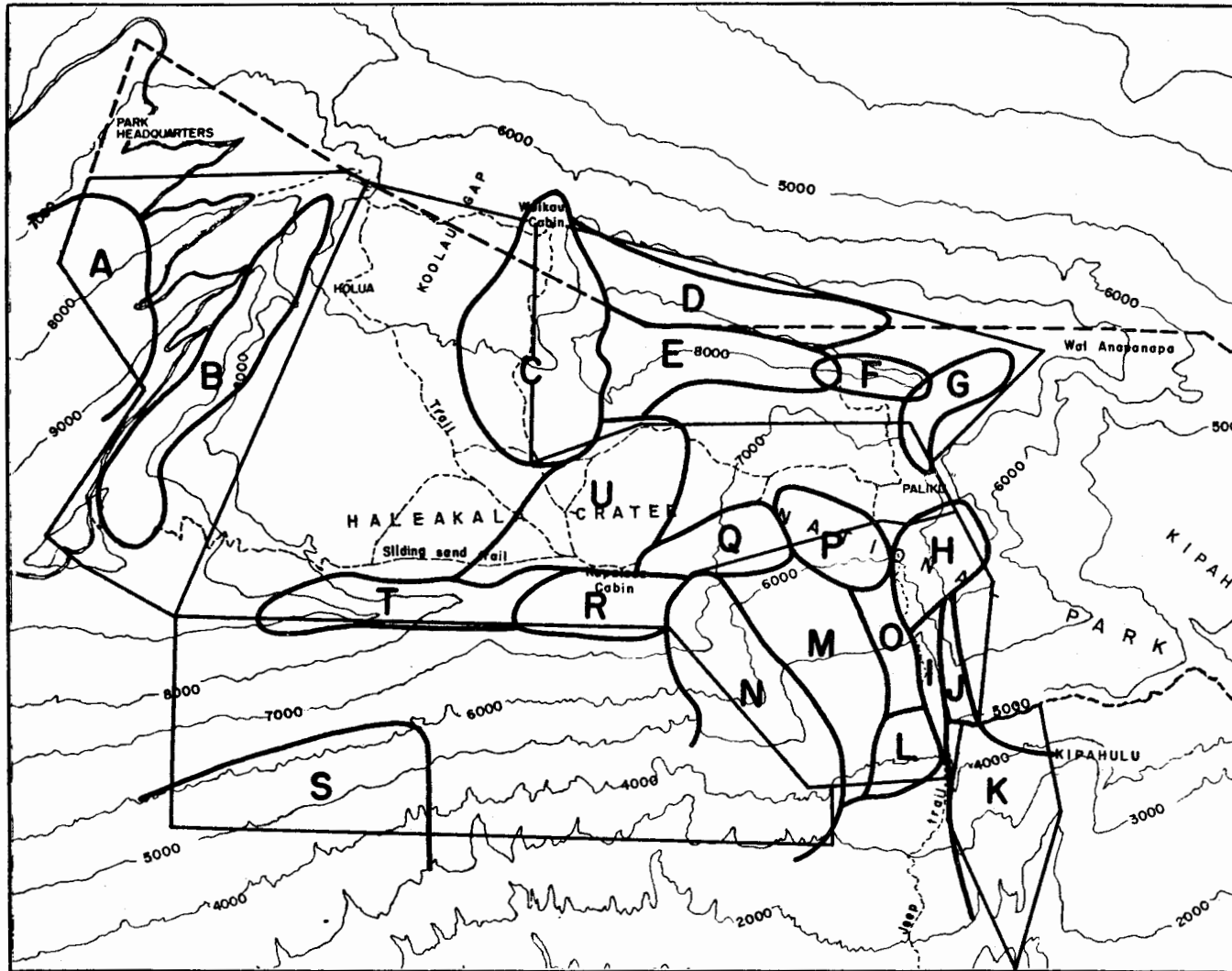


Figure 2. Map of the Crater District, Haleakala National Park showing the ranges of the principal goat herds in the Park in 1981. There is some overlap of ranges which has been omitted to preserve clarity.

