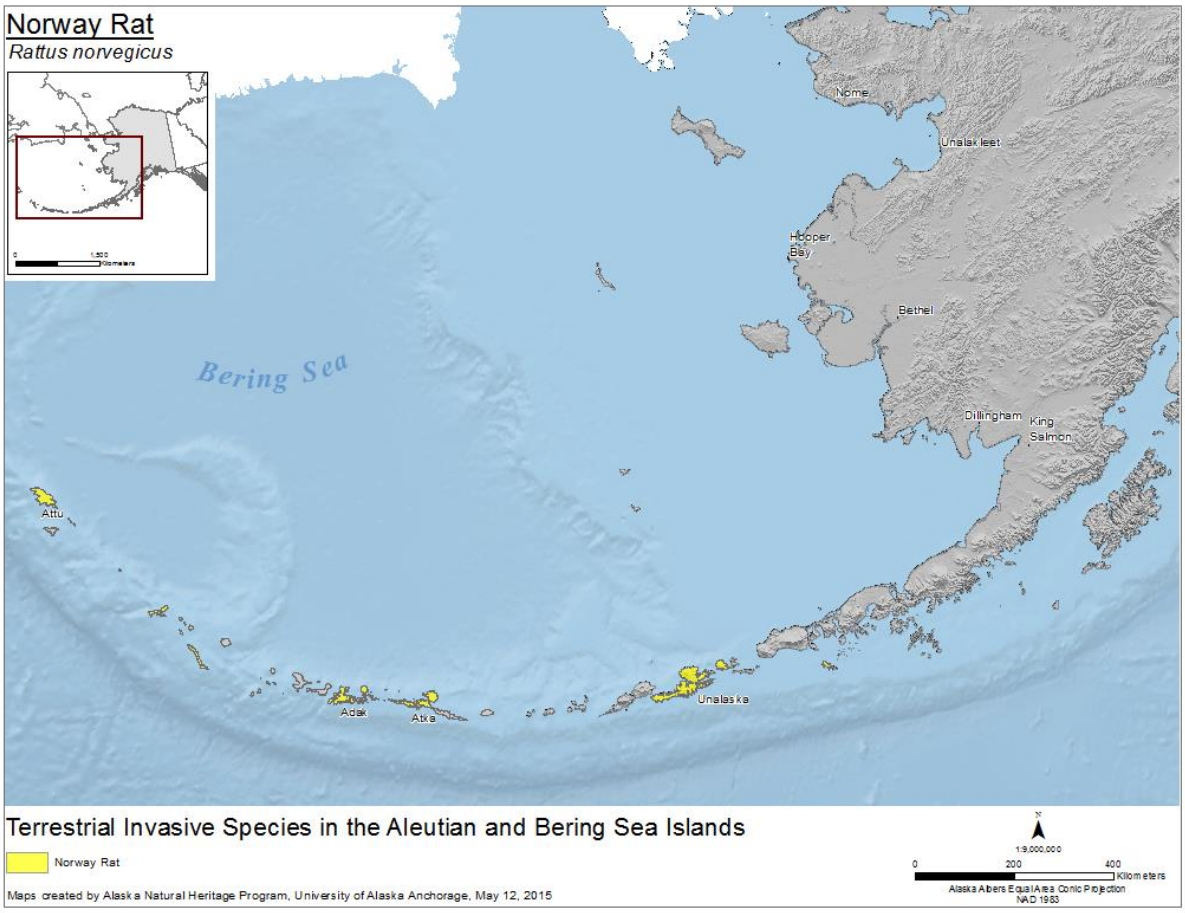
Appendix 4

Species Ranking Templates

Common Name	Invasiveness Score	Level
Norway rat	91	Extreme
Fox	85	Extreme
Roof rat	78	High
House mouse	76	High
Domestic cat	76	High
European Rabbit	68	Moderate
Horse	67	Moderate
Muskrat	64	Moderate
European hare	62	Moderate
Cattle	61	Moderate
Sheep	60	Moderate
Reindeer/Caribou	59	Modestly
Ground squirrel	47	Weak
Deer mouse	42	Weak
Bison	39	Very Weak
Elk	39	Very Weak
Alaskan hare	31	Very Weak

Scientific name: *Rattus norvegicus* Common name: Norway rat



Range Map – ABSI LCC Region

Alaska invasion/introduction history

The Norway rat (*Rattus norvegicus*) was first accidentally introduced on Rat Island from a Japanese shipwreck in 1780, and it continued to spread throughout the Aleutian Islands and the Alaska Maritime National Wildlife Refuge (AMNWR) on cargo ships during WWII (Murie 1959, Ebbert and Byrd 2002). In Alaska, this rat is established as far north as Nome and at some point in time had populations on 17 islands within the AMWR Refuge. Islands that have supported the Norway rat are Adak, Akutan, Amaknak, Amchitka, Atka, Attu, Bolsoi Islets, Great Sitkin, Kagalaska, Kiska, Little Kiska, Ogangen, Rat, Sanak, Sedanka, Shemya, and Unalaska. They have since disappeared from Ogangen and Sanak, been eradicated from Rat Island, have an unknown status on Little Kiska and Shemya, and are presumably present on the rest (Bailey 1993, Ebbert et al. 2007, MacDonald and Cook 2009).

Ranking Summary		
	Potential Max	Score
Distribution	30	30
Biological Characteristics	30	25
Ecological Impact	30	27
Feasibility of Control	10	9
Total	100	91
Invasiveness (out of 100) = 91 Extremely invasive		

Distribution **Score**

Current global distribution ***10/10***

The Norway rat is native to Asia, has been introduced worldwide, and is more common in cold climates (Kucheruk 1990, Nagorsen 1990).

Extent of the species US range and/or occurrence of formal state or provincial listings ***10/10***

Invasive in all US states and the majority of Canadian provinces and territories (Nature Serve 2009, Patterson et al. 2003).

Role of anthropogenic and natural disturbance in establishment ***5/5***

This species is typically commensal with humans and readily establishes in urban areas (Vignieri 2006). However, once introduced, the Norway rat can establish in undisturbed habitats on islands and along beaches (MacDonald and Cook 2009).

Climatic similarity between site of origin and release ***5/5***

The Norway rat is most common in cold climates and occurs in northern latitudes with similar climatic zones as Alaska (Kucheruk 1990, MacDonald and Cook 2009, Vignieri 2009).

Total for distribution **30/30**

Biological Characteristics and Dispersal **Score**

Invasive elsewhere ***5/5***

Invasive worldwide (Nagorsen 1990).

Dietary specialization ***5/5***

The Norway rat is omnivorous, eating a wide variety of plant and animal material (Johnson 2008). This rat preys on nesting birds (eggs, nestlings, and adults), intertidal invertebrates, seeds, berries, other plant parts, and food scraps left by humans (Drever and Harestad 1998, Johnson 2008, Landry 1970, Major et al. 2006, Moors 1990).

Habitat specialization ***5/5***

The Norway rat nests in burrows, which can be created in the ground, trees, rock piles, buildings, and natural crevices (Johnson 2008). This rat is often commensal with humans and can easily find suitable habitats in urban areas (Johnson 2008, Vignieri 2009).

Average number of reproductive events per adult female per year ***5/5***

A female has 3-6 litters per year, with 2-13 offspring (average of 7 offspring) per litter (Vignieri 2009).

Potential to be spread by human activities ***5/5***

Norway rats hitchhike to new locations on ships and airplanes by walking on board or hiding in cargo (Fritts 2007, Johnson 2008). The Norway rat is commensal with humans, so as fisheries, tourism, and human populations increase in Alaska, chances for accidental introductions of rats from increased human traffic rises (Ebbert and Byrd 2002).

Innate potential for long distance dispersal ***0/5***

The Norway rat does not have any mechanisms for long distance dispersal. They make daily movements of up to several kilometers on land or several hundred meters in water (NatureServe 2009, Taylor et al. 2000).

Total for biological characteristics	**25/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***10/10***

This species is known to severely reduce or extirpate native ground nesting seabirds, burrow nesting seabirds, and shorebirds (e.g. Storm Petrels, Puffins, Auklets, Gulls, Black Oystercatchers, and Rock Sandpipers) by feeding on individual birds and disturbing nesting adults (Ebbert and Byrd 2002, Kurle et al. 2008, Major and Jones 2005). The rat carries disease that can affect humans and other mammal species, particularly other rodents (Vignieri 2009).

Impact on natural community composition ***10/10***

The Norway rat reduces the biodiversity of insular avifauna by causing declines or extirpating many ecologically important bird species (Ebbert and Byrd 2002, Kurle et al. 2008, Major and Jones 2005). This impacts marine intertidal communities by reducing the densities of foraging birds, which in turn shifts the intertidal community from algae to invertebrate dominated (Kurle et al. 2008). A reduction in seabirds may reduce marine to terrestrial nutrient paths, consequently impacting below-ground invertebrate communities (Towns et al. 2009). Additionally, presence of the rat can cause hyperpredation, as they help to support larger predator populations that in turn prey upon more birds (Ebber and Byrd 2002).

Impact on natural ecosystem processes ***7/10***

Marine birds connect marine and terrestrial ecosystems by feeding on ocean resources and dropping guano on land. As bird densities decrease, this changes nutrient cycling, soil fertility, and productivity, impacting belowground organisms. It also causes a shift from algae- to invertebrate-dominated intertidal communities (Fukami et al. 2006, Kurle et al. 2008, Simberloff 2009).

Total for ecological impact	**27/30**

Feasibility of control	Score
Number of populations in Alaska	***2/3***

This rat is established as far north as Nome and at some point in time had populations on 17 islands within the Refuge. Islands that have supported the Norway rat are Adak, Akutan, Amaknak, Amchitka, Atka, Attu, Bolsoi Islets, Great Sitkin, Kagalaska, Kiska, Little Kiska, Ogangen, Rat, Sanak, Sedanka, Shemya, and Unalaska. They have since disappeared from Ogangen and Sanak, been eradicated from Rat Island, have an unknown status on Little Kiska and Shemya, and are presumably present on the rest (Bailey 1993, Ebbert 2008, MacDonald and Cook 2009).

Significance of the natural area(s) and native species threatened	***3/3***

The insular communities that the Norway rat has invaded are often refuges and source populations for large colonies of birds, such as the Least Auklet and Ancient Murrelet (Bertram 1995, Major and Jones 2005). A number of infested islands support potentially vulnerable avian populations such as Kittlitz's and Marbled Murrelets.

General management difficulty	***4/4***

Eradication of rats on islands is expensive and involves long-term monitoring, but it has been accomplished on many islands (Ebbert and Byrd 2002, Fritts 2007, Howald et al. 2007, Taylor et al. 2000). The best management practices are preventative, and can include public education and outreach and establishing bait and trap stations at ports. Removing clutter and vegetation that may act as shelter or corridors for the rat around ports is helpful. Rodenticides can also be used (Fritts 2007, Johnson 2008).

Total for feasibility of control	**9/10**

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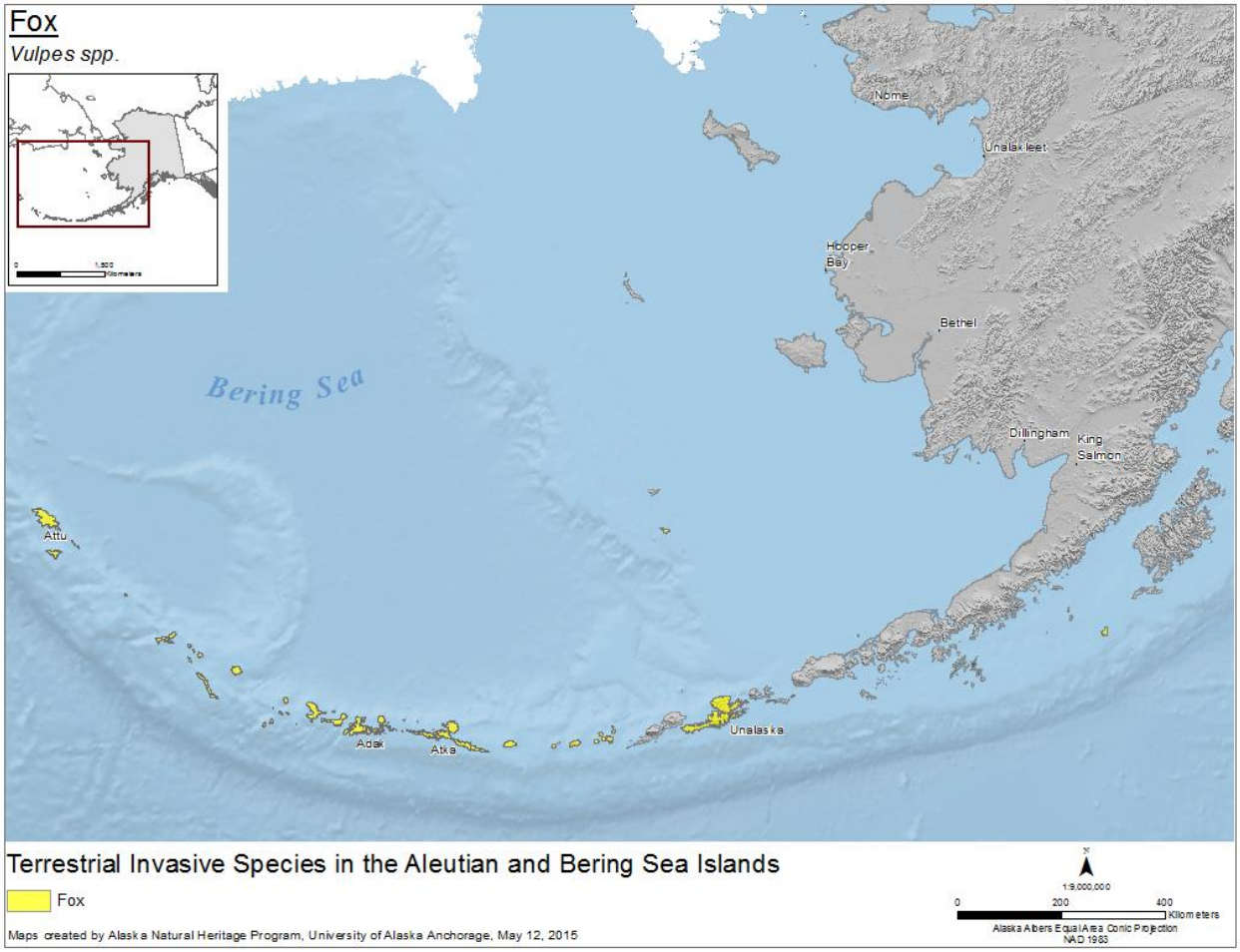
Reviewer(s): J.P. Reimer, C. Greenstein, Alaska Center for Conservation Science

Scientific name: *Vulpes lagopus, V. vulpes* Common name: Fox, Arctic and red



Range Map – ABSI LCC Region

Alaska invasion/introduction history

Nominated as one of the 100 "World's Worst" invaders, Arctic and red foxes were introduced by Aleut and Russian fox ranchers on over 450 Alaskan islands, with the first intentional introductions taking place around 1741. Another 86 islands in the Aleutian chain were stocked with foxes between 1910 and 1940, at which point the Alaska Maritime National Wildlife Refuge stopped permitting their introduction. Seabird declines across Refuge islands precipitated changes in government policy regarding fox ranching on islands; eradication efforts started in 1949 and by 2002 they had been eliminated from 39 islands and over 500,000 hectares (Bailey 1993, Ebbert 2000, Ebbert and Byrd 2002). Bailey (1993) sites foxes on a total of 65 islands: disappeared on 26; eradicated on 33; and present on 6, although one of these islands, St. George, supports a native population.

