3.0 ANIMAL CONTROL

Fencing and community hunting at Honouliuli Preserve, Oahu

Because of the absence of large native grazing animals (ungulates) in the Hawaiian islands, native forests evolved for millions of years without any need to develop chemical or thorny defenses against browsing animals such as goats, sheep or cattle. However, the arrival of the Polynesians around 500 A.D. and the Europeans in the late 1700s also marked the arrival of a host of animals including ungulates, rats, cats, and mongooses to our otherwise isolated islands. Even as late as the early 1960's the Territorial government attempted to make Hawaii the 'game capital of the Pacific' as a tourist draw by introducing new species of game animals to Hawaii (Tomich 1986).

Today, non-native feral animals are one of the worst threats to native species and ecosystems in Hawaii. The devastating effects of ungulates and rodents are well documented and apparent in every native terrestrial ecosystem on every main island in the archipelago (Stone 1984).

Goat erosion evident on the left side of the left hand photo. Mosquito laden pig wallow in the right photo.

Impacts of alien animal pests on native ecosystems and humans include:

- **Destruction of native plants and their seed crop, preventing natural regeneration and altering forest microclimates** (Spatz and Mueller-Dombois 1975; Jacobi 1976, Baker 1979; 1981; Katahira 1980;Yoshinaga 1980; Higashino and Stone 1982; Diong 1982; Ralph and Maxwell 1984; Aplet, Anderson, and Stone 1991; Katahira, Finnegan, and Stone 1993);

- **Soil disturbance at a landscape scale, promoting erosion and surface water pollution because of increased sedimentation** (McEldowney 1930; Warner 1959-1969);
- **Loss of forest and ground cover resulting in lower groundwater recharge rates and diminished stream flows.** The entire island of Kahoolawe and the once wet forested slopes of West Molokai are testament to the punishment inflicted by unchecked feral goat populations and subsequent lowering of the water table;
- **Sedimentation of coral reefs, higher frequencies of algal blooms, and decreased shoreline property values.** West Molokai is again an example of the effects on marine resources of uncontrolled feral animal populations;
- **Contamination of surface waters due to water borne diseases** (*Leptospira* sp., *Giardia, Cryptosporidia, Staphylococcus aureus*) (Warner 1959-1969, Giffin 1978);
- **Contamination of soil and game meat with the following diseases transmittable to humans: pseudorabies, brucellosis, trigynosis, leptospirosis, anthrax, typhus, and campylobacteriosis** (Giffin 1978);
- **Create breeding grounds for disease bearing mosquitos** (Baker 1979);
- **Spread plant diseases and pathogens** (Baker 1979);
- **Permanent loss of forest, shrublands, bogs, and other uniquely Hawaiian habitats;**
- **Facilitation of invasive species into native forests, shrublands, and bogs through browsing and trampling of native species, dispersal of alien plant seeds, and soil disturbance favoring weeds** (Spatz and Mueller-Dombois 1975; Jacobi 1976, 1981; Yoshinaga 1980;Higashino and Stone 1982; Diong 1982; Aplet, Anderson, and Stone 1991); and
- **Destruction of native animals, nesting sites including eggs and chicks, and food sources for native wildlife** (Mountainspring 1987).

In order to minimize or prevent these impacts, ungulate control is often the first step in any forest restoration program and is vital to ensure long-term success. In fenced areas, forest recovery is often dramatic once animals are completely removed. This chapter will briefly describe some of the major animal threats to Hawaiian island ecosystems and what management control techniques are currently used in the field. The emphasis in this chapter is on the control of existing, widely established animal threats. Techniques for the early detection and prevention of additional vertebrate threats such as coqui frogs, parrots, and large chameleons are beyond the scope of this manual.

It should be remembered that the native forests of today were saved by the Territorial foresters in the early and mid-twentieth century. Their systematic and sustained fencing and hunting efforts remain a model of aggressive ungulate control. For example, from 1910-1958 the Hawaii Territorial Board of Agriculture and Forestry undertook an intensive and ruthless campaign to eradicate pigs on all islands by (Diong 1982). We would be wise to emulate their efforts if future generations are to also benefit from the watershed resources that we presently enjoy and take for granted.

Territorial Foresters at work in 1912 saving the forests we see today.

3.1 VERTEBRATE PESTS: UNGULATE CONTROL STRATEGIES AND METHODS FOR FERAL MAMMALS

The vertebrate pests generally found in Hawaii's forests are feral mammals which include cattle, goats, sheep, deer, pigs, rats, mice, and cats. Parkes (1991) lists six management strategies for vertebrate pests:

1) **Eradication:** Usually not feasible except for off-shore islands and local areas.
2) **One-off/permanent control:** Still requiring long-term maintenance, fencing or exclusion netting is an example of this strategy.
3) **Sustained control:** Suitable for game management areas where the goal is to maintain habitat requirements for continued hunting opportunities
4) **Sporadic or occasional control**: Unfortunately, this is a common practice which can result in a significant waste of monetary resources. Animals are removed with no clear goal other than to kill pests (Braysher 1993).
5) **Commercial or recreational hunting**: Ineffective at reducing animal populations for meaningful habitat recovery.
6) **No control**

Control methods for these animals include:

- Fencing
- Shooting (ground or aerial hunting)
- Hunting with dogs and knives or bows
- Trapping with cages
- Neck snaring
- Non-lethal leg snaring (a form of trapping)
- Baiting with poison (rodenticides) and
- Repellants (non-toxic chemicals to discourage browsing)

No toxicants (e.g. Compound 1080 [sodium monofluoroacetate]) are currently approved to control ungulates in Hawaii, although they are employed with success in New Zealand (Parkes 1983). While leg or foot traps for cats are not prohibited in Hawaii, they are not generally used by managers. Community pig hunters however often use non-lethal leg snares for pigs (power strap method).

The most common control methods currently used in Hawaii include fencing, shooting, trapping, neck snaring, and baiting with rodenticides. A discussion of the ethical and cultural issues associate with animal control can be found at the end of this chapter. Cost-effective feral animal control programs require a strategic, systematic, and integrated approach combining several control methods to eliminate unwanted populations and prevent re-invasion. C.P. Stone (1984) summarizes his recommendations for ungulate control programs:

Primary emphases in ungulate control should be:
1. The necessity for efforts lasting many years
2. Continual learning and feedback about success of control (monitoring).
3. Provision for sufficient resources to effect reduction.
4. The development of multiple methods to reduce animals.

Ungulate control, like weed control requires a thoughtful planning process and aggressive execution in the short and long-term. Defining the problem in terms of the damage being caused is the first step in effective management (Braysher 1993). Delaying fencing or removal programs only compounds ecosystem problems often resulting in costly weed control or restoration programs (Reeser and Harry 2005). Intact forests can only bleed so much before systemic failure begins.


Pig damage in a once pristine East Maui rainforest.

Fencing is the most successful and cheapest long-term solution to ungulate problems. Even after fences are complete, ungulate control outside of fenced areas is still required to keep pressure off the fences from animals attempting to dig, jump, ram, or squeeze their way back in. Fencing gives managers the opportunity to eradicate feral ungulates from their best native forested areas and keep them ungulate free for decades. In the face of hunter opposition to large-scale fencing, managers must remind themselves of their first and foremost role as stewards of the forest. Native dry forests in Hawaii are all but extinct and mesic forests will be next unless aggressive ungulate control measures are undertaken across large acreages for the next decade.



Fencing in a wet forest at left and dramatic native shrub recovery after fencing depicted in the photo at right.

Research and experience have shown that the most effective way to control feral ungulates over large landscapes is by using a strategic, systematic, and integrated approach which includes some combination of fencing, hunting, live-trapping, aerial shooting, and if possible snaring. The Texas Animal Damage Control service used neck snares, cage or pen traps, hunting with dogs, and aerial hunting with helicopters to eliminate feral pigs. From 1983-1992, they reported that snaring accounted for 55% of the pigs removed. Aerial hunting accounted for 17%. Trapping accounted for 14%, and hunting with dogs accounted for 6.3% (Littauer 1993). For another example, a case study of the pig eradication efforts employed on Santa Cruz Island is described at the end of the section on feral pig control.

Community support for such intensive and long-term ungulate control programs is vital to deter vandalism of fences and acceptance of conservation goals as social goods. Managing people and community opinions is in many respects a far more difficult enterprise than managing ungulates.

Importantly, weed control and fire pre-suppression should also be planned in conjunction with animal control efforts since the removal of ungulates is often accompanied by a large increase in alien plant growth in areas not completely dominated by native vegetation.

An unpublished draft of a paper edited by Don Reeser and Bryan Harry outlines the following core elements of a successful ungulate control program (Reese and Harry 2005). One could argue that a sixth element, community outreach and support is also essential. Portions of this paper are summarized, duplicated and adapted below. The lessons learned assume a closed system (i.e. fenced area).

Ungulate Control Strategies: Lessons learned

1) **Populations of ungulates must be isolated into discrete management units:** Fences and sometimes natural barriers such as cliffs, the ocean, or lava flows, are used to form management units to contain feral animals. The size of the management units will vary according to the ability of managers to eradicate animals within exclosures and the type of animal being controlled. Typically, pig exclosures are within the 100-1000 acre range given the difficulty of removing all pigs and maintaining fencelines in high pig density areas.

2) **A strategic, systematic, and integrated approach is needed:** Efficiency and effectiveness result from a strategic, systematic, integrated approach to removing ungulates. A consistent, phased strategy is usually needed involving multiple methods of animal removal. This sequenced and methodical strategy should begin with methods that quicky remove the majority of the animals (e.g. aerial shooting and/or intensive trapping), followed by systematic ground based control methods and monitoring that cover every inch of a fenced unit.

3) **Animals must be removed in greater numbers than their annual reproduction. Keep the pressure on until every ungulate is eradicated to avoid wasting time and money:** In order to reduce pig populations, more than 70% of their local population must be removed each year. Uncontrolled, a pig population can double in numbers every four months until the population reaches carrying capacity (Barrett and Stone 1993). For goat, sheep, and deer populations, more than a third of the local population needs to be removed for population declines (Jenkins, Nugent, and Maguire 1994). This scale of animal removal requires a huge and highly aggressive effort. Before fence units are even finished, managers should consider increased ungulate control efforts to avoid the problem of concentrating animals in smaller areas.

