Biological Control of Aleutian Island Arctic Fox: A Preliminary Strategy

Edward W. West and Robert L. Rudd

Drs. West and Rudd are with the Department of Zoology, University of California, Davis, California.

Intentional introduction of exotic animals can normally be expected to yield unanticipated biological consequences. Single-purpose introductions frequently result in ecological catastrophe. Islands are particularly vulnerable to such assault.

Arctic foxes (Alopex lagopus), released for the purpose of fur farming on the Aleutian Islands formerly devoid of land predators, have significantly altered nesting avifaunal diversity, abundance and productivity. A program for restoring the historic distribution and abundance of critically affected bird species is described. In a long-term study biological control methods are proposed to test the hypothesis that introduced sterile red foxes (Vulpes fulva), apparently a competitively superior species, will markedly reduce or extirpate resident Arctic foxes.

Introduction

Attitudes toward population control of introduced mammals range from regarding them equal or superior to native forms to irrational hostility toward an introduced species. Most introductions can be viewed as detrimental in some aspect (Roots, 1976). Although population reductions (and the extreme form — eradication) may be generally regarded as beneficial, controversy inevitably accompanies the methodologies by which reductions are attemped (Hutchins *et al.*, 1982). Trapping, shooting, exclusion, and poisoning are the traditional methods used in mammalian population control. Novel, often species-specific, methods such as biological control have been introduced into insect and weed control practices but have been rarely attempted in mammal control. One of us has extensively reviewed the many aspects of pest population reduction (Rudd, 1964). The present article describes an example of attempts at eradication of a predatory mammal population in the Aleutian Islands by specific biological means.

The target species is the Arctic fox, *Alopex lagopus*. Displacement by biological and behavioral means subsumes our methods and purposes. The specific method is generally known as the sterile male technique. Detailed ecological information is vital to biological control of this sensitive character. Especially important is the fact that fox populations to be controlled are only those on small islands (West *et al.*, 1982). Throughout all our work is the background attitude that humane and scientific considerations can be effectively combined, as well described by Kellert (1982).

The delicate balance of natural

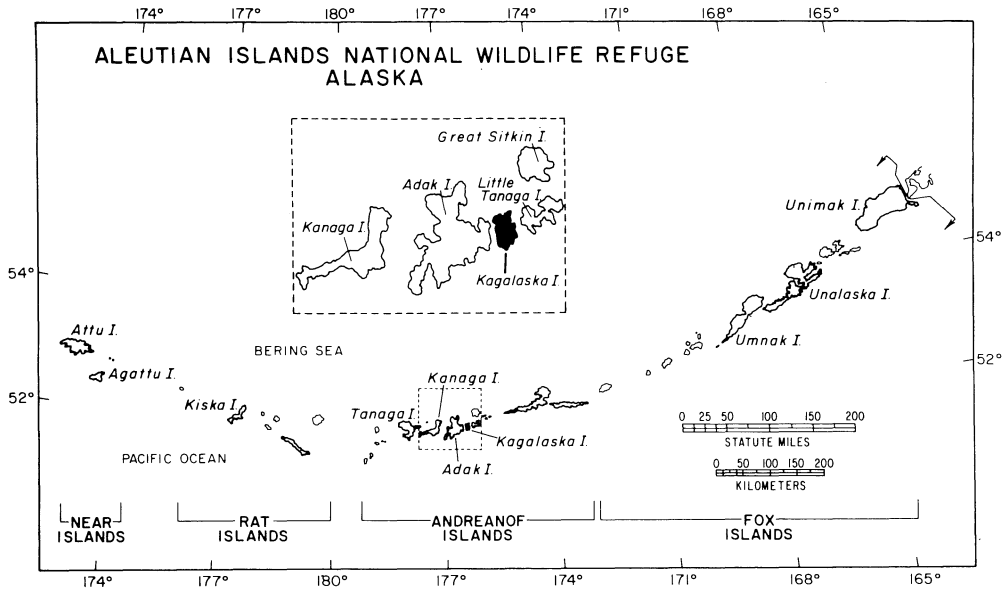

FIGURE 1 Aleutian Islands in Alaska

island ecosystems can be easily upset by the introduction of foreign organisms. Island species, isolated from complex mainland ecosystems, evolve to form relatively simple communities. These systems generally lack sufficient natural controls to respond effectively to competition or predation by introduced species. Without strong checks on their growth, non-island species increase rapidly. This population growth invariably occurs at the expense of many forms of endemic fauna.