Ranking Summary		
	Potential Max	Score
Distribution	30	30
Biological Characteristics	30	20
Ecological Impact	30	27
Feasibility of Control	10	8
Total	100	85
Invasiveness (out of 100) = 85 Extremely invasive		

Distribution **Score**

Current global distribution ***10/10***

The Arctic fox is circumarctic and present in all Arctic tundra habitats (IUCN 2015, NatureServe 2015). The red fox is holarctic; they are present in the northern hemisphere from Central America and North Africa to the Arctic Circle and are the mostly widely distributed carnivore in the world (GISD 2010, IUCN 2015). In addition to North America, the red fox has been introduced to Australia, Tasmania, Falkland Islands, Kuril Islands in Russia, and the Isle of Man in the UK (Ebbert 2000, IUCN 2015).

Extent of the species US range and/or occurrence of formal state or provincial listings ***10/10***

The Arctic fox is native to western and northern Alaska, northern Canada southward to the northern Northwest Territories, northern parts of Quebec, Manitoba, and northeastern Alberta, and occasionally farther south (NatureServe 2015). They are native to some Bering Sea islands and many Arctic islands and are better adapted to the Aleutians relative to the red fox (Chapman and Feldhammer 1982, Fay and Cade 1959). They have been known to travel on sea ice to the North Pole and to establish populations at up to 3000 meters elevation (IUCN 2015).

The red fox is native to North America is a boreal species that occurs in northern parts of the continent, including Alaska, and farther south in high elevation montane habitats (Kamler and Ballard 2002). European subspecies of the red fox were introduced to North America in the 1600s-1900s, originally for sport hunting (Churcher 1959, Godin 1977, Kamler and Ballard 2002, Nowak 1991). Introductions continued over time, establishing populations throughout the eastern US that expanded northward and westward throughout lowland regions (Churcher 1959, GISD 2010). A second, disjunct, population of the red fox was introduced in a similar fashion throughout the 1800s-1900s on the west coast, spreading through western lowlands southward to northern parts of Mexico (Aubry 1984, GISD 2010, Lewis et al. 1999).

The North American native red fox has been largely replaced by, or hybridized with, the European red fox. Native populations still exist at high elevations in the western US and have important life history traits that differ from introduced foxes. The native red fox is cold-adapted, occur in montane and boreal habitats, and persist at relatively low densities. The introduced fox is a habitat generalist occupying a wide variety of landscapes from desert, to tundra, to urban settings (Aubry 1984, Crabtree 1993), and occurring at densities of 0.5-1 fox per square km (Sargeant 1972, Voigt 1987). The introduced red fox potentially poses a threat to surviving native red fox populations (Kamler and Ballard 2002).

In Alaska, the red fox naturally occurs on some of the nearshore islands of the Alaskan Peninsula and on the Fox Island group of the eastern Aleutians. Intentional introductions to Alaskan islands first occurred around 1741, when both the Arctic and red fox were translocated to several Aleutian Islands. Fox ranching peaked between 1910 and 1940 when most habitable Aleutian Islands were stocked with these species (about 86). Those that did not have foxes introduced were either too rugged or small for easy access by wooden boat (Ebbert and Byrd 2002, Kamler and Ballard 2002).

Role of anthropogenic and natural disturbance in establishment ***5/5***

Foxes can disperse great distances without human intervention and survive well in undeveloped areas.

Climatic similarity between site of origin and release ***5/5***

The Arctic and red fox are circumarctic and holarctic, respectively, and well adapted to climatic zones that occur in Alaska.

Total for distribution	**30/30**

Biological Characteristics and Dispersal	**Score**

Invasive elsewhere ***5/5***

Invasive in other parts of the US, and in Australia, Tasmania, and other locations. The red fox has descended from European species and is well adapted to urban areas, human activity, and anthropogenic environmental changes (Kamler and Ballard 2002).

Dietary specialization ***5/5***

Both the Arctic and red fox are omnivorous generalists and opportunists. The Arctic fox will eat berries, eggs, birds, hares, squirrels, voles, lemmings, ringed seal pups, garbage, and leftover carrion from other large predators, including polar bears; they also cache food (NatureServe 2015). The red fox's primary prey is ground nesting birds, and semi-arboreal and/or ground-dwelling mammals of small to medium size (e.g, mice and rabbits; DEWHA 2008, NatureServe 2015). It will sometimes scavenge on carrion or garbage and also eats insects, eggs, vegetables, and fruit (Saunders et al. 1995). The red fox maintains a regular foraging route (NatureServe 2015).

Habitat specialization ***5/5***

On the Aleutian Islands the Arctic fox inhabits maritime areas, while elsewhere it occupies Arctic and alpine tundra. Habitat used includes tundra, usually near shores, and ice; it will move farther out onto pack ice during the winter, and where soil is available it will burrow into dirt to create dens in hillsides and banks. In the winter it may tunnel into snowbanks. In northern Alaska it has been known to utilize dumps. Breeding grounds include coastal plains and coastal parts of Canada and High Arctic islands; they typically breed above tree line in North America, and young are born in underground dens. Unsuitable habitat consists of very rugged ridges and thick forests (IUCN 2015, NatureServe 2015).

The red fox uses a wider variety of habitat types than the Arctic fox (Kamler and Ballard 2002). They can be found in forests, woodlands, shrub lands, deserts, range lands, croplands, hedgerows, grasslands, savannas, sand dunes, riparia, tundra, sea ice, agricultural areas, disturbed places, and suburban and urban areas (GISD 2010, IUCN 2015, NatureServe 2015). In mountainous regions they are found up to and above tree line, ranging from sea level to 4500 meters elevation (IUCN 2015). The red fox is most abundant in fragmented and mixed landscapes, agricultural or otherwise, because

the environmental heterogeneity provides a variety of den sites, cover, and foraging opportunities (IUCN 2015, Saunders et al. 1995). They also prefer open and semi-open areas, relatively dry climates, and places with abundant scrub and/or woodland edges (IUCN 2015, NatureServe 2015). Den sites are found in wooded areas, open fields, under buildings, under stumps, in hollow logs, and in soil burrows. Mountainous, heavily forested, and homogenous open environments are less preferred habitats. Although the red fox will avoid dense, closed canopy forests as primary habitat, they will utilize them for hunting and foraging (NatureServe 2015, Saunders et al. 1995).

On Alaskan islands both foxes are most successful on islands with accessible beaches or tidal benches that can be used for foraging, which is particularly useful throughout the late fall and winter when migratory birds are absent (Stephenson 1970).

Average number of reproductive events per adult female per year ***0/5***

Both the Arctic and red fox have one litter per year. Litter size depends on food resources, with fewer young born when food is scarce. Average litter size is 4-5, but may range from 1-10 (NatureServe 2015, Saunders et al. 1995).

Potential to be spread by human activities ***0/5***

Foxes were intentionally introduced to many Aleutian and Bering Sea islands in the last few hundred years. However, as their negative impacts on bird populations have become obvious, human introductions have ceased.

Innate potential for long distance dispersal ***5/5***

In Alaska, the arctic fox migrates in the fall and early winter toward the sea, and moves back inland in the late winter to early spring (Underwood and Mosher 1982). Their summer territory average 4-60 sq km, and their winter range is typically larger, averaging 10-20 sq km, up to 75 sq km. Ranges are larger where food resources are slim (Audet et al. 2002, Prestrud 1992). Migratory populations have much larger home ranges, and “floaters” may cover a much larger area than territorial foxes. This species has been known to migrate several hundred km (Audet et al. 2002). They are also known to travel thousands of miles over sea ice following polar bears and eating leftover carrion (Tarroux et al. 2010). Furthermore, the Arctic fox is a strong swimmer and has been known to cross over two km of water (Audet et al. 2002).

The red fox home range varies from dozens to thousands of hectares, depending on habitat quality (NatureServe 2015). Their summer range is typically 142-1280 acres (Ables 1969), while their winter range is larger. Dispersal range is highly variable. They have been known to travel 300 km in North America (Corbet and Harris 1991). However, average dispersal is reported as 2.8-43.5 km for males and slightly less for females (Saunders et al. 1995), or 31 km for males and 11 km for females (Storm et al. 1976). Caire et al. (1989) report average range of 2-4 km or up to 8 km where food is less abundant.

Total for biological characteristics	**20/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***10/10***

Foxes can cause population declines in nesting birds by eating adults, nestlings and eggs, and they also cache birds and eggs. Those most affected are seabirds, waterfowl, shorebirds, and ptarmigan

(Bailey 1993). Most of Alaska's insular bird populations have not coevolved with terrestrial mammals and consequently are not able to coexist with them (Byrd 1998, GISD 2010, Jones 1963). Moreover, most islands that have introduced foxes lack trees, so birds nest on the ground or in burrows, which increases their vulnerability to predation (Byrd 1998, Jones 1963). During intentional fox introductions in past centuries, most islands were stocked with just a few fox pairs (Janson 1985, USFWS 1929-1939), but these few breeding pairs and their offspring quickly reduced bird numbers (Black 1984, Murie 1936, 1937).

Aleutian Canada Geese have been particularly impacted by fox introductions, because in addition to nesting on the ground like many other species, they are also flightless in late summer for several weeks. These geese were extirpated on all islands with introduced foxes. The present population of Aleutian Canada Geese has reestablished from just three islands where fox introductions did not occur (Bailey and Trapp 1984, Hatch and Hatch 1983, Jones 1963).

Arctic birds' most common predator is the arctic fox (e.g. Lesser Snow Goose, Black Brant; NatureServe 2015). When introduced to islands foxes have a devastating effect on communities of seabirds (Bailey 1993, Birkhead and Nettleship 1995, Lensink 1984). The arctic fox has limited the distribution and abundance of Brant (Raveling 1989), and has inhibited Aleutian Canada Goose restoration attempts (NatureServe 2015).

Globally, the red fox has caused extinctions and declines in many native species (Kamler and Ballard 2002). In Australia they have had negative impacts on ecosystems and species, particularly small to medium-size marsupials and rodents (GISD 2010, Strahan 1995). In North America, the red fox has reduced populations of nesting ducks, sage grouse, and pheasants in the Great Basin, and in California they pose a threat to 24 threatened and endangered species (Kamler and Ballard 2002). In addition to birds, they are also culpable for reductions in small canids, including native subspecies of red foxes and the endangered San Joaquin kit fox in California (Ralls and White 1995).

Impact on natural community composition ***7/10***

Foxes cause reductions in multiple bird species populations. Fox-free islands in the Aleutians have seabird densities two orders of magnitude higher than islands with foxes (Croll et al. 2005). Where introduced foxes and rabbits both exist, there is a lag time between a rabbit population crash and fox population decline, at which point foxes will prey more heavily on native species. Foxes also potentially carry diseases that can affect other species (GISD 2010, Saunders et al. 1995).

Impact on natural ecosystem processes ***10/10***

Reductions in seabird populations cause changes to community structure and plant productivity by reducing marine to terrestrial nutrient transport, consequently impacting soil fertility and vegetation composition. Fox-free islands are dominated by productive graminoid ecosystems, while islands with foxes are dominated by less productive dwarf shrubs and forbs, effectively transforming grasslands into maritime tundra. The change in landscape reflects relatively low soil fertility. Where foxes are not present, islands have significantly more soil nitrogen and three times as much soil phosphorus. They support grass and sedge biomass a factor of three higher, and this vegetation has significantly higher nitrogen content. Because ocean-derived nutrients fuel higher trophic levels within these island ecosystems, these fundamental changes in nutrient transport can have far reaching ramifications for insular ecosystems (Croll et al. 2005).

Total for ecological impact **27/30**

Feasibility of control	Score
Number of populations in Alaska	***2/3***

The Arctic fox has been successfully eradicated from 39 Aleutian Islands (DIISE 2015) and remains on six (TIB 2015). The red fox is present on Unalaska and Umak islands (TIB 2015). An assessment by Bailey (1993) of both Arctic and red foxes lists them as disappeared on 26 islands, eradicated on 33, and present on 6. However, one island on which they are present, St. George, supports a naïve population of foxes.

Significance of the natural area(s) and native species threatened ***3/3***

Sixty-four species of birds breed in the western and central Aleutians, of which 30% are endemic. Many birds evolved without any mammalian predators and consequently have no adaptation to defend against them (Ebbert 2000).

Unalaska has both the Arctic and red fox and also supports the endangered Marbled Murrelet (*Brachyramphus marmoratus*) and critically endangered Kittlitz's Murrelet (*Brachyramphus brevirostris*). Amak Island has the red fox and also supports the vulnerable Red-legged Kittiwake (*Rissa brevirostris*). The Arctic fox co-occurs with the vulnerable Red-legged Kittiwake on the islands of Otter, St. George, Koniuji, Unalga, and Bering. The Arctic fox co-occurs with the endangered Marbled Murrelet and critically endangered Klittlitz's Murrelet on the island of Atka (TIB 2015).