   Even a 25% reduction in animal control removal efforts can significantly increase the overall costs and time required for complete eradication from a fenced area. For example, at The Nature Conservancy's Kona Hema Preserve, it took three years to remove 420 pigs from a 1,800 acre fenced unit. The approximate cost of pig eradication was $67/acre or $40,000 annually, for a 3 year total of $120,000 (not including fencing). Using a VORTEX population model, a diminishment of effort to 75% (costing $30,000/yr) would have taken 10 years for complete eradication and would have cost $300,000, more than doubling the cost per acre. Any effort less than 60% of the current effort would have resulted in unsuccessful eradication. (L. Nelson pers. comm.).

4) **Fenceline inspection and maintenance is a never ending process:** Years of ecosystem recovery and management costs can be quickly negated if fences are allowed to fall into disrepair and only annual incremental increases in animals are removed. Regular fenceline inspections are needed as well as inspections after heavy storm or wind events. During the course of fence construction, additional material should be strategically placed in anticipation of fenceline failures in the future. This allows for the quick repair of damaged fencelines in remote areas. Placing permanent snare sets or live traps in an ungulate free fence area is a 'last line of defense' tactic to control any animals that penetrate fencelines.

5) **Monitoring for any increases in feral animal populations and ingress is also a never ending process:** Vigilance monitoring to detect animal ingress must be done on a regular and systematic basis. Coupled with animal removal is a monitoring program to best utilize data from animals killed in order to determine the success of ungulate control operations. Monitoring allows managers to carefully track the numbers of animals removed and their demographic data (sex, age, reproductive status) in order to evaluate the effectiveness of ungulate control

programs and refine management strategies. Given the difficulty of eradicating animals from any sizable area, it is unconscionable to neglect monitoring and allow populations to rebound to former levels. A tiny goat population if left unchecked can recover to 90% of its former levels in only four years (Reese and Harry 2005).

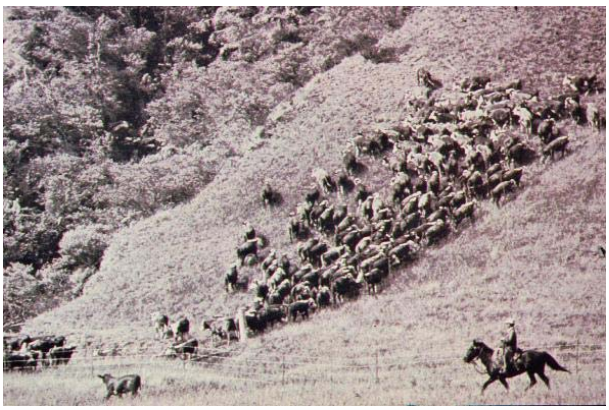
Monitoring programs to detect 'sign' or browsing usually involves regular helicopter transect inspections, ground transect analysis, and sometimes snare transects for pigs in remote areas. Judas goat searches are very effective in monitoring goat-free areas. Judas pig searches are being effectively used on Santa Cruz Island in California (see case study at the end of this chapter). Belt transects are initially good for orientation and detecting gross changes in ungulate activity levels. However, as animal population levels fall to low levels (e.g. <1 pig/km^2), systematic scouting is more effective at detecting animal presence or absence (Anderson and Stone 1993).

Detection of animal presence during helicopter transect inspections is difficult in remote, closed canopy forests. One untried method for detecting pigs is to drop bait (e.g. fermented corn/molasses mash or synthetic pheromones) from the helicopter in blaze orange colored bags that easily break apart containing fluorescent dye along with the bait. Locations of the dropped bait along transects are plotted with a GPS. A follow-up, aerial monitoring trip would detect if any of the bags were broken into or moved by pigs in the area. Any bags dropped from the helicopter would of course need to be fairly heavy to prevent them from being sucked toward the tail rotor. A similar approach could be tried in conjunction with ground based monitoring transects when workers are unable to effectively scout because of difficult terrain, but still need to determine levels of pig activity in an area.

Forward Looking Infrared Radar (FLIR) detection methods remain problematic unless the terrain is similar to flat open pasture and ungulate densities are fairly high to avoid problems of false positives.

5) Plan how to remove the last ungulates from an area before control efforts begin. Ungulates become quickly educated to control methods**.** Smart ungulates are difficult to catch and thus very costly to remove. If the goal is eradication, plan from the beginning how to eliminate failure (N. Macdonald pers. comm.). If at all possible, keep hunting pressure off the target animals to keep them ignorant of control methods until systematic and aggressive removal programs begin that ensure the last remaining animals can be removed. When removal programs begin, ensure a 100% control rate in any animal encounter.

3.1.1 CATTLE



- **Description:** Domestic cattle (*Bos taurus*) were introduced to the islands by the Europeans in 1793. Feral cattle are still found in forest areas on most of the major Hawaiian islands wherever ranch fencing is inadequate. Cattle, due to their sheer size and weight, have high demands for space and fodder. Cattle are also used in Hawaii to reduce fire fuel loads near wildland/urban interface areas and where other vegetative control methods are not as cost-effective.
- **Damage caused**: Cattle graze and browse native vegetation, compact soil, trample undergrowth, and spread weeds (e.g. gorse) through their feces or on their bodies, degrading forested areas to grassland pasture. Several grasses and legumes purposely introduced for cattle forage have also become noxious weeds. Riparian (stream) areas are particularly susceptible to damage caused by cattle.
- **Control methods:** Conventional 4 foot ranch fencing is usually sufficient. However, because cattle can damage fences by rubbing and leaning, a solar powered, electrified top "hot wire" is recommended where feasible. Placing braces on the outside of fences can prevent damage to fence corners. One-way gates are also helpful. General fencing protocols as well as a table of fencing specifications are further described in Appendix 2A.

  Feral cattle are also controlled by herding with helicopters or dogs, baiting and trapping with cattle pens and water, and aerial shooting. Preventing cattle from entering forested areas in the first place is the cheapest and preferred method. Good fences make good neighbors and managers should work with ranchers to retrieve livestock and contain them within pastures. A number of federal farm assistance programs are available to financially assist ranchers with protecting natural resources within and around their ranches.

3.1.2 GOATS


- **Description:** The goat (*Capra hircus*) was introduced to the Hawaiian Islands in 1792. Populations currently exist on nearly all the main Hawaiian islands. They are extremely agile and can jump or climb sloping trunks to reach trees and leaves over 6 feet high. They are also able to forage and thrive in extremely rugged terrain.
- **Damage caused:** Goats voraciously eat nearly every kind of vegetation and can thrive in a variety of environmental conditions from coastal areas to wet forests. They strip bark, trample undergrowth, compact soil, spread weeds, and cause significant erosion. The entire island of Kahoolawe and tens of thousands of acres of formerly forested areas of Molokai are just two examples of the biological disasters caused by large, unmanaged goat populations.
- **Control methods:** Fencing is the best (and cheapest) long-term control method. However, because of the goat's high jumping ability, it is recommended that electric fencing be used where feasible as well as a minimum 4 foot height of graduated mesh. Also, the social nature of goats highly motivates them to push under or through fences at gaps in order to join the rest of the herd. To prevent this, ground skirt fencing or running the bottom wire and barb wire flush with the ground is needed. Goats also get their horns caught in the fence mesh and routine fence checks are needed to repair damage and remove trapped goats.

  Because conventional hog wire fencing of cliff areas is extremely difficult at best, managers may need to deploy 'slinky' type fences. This type of light weight fencing is consists of coiled stainless steel wire similar to military concertina wire, but without the razors or barbs. It is used to block access in steep country or in high corrosion areas and several height sizes can be purchased. 52 inch high livestock panels with graduated mesh are also convenient to use along narrow and rugged ridgelines as they are easily cut to fit the terrain and do not require labor intensive corner bracing. Conventional fencing protocols as well as a table of fencing specifications are described in Appendix 2A.

  Ground hunting using high-powered rifles, high quality scopes and range finders is another common control method for goats. Common rifle calibers are .270 and .308 given the need for a flat trajectory over long distances. .223 semi-automatic rifles can be sufficient at shorter distances. Dusk and dawn are usually the most productive hunting periods as goats move into open areas for feeding or

display. Eliminating the dominant billy goat in a herd first, causes disarray in the remainder of the herd. Additional herd members will often remain in the open given the lack of a leader to lead them into cover.


Tagging and collaring a Judas animal

As herds become smaller through control and harder to find, the ‘judas goat’ technique can be used. A preferably white coated goat is captured and attached with an orange colored radio collar and/or GPS device and its ear tagged with a yellow or orange card. It will then be released to rejoin the herd on its own. The ‘Judas goat’ and the herd can then be located using radio telemetry or GPS and hunting can resume. Upon recapture, the waypoints from the GPS device from the goat can be downloaded to determine where the goat was wandering over time. Multiple small herds can be eliminated using the same collared goat. Goats ideally should be released into the same area that they were captured to maximize their survival over time. Several goats of both sexes and varying ages may need to be collared to ensure that time and money are not spent on a particular goat that happens to prefer a solitary life. However, young male goats were found to make the best Judas goats (N. Macdonald pers. comm.). The Judas goats also may not necessarily herd up with other goats, but the Judas goats can at least be used to find the general area of recent goat activity. A more sophisticated radio collar has a pulse monitor. When goats encounter other goats their pulse rate increases from about 45-60 beats per minute. This area can then be identified and control teams moved into place.


Deploying Judas animals and radio telemetry collars in use at Santa Cruz Island, California. Note the multi-frequency, specially modified antenna in use on the helicopter used for tracking.

GPS and radio telemetry systems are generally fairly expensive for the better models with GPS systems including hardware costing around $5000 and a Telonics VHF radio collar costing about $2800 not including very pricey replacement batteries that must be factory ordered.

It should be remembered that in most cases, ground hunting alone will not significantly reduce goat numbers. From approximately 1920 to 1970, 70,000 goats were removed from Hawaii Volcanoes National Park with no noticeable effect. It was only when fence units were erected that goat eradication was successful in a period of less than ten years (Loope et. al. 1988).