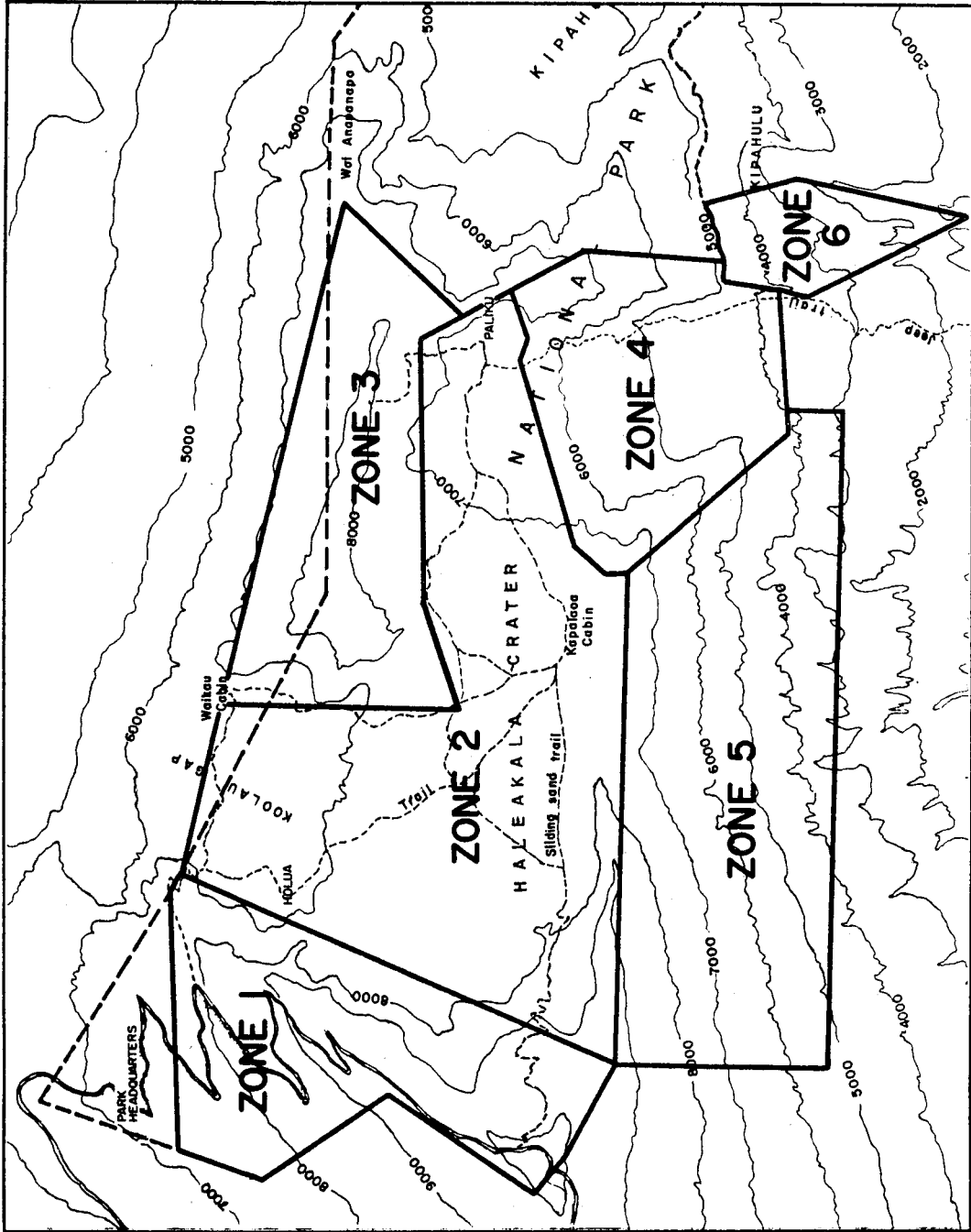


Figure 3. Map of the Crater District, Haleakala National Park showing proposed zones for managing feral goats in the Park.

