Feral Pig Control in Hawaii: Evolution of Control Methods

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ABSTRACT: The Nature Conservancy (TNC) of Hawaii manages preserves on all of the major Hawaiian Islands, effectively protecting over 36,000 acres. Through the development of partnerships, TNC has fostered and cared for over 200,000 acres of watershed lands throughout the state. Hawaii's native forests evolved without the presence of large mammals. In Hawaii, there are only 2 native species of mammals: the Hawaiian hoary bat and the Hawaiian monk seal. The historical lack of large native mammals has left Hawaiian native forests vulnerable, unable to evolve defenses and recover from damage caused by feral pigs and other feral ungulates. Feral pig control in Hawaii is challenging because of the remoteness of the rainforest locations with diverse topography and constantly changing weather conditions. These challenges, among others, have forced managers to integrate and utilize many different methods of control in order to maintain zero-tolerance levels within TNC preserves and throughout the managed watershed areas.

KEY WORDS: Hawaii, invasive animal control, feral pigs, ProHunt, *Sus scrofa*, techniques, wild pigs

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INTRODUCTION

The Hawaiian Islands are renowned worldwide for incredible species diversity. Thousands of miles from the nearest land mass, the Islands' native forests and oceans are among the world's biological treasures, sheltering more than 10,000 native land species and more than 7,000 unique ocean species – more than 90% of which are endemic or found only among these islands (TNC 2014). Hawaii's native species evolved over millennia without predators or competition, and therefore did not develop protective qualities such as scent, flight, thorns, or toxins; this leaves them extremely vulnerable to change. Today, more than half the native forests, plants, and animals in the Hawaiian Islands are either extinct or highly threatened.

One cause of high extinction rates and threats to unique island species is the arrival and proliferation of humans and nonnative species. Nonnative vertebrates can directly or indirectly lead to species extinction, and land managers globally must address these threats with ambitious efforts to protect remaining native species (Sax and Gaines 2008). Specifically, feral ungulates (hoofed animals such as pigs, cows, deer, etc.) have been a focus of land managers in many areas around the world, including the Hawaiian Islands.

Humans have been occupying the Hawaiian Islands for more than 1,500 years and have dramatically changed the Hawaiian landscape. Anthropologists believe that Polynesians from the Marquesas and possibly the Society Islands first populated the Hawaiian Islands sometime between 300 and 500 A.D. One of the earliest dated archaeological sites excavated is the Bellows or Waimanalo Beach site on Oahu, which appears to have been initially occupied between 450 and 500 A.D., or possibly as early as 327 A.D. Human land uses such as agriculture, water diversion, ranching, and urban development have altered native habitats. Nonnative species have been both accidentally and intentionally introduced.

Polynesians intentionally introduced animals such as the pig (*Sus scrofa*), the dog (*Canis familiaris*), and the chicken (*Gallus gallus*). They also brought with them, probably inadvertently, the Polynesian rat (*Rattus exulans*), 4 species of geckos (*Lepidodactylus lugubris*, *Gehyra mutilate*, *Hemiphyllodactylus typus*, and *Hemidactylus garnoti*), 3 types of skinks (*Cryptobleparus*, *Lipinia*, and *Emoia*), and land snails (*Lemellaxis gracilis*, *Lamellidea oblonga*).

While early European visitors such as Cook, Ellis, and Douglas all wrote of seeing domesticated pigs around the homes of Hawaiians, botanists such as Macrae and Menzies, who did considerable hiking in the Islands and wrote detailed journals, never mentioned seeing wild pigs in the native forests of the Islands. For example, Menzies described forests of the Kona slopes of Hawaii that were so dense and filled with ferns and undergrowth that he was unable to walk through them, suggesting an absence of feral pigs, which typically damage undergrowth and open up the forest floor (Pratt and Stone 1990).

The European domestic pig, like the domestic goat (*Capra hircus*), was introduced to Ni'ihau during Captain Cook's first voyage, February 2, 1778. Of the early European domesticated introductions that became feral, cattle (*Bos taurus*), goats (*Capra hircus*), pigs, and sheep (*Ovis aries*) were – and continue to be – very destructive to native ecosystems. Other more recently-introduced ungulates such as mouflon sheep (*Ovis musimon*), axis deer (*Axis axis*), and mule deer (*Odocoileus hemionus*) have also caused the degradation of native forests in certain areas (Pratt and Stone 1990).

