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Reversing the impacts of feral pig on the Hawaiian tropical rainforest ecosystem

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Introduction

Hawaii is sometimes called “the paradise of the Pacific” because of its spectacular beauty, abundant sunshine, expanses of lush green plants, and gaily-colored flowers (Murakane, 2003). Many species of animals and plants have been introduced to the Hawaiian Island, and for some it has become an invasive problem, such as the feral pig. Feral pigs are pigs that have lived in the wild as a result of escaped captivity or have been released for game hunting into the wild. Feral Pig (*Sus scrofa*), was first introduced to Hawaiian Island around 1500 years ago by Polynesians, then in the 18 century the Europeans introduced another pig species (Brower, 1985). For the Hawaiian Island and its rain forest, feral pigs are an invasive species because they eat massive vegetation causing native plant extinction, as well as soil erosion and soil compaction in their tracks.

There have been many attempts to control Hawaii’s feral pig. These efforts include hunting, trapping, fencing, poisoning, and snaring. A few of these management techniques have been shown to have a great effect on the feral pig population and the recovery of the Hawaiian ecosystem. To save the Hawaiian Islands and the rain forests, the feral pig’s impact needs to be minimized.

Feral Pig: An Overview

Feral pig habitat

Feral pigs can occupy in variety of habitats, but they tend to prefer moist forests areas with green forage trees and wooded areas that are closed to the water sources (Gingerich, 1994). The Feral pig is not typically aggressive and will retreat if approached. However, when cornered, wounded, or defending young, they may charge and are capable of inflicting serious wounds with their razor sharp tusks (Nowack 1991 and Gingerich, 1994).

Feral pigs are opportunistic breeders, capable of breeding year round if conditions are favorable. The piglets reach breeding age at between 10 and 12 months (Wodzicki, 1950). Feral pigs are also polyestrous: adult females have a 21-day oestrus cycle and a gestation period of about 112-114 days. With a gestation period about 113 days, feral sows are capable of producing two litters per year, averaging seven piglets per litter. However the average is 1.1 litters per year (Caley, 1997).

Feral pigs commonly travel in groups or herds ('sounders') of 10 to 20 individuals (vanLoon,

1979), and in short distance, averaging around 1.0 km² daily (Caley, 1997). Yearly home ranges can sometime be larger, averaging 31 km² for feral boars and 19 km² for feral sows (data from San Catalina Island, Hawaii). Larger dominant boars may have home ranges greater than 50 km² due to their need for more resources (Baber and Coblentz, 1986). However, 95% of boars and sows were recaptured within 6 to 15 km (Caley, 1997) respectively, from their initial point of capture.

Geography

Feral pigs originally occurred in Europe, Asia, North Africa, and the Malay Archipelago and were later introduced throughout the world as domesticated animals by humans (Storer, 1992). They can be found nearly everywhere, from homes to barns to boggy marshes and mountainous terrain.

Currently, Hawaii feral pigs have occupied every Island in the Hawaiian state. The main Hawaii Island, KahoOlawe, Molokai, and Oahu islands have had feral pigs' infestation and are now still abandoned with feral pig population (HEAR, 2003). As for Maui Islands, the feral pig's impacts just have been newly recorded in comparison to other islands. Feral pigs were introduced to East Maui in the 1930's after they had escaped from coastal communities and later on introduced to West Maui in the 1960's when some escaped from a farm (Nicolai, 2001). On Kauai Island, the feral pigs are widespread and found everywhere except isolated parts of the Na'pali coast (HEAR, 2003). As of recent years, the strong emphasis of feral pigs eradication have made Lanai Island feral pig free (HEAR, 2003).

Feral pigs still exist in large numbers on most of the Hawaiian Islands. As a result of their large population, feral pig's impact will continue to be a problem for the Islands plants and especially their rain forest plant communities.

Pig Influence on the Hawaiian Tropical Rain Forest Ecosystem

The rain forest lands are being lost at a dramatic rate, and over the past 30 year about 50% or great were being degraded by feral infestations, mostly pigs (HEAR, 2003). As of today, only 10% of Hawaii's the remaining rain forest presently receives protection from feral pigs (Cory, 2002). These lost and degraded forests are mostly low elevation rain forests.

There are still large areas of high quality rain forests on many of the Hawaiian Islands like Maui, Oahu, and other, but they are mostly on the steep windward slopes, ridges hill, and maintain peaks (Cuddihy and Stone, 1990). Maui has about 140,000 hectares of rain forest that are still dominated by native plant species; a similar area of rain forest remains in the four main islands combined (Main Hawaii Island, KahoOlawe, Molokai, and Oahu) (Cuddihy and Stone, 1990, Jacobi and Scott 1985). These rain forests could soon be degraded by feral pigs.