General management difficulty ***3/4***

Fox control methods include baiting, fencing, trapping, or shooting. Baiting may be the only available method for treating large areas (Gentle et al. 2007, GISD 2010), but this approach is of limited effectiveness due to dispersal abilities, and also because foxes may cache bait and the poison can degrade (Gentle et al. 2007). Also, poison baits run the risk of harming non-target species. Baits can also be used to deliver non-lethal fertility regulators (Marks et al. 1996), or oral vaccinations to prevent disease transmittal to other species. This latter technique has been highly successful in central and western Europe in eliminating the spread of rabies (Vos 2003). However, baiting is expensive. One control effort found that one season of aerial baiting of 35,000 sq km cost 1.3 million dollars (DEWHA 2008). Fencing can be effective but can cost an average of ten thousand dollars per kilometer (DEWHA 2008). Sterilized red foxes have been employed to remove introduced populations of Arctic foxes on some islands, as there are numerous examples of these species being unable to concurrently establish viable populations (Bailey 1992, 1993, USFWS 1929-1939). In 1999 foxes were eliminated from a 90,000 ha island using traps (GISD 2010). In order for trapping to be effective, it needs to take place in late winter when birds are unavailable and cached food stores are depleted. The Fish and Wildlife Service used toxicants to reduce fox populations from 1949 until the early 1970s, but they were banned in 1972 by federal regulations (Ebbert 2000, GISD 2010).

After fox removal bird populations can rebound with little to no human intervention (Ebbert and Byrd 2002), with most nesting seabird populations increasing four to five fold within a decade of fox removal (Byrd et al. 1994). For example, populations of the Aleutian Canada Goose, initially aided by transplantation to islands without foxes, has led to an increase from fewer than 1000 individuals in 1975 to over 35,000 in 2000 (Byrd 1998).

It is worth noting that the Arctic and red fox are native on some Alaskan Islands. Some of these native populations are at very low levels and declining (e.g. the Arctic fox on St. Paul in the Pribilof Islands; IUCN 2015).

Total for feasibility of control	**8/10**

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Acknowledgements

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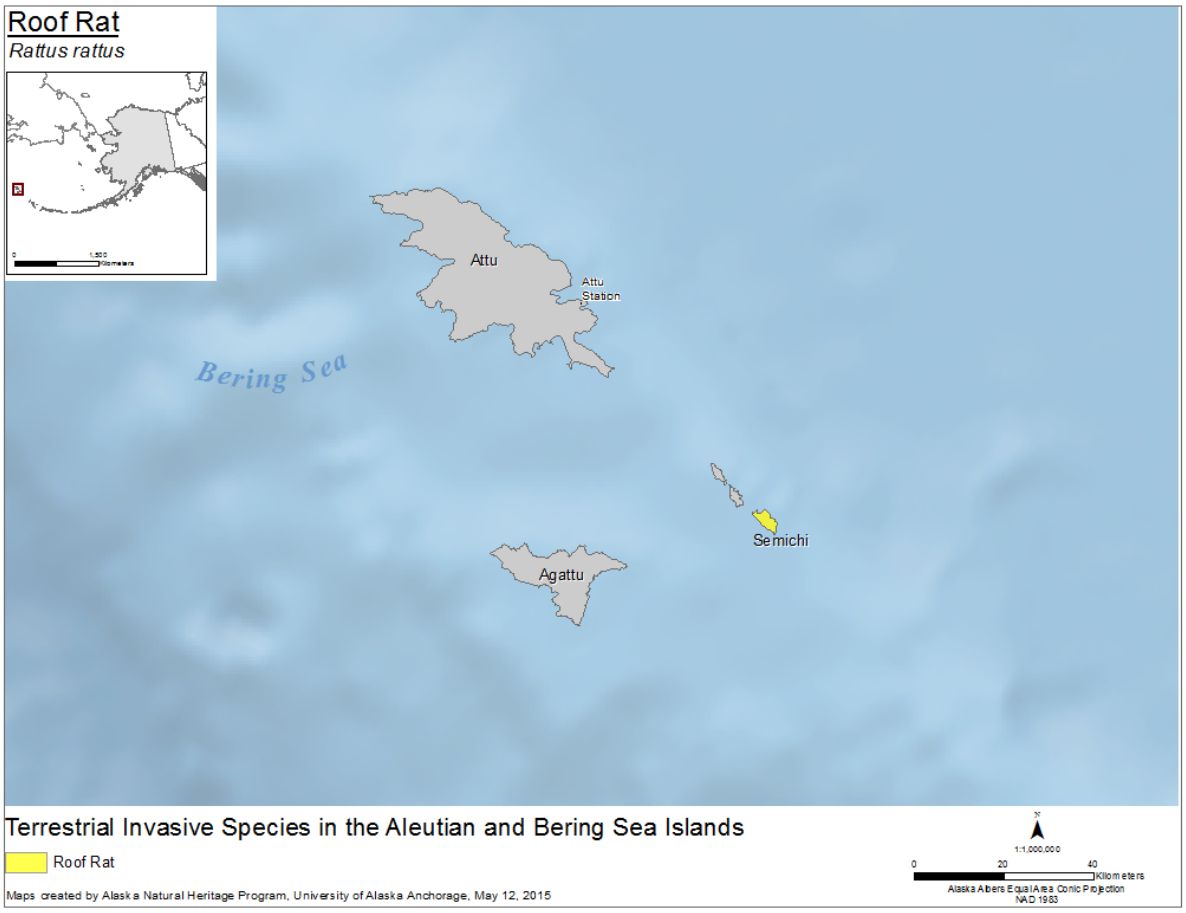
Scientific name: *Rattus rattus* Common name: Roof rat



Range Map – ABSI LCC Region

Alaska invasion/introduction history

Nominated as one of the top 100 "World's Worst" invaders, the roof rat has been introduced to Alaska as a hitchhiker on ships (GISD 2011). It was introduced, and still may be present, on Shemya Island (Taylor and Brooks 1995).

Ranking Summary		
	Potential Max	Score
Distribution	30	21
Biological Characteristics	30	24
Ecological Impact	30	24
Feasibility of Control	10	6
Total	100	75
Invasiveness (out of 100) = 75 Highly invasive		

Distribution	Score
Current global distribution	***10/10***

Widespread and global distribution, present on all continents except Antarctica (GISD 2011, NatureServe 2015, Vignieri 2006).

Extent of the species US range and/or occurrence of formal state or provincial listings ***7/10***

ISSG (2011) lists the following areas with known roof rat presence: Alaska, California, Hawaii, and Arizona; in Canada, British Columbia, Cox Island, and Queen Charlotte Islands. The Internet Center for Wildlife Damage Management (Marsh 1994) additionally lists: Oregon, Washington, Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, North Carolina, and South Carolina. NatureServe (2015) lists the roof rat as occurring in 28 U.S. states and five Canadian provinces.

Role of anthropogenic and natural disturbance in establishment ***2/5***

The roof rat is commensal with humans but is also able to establish in semi-natural and natural habitats (Amori et al. 2008, Vignieri 2006).

Climatic similarity between site of origin and release ***2/5***

The roof rat is native to the Indian Subcontinent, which has a variety of climate types, but is typically milder than Alaska (GISD 2011, NatureServe 2015).

Total for distribution	**21/30**

Biological Characteristics and Dispersal	Score
Invasive elsewhere	***5/5***

Globally invasive (GISD 2011).

Dietary specialization ***5/10***

Generalist omnivore. It is partial to grain but will eat a wide variety of plants and animals, including insects, moths, spiders, beetles, snails, birds, eggs, fruit, and vegetation (GISD 2011, Innes 1990, Innes et al. 1999).

Habitat specialization ***5/5***

Inhabits shrub lands, scrublands, grasslands, range lands, woodlands, forests, riparia, coastlands, agricultural areas, disturbed sites, and urban areas. The specific habitat utilized varies by location. They are commonly arboreal, and both nest and search for food in trees (GISD 2011, NatureServe 2015).

Average number of reproductive events per adult female per year ***5/5***

This species breeds year round, averaging 3-6 litters per year, with 2-22 individuals per litter. Frequency of litters depends on food supply and season and can be as frequent as 27 days apart. Gestation takes 20-26 days and they are able to breed 18 hours after giving birth. They reach sexual maturity at 3-4 months (GISD 2011, NatureServe 2015, Vignieri 2006).

Potential to be spread by human activities ***3/5***

Common on ships, and often stow away on sea freight, in living spaces, holds, and hulls (GISD 2011).

Innate potential for long distance dispersal ***1/5***

The roof rat typically does not migrate (NatureServe 2015). It avoids swimming, although they have been known to cross up to 500 m of calm waters (GISD 2011).

Total for biological characteristics	**24/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***10/10***

The roof rat has been implicated in the predation of sea birds in numerous locales around the world (for examples see GISD 2011) and are associated with "catastrophic" bird population declines on islands (GISD 2011). Rat species have been responsible worldwide for more extinctions of insular birds than any other introduced species (King 1980). Rats are known to extirpate burrow-nesting seabirds (e.g. Tufted Puffin, Cassin's Auklet, Storm Petrels), and to reduce shorebird populations (e.g. Black Oystercatcher, Rock Sandpipers), as well as other ground-nesting birds (Ebbert and Byrd 2002). In the 1950s, on Canada's Queen Charlotte Islands, rats were culpable for the extirpation of two types of Petrels and two types of Auklets; Tufted Puffins went from a population size in the hundreds of thousands to rarely observed (PBS Undated). Where rats are present they will kill incubating adults, chicks, and eggs (Major and Jones 2005). Species particularly sensitive to predation include Auklets, Murrelets, Tufted Puffins, and Storm Petrels (Ebbert and Byrd 2002 and numerous references in Stolzenburg 2012). Moreover, those Aleutian Islands with rat species (e.g. Adak, Attu, and Unalaska) host no Auklets, Ancient Murrelets, Storm Petrels or Puffins, while nearby rat-free islands support these birds in large numbers (Ebbert and Byrd 2002, Kuletz and Hess Undated). The roof rat has also contributed to or caused the extinction of multiple species, including plants, invertebrates, reptiles, and small mammals, particularly on islands. Species of equal size or smaller than rats are most vulnerable to predation. On smaller islands rat densities are higher and more stable; consequently, predation impacts are higher (GISD 2011).

Additionally, the roof rat has been implicated in the extinction of two species of rats endemic only to Christmas Island in the Indian Ocean (Vignieri 2006). They have also been implicated in declines of Hawaiian fauna (Atkinson 1977, Buxbaum 1973, Bertram and Nagorsen 1995).

Impact on natural community composition ***7/10***

The roof rat competes with other native species for plant and invertebrate food sources (Lindsey et al. 2009). They carry many diseases which can impact other mammal species, particularly other rodents (Vignieri 2006), and could potentially introduce diseases that would harm northern fur seal populations on the Pribilof Islands (PBS Undated). On islands that also support non-native foxes, rats can cause hyperpredation, by acting as a supplemental food source through the winter, allowing foxes to maintain large populations and consequently increase the impacts that foxes have on birds the rest of the year (Ebbert and Byrd 2002).

Impact on natural ecosystem processes ***7/10***

As rats limit bird populations, the lack of guano and burrowing activities from birds affects vegetation communities and soil properties (Croll et al. 2005).

Total for ecological impact	**24/30**

Feasibility of control	Score
Number of populations in Alaska	***1/3***

The roof rat was introduced, and still may be present, on Shemya Island (Taylor and Brooks 1995).

Significance of the natural area(s) and native species threatened	***1/3***

Although the roof rat has great potential to cause negative impacts to the millions of nesting birds and fur seals that inhabit the Aleutian and Bering Sea Islands, at this time the rat's population is limited, and poses a small risk to insular species.

General management difficulty	***4/4***

Before the 1980s it was believed to be impossible to remove rodents established on an island (Stolzenburg 2012). However, since the advent of effective rodenticides and application techniques, islands over 100 square kilometers have had successful extirpation projects (e.g. Campbell Island; McClelland 2011). It is difficult to eradicate rats from islands, particularly in the early stages of invasion, due in part to atypical behavior of newly introduced individuals and the ineffectiveness of bait traps when competition for food is low. Trapping has limited success because individuals may be trap-shy and go on to repopulate. The only proven effective method to control rodents on large islands is poison bait. Rat poison has been successfully used to seasonally control or eradicate rats from small areas. Anticoagulant poisons are commonly used on ships, but these can lead to primary or secondary poisoning of non-target species. Additionally, waterways can be polluted by rat poisons and their associated breakdown products (GISD 2011), and rats can develop a resistance to poisons over time. Oral contraceptive control methods are being studied. Snap traps cause minor losses of non-target taxa, but can be more effective than poison (Ebbert and Byrd 2002, GISD 2011).

Prevention is the most cost effective type of control, as eradications are expensive, time consuming, and difficult processes, particularly on islands more than a few thousand hectares (Ebbert and Byrd 2002, GISD 2011, Kuletz and Hess Undated). It is preferable to respond quickly to shipwrecks and control rats as they reach shore or while they are still on the ship (Ebbert and Byrd 2002).

