Eradications of invasive species to restore natural biological diversity on Alaska Maritime National Wildlife Refuge

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Abstract The Alaska Maritime National Wildlife Refuge encompasses over 1.9 million hectares and more than 2500 coastal islands in Alaska. Like many other islands in the world, many refuge islands have had accidental and intentional introductions of non-endemic mammals (e.g., Arctic and red fox, ground squirrel, Norway rat, house mouse, caribou, reindeer, cattle, Arctic and European hare) that have drastically altered these fragile insular ecosystems. Although new introductions are prohibited, accidental introductions, particularly of rodents, are still of great concern. As part of a programme to restore native biological diversity, refuge personnel have surveyed most islands for exotic species, evaluated impacts of invasive wildlife on native birds, employed predator eradication methods, and assessed benefits of successful eradication. This paper reviews the history of these projects; particularly the effort resulting in eradication of introduced foxes from 39 islands totalling more than 500,000 hectares.

Keywords Aleutian Islands; Arctic fox; *Alopex lagopus*; island ecosystems; predator control; caribou; *Rangifer tarandus*; Norway rat; *Rattus norvegicus*; red fox; *Vulpes vulpes*; restoration; seabirds; ground squirrel; *Spermophilus parryii*.

INTRODUCTION

Impacts of alien species introductions to island ecosystems all over the world are well documented (e.g., Moors and Atkinson 1984). In spite of isolation and a harsh environment, Alaskan islands have not escaped accidental and intentional introductions (Elkins and Nelson 1954; Manville and Young 1965; Jones and Byrd 1979). Until about three hundred years ago, no terrestrial mammals were found on most islands (e.g., the central and western Aleutian Islands) south of the winter ice pack and isolated from the mainland since the Pleistocene (USDA Bureau of Biological Survey 1938; Murie 1959; Hopkins 1967; Tikhmenev 1978; Bailey 1993; Liapunova and Fedorova 1994). Surrounded by highly-productive seas, many of these islands provided nesting sites for large populations of marine birds. The native peoples of the region generally did not move terrestrial mammals around, and the islands retained largely intact faunas until Vitus Bering's discovery voyage in 1741.

The first deliberate introductions occurred soon after 1741, when Arctic foxes (*Alopex lagopus*) and red foxes (*Vulpes vulpes*) were released on several islands in the Aleutian chain (Black 1984; Jason 1985; Bailey 1993). The heyday of fox ranching occurred between 1910 and 1940 when nearly every habitable Aleutian island (about 86) was stocked with foxes, except for a few islands either too small or too rugged for regular access by wooden boat. To supplement the food available for foxes, particularly after bird populations declined, some trappers stocked islands with rodents such as ground squirrels (*Spermophilus parryii*) to the further detriment of native bird species (Peterson 1967; Janson 1985; Bailey 1993). New island residents brought with them livestock such as cattle, sheep, goats, horses, reindeer and bison. By the 1940s, most islands had some species of mammal introduced (Bailey 1993). After the Second World War, caribou (*Rangifer tarandus*) were purposely introduced to Adak Island (then a naval base) for sporting purposes (Jones 1966).

The earliest recorded accidental mammal introduction was prior to 1780 when Norway rats (*Rattus norvegicus*) became established on Rat Island from a Japanese shipwreck (Brooks 1878; Brechbill 1977; Black 1984). Norway rats became established on at least 16 other islands within the refuge over the last 200 years (Bailey 1993).

Despite reduction of native bird populations on islands with foxes and rats, enough islands remained free of terrestrial mammals in the early 20th century to draw attention of conservation-minded people to their wildlife values. Between 1909 and 1913, nine different islands or island groups in Alaska were set aside as National Wildlife Refuges, including the Aleutian Islands where many introductions of exotics had occurred.

Biologist O. J. Murie (1936, 1937) visited the region in 1936 and 1937; and he reported to government policy makers in Washington, D.C. on the decline of seabirds on refuge islands with foxes. This changed government policy on the use of the islands for fox ranching. Soon after WWII, Robert Jones (the first resident manager of the Aleutian Islands NWR) began eradication of introduced foxes.

