

2016

To:

DEPARTMENT OF LAND AND NATURAL
RESOURCES
Division of Forestry and Wildlife

From:

THE KO'OLAU MOUNTAINS WATERSHED
PARTNERSHIP
UNIVERSITY OF HAWAI'I
Office of Research Services
Pacific Cooperative Studies Unit
University of Hawai'i at Manoa



FERAL UNGULATE MANAGEMENT, KO'OLAU RANGE, O'AHU: 2016 ANNUAL REPORT

Abstract

Feral goats (*Capra hircus*) are among the most harmful invasive species on oceanic islands, including Hawai'i. They are notorious for destroying vegetation, increasing erosion, and thriving in a range of habitat types. On O'ahu, naturalized populations are known from two locations in the Ko'olau Mountains, at the cliffs behind the town of Waimanalo and Kualoa Ranch. Goat control was initiated at Kualoa Ranch in 2009, with joint efforts by the Ko'olau Mountains Watershed Partnership (KMWP), the Hawaii Division of Forestry and Wildlife (DOFAW), and volunteers, but an interruption in the work in 2011-12 allowed the population to bounce back from a significantly reduced status. The goat population at Waimanalo, likely descendants of escapees from nearby farms, started to increase dramatically around 2012. Aerial surveys using forward looking infrared (FLIR) were conducted to gauge population size and distribution. Control methods included ground hunts and snares, with shooting being most effective. Between 2013 and 2016, a total of 2315 hours (97 hunter days) were spent controlling 71 feral goats at Kualoa Ranch and 1812 (87 hunter days) were spent at Waimanalo removing 200 goats and 20 mouflon sheep (*Ovis montanus*). Populations at both sites began to steadily decrease in 2015 as a result of collaborative hunts. No goats have been seen at Waimanalo since November 2015, and at Kualoa since March 2016. We will continue to monitor the area through a combination of ground-based binocular and aerial FLIR surveys, as well as game cameras to ensure we have not missed any animals. Photopoints show a rebound and regrowth of vegetation at Waimanalo, likely the result of ungulate removal. Photopoints and vegetation plots at Kualoa and Waimanalo will continue to be used to track changes in vegetation response over time.

Introduction

Feral goats (*Capra hircus*) are among the most harmful invasive species on oceanic islands, including Hawai'i. They are notorious for destroying vegetation, increasing erosion, and thriving in a range of habitat types. Through removal of plant cover, trampling of soil, and repeated use of trails, feral goats may increase erosion and encourage degeneration of watersheds (Yocum 1967). Removal of feral ungulates from areas managed for their values as native ecosystems in Hawai'i is a key step in reducing disturbance of native vegetation and preventing extinctions of rare plants. Due to their large physical size and gregarious behavior, feral goats are ideal candidates for successful eradications on small to midsized islands (Chynoweth et al. 2013).

Naturalized populations of feral goats are known from only two locations in the Ko'olau Mountains of O'ahu, both on the windward side. A population of feral goats was growing on the ridge behind the Oceanic Institute and Sea Life Park at Waimanalo for several years; the animals are likely the descendants of escapees from nearby farms. In 2012 it was also reported that mouflon sheep (*Ovis montanus*) were present in the area. The first wildlife control shoot for feral goats and sheep took place in April, 2013, with Hawaii Department of Land and Natural

Resources (DLNR) shooters and the Ko'olau Mountains Watershed Partnership (KMWP) providing spotters and keeping the general public out of the area.

The second population of feral goats in the Ko'olau's is at Kualoa Ranch. Feral goats have been controlled at Kualoa Ranch since 2009, with joint efforts by KMWP, DLNR, and volunteers. There was an interruption in the work in 2011-12 that allowed the population to bounce back from a significantly reduced status. KMWP resumed feral goat control at Kualoa Ranch in 2013.

With support from the Hawaii Invasive Species Council (HISC) and the state's Department of Land and Natural Resources (DLNR), control efforts for feral goat populations at Kualoa Ranch and Waimanalo were funded continuously from 2013 to 2016. The last feral goat was taken at Waimanalo in 2015, and the population at Kualoa Ranch was presumed to be around 5 animals at the end of 2015. Our objective for the grant period January 1 – December 31, 2016, was to continue shooting and trapping the remaining few goats at Kualoa Ranch with the goal of eradication, and continued monitoring of goats at Waimanalo to ensure continued eradication status. This report focuses on our management activities conducted during 2016, but also provides a summary of the results of ungulate control efforts at Kualoa Ranch and Waimanalo from 2013 to 2016.