Since the introduction of nonnative animals, plants, and human use impacts, numerous governmental and non-governmental organizations have invested tremendous effort to halt species loss in the Hawaiian Islands. Early on it was well documented that feral ungulate control and fencing was needed to preserve natural areas where native species still persisted.

METHODS

Early strategies for feral pig control focused on 2 major tools and began in the early 1980s. Fencing and trapping were combined and contributed to the majority of control being done in Hawaii preserves. The fencing strategy has not changed much over the years, with high-priority high-output watershed areas being the focus for large-scale fencing projects. Once the fencing of a priority area had been completed, control of feral ungulates began and consisted primarily of trapping due to the remoteness of these areas. Fencing in remote areas requires a high degree of persistence and patience. High elevation native dominated forest, where access is limited to helicopters, involves complex logistical planning in order to insert materials and staff. Heavy-duty weather resistant fencing materials are a must for these areas that consistently see adverse weather conditions. Because of the logistical complexity, high cost of materials, and person-hours involved, fencing although highly effective has proven to be a very expensive management tool.

Historically, box traps and snares have been the predominant forms of trapping in use for control activities. The use of cable snares set in high-traffic areas allowed managers to saturate an area where the snare could function as a control tool around the clock. Although snaring was and still is a controversial tool in Hawaii, it became the most effective tool as it is cost-efficient and requires a low amount of staff hours. Box traps proved ineffective at controlling large pig populations in remote areas. Moving away from box traps, corral traps have been used and have proven to be much more effective. The current and most effective design incorporates a circular panel trap with a wing section near the gate, used to funnel the animals into the trap. The circular design allows multiple pigs to enter the trap and minimizes impact on corners, which proved to be weak spots in the box trap design, where pigs would concentrate most of their effort at escaping. Newer designs have incorporated remote triggers and wider gates to improve effectiveness and allow traps to be deployed in more remote areas.

Volunteer community hunters and staff hunting supplied the other means of control. On-the-ground hunting proved difficult in remote areas where community hunters could not access, and staff needed to utilize helicopters in order to access certain areas. Early staff hunts were primarily opportunistic and were used only in areas where snaring was not an option. Other challenges arose when animal numbers began to drop and community hunter interest began to taper off. Even when offering a bounty per pig, finding community hunters who would consistently hunt became difficult. Another challenge presented itself as more and more management activities piled up and data management became increasingly important.

Navigation and data management proved to be challenging in the early days where managers relied on hand-drawn maps, a compass, and a data sheet to locate and keep track of snares and navigate challenging terrain. With the advent of GPS/GIS technologies in 2005, managers were able to transition to this new technology in order to get a better understanding of the extent and effectiveness of the old snaring strategies. This technology gave rise to more informed management, allowing the detailed analysis of effort and effectiveness on the ground.

An influential project came to fruition in 2007, effectively paving the way for Nature Conservancy managers as well as managers throughout the state to incorporate new technologies and learn from experts within the industry. A statewide plan, The Forest Bird Recovery Project (MFBRP 2014), aimed to remove all ungulates from managed areas within the entire state. This became a pivotal point in the evolution of control techniques in Hawaii and opened funding pathways allowing managers to improve on existing management methods at a rapid pace. To achieve and maintain a lofty goal of zero tolerance in managed areas, managers needed to utilize all of the techniques they have been using as well as to implement new strategies and tools.

In conjunction with the State of Hawaii's Forest Recovery Project, The Nature Conservancy (TNC) and partners, The East Maui Watershed Partnership, launched the GoDeep initiative. The GoDeep goal stated: "TNC and EMWP will dramatically decrease ungulates throughout the 12,000-acre focal area to achieve near zero damage and activity levels within 3 years, and set up an on-going 'no tolerance' management program that will maintain near zero damage and activity levels" (TNC 2006). During this 3-year initiative, TNC hired a professional hunting team from New Zealand (Prohunt Ltd, Waikato, NZ) to hunt throughout the state and rapidly decrease the feral pig populations in TNC preserves (Figure 1). The Prohunt control effort focused on several field objectives outlined in Table 1 and allowed staff and local hunters an opportunity to learn new techniques while in the field.

Table 1. Maui ProHunt project areas and objectives.