The Aleutian Islands, other island refuges, and additional islands not previously designated as refuges were consolidated in 1980 to become the Alaska Maritime National Wildlife Refuge (AMNWR) under the Alaska National Interest Lands Conservation Act authority. The AMNWR refuge boundaries encompass 1.9 million hectares and over 2500 islands around the coast of Alaska. Few islands are greater than 2000 km^2. The primary purpose of the new refuge was to conserve (and restore where necessary)

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populations of marine birds, marine mammals, and terrestrial endemics. Most of the refuge land is undeveloped, uninhabited and stable except for some scattered communities, military bases, and abandoned cattle ranches and fox farms. Loss of habitat due to human development is not as great a threat in this region as is habitat degradation and conversion caused by invasive species.

The refuge islands discussed in this paper extend from west of Kodiak Island along the Alaska Peninsula and throughout the Aleutian Islands between the Bering Sea and the Gulf of Alaska. These islands range from slightly above sea level to steep glaciated volcanoes over 1900 m. Soils form in volcanic ash or cinders over basaltic rock, and higher elevations sometimes are covered in bare rock and basaltic rubble. Vegetation types change with elevation from coastal lowland bands of grass-covered dunes backed by herbaceous meadows to dwarf shrub communities (e.g. *Salix* spp. and *Empetrum nigrum*) in higher exposed areas. Precipitation (from 530 mm to 2080 mm) varies between large and small islands, and coastal and inland areas.

Restoration of native biological diversity by removing introduced predators and preventing additional accidental introductions is a major priority of the refuge. Foxes, ground squirrels, cattle, reindeer, caribou and rats are invasive species of primary refuge management concern. These species directly interfere with native birds through predation or loss of nesting habitat because of vegetation changes caused by overgrazing and trampling. Other exotic animals currently inhabiting refuge islands, but having minor or unknown impacts, include house mice (*Mus musculus*), deer mice (*Peromyscus* sp.), voles (*Microtus* spp.), hares (*Lepus* spp.), and hoary marmots (*Marmota calagita*). This paper summarises issues involving the major invasive species and how the refuge responds to the challenges that they pose.

FOXES

Distribution

Foxes were introduced to islands by Russians and by Aleut fox ranchers. Foxes were released on more than 450 Alaskan islands (Bailey 1993). Red foxes occur naturally on some near-shore islands along the Alaska Peninsula, and on the Fox Islands in the eastern Aleutians. Rainforests on Southeast Alaska islands provided poor habitat for red foxes, and they typically did not survive to become self-sustaining populations. Native to Bering Sea islands normally surrounded by sea ice (e.g. the Pribilofs, St. Matthew and St. Lawrence islands), Arctic foxes are apparently better adapted than red foxes to the Aleutian Island environment (Fay and Cade 1959; Chapman and Feldhammer 1982). Both species survived best on islands with tidal benches or accessible beaches for foraging. These habitats provide food during late fall and winter after migratory birds leave the islands (Stephenson 1970). Blue foxes (one morph of the Arctic fox) were more valuable than red foxes and eventually were placed on more islands than red foxes were. Introduced Arctic foxes currently remain on eight islands, which contain refuge lands, and introduced red foxes are still present on one refuge island.

Impact

Foxes severely reduce populations of nesting birds by eating eggs, nestlings and adult birds in summer and caching birds and eggs for later consumption. Particularly affected are waterfowl, shorebirds, seabirds, and ptarmigan (Bailey 1993). Vegetation also could be affected by the loss of fertilisation from large bird colonies.

Most of Alaska's breeding seabirds are not adapted to coexisting with terrestrial mammals. Almost all islands where introduced foxes persisted are treeless, so resident birds are particularly vulnerable since most species nest on the surface of the ground or in earthen burrows. For instance, foxes eliminated populations of Aleutian Canada geese (*Branta canadensis leucopareia*) on all but three islands, driving this endemic taxa close to extinction (Jones 1963; Byrd 1998).

Local residents (Aleuts and non-native fox ranchers) quickly recognised the impact of foxes on native birds, particularly the abundant seabirds. Most islands were stocked with only a few pairs of foxes (USFWS 1929-1939; Janson 1985), yet these introduced predators and their offspring quickly reduced populations of birds (Murie 1936; 1937; Swanson 1982; Black 1984).

Restoration

The staff of AMNWR began eradicating foxes from islands in 1949. To date (2002) foxes have been removed from 39 islands totalling more than 500,000 ha. There are plans to eradicate foxes from at least four more islands. Eradication efforts were hampered by federal regulations prohibiting toxicant use after 1972. Nevertheless, progressively larger islands have been cleared using only traps, firearms, snares, and M44 devices; in 1999 we exterminated foxes by trapping from a 90,000 ha island. We plan to eradicate foxes on smaller remaining islands without toxicants. Ebbert (2000) compares methods used to eradicate foxes on small and large islands.