Total for feasibility of control	**6/10**

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Acknowledgements

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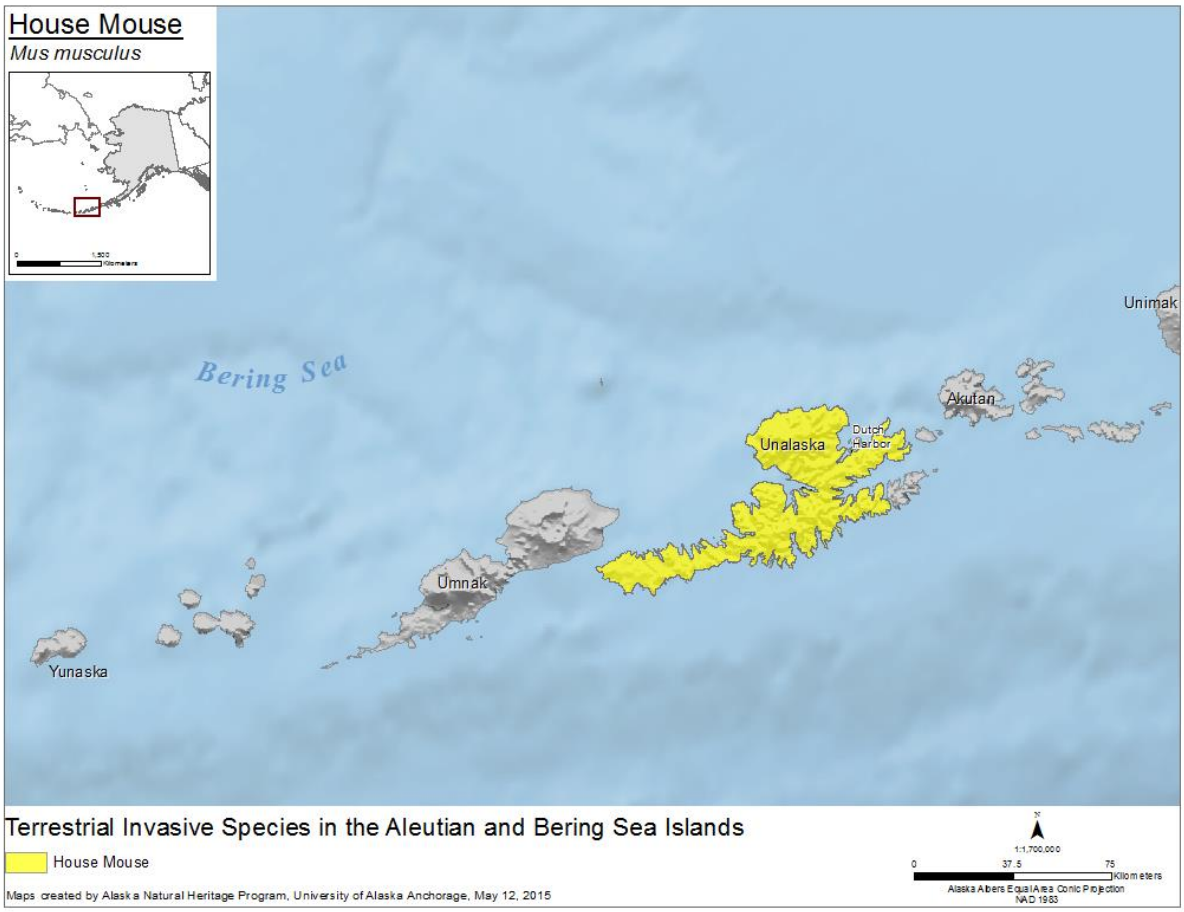
Scientific name: *Mus musculus* Common name: House mouse



Range Map

Alaska invasion/introduction history

The introduction and spread of the house mouse (*Mus musculus*) is poorly documented in Alaska. Historical records indicate the house mouse was first recorded on St. Paul Island in 1872 (Manville and Young 1965), on Unalaska Island in 1875 (Bailey 1993), in Wrangell and Sitka around 1891 (MacDonald and Cook 2007), in Juneau forests in 1895, and on Kiska Island in 1937 (MacDonald and Cook 2009). More recent records indicate that the house mouse lives in most urban areas and several islands throughout Alaska (MacDonald and Cook 2009). It has been observed on the mainland around Juneau, Kasilof, Anchorage, Eagle River, Chugiak, Palmer and Fairbanks. Additional island observations have been reported from Kodiak, Afognak, Hog, St. George, and Bering Islands (see references in MacDonald and Cook 2009; TIB 2015).

Ranking Summary		
	Potential Max	Score
Distribution	30	27
Biological Characteristics	30	26
Ecological Impact	30	17
Feasibility of Control	10	6
Total	100	76
Invasiveness (out of 100) = 76 Highly invasive		

Distribution **Score**

Current global distribution ***10/10***

The house mouse is cosmopolitan, occurring on all continents except Antarctica (GISD 2010, IUCN 2008, NatureServe 2009).

Extent of the species US range and/or occurrence of formal state or provincial listings ***10/10***

The house mouse occurs throughout the United States and Canada, except the Northwest Territories and Nunavut (GISD 2010, NatureServe 2009).

Role of anthropogenic and natural disturbance in establishment ***2/5***

The house mouse is commensal with humans, typically occurring in anthropogenic environments, but can also persist in natural areas (Musser et al. 2008, Pocock et al. 2004).

Climatic similarity between site of origin and release ***5/5***

The house mouse survives at similar latitudes and climatic conditions to those in Alaska throughout its worldwide range.

Total for distribution **27/30**

Biological Characteristics and Dispersal **Score**

Invasive elsewhere ***5/5***

The house mouse is invasive throughout the world.

Dietary specialization ***5/5***

The house mouse is a generalist omnivore, feeding on plant material, insects, human food, and even man-made household materials (e.g., glue, soap; GISD 2010).

Habitat specialization ***5/5***

The house mouse lives in a wide range of habitats, often in close association with humans. In anthropogenic settings it utilizes buildings, grain houses, fields, and croplands; in natural environments it uses grasslands, low elevation forests, and beaches (Bronson 1979, NatureServe 2009).

Average number of reproductive events per adult female per year ***5/5***

The house mouse breeds year round and females have 5-10 litters per year, giving birth to an average of 5-6 young per litter (GISD 2010).

Potential to be spread by human activities ***5/5***

The house mouse can hitchhike in cargo that is transported extensively. Baker (1983) estimated that tens of thousands of mice leave the US each year as stowaways in grain, straw, and hay shipments. Reintroductions of the house mice to islands where they have been eradicated is highly likely.

Innate potential for long distance dispersal ***1/5***

The house mouse does not typically move long distances, although the occasional dispersal event may take place due to changing environmental conditions, habitat disturbances, social interactions, or overcrowding (Pocock et al. 2004).

Total for biological characteristics	**26/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***7/10***

On islands where the house mouse is the only introduced mammal, its feeding habits can reduce native vegetation, increase mortality of healthy seabird chicks, and cause declines or extinctions of invertebrate species (Angel et al. 2009). Invasive rodents transmit disease, potentially impacting native small mammal populations (Traveset et al. 2009). Where other introduced or predatory species are present, the effects of the house mouse may be lessened, due to competition and predation (Angel et al. 2009, Courchamp et al. 1999, Harris and Macdonald 2007, Quillfeldt et al. 2008, Wanless et al. 2007).

Impact on natural community composition ***7/10***

The house mouse can potentially alter vegetation communities by foraging on native plants and seeds, and increasing opportunities for nonnative flora to establish (Angel et al. 2009, Traveset et al. 2009). A reduction in native vegetation may interfere with invertebrate development (Angel et al. 2009), and additional pressure caused by predation may further alter invertebrate community composition. Changes to invertebrate diversity and abundance can subsequently affect bird foraging patterns (Crafford and Scholtz 1987, Rowe-Rowe et al. 1989).

Impact on natural ecosystem processes ***3/10***

Changes in vegetation and invertebrate composition can affect bird populations, cause increased erosion, and alter nutrient cycling, mineralization, trophic systems, and overall productivity (Chown and Smith 1993, Crafford 1990, Croll et al. 2005, Fukami et al. 2006, Smith et al. 2002, Traveset et al. 2009).

Total for ecological impact	**17/30**

Feasibility of control	Score
Number of populations in Alaska	***2/3***

On the mainland, the house mouse has been reported around Juneau, Kasilof, Anchorage, Eagle River, Chugiak, Palmer and Fairbanks. Island observations have been reported in Sitka, and on Wrangell, Kodiak, Afognak, Hog, Unalaska, Kiska and St. Paul, St. George, and Bering Islands (see references in MacDonald and Cook 2009; TIB 2015).

Significance of the natural area(s) and native species threatened ***1/3***

The house mouse usually inhabits disturbed areas; on St. Paul Island it is only known from the community area and dump (Ebbert and Byrd 2002). Although there are no documented incidences of the house mouse directly threatening sensitive species, it is worth monitoring islands with the house mouse because they also support a number of listed species. The vulnerable Red-legged Kittiwake is present on Bering, St. George, and St. Paul Islands. The latter also hosts the rare Pribilof Island shrew. The vulnerable Kittlitz's Murrelet is present on Kodiak and Unalaska Islands (TIB 2015).

General management difficulty ***3/4***

Eliminating the house mouse can be difficult, and the same approach does not fit all infestations (Witmer and Jojola 2006). In urban areas house mouse control involves population reduction by using traps, toxicants, repellants, and fumigants (GISD 2010). Anticoagulant poison has been used to successfully eradicate mice from 28 islands (MacKay et al. 2007). An eradication project in Australia had success using poison in specially designed traps that prevented non-target species from accessing the bait; this method only required an intensive, short term investment of resources (Moro 2001). Currently, there is no eradication program active in the Alaska Maritime National Refuge (Ebbert and Byrd 2002).

Total for feasibility of control	**6/10**

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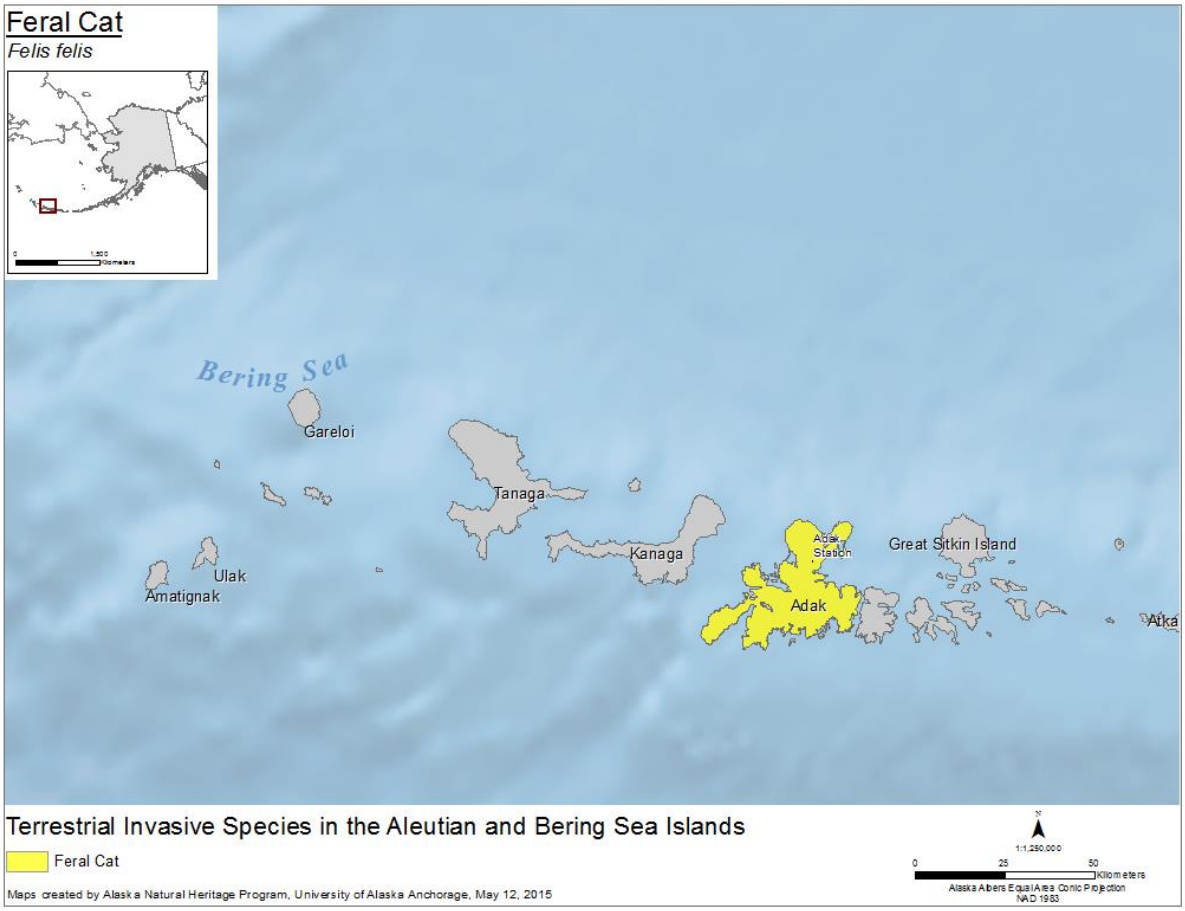
Reviewer(s): J.P. Reimer, C. Greenstein, Alaska Center for Conservation Science

Scientific name: *Felis catus* Common name: Domestic cat



Range Map – ABSI LCC Region

Alaska invasion/introduction history

Nominated as one of the top 100 "World's Worst" invaders, the cat has been introduced worldwide as a domesticated pet and is occasionally abandoned to become feral (GISD 2011). The Threatened Island Biodiversity Database (TIB 2015) only shows the domestic cat on St. Paul Island. However, the domestic cat is also reported from Adak (Alaska Maritime National Wildlife Refuge biologists, pers. comm. 2006). This species was previously found on Aziak and Derbin Islands, but was successfully eradicated in 1964 and 2000, respectively (DIISE 2015).

Ranking Summary		
	Potential Max	Score
Distribution	30	24
Biological Characteristics	30	19
Ecological Impact	20	17
Feasibility of Control	10	7
Total	90	67
Invasiveness (out of 100) = 76 Highly invasive		

Distribution **Score**

Current global distribution ***10/10***

Worldwide distribution (NatureServe 2015).

Extent of the species US range and/or occurrence of formal state or provincial listings ***10/10***

The domestic cat is present throughout the US and Canada. The US hosts 30-100 million feral cats (Rebstock 2006).

Role of anthropogenic and natural disturbance in establishment ***2/5***

Cats are translocated by people as pets, then abandoned, or else litters are left to become feral. Early introductions in the eighteenth and nineteenth centuries were due to ships carrying cats to control their rat populations; cats were able to escape from ships and establish on land (GISD 2011). The cat requires translocation by humans, and is often found near towns and villages, but once introduced to a new place it can persist in natural environments and is often found several miles from any human settlement (NatureServe 2015).

Climatic similarity between site of origin and release ***2/5***

The domestic cat is descended from the Old World wild cat, whose native range is Palearctic: South Africa to Scotland, China to Morocco (NatureServe 2015). The cat was domesticated about 3000 years ago in the eastern Mediterranean (GISD 2011), which has a milder climate than Alaska.

Total for distribution **24/30**

Biological Characteristics and Dispersal **Score**

Invasive elsewhere ***5/5***

Introduced worldwide and invasive in many countries (GISD 2011).