On the Aleutian Islands in Alaska (Fig. 1) Arctic foxes (*Alopex lagopus*, Fig. 2), introduced for purposes of fur farming, have eliminated many breeding populations of marine bird species and threaten the total extinction of a race of Canada Goose (*Branta canadensis leucopareia*). In an effort to restore island ecosystems to their natural state, research has been conducted in cooperation with the U.S. Fish and Wildlife Service to develop an arctic fox management program using biological control techniques. Sterile red foxes, (*Vulpes fulva*, Fig. 3), a competitively superior species in sympatric mainland habitats, will be ultimately introduced on a target island (Kagalaska). Studies on ecology and population dynamics of interactions between the two species will provide an empirical test of the potential for complete competitive exclusion of the arctic fox by red foxes.

History

Foxes were first introduced to the Aleutian Islands in 1886 by the Russian-American Company for the purpose of establishing fur "ranches" (Ashbrook and Walker, 1925). Pairs of foxes were transported to many islands and left to breed and multiply. After several years the surplus was trapped off. Islands were frequently selected on the basis of bird abundance, a natural food source. By 1925, foxes had been introduced to 77 islands. By 1936 over 25,600 pelts had been taken from the Archipelago (Jones and Byrd, 1979). The economic depression after 1929, destroyed the market for wild furs (Chesemore, 1975). With the onset of World War II, fur farming was virtually eliminated in Alaska. The foxes remained and without frequent harvest their numbers increased. Many endemic bird populations were markedly reduced or eliminated.

The full impact of fox introductions was first assessed in 1936. Murie (1959) conducted a two-year faunal survey of 22 islands along the chain. His findings showed significant reductions in bird species diversity, distribution and productivity. These changes, he concluded, were primarily due to fox predation. Large colonies of ancient murrelets (*Synthliboramphus antiquus*) and Cassin's auklets (*Ptychoramphys aleuticus*) vanished from Sanak Islands. Storm petrels (*Oceanodroma sp*) were entirely eliminated from Salt and Ilak islands. Cassin's auklets went extinct on Keegaloo and Adugak Islands. Whiskered auklets (*Aethia pygmaea*) were also eliminated from the Near Islands.

Recent bird surveys of other Alaskan Islands document a continued and more widespread reduction in bird populations by the foxes (Stephenson, 1970; Bailey, 1978; Bailey and Faust, 1980, 1981). Crested auklets (*Aethia cristatella*) and parakeet auklets (*Cyclorrhynchos psittacula*) are still heavily preyed upon by fox on St. Lawrence Island. Horned puffins (*Fratercula corniculata*) and tufted puffins (*Lunda cirrhata*) are also taken in high numbers. On Big Koniuji Island, Moe (1977) determined that 6 adult and 7 juvenile fox killed 763 crested auklets and 95 horned puffins over a three-month period. On a recent survey of the Alaska Peninsula, which have, or have had foxes, no nocturnal seabirds were found (Bailey, 1978). The most significant, and currently most pressing, ecological concern is the near total extinction of the Aleutian Canada goose (*Branta canadensis leucopareia*). It has vanished from its former extensive nesting range in the Aleutians except for a small population on Buldir Island (Jones and Byrd, 1979).

Early Management Programs

Former attempts by the United States Fish and Wildlife Service to reduce the impact of fox predation on the Aleutians

FIGURE 2 Arctic fox (*Alopex lagopus*)