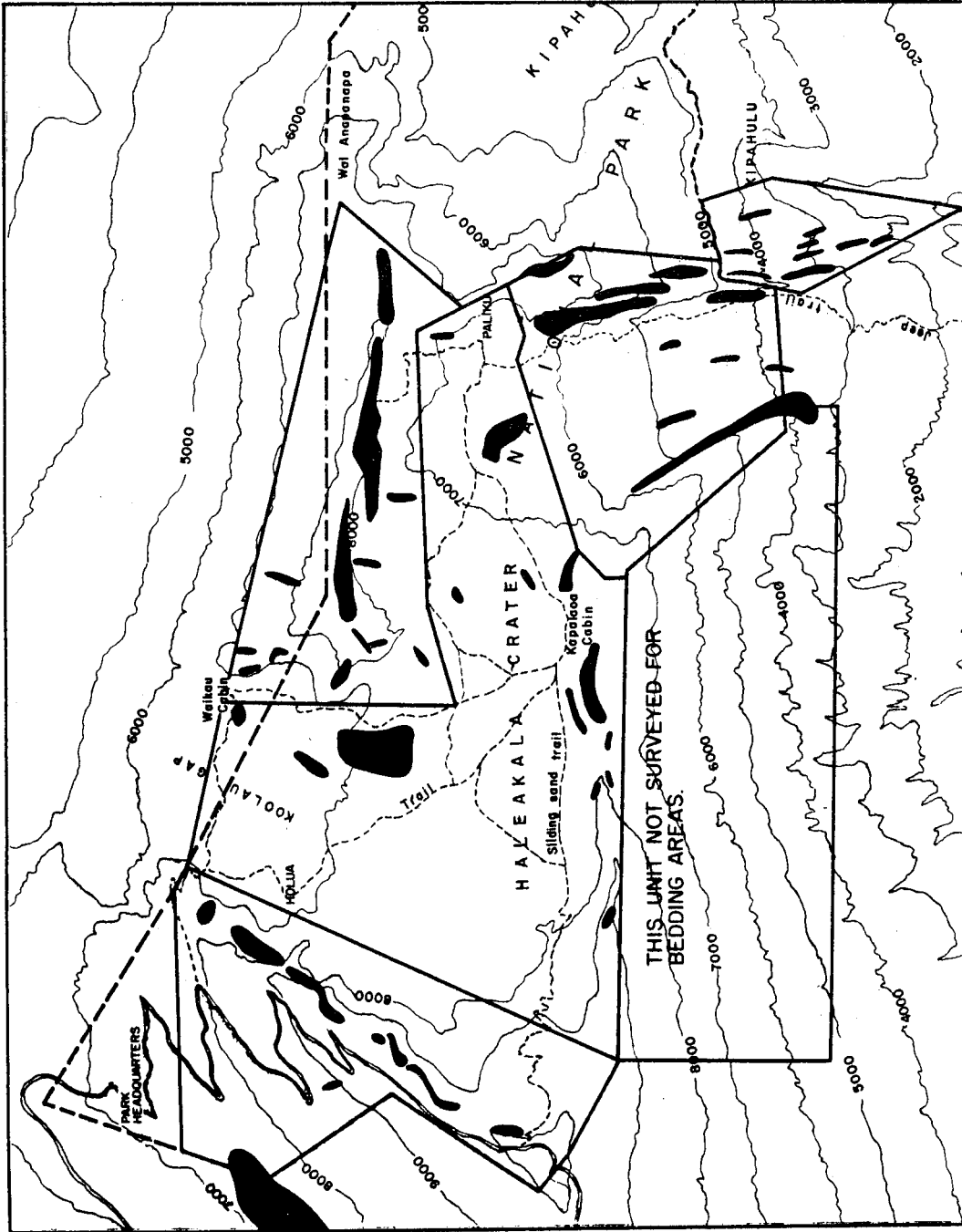


Figure 4. Map of the Crater District, Haleakala National Park showing the principal bedding sites of feral goats in 1981.