In order to clear fenced units of goats, a phased reduction program is usually employed (Reeser and Harry 2005). Specifically recruited and trained volunteer hunters can be used for the initial knockdown phase in non-remote areas. For the next phase, Judas goats are released and professional hunters remove most of the remaining population, aided by Judas goats. For the mop up phase, professional shooters from helicopters remove remnant individuals along cliffs. Judas goats are left to help professional hunters monitor and shoot any strays or new entries. Lastly, fences are routinely inspected and repaired to prevent ingress.

While sensitive to the concerns of the hunting and local resident communities, one major problem with using volunteer hunters in the first phase of control efforts is that ungulates become quickly educated to control methods and the emphasis on animal retrieval considerably slows control efforts. Consequently, eradication of ungulates from those management units becomes that much more costly and difficult for staff or professional hunters in the next phase of control.

In Makua Valley on Oahu a similar phased approach was used. Fencing was completed. Volunteer hunters and snares were then used, followed by aerial hunting and more snaring. The Judas goat method was tried on a limited basis but logistical problems rendered the goats released ineffective at finding the remaining goats in the valley.

Aerial hunting using autoloading 12 gauge shotguns or semi-automatic rifles (.223 Mini-Ruger) is also very effective for removing larger numbers of goats in a

short time. However, aerial hunting requires special training and certification as well as a very skilled pilot. Currently, Hawaii State law prohibits aerial shooting unless the shooter is state employee and is certified as a seated aerial gunner even on private lands. For shotguns, a preferred ammunition is a 3 inch magnum copper plated buffered #4 buckshot. This load provides good penetration and knock-down capability, which is desirable for humane kills (Littauer 1993). Semi-automatic rifles are modified by adding match barrels and match triggers to increase effectiveness. A red dot scope allowing the shooter the use of both eyes is also commonly used in aerial hunting operations. The disadvantages of aerial hunting are the risks inherent in any helicopter operation, poor weather which limits operations, and thick cover making hunting difficult. $800 per hour helicopter costs can also be prohibitive. Goats also quickly learn to become skittish at the sound of helicopters if aerial hunting is conducted too frequently, making detection difficult.

Bow hunting is also employed in game management units but is not a preferred method for resource managers given its limited effectiveness over time. Hunting and hunting related issues will be discussed in Section 3.2.

Snaring can also be a highly effective control method and is used in remote areas or areas with limited access due to terrain. However, because of the political issues associated with snaring, it is often used as a last resort. A discussion of the ethical issues associated with animal control is found at the end of this chapter.

3.1.3 MOUFLON SHEEP

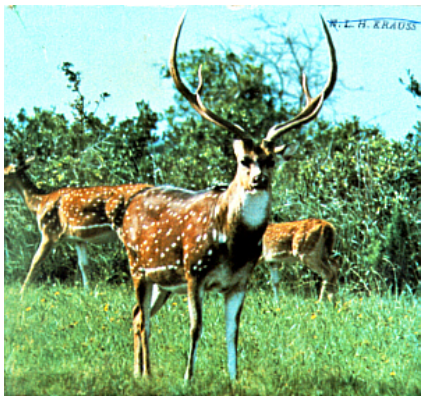
- **Description:** Introduced in the 1960s to the island of Hawaii for hunting, mouflon sheep have since thrived along the slopes of Mauna Kea. They are also present on Lanai.
- **Damage caused:** Sheep graze native vegetation, trample undergrowth, spread weeds, and cause erosion. Mamane/naio forests on Mauna Kea have been particularly hard hit by mouflon sheep.
- **Control methods:** Graduated hogwire mesh fencing at a minimum of 6’ is recommended. ‘Slinky’ type fencing may also be needed for cliff areas. Ground hunting with rifles is the most common technique for sporadic sheep control. Specifically recruited and trained volunteer hunters can be used for the initial knockdown phase in non-remote areas (Reeser and Harry 2005). Bolt action .270

and .308 caliber rifles are commonly used, but semi-automatic .223 rifles can be sufficient. The effectiveness of public hunting is limited. On the slopes of Mauna Kea on State land, volunteer hunting and staff assisted hunts failed to keep mouflon sheep populations at low levels after aerial shooting brought numbers to around 100 animals (Giffin in Environment Hawaii 1999).

Highly motivated volunteers given enough time can nevertheless be effective at sheep removal. On Santa Cruz Island from 1982-1992, largely volunteer hunting groups removed 36,000 sheep, completely eradicating sheep from the 96 square mile island.

Professional ground hunting teams with dogs combined with an aerial hunting team is particularly effective (Reeser and Harry 2005). The dogs and ground personnel will flush a sheep out into the open where the aerial hunting team can dispatch the sheep. Also, personnel in the helicopter can act as 'eyes in the sky' notifying ground personnel of animals in their area that may be blocked from view by brush or terrain.

3.1.4 AXIS DEER/MULE DEER



Axis deer

Mule deer

- **Description:** The first deer (*Axis axis*) were introduced to Hawaii in 1868. The majority of deer are on Lanai, but substantial and growing populations are also on Maui and Molokai. Mule deer are on Kauai. Because they are nervous, cautious animals, deer prefer the protection of the forest margins, however they thrive in a broad range of other habitats as well, including coastal kiawe thickets on Molokai.
- **Damage caused:** Deer graze native vegetation, trample undergrowth, spread weeds, and cause erosion. Deer populations will grow exponentially if left unchecked and food resources are adequate. Large deer removal efforts in the face of widespread deer diseases are currently underway in parts of the U.S. because deer populations were allowed to grow up to and beyond carrying capacity.
- **Control methods:** Deer fencing is highly effective if built properly. Deer are able to jump over or through fences when scared or will repeatedly jump into a well constructed high tensile fence and damage it to the point of fence failure. Covering the fence with a fabric has also been recommended to signal to deer that an impenetrable barrier is in front of them, although this is probably infeasible for miles of fenceline. Generally a minimum of 6 foot 6 inch high, graduated mesh

wire fence is recommended for deer with significant reinforcement by spacing posts at closer intervals. Since deer can still jump a six foot fence if they have enough running room or something to leap off from, 7 foot high fencing is better. However, given the difficulty of building tall fences in rugged terrain, some managers have opted to build shorter fences with the hope that deer will not jump over the fences unless pressured or faced with severe food or water shortages. An electrified top wire can also be used where feasible. General fencing protocols as well as a table of fencing specifications are further described in Appendix A.

Ground hunting with high-powered rifles at dusk and dawn is the most common technique for deer. Bolt action .270 and .308 caliber rifles are commonly used. Volunteer hunters can be used for the initial knockdown phase in non-remote areas followed by staff hunts to remove deer when volunteer interest wanes. If possible, hunting pressure should not begin until a plan for complete removal is set in place to keep deer naïve to hunting methods. Additionally, waiting until the mating seasons is underway also aids removal efforts as deer become more social and remain in groups for longer periods of time. Because deer are nocturnal and stunned by bright lights, night hunting using spotlights is employed, but prohibited in public hunting areas due to safety concerns. When 'night spotting' is used, lower caliber rifles are recommended for safety reasons (e.g. .22 magnum).

Timed feeders can also be used to attract deer into a designated feeding where they can be hunted with rifles, bow or snared. Cracked or whole corn is a suitable bait as the corn is sterile and can be cheaply obtained and stored.

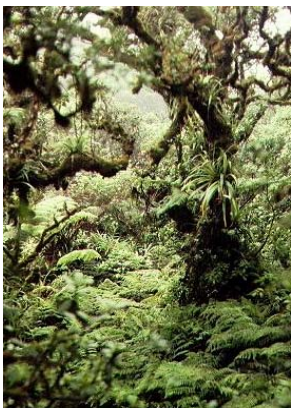
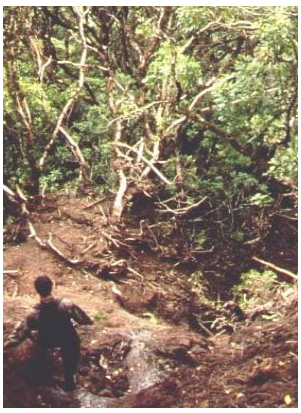
A timed feeder with cracked corn can essentially re-domesticate feral animals and allow for effective removal efforts.

Snaring can also be a highly effective control method and is used in remote areas or areas with limited access due to terrain. However, because of the political issues associated with snaring, it is often used as a last resort. Hunting and ethical issues related to animal control will be discussed in at the end of the chapter in Section 3.2.

3.1.5 PIGS

- **Description:** Hawaii's pigs (*Sus scrofa*) are a feral hybridization of both a domestic Polynesian pig (brought to the islands in the 1600s) and a European introduction (brought by Captain James Cook in 1778). They are a major threat to Hawaii's native plants and animals and may be the greatest current modifiers of Hawaii's native forests given their large and widespread populations across the main Hawaiian islands.

- **Damage caused:** Due to uprooting, pigs can quickly destroy 80 percent of the plant ground cover in areas where they are found. Pigs also commonly uproot native tree ferns to eat the starchy interior and dig up the soil for wallows. These destructive activities create cavities in which water can collect, creating breeding grounds for mosquitoes (*Culex quinquefasciatus* and *Aedes japonicus*). Mosquitoes can then infect native birds with diseases such avian malaria (*Plasmodium relictum*) and bird pox (*Avipoxvirus*), to which they have little or no natural immunity. Pigs also eat large amounts of plant matter, trample undergrowth, and spread weeds on their hooves and through their feces.


The progression from pristine to heavily degraded can sadly be all too quick.

- Feral pigs also can harbor a number of diseases transmittable to humans including: brucellosis, trigynosis, leptospirosis, anthrax, typhus, and campylobacteriosis.

- **Control methods:** Fencing such as conventional 4 foot hogwire or hog panels adequately excludes feral pigs once they are completely eradicated from the site.

Semi-rigid, 36” or 52” high hog panels with graduated mesh are becoming more commonplace for fencing because of their flexibility (but higher strength), the reduced need for clearing large fence corridors, and the faster construction time as time consuming corner braces are not needed. Panels are also easily cut to needed sizes and bottom configurations and are especially useful along rugged ridgelines. The disadvantage of panels is their higher cost and heavier weight. A 16 foot long, 52 inch high panel currently costs about $40 or $2.50/foot whereas hogwire is about $1.27/foot. Because pigs dig, a ground fence skirt is often necessary in soft soils or along steeper slopes with uneven terrain. Given the acidity of forest soils, ground skirting and barb wire often deteriorate quickly when flush against the ground. Bezinal wire fencing or barb wire can now be ordered with a plastic coating over the galvanizing prolonging the lifetime of the wire considerably.