Dietary specialization ***5/5***

The cat is a generalist carnivore. Diets vary between mainland and island populations, as the cat is able to take advantage of whatever is available, including small mammals (e.g. rodents and rabbits), birds, arthropods, and lizards (GISD 2011, NatureServe 2015). It is able to eat birds of equal size to itself (Dickman 1996).

Habitat specialization ***5/5***

Generalists utilizing a variety of habitat types. The domestic cat can live in wetlands, tundra, scrublands, shrub lands, riparia, rangelands, croplands, hedgerows, grasslands, forests, woodlands, coastlands, agricultural areas, disturbed places, and urban and suburban areas (GISD 2011).

Average number of reproductive events per adult female per year ***2/5***

Reproductive maturity is reached at 7-12 months, and gestation is about 65 days, allowing a cat to be in estrus up to five times per year. However, it is more common for a cat to have 1-3 litters annually. The domestic cat can reproduce any time of year as long as habitat and food suffice. Litters are typically 4-6 individuals (Brickner 2003, Rebstock 2006).

Potential to be spread by human activities ***1/5***

This species is almost exclusively spread by humans, but kept as pets and spayed or neutered. A cat may become feral when owners fail to sterilize them and litters grow up wild or when pets are abandoned.

Innate potential for long distance dispersal ***1/5***

Aside from walking, the only dispersal mechanism for the cat is transportation by humans of individuals that have not yet become feral. Studies on feral cat home ranges show that they vary in different habitats, and likely depend on prey availability, with typical home ranges of 75-985 hectares (Barratt 1997, Edwards et al. 2001, ISSG2011, Rebstock 2006).

Total for biological characteristics **19/30**

Ecological Impact	Score

Impact on population dynamics of other species ***10/10***

The cat affects other species through predation, competition, and disease transmission (Medina et al. 2011). The domestic cat is known to impact at least 175 vertebrate species on 120 islands, some of which are listed as threatened or endangered. Insular feral cats are the primary threat to 8% of endangered reptiles, mammals, and birds globally, and are culpable for 14% (33 of 238) of worldwide extinctions of these same vertebrate groups (based on IUCN Red List 2008; Medina et al. 2011, Rebstock 2006). It has also contributed to the decline of dozens of species of endemic and insular birds across multiple continents (GISD 2011). The cat has the greatest impact on endemic species, specifically small to medium size mammals (Dickman 1996, Medina et al. 2011).

Impact on natural community composition ***7/10***

The cat carries diseases that can affect both animals and humans. Predation on native herbivores can have a negative impact on seed dispersal, or have secondary dispersal effects on invasive plants (Bourgeois et al. 2004, Nogales et al. 1996). By reducing prey populations, the cat negatively impacts native predator populations (Rebstock 2006). The negative influence of the cat is exacerbated in the presence of additional exotic predator and/or prey species (e.g. mice, rabbits, rats; Dickman 1996, GISD 2011, Jones et al. 2008, Towns et al. 2006).

Impact on natural ecosystem processes ***u/10***

Unknown.

Total for ecological impact **17/20**

Feasibility of control	Score
Number of populations in Alaska	***1/3***

The Threatened Island Biodiversity Database (TIB 2015) only shows the domestic cat on St. Paul Island. However, the cat is also reported from Adak (AMNWR biologists, pers. comm. 2006). The feral cat was previously found on Aziak and Derbin Islands, but was successfully eradicated in 1964 and 2000, respectively (DIISE 2015).

Significance of the natural area(s) and native species threatened ***3/3***

A number of threatened and endangered species are at risk of predation by the domestic cat (Rebstock 2006). On St. Paul island, which hosts the feral domestic cat, two listed species are present: the Pribilof Island Shrew (*Sorex pribilofensis*, endangered), and the Red-legged Kittiwake (*Rissa brevirostris*, vulnearable; TIB 2015). As previously mentioned, there is ample evidence of the domestic cat causing population declines, extirpation, and extinction of native species globally.

General management difficulty ***3/4***

Successful eradication of the feral cat has happened on less than 100 islands, which is a small percentage of the estimated 9000 on which they have been introduced (Campbell et al. 2011, Nogales et al. 2004). On islands less than 1000 hectares eradication is feasible (Medina et al. 2011). However, successful eradications have only taken place on two islands over 10,000 hectares in size (Nogales et al. 2004). Populations can be managed with use of feline-specific viruses and culling (Courchamp and Sugihara 1999). However, a significant management challenge with the feral domestic cat is the moral dilemma and public opposition caused by their relationship with humans as pets. More humane methods of control include trapping followed by sterilization, euthanization, or relocating feral kittens to animal shelters for adoption.

Total for feasibility of control	**7/10**

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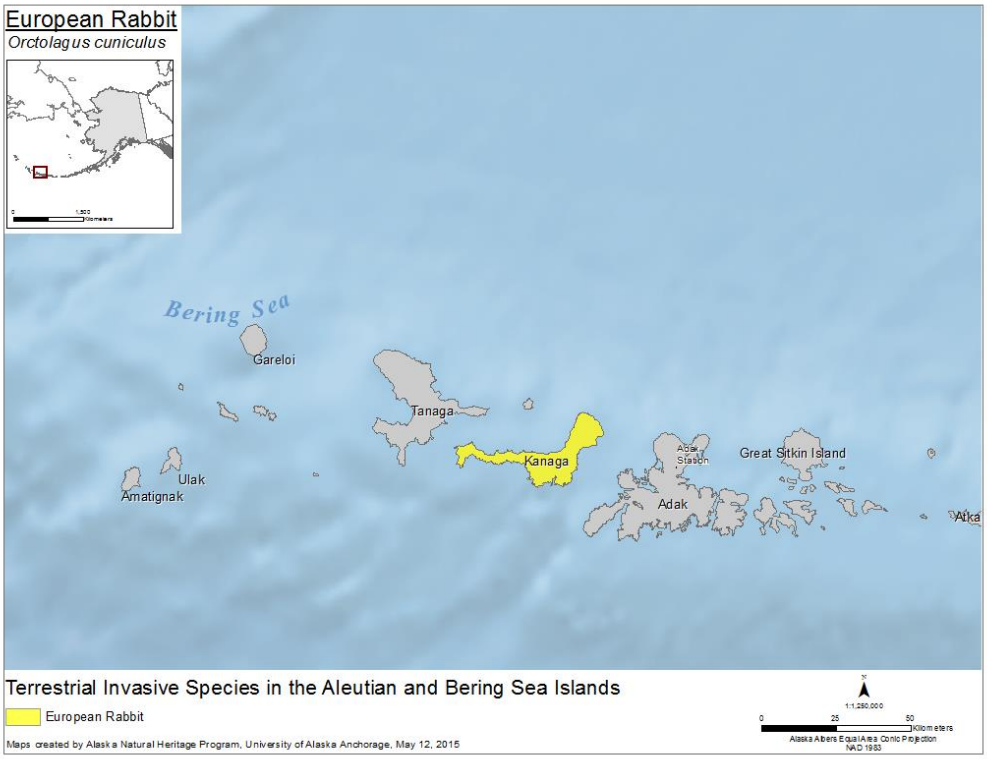
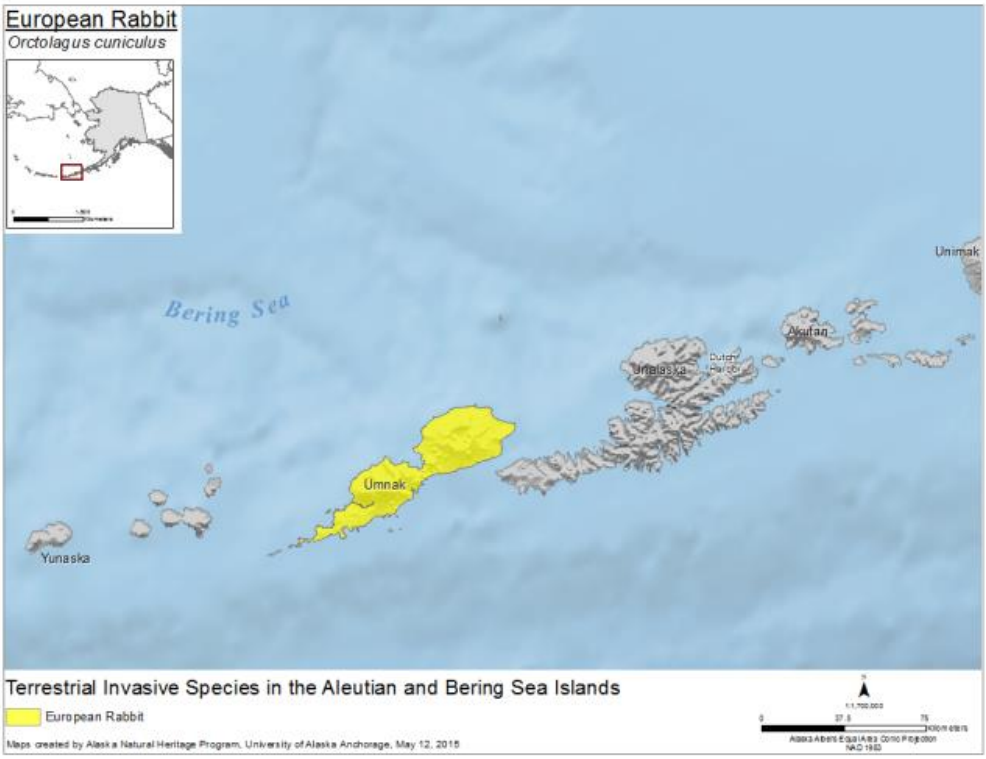
Authors: C. Greenstein, Alaska Center for Conservation Science

Scientific name: *Oryctolagus cuniculus* Common name: European rabbit





Range Map – ABSI LCC Region

Alaska invasion/introduction history

Nominated as one of the 100 World's Worst invaders, the European rabbit (*Oryctolagus cuni*culus) has been released on islands across the world to provide a source of food for returning or marooned sailors (ISSG 2010). The European rabbit was introduced around 1940 to Poa and Tangik islands by an Akutan village resident (USFWS 2010). They have since been eradicated on Poa Island and disappeared from a few others including Kanaga and Umnak islands (MacDonald and Cook 2009, DIISE 2015). They may still be present on Ananiuliak and Tangik islands (Bailey 1993).

Ranking Summary		
	Potential Max	Score
Distribution	30	17
Biological Characteristics	30	18
Ecological Impact	30	27
Feasibility of Control	10	6
Total	100	68
Invasiveness (out of 100) = 68 Moderately Invasive		

Distribution **Score**

Current global distribution ***10/10***

Present on all continents except Antarctica; introduced on more than 800 islands and island groups (Lees and Bell 2008).

Extent of the species US range and/or occurrence of formal state or provincial listings ***0/10***

In North America the only large population is throughout the San Juan Islands, off the coast of Washington (Flux 1994). It is not widespread in North America, possibly due to established native populations of rabbits (*Sylvilagus* spp.; Lees and Bell 2008).

Role of anthropogenic and natural disturbance in establishment ***5/5***

Although initial introductions of the European rabbit to Aleutian and Bering Sea islands requires human influence, once established, they thrive in undisturbed environments.

Climatic similarity between site of origin and release ***2/5***

The European rabbit is native to the Iberian Peninsula (Spain, Portugal, and a portion of southern France) and a small part of northwest Africa, and it is now domesticated worldwide (Parker 1990, Wilson and Reeder 1993). Throughout its evolutionary history in Iberia and throughout ice ages, it was subjected to environmental extremes, which may explain its modern environmental plasticity and tolerance to a wide variety of ecotypes and food sources (Lees and Bell 2008).

Total for distribution **17/30**

Biological Characteristics and Dispersal	Score

Invasive elsewhere ***5/5***

Invasive in much of the world, yet endangered in its native range (Lees and Bell 2008).

Dietary specialization ***5/5***

The European rabbit is a generalist herbivore; it eats a variety of roots, tubers, bark, buds, leaves, grasses, nuts, seeds, grains, flowers, and fruit, and is coprophagic (Macdonald 1984, Vaughan et al. 2000). Although it has preferred forage species, where these are not available, it will adapt by feeding on less desirable species (Donlan et al. 2002).

Habitat specialization ***2/5***

The European rabbit prefers sites with light soil, adequate cover, a sunny aspect, and less than one meter of rain annually. It tolerates more rainfall where soils are light and/or where there are other species that contribute to maintaining a short layer of grass. In wetter places this rabbit prefers dunes, rocky riverbeds, sunny coastal slopes, and outcrops of rocks on limestone hillsides. In addition to a preference for drier sites and grasslands, it also favors open country and sea level to low elevations. Despite these preferences, the European rabbit is able to establish in less ideal ecotypes, and often utilizes forests, shrub lands, scrublands, deserts, and rangelands, as well as disturbed and urban settings such as parks, lawns, cemeteries, and gardens. While the spread of agriculture has aided the rabbit in extending its range, modern plowing methods preclude rabbit establishment (ISSG 2010, Parker 1990).

The European rabbit will typically avoid wet and cold ecotypes, unbroken scrub, highly developed places, alpine, and elevations over 1500 meters (Lees and Bell 2008). In northern latitudes, suitable habitat is delimited by the depth of snow cover (Flux 1994).

Average number of reproductive events per adult female per year ***5/5***

This rabbit reaches sexual maturity at 3-8 months and can reproduce year round. Gestation lasts 30 days, and breeding can occur monthly, as females enter estrus after giving birth. Average litter size is 5-6, with several litters a year averaging 18-30 young per female annually (Nowak 1999, Vaughan et al. 2000).

Potential to be spread by human activities ***1/5***

Translocation by people was common in the 1700-1800s, as ships carried rabbits for food and released them on islands as a subsistence source for sailors. It is still possible that domestic rabbits will be released into the wild, but it is unlikely now that the negative effects of rabbit introductions are well understood (ISSG 2010).

Innate potential for long distance dispersal ***0/5***

Home range is typically 1-50 acres, but varies depending on food abundance and population density (Parker 1990). Long distance dispersal is unlikely without human intervention.

