

- for Dairy Purposes, Technical Bulletin No. 17. HMSO, London.
- Markowitz, H. and Woodworth, G. (1978) Experimental analysis and control of group behavior. In: Markowitz, H. and Stevens, V.J., eds., *Behavior of Captive Wild Animals*. Nelson-Hall, Chicago, IL.
- McGrew, W.C. (1981) Social and cognitive capabilities of nonhuman primates: lessons from the wild to captivity. *Int J Study Anim Prob* 2:138-149.
- Meyer-Holzappel, M. (1968) Abnormal behavior in zoo animals. In: Fox, M.W., ed., *Abnormal Behavior in Animals*. W. B. Saunders, Philadelphia.
- Meynell, G.G. and Meynell, E. (1970) *Theory and Practice in Experimental Bacteriology*. Cambridge University Press, London, U.K.
- Morgan-Jones, S.C. (1982) A method of enumerating salmonellas in poultry environments. In: Corry, J.K.L., Roberts, D. and Smith, D.G., eds., *Methods for the Isolation and Identification of Food Poisoning Organisms*, Society of Applied Bacteriology Technical series No. 17. Academic Press, London (in press).
- Murphy, D.E. (1976) Enrichment and occupational devices for orangutans and chimpanzees. *Int Zoo News* 23: 24-26.
- Olesiuk, O.M., Snoeyenbos, G.H. and Smyser, C.F. (1971) Inhibitory effects of used litter on *Salmonella typhimurium* transmission in the chicken. *Avian Dis* 15:118-124.
- Snoeyenbos, G.H. (1967) An epidemiological study of salmonellosis in chickens. *Avian Dis* 11:653-667.
- Tucker, J.F. (1967) Survival of salmonellae in built-up litter for housing of rearing and laying fowls. *Br Vet J* 123:92-103.
- Turnbull, P.C.B. and Snoeyenbos, G.H. (1973) The roles of ammonia, water activity, and pH in the salmonellacidal effect of long-used poultry litter. *Poult Sci* 12:72-86.

Introduced Species and the Issue of Animal Welfare

Michael Hutchins, Victoria Stevens and Natasha Atkins

Recently, considerable debate has been heard about the control or elimination of introduced or "exotic" animals on publicly held U.S. lands. Species introductions, whether intentional or unintentional, seem to be an inevitable result of human activities, but they may result in both economic and ecological problems: It has been estimated that over 90 percent of all such introductions have been harmful in some respect. Control of exotics can be accomplished through containment, shooting, poisoning, reintroduction of native predators, introduction of disease organisms, live capture and removal, and reproductive inhibition.

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Those who must make decisions about the fate of introduced species need to seek a balance between the rights of the individual animals and preserving the viability of whole ecosystems. One important consideration is that, although the control of exotic animal populations may adversely affect individual sentient beings, inaction may cause widespread suffering to many species and consequent loss of biological diversity.

Zusammenfassung

Eine heftige Debatte betraf kürzlich das Thema der Kontrolle oder Eliminierung von eingeführten oder "exotischen" Tieren auf Land in öffentlichem (US) Besitz. Die Einführung von Tierarten, ob beabsichtigt oder unbeabsichtigt, scheint ein unvermeidliches Resultat menschlicher Aktivitäten zu sein, doch rufen sie sowohl wirtschaftliche wie oekologische Probleme hervor. Schätzungsweise hatten über neunzig Prozent dieser Einführungen in gewisser Hinsicht eine schädliche Wirkung. Eine Kontrolle von Exoten kann erreicht werden durch Abriegelung, Erschiessen, Vergiften, Wiedereinführung von heimischen Raubtieren. Einführung von Krankheitserregern, Fang und Entfernen, sowie Geburtenkontrolle.

Diejenigen, welche die Entscheidung über das Schicksal eingeführter Tierarten treffen, müssen für ein Gleichgewicht sorgen zwischen den Rechten der einzelnen Tiere und der Erhaltung der Lebensfähigkeit des gesamten Oekosystems. Obwohl die Kontrolle exotischer Tierpopulationen sich schädlich auf einzelne empfindsame Lebewesen auswirken kann, ist es wichtig daran zu denken, dass Inaktivität ungeheures Leid für viele Tierarten bedeuten und demzufolge den Verlust der biologischen Vielfalt hervorrufen kann.

Introduction

There has been considerable controversy over attempts to control or eliminate introduced or "exotic" animals on federally managed lands in the United States. Some resource managers and conservationists argue that exotic animal populations should be controlled, since they cause considerable habitat disruption, prey on or compete with native fauna, and alter natural ecosystems. This view has been hotly contested by some animal welfare and animal rights organizations, which have objected to the proposed methods of control, especially those that involve harassment or killing. In some instances, such as the case of the Grand Canyon burros, differences of opinion have led to long and costly court battles (Laycock, 1974; Reiger, 1980; Stocker, 1980). The purpose of this paper is to examine the introduced species issue in more

detail, paying particular attention to the interests of animal welfare/animal rights advocates. Our discussion will focus on introduced mammals, because these animals, since they are both sentient and appealing, comprise the principal focus of animal welfare/animal rights concerns.

Origins of Exotic Species

One of the many ways in which humans alter their environment is by transporting organisms across natural barriers to dispersal. By definition, exotic animals are those that do not occur naturally, either presently or historically, in a particular ecosystem. An introduction is defined as the release, escape, or establishment of an exotic animal into a natural ecosystem. Introductions can be differentiated into two basic types: purposeful and accidental (Courtney, 1978).

Purposeful introductions are those that are made for a reason, usually to fulfill some real or perceived human need. For example, reindeer were introduced to Alaska to provide the mining industry with a means of transporting freight, provisions, and correspondence through harsh, subarctic terrain. They were imported to become "to the far north what the camel is to desert regions" (Jackson, 1897). Sportsmen and game managers have been responsible for numerous introductions. A desire to hunt familiar or fashionable game led European settlers in New Zealand to import a variety of large herbivores, including the chamois, red deer, and Himalayan tahr. This tradition has also been followed in the United States, where exotic ungulates, such as the European wild boar, Barbary sheep, and Nilgai antelope, roam the forests, deserts and plains—sometimes in considerable numbers (Laycock, 1966).