Study Area

Both Kualoa Ranch and Waimanalo are located on the windward side of O'ahu (Figure 1). Kualoa is a privately owned 2,000 plus acre ranch. The valley floor at Kualoa has been highly disturbed due to ranching activities, yet this area still supports native mesic forest dominated by *Diospyros hillebrandii* (Lama) and *Metrosideros polymorpha* (Ohia), with documented occurrences of rare and endangered plants such as *Cyanea crispa*, *C. acuminata*, *C. truncata*, *Pteralyxa macrocarpa*, and *Eurya sandwicensis*, among others. The goats range includes ~400 acres of the ranch, in habitats dominated by steep vegetated cliffs and gulches (Figure 2).

The Waimanalo cliffs are located behind the Oceanic Institute, north of the town of Waimanalo. This area is substantially drier than the Kualoa Ranch site, with large expanses of native dry cliff vegetation, and ridge-tops with mesic native shrubland and forest. Feral goats and mouflon sheep range across ~200 acres in areas dominated by very steep cliffs (Figure 2).

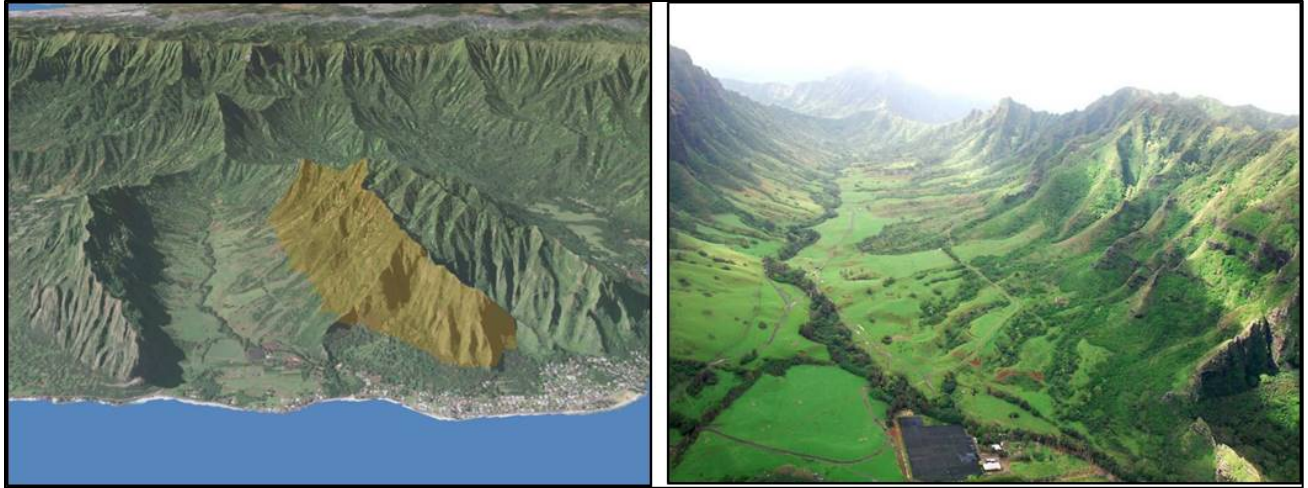


Figure 1: A) Aerial perspective of Kualoa Ranch with the ungulate control focus area highlighted in brown (left); B) Photo of Kualoa Ranch, with steep terrain rising abruptly from valley floor (right).