Project Areas	Field Objectives
Waikamoi Preserve	Ground hunting, trapping, GPS collaring, and ear tagging
Kapunakea Preserve	Ground hunting, trapping, GPS collaring, and ear tagging
Kahakuloa (NAR)	GPS collaring and tracking for data collection

Additional project objectives for all areas:

- Local Hawaii staff hiring and training
- TNC staff training in field work, team hunting, helicopter use, and dog handling
- Evaluate feasibility of TNC dog program
- Contribute to written, strategic ungulate control plans for East Maui Watershed Partnership and Kahakuloa NAR
- Weekly progress reports, bi-weekly strategic planning meetings, and business advisory group meetings

Adaptive sweeps and hot-spot hunting with highly trained hunting dogs comprised the majority of Prohunt's methods for on-the-ground hunting efforts and contributed to the majority of dispatched animals in Waikamoi Preserve on the island of Maui (Figure 2). Sweeps were done in an intensive and systematic manner so that all of the area is hunted and all the target animals are put at risk. This method contributes to a higher

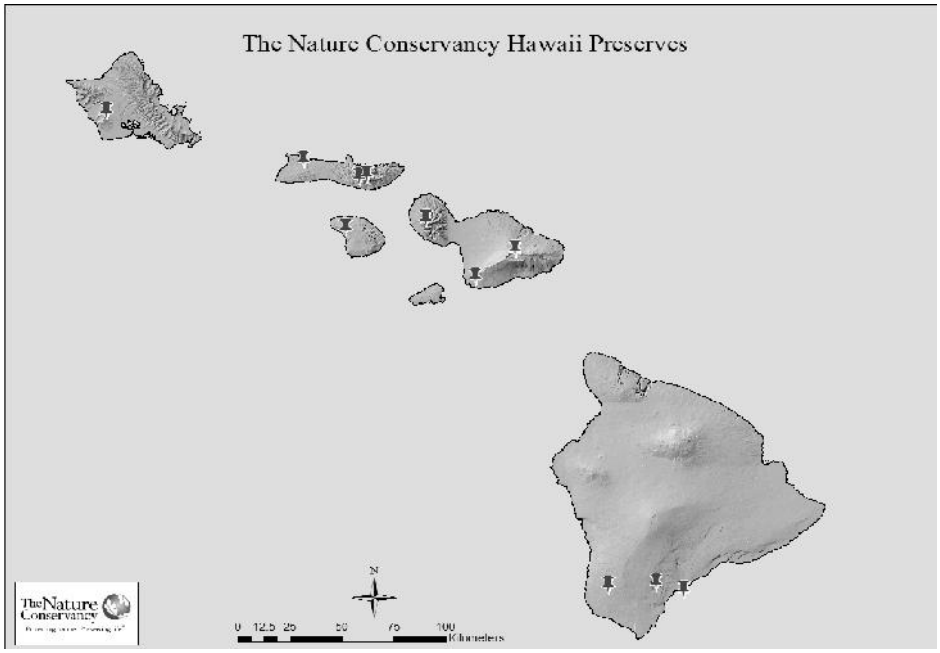

Figure 1. Nature Conservancy reserves in the state of Hawaii.