What make feral pigs such a big problem for the Hawaiian rain forests are their unique habits. The feral pigs alter the forest condition to the extent that the forest floor can no longer maintain any native plant species. This is done by aggressive uprooting tree and underground plant masses with their trunk, erosion the forest soil with their massive consumption of under-storey plants, and creating an opportunity for invasive plants (Diong, 1982). Native plants like Ohi'a (*Metrosideros polymorph*a Gaud), and Koa (*Acacia koa* A. Gray) once dominated the forest floor, but now are now overrun by invasive species (Murakane, 2002). The invasive species such as

banana poka and guava are replacing indigenous Hawaiian plants (Cory, 2002).

Consequently, controlling feral pigs is considered essential to the survival of these rain forests by most conservationists. The control method needs to be swift and productive because feral pig degradation is difficult to reverse after invasive plant has occurred (Cory, 2002). The devastating effect of the feral pigs on the Hawaiian native vegetation has led many national parks and governmental institutions to establish management techniques to deal specifically with them.

Monitoring Techniques

There has been some monitoring of feral pig populations in Hawaiian rain forests to evaluate the effectiveness of the various control methods (Sweitzer and Van Vuren, 2000). Feral pigs are surveyed using techniques ranging from advanced technology, such as GPS, to radio tracking, to in-person tracking. The first tracking on feral pigs was done with radio collars to determine home range and patterns of movement for better application of the control management (Hone and Stone, 1989). Using trackings signs of as feral pig, activities were classified as old, intermediate, or fresh. The fresh category is an indicator of newly impacted site (Hone and Stone, 1989). These tracking techniques have also allowed managers to direct resources to the locations with the most recent activity.

There has been much less monitoring of the rain forest recovery. On the main Hawaiian Island, there has been monitoring of the recovery of microarthropods and understory rain forest plants. The monitoriong goal of this project is to evaluate the time it takes for the microarthropods to rebuild the soil (Vtorov, 1993). The information from monitoring of the microarthropods can potentially be used to help design a program for the whole rain forest ecosystem monitoring.

Management Techniques

In early 1900's, the damage caused by the feral pigs in the Hawaiian native rain forests was recognized and the Hawaii Territorial Board of Agriculture and Forestry started a feral pig eradication project that lasted until 1958 that removed 170,000 pigs from forests statewide (Diong, 1982). This eradication project compared five control techniques: fencing, trapping, snaring, hunting, and poisoning.

For the Hawaiian rainforest, fencing and snaring proved to be the most effective because fencing keeps tropical area pigs from spreading (Johnstone, 1985), and snaring removes them in large number at relatively low cost (Anderson and Stone, 1993). To get the most benefit, the two control techniques usually need be used to reduce the population by at least 70% annually to offset reproduction in the following year which can increase populations by as much as 80-110% (Caley, 1997).

Fencing

Twenty-five years ago, fencing was tested by Hawaii Volcanoes National Park as a method of promoting natural tropical forest restoration. Fencing falls in to two categories, Non- electrifying fence and electrifying fence. The effectiveness of either of the two kinds of fence depends on their design and their application. Fencing can be placed in location where it would deter feral pig from the area and can also be designed to provide the most effective enclosure with the right combination of design schematic (Hone and Atkinson, 1983).

The common non-electrifying fence designs consists of net wire or diamond mesh construction with the spacing of vertical wires at about 15 cm (6 inches) or less to be pig-proof (Hone and Atkinson 1983, Tilley, 1973). In general, fence must be at least 91 cm (36 inches) tall and must be tightly stretched and/or buried beneath the ground at the bottom to be effective (Tilley, 1973).

Electrifying fence need to be constructed with two layers of fence. The first layer of fence should be made of non-electrifying net wire and the second lay needed to be made of electrifies wire fence. The two fences needed to be spaced about 30 cm (12 inch) to 60 cm (24 inch) away from one another. The electrified wire fence needed to be toward the pig side of the fence and 24 cm (9.5 inches) above ground (Hone and Atkinson, 1983). The design allows the pigs to encounter the live wire first when trying to enter the enclose areas. Finally, the main fence is grounded to increase effectiveness.

Using fence as a control agent for feral pigs is the most expensive control method, but it can be the most effective method in stopping spread. Fencing can be a useful tool in preventing spread and easy access to other areas (Loope & Medeiro, 1995), to avoid resettlement (Parkes, 1990a), or to divide a population in order to reach gradual eradication (Johnstone, 1985). Enclosed areas can stop feral pig damage by 40% to 70% compare to unenclosed area (Katahira, 1980). Electric fences could be useful alone or in combination with conventional non electrifying fences (Savory, 1991). Although, electrified fence has the ability to deter nearly 94% of pigs from crossing it (Hone and Atkinson 1983).