Response

The response of native bird populations to fox removal has rarely been quantitatively documented. Nevertheless, it seems that populations of waterfowl, shorebirds, ptarmigan, seabirds, and possibly passerines increase following fox eradication, and without release of captive-reared birds or translocations (Williamson and Emison 1969; Day *et al.* 1979; Nysewander *et al.* 1982; Zeillemaker and Trapp 1986; Byrd *et al*. 1984; Byrd *et al*. 1997). Most populations of nesting seabirds increased at least four to five folds within 10 years of fox removal (Byrd *et al.* 1994). Ini-

tially, restoration of the endangered Aleutian Canada goose required transplanting geese to fox-free islands (Byrd 1998), but their populations have now increased from less than 1000 birds in 1975 to more than 35,000 in 2000 due to fox eradication (Byrd 1998).

RATS

Distribution

The adaptable Norway rat is established as far north as Nome, Alaska (65 degrees north latitude). Norway rats have become established on more than 16 islands within the refuge (Bailey 1993). About five of these sites were occupied by the military during WWII where numerous cargo ships unloaded supplies from ports where rats were prevalent. Ship rats (*Rattus rattus*) also became established for a time on one island occupied by the military, but were confined primarily to buildings and apparently disappeared when most buildings were removed (Taylor and Brooks 1995).

Impact

Rats extirpate most species of burrow-nesting seabirds (e.g., storm petrels *Oceanodroma* spp., Cassin's auklet *Ptychoramphus aleuticus*, tufted puffin *Fratercula cirrhata*), and they probably reduce populations of shorebirds (e.g., rock sandpiper *Calidris ptilocnemis*, black oystercatcher *Haematopus bachmani*) and other ground-nesting species. The probable result of rats becoming established on refuge islands used by colonial waterbirds is the eventual destruction of fossorial, crevice-nesting, and accessible surface-nesting seabird colonies as well as drastic reductions of certain species of other ground-nesting birds. On islands with introduced foxes, rats probably provide supplemental winter food, which keeps fox populations relatively high and thereby increases the impact of foxes on native birds during the breeding season. Some refuge islands (e.g., the Pribilof Islands) have endemic small mammals that may be vulnerable to predation and competition by Norway rats.

Prevention

Chances for accidental rat invasions on additional refuge islands are increasing now that fisheries, coastal tourism, and human population are increasing in Alaska. Once rats become established on islands larger than a few thousand hectares, removal is difficult and expensive. Rapid response following shipwrecks is needed to kill rats while they remain on the ship or as they come ashore. The refuge is prepared for such an eventuality (USDI 1993). Planned action involves local dispersal of single-dose baits adjacent to a grounded wrecked vessel or on the vessel itself.

Expanding on-shore fish processing development in the Bering Sea has recently resulted in new fish plants on two rat-free islands in the Pribilof Islands. Both communities, assisted by AMNWR staff, established bait and trap stations at their docks to eliminate rats that may disperse from infested vessels. The refuge continues to assist the two communities in developing and implementing rodent preventative measures (DeGange *et al.* 1995). Furthermore, an education outreach is underway to inform shipping companies of the dangers of rats on their vessels.

GROUND SQUIRRELS

Distribution

At least two subspecies of Arctic ground squirrels occur on approximately 17 refuge islands. *Spermophilus parryii ablusus* was introduced in the Aleutian Islands, and *S. p. nebulicola* is found on islands south of the Alaska Peninsula (Dufresne 1946). George Steller, naturalist on the first Russian ship to sail in Aleutian waters, noted in the Shumagin Island group that ground squirrels were present on islands near the Alaska mainland, but not on those farther offshore (Golder 1925; Stejneger 1936).

Ground squirrels were used by Native Alaskans and early Russians for clothing (parkas) and food and were transplanted on some islands from the mainland or islands where they were naturally occurring (L. Black, pers comm.). Ranchers also introduced ground squirrels to some islands as food for foxes, after seabirds declined (Peterson 1967; Swanson 1982; Janson 1985). Many introductions were not documented, and it is unclear whether some current populations on islands close to the mainland are native or introduced (Bailey 1993). Preliminary genetic analysis on squirrels collected in the Shumagins shows minor differentiation among islands (J. Cook, pers. comm.), but more samples are needed to determine if any island populations are unique.