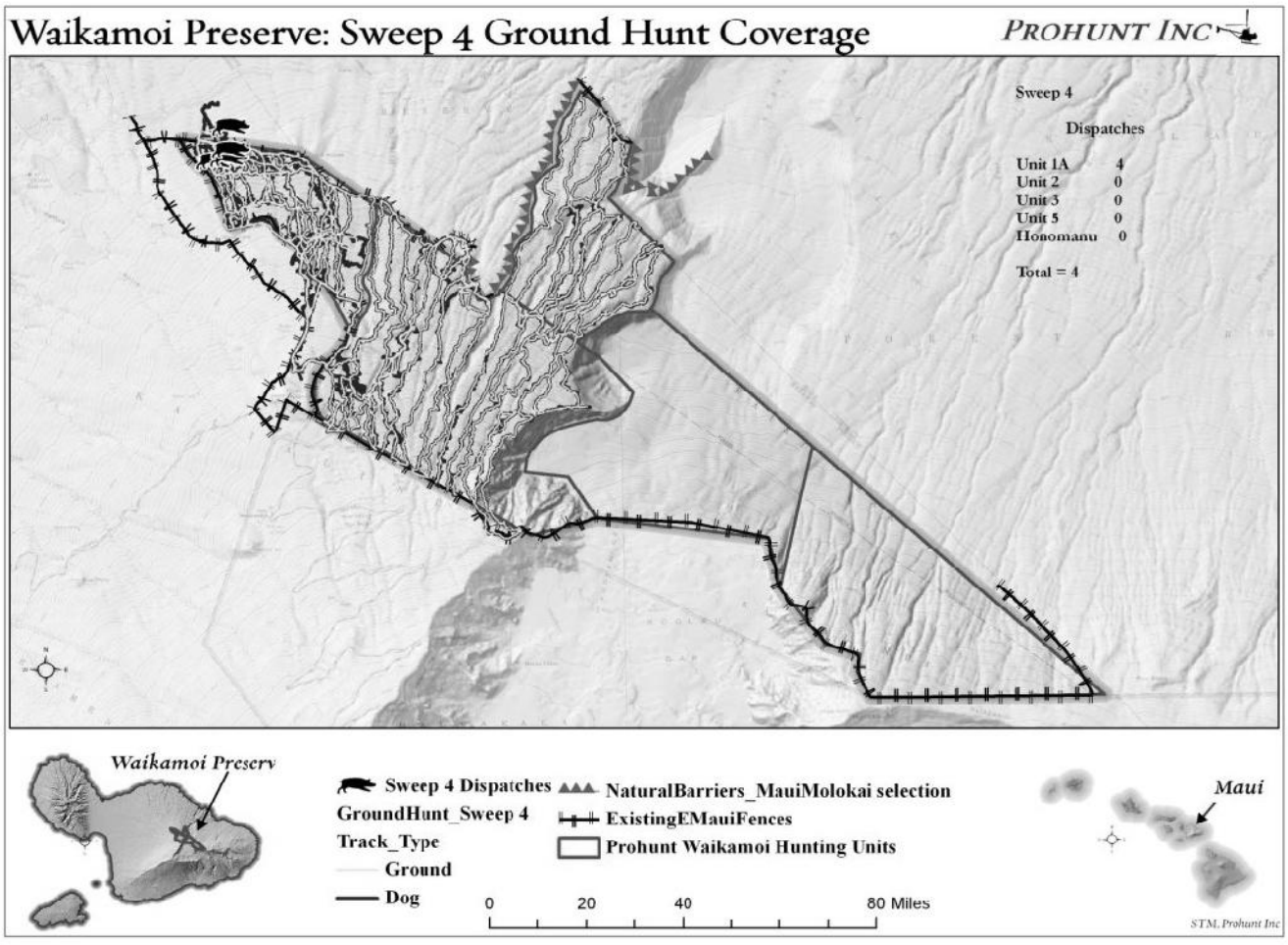

Figure 2. An example of hunting coverage displaying parallel transects spaced 150-200 m apart.

success rate of dispatches and less targeted animals becoming educated or aware of being hunted. Hot-spot hunting is used as a method of quality assurance to gauge the relative effectiveness of the main hunting program and targeting known or suspected survivors from the hunting sweeps (Prohunt 2008).

The Prohunt team also effectively used trapping as a means of collecting animals to collar for a catch-and-release study. The trapping design used by Prohunt consisted of a corral design fitted in a circular shape (Figure 3). The trap is outfitted with a one-way gravity-fed gate and a small wing to funnel animals through the entrance. The trapping was successful in certain areas throughout the state, although failure rates were high for the GPS collars. The collars were deployed as part of a 120-day period in order to track the movement of the animals throughout the preserves. Several different collar redesigns were attempted, and although some usable data were retrieved, the failure rate for collars deployed for the full 120-day study was 100%. According to the manufacturer, the failures resulted from housings that had problems with sealing, faulty release mechanisms, faulty download antennas, and production problems with the wiring of 5 separate circuit boards. Most of these problems persisted throughout the study even with updated models, but the most significant problem with the collars was the integrity of the housings, which allowed the ingress of moisture damaging both the GPS logging and VHF signal.

Figure 3. Prohunt corral trap design.

RESULTS / MOVING FORWARD

Significant progress has been made in order to streamline management techniques and instill fresh knowledge as well as new technology to managers throughout the state. As a direct result of the Forest Bird Recovery Project and the GoDeep initiative, TNC was able to learn some fundamental lessons and gain a vast amount of applicable knowledge pertaining to feral pig management. Some if not all of these lessons are now being applied in the day-to-day management at many of TNC Hawaii's preserves. Looking at historical catch records for Waikamoi Preserve (Figure 4) we see a dramatic decline in catches over a 24-year period, specifically between the years of 2008 and 2010 when many of these techniques were implemented.