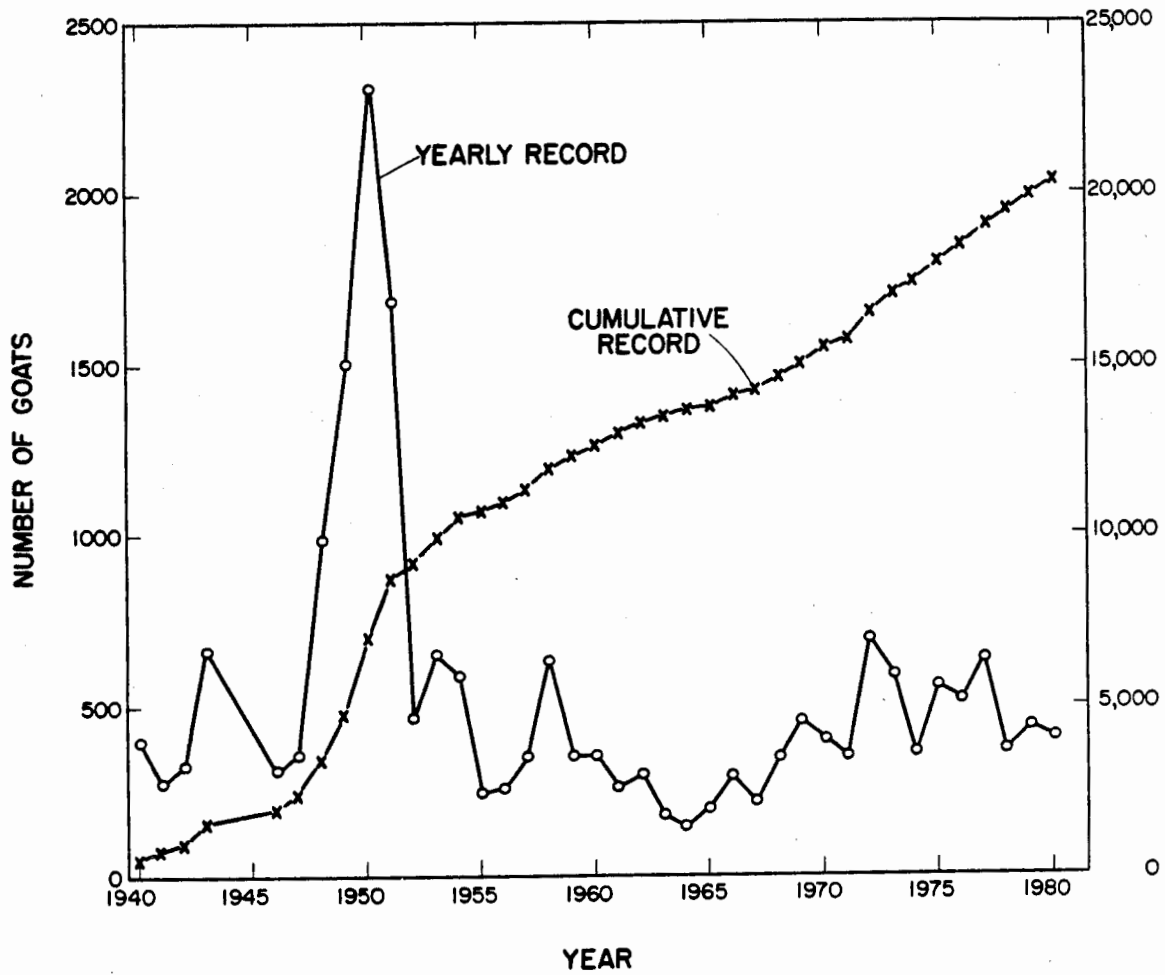


Figure 5. The annual and cumulative harvest of feral goats in Haleakala National Park from 1940-1980.