Plastic coated barb wire and plastic coated high tensile hog wire

The lowermost fence wires can also be set below ground to deter digging. Barb wire is ineffective once pigs begin tunneling or the earth beneath bottom wire or barb wire is eroded more than 4” away.

52” hog panels and ground skirt

48” hogwire and diagonal corner brace

Electric fencing where feasible (e.g. pasture areas) may also be effective. Placing a ‘standoff wire’ 4 inches toward the pig side of the fence and 10 inches off the ground may increase effectiveness. Existing hog wire fences can be easily retrofitted with a single electric hotwire to keep pressure off the main fence with clip on ‘outriggers’. Electric wires are commonly powered by relatively inexpensive solar panels. The main fence is also grounded to increase effectiveness (Littauer 1993).

A ‘slinky’ fence is also finding use in extremely steep areas to prevent pig ingress. This type of fencing essentially consists of coiled stainless steel wire similar to military concertina wire but without the razors. Fencing guidelines are detailed in Appendix A.

Ground shooting or hunting with hunting dogs and knives are also commonly practiced controls. Pig hunting with dogs is a very popular local tradition, for recreation and subsistence. Due to the local interest, volunteer hunting programs are commonly employed by resource managers, although their effectiveness is often limited. Several studies have shown that public or volunteer hunting is not effective in controlling feral pigs in remote areas (Anderson and Stone 1993; Barrett and Stone 1983; Molokai Hunting Test Working Group 1998). Experienced dogs are the key to successful hunts. Usually, dog and knife hunters will use a range of dog breeds for different purposes. Short or long-range ‘trackers’ pick up the pig scent, chase down the pig and begin barking to signal that a pig is cornered. ‘Grabbers’ such as pit bulls hold the pig until the hunter dispatches the pig. Dogs are also sometimes fitted with radio collars to assist tracking them, particularly in poor weather, or deeply dissected terrain. Training dogs takes time and effort, particularly if they are used around livestock. With a fairly minimal degree of aversion training, dogs can be quickly trained to only hunt one particular ungulate species and avoid livestock or other non-target ungulates. Also, because dogs are commonly injured while hunting, veterinary bills can be expensive. Hunting issues are discussed further in Section 3.2.


Dogs of varying age and ability returning from a hunt and a ‘sentinal’ neck snare in use as a last ditch control method in a pig free fenced area.

Neck snares have proven to be a highly effective albeit controversial control option. In remote areas in Hawaii, snaring can be the most cost-effective method for controlling pigs (Anderson and Stone 1993). In the upper elevation mountain areas of East Maui, the use of snares in unfenced areas lowered pig activity levels from about 70 percent to less than 2 percent. The snare is made from a loop of steel cable attached to a secure object and placed in a spot where the loop catches the animal as it passes through the area. A sliding lock closes the loop but does not open easily. A heavy swivel is commonly used at the end of the cable to minimize the risk of breakage when the captured animal twists around. Aircraft quality galvanized steel cable 3/32 or 1/8 inches in diameter is preferred. Large pigs can still break high quality snares even when set properly. In addition to animal welfare concerns, any livestock or hunting dogs are also at risk of being caught in snares. Setting snares is also far less time consuming than hunting with dogs. If used at all, snares should only be used by professional resource managers and be checked as frequently as possible to avoid prolonged animal suffering if a non-lethal catch occurs. Also, checks should be done much more frequently during the initial period of control when catch rates will likely be higher. Anderson and Stone (1993) recommend that new sets be established rather than moving snares to new locations as pigs would often return to the same area even after a considerable amount of time passes. Baiting snare areas with fruit, bread, seed corn, macadamia nuts, or carrion also increases their effectiveness. However, some managers do caution against checking snare sets too frequently as the smell of humans may deter pigs from entering the area. Snaring remains a highly controversial tool for controlling feral ungulates (in part because of its effectiveness) and as such many resource managers minimize its use when other options are cost-effective in the long-term (e.g. fencing) or are more politically attractive.

Box or circle traps made from hog panels or hog wire can also be used to effectively control pigs, although the baiting and checking of traps is highly labor intensive as traps need to be checked regularly to be used humanely and effectively. Commonly used bait includes bread, fruits, macadamia nuts, and seed corn. Bait is commonly spread around and in the trap for several weeks with the door wired open to draw pigs to the area and accustomed to the trap. The trap can then be set with bait left inside. In Texas, carrion has also been used effectively as bait for both traps and neck snares. Multiple pigs can be caught in one trap if an appropriate trap size and a one-way swing door is used. A simple cushion made of rolled fence wire or other material is placed at the bottom of the door to assist pigs upon encountering the swing door. Traps are commonly made from hog panels or doubled hog wire mesh. The Nature Conservancy's 4000 acre Honomalino management unit in south Kona was fenced and cleared of pigs over five years largely through trapping. It took 3 years to clear the 1800 acre Kapua unit also in South Kona also using trapping as the primary means of pig removal. Staff hunting using dogs also supplemented trapping efforts. The primary disadvantage of traps is their size and weight. They are bulky and difficult to transport. Traps are also vulnerable to theft when placed near public roads. Pigs may also become trap shy or avoid traps when ample food supplies are available elsewhere. It took

nearly a year for pigs in the Kamakou Preserve on Molokai to begin feeding on the macadamia nuts used as bait.


Box trap using panels and a one way door at left. At right, a simple corral trap made from hogwire.

- Bow hunting combined with the use of timed feeding stations has also been an effective method of removing pigs from farms adjacent to forest areas. Gunshots or barking dogs will scare a herd of pigs away from an area. However, an arrow is relatively silent and ideally, a number of pigs can be removed in one trip as they continue to approach the feeding area at dawn or dusk. Bait commonly consists of whole or cracked corn. A corn mash bait can also be made to draw pigs into a designated feeding area instead of a timed feeder. The bait consists of a mixture of fermented corn and molasses. Attractants consisting of female hog pheromones are also sometimes used by bow hunters, and can be surprisingly effective at drawing boars into specific areas. One method involves placing scent at various points along a hunting loop trail in an area of known pig activity. Later in the day, the bow hunter returns to that same loop trail to see if any boars have been drawn into the area by a presumed sow in heat. Synthetic pheromones are commercially available locally or online or natural pheromones can be obtained from harvested sows in estrus.
- Poisoning is not used in Hawaii as no toxicants are approved for use. It is worth noting that a comparison study between Hawaii Volcanoes National Park (HAVO and a national park in New Zealand (where feral pigs are also a problem), showed that the New Zealand method of poisoning pigs was 34 times cheaper and much more effective than the integrated Hawaii strategy of hunting, trapping, snaring and fencing. Pigs were reduced at both parks, but poisoning in the New Zealand park cost \$35/km^2 whereas at HAVO, \$1180/km^2 was expended (Hone and Stone 1989).
- Judas Pigs: The Santa Cruz Island Pig Eradication case study is described below. Judas pigs are being used extensively and effectively in this eradication project nearing completion.

Case Study #1: Honouliuli Preserve, Oahu

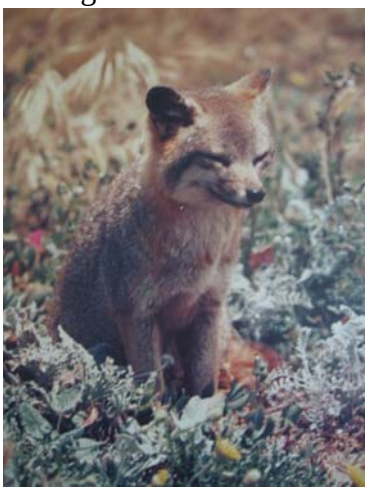
An example of a moderately successful integrated ungulate control program is at Honouliuli Preserve on Oahu, currently managed by The Nature Conservancy. The entire preserve is divided into three hunting units, two units for dogs and knife hunting, and one unit for bow hunting and/or box trapping only due to rancher concerns below that area of the preserve. Fencing is the primary pig control strategy for the most important biological

areas and weekly community hunting is used to relieve pressure on existing fences. Timed feeders are also used by bow hunters and resource management staff to draw pigs down and away from feeding in more intact and unfenced native forest areas. As a last resort, snaring was also used for a one year period in more remote unfenced areas when community hunting proved ineffective at preventing damage to unfenced rare plant and animal species. Trapping is also used by volunteer hunters who regularly check box traps. Informational briefings are also made to the Pig Hunters Association of Oahu to inform them of fencing proposals, snaring areas, and to recruit community volunteer hunters. In a six month period, 24 pigs were removed from a 3600 acre dry-mesic forest area. 12 of those 24 pigs were caught by volunteer dog and knife or bow hunters. All fenced units have remained pig free for over three years and even some unfenced areas have shown good recovery of native ground cover. The density of pigs is usually fairly low at Honouliuli in general due to the lack of an adequate food and water supply to support higher pig populations.

Case Study #2: Pig Eradication from Santa Cruz Island, California

Situated off of Ventura California, Santa Cruz Island is 60,000 acres or 96 square miles in size and is currently managed by both The Nature Conservancy and the National Park Service. The goal of conservation efforts on Santa Cruz Island is the recovery of a unique native ecosystem as well as the recovery of numerous rare and endangered plants and animals, most notably the Santa Cruz Island fox. From 1982-1992 36,000 sheep were removed from this largest of the Channel Islands and the pig eradication effort began in 2004 following a lengthy public information campaign, and Environmental Impact Statement and public review process. However, before pig eradication efforts began, 27. 5 miles of hogwire fences were constructed, dividing the island into 5 discrete management units in order to facilitate pig removal efforts. The terrain as depicted in the photo above, is often highly dissected and covered by a mosaic of open understory and thick chaparral. The pig eradication effort is expected to take two to three years and an estimated 80% of the total pig population has already been removed as of March 2006. A $4 million dollar, two year fixed price contract was awarded to Prohunt New Zealand following a competitive bidding process. Prohunt is a professional hunting company based in New Zealand that specializes in contracted animal wildlife control. In addition to their own staff, Prohunt brought their own helicopter (shown above), pilot, and hunting dogs to Santa Cruz Island. All hunting dogs went through extensive quarantine

procedures as well as aversion training to ensure the protection of the critically endangered Santa Cruz Island fox.