The TNC dog program has become an integral part of post-Prohunt management for several island programs. Although Prohunt removed a large number of feral pigs on Maui, some animals still remained in fully enclosed units. Utilizing the newly-formed dog program immediately after the contractors left allowed the team to continue hunting the last animals as well as monitor Prohunt's progress, without losing any ground gained from the consistent hunting efforts of the contractors. Employing techniques such as systematic sweeping with dogs, hot-spot hunting, and utilizing the latest GPS tracking technology allowed staff to fully integrate these procedures into their management. Since the dog program's inception, staff assisted partnering agencies with hunting in their reserves as well as helping to build their capacity to hunt in a more effective manner.

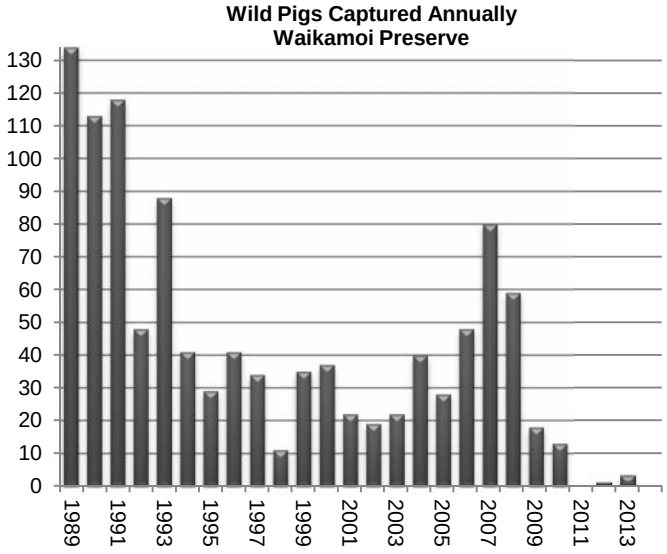

Figure 4. Number of wild pigs captured annually within TNC's Waikamoi Preserve, 1989 through 2013.

Trap designs learned have also been utilized and deployed with varying degrees of success. Deploying traps in areas with relatively low ungulate activity have proven ineffective compared to a higher success rate when deployed in a new area with a large initial population. Moving away from the historically ineffective box trap design and moving toward a corral trap design has greatly improved success rates and amount of captures. Trap design continues to evolve as newer technology is introduced and more knowledge is made available, the most recent advancement being remote triggers and wider gates. An entire "sounder" (or group of pigs) can be trapped utilizing an 8-ft gate and a remote trigger system when properly pre-baited and monitored. The most effective methods have involved pre-baiting an area with a known population, effectively familiarizing the sounder to a specific feeding time and then building the trap around the feeder, utilizing a wider gate and a remote trigger system. One of the key factors at successfully trapping an entire sounder is to monitor the area and trap at all times. This, until recently, has proven difficult, but

with the advent of game cameras and the swiftness at which the technology improves, monitoring is becoming increasingly effective at determining where and when to set a trap.

Game cameras are being utilized not only for trap monitoring but for a whole host of management activities. The early models were able to take pictures via a motion detector, but they were unreliable and the pictures were of poor quality. Newer technology incorporated into some of the more recent models includes features that allow pictures to be sent via a cellular signal to either an email address or a mobile phone. This allows managers the ability to track animal movements and respond instantly to either a triggered trap or any ingress that may occur within a fenced unit, greatly increasing the success rates of hunting activities.

Some of the most exciting technology that is rapidly being deployed for ungulate control purposes in Hawaii is Thermography. Infrared thermography (IRT), thermal imaging, and thermal video are examples of infrared imaging science. Thermographic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 9,000-14,000 nanometers, or 9-14 µm) and produce images of that radiation, called thermograms (OMICS International 2014). Since infrared radiation is emitted by all objects above absolute zero, thermography makes it possible to see one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night. Although primarily used for military, surveillance, and commercial property inspection applications, thermal imagery is gaining in popularity for use in wildlife management. Thermal imaging affords managers the opportunity to survey large areas in a short amount of time, thus increasing efficacy of monitoring operations. Limitations to this technology do exist, and as for now thermal imagery has a difficult time penetrating dense canopy cover. Though limitations are present, thermal imaging allows, in certain conditions, the user to detect more than can be seen with the naked eye.

Control techniques in Hawaii have evolved from humble beginnings and rudimentary practices. Many of these techniques are still in use today, although they have been improved upon over the years and represent a shift in technology and updated emphases to reduce if not eliminate populations in managed areas. Resource managers, now more than ever, have access to technology and information that was previously unavailable. As technology continues to grow at an exponential rate, resource managers must adapt to the changing landscape and remain vigilant in their fight to protect the natural environment.

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