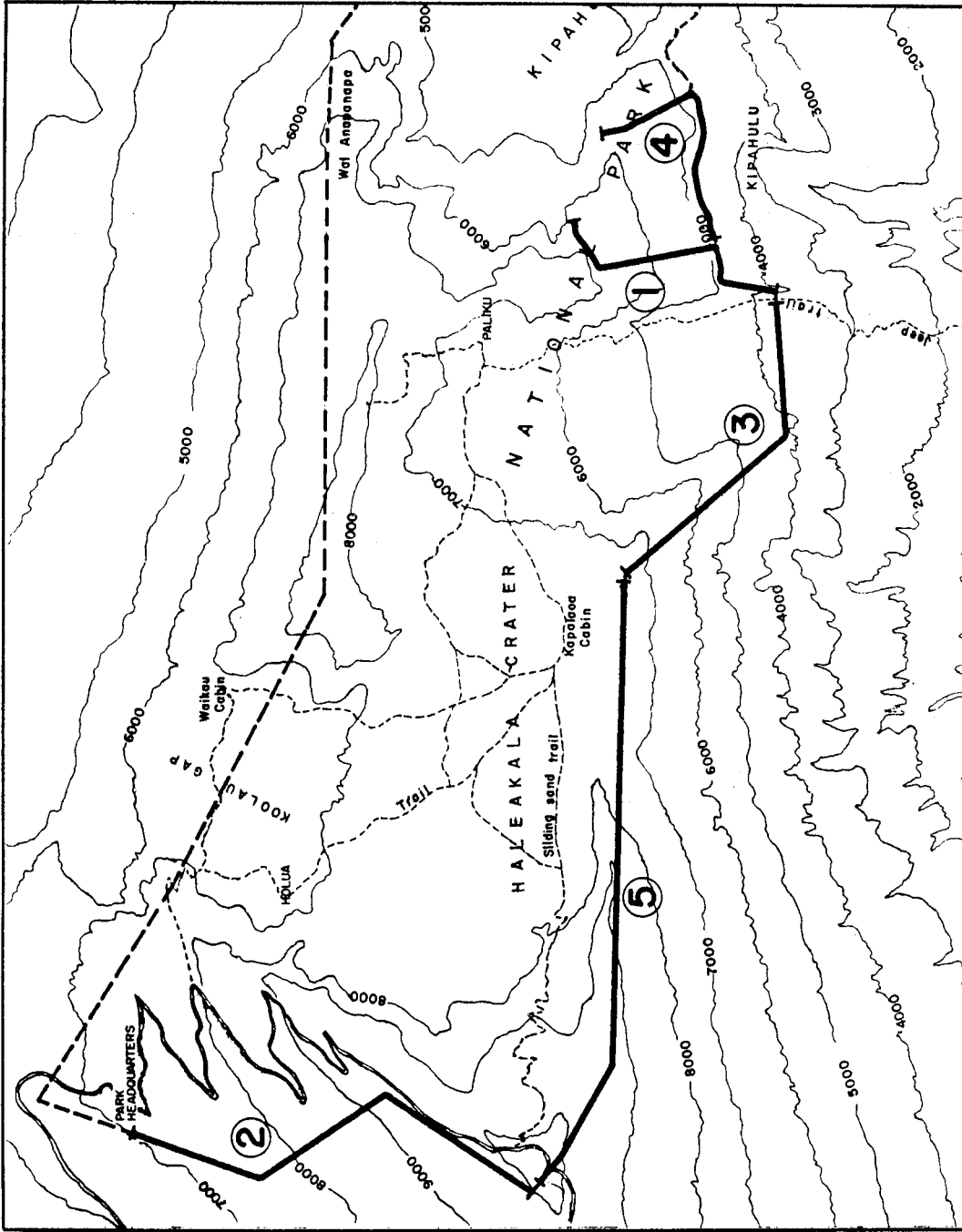


Figure 6. Map of the Crater District, Haleakala National Park showing the recommended sequence of boundary fence construction.