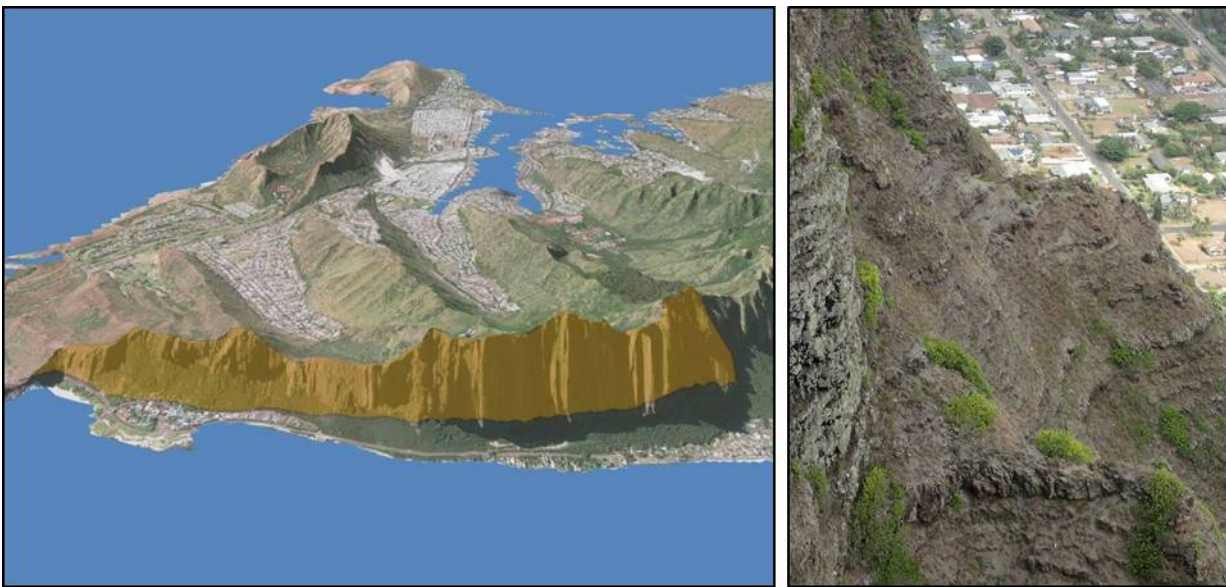


Figure 2: A) Aerial perspective of Waimanalo cliffs with the ungulate control focus area highlighted in brown (left); B) Photo of steep, rugged terrain at Waimanalo (right).

Methods

In order to eradicate all of the feral goats from Kualoa Ranch and Waimanalo cliffs, we employed a multi-faced approach throughout the control campaign. Aerial surveys using forward looking infrared (FLIR) were conducted to gauge population size and distribution of both populations. Ground hunts with KMWP and DOFAW staff and contractors were initially employed to remove animals (2013 – 2015). As goat numbers decreased, we employed traps (snares) to increase removal rates at the Kualoa site. The final phase of eradication was

confirmation of the absence of goats using aerial and ground (binocular) surveys and game cameras.

Kualoa Ranch: A control hunt with KMWP and DOFAW staff was undertaken at Kualoa Ranch in January 2016. Access to control sites at Kualoa Ranch was generally via helicopter due to the steep and rugged terrain. In addition to hunting, 250 traps were set along established goat trails and other areas of high activity. Since the goat population was at such low levels by the start of 2016, the majority of effort was spent scoping and monitoring for continued goat presence. Scoping consisted of ground surveys with forward looking infrared (FLIR) and binocular scoping from suitable vantage points. Three game cameras were placed in areas known to be frequented by goats along old game trails to monitor any movement in the area. KMWP staff also began to monitor vegetation response with the establishment of five new photopoints (Figure 3).

Waimanalo: The last known feral goat was recorded at Waimanalo in November 2015, therefore all activities conducted at this site in 2016 were related to monitoring. Similar to Kualoa Ranch, an aerial survey with FLIR was conducted as well as ground surveys and binocular scoping from suitable vantage points. Three game cameras were deployed to monitor continued goat presence. Five photo points, established in 2015, were revisited nearly one year after the last feral goats were removed (Figure 4).