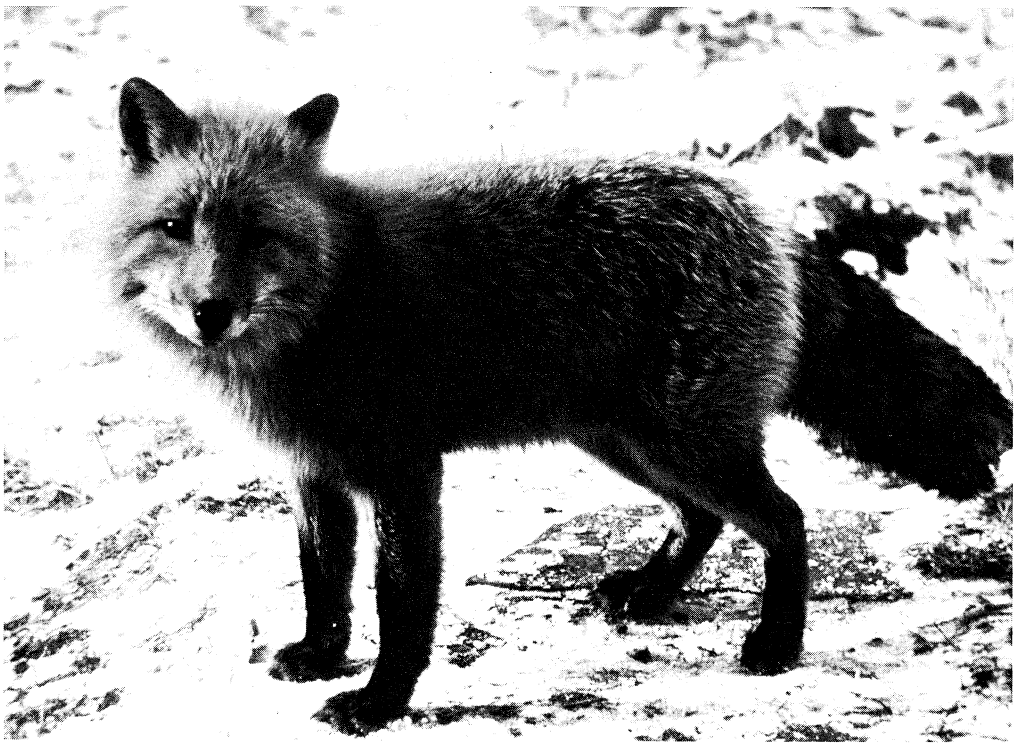

FIGURE 3 Alaskan red fox (*Vulpes fulva*)

followed the standard control method of broadcasting lethal baits on selected islands (Springer *et al.*, 1978). This technique freed only one island (Amchitka) of foxes. In 1972, an executive ban on chemical control agents (primarily compound 1080) limited control activities to trapping, shooting and the use of M-44's "coyote getters" (gas-propelled cyanide guns). These techniques were comparatively slow, expensive and extremely difficult to support logistically. Clearly, a more expedient, more humane, and target-specific program is required to achieve the management objective of removing foxes.

Biological Control

Biological control is a management program that uses natural controls to regulate the population density of a pest species. Zoogeographic patterns and field observations of arctic-red fox interactions suggest that the red fox naturally controls the numbers of arctic fox locally by competitive exclusion and predation.

Competition occurs when two species vie for the same resource in limited supply. Interaction between species reduces the fitness and the population size of the weaker species. This process can occur in one or both of two ways (Pianka, 1974). The first, termed interference competition, occurs by direct physical interaction, such as aggressive encounters. In this instance an excessive amount of time and energy is required for competition or its avoidance, so that the amount remaining for self-maintenance and reproduction drops below survival level. The second process, termed exploitation competition, occurs when one species monopolizes a limiting and essential resource (e.g., food or denning sites) thereby making its use unavailable to its competitor). The extent to which competition will occur will be propor-

tional to the degree to which resource requirements overlap. If the overlap is complete, coexistence is not possible and over time the less fit species will die out or be excluded from the range of sympatry. This ecological relationship is commonly referred to as the competitive exclusion principle (Hardin, 1960).

Research on the dynamics of sympatric populations of arctic and red fox suggest that both types of competition occur. In Russia, Skrobov (1960) and Chirkova (1968) noted that red fox replace arctic fox wherever their ranges overlap. On Hardangervidda, Norway, Oestybe *et al.* (1978) found that the red fox occupied 50% of the dens originally dug by arctic foxes. Similar exclusions have been recorded by Marsh (1938) in Manitoba, Canada.

Recent comparative analysis of the social dynamics, territoriality and population structure of arctic and red fox by use of radiotelemetry in Great Britain and Iceland also showed marked similarities between the two species (Hersteinsson & MacDonald, 1982). These similarities suggest that complete direct competition between the two species underlies present allopatric distribution.