Impact

Certain species of ground squirrels prey on eggs (Errington and Hamerstrom 1937; Horn 1938; Stanton 1944; Sowls 1948; Bedard 1969; Leschner and Burrell 1977; Sargeant and Arnold 1984; Sargeant *et al.* 1985). Arctic ground squirrels in research enclosures pounce on large duck eggs but are apparently not adept at opening them (B. Barnes, pers. comm.). Nevertheless, this species is known to take passerine eggs (B. Barnes, pers. comm.) and chicks and eggs of seabirds (Geist 1933; Cade 1951; Sealy 1966). The impact of introduced Arctic ground squirrels on nesting birds in AMNWR is not well documented, but we have observed that storm petrels and other small burrow-nesting species rarely occur on islands inhabited by ground squirrels.

Ground squirrels also directly affect native vegetation by feeding on stalks, stems and seeds, and contribute to overgrazing and erosion (Bailey and Faust 1981; Bailey and McCargo 1984). There is still a need to collect and analyse information to understand the biology and impact of non-native Arctic ground squirrels on refuge islands.

Restoration

We are at the beginning stages of devising or modifying existing control methods to eradicate introduced ground squirrels on 1450 ha Kavalga Island in the central Aleutians. Elsewhere in the United States, other ground squirrel species are controlled for agricultural purposes using poison baits, fumigants, trapping and shooting. Poison baits seem most practical for use on islands within the refuge. New registration may be required to use existing or new toxicants on AMNWR.

Potential non-target species that are the most likely scavengers of dead or dying ground squirrels include bald eagles (*Haliaeetus leucocephalus*), gulls (*Larus* spp.), and common ravens (*Corvus corax*). We may need to collect and dispose of ground squirrels dying above ground to minimise secondary poisoning hazard.

Predicted Response

Vegetation reduced by ground squirrels will likely recover rapidly and erosion of overgrazed areas will be slowed. Productivity will increase the first season after ground squirrels are eradicated for bird species on which egg or chick predation has been severe. We predict species that nest in earthen burrows such as storm petrels and surface-nesters such as shorebirds and passerines will benefit most from introduced ground squirrel eradication.

LARGE UNGULATES

Distribution of reindeer and caribou

Reindeer (*Rangifer tarandus asiaticus)*, a native ungulate of Eurasia, were brought to Alaska from Siberia in 1891. Reindeer were introduced on several islands in the eastern Aleutians to provide Alaska natives a commercial commodity to enhance their economic inclusion in the territory's development (Swanson and Barker 1992). Ultimately, reindeer were introduced to six islands that are now part of AMNWR.

Caribou (*R. t. arcticus*) are native to mainland Alaska but occasionally swim to nearby large islands. The only introduction in the refuge is on Adak Island in the central Aleutians where caribou were purposefully released in the late 1950s at the request of the U.S. Navy (Jones 1966). They have persisted, and the herd was recently estimated at approximately 900 animals (Williams 1998).

Distribution of livestock (cattle, horses, sheep)

Although a few cattle were brought to some of the islands during the fox ranching era, cattle ranching did not begin on most Alaskan islands until after WWII. Cattle ranching has occurred on at least eight islands containing refuge lands, but currently cattle occur on one refuge island and three other islands with both refuge and private lands. These same islands also have horses, and one has sheep.

Impact of introduced ungulates

Grasses and other flowering plants provide summer and fall foods for ungulates, but it is during winter that food becomes limited. Reindeer detect lichens through as much as 1m of loose snow and reach them by pawing. Reindeer "crater" into mineral soil while foraging on roots of forbs, dislodging plants, causing more severe damage. Introduced ungulates on relatively-small islands typically overgraze, damage the vegetation communities, and sometimes starve to death (e.g., Klein 1968). The first reindeer released on two islands in the eastern Aleutians died out from starvation relatively soon after stocking (Brickey and Brickey 1975), but later stockings have resulted in herds that have persisted. For reindeer on Alaskan islands, the common pattern has been rapid population growth resulting in depletion of native forbs, especially lichens (Swanson and Barker 1992). During overgrazing, more willow stem is consumed than can grow each season, and the plant eventually dies. When less-preferred forage is depleted before or during winter, the population crashes because of starvation (Palmer 1945). If the herd does not die out completely, the island does not sustain previous population levels due to long-term damage to lichens. Lichens may take 20 years or more to recover (Palmer 1945). Severe overgrazing and trampling by reindeer on preferred hilly areas also cause soil erosion and permanent loss of natural plant communities, reducing natural biological diversity and, in some cases, causing desert conditions. Typically, livestock are allowed to overgraze, and frequently cattle are abandoned because of difficulties in bringing them to market. Selective grazing by cattle makes sandy coastal areas especially vulnerable to damage (Talbot *et al.* 1984), and cattle ranching has led to the establishment of invasive plant species (Daniels *et al.* 1998).