Kualoa Ungulate Control 2016

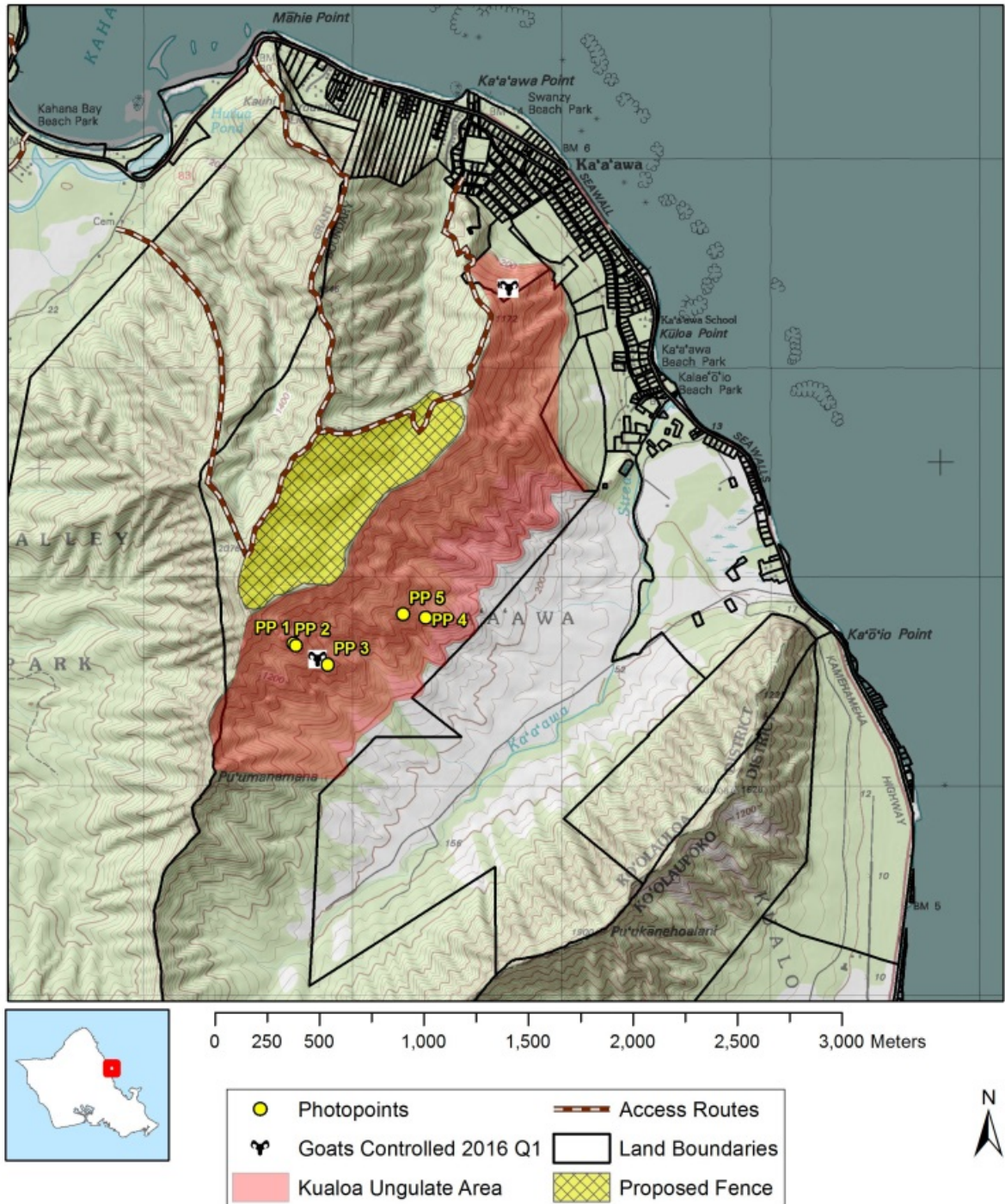


Figure 3. Ungulate control area at Kualoa Ranch with photopoints locations and sites of feral goats removal in 2016.

Table 1. Feral goats and sheep controlled between 2013 and 2016 at Kualoa and Waimanalo.

Unit/Species	2013 - 2014	2015				2016				Total
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Kualoa Ranch - goats	35	11	11	10	1	3	0	0	0	71
Waimanalo - goats	126	43	18	12	1	0	0	0	0	200
Waimanalo - sheep	20	0	0	0	0	0	0	0	0	20
Total	181	54	29	22	2	3	0	0	0	291

From 2013 to 2016, a total of 2315 hours (97 hunter days) were required for the removal of 71 feral goats at Kualoa Ranch, with 167 hours in 2013, 570 hours in 2014, 1243 hours in 2015, and 335 hours in 2016 (Figure 5). This includes aerial and ground scouting prior to control hunts, active hunting, and time spent setting and checking traps. Between 2013 to 2015, average hours/goat removed ranged from 19.6 to 55.6. With populations greatly reduced by the end of 2015, more time was spent searching and the effort required per removal doubled to 111.6 hours/goat in 2016.