Fencing has played a major role in the recovery of previously pig-damaged areas, however fencing only keeps the pigs out; it does not control their populations. Another problem, if a number of hogs are causing damage and are using one fence hole to enter the damage area, it can take a considerable amount of time to stop the problem (Loope, 1989). For this reason, fences can require substantial amounts of maintenance to assure their effectiveness and may not be practical in areas of rugged topography (Rollins, 1997). Although fencing has been an effective strategy in aid other technique (Loope, 1989) such as snaring.

Snaring

Snaring has been the main control method used on the Hawaiian Islands, and it proved to be an effective way of removing significant numbers of feral pigs. Snaring can be used where feral pig tracking locations indicates new feral pig infestations (Anderson and Stone, 1993). The effectiveness of snaring greatly depends on snare design. There are different kinds of snares design but the kind preferred by many Hawaiian national park managers is foot-snaring (TWDMS, 1998m). It consists of a loop of steel cable attached to a secure object or a heavy drag and placed in a location to catch the animal as it passes through the loop. The snare usually has some kind of sliding locked device that allows the loop to close but not open easily. A loop of about 25-30 cm (10-12 inches) in diameter is most effective and should be suspended about 18-20 cm (7-8 inches) above the ground to catch a 13.5 kg (30 lb.) pig (TWDMS, 1998m).

Some managers have been reluctant to use snares; other managers employed snares freely (Anderson and Stone, 1993). Still, snaring is maybe the only cost effective way to get the pig population low enough to keep areas of high natural value from disappearing. Snares used accounts for 55% of the feral hogs removed by TADCS control efforts during 1983-1992 (Jeffery 1999). Some traps can be designed without inflicting serious injuries on the pig (Onderka, Skinner & Todd, 1990), while others can also be designed to be broken when an animal that is bigger than the target is caught (Phillips, 1996).

Snares are of relatively low cost compared to other control techniques such as hunting and poisoning. The disadvantage of snares is that pig has to pass over the snaring for it to work (Stone and Loope, 1987). Another disadvantage is that large feral pig occasionally breaks snares (Nicolai, 2001). As Jeffery (1990) point out, snaring is effective in reduce the feral pig population but it takes time.

Post-Removal Forest Recovery

Feral pig removal is an important first step in a restoration of native rain forest because native plants cannot thrive where pigs are grazing and rooting. The removal of feral pig from forested areas will hopefully reverse the degradation of soil and allow the native species to return (Vtorov, 1993). As of today, there are only a few publications available about the effect of feral pig removal on the rain forest. The reason for the lack of information on recovery may be that plants rapidly recolonize after removal of the feral pig. Sweitzer and Van Vuren (2002) suggest feral pig tillage prepares he soil for seed to germinate. It is unclear, however, if this newly created habitat favors indigenous species or the spread of exotics. The recovery rate of native rain forest species after the removal of feral pig has shown that different rates of recovery for understory species and large tree species (Hone and Stone 1989). The rate of recovery for understory species was between 4 to 7 years but is longer for trees because tree seedlings take about 2 years to germinate after the feral pigs are removed.

Forest plant recovery greatly depends on the favorable condition of soil (Cuddihy and Stone, 1990). For this reason, microarthropods are a good indication of possible soil recovery because microarthropod cannot exist in compact soil where it is the after effect of feral pig occupation (Vtorov, 1993). Furthermore, soil microarthropods can also be used to indicate biodiversity because their abundant correlates with high species diversity areas (Vtorov, 1993).

The recovery rate for microarthropod populations took 4 years and 7 years for forest soil to recovery to where the density doubled and biomass increased by 2.5 times (Vtorov, 1993). Springtail *(Collembola* spp.) were dominant among the microarthropods species and their populations very much reflected the changing of soil conditions during forest recovery (Vtorov, 1993). The study further compared density and biomass between uninfected sites with infected site. The uninfested sites have over 50% of the individuals and 70% of the biomass compared to uninfested sites. In site where pigs still occur, only 30% of individual and 20% of biomass remains (Vtorov, 1993). Sites from which pigs were removed 2 and 4 years previously did not differ in community structure, numbers, or biomass of soil microarthropods from infested sites.

Conclusion

The success of reversing the degradation of Hawaiian rain forest ecosystem depends greatly on the removal of feral pigs from impacted sites. Feral pigs have proved to be a major factor in rain forest degradation because they destroy native understory, provide space of invasive species, created massive erosion of soil and organic matter, and damage tree composition and root systems. This degradation of the rain forest has led to the application of several control techniques, including fencing and snaring that this paper recommend for removal of feral pig in native Hawaii rain forest. Fencing and snaring provided to be the most effective for managing feral pig population because they limit the dispersal of feral pig as well as remove of large number of pigs. The information for the recovery rates is still too minimal to provide any

satisfactory comparison or understanding of recovery after feral pig removal. That is why more research needs to be done, such as estimating differences in recovery rates of various indigenous species.

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