Restoration and response

In most cases, reindeer, caribou, and livestock occur on islands with mixed ownership (usually with native villages) within the refuge. Native traditional councils typically manage reindeer for commercial meat and antler production and sometimes for sport hunting. Cattle grazing has been allowed by special permit. Ideally, introduced ungulates would be excluded from refuge properties, but there is no current plan or funds to erect and maintain fencing. Presently, the refuge staff works with local traditional councils, other government agencies and with permittees to develop management plans to minimise the negative impacts of grazing, trampling, and erosion. Swanson and Barker (1992) reviewed the history and range conditions of reindeer populations on Alaskan islands.

In the past, the refuge staff has removed reindeer and cattle from wholly-owned refuge islands, but these actions caused controversy and resulted in hard feelings by some local residents. For example, in the early 1990s, reindeer

were removed from Hagemeister Island by live capture and shooting after the permittee failed to comply with maximum stocking rates, and damage was evident (Swanson and LaPlant 1987). At great public expense, 450 reindeer were live captured and transported to a nearby native village and the others were shot (most carcasses distributed to village for food). Nevertheless, the press provided substantial negative publicity (J. Stroebele, pers. comm.). In another case in 1985, substantial funds were spent to try to capture and transport feral cattle off Simeonof Island to nearby private locations before the remaining animals were shot. Again negative publicity occurred. In spite of poor public relations these management actions were necessary to restore native biological diversity. Response of native vegetation to removal of ungulates has occurred, and substantial restoration of some plant communities appears likely (S. Talbot pers. comm.).

Sport hunting kept the caribou populations at Adak under reasonable control until the number of residents on the island dropped from more than 5000 to less than 500 in the early 1990s because of the US Navy base closure. The caribou population is now expanding rapidly and habitat damage is inevitable (USDI & ADFG 1994). The island is now in joint ownership by the refuge and Native Village Corporation. Therefore, complete removal of the caribou is unlikely.

OTHER INVASIVES

Distribution

Bailey (1993) lists introductions of rodents and hares on refuge islands. House mice are known to live on St. Paul Island only in the community area and dump. Introduced voles are found on at least two islands, both south of the Alaska Peninsula, and marmots on another. Hares were released on at least 10 islands and still survive on a few. Deer mice occur on one island.

Impact

Although there is little documentation that the species listed above pose significant threats to native species on AMNWR, they probably negatively affect native forms. Small mammals negatively change native vegetation and habitat in other areas. Native voles are a significant predator of eggs and nestling parakeet auklets on St. Lawrence Island (Sealy 1982), and introduced voles may be responsible for sparse vegetation on small islands in the Sanak Group (E. Bailey, pers. comm.).

Deer mice are significant egg predators and severely limit reproduction of Xantus murrelets (*Synthliboramphus hupoleucus*) on Santa Barbara Island in California (Murray *et. al.* 1983) and elsewhere (Maxon and Oring 1978).

Restoration and response

Currently no plans exist to remove any small mammal species referred to in this section, although we may attempt to eradicate other non-native rodents on islands where rat or ground squirrel eradication is planned. An evaluation similar to that described for ground squirrels is needed prior to eradication efforts.

DISCUSSION

Implications for work

Because of the controversial nature of eradication projects in the United States, results of the fox eradication programme are not widely published. Now that the red fox eradication programme nears conclusion, publication of methods used and results achieved is more appropriate. Lessons learned during this project are applicable to other island restoration projects.

The U.S. Fish and Wildlife Service does not permit introduction of exotic species on refuge lands. The State of Alaska's wildlife laws are also stringent. Refuge islands remain some of the most inaccessible and least-visited islands in the U.S. National Wildlife Refuge System. The islands are fairly safe from deliberate introductions; however, a constant vigil is needed to prevent the accidental introduction of rats through shipwreck or transfer of infested material.