Some introductions have occurred in a deliberate effort to eliminate exotic species. For example, the mongoose was imported to Hawaii in an attempt to control the Norway rat—also an immigrant and a significant agricultural pest (Laycock, 1966; Randall, 1971). The purpose of other introductions has been to make animals available for human consumption. In the eighteenth and nineteenth centuries, domestic goats and sheep were routinely placed on oceanic islands such as Hawaii and the Galapagos Islands to serve as a source of fresh meat for the crews of ships sailing in remote seas (Coblentz, 1976).

Accidental introductions include any that occur unintentionally (Courtney, 1978). For example, the ubiquitous house mouse and Norway rat entered North America as stowaways on ships (Elton, 1958). The European rabbit, which is commonly raised for human consumption, has been a frequent escapee. Mil-

lions of feral rabbits inhabit Australia and other oceanic islands (Holdgate, 1967; Roots, 1976). In addition, domestic cats and dogs often adopt a feral or semiferal existence in the vicinity of human habitation (Denny, 1974).

A case that appears to fit well within either classification is that of the feral burros that roam the southwestern United States. Domestic burros were brought to North America in the sixteenth century by the Spanish, who used them as beasts of burden (McKnight, 1958). In the mid to late 1800's, burros were also used by American prospectors who, upon abandoning their dreams of unlimited wealth, released their animals into the desert. Since they were descended from the African wild ass (*Equus asinus*), which is adapted to arid climates, the introduced burros proliferated, and thousands are believed to inhabit the region today. The burro was originally brought to North America as a beast of burden and therefore represents a purposeful introduction; however, its release and subsequent establishment into North American ecosystems are consequences that perhaps cannot be called purposeful, in the true sense of the word.

Ecological Effects of Exotic Species

Species introductions are common and, whether intentional or unintentional, they seem to be an inevitable result of human activities. Why, then, are some resource managers and conservationists so adamant about controlling or eliminating exotic animals?

Concern about exotic animals can be divided into two categories: economic and ecological. Economic concerns include the problems related to financial losses caused by exotic animals, such as those that result from the destruction of agricultural crops or from competition with livestock. While such

problems may be important, we will not focus on them here. Instead, we will concentrate on the relationship between native ecosystems and introduced animals, because it is this issue that generates some difficult philosophical questions.

An impressive literature exists on the ecological effects of introduced mammals, and it is estimated that over 90 percent of all such introductions have been harmful (Roots, 1976). This is not surprising when one pauses to consider the nature of ecosystems. Having evolved over many millenia, ecological systems are like vast, finely tuned machines made up of numerous interrelated parts. The integration of the parts is responsible for the machine running smoothly. In ecosystems, the "parts" are organisms or important environmental features, which may be intricately interrelated and interdependent. Following this line of reasoning, the introduction and

successful establishment of an exotic species can be likened to throwing a wrench in the machine and having it "foul up the works." Of course, unlike machines, ecosystems can continue to "operate" after the introduction of non-native organisms, but they may be altered significantly in the process.

Perhaps the most pervasive ecological disruption caused by introduced mammals is the destruction of soils—the basis of much, if not all, of terrestrial life (Fig. 1 and 2). A dramatic example of soil damage caused by an exotic mammal is the transformation that took place on the island of St. Helena following the introduction of domestic goats. In 1501, this subtropical island in the Atlantic Ocean was densely covered with forest vegetation, but in 1513 goats were imported by the Portugese. With an abundant food supply, and no predators or competitors to limit their population,

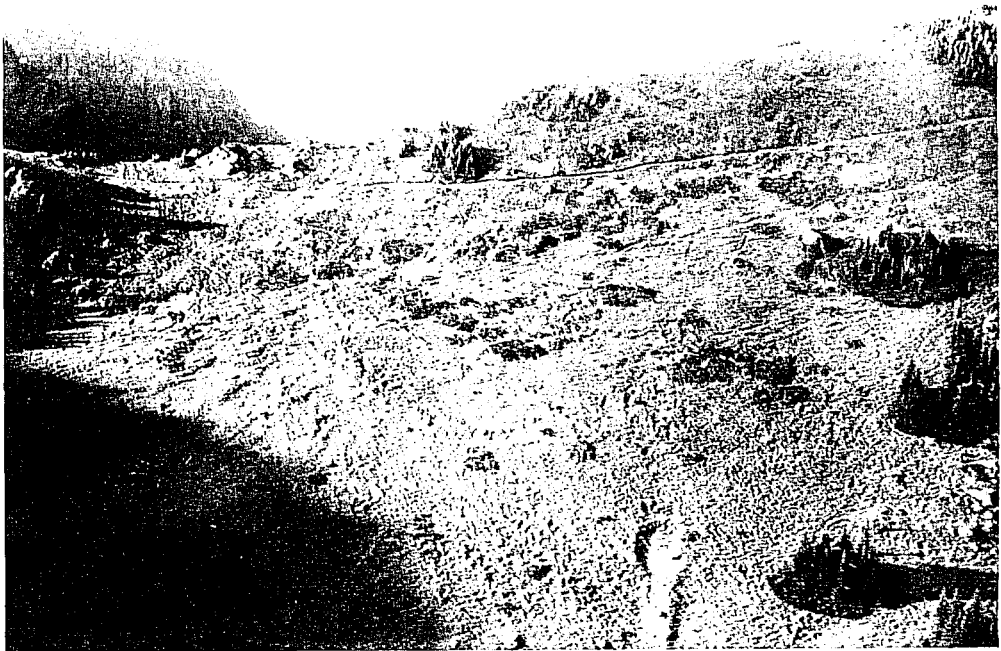


FIGURE 1 Aerial photography showing trails, dust-bathing sites, and erosion caused by introduced mountain goats in fragile alpine vegetation — Olympic National Park. (Photo by M. Hutchins)



FIGURE 2. Aerial photograph, Olympic National Park. (Photo by M. Hutchins)

the animals multiplied rapidly. Hoards of foraging goats decimated vegetation on the island's steep slopes and, in the absence of plant cover, tropical rainstorms washed away much of the topsoil. Today, the island's landscape is barren, and native vegetation survives only on cliffs that are inaccessible to the goats (Holdgate, 1967).

By reducing vegetative cover, introduced herbivores can also affect the water storage capabilities of mountain slopes. New Zealand is an island country that has no large native mammalian herbivores. The region's natural vegetation evolved in the absence of heavy grazing pressure, and therefore did not develop chemical or physical adaptations for protection. (Plants with a history of exploitation by herbivores tend to evolve adaptations such as toxins, thorns, or rapid growth and reproductive rates to protect them from their "predators.") After deer and other ungulates were introduced to the west coast of New Zealand, the vegetative cover was severely reduced. With few plants to stabilize the soil or to retain moisture, ground water

runoff led to excessive erosion, silting of rivers and streams, and large fluctuations in stream levels (Roots, 1976).