Total for biological characteristics	**18/30**

Ecological Impact	Score

Impact on population dynamics of other species ***10/10***

This rabbit competes with native species for shelter and food, it destroys habitat for small animals by over-browsing and causing erosion, and it contributes to overall reductions of native flora and fauna (Courchamp et al. 2003). Negative effects from herbivory are most pronounced on small islands, as rabbits can decimate the island's resources before their population is regulated by density-dependent effects (Lees and Bell 2008). Numerous examples exist for the European rabbit causing negative impacts on species. In Alaska, it may take over burrows previously used by the Tufted Puffin (*Fratercula cirrhata*), and potentially other species, because they prefer to use existing burrows rather than dig their own (USFWS 2010, Williams et al. 1995). Grazing that removes cover from burrow entrances can cause an increase in chick mortality by exposing them to predatory birds (Williams et al. 1995). Puffins and Auklets are sensitive to erosion, which can cause them to abandon their nests, and the European rabbit increases erosion by removing vegetation and digging (Rodway et al. 1996, USFWS 2010). On Hawaii's Laysan Island, between 1903 and their eradication in 1923, introduced rabbits eliminated 26 plant species and three land bird species (ISSG 2010). Sea lion pups in New Zealand suffered declines where the European rabbit was present, as modifications to microtopography caused the pups to become trapped in burrows (Torr 2002).

Impact on natural community composition ***10/10***

The most significant impact this rabbit has is overgrazing, creating depauperate landscapes and erosion, which leads to cascading ecosystem impacts (Eldridge and Myers 2001). Additionally, the rabbit causes hyperpredation by acting as a supplemental food source for predators, supporting larger populations of foxes, cats, etc., which in turn prey upon more native species (Courchamp et al. 2003, ISSG 2010, Lees and Bell 2008). Predators of the rabbit include owls, hawks, mustelids, felines, and canines. Where other invasive species are present, they can have synergistic effects that negatively impact an ecosystem. For example, grazing by rabbits can cause a decrease in native vegetation and increase in exotic forbs, particularly Mediterranean forbs that the European rabbit co-evolved with (Holmgren et al. 2000).

Impact on natural ecosystem processes ***7/10***

Overgrazing by rabbits causes vegetation reductions and erosion, which can have cascading effects on ecosystem processes (ISSG 2010). However, at lower population densities and/or where resources are abundant, rabbit excrement can increase soil fertility, which can improve plant cover (Willott et al. 2000).

Total for ecological impact	**27/30**

Feasibility of control	**Score**

Number of populations in Alaska ***1/3***

The European rabbit was introduced around 1940 to Poa and Tangik islands by an Akutan village resident (USFWS 2010). It has since been eradicated on Poa Island and disappeared from a few others including Kanaga and Umnak Islands (MacDonald and Cook 2009, DIISE 2015). It may still be present on Ananiuliak and Tangik Islands (Bailey 1993).

Significance of the natural area(s) and native species threatened ***2/3***

The European rabbit acts as an ecosystem engineer, severely degrading habitat for other native, potentially threatened or endangered species (Macdonald 1984, Nowak 1999). In Alaska, it can displace Puffins, Auklets, and potentially other seabird species (USFWS 2010). Elsewhere it is an

agricultural pest, as it eats crops and competes with domestic animals, costing the US millions of dollars annually.

General management difficulty ***3/4***

Chemical, biological, and mechanical control options are available. Chemical control includes fumigating warrens and baiting (Flux 1993, Moseby et al. 2005). The European rabbit has been successfully eradicated from several islands elsewhere in the world using poison baits (see Merton 1987 and Torr 2002); however, using poison can affect non-target species through primary or secondary poisoning (ISSG 2010). Biological control options include using rabbit haemorrhagic disease virus and myxomatosis, with fleas as vectors (Moseby et al. 2005). However, myxomatosis causes a great deal of suffering for the rabbit, and rabbit haemorrhagic disease may not be effective in the long-term. Neither biological control method is likely to cause eradication (ISSG 2010). Competition from hares, where hares are native, can be more effective than introducing disease (Flux 1993). Where grazing species are present, removing them can cause an overgrowth of vegetation that creates unsuitable habitat or grazing ground for rabbits (ISSG 2010). Mechanical control includes warren ripping, fencing, and shooting (ISSG 2010, Moseby et al. 2005). This latter option has been considered for control on Poa and Tangik Island (USFWS 2010). Removing rabbits doesn't guarantee a return to pre-rabbit conditions. Restoration and remediation efforts may be necessary to return the landscape to viable habitat for native species (Lees and Bell 2008).

Total for feasibility of control	**6/10**

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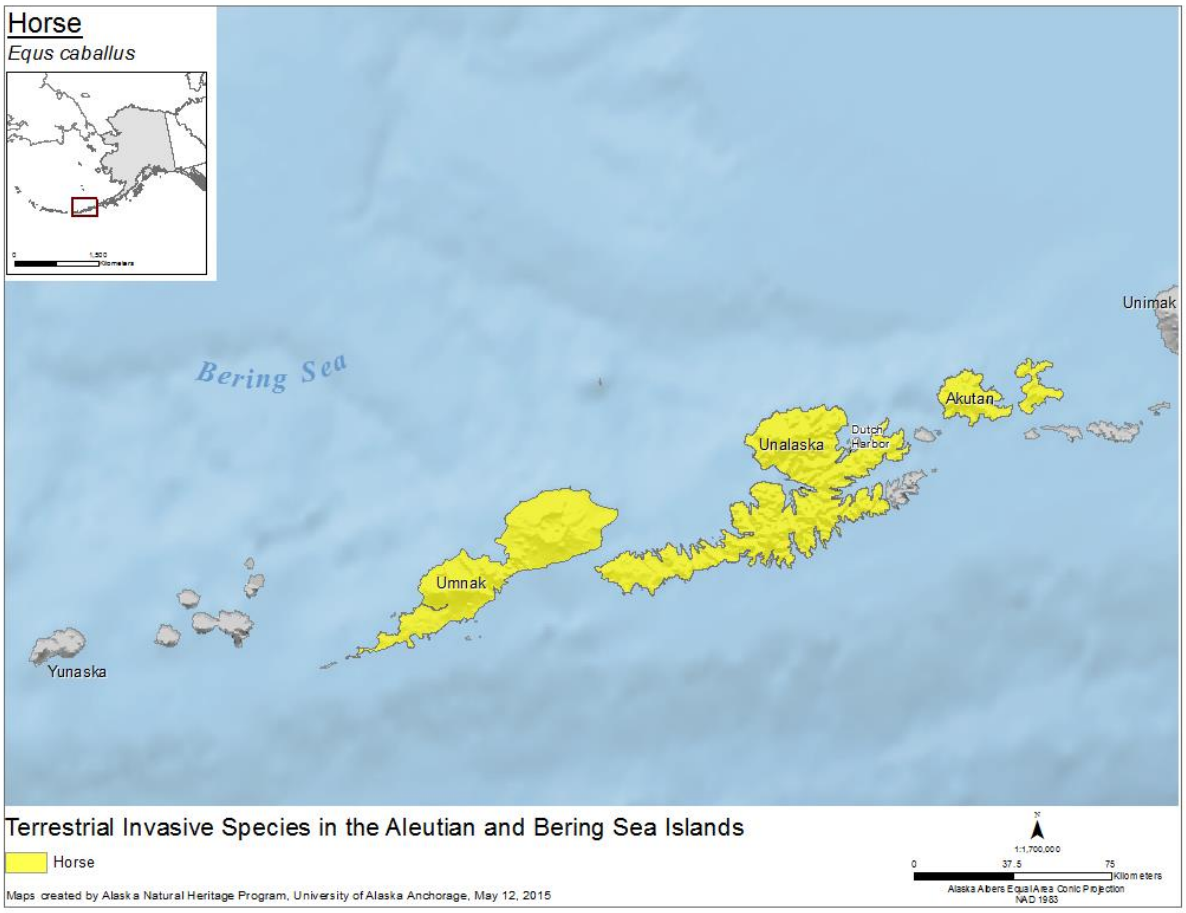
Acknowledgements

Authors: C. Greenstein, Alaska Center for Conservation Science, University of Alaska Anchorage.

Scientific name: *Equus caballus* Common name: Horse



Range Map

Alaska invasion/introduction history

Horses were domesticated 2500-5000 years ago from now extinct ancestors in Eurasia (Dobbie et al. 1993). They have since been introduced worldwide and have established many feral populations. In the Aleutian Islands, they are present on Akun, Akutan, Umnak, and Unalaska islands; they have been introduced but their status is uncertain on Long, Rabbit, Sanak, Cliff, and Finneys islands (Ebbert pers. comm., Ricca unpublished).

Ranking Summary		
	Potential Max	Score
Distribution	30	21
Biological Characteristics	30	19
Ecological Impact	30	21
Feasibility of Control	10	6
Total	100	67
Invasiveness (out of 100) = 67 Moderately invasive		

Distribution **Score**

Current global distribution ***10/10***

Modern horse ancestors were native to Eurasia, ranging from northern Mongolia and Turkestan westward to eastern Hungary and Poland (Long 2003). Horses have been introduced worldwide and feral populations exist on every continent except Antarctica, although they are on the nearby Kerguelen Archipelago (Lever 1985, Long 2003).

Extent of the species US range and/or occurrence of formal state or provincial listings ***7/10***

Feral horses are present in 17 US states and four Canadian territories (NatureServe 2015).

Role of anthropogenic and natural disturbance in establishment ***2/5***

Initial introductions are implemented by humans, but once a population becomes feral they thrive in undisturbed habitats.

Climatic similarity between site of origin and release ***2/5***

Native to parts of Eurasia with similar climate.

Total for distribution **21/30**

Biological Characteristics and Dispersal **Score**

Invasive elsewhere ***5/5***

Feral populations exist in many countries worldwide.

Dietary specialization ***5/5***

Horses prefer to eat grasses, but will also graze and browse on other graminoids, forbs, shrubs, roots, fruits, bark, and buds (Csurhes et al. 2009).

Habitat specialization ***5/5***

The horse prefers open grasslands, but will also use wetlands, riparia, scrublands, shrub lands, forests, subalpine areas, ridgetops, coastlands, deserts and semi-desert plains, disturbed and agricultural areas. They prefer to stay near watering holes but will travel 50 km away from a water source in search of food (Csurhes et al. 2009).

Average number of reproductive events per adult female per year ***0/5***

Feral horses average one offspring every two years, but may give birth once every one to three years. Twins are uncommon (Dobbie et al. 1993, Groves 1989, Kirkpatrick and Turner 1991).

Potential to be spread by human activities ***1/5***

Although horses have been spread worldwide by humans in the past, now that the negative impact of feral populations is understood, new introductions are uncommon.

Innate potential for long distance dispersal ***3/5***

Feral horses can travel 50 km in a day in search of food and water (Csurhes et al. 2009). Their home range has been reported as usually less than 25 sq km and up to 300 sq km (e.g. in Wyoming; NatureServe 2015), or 32-70 sq km (e.g. in Australia; Csurhes et al. 2009). Mixed groups that include mares and foals typically stay within 50 km of a water source, while groups of bachelor stallions will have a larger home range and travel farther from water (Csurhes et al. 2009). On islands where the horse has been introduced, large expanses of water likely act as a barrier to dispersal.

Total for biological characteristics	**19/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***7/10***

Introduced ungulates alter population dynamics of species native to Aleutian and Bering Sea islands owing to the lack of interspecific competition for forage resources and top-down control from native predators. They alter native vegetation by trampling, crushing, browsing, over-grazing, and cratering into soil (Aston 1911, GISD 2010). Soil disturbance and removal of native vegetation can potentially promote the establishment of nonnative plants, as horses can transport propagules in their manes, tails, and excrement (Csurhes et al. 2009, Ebbert and Byrd 2002).

The horse can harm bird populations by trampling surface and burrow nesting birds and altering soil properties that affect burrowing birds (Ebbert and Byrd 2002). One study found that the presence of feral horses drastically increased predation on bird eggs, likely due to increasing the visibility of nests (Zalba and Cozzani 2004). Additionally, feral horses can harbor disease that can potentially affect other species (Csurhes et al. 2009).

Impact on natural community composition ***7/10***

Impacts of feral horses on plant communities of Aleutian and Bering Sea islands are not well quantified. However, in other regions feral horses have been known to damage fens, bogs, and alpine fields, and cause an overall decrease in biodiveristy (Csurhes et al. 2009). In drier climates, one study in Nevada showed that springs with horse exclosures had much more grass and shrub richness, abundance, and percent cover, as well as more burrowing small mammal activity (Beever and Brussard 2000). Other studies have shown that after removal of horses there was an increase in ants and ant mounds (Csurhes et al 2009). In salt marshes horses have been observed reducing above ground biomass by 50% or more, causing a reduction in snail populations, and inhibiting the density and richness of fishes (Levin et al. 2002, Turner 1987). Elsewhere feral horses have been observed reducing the abundance of macropods and native rodents (Nimmo and Miller 2007). Additional studies have documented changes to the community composition of crabs and reptiles (Csurhes et al. 2009, Nimmo and Miller 2007).

Impact on natural ecosystem processes ***7/10***

Because horses use hindgut fermentation for digestion, their impacts on nutrient cycling may differ from ruminants (e.g., caribou, cattle) that digest plant fiber much more efficiently (Demment and Van Soest 1985)**.** However, like other ungulates, horses contribute to soil erosion, compaction, and track formation, accelerate the rate of dune erosion, and change dune morphology (Csurhes et al. 2009, De Stoppelaire et al. 2004, Ebbert and Byrd 2002). They can reduce water quality of springs, streams, and watering holes by trampling banks and contaminating the water with feces, and loss of littoral and aquatic flora leads to a loss of biological activity.

Total for ecological impact	**21/30**

Feasibility of control	**Score**

Number of populations in Alaska ***1/3***

In the Aleutians, the horse is present on Akun, Akutan, Umnak, and Unalaska Islands; they have been introduced but their status is uncertain on Long, Rabbit, Sanak, Cliff, and Finneys Islands (S. Ebbert pers. comm.).

Significance of the natural area(s) and native species threatened ***2/3***

Several AMNWR islands with introduced ungulates also support USFWS Region 7 priority species, and those taxa affected include the Tufted puffin, Fork-tailed storm petrels, Harlequin duck, Emperor geese, and Steller's eiders. Ground nesting land birds such as Rock ptarmigan and Lapland longspur are also affected (USFWS-AMNWR pers. comm.).