About only 250 of the endemic Santa Cruz Island foxes remain, and intensive captive breeding efforts are also underway. Dog kennels, intensive quarantine procedures, and aversion training ensure the safety of the wild foxes. Photo at left courtesy of The Nature Conservancy.

ProHunt operates at a level of efficiency and effectiveness that reflects a goal of getting the job done as quickly as possible and earning a profit. This private contract-based model of pig eradication at a large scale has its benefits and efficiencies. Prohunt has fewer limitations and obstacles than many government agency staff (e.g. helicopters protocols, working hours, control strategies and methods). The drawbacks to private contracting can include a negative public perception and in some cases cost.

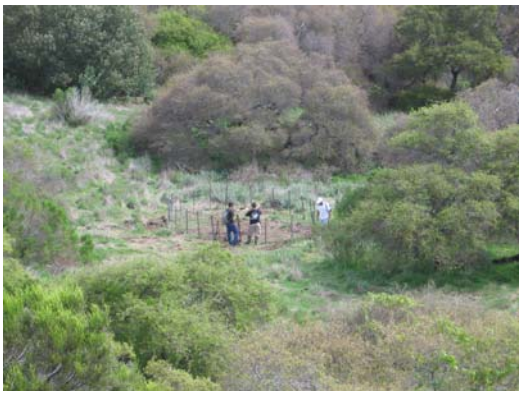
ProHunt's efficiency and effectiveness result from a strategic, systematic, integrated approach to removing pigs as well as highly skilled staff. They are very methodical in their approach to animal control and use a consistent, sequenced strategy. Their approach to each of the fenced units is as follows. Fenced units are generally cleared one at a time, although trapping may begin in an adjacent unit while hunting with Judas pigs and mop up scouting finishes in another unit.

1. Pre-baiting corral traps
2. Live trapping/Aerial shooting
3. Ground hunting with dogs assisted by their helicopter
4. Ground/aerial hunting with Judas pigs, and
5. Scouting and monitoring.

As of March 2006, 4734 pigs total had been removed by Prohunt with a total estimated population of about 6000 pigs before the start of control efforts.

Efficacy of Control Methods as of March 2006 on Santa Cruz Island

Method	**Percent of total pigs removed**	**Number of pigs removed**
Trapping	16%	741
Aerial shooting	79%	3751
Ground based hunting using dogs	4%	193
Miscellaneous	1%	49



1. Pre-baiting corral traps: Traps are used for the initial knockdown of pig populations in fenced units to avoid educating pigs about the threat of dogs. Using doubled hogwire rolls, simple corral traps were deployed in areas of high pig activity in the larger fenced units. Trap material is easily deployed by helicopter. Baiting using sterile cracked corn is also done by helicopter usually on the weekends when the helicopter is not needed to support the ground hunting teams. Food availability on Santa Cruz Island is generally limited so the pigs quickly learn to associate the sound of the helicopter with the arrival of food. Traps doors are secured open with food for several weeks until the pigs become well accustomed to feeding in the traps. Traps are placed near some cover but with open areas around the trap to assist with aerial shooting.

2. Live trapping/Aerial shooting: Pigs caught in the traps are aerially shot and removed from the traps by helicopter. Any pigs that may escape from the traps will often still come back to the traps the next day or so given their strong association with the traps and a ready food supply and because they are contained by the larger fences. As the number of pigs caught in the traps begins to decline, more systematic aerial shooting covering a larger area begins, although traps remain in place and are kept baited to keep attracting pigs to the trap area. Helicopter routes are also tracked using GPS to ensure systematic coverage. Aerial shooting is done with .223 Mini-Ruger Ranch rifle modified with a match barrel, match trigger, and red dot scope. All ammunition is non-lead based (using bismuth) to avoid secondary poisoning of bald eagles that are beginning to re-colonize the island.

3. Ground hunting with dogs assisted by their helicopter: As the pigs removed by aerial shooting begins to decline, systematic ground hunting with dogs begins. Hunting teams and their dogs are dropped off at the head of gulches and methodically work downwards to the gulch bottom. Ground hunters are in constant communication with the helicopter which serves as an ‘eye in the sky.’ The helicopter can readily direct ground shooters to pigs, move hunters and dogs back to the top of adjacent gulches, and deploy additional dogs as dogs tire. Dogs are carried in specially built ‘pods’ attached to the sides of the helicopter. The helicopter remains with the ground teams primarily to support them as needed. Hunters work in teams using only one or two dogs per subgulch and are in close communication with each other. Dogs are highly trained and will only bark up a pig and not attempt to bite it. Ground hunting teams carry GPS tracking units to record their routes and radio collars are placed on the hunting dogs to assist hunting and retrieve any lost dogs. Ground hunts usually end around mid-morning as the dogs tire and

efficiency begins to drop off. Nearly every inch of each management unit is covered by ground teams typically in two sweeps with each sweep lasting several weeks depending on the size and terrain of the management unit. GIS processing is done at the end of each day to guide hunting efforts the following day.



Tagging, inducing estrus, radio and GPS collaring, and deploying Judas pigs.

4. Ground/aerial hunting with Judas pigs: In conjunction with ground hunts, Judas pigs are extensively used for the mop-up phase of control efforts in mostly cleared fenced units. Up to 12 Judas pigs are used in one unit, they are randomly placed but pulled from that particular area. Both boars and sows are used, with some sows placed into estrus via commercially available hormones to assist with congregating males near Judas sows in heat. Pigs are captured using the helicopter and pig cage. Animals are tagged, sexed, and collared with both a GPS unit to track their routes upon re-capture and a VHF radio collar. The radio collar allows the helicopter or ground teams to track their movements upon release. The specially built cage for transporting pigs has a trap door on the bottom of the cage that can be remotely released by the helicopter pilot. This eliminates the need to have ground personnel assist in releasing Judas pigs.

Forward looking infrared radar (FLIR) technology was experimentally used to gauge pig densities but could not be extensively used for control efforts for several reasons including rugged terrain and cover making detection difficult, a number of false positives once the terrain began heating up with the sunrise, and the fact that pigs would simply move out of the area after flyovers.

Extensive transect monitoring will likely proceed once Prohunt's eradication efforts are complete to ensure complete eradication from the island.

Prohunt base camp Central Valley, Santa Cruz Island

3.2 HUNTING AND HUNTING RELATED ISSUES

Hunting can be a very effective method of animal control, and is a popular sport and tradition among Hawaii locals. For this reason, many islands have found some political success with volunteer hunting programs. Resource management agencies like the National Park Service and National Wildlife Refuge System however, have found much greater success at meeting long-term resource management goals using professional hunting programs, particularly in remote areas. Volunteer hunts, which bring together conservationists and community hunters provide can on occasion provide a cost-effective means to minimize the threat of feral ungulates on native plants and ecosystems. Currently on Molokai, large goat herds are also being controlled by community hunters who are flown by helicopter into areas otherwise inaccessible to them. At Honouliuli Preserve on Oahu, volunteer hunters help to keep pig pressure off fenced areas through their hunting efforts. In more urban and rural farm areas, mostly volunteer hunters and trappers perform a highly valuable service to farms, golf courses and graveyards by removing feral pigs from adjacent areas.

However, these programs also face a number of difficulties. A few of them are listed below:

- Community based hunting programs are often ineffective at achieving natural resource management goals simply because not enough animals are removed over time. Animal reproduction rates nearly always outpace volunteer hunter catch rates.
- Participation fluctuates as animal populations fluctuate. For example, hunter participation drops as pig populations drop, which in turn results in pig populations increasing again.
- Persistent public hunting pressure quickly educates ungulates making subsequent hunts or control work increasingly difficult.
- Hunters often do not or cannot hunt in remote areas without road access, therefore road and facilities maintenance is necessary. Further, remote areas sustain high levels of ungulate damage as animals are pushed by more intensive hunting activity in lower elevations.
- Flying hunters and dogs via helicopter into remote areas is extremely expensive and often logistically complex. For example, harvesting animals for their meat is a considerable additional expense in terms of the time and money required to bring coolers back from remote areas with helicopter vendor rates now around $800-$1000/hour. Further, field handling of carcasses and removal from remote sites does not meet USDA requirements for meat handling and processing for public consumption.



Transporting hunting dogs to remote sites by helicopter is logistically difficult and expensive.

- Hunters may be motivated (or allowed) to hunt only the largest 'trophy' animals, leaving females and younger, smaller animals to maintain and increase populations over time.
- Hunters may be hesitant to hunt unfamiliar or remote areas for fear of losing their dogs or intruding upon other hunter's hunting area.
- Permitting hunting in biologically important areas risks both damage to rare native vegetation and animals and the potential of alien introductions.
- Value differences between hunters and natural resource managers create tensions which are sometimes difficult to overcome. Vandalism of fences is an unfortunate result.
- Snaring programs and hunting with dogs need to be in entirely separate areas in most cases.
- Liability, trespassing, accidental forest fires, theft, injury to livestock and pets, and vandalism are common concerns are among private landowners, resource managers, ranchers, and farmers with regard to hunters.
- Hunter access is often highly restricted due to the above landowner concerns.
- Other user conflicts may restrict hunting such as recreational hiking or horseback riding in forest areas.

Overcoming these numerous difficulties is still possible and often politically highly desirable if communities are to be truly engaged in the protection of their own native resources. The approach of each resource manager to hunting will necessarily differ with respect to their own management goals and the concerns of stakeholder and community interests. It should be remembered however, that feral animals are replaceable, whereas endangered native plants, animals and communities are not.