There are numerous accounts of habitat modification caused by introduced herbivores (Baker and Reeser, 1972; Baldwin and Fagerlund, 1943; Bratton, 1974, 1975; Coblenz, 1977, 1978; Carothers et al., 1976; Hamann, 1975; Howard, 1964; Hutchins and Stevens, 1981; Mark and Baylis, 1975; Muller-Dombois and Spatz, 1975; Pickard, 1976; Spatz and Muller-Dombois, 1973; Wardle, 1974; Yocum, 1976). In some cases, these animals have caused significant alterations in plant community structure by foraging preferentially on some species and rejecting those that are unpalatable. In other instances, trampling of fragile soils has created ideal conditions for disturbance-adapted exotic plants, which may outcompete native species. In many cases, introduced herbivores have been strongly implicated in the elimination or near elimination of native plants (Fig. 3-6).

In the course of changing the composition of plant communities, or reducing the degree of plant cover, introduced



FIGURE 3. Feral goats on Santa Catalina island off the coast of California. Note the lack of vegetation. (Photo by B. Coblenz)

herbivores may also affect native fauna. These effects can be direct or indirect. An indirect effect is illustrated by the endemic land iguanas and their predators, the hawks, on Barrington Island in

the Galapagos. Because of the cover afforded the iguana by vegetation, these species had coexisted for thousands of years. However, introduced goats ate much of the vegetation, leaving the

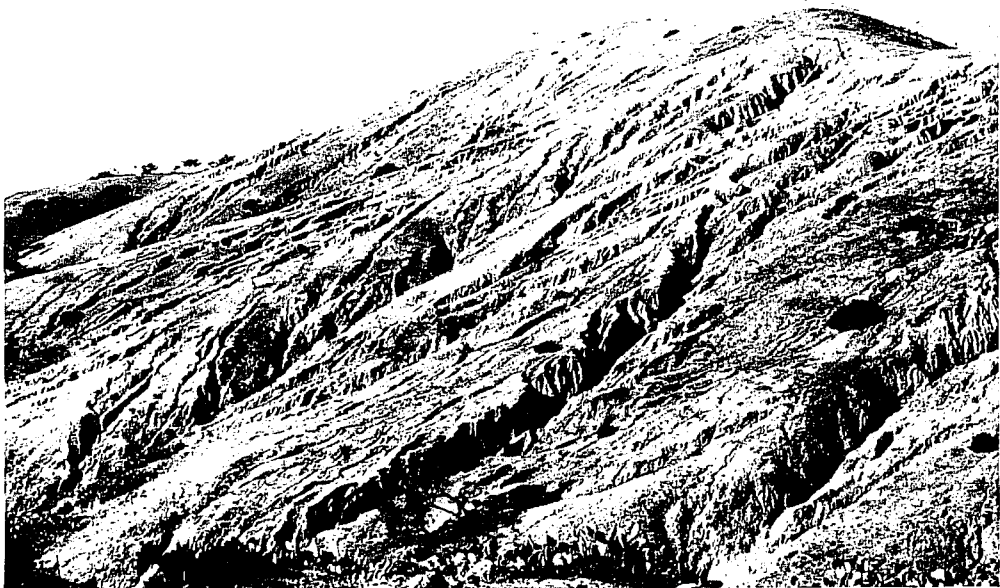


FIGURE 4. Coffee Pot Canyon on Santa Catalina Island. Introduced domestic goats reduced the plant cover, thus resulting in extensive erosion. (Photo by B. Coblenz)



FIGURE 5. Fence erected on Santa Catalina Island. The right side is goat-free. Note the differences in vegetative cover. (Photo by B. Coblenz)

iguanas with no place to hide in time of danger. As a result, they were captured more frequently by the hawks, and were soon threatened with extinction (Dowling, 1964). Non-native herbivores also compete directly for food and other resources with native animals. For example, seed-eating birds became extinct on Guadalupe Island in Mexico following the importation of domestic livestock, which consumed many of the same plants (Greenway, 1958). In addition, it has been suggested that introduced ungulates, such as the burro and Barbary sheep, have contributed to the decline of the native bighorn sheep (*Ovis canadensis*) in the southwestern United States (Hansen, 1980). One study found that the diets of burros and bighorns overlap by as much as 52 percent (Walters and Hansen, 1978), and it follows that any vegetation eaten by feral burros would not be available for the bighorns (Fig. 7).

While introduced herbivores (primarily ungulates) cause the most severe habitat alteration, non-native carnivores have been responsible for the greatest number of species extinctions. For exam-

ple, the introduced mongoose of Hawaii preys on birds' eggs and nestlings; on the island of Molokai, this predator was responsible for eliminating the dark-rumped petrel and Newell's shearwater. Kauai is the only main island in the archipelago that has its original complement of endemic birds. Not surprisingly, it is the only island that is mongoose-free (Kramer, 1971). The introduced black rat has also been implicated in the decline or disappearance of several Hawaiian bird species (Atkinson, 1977). Feral dogs and cats cause considerable mortality in wildlife populations. For example, feral housecats prey on endemic birds and reptiles in the Galapagos Islands, Hawaii, and the West Indies (Konecny, pers. comm.; Iverson, 1978; Kramer, 1971).

Exotics can affect native animals in many other ways. Diseases carried by introduced animals may have profound effects on native wildlife species that have not previously developed an immunity. The effects can be particularly severe when native animals contract these new diseases, while simultaneously having to compete

with exotics for food and other resources. In Africa, the Cape buffalo (*Syncerus cafer*) was nearly eliminated by rinderpest, a disease imported from Asia with domestic cattle (deVos et al., 1956). Internal parasites (cestodes, nematodes, and trematodes) have moved among continents in exotic animals and, in some cases, have been transmitted to native wildlife. Ectoparasites (ticks, lice, fleas, etc.), which carry diseases such as bubonic plague and typhus, have been imported to various regions on rodents like the black rat (deVos et al., 1956).