Suggestions for improvement

To document the benefits of removing invasive species, biological monitoring must continue on the few islands where pre-eradication data exists. Widespread genetic sampling of Arctic ground squirrels is necessary to determine the native status of island populations before eradication can proceed. To efficiently eradicate ground squirrels and other rodents from refuge islands, development of new baiting strategies or the modification of existing methods are needed. Modification of existing pesticide registration for island applications is also necessary.

Public education and acceptance of the need to remove large herbivores, such as cattle and reindeer, from islands must be accomplished before further eradication of these species can proceed. Even if methods are devised to efficiently eliminate these large, familiar and once-domesticated animals, the project could not be considered successful if it results in long-lasting damage to trust and public perception of the AMNWR and its mission.

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REFERENCES

Bailey, E. P. 1993. Introduction of foxes to Alaskan Islands - history, effects on avifauna, and eradication. United States Department of Interior. U.S. Fish and Wildlife Service Resource Publication 193.

Bailey, E. P. 1992. Red foxes, *Vulpes vulpes*, as biological control agents for introduced Arctic foxes, *Alopex lagopus*, on Alaskan Islands. *Canadian Field-Naturalist 106*: 200-205.

Bailey, E. P. and N. Faust 1981. Summer distribution and abundance of marine birds and mammals between Mitrofania and Sutwik islands south of the Alaska Peninsula. *Murrelet 62*: 34-42.

Bailey E. P. and D. McCargo 1984. Eradication of fox on Bird Island and incidental surveys of seabirds in the Shumagin Islands, Alaska. Report, U.S. Fish and Wildlife Service, Homer, AK.

Bailey E. P. and Trapp, J. L. 1984. A second wild breeding population of the Aleutian Canada goose. *American Birds 38*: 284-286.

Bedard, J. H. 1969. The nesting of the crested, least, and parakeet auklets on St. Lawrence Island, Alaska. *Condor 71*: 386-360.

Black, L. T. 1984. *Atka – an ethnohistory of the western Aleutians*. Limestone Press, Kingston, Ontario.

Brechbill, R. A. 1977. Status of the Norway rat. In M. L. Merritt, and R. G. Fuller (eds.). *The environment of Amchitka Island, Alaska*, pp. 261-267. Technical Information Center, Energy Research and Development Administration, Oak Ridge, Tenn.

Brickey, J. and Brickey, C. 1975. Reindeer, cattle of the Arctic. *Alaska Journal Winter Edition*: 16-24.

Brooks, C. W. 1878. Report of Japanese vessels wrecked in the North Pacific Ocean, from the earliest records to the present time. *Proceedings of the Academy of Sciences*: 50-66.

Byrd, G. V. 1998. Current breeding status of the Aleutian Canada goose, a recovering endangered species. In D. H. Rusch, M. D. Samuel, D. D. Humburg, and B. D. Sullivan (eds.). Biology and management of Canada geese, pp. 21-28. Proceedings of the international Canada goose symposium, Milwaukee, Wisconsin.

Byrd, G. V.; Bailey, E. P. and Stahl, W. 1997. Restoration of island populations of black oystercatchers and pigeon guillemots by removing introduced foxes. *Colonial Waterbirds 20*: 253-260.

Byrd, G. V.; Trapp, J. L. and Zeillemaker, C. F. 1994. Removal of introduced foxes: a case study in restoration of native birds. *Transactions North American Wildlife & Natural Resources Conference 59*: 317-321.

Cade, T. J. 1951. Carnivorous ground squirrels on St. Lawrence Island, Alaska. *Journal of Mammalogy 32*: 358-360.

Chapman, J. A. and Feldhammer, G. A. 1982. *Wild mammals of North America – biology, management and economics.* John Hopkins University Press, Baltimore, MD.

Daniels, F. J. A.; Talbot, S. S.; Talbot, S. L. and Schofield, W. B. 1998. Geobotanical aspects of Simeonof Island, Shumagin Islands, Southwestern Alaska. *Ber. D. Reinh.-Tuxen-Ges. 10*: 125-138. Hannover, Germany.

Day, R. H.; Early, T. J.; Lawhead, B. E. and Rhode, E. B. 1979. Results of a marine bird and mammal survey of the western Aleutian Islands - summer 1978. Unpub. rep., U.S. Fish and Wildlife Service, Adak, AK.

DeGange, A. R.; Sowls, A. and Fairchild L. 1995. A strategic plan to protect island ecosystems in Alaska from the introduction of rodents. U. S. Fish and Wildlife Report, Homer, AK.