Summary of Community Concerns

Wasted Meat: One common community concern of an ungulate control program is the wasting of meat from animals killed during the course of control work. It is worth noting however that far fewer animals are killed over time in fenced areas, once fencing is complete and animals eradicated from those units (Reeser and Harry 2005). Also, the total cost of salvaging meat from carcasses is oftentimes far greater than simply going to the store and buying equal amounts of prime cuts. For example, if one factors in vehicle fuel costs, ammunition costs, hunting license costs, dog food and veterinary costs, and

time spent hunting, ‘subsistence’ hunting may become a money losing, not money saving effort. From the management perspective, many managers prefer that animals be left to recycle the nutrients back into the forest rather than taking inordinate amounts of staff field time and considerable expense to dress, store and transport meat. Live trapping as mentioned previously can be effective and is good for public relations, but again, the labor costs of checking traps is considerable. Providing community hunters the first opportunity to ‘hunt out’ fenced areas before using other control methods is commonly done by managers in an effort to engage the local community in the protection of their own native resources as well as alleviate concerns about the wasting of meat.

A pilot program to establish small-scale, cooperative pig, sheep, or goat farms could be tried if community hunters are interested in cost-effectively providing ‘meat on the table’ for their families. Numerous rural development and farm assistance programs are available to financially assist individuals and groups with such an effort.

Loss of Access: Loss of access to favored hunting grounds because of fencing or resource management activities is another common hunter concern despite the availability of tens of thousands of acres in State designated Game Management Areas and Hunting Units within State Forested areas. Countless acts of vandalism to fences and gates continue to occur annually, resulting in repair costs in the tens of thousands of dollars. Initiating a community outreach program to detail why fencing is necessary for an area and the overall resource management goals is one proactive approach to improving community relations with the hunter community. A federal grant program through the U.S. Fish and Wildlife Service to improve hunter access to remote areas is also being tried in numerous areas throughout the state. An innovative ranger program to train students from the Waianae community on Oahu on basic resource management methods is also underway. The intent is to educate younger hunters on the goals of the conservation community as well as to provide hands-on job training in an effort to bypass the strife between hunters and conservationists.

Denial of Traditional Practices: Denial of access for hunting is also seen as a denial of traditional cultural hunting ‘rights’ and practices. As pig, goat, and deer hunting has been practiced for several generations in Hawaii it can rightly be regarded as a strong cultural tradition across Hawaii’s local ethnicities and not just among Hawaiians. Much debate is centered on this issue of whether hunting is a ‘right’ or privilege. Resolving the dynamic values and traditions of a very diverse hunting community with the values of conservationists is a difficult but necessary endeavor if the goal of fully fenced game areas and fenced important native areas is to be reached.

Since the time when early Polynesians brought the pig to Hawaii, the pig has played not only an important dietary role, but also an important role in Hawaiian legends, ceremonies, and spiritualism. (Jenkins et al. 1994). Indeed, “pigs were highly prized as gifts to gods and to humans.” (Mitchell 1992). With the recent resurgence in interest and practice of traditional Hawaiian protocols, the pig clearly has significant cultural importance for ceremonial practices, and the perceived indignities-like snaring or the wasting of meat is offensive to practitioners (Jenkins et al. 1994).

Contrastingly, some Hawaiians see the pig as very damaging. They believe these non-native animals pose threats to unique and culturally important native ecosytems, justifying strong control actions (Puanani Anderson-Wong, pers. comm.).

Humane/Ethical Issues: Humane concerns are also responsible for much of the controversy surrounding unattended neck snaring, unattended trapping, and hunting with dogs. Humane groups oppose neck snaring in particular as it can be one of the most inhumane methods of killing due to the length of time a captured animals can suffer in the snare, particularly if the animal is not snared by its neck as intended (Jenkins et al. 1994). Hunting with grabbing dogs also causes great suffering to pigs and to the dogs themselves as dogs are commonly injured by pigs during hunts.

From the humane perspective, fertility control, live-trapping and prompt relocation, and driving animals out of preserves are the most acceptable control methods because they are non-lethal. Of the lethal control methods, shooting by professional hunters appears least inhumane because of the low wounding rate and quick death (Jenkins et al. 1994). In their year 2000 report, the American Veterinary Medical Association's Panel on Euthanasia recommended a gunshot to the head as the most practical means of killing wildlife and free-ranging animals when euthanasia is not possible from the animal or human safety standpoint (AVMA 2000). They do caution this practice by stating that challenging conditions in the field in no way reduces or minimizes the ethical obligation of the responsible user to reduce an animal's pain and distress to the greatest extent possible during the taking of an animal's life.

3.3 RODENTS

- **Description:** Rats (*Rattus exulans*) were first introduced by the Polynesians in the 1600s, and then again by the Europeans 200 years later, in two forms: the black rat (*R. rattus*) and the Norway rat (*R. norvegicus*). House mice (*Mus musculus*) and mongooses are also a European introduction. These rodents are found in all native habitats from sea level to over 3000m in elevation, although mongooses generally prefer lower, drier elevations. Because of its size, arboreal behavior and nocturnal habits, the black rat is often considered one of the greatest threats to native forest birds.

Photo by Jack Jeffrey

- **Damage caused:** Rats have a large impact on the native ecosystem as omnivorous predators. They are agile tree climbers and feed on insects, snails, eggs, young and adult birds, and a wide range of fruits, seeds, and other plant material. Rodents are also a hazard to human health, as they are able to transmit leptospirosis and murine typhus.

- **Control method:** Hand applied poison baits and snap traps are the most common and effective control method against rodents.

Typical bait staion and snap trap placement. In areas where pigs are present, bait stations need to be secured above ground and out of reach of ungulates. Good snap placement in rat 'dens' or rat pathways increase effectiveness of snapping efforts.

- Applicators should be aware of the specific restrictions that exist for the State of Hawaii, including the use of tamper resistant boxes and a current license as a certified restricted use pesticide applicator to apply Diphacinone® rodenticide in conservation areas. Incidentally, much more toxic rodenticides such as Warfarin® which require only a single feeding for a lethal dose are available for home and commercial use without restriction. Appendix 3B details the regulatory requirements as well as describing methods for improving the effectiveness of bait stations and snap traps in the field. Be aware, however, that some brands of bait blocks may contain viable weed seeds that if germinated, may be a threat to native species.

  Efforts are currently underway to secure approval for the use of aerial broadcasting as a method of applying rodenticide in ungulate free exclosures following successful aerial efforts in New Zealand and British Columbia, Canada, and successful hand broadcasted baiting efforts in the Northwestern Hawaiian Islands and at Hawaii Volcanoes National Park.

- Small mammal fencing is another option, though it is much more costly and less commonly used. At Karori Wildlife Sanctuary in New Zealand, fences are made of a very fine mesh, excluding all land animal pests. A demonstration project was also done on the island of Hawaii by the Xcluder™ Pest Proof Fencing Company. A mesh wall is a more appropriate term for this type of fencing given its impregnability.

Excluder fence demonstration project on the Big Island done to assess effectiveness on uneven lava substrate.

3.4 CATS

- **Description**: Feral cats (*Felis catus*) were probably introduced by Europeans in the late 1700s. They are rampant in populated areas and also inhabit all forest types in the Hawaiian islands. Feral cats can have an unusually large home range.

- **Damage caused:** Cats famously prey on birds, eggs and rodents, but large insects may also makeup a significant portion of a feral cat's diet. In a study of diets and home ranges of feral cats, bird remains were discovered in 68 percent of cat scats collected in a montane wet forest of Hawaii (Smucker et al. 2000). Feral cats can also be a threat to human health as they can transmit disease (toxoplasmosis) placing pregnant women and immune suppressed individuals particularly at risk.

- **Control methods**

Box trapping: Box or cage traps are commonly used to trap cats in urban areas and can be effective in forest settings. However, most cats are wary of confinement and will also avoid the cage if their footing is unstable upon entry. Cage traps need adequate shelter, food, water, and regular checking if they are to be used humanely. Taped cat cries are also used where feasible to draw feral cats into a trap.

Leg traps: although not commonly used in Hawaii, they may prove effective where cats regularly use a trail in a narrow area. Again, regular checking is required.

No toxicants are currently approved for use in Hawaii and it is illegal to use products such as liquid Tylenol for feral cat control.

3.5 INVERTEBRATE PESTS

Slug found consuming critically endangered *Cyanea pinnatifida* fruit, Honouliuli Preserve.

The most destructive invertebrates in mesic forests are arguably ants, slugs, cannibal snails, black twig borer beetles and wasps. In urban and agricultural areas, these invertebrate pests are most commonly controlled with poison bait. For example, aerial baiting to control ants is a common practice in pineapple fields. However, many poison

baits used in agricultural areas are not labeled for use in conservation areas. Control methods are not discussed in detail in this manual for this reason. The severity and scope of impact of alien invertebrates on forest animals and plants is quite clear in many circumstances. If left unchecked, *Vespula pennsylvanica* wasps can deplete insects from hundreds of acres of forest by forming wasp colonies in the millions; severely disrupting food webs for native birds. Slugs can prevent recruitment of rare and common native forest species by consuming nearly all seedlings, leaving alien species like guava to proliferate and native canopy species to eventually disappear (S. Joe pers. com.). Black twig borer beetles use a wide variety of native semi-hardwood tree species as hosts (e.g. koa, hame, kopiko) and along with their associated pathogenic ambrosia fungus, are thought to be responsible for the near extinction of a number of endangered tree species. Promising research is currently underway to develop toxic attractants to control black twig borers in forested areas and coffee farms. Future drafts of this book may address invertebrate control methods in more detail. The Hawaii Ecosystems at Risk (HEAR) website www.hear.org details some of the most current research and invertebrate control efforts in Hawaii. Frank Howarth's article on the 'Impacts of Alien Land Arthropods and Mollusks on Native Plants and Animals in Hawaii' remains one of the most concise summaries of the problems of Hawaii's established invertebrate pests and is also now available online also the HEAR website. A full citation for this articles as well as another related article by Gagne and Christensen is given below and marked with asterisks.

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APPENDIX 3A: FENCING PROTOCOL

SUMMARY: Fence construction can be broken down into several steps usually performed in this order:

A. Fenceline scouting/scoping
B. Fence corridor clearing and fence material delivery to work site
C. Setting the line, pounding posts and constructing corner braces,
D. Stretching fence mesh and clipping barb and mesh wire
E. Setting deadman anchors, stretching and securing ground skirts, installing any electrified wires.
F. Installing any crossing styles, gates, one-way pig doors, dog ramps, or stream barriers.