General management difficulty ***3/4***

Management of the feral horse is regulated by the Wild Horse and Burro Act of 1971. Management options include fertility control, in which dominant males can be sterilized, or contraceptives can be administered to females, which can limit reproduction rates. Either enclosure or exclosure fencing can be used to keep horses away from sensitive habitats. Horses can be caught in traps or mustered. After capture they can be put up for adoption or culled. Culling is used in other countries, and can be carried out on the ground or by helicopter; however, this is not the best option, as it is often met with public opposition (Csurhes et al. 2009, Ebbert and Byrd 2002, NatureServe 2015, Nimmo and Miller 2007).

Total for feasibility of control	**6/10**

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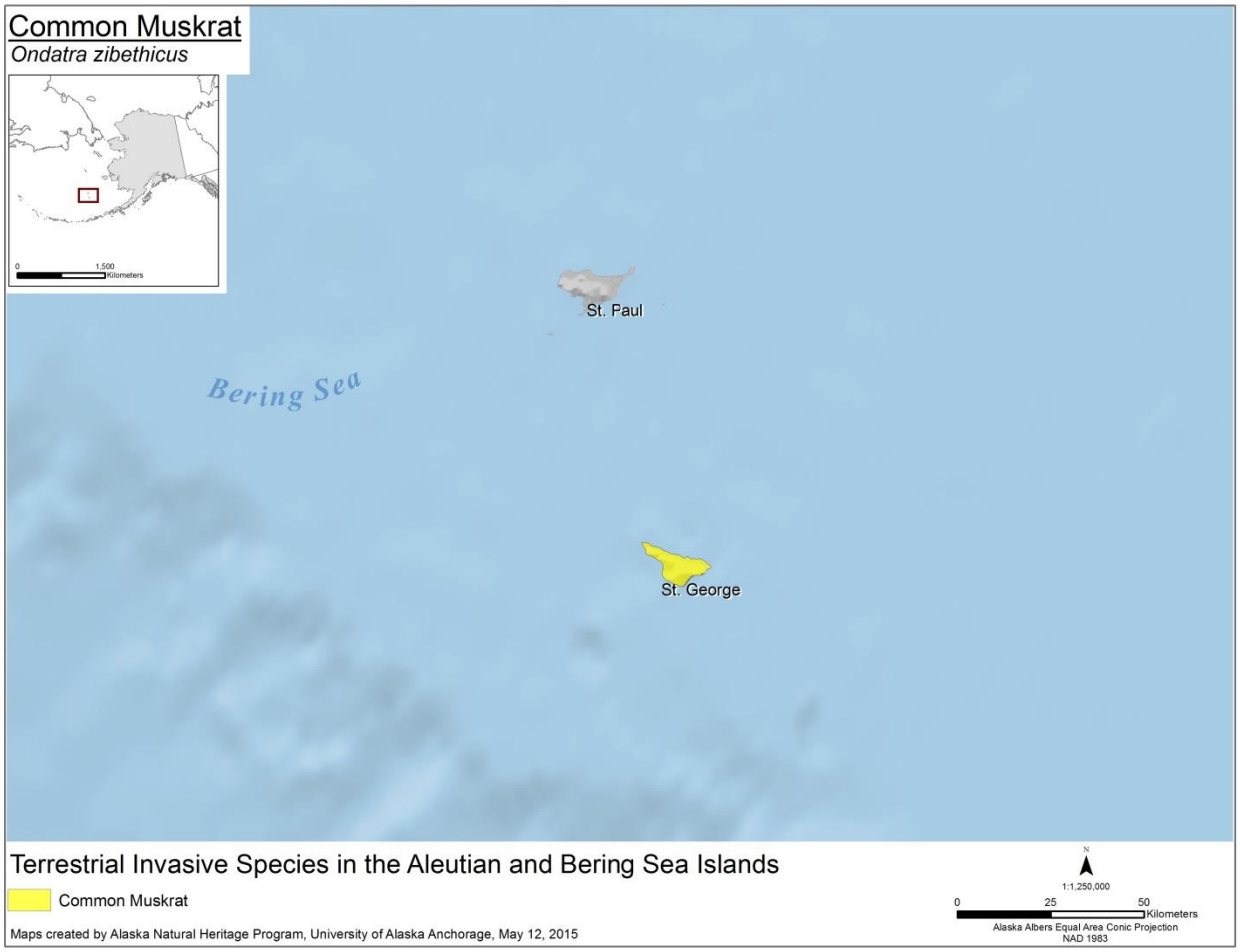
Acknowledgements

Authors: C. Greenstein, Alaska Center for Conservation Science

Reviewer(s): M. Ricca, United States Geological Survey

Scientific name: *Odontra zibethicus* Common name: Muskrat



Range Map – ABSI LCC Region (former distribution, no longer occurs)

Alaska invasion/introduction history

The muskrat (*Odontra zibethicus*) is native to most of the US and Canada, including the majority of Alaska. It was introduced to St. George Island in 1913 but died out its first winter (MacDonald and Cook 2009). It has been introduced in many countries around the world and its adaptability and high fecundity make it an extremely invasive pest elsewhere.

Ranking Summary		
	Potential Max	Score
Distribution	30	30
Biological Characteristics	30	13
Ecological Impact	30	21
Feasibility of Control	10	0
Total	100	64
Invasiveness (out of 100) = 64 Moderately invasive		

Distribution	**Score**

Current global distribution ***10/10***

The muskrat has been introduced and is now widespread throughout the Palearctic, additional portions of Asia, and also parts of North and South America (Musser and Carleton 2005, NatureServe 2015).

Extent of the species US range and/or occurrence of formal state or provincial listings ***10/10***

The muskrat is native to most of the US and Canada (Linzey 2008, NatureServe 2015). It is native in Alaska and occurs throughout most of the state, with the exception of the Arctic slope north of the Brooks Range, the Alaska Peninsula west of Ugashik Lakes, and some islands in Southeast (Earnest 2008).

Role of anthropogenic and natural disturbance in establishment ***5/5***

Once introduced in the Palearctic, the muskrat became widespread and abundant in natural habitats.

Climatic similarity between site of origin and release ***5/5***

Native to most of Alaska.

Total for distribution **30/30**

Biological Characteristics and Dispersal	**Score**

Invasive elsewhere ***5/5***

Invasive in many countries worldwide.

Dietary specialization ***5/5***

The muskrat primarily feeds on littoral zone aquatic vegetation, including cattails, cordgrass, bulrush, and horsetails, and sometimes also eats upland vegetation (NatureServe 2015). When vegetation is scarce it will feed on mollusks, crustaceans, turtles, mice, birds, frogs, and fish (Hanson et al. 1989, Willner et al. 1980).

Habitat specialization ***0/5***

The muskrat will primarily use brackish or freshwater marshes, swamps, ponds, lakes, slow moving water, forested and herbaceous wetlands, riparia, rivers, and creeks. It burrows into banks to build dens, or builds conical houses from vegetation in shallow water. They frequently occur with cattails

and are dependent on littoral vegetation for food and shelter building (Caire et al. 1989, NatureServe 2015).

Average number of reproductive events per adult female per year ***2/5***

The muskrat typically has two or three litters per year, with one to 12 offspring (average 5-7) per litter (Earnest 2008, NatureServe 2015, Snyder 1993).

Potential to be spread by human activities ***1/5***

Historically the muskrat was introduced to new locations for the fur industry. However, modern introductions are unlikely.

Innate potential for long distance dispersal ***0/5***

Home ranges are small, ranging from several meters to several hectares, depending on habitat suitability (Baker 1983, Marinelli and Messier 1993). The muskrat can potentially disperse longer distances, and has been known to return home when displaced 3-4 km (Erickson 1963). In Sweden they disperse an average 3.2 km per year (Willner et al. 1980).

Total for biological characteristics	**13/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***7/10***

At high population densities the muskrat destroys habitat and reduces aquatic vegetation, as they eat it and use it for building (Linzey 2008). Impacts are more pronounced where habitat is poor or there is less vegetation to begin with. Populations can rapidly increase when the muskrat is introduced to a new area, but will decline as vegetation is reduced and can no longer support the population size (Skyriene and Paulauskas 2012). Where native vegetation has been degraded by the muskrat, opportunities for invasive plant introductions may increase (Snyder 1993). This species can potentially transmit parasites to other animals. Elsewhere in the world muskrats feed on threatened freshwater mollusk species, including Anodonta, Unio, and Margaritifera (Skyriene and Paulauskas 2012).

Impact on natural community composition ***7/10***

The muskrat can change community composition by preferentially feeding on certain plants, altering species diversity and richness, and often causing an overall loss of biomass and increase in heterogeneity. They can create mudflats, and altered plant communities commonly interfere with successional processes (Skyriene and Paulauskas 2012).

Impact on natural ecosystem processes ***7/10***

At high population densities the muskrat destroys habitat, damages embankments with excessive burrowing, and causes erosion (Linzey 2008, Skyriene and Paulauskas 2012). Burrowing can influence water chemistry and physical properties, and both burrowing and vegetation loss contribute to modifications in nutrient cycling (Skyriene and Paulauskas 2012).

Total for ecological impact	**21/30**

Feasibility of control	Score
Number of populations in Alaska	***0/3***

The muskrat was intentionally introduced to St. George Island in 1913 but died out its first winter (MacDonald and Cook 2009).

Significance of the natural area(s) and native species threatened	***0/3***

The muskrat is not currently known to exist on any Aleutian or Bering Sea Islands.

General management difficulty	***0/4***

There are no records of the muskrat being introduced and persisting on any Aleutian or Bering Sea Islands. Where muskrats are an introduced nuisance species, control methods include trapping, hunting, or poisoning (Linzey 2008).

Total for feasibility of control	**0/10**

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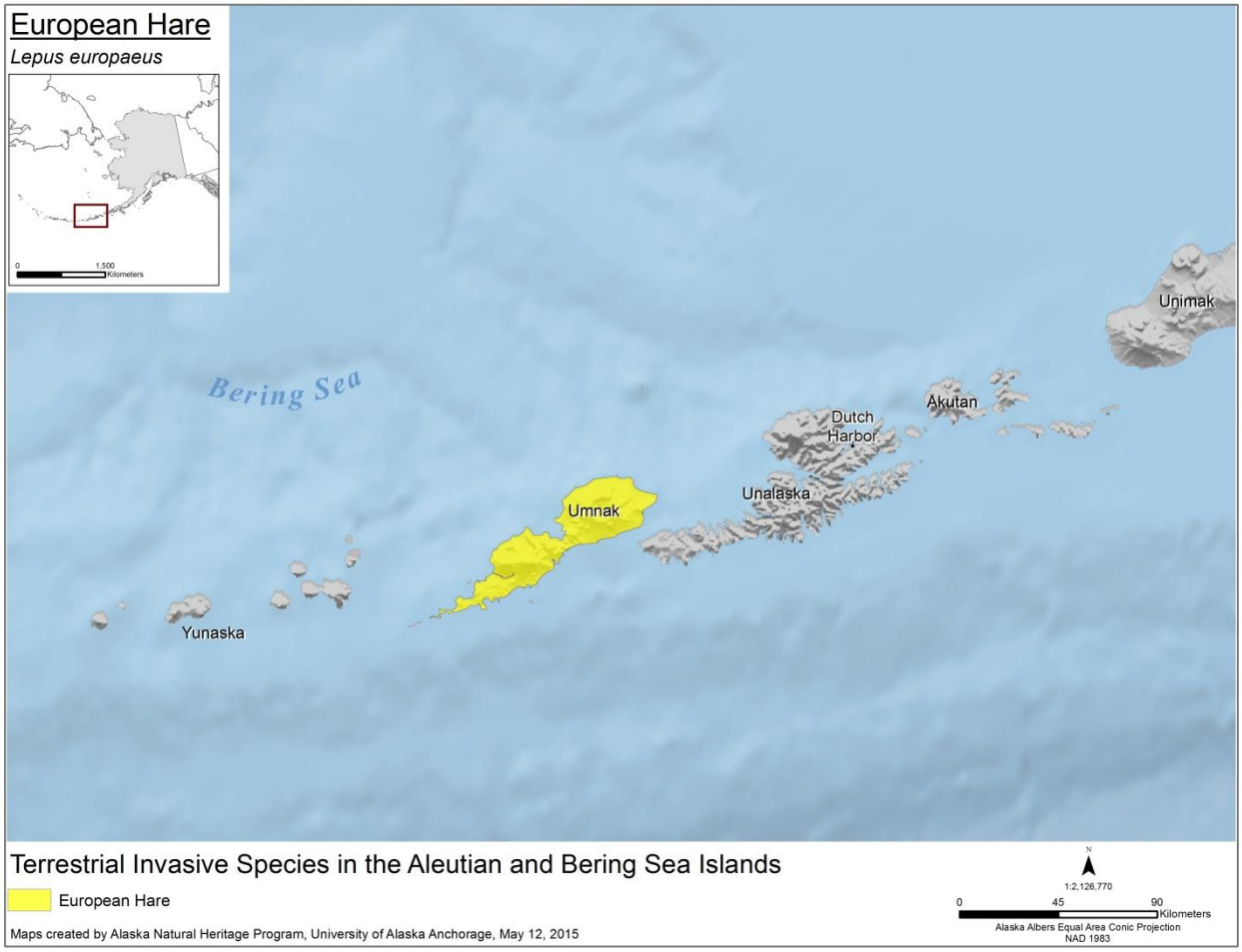
Acknowledgements

Authors: C. Greenstein, Alaska Center for Conservation Science

Scientific name: *Lepus europaeus* Common name: European hare



Range Map

Alaska invasion/introduction history

The European hare has been introduced as a game species worldwide (Smith & Johnston 2008). In Alaska, Hog and Umnak Islands previously had intentional introductions of the European hare, but their current status is unknown (Bailey 1993). This species was released on ten or more Alaska Maritime National Wildlife Refuge islands and may still be present on a few (Ebbert and Byrd 2002).