It is evident from these examples that introduced mammals can cause considerable habitat modification, as well as affect native animal populations through competition, predation, or transmission of parasites and disease. However, there are additional "side effects" of species introductions that are much more subtle. For instance, some

exotic mammals may interbreed with closely related species, and thereby alter the genetic composition of natural populations (deVos et al., 1956). Often, hybridization results in offspring that are ill suited for survival or are incapable of reproduction. In Czechoslovakia, introduced domestic goats hybridized with native ibex at such a high rate that they effectively eliminated the latter (Turcek, 1951).

In summary, there is ample evidence that: (1) exotic mammals can cause significant changes in natural ecosystems, (2) such changes are usually deleterious, and (3) it is impossible to predict the nature or extent of such changes and their ultimate impact on native flora and fauna. A recognition of these facts has led some biologists to label introductions of non-native organisms as "species pollution" and "ecological roulette" (Courtney and Ogilvie, 1971).

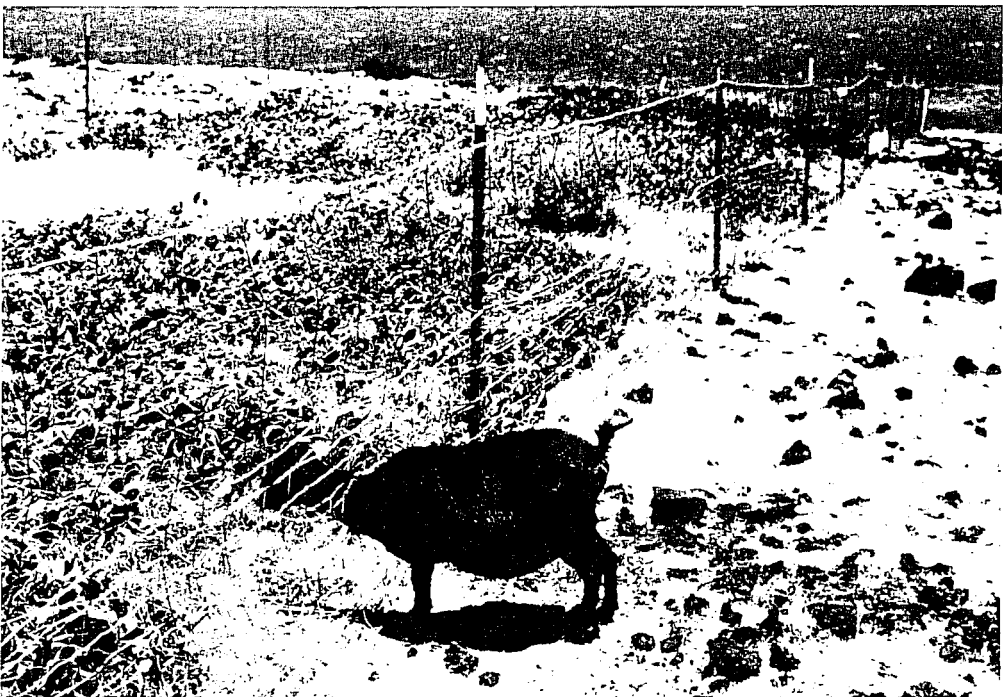


FIGURE 6. An enclosure in Hawaii Volcanoes National Park illustrates the loss of vegetative cover due to the foraging activities of introduced herbivores. A feral goat is attempting to forage on vegetation inside the enclosure. (Photo by D. Reeser)

U.S. Park Service



FIGURE 7. Burros brought to North America by the Spanish in the sixteenth century. Thousands now roam the deserts of the Southwest.

Controlling Exotic Animals

In an effort to preserve native ecosystems and to curb the adverse effects of introduced animals, biologists have recommended numerous methods of control. Sometimes complete elimination of the exotic is advocated, while in other cases, controlling populations at lower than current levels has been proposed. Solutions have ranged from live capture and removal to shooting and poisoning. Because the methods used to control exotics are a major point of contention between animal welfare/animal rights organizations and resource managers, we will discuss this issue in more detail.

Once it has been determined that some sort of action is necessary or desirable, resource managers must evaluate each method in terms of its feasibility, cost, potential for environmental disruption, and humane considerations.

The methods available for controlling exotic animals fall into five basic categories, each with its associated costs and benefits. The categories include: containment, direct killing (by shooting, poisoning, trapping, etc.), predator and disease introduction, reproductive inhibition, and live capture and removal. Field conditions and the nature of the organism generally dictate which alternatives are likely to be the most feasible.

Control through containment has been advocated in some situations. Confining exotic animals to particular areas, it is argued, can reduce environmental alteration. This is a popular alternative among many humane advocates, since it is a nonlethal solution. However, this method has several shortcomings. First, fences meant to contain exotic animals can also prevent the natural movements of native species (Carothers *et al.*, 1976). Second, by restricting the animals to a particular area, the degree of environmental modification is often intensified locally. Third, containment may not be possible because of the difficulty associated with keeping certain animals in the desired area; for species that can climb, jump or burrow, effective containment would be difficult and expensive. The nature of an animal's habitat can also be prohibitive. For example, erecting fences in rugged mountainous terrain may prove difficult or impossible. Moreover, even if the animals were effectively restricted to a particular area, periodic efforts at population control would probably still be necessary.

The use of firearms has been advocated to control feral ungulates, such as burros and goats. This method does have some advantages, such as low cost and minimal impact on the environment. However, many animal welfare/animal rights advocates find shooting unacceptable. While a well-placed bullet can result in a rapid, humane death, even the best of marksmen sometimes miss their targets. When death from shooting is not immediate, the animal may suffer pain. In addition, when shooting is done from aircraft, animals may be badly traumatized by the chase, and the probability of a humane death is much reduced.

Opponents of shooting may advocate euthanasia, but the drugs used for this purpose are often dangerous and expensive and require trained personnel to handle and inject them. In addition, if the

animal cannot be captured easily before the drug is administered, such efforts can result in considerable trauma. Obviously, euthanasia is practical only when large animals are involved, and when they occur in small, relatively contained populations.

Poisons or lethal traps have been successful in controlling some animal populations, but these methods have several distinct disadvantages, the most serious of which is their ability to kill indiscriminately. In the process of controlling exotics, many native animals may be destroyed as well. In addition, many animal welfare/animal rights advocates consider these methods to be inhumane.

The reintroduction of native predators has had increasing appeal as a "natural" method for controlling populations of exotic animals. However, there is no guarantee that the predator will prey exclusively on the species targeted for control, or that the rate of predation will be high enough to significantly reduce population growth. The introduction of exotic predators to control populations of exotic herbivores is inadvisable, since there is no way to predict the range of species that they will include in their diet.