Since one roll of hog wire is 330 feet or 100 meters in length, all the steps can be repeated over 100 meter stretches so that the fence is fully constructed 100 meters at a time.

Techniques used in the construction of a fence are dependent on terrain, cover, management goals, and the skills of the construction crew. One protocol can never satisfy all working conditions but the following general guideline should meet most field conditions.

1. FENCELINE SCOPING AND PLANNING

1. The goals of the ungulate control program will dictate the type, size and location of ungulate fences. Funding should dictate the size, but not the type of fence used. For example, using pig fencing without ground skirting in high density pig areas is simply unwise and ultimately ineffective. Similarly, planning for future ungulate invasions may be more expensive in the short-term but cheaper in the long-term. For example, building a 7 foot high deer fence is more costly up front, but far cheaper in the long run than attempting to retrofit an existing 4 foot pig fence several years later.
    a. Usually the fence route will run along natural topographical features, property lines, vegetation communities, ridgelines or use natural barriers like cliffs.
    b. Straight runs as much as the topography allows is optimal for ease of construction.
    c. Minimizing impacts to native vegetation, streams, erosion prone slopes and important biological resources like rare plants, nesting trees, snail habitat requires thoughtful consideration during initial fenceline planning and scoping.
    d. Weed invasion along fence corridors should also be taken into consideration and managed as needed.
    e. Fence corridors can also have positive benefits such as providing a fire line or a fuel break in the event of a fire and access routes into remote areas.

f. Be aware of sources of fence failure such as large dead trees, landslide areas, flashfloods, ungulate densities, and vandalism when planning fence routes.
g. Strategic fencing using cliff lines and vertical drops is often fraught with the difficulty of scouting the cliffline both in the air and on the ground to ensure its impregnability. When in doubt, construct a complete fence route. Ungulates are often surprising in their determination and climbing abilities.
h. During initial flagging of the fence route, alternative fence routes should also be scouted to ensure the optimal placement of the fenceline. Poor planning results in miscalculated material needs and logistical difficulties of moving very heavy fencing materials in steep terrain.
i. Determining straight lines in thick, overhead brush for proposed fencelines is difficult at best. Standard surveying equipment such as a compass, GPS, pvc poles, laser levels, and range finders make this task easier. A sharp machete is also invaluable.
j. Taking the time to double check fence measurements, placement of drop zones, and material calculations will save you from costly mistakes.

2. FENCELINE CLEARING AND MATERIAL DELIVERY
   a. If not using hog panels, clear a corridor slightly wider than the height of the fence to allow ease of rolling out fence mesh.
   b. When possible, avoid cutting down large native trees, and detour around rare species.
   c. Cut down hazard limbs and dead trees before they fall on the completed fence. Felled limbs can also be later used for waterbars during construction.
   d. Brush in a straight line along fencing route.
   e. Fence braces need additional brushing for ease of installation.
   f. Large shrubs and trees need to be cleared and cut as flush to the ground or even slightly below ground level as possible. Stumps are not only trip hazards, they will also hang up fence mesh when material is being unrolled.
   g. If not using fence skirting, the ground should also be leveled as much as possible to allow the bottom wire and barb wire to ideally be no more than 2 inches off the ground. Taking the time to level the ground at the onset is often much easier than having to re-pound posts lower or using deadman anchors to bring the bottom wire closer to the ground.
   h. Since fence rolls are 330 ft (100m) in length, usually fence material drop zones are spaced 100m apart. Placing material at the top of small hills makes unrolling much easier. Dropping material on narrow, knife edge ridges requires a method of immediately securing the load to a tree or post to avoid having the load roll downhill. Pallets can also be placed under fence rolls to avoid this mishap.

3. SETTING THE LINE, CONSTRUCTING BRACES AND POUNDING POSTS
    a. Often it is easier to roll out the fence mesh before setting the bottom line and pounding any posts. Place the mesh on the side of the fence corridor to get it out of the way of post pounding.
    b. Tie a string between two guide posts that are separated as far apart as the terrain will allow. On uneven terrain set string in shorter intervals as allowed.
    c. If fenceline bends, make the bend have several shorter straight sections with the string running from corner to corner. Reset posts as needed to eliminate as many bends and corners as possible. Ideally, the fenceline will also run next to the unbrushed area so that once the fence is upright, the rest of the corridor can be used as a foot or vehicle path for maintenance.
    d. Once the final fenceline is determined, barbwire can also be rolled out and stretched to serve as a bottom guide for the alignment of posts instead of the string.
    e. If working in steep terrain or in loose soils, it may be easier to roll out any fence skirting and temporarily secure it to aid in footing. Constructing simple ladders is also of great benefit in steep sections.
    f. Brace all corners and crossing styles with additional posts and wire. The nubs of corner posts need to face away from the direction of the tension. Fence mesh may need to be placed on the proper side of a post before the brace is constructed.
    g. A variety of corner braces can be used depending on the terrain and necessity. Internal or external braces, horizontal or diagonal, a single bisecting angle or two diagonal braces may be needed. In some cases, even pounding additional posts flush with each other can serve as a brace when terrain disallows any of the above options.
    h. Pound posts about 10 feet apart on the far edge of the brushed corridor so that the hog wire can be rolled out in the clear area if not done so already. Posts may need to be spaced closer in steeper areas or where animal pressure will be especially significant for additional strength. If the fence mesh cannot be stretched, closer post spacing is needed. Pound posts in approximately 2.5 feet, leaving the lowermost nub no more than two inches above ground level. Posts should be pounded in perpendicular to the slope for proper clipping of posts to the horizontal fence mesh wires. Taller posts are needed in softer soils where they can be pounded in deeper. A rock drill and cement is often needed in rockier terrain
    i. In areas where the terrain dips and posts are prone to popping up once the tension is on, posts can be anchored by pounded in a second post at a 30-45 degree angle to the upright post. The second (or even third) angled post is secured to the upright post with o-clamps or smooth wire at ground level where the posts intersect. The effect is an in-line brace and is often much easier to construct than a deadman anchor.
    j. Orient posts with nubs facing toward the outside of the exclosure.

k. Periodically re-sight along the pounded posts to ensure their straight alignment and push posts into place as needed. Pull up any posts grossly out of alignment and re-pound. A crooked line of posts will make stretching the fenceline exceedingly difficult as the vertical wires of the mesh will constantly hang up on nubs once any kind of tension is applied.
l. Posts may twist in the ground because of roots, etc., a pipe wrench can be used later to straighten. If a post twists badly, reposition and pound again.

4. STRETCHING AND CLIPPING BARB WIRE
   a. Level ground as needed, being careful to not dig too deep when removing stumps. A hazelhoe is very useful for leveling and benching.
   b. Roll out barb wire.
   c. On uneven ground, don't tighten too much; stepping on the wire in low spots can give you an idea of tension.
   d. On flat and even ground barbwire tension can be tighter, but because the wire is twisted it has a lower breaking strength than smooth wire.
   e. Clip off the barb below the first nub above the ground on each post. Allow space for hog wire to be clipped off at the same nub.
   f. On uneven terrain, have people step down on the barb in holes or depressions while tightening.
   g. Barb wire is unnecessary if fence skirting is used.

5. STRETCHING HOG WIRE
   a. Roll out the hog wire in the brushed corridor.
   b. Stand up sections of the fence with the smaller squares along the ground.
   c. On uneven ground, stretch shorter sections as terrain allows using the "come along", rope, and 2x4 "sandwich" device.
   d. Hog wire can be stretched around one or two corners at the most depending on the angle of the corner. 90 degree corners are very difficult to stretch wire around.
   e. When standing the fence up, the fence can be hung loosely on the posts. Unhook the fence from the posts before stretching and be aware of roots and snags which may catch the fence as it is tightened.
   f. Use the bottom part of the fence as an apron on hill crest situations.
   g. At dips in the terrain, have persons stand on the fence to get an idea of the final tension needed.
   h. Use only sturdy trees or multiple tie off points to secure the come a long. Posts can also be used for tie off points when trees are unavailable. Posts should be pounded in at a 30 degree angle to minimize bending in the direction of the tension.
   i. Initially clip in or staple hog wire starting from the point furthest from the come along to preserve maximum tension. Use vertical wires near posts strategically to catch the fence from slacking backwards when tension is released. Wooden posts at corners or other strategic intervals are handy as the hog wire can be stapled to the post preserving fence tension.

6. CLIPPING OFF FENCE MESH
    a. Five or six clips are placed on each post. More clips are needed for taller fences.
    b. Clip bottom wire below the first nub above the ground (the same place as the barb) and the next wire.
    c. Skip one wire, clip off.
    d. Skip two wires, clip off.
    e. Clip top wire.
    f. This is a guideline. Clip as necessary.
    g. Pinch clips closed at critical points, such as corners and step-overs.
    h. Aluminum tie wire can be used in place of clips when securing mesh to corner posts which have nubs facing away from the tension. Tie wire is also handy when the bottom wire is flush against rocky ground preventing wrapping of the clip wire around the mesh wire.

7. SETTING DEADMAN ANCHORS OR DUCKBILL ANCHORS
    a. On uneven ground, one 3 foot anchor goes between each post. Set anchor at the low point between the T-posts.
    b. Pound all anchors on unbrushed side of the fence.
    c. Pound anchors at an angle so as not to be pulled out by the tension in the fence.
    d. Pound the anchor in until 3 nubs remain above ground.
    e. Use two clips below the first nub above the ground. One clip on the barb. One clip on the bottom hog wire.
    f. Duckbill anchors can be used in place of deadman anchors to bring the bottom wire closer to the ground.

8. CONSTRUCTING FENCE SKIRTING
    a. Roll out the 3 ft. fence skirting with the small mesh holes next to the small mesh holes of the upright fence.
    b. Overlap the upright fence mesh and secure the fence skirt to the second or third horizontal wire of the upright mesh using galvanized hogrings or aluminum tire wire.
    c. Secure the fence skirt to the ground by pounding in deadman anchors, duckbill anchors, or nailing it to available roots. Large ohia logs and other long-lasting wood trees can also weight down the fence skirt if the terrain is too rocky. It should be noted that large pigs can be surprisingly strong and have been known to move boulders and logs in their efforts to dig under fencelines. Long sections of skirting can also be ‘stitched’ into the ground by using smooth wire woven in and out of the fence skirting and clipping the smooth wire to anchors at regular intervals. Pounding in the anchors will tension the smooth wire and secure the skirting tightly to the ground.