Red fox are also known to prey upon arctic fox. Alaska trappers consider red foxes to be one of the primary predators of arctic fox (Chesemore, 1975). Marsh (1938) found that red foxes often attacked and killed trapped arctic foxes. Fur farmers noted that if arctic and red fox were placed on the same island the arctic fox was soon exterminated. Recent behavioral observations of interactions between captive arctic and red foxes showed that red fox pairs dominated the use of enclosures and forced arctic foxes to use less preferred denning and feeding areas (Rudzinski *et al.*, 1982).

Available biological evidence strongly suggests the hypothesis that red foxes will eliminate arctic fox when introduced on the same island. It is therefore very likely that a management program using the red fox as a control agent would be successful. It would also be comparatively rapid, economical and environmentally safe.

Field Research

Validation of the hypothesis that red fox are effectively displacing the arctic will be obtained if, after introduction, there is a marked displacement of arctic fox from prime denning and foraging sites and a sharp decline in arctic fox numbers.

Baseline data on arctic fox density, home range, dennings and foraging patterns have been gathered on Kagalaska Island (Fig. 1) and are presented elsewhere (West *et al.*, 1982). Foxes have been trapped in large box traps, ear-tagged and fitted with collars bearing radio transmitters. Tracking results show that resident foxes den and forage almost exclusively along the coast. Analysis of scat composition shows that fox diet is comprised largely of beach amphipods and birds, although fish are taken during salmon runs. Recapture data provide an index to density.

In the future sterilized red fox, collected in the eastern Aleutian Islands, will be introduced to the island. Groups of pairs will be released in selected bays and coves. From an analysis of similarities in food and density requirements (West *et al.*, 1982) it is estimated that these introductions will minimally require an approximate 1:2 red to arctic fox ratio and noticeably increase the fox population of the island. Available food and den sites will then be subject to intense interspecific competition.

Discussion

The success of a biological control program of this nature depends greatly upon the intensity of competition immediately following introduction of the red fox. Island habitats provide optimal conditions for maximizing the factors in several ways. Islands are confined areas; emigration to escape competitive inter-

actions is not possible. In addition, because of the relatively small size of the islands, the carrying capacity and equilibrium density for foxes is rapidly attained. Arctic fox numbers are assumed to be at saturation density. Fluctuations in population density are primarily density dependent. Increasing the density of foxes will immediately maximize competitive pressure. The highly seasonal nature of the Aleutian Island environment also favors concentration and focusing of competitive impact. Breeding birds provide ample food for the foxes during the spring and summer. During the winter, however, most birds migrate. The foxes are then forced to subsist on beach amphipods and carrion (Murie, 1959; this study). These food items have limited food value and the foxes are nutritionally stressed.

Optimally, red fox introductions should be made during midsummer to minimize the predatory impact on nesting birds, and to allow sufficient time for the foxes to acclimate to the island before winter sets in. Introduction of foxes from the eastern Aleutian Islands would minimize the acclimation period. To minimize intraspecific competition between the red foxes, introductions should be made at several localities around the island, or at periodic intervals to allow adequate time for dispersal. All introductions should be made within one season to maximize interspecific competition.

Red fox displacement of arctic foxes away from prime feeding areas will cause a multifaceted reduction in arctic fox numbers. As arctic fox are forced into already saturated areas, starvation will occur in addition to secondary causes of mortality induced by physiological stress. Fecundity could be expected to drop due to reabsorption of embryos and poorer kit survival. Under conditions of stress foxes are also known to cannibalize mates, young and littermates (MacPherson, 1969; Chesemore, 1975; Fox, 1975). These factors acting in concert will provide a system of natural control that is species-specific and avoids the often haphazard methods of trapping, shooting and poisoning. The management system proposed exploits naturally occurring processes that are precise and enduring. They easily and logically apply to islands in the Aleutian chain and may also be modified for other species of insular introduced mammals (cf., Barnett and Rudd, 1983).

Acknowledgments

Financial support under cooperative agreement with the U.S. Fish and Wildlife Service, Alaskan Region, is gratefully acknowledged. We extend our thanks to many individuals, particularly in the Aleutian Islands, but most especially note with warmest thanks the sustained high interest of Dr. Ronald L. Garrett of Anchorage and Bethel, Alaska.

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