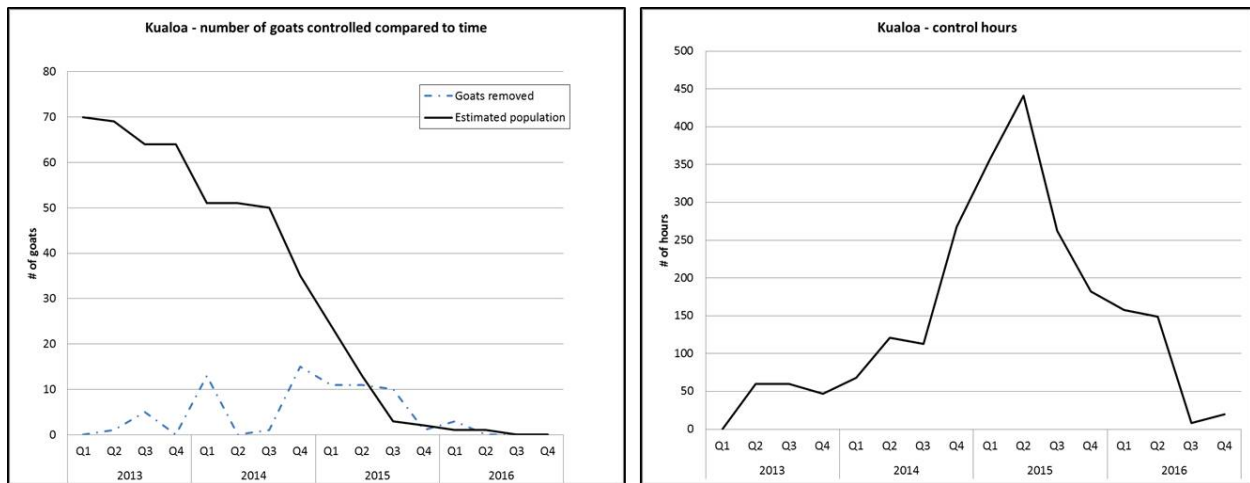


Figure 5. Kualoa Ranch goat control effort, 2013 – 2016.

Waimanalo: A total of 200 feral goats and 20 mouflon sheep have been removed from Waimanalo since the project began in 2013. The last mouflon sheep at Waimanalo was sighted and removed in 2014. Since HISC began supporting the project in January 2015, 74 goats have been removed from this site (Table 1). The last feral goat was removed from Waimanalo on November, 2015, and this population is now considered eradicated from the unit. Twenty-eight% (n = 56) of the goats removed were female, 24%, (n = 49) were male, and 48% (n = 95) were unknown. All animals were removed by shooting.

From 2013 to 2016, a total of 1812 hours (87 hunter days) were required for the removal of 200 feral goats from Waimanalo, with 369 hours in 2013, 486 hours in 2014, 846 hours in 2015, and 120 hours in 2016 (Figure 6). This included aerial and ground scouting prior to control hunts and active hunting; effort in 2016 was for continued scouting and monitoring. Between 2013 to 2015, hours/goat removed ranged from 6.8 to 11.4, with an average of 8.8 hours/goat. During 2016, KMWP staff spent 120.5 hours during 12 trips conducting ground and aerial surveys, checking game cameras and monitoring vegetation.

Vegetation at Waimanalo seems to be positively responding to the removal of feral ungulates (Figure 7). We expect to see similar response at Kualoa Ranch over the next year post-eradication.