The introduction of disease organisms has also been used to control populations of exotic animals. But diseases often have the same disadvantages as toxins or traps, in that there is no guarantee that they will affect only those species designated for control. However, some disease organisms will affect only particular types of animals. The classic example of a disease organism that was used to control an exotic mammal is that of myxomatosis—a viral disease imported to Australia in an attempt to control the European rabbit. The virus was effective initially, but the rabbits eventually developed an immunity, and the virus itself became less virulent (Fenner, 1965). New strains have subsequently been introduced, with some success (B. Coblentz,

pers. comm.).

Reproductive inhibition is another possible nonlethal solution. Several methods have been attempted, but their practicality and effectiveness are questionable. Tubal ligations, castration, and chemosterilization are feasible for some animals, and have the advantage of being permanent forms of reproductive control. The disadvantage of these alternatives is that they all involve capturing and handling the animals, and may result in considerable psychological and physiological trauma. Hormone implants and orally administered reproductive inhibitors require repeated applications, sometimes on a daily basis. In addition, these methods may have deleterious side effects (Matsche, 1977a, 1977b, 1980; Seal, 1976). Methods involving surgical procedures may lead to infection or death (Zwank, 1981). Mechanical devices that prevent conception have also been developed, but were found to be ineffective and impractical (Matschke, 1976). At present, reproductive inhibition is feasible only for small or confined populations where animals can be captured easily. It is also a gradual, rather than a rapid method of control: if reproductive inhibition is used as a method for complete elimination, then environmental alteration can be expected to continue until the population eventually dies out.

Live capture and removal is another nonlethal method of population control. However, it has numerous limitations. Indeed, the animals are often subjected to considerable physical and psychological stress while being captured and transported. Some animals may suffer limb fractures and lesions as a result of falls, and some may succumb to overdose from drugs or to shock (Stelfox, 1976). Others may contract capture myopathy—an often fatal muscular disorder in hoofed animals that is induced by the trauma of capture and transportation (Chalmers and Barrett, 1977; Spraker, 1977, 1978). The specific characteristics of the host habitat

may also limit the effectiveness of live capture and removal. Relatively inaccessible areas, such as mountainous terrain or dense forests, can make the location, capture, and transport of large animals difficult, if not impossible.

An additional problem limiting the effectiveness of live capture and removal is that of the ultimate disposition of the animals. Public adoption of captured exotics is feasible only for a few domestic species, such as horses and burros, and then only in limited numbers. For other animals, such as reindeer or mongooses, such a strategy is impractical. It is possible that these animals could be released in some other location. However, unless the release site falls within their native range, the animals are just as likely to cause habitat alteration in their new host environment as they were in the previous one.

In addition, a major drawback to live capture and removal programs is the cost (Fig. 8). The Fund for Animals reportedly spent \$500,000 to remove about 600 burros from the Grand Canyon (Anonymous, 1981). Often, introduced ungulates are found in remote or inaccessible areas. Even if live capture and removal were feasible, expensive equipment (such as helicopters) and personnel trained in capturing and handling the animals would be necessary. Because of the exorbitant costs, most capture and transport programs must rely on a very unpredictable funding base—private-interest groups.

Discussion

In order to examine the relationship between introduced species and the animal welfare/animal rights movement, we have organized the discussion around two critical questions:

1. Are efforts to eliminate or control exotic animals—regardless of what method is chosen—incompatible with the philosophical tenets of the animal welfare/animal rights movement?



FIGURE 8. Method used to transport introduced mountain goats from Olympic National Park. This illustrates the expense of live capture and removal programs. (Photo by M. Hutchins)

The newly emergent concept of animal rights has been central to many recent debates involving animals, whether they are found on farms, in laboratories, or in the wild. Attempts to control destructive exotic mammals, such as the Grand Canyon burros, have been opposed by animal welfare and animal rights organizations whose members perceive the harassment or death of sentient beings to be unjustified or cruel and immoral. (But see also the discussion on domestic animals, below.) However, the introduced-species issue is not as straightforward as those that involve obvious cruelty to animals. While the humane treatment of sen-

tient animals is certainly a desirable goal, so is the preservation of natural ecosystems and native wildlife. The welfare of animals has been a concern of both the conservation and humane movements; but, despite this superficial similarity, profound differences exist. Callicott (1980) has compared the "land ethic" of Aldo Leopold (1949) with the "humane ethic" of Peter Singer (1975). While only sentient animals are afforded moral standing according to the humane ethic, the land ethic is more holistic, focusing not only on animals, but also on plants, soils, and waters. While we recognize that philosophical differences exist within

various factions of both the conservation and humane movements, we consider their radically divergent emphasis on the individual as opposed to the species or ecosystem to be a crucial issue.

We perceive many difficulties in the efforts of humane organizations to defend the rights of introduced species. Myers (1979) and Erlich and Erlich (1981) have identified habitat disruption as the most significant threat to wild-animal populations. Therefore, a concern for wild animals needs to be expressed in a willingness to protect natural ecosystems. On a superficial level, animals appear to be separate entities, moving independently and freely within their environments. In fact, nothing could be further from the truth. All living organisms are closely tied to the habitats in which they have evolved. Thus, if the introduction of an exotic herbivore leads to an alteration in plant community structure, native animals that depend on certain plants for food or cover may starve or be captured more frequently by their predators. While an effort to control or eliminate exotics may sometimes necessitate the killing or harassment of individual sentient animals, inaction may result in widespread suffering. A difficult question for humane organizations contemplating legal or political action against government agencies that want to control introduced animals is: Are we willing to live with the suffering of the many other organisms that are adversely affected by the exotic species?

Animal welfare/animal rights advocates must also contend with the realization that many nonlethal methods of population control may be less effective and less humane than lethal methods, such as shooting. Indeed, if one's goal is to reduce pain and suffering, then the advocacy of methods such as reproductive inhibition or live capture and removal must be questioned. The exorbitant costs of live capture and removal are also ethically questionable, especially when one

considers that funds are limited and could possibly be put to better use. For example, poaching and smuggling, stimulated by a lucrative wildlife trade, has helped to push many species to the brink of extinction. The half million dollars spent by the Fund for Animals to remove the Grand Canyon burros could have been used to alleviate the suffering of a greater number of animals, had it been made available to organizations like the World Wildlife Fund, whose objective is to save endangered species from extinction.