Dufresne, F. 1946. *Alaska's animals and fishes*. A. S. Barnes and Company, New York.

Ebbert, S. 2000: Successful eradication of introduced Arctic foxes from large Aleutian Islands. *Proceedings Vertebrate Pest Conference 19*: 127-132.

Elkins, W. A. and Nelson, U. C. 1954. Wildlife introductions and transplants in Alaska. Presented at the Fifth Alaska Science Conference, Anchorage, Sept. 7-10. Mimeo.

Errington, P. L. and Hamerstrom, F. N Jr. 1937. The evaluation of nesting losses and juvenile mortality of the ring-necked pheasant. *Journal of Wildlife Management 1*: 30-20.

Fay, F. H. and Cade, T. J. 1959. An ecological analysis of the avifauna of St. Lawrence Island, Alaska. *University of California Publications in Zoology 63*: 73-150.

Geist, O. W. 1933. Habits of ground squirrels *Citellus lyratus* St. Lawrence Island, Alaska. *Journal of Mammalogy 14*: 306-308.

Golder, F. A. 1925. Bering's voyages, Vol. II. American Geophysical Research Series No. 2, New York, NY.

Hopkins, D. M. 1967. The Cenozoic history of Beringia – a synthesis. In D. M. Hopkins (ed.). *The Bering Land Bridge*, pp. 451-484. Stanford University Press, Stanford, Calif.

Horn, E. E. 1938. Factors in nesting losses of the California Valley Quail. *Transactions of the North American Wildlife Conference 3*: 741-746.

Janson, L. 1985. Those Alaskan blues: a fox tail. Alaska Historical Commission Studies in History No. 186. Department of Education, State of Alaska, Anchorage.

Jones, R. D. Jr. 1963. Buldir Island, size of a remnant breeding population of Aleutian Canada geese. *Wildfowl 14*: 80-84.

Jones, R. D. Jr. 1966. Raising caribou for an Aleutian introduction. *Journal of Wildlife Management 30*: 453-460.

Jones, R. D. and Byrd, G. V. 1979. Interrelations between seabirds and introduced animals. In Bartonek, J. C.; and D. N. Nettleship (eds.). Conservation of marine birds of northern North America. Wildlife Research Report 11, pp. 221-226. U.S. Fish and Wildlife Service, Wash., D.C.

Klein, D. R. 1968. The introduction, increase and crash of reindeer on St. Matthew Island. *Journal of Wildlife Management 32*: 350-367.

Leschner, L. L. and Burrell, G. 1977. Populations and ecology of marine birds in the Semidi Islands. In Environmental assessment of the Alaskan continental shelf, annual reports of principal investigators, Vol. 4, p. 13-109. National Oceanic and Atmospheric Administration Environmental Research Laboratory, Boulder, Colo.

Liapunova, R. G. and Fedorova, S. G. (compilers). 1994. Kyrill T. Khlebnikov. Notes on Russian America. Parts II-V: Kad'iak, Unalashka, Atkha, the Pribylovs. Translated by M. Ramsay. R. Pierce (ed.). The Limestone Press, Fairbanks, AK.

Manville, R. H. and Young, S. P. 1965. Distribution of Alaskan Mammals. Cir. No. 211, Bur. of Sport Fisheries and Wildlife, U.S. Govt. Print. Office, Washington, DC.

Maxon, S. J. and Oring, L. W. 1978. Mice as a source of egg loss among ground-nesting birds. *Auk 95*: 582-584.

Moors, P. J. and Atkinson, I. A. E. 1984. Predation on seabirds by introduced animals and factors affecting its severity. *ICBP Technical Publication 2*: 667-690.

Murie, O. J. 1936. Biological investigations of the Aleutians and southwestern Alaska. Unpub. field notes, U. S Fish and Wildlife Service, Washington, DC.

Murie, O. J. 1937. Biological investigations of the Aleutians and southwestern Alaska. Unpub. field notes, U. S Fish and Wildlife Service, Washington, DC.

Murie, O. J. 1959: Fauna of the Aleutian Islands and Alaska Peninsula. *North American Fauna 61*: 1-406.

Murray, K. G.; Winnett-Murray, K. and Eppley, Z. A.; Hunt, G. L. Jr; Schwartz, D. B. 1983: Breeding biology of the Xantus' murrelet. *Condor 85*: 12-21.