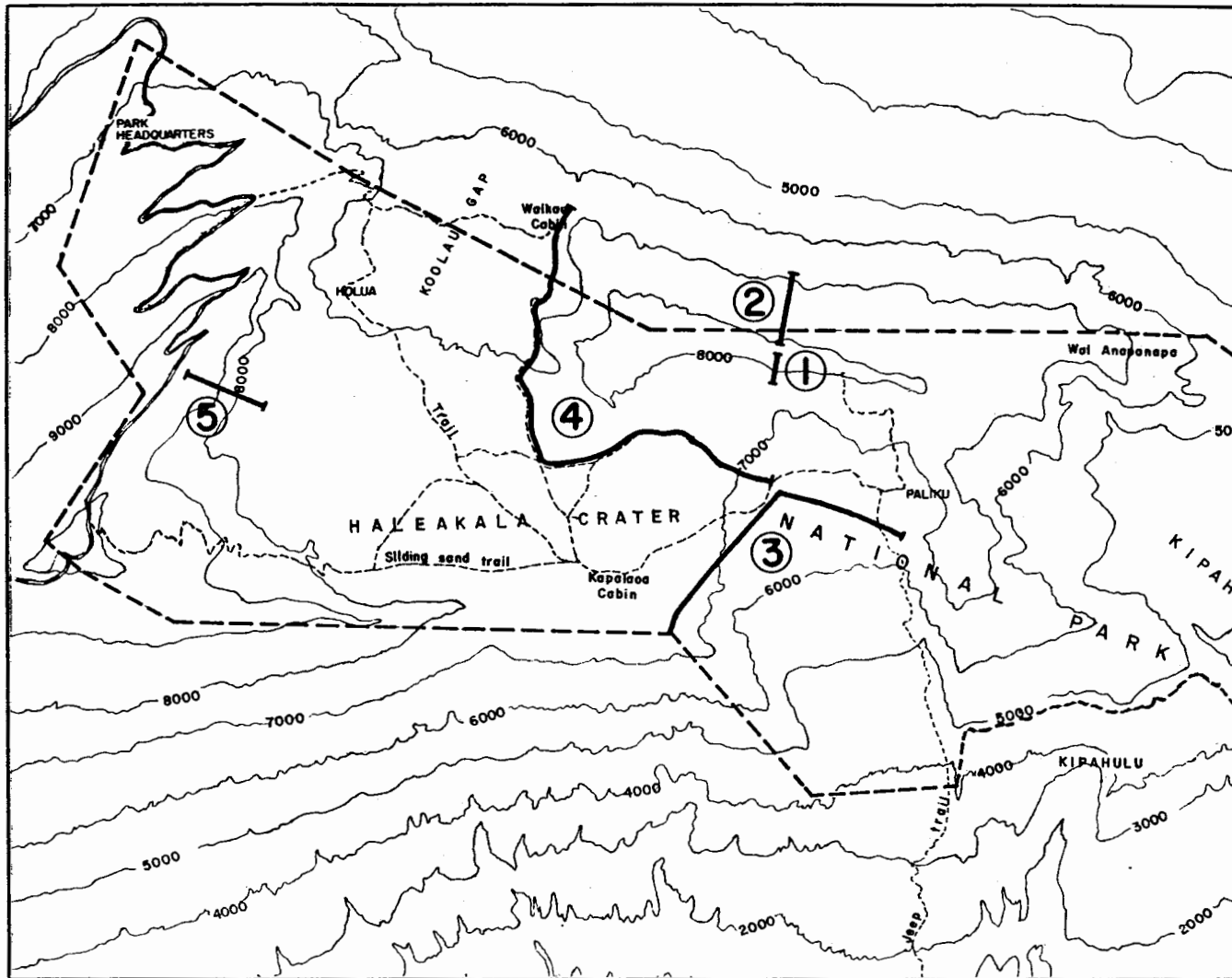


Figure 7. Map of the Crater District, Haleakala National Park showing recommended drift fencing inside the Park to aid feral goat control after the boundary fencing is completed.