Even philosophers who argue that nonhuman animals have a "right to life" recognize that such a right is not absolute. According to Regan (1976): "There may arise circumstances in which an individual's right to life could be outweighed by other, more pressing, moral demands, and where, therefore we would be justified in taking the life of the individual in question." This attitude is reflected in the policy of The Humane Society of the United States toward stray cats and dogs. Each year, millions of unwanted pets are put to death by organizations dedicated to the promotion of animal welfare and animal rights. Ironic as this may seem, the death of countless animals is seen as an acceptable alternative to the starvation and misery that would accompany overpopulation. We believe such actions are also justifiable for wild animals, though this may be unfortunate. But we do not place the burden of moral responsibility on animals (Feinberg, 1978), and this may account for the guilt that we feel in causing them to suffer or in taking an "innocent" life. It is certainly not the fault of introduced animals that they were captured and transported to another habitat by humans. However, the fact remains that exotic species do exist and are, in many cases, causing significant ecological changes at the expense of other animals. Indeed, while we discuss the rights of introduced animals, still others may be driven toward extinction.

In transporting animals from one place to another and allowing them to remain, we rob *native* organisms of their "right to life." To argue that people should not have created such problems in the first place is, at this point, entirely unproductive. And to assume that our ecological problems would suddenly be solved if we "let nature take its course" is naive, since we are often forced into active management of our few remaining natural ecosystems. Human intrusions are subtle, and diverse; potential threats require constant monitoring, and once identified, may require immediate action to prevent any permanent damage.

2. Is the elimination or control of exotic animals justifiable under all circumstances? In what circumstances is it justifiable?

Some recent control programs involving federal lands have been justified by statutes authorizing the protection of native organisms and ecosystems; however, it may be difficult to justify such actions on all lands. Lands under federal jurisdiction are managed to meet their stated purpose under the law, and this may have little relevance to the preservation of natural ecosystems. For example, National Forests, wildlife refuges, and rangelands are seldom managed so as to preserve natural ecosystems, and the agencies managing these lands have come under repeated attack for allowing economic interests to take precedence over ecological concerns. In some cases, the viability of ecosystems is of concern to resource managers only when it affects the production of commercially important livestock or game animals. For example, in Olympic National Park, federal officials have recognized a need to control a population of introduced mountain goats (Hutchins and Stevens, 1981), but Washington state game managers oppose complete removal because it would eliminate hunting opportunities on adjacent lands. In

addition, some of the goats captured by the National Park Service and removed to reduce pressure on the region's fragile ecosystem were shipped by state game officials to Nevada and Utah—areas well outside the animals' native range. The goats were imported to these areas specifically for the purpose of recreational hunting. If government agencies such as the National Park Service wish to justify the elimination or control of exotic animals on the premise that it will protect native ecosystems, then they must be more consistent in formulating and applying their own policies: Simply transporting the problem to another area is not a solution.

There are laws that seek to control the importation of foreign organisms into the United States (e.g., Carter, 1977); however, there are no regulations limiting the introduction of exotic species into natural ecosystems (Courtney, 1978). Protests by animal welfare/animal rights organizations have sometimes forced federal agencies into preparing Environmental Impact Statements (e.g., in the case of the Grand Canyon burros; U.S. Interior Department, 1980) to justify their removal of exotics, but no similar studies are required before new species are introduced by state game agencies.

On the basis of this discussion, it is evident that the control or elimination of exotic species cannot always be justified on the basis of preservationism; however, advocates of control can argue much more convincingly in the case of National Parks. These few areas constitute a relatively small portion of our total land area and contain the only remaining habitats that are still relatively pristine (Houston, 1971). If the control of destructive exotics is made possible on these lands, we believe that every effort should be undertaken to preserve the native animal and plant communities. At least, by exerting control on this limited geographic scale, we will have succeeded in preserving some aestheti-

cally and biologically critical areas. Advocates of control can also argue convincingly in some cases that do not involve National Parks. For example, when exotic species threaten the existence of rare or endangered native organisms that live outside park boundaries, then control can be justified. It might also be appropriate to control exotic animals on lands adjacent to parks or other sensitive areas in order to prevent recolonization.

In arguing against the control of certain exotic animals, some animal welfare/animal rights advocates have questioned whether any benefits would actually result from such actions. However, there are several instances in which the control or elimination of exotic mammals has had beneficial effects. When small enclosures were erected to study the effect of feral goats on native flora in Haleakala National Park, Hawaii, the seeds of a heretofore unknown leguminous plant began to germinate (Baker and Reeser, 1972). The elimination of feral rabbits from Laysan Island in the leeward Hawaiian chain saved the endemic Laysan teal from almost certain extinction (Warner, 1935). At the time the rabbits were eliminated, the birds' population had been reduced to less than seven individuals. Now there is a healthy population. The loss of biological diversity that could have resulted would have been a great price to pay for inaction. Myers (1979) has estimated that nearly 1 million species of animals and plants will vanish from this planet by the end of the century, if habitat destruction is allowed to proceed at current rates. While exotic species represent only one kind of habitat degradation caused indirectly by humans, they are a significant contributor to the problem.

While we recognize the need to control or eliminate some exotics in biologically critical areas, we would not argue for the elimination of all exotics. There are major obstacles to the develop-

ment of effective control programs, such as their cost and the high degree to which some exotic species have become established. The high cost of control makes it necessary to set priorities—perhaps only the most destructive of non-native organisms should be targeted for action. As Darling and Eichorn (1967) have noted: "The question of the status of exotics should not cause hysterical reactions until each example is thought through." Of course, some exotics, such as the Norway rat, have become so firmly established that complete elimination has proved to be impossible. Some animal welfare/animal rights organizations have argued that federal agencies should be required to prove that exotics are in fact causing irreparable damage before control programs are implemented. While we recognize the importance of monitoring the actions of government agencies, there are several reasons for rejecting this position. First, it is impossible to predict the long-term effects of exotics on native fauna and flora, and even more difficult to quantify the nature of such effects. We really know very little about the inner workings of most ecosystems—systems of biological interdependencies can be extremely subtle, and in the absence of such information, precise prediction is impossible. Second, detailed studies of the ecological impacts of exotic animals may take years to complete and, while the irreparable damage is being documented, it may have already taken place. To some extent, resource managers must act on the basis of intuition and previous experience. If there is any evidence that significant habitat alteration is being caused by exotics, then fast and decisive action might be necessary and justifiable.