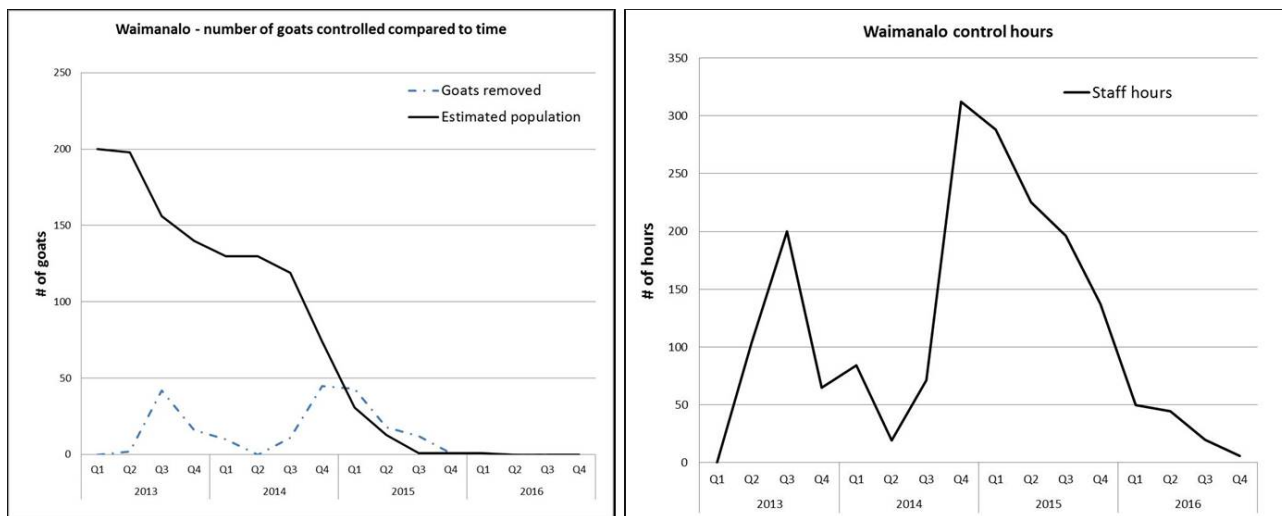


Figure 6. Waimanalo goat control effort, 2013 – 2016.



Figure 7. Photo point at Waimanalo taken on August 4, 2015 (left) and retaken on August 11, 2016. showing regrowth of grasses and shrubs.

Discussion

We are confident that all feral goats and sheep have been successfully eradicated from Waimanalo and are gaining increasing confidence that Kualoa Ranch is also goat free. This is a huge success story for watershed protection in the Ko'olau Mountains. During the next several months, we will begin to remove the remaining 150 traps from Kualoa Ranch as we begin to withdraw effort in that unit. As part of our exit strategy at both Kualoa and Waimanalo, KMWP will continue to monitor both areas through a combination of bi-annual ground-based binocular and aerial FLIR surveys, and game cameras in high use areas, to ensure both units remain ungulate free.

In an interesting collaboration, KMWP began communicating with hang gliders who launch from Kamehame Ridge at Waimanalo and have an excellent view of much of the area. Reports of goat sightings from the hang gliders helped supplement ground recon trips. We will continue to maintain contact with this group over the next few years, to ensure no additional goats are spotted from the air.

We employed different control strategies at Waimanalo than we did at Kualoa Ranch. Due to permitting constraints from the land owner, the only eradication method that was admissible at Waimanalo was ground-based hunting. At Kualoa Ranch, a combination of ground hunting and trapping was employed. Less overall effort was required to achieve the goal of eradication at Waimanalo, even though the feral goat population was higher there than Kualoa Ranch (200 vs. 71). There are likely numerous factors contributing to the success at Waimanalo including: the range of the animals was much smaller at Waimanalo (200 acres) than Kualoa (400 acres) so the animals were more constrained in their distribution; Waimanalo is less vegetated than Kualoa affording easier detection of goats and fewer places for them to seek refuge once disturbed; and the terrain is not as steep so hunting from above was a viable option.

At Kualoa Ranch, the terrain is much steeper and more highly vegetated, therefore hunting from above was not always feasible. Once disturbed, goats would seek refuge in dense vegetation and not be seen for the remainder of the hunt. In this case, we found that the use of multiple control methods were crucial to the successful eradication of goats from this unit. As the effectiveness of ground hunting diminished, trapping was employed in order to increase our chances of success.

Monitoring photopoints already show a rebound and regrowth of vegetation at Waimanalo, likely the result of ungulate removal. Photopoints at Kualoa and Waimanalo will continue to be used to qualitatively track changes in vegetation response over time. In addition, paired point intercept vegetation plots as described by Stone et. al. (1992) will be installed in both units to quantitatively measure changes in native and non-native vegetation response.

Acknowledgements

The successful eradication of goats from both Waimanalo and Kualoa would not have been possible without funding support from the Hawaii Invasive Species Council (HISC) and the Hawaii Department of Land and Natural Resources (DLNR). We are especially thankful to Mary Ikagawa, former KMWP Coordinator, who initiated this work in 2013. Josiah Jury, KMWP Ungulate Management Lead should be recognized for his leadership and determination in seeing the project through with such positive results. We would especially like to thank those that spent countless hours in the field including: Ryan Peralta, Jason Misaki, Chris Miller, Jared Char, and Virgil Torres, DOFAW; contractors Brian Akina and Pat Conant; and KMWP field crew and interns Titus LaFredez, Josh Serrano, Chelsea Arnott, Richard Pender, Bryan Buckingham, Jared Clapper, Josh Serrano, Maggie Berger, Alison Crowley and Pua Heimuli. We also thank the staff at Kualoa Ranch, especially John Morgan and Taylor Kellerman, for their continued support of this project.

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