9. FINISHING STEPS: RE-POUNDING, STYLES, GATES AND OTHER CONSIDERATIONS

a. All posts and anchors can be pounded in an inch more to set the bottom wires tight to the ground if not already. If holes remain along the bottom of the fence, pieces of hog wire can be used as an apron.
b. Crossing styles can be easily constructed using posts and 'o' ring clamps to secure horizontal pieces to vertical posts. Nubs on horizontal pieces should face upward for maximum foot traction.
c. Gates are quite useful for high traffic areas, but should be built to open in only one direction (outwards from the enclosure) and be self-closing using springs or spring hinges.
d. Dog ramps and one way pig doors can also be built into the fenceline where desirable.
e. Stream crossings are particularly challenging, particularly given the flashiness of Hawaiian streams. Two strategies used by fence builders to fence a stream are mentioned here.
f. In intermittent and low flow streams, a hinged apron can be built in the stream bed. The apron is weighted with rocks or logs to prevent ingress in dry periods. During heavy flows, the apron lifts and is held by the hinge. The apron is again weighted down after the flow recedes.
g. In perennial, high flow streams, and in more remote areas with seasonal stream flow, a variation of the hinge technique is used using a heavy rubber mat instead of a fence apron. The rubber mat lifts during high flows and hopefully sits tight enough across the stream during low flow periods to prevent ungulates from moving upstream. Barb wire can also be stapled to the rubber mat as additional deterrence.
h. Fence 'wings' using panels or fence mesh can also be constructed at vertical cliff areas to prevent animals from moving around the end points of fencelines at cliff edges. The 'wing' simply extends the fenceline into open space preventing animal movement.

TOOLS AND SUPPLIES:

Barbwire spool roller
Post pounders
Barb stretcher
Come-along
Small sledge hammers
Fence tool – wire cutter, plier, etc.
Hog ring pliers
Tool bag
Gloves
Flagging
Ropes – as safety lines, if needed

Pulaski/Fire ax
Hazelhoe

Hand and longhandled picks
Chain saw
Gas powered auger
Weed eater
Gas powered rock drill
Machete
Construction string
10 penny nails or hex wrench for clips
Hip chain

FENCE MATERIALS NEEDED:

- Galvanized Anchors – Anchors should be spaded. Plan to use 40 anchors per roll of hog wire.
- Galvanized Barb Wire – One roll is 300 yards. Plan to use one roll of barb to 3 rolls of hog wire.
- Galvanized T-Posts – Plan to use 30 to 40 posts per roll of hog wire, various heights.
- Galvanized Unspaded posts-For horizontal braces and crossing styles
- Wooden posts-Treated and pointed at one end, various heights.
- Galvanized T-Post Clips – Plan to use 225 clips per roll of hog wire.
- Aluminum tie wire – Useful for securing hogwire to corner posts when conventional clips are too small.
- Galvanized Fence Wire – One roll is 330 feet (100 m). Measure fence line and plan accordingly. Extra material can also be used for fence repairs in the future.
- Galvanized Fence Panels-Width and height vary and can be cut to size. Usually panels are 16 ft. in length and 36-52 inches in height. Anticipate areas of overlap.
- Galvanized Smooth wire: 12 gauge usually most useful.
- Galvanized Duckbill anchors and setting post.
- Galvanized Fence staples.
- Various hardware for securing braces (caps, post brackets, nuts, bolts, and washers).
- Gates, gate posts, and hardware.

Fencing Specifications Table:

Target species	**Mininum Fence height**	**Graduated meshing**	**Fence skirting recommended**	**Electric top wire recommended**
Cattle	48”	No	No	Yes (as feasible)
Goats	48” (52” better) Slinky fence useful	Yes (no gaps at ground)	Yes (24”-36” as needed)	Yes (as feasible). Additional hot wires may be needed to control billys
Sheep	60”	Yes	No	Yes (as feasible)
Deer	78 (84” better) Slinky fence useful	Yes	No	Yes (as feasible)
Pigs	42” (48” better) Slinky fence	Yes (no gaps at ground)	Yes (24”-36”) as needed in soft soils	No

APPENDIX 3B: RODENTICIDE BAITING GUIDELINES

Under FIFRA Section 24c, the use of rodenticide in conservation areas is permitted in the State of Hawaii if SPECIAL LOCAL NEED (SLN) labeling is obtained. As with any pesticide, users must follow the product's instructions for use as well as the SLN label's restrictions. The SLN permit details:

1. WHAT PESTICIDE PRODUCT MAY BE USED: Pesticides that may be used are RAMIK Mini Bars®, JT Eaton Bait Blocks with Molasses / Peanut Butter Flavor®, or JT Eaton Bait Blocks with Fish Flavorizer®. Diphacinone is the active ingredient. Diphacinone is an anti-coagulant originally developed for use in humans to alleviate blood clotting. During animal testing it was found to be highly effective as an anti-coagulant in rodents.

2. WHO CAN APPLY WHICH PESTICIDE PRODUCT:At the time of this manual's publication, Eaton's Bait Blocks were re-classified as a Restricted Use Pesticide due to secondary poisoning concerns in the continental U.S. Restricted Use Pesticides require applicators (or their immediate supervisors) to have a current certification in restricted use pesticides obtainable from the State of Hawaii Dept. of Agriculture.

3. WHAT ADDITIONAL CROP OR SITES THE PESTICIDE MAY BE USED TO TREAT: These sites include forests, offshore islands and other non-crop outdoor areas.

4. WHAT RESTRICTIONS APPLY TO TREATING THE CROP OR SITE:
    a) Bait stations must be <u>tamper-resistant</u>. (Note: Experts have found that some models of bait stations are not tamper-resistant.)
    b) Bait stations should be secured on the ground in ungulate free fenced areas or in trees at least three feet above the ground where ungulates are still present.
    c) You must have SLN labeling on hand during application.

5. HOW SHOULD THE STATIONS BE PLACED:
    a) A grid setup is generally recommended to ensure adequate protection of resources conserved. Stations are to be spaced in 75-150 ft intervals. This number is based on extensive radio-collar work in Hawaiian rainforests (these figures can be adapted for dry forests, if substantial data is provided and approved).
    b) Place stations near rodent pathways and dens (e.g. rock overhangs, tree cavities, small caves etc.). Do not place bait stations out in the open or within 15 feet of any body of water or stream.
    c) If placing bait stations in areas that are not pig free (i.e. unfenced areas), bait boxes must be tied a minimum of 3 feet off the ground in an area inaccessible to feral pigs.
    d) Placing stations too close to protected resources can also invite rodent predation. For example, stations should not be placed at the base of

nesting trees for endangered birds, but rather an appropriate distance away (e.g. 50ft.).

e) Rodents may take a while to find a bait station, particularly if stations are tied in trees away from natural rodent dens. Adding smears of peanut butter to the inside lid of the box upon initial deployment may aid rodents in finding the stations. Also placing 'rodent ramps' using available tree limbs can also assist rodents in getting up to the bait stations in trees.

6. WHAT DOSAGE OR DILUTION TO USE:
   a) 4-16 oz. of bait per station. As indicated on the label, no more than a pound (16 oz.) should be in the station at any one time. Less bait may be needed at each station over time following the initial knockdown of target populations.

7. WHEN THE PESTICIDE SHOULD BE APPLIED:
   a) To be determined by the species to be protected. Some agencies bait year round at six week intervals (after the initial knockdown period) to protect snail populations. Other agencies bait only seasonally during rare plant flowering/fruiting periods or bird nesting seasons.
   b) Bait should also generally be replaced after periods of sustained heavy rainfall as it will likely be spoiled.

8. WHAT SPECIAL EQUIPMENT IS NEEDED:

   a) Inserting a chicken wire mesh in the bait station to raise the bait off the bottom of the box can prevent the decomposition of bait in wet conditions. Also using the wire rod as intended by the manufacturer to suspend the bait or placing the bait in a plastic bag will also extend bait longevity. Drilling drainage holes in the corner of bait boxes will also keep bait fresher for longer periods.
   b) Snap traps are also recommended in conjunction with baiting for initial knockdown of rat and mice populations as well as for presence/absence monitoring. Bait avoidance does happen.

9. OTHER SPECIAL REQUIREMENTS:
   a) Bait stations must be labeled with name and phone number of responsible agency.
   b) Treated areas must have warning signs. Signage shall follow the wording as designated on the SLN label.
   c) Check area periodically and collect and dispose of any dead animals found.
   d) Spoiled or uneaten bait and dead animals collected may be buried on-site. However, burial on site shall be at a depth such that it will not result in exposure to non-target animals.
   e) All users must consult the U.S. Fish and Wildlife Service, in writing, of each new location two weeks prior to deployment.

f) Secondary poisonings shall be reported to the Dept. of Agriculture as indicated on the SLN label.

BAITING CHECKLIST

1. Obtain Restricted Use Pesticide Applicator's certification.
2. Notify the U.S. Fish and Wildlife Service at least 30 days before baiting to obtain other approvals as needed.
3. Determine the species to be protected based on resource management goals and objectives for the area.
4. Determine the target species to be controlled (rats, mice, mongoose).
5. Determine which type of bait will be used (e.g. Eaton's 2 oz. blocks peanut butter/molasses flavorizer for rats or Fish flavorizer for mongoose)
6. Determine the type of station to be used. If making your own, submit a description and preferably a sketch. (Note: stations must be inspected and approved) before deployment if using a non-standard model.
7. Determine the potential non-targets in the area. Is it the project area fenced? Is there public access and potential for tampering?
8. Post warning signs (wording different from the language required on the SLN label needs approval).
9. Determine the spacing and location of stations. Mark and map station locations and resources to be protected.
10. Determine the frequency to check / recheck stations. Monitor bait take and adjust the frequency of checking and amount of bait deployed accordingly.
11. Record the amount of bait used per calendar year: EPA requires a report of how much pesticide is being used under each 24c label.