Epilogue

We have identified several difficult problems for the animal welfare and animal rights movement in defending introduced species. However, our purpose is

not to question the ethical foundations of the movement or to challenge the sincerity of its beliefs. We wish only to broaden its perspective. Michael Fox—a leading proponent of the animal welfare and animal rights movement—has argued recently for a more moderate approach to the issue of animal rights (Fox, 1978, 1979). He views the arguments of Singer (1975) and other “radical” animal liberationists as falling short of the requirements for a practical humane ethic. Indeed, many other more ardent defenders of animal rights have focused exclusively on the protection of sentient animals, and often their attention is concentrated only on those animals that are perceived as being appealing or “cute.” Fox (1979) recognizes the inherent weakness of this philosophy, noting that: “The ecological imperative of responsible stewardship concerns our treatment of, and relationship with all of creation, both sentient and nonsentient.” He envisions the animal welfare/animal rights movement as an important transition to a more holistic “eco-ethic.” While we agree that a recognition of the rights of all living things is an important step toward the attainment of such a goal, we also stress that responsible stewardship may involve difficult, and sometimes painful, decisions. In some cases, our actions may result in the death or suffering of other sentient beings. Of course, we do not believe that cost-effectiveness should be the sole consideration in the development of animal management strategies. A society’s values are just as important as its economics. When the need to control a destructive animal has been identified, then reductions should be accomplished in the most humane manner possible, given the limitations of the situation. When the purpose of such reductions is to preserve natural ecosystems or to protect endangered animals and plants, it should not be viewed as incompatible with the humane ethic.

The controversy surrounding the

control of exotic animals illustrates some of the complex ethical problems that confront the animal welfare/animal rights movement, conservationists, and wildlife managers today (also see Callcott, 1980; Rodman, 1977). We believe that such problems must be confronted directly and openly if the movement is to retain its credibility and maintain its momentum. Aldo Leopold once said that “a thing is right when it tends to preserve the integrity, stability and beauty of the biotic community” (Leopold, 1949). In addition, Blackstone (1978) has observed that the environmental crisis “involves not merely what some consider to be isolated and particular problems, such as the pollution of our lakes and rivers, the smog of our cities, and the devastating effect of pesticides, on food chains; it involves a threat to life on this planet and certainly to the quality of that life.” In fact, if humane organizations are unable or unwilling to broaden their perspective to encompass the whole of nature, they will risk a total alienation of the environmental community. Moreover, in adhering to a philosophy that emphasizes a reverence for life, but that ignores the conditions necessary for its survival, they may ultimately be unfaithful to their own ideals.

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References

- Anonymous (1981) Wild burros still under fire. *Newsweek* 97(15):17-18.
- Atkinson, I.A.E. (1964) Relations between feral goats and vegetation in New Zealand. *Proc NZ Ecol Soc* 11:39-44.
- Atkinson, I.A.E. (1977) A reassessment of factors, particularly *Rattus rattus* L., that influenced the decline of endemic forest birds in the Hawaiian Islands. *Pacific Sci* 31(2):109-133.

- Baker, J.K. and Reeser, D.W. (1972) Goat management problems in Hawaii Volcanoes National Park. *U.S. Dept Int Nat Res Rep* 2:1-22.
- Baldwin, P.H. and Fagerlund, G.O. (1943) The effect of cattle grazing on koa reproduction in Hawaii National Park. *Ecology* 24(1):118-122.
- Blackstone, W.T. (1978) Is there an environmental ethic?, In: Blackstone, W. H., ed., *Philosophy and Environmental Crisis*. University of Georgia Press, Athens, GA.
- Bratton, S.P. (1974) The effect of the European wild boar (*Sus scrofa*) on the high elevation vernal flora in Great Smokey Mountains National Park. *Bull Torrey Bot Club* 101(4):198-206.
- Bratton, S.P. (1975) The effect of the European wild boar, *Sus scrofa*, on grey beech forest in the Great Smokey Mountains. *Ecology* 56:1356-1366.
- Callicott, J.B. (1980) Animal liberation: a triangular affair. *Environ Ethics* 2:311-338.
- Carothers, S.W., Stitt, M.E. and Johnson, R.R. (1976) Feral asses on public lands: an analysis of biotic impact, legal considerations and management alternatives, In: *Trans 41st North Am Wildl Conf*, pp. 396-406.
- Carter, J. (1977) Exotic organisms. Executive Order 11987, May 24, 1977, p. EO-1. In: Anon, *The President's environmental program, 1977*. Council on Environmental Quality. U.S. GPO, Washington, DC, 66 pp.
- Chalmers, G.A. and Barret, M.W. (1977) Capture myopathy in pronghorns in Alberta, Canada. *J Am Vet Med Assoc* 171:918-923.
- Coblentz, B.E. (1976) Wild goats of Santa Catalina. *Nat Hist* 85:71-77.
- Coblentz, B.E. (1977) Some range relationships of feral goats on Santa Catalina Island, California. *J Range Manage* 30 (6): 415-419.
- Coblentz, B.E. (1978) The effects of feral goats on island ecosystems. *Biol Conserv* 13:279-286.
- Courtney, W.R. (1978) The introduction of exotic organisms, In: H.P. Brokaw, ed., *Wildlife and America*. U.S. Fish and Wildlife Service, Washington, D.C.
- Courtney, W.R. and Ogilvie, V.E. (1971) Species pollution. *Anim Kingdom* 74 (2): 22-28.
- Darling, F.F. and Eichorn, N.D. (1967) *Man and Nature in National Parks*. Conservation Foundation.
- Denny, R.N. (1974) The impact of uncontrolled dogs on wildlife and livestock, In: *Proc 39th Am Wild Conf*, pp. 257-291.
- deVos, A., ManVillie, R.H., and VanGelder, R.G. (1956) Introduced mammals and their influence on native biota. *Zoologica* 41:163-194.
- Dowling, H.G. (1964) Goats and hawks — a new theory of predation on the land iguana. *Anim Kingdom* 67(2):51-56.
- Elton, C.S. (1958) *The Ecology of Invasions by Animals and Plants*. Chapman and Hall, London.
- Erlich, P. and Erlich, A. (1981) *Extinction*. Random House, New York, NY.
- Feinberg, J. (1978) Human duties and animal rights, In: W.T. Blackstone, ed., *Philosophy and Environmental Crisis*. University of Georgia Press, Athens, GA.
- Fenner, F. (1965) Myxoma virus and *Oryctolagus cuniculus*: two colonizing species, In: H.G. Baker and G.L. Stebbins, *The Genetics of Colonizing Species*. Academic Press, New York.
- Fox, M.W. (1978) Man and nature: biological perspectives, In: R.K. Morris and Fox, M.W., eds., *On the Fifth Day: Animal Rights and Human Ethics*. Humane Society of the United States, Washington, D.C.
- Fox, M.W. (1979) Animal rights and nature liberation, In: D. Paterson and Ryder, R.D., eds., *Animal Rights — A Symposium*. Centaur Press, Sussex, England.
- Greenway, J.C. (1958) *Extinct and Vanishing Birds of the World*, Special Publication 13. *Am Comm Int Wildl Protect*, New York, NY.