Nysewander, D. R.; Forsell, D. R.; Baird, P. A.; Shields, D. J.; Weiler, G. J. and Kogan, J. H. 1982. Marine bird and mammal survey of the eastern Aleutian Islands, summers of 1980-81. Unpub. rep., U.S. Fish and Wildlife Service, Anchorage, AK.

Palmer, L. J. 1945. The Alaska tundra and its use by reindeer. U.S. Department of Interior. Bureau of Indian Affairs. Juneau, AK. 28 pp. (Mimeo).

Peterson, R. S. 1967. The land mammals of Unalaska Island: present status and zoogeography. *Journal of Mammalogy 48*: 119-129.

Sargeant, A. B. 1985. Responses of three prairie ground squirrel species, *Spermophilus franklinii, S. Richardson,* and *S. tridecemlineatus*, to duck eggs. *The Canadian Field-Naturalist 101*: 85-97.

Sargeant, A. B. and Arnold, P. M. 1984. Predator management for ducks on waterfowl production areas in the northern plains. *Proceedings of Vertebrate Pest Conference 11*: 161-167.

Sealy, S. G. 1966. Notes on the carnivorous tendencies of some sciurids. *The Blue Jay 24*: 37-38.

Sealy, S. G. 1982. Voles as a source of egg and nestling loss among nesting auklets. *The Murrelet 63*: 9-14.

Sowls, L. K. 1948. The Franklin ground squirrel (*Citellus franklinii* Sabine) and its relationship to nesting ducks. *Journal of Mammalogy 29*: 112-137.

Stanton, F. W. 1944. Douglas ground squirrels as a predator on nests of upland game birds in Oregon. *Journal of Wildlife Management 8*: 153-161.

Stejneger, L. 1936. George Wilhelm Steller, the pioneer of Alaska's natural history. Harvard University Press, Cambridge, MA.

Stephenson, R. O. 1970. A study of summer food habits of the Arctic fox on St. Lawrence Island, Alaska. M.S. Thesis, Univ. Alaska, Fairbanks.

Swanson, H. 1982. The unknown islands. Cuttlefish VI, Unalaska School District, Unalaska, AK.

Swanson, J. D. and Barker, M. W. H. 1992. Assessment of Alaska reindeer populations and range conditions. *Rangifer 1*: 33-43.

Swanson, J. D. and LaPlant, D. J. 1987. Range survey of Hagemeister Island, Alaska. Vols. I and II. September 1987. US. Department of Agriculture. Soil Conservation Service. Anchorage, AK.

Talbot, S. S.; Savage, W. F. and Hedrick, M. B. 1984. Range inventory of Simeonof Island, Alaska – Report. U. S. Fish and Wildlife Service, Anchorage, AK.

Taylor, R. H. and Brooks, J. E. 1995. A survey of Shemya rodents. Project Report. U. S. Fish and Wildlife Service Legacy Project 1244. Alaska Maritime National Wildlife Refuge, Homer, AK.

Tikhmenev, P.A. 1978. *A history of the Russian-American Company, (translated from Russian and edited by R. A. Pierce and A. S. Donnelly).* University of Washington Press, Seattle.

United States Department of Agriculture. Bureau of Biological Survey. 1938. US. Government Reservations in Alaska.

United States Department of Interior and Alaska Department of Fish and Game. 1993. Environmental Assessment Proposed Emergency Use of Toxicants to Prevent Accidental Introductions of Rats from Shipwrecks on Islands in the Alaska Maritime National Wildlife Refuge. Prepared November 1993. Homer, Alaska.

United States Department of Interior and Alaska Department of Fish and Game. 1994. Environmental Assessment for Removal of Introduced Caribou from Adak Island, Alaska. Prepared July 28, 1994. Anchorage, Alaska.

United States Fish and Wildlife Service. 1929-1939. USFWS and US Department Agric. Bur. of Biol. Survey, Aleutian Islands National Wildlife Refuge Annual Permits for Fur Farming. Unpub. file documents, Alaska Maritime National Wildlife Refuge, Adak, Alaska.

Williams, J. C. 1998. Aerial surveys of barren-ground caribou at Adak Island, Alaska in 1998. U.S. Fish and Wildlife Service Report AMNWR 99/01.

Williamson, F. S. L. and Emison, W. B. 1969. Studies of the avifauna on Amchitka Island, Alaska; annual progress report, June 1968-July 1969. US. Atomic Energy Commission Report BMI-171-125, Batelle Memorial Institute, Columbia, Ohio.