- Hamann, O. (1975) Vegetational changes in the Galapagos Islands during the period 1966-73. *Biol Conserv* 7:37-59.
- Hansen, R.M. (1980) Habitat. In: G. Monson and Sumner, L., eds., *The Desert Bighorn*. University of Arizona Press, Tucson, AZ.
- Holdgate, M.W. (1967) The influence of introduced species on the ecosystems of temperate oceanic islands, In: *Towards a New Relationship of Man and Nature in Temperate Lands. Part III, Changes Due to Introduced Species*. IUCN, Morges, Switzerland.
- Houston, D. (1971) Ecosystems of national parks, *Science* 172:648-651.
- Howard, W.E., (1964) Introduced browsing animals and habitat stability in New Zealand. *J Wildl Manage* 28(3): 421-429.
- Hutchins, M. and Stevens, V. (1981) Olympic mountain goats. *Nat Hist* 90(1):59-69.
- Iverson, J.B. (1978) The impact of feral cats and dogs on populations of the west Indian rock iguana, *Cyclura carinata*. *Biol Conserv* 14(1):63-74.
- Jackson, S. (1897) Annual report on the introduction of domestic reindeer into Alaska. *US Bur Ed* 7:1-124.
- Kramer, R.J. (1971) *Hawaiian Land Mammals*. Charles A. Tuttle Co., Rutland, VT.
- Laycock, G. (1966) *The Alien Animals*. Natural History Press, New York, NY.
- Laycock, G. (1974) Dilemma in the desert: burros or bighorn? *Audubon* 76(5): 116-117.
- Leopold, A. (1949) *A Sand County Almanac*. Oxford University Press, New York, NY.
- Mark, A.F. and Baylis, G.T.S. (1975) Impact of deer on Secretary Island, Fiordland, New Zealand. *Proc NZ Ecol Soc* 22:19-24.
- Matsche, G.H. (1976) Non-efficacy of mechanical birth control devices for white-tailed deer. *J Wildl Manage* 40 (4):792-795.
- Matsche, G.H. (1977a) Micro-encapsulated diethylstilbestrol as an oral contraceptive in white-tailed deer. *J Wildl Manage* 41(1):87-91.
- Matsche, G.H. (1977b) Fertility control in white-tailed deer by steroid implants. *J Wildl Manage* 41(4):731.
- Matsche, G.H. (1980) Efficacy of steroid implants in preventing pregnancy in white-tailed deer. *J Wildl Manage* 44 (3):756-758.
- McKnight, T.L. (1958) The feral burro in the United States: distribution and problems. *J Wildl Manage* 22(2):162-179.
- Muller-Dombois, D. and Spatz, G. (1975) The influence of feral goats on the lowland vegetation of Hawaii Volcanoes National Park. *Phytocoentologica* 3(1): 1-29.
- Myers, N. (1980) *The Sinking Ark*. Pergamon Press, New York, NY.
- Pickard, J. (1976) The effect of feral goats (*Capra hircus* L.) on the vegetation of Lord Howe Island. *Aust J Ecol* 1:103-114.
- Regan, T. (1976) Do animals have a right to life?, In: T. Regan and Singer, P., eds., *Animal Rights and Human Obligations*. Prentice Hall, Englewood Cliffs, NJ.
- Reiger, G. (1978) Wild boars, burros, horses cause park service apoplexy. *Audubon* 80(3):119-122.
- Rodman, J. (1977) The liberation of nature? *Inquiry* 20:83-131.
- Roots, C. (1976) *Animal Invaders*. Universe Books, New York, NY.
- Seal, U.S., Barton, R., Mather, L., et al. (1976) Hormonal contraception in captive female lions (*Panthera leo*). *J Zoo Anim Med* 7(4):12-20.
- Singer, P. (1975) *Animal Liberation*. Avon Books, New York, NY.
- Spatz, G. and Muller-Dombois, D. (1973) The influence of feral goats on koa tree reproduction in Hawaii Volcanoes National Park. *Ecology* 54:870-876.
- Spraker, T.R. (1977) Capture myopathy of Rocky Mountain bighorn sheep, In: *Trans Desert Bighorn Sheep Council 1977*, pp. 14-16.

- Spraker, T.R. (1978) Pathophysiology associated with capture of wild animals, In: R.J. Montali and Migaki, G., eds., *The Comparative Pathology of Zoo Animals, Symp Natl Zool Park*, Smithsonian Institution, Washington, DC.
- Stelfox, J.G. (1976) Immobilizing bighorn sheep with succinylcholine chloride and phencyclidine hydrochloride. *J Wildl Manage* 40(1):174-176.
- Stocker, J. (1980) Battle of the burro. *Nat Wildl* 19(5):14-16.
- Turcek, F.J. (1951) Effect of introductions on two game populations in Czechoslovakia. *J Wildl Manage* 15:113-114.
- U.S. Department of the Interior (1980) *Feral Burro Management and Ecosystem Restoration Plan and Final Environmental Assessment*. National Park Service, Grand Canyon National Park.
- Walters, J.E. and Hansen, R.M. (1978) Evidence of feral burro competition with desert bighorn sheep in Grand Canyon National Park, In: *Trans Desert Bighorn Sheep Council 1978*, pp. 10-16.
- Wardle, J. (1974) Influence of introduced mammals on the forest and shrublands of the Grey River Headwaters. *NZ J Sci* 4(3):459-486.
- Warner, R.E. (1963) Recent history and ecology of the Laysan duck. *Condor* 65:3-23.
- Yocum, C.F. (1967) Ecology of feral goats in Haleakala National Park, Maui, Hawaii. *Am Mid Nat* 77(2):418-451.
- Zwank, P.J. (1981) Effects of field laparotomy on survival and reproduction in mule deer. *J Wildl Manage* 45(4):972-975.

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