Ranking Summary		
	Potential Max	Score
Distribution	30	17
Biological Characteristics	25	17
Ecological Impact	10	7
Feasibility of Control	3	1
Total	68	42
Invasiveness (out of 100) = 62 Modestly invasive		

Distribution **Score**

Current global distribution ***10/10***

The European hare is native to most of Europe and parts of Asia and has been introduced throughout the world to many countries and islands, including North and South America, Australia, and parts of Europe (GISD 2010, NatureServe 2015, Smith and Johnston 2008).

Extent of the species US range and/or occurrence of formal state or provincial listings ***3/10***

Introduced in Alaska, Connecticut, Massachusetts, Michigan, New Jersey, New York, and Ontario (NatureServe 2015).

Role of anthropogenic and natural disturbance in establishment ***2/5***

Intentionally introduced around the world as a game species, but once introduced can persist in both natural and anthropogenic environments (Smith and Johnston 2008).

Climatic similarity between site of origin and release ***2/5***

Native to regions of Eurasia with a climate similar to parts of Alaska.

Total for distribution **17/30**

Biological Characteristics and Dispersal **Score**

Invasive elsewhere ***5/5***

Invasive in many countries worldwide.

Dietary specialization ***5/5***

The European hare eats fruits and grasses in the summer, and feeds on bark, buds, and seedlings in the winter (NatureServe 2015). It will also eat agricultural crops, where available (Smith and Johnston 2008).

Habitat specialization ***5/5***

The European hare uses a wide range of habitats, including shrub land, scrubland, grassland, agricultural and disturbed areas (GISD 2010), at elevations of 0-2300 meters (Spitzenberger 2002). This hare does not use burrows or nests (NatureServe 2015).

Average number of reproductive events per adult female per year ***2/5***

Averages three litters per year, although they may range from one to four litters. The European hare gives birth to one to three young at a time (GISD 2010, NatureServe 2015).

Potential to be spread by human activities ***u/5***

Unknown.

Innate potential for long distance dispersal ***0/5***

Home range can average from five ha (in Canada; Banfield 1974) to 149 ha (in Australia; Stott 2003).

Total for biological characteristics	**17/25**

Ecological Impact	**Score**

Impact on population dynamics of other species ***7/10***

Hares and rabbits can both destroy habitat and cause defoliation and erosion (McChesney and Tershy 1998). The European hare can hybridize with native hares, which can have negative impacts on native species' survival and genetic integrity (GISD 2010).

Impact on natural community composition ***u/10***

Unknown.

Impact on natural ecosystem processes ***u/10***

Unknown.

Total for ecological impact	**7/10**

Feasibility of control	**Score**

Number of populations in Alaska ***1/3***

Hog and Umnak Islands previously had intentional introductions of the European hare, but their current status is unknown (Bailey 1993). This species was released on ten or more Alaska Maritime National Wildlife Refuge islands and may still be present on a few. Impacts on refuge lands are unknown or minor (Ebbert and Byrd 2002).

Significance of the natural area(s) and native species threatened ***u/3***

Unknown.

General management difficulty ***u/4***

Unknown.

Total for feasibility of control	**1/3**

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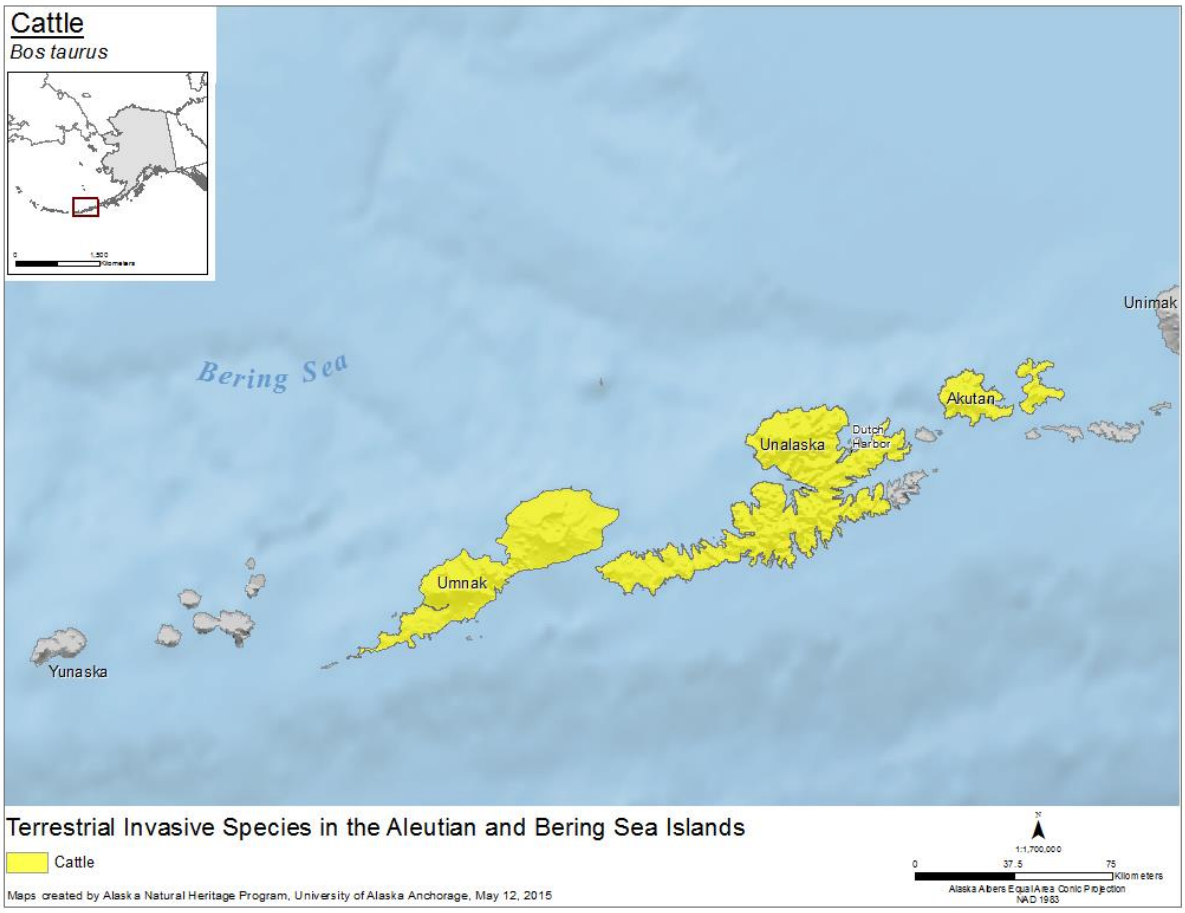
Acknowledgements

Authors: C. Greenstein, Alaska Center for Conservation Science

Scientific name: *Bos taurus* Common name: Cattle



Range Map

Alaska invasion/introduction history

Cattle were first introduced to Alaska from Siberia in the 1780s-1790s to build an agricultural base and meet the demand for dairy and meat products in Russian posts across the state (Bancroft 1886, Elliott 1887). Cattle ranching on Alaskan islands began after WWII (Ebbert and Byrd 2002), and often ranching and herding efforts failed and cattle were left to become feral (Renner et al. 2014). Historically, cattle have been introduced on eight or more islands on Alaska Maritime National Wildlife Refuge (AMNWR) lands, and as of 2002 they remain on Akun, Akutan, Chirikof, Long, Umnak, Unalaska, and Wosnesenski (Renner et al. 2014). An additional population of cattle was established on Chirikof Island, which is not an Aleutian island but is part of AMNWR.

Ranking Summary		
	Potential Max	Score
Distribution	30	20
Biological Characteristics	30	14
Ecological Impact	30	21
Feasibility of Control	10	6
Total	100	61
Invasiveness (out of 100) = 61 Moderately invasive		

Distribution **Score**

Current global distribution ***10/10***

Cattle are domesticated worldwide and feral in parts of Spain, France, Australia, New Guinea, US, Columbia, Argentina, Galapagos, Hispaniola, Tristan da Cunha, New Amsterdam, and the Juan Fernandez Islands (Wilson and Reeder 1993).

Extent of the species US range and/or occurrence of formal state or provincial listings ***0/10***

Domestic cattle are present throughout the US and Canada, but feral populations only exist in Alaska and Hawaii, and were once present in California (GISD 2007).

Role of anthropogenic and natural disturbance in establishment ***5/5***

Although cattle need human intervention to be introduced to an area, once established they thrive in undisturbed habitats.

Climatic similarity between site of origin and release ***5/5***

Cattle are descended from Eurasian-North African aurochs, which went extinct due to over-hunting in the 1600s (NatureServe 2015, Parkes 2005). Cattle were domesticated between 5000-6000 BC in the Middle East, and also in Denmark, Germany, and Switzerland, and then spread throughout Europe and Africa (Parkes 2005).

Total for distribution **20/30**

Biological Characteristics and Dispersal **Score**

Invasive elsewhere ***5/5***

Cattle have become feral in several other places worldwide Courchamp et al. 2003).

Dietary specialization ***5/5***

Herbivores; will eat grasses, forbs, shrubs, and saplings. Feral cattle will sometimes walk over and straddle saplings over six meters tall to make the leaves at the top accessible for eating (GISD 2007).

Habitat specialization ***2/5***

Uses hardwood forests and woodlands, scrublands, shrub lands, grasslands, agricultural areas, and urban areas across a wide range of latitudes (GISD 2007, NatureServe 2015).

Average number of reproductive events per adult female per year ***0/5***

One reproductive event per year, giving birth to one calf (GISD 2007).

Potential to be spread by human activities ***1/5***

Although cattle were originally introduced to Alaskan islands by people, introductions are now uncommon.

Innate potential for long distance dispersal ***1/5***

Unless cattle are confined they will wander, forming feral herds, and can roam quite far (GISD 2007). On islands where cattle have been introduced, large expanses of ocean likely act as a barrier to dispersal.

Total for biological characteristics	**14/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***7/10***

Introduced ungulates alter native vegetation by trampling, crushing, browsing, and over-grazing (Aston 1911, Wodzicki 1950). Cattle may harm bird populations by trampling surface and burrow nesting birds and altering soil properties that affect burrowing birds (Ebbert and Byrd 2002).

Outside of Alaska feral cattle impact additional sensitive species. In Hawaii, cattle have had devastating effects on the vulnerable *Acacia koaia* tree (Baldwin and Fagerlund 1943). Cattle have contributed to the critically endangered status of the Amsterdam albatross (*Diomedea amsterdamensis*) by degrading their breeding sites (BirdLife International 2007). They affect raptors in the Southwest US (see Kochert et al. 1988), and in California feral cattle impact mule deer (see Loft et al. 1987 and Kie 1991). They also affect other species in the Cerividae family in Alberta, Canada (see Telfer 1994).

Impact on natural community composition ***7/10***

Recent range surveys found cattle on islands in the eastern Aleutians and Shumagin Islands. These surveys revealed damage to multiple areas, including coastal erosion in beach wild-rye (*Elymus mollis*) communities and rutting pits in lowland crowberry (*Empetrum*) communities. Non-native graminoids and forbs have become established on several cattle-occupied islands, and were likely introduced during previous ranching activities (Sonnen 2014, Bella 2014). Cattle can cause vegetation to transition to communities dominated by lupine and less palatable graminoids (Dinkel 2014). Though not explicitly studied on Aleutian and Bering Seas islands, larger animals, such as cattle, can subsist on lower quality forage owing to lower mass-specific metabolic rates but need to consume it in greater quantities (Demment and Van Soest 1985). Consequently, cattle may have greater per-capita impacts on plant communities and ecosystem function in comparison to smaller ungulates such as sheep, reindeer, and caribou.

In regions outside of Alaska, feral cattle can decimate ground vegetation in forested habitats, including shrubs, young trees, and ferns, leaving only a few unpalatable species behind. In subalpine areas cattle browse and trample low-canopy vegetation. This species can inhibit regeneration of a variety of forbs and *Poa* tussocks (Parkes 2005). Both cattle ranching and feral grazing can increase the spread of non-native plants and aids in their establishment (Daniels et al. 1998).

Impact on natural ecosystem processes ***7/10***

Large non-native herbivores, such as cattle, can transition native ecosystems to alternative states (Suding et al. 2004). The most visible effects of feral cattle include soil compaction, coastal erosion, dune formation, and eroded trails that cause gulley formation. (Ebbert and Byrd 2002, Bella 2014, Sonnen 2014). Effects of cattle on nitrogen cycling on these islands are not well quantified.

Total for ecological impact	**21/30**

Feasibility of control	**Score**

Number of populations in Alaska ***1/3***

Historically, cattle have been introduced on eight or more islands on AMNWR lands, and as of 2002 they remain on Akun, Akutan, Unalaska, and Umnak, which are under mixed ownership; and on Chirikof, Wosnesenski, and Long islands which are exclusively owned by AMNWR (Renner et al. 2014). In some cases, cattle co-occur with introduced horses and sheep (Ebbert and Byrd 2002). As of 2014, approximately 2024 cattle occupy Chirikof and 129 occupy Wosnesenski (USFWS 2015)

A population of cattle was established on Chirikof Island, which is part of AMNWR but not an Aleutian Island, in the late 1800s to early 1900s. The first introductions were from Russian stock, and then a variety of domestic breeds were added over the decades, including European taurine cattle (ca. 1920), Hereford (ca. 1975), Shorthorn, Highland, and Angus (Decker et al. 2015; d'Oro 2003, 2005; Fields 2000; Long 1975; MacNeil et al. 2007). This unique assemblage of domesticated cattle intermixing has resulted in the Chirikof cattle being a distinct breed, genetically different from other commercial cattle, and potentially important for conservation and for the beef industry (Decker et al. 2015, MacNeil et al. 2007). Chirikof begame part of AMNWR in 1980, at which point the US Fish and Wildlife Service (USFWS) began removing introduced species from the island. However, at this time the emphasis was on foxes, and in some cases cattle from other islands, but not Chirikof, where grazing leases were active through the 1900s. The last grazing lease expired in 2000 yet cattle remain on the island. In 2013 USFWS initiated another effort to remove cattle in order to improve bird habitat (Decker et al. 2015).

Significance of the natural area(s) and native species threatened ***2/3***

Several AMNWR islands with introduced ungulates also support USFWS Region 7 priority species, and those taxa affected include the Tufted puffin, Fork-tailed storm petrel, Harlequin duck, Emperor geese, and Steller's eiders (USFWS-AMNWR, pers. comm.).

General management difficulty ***3/4***

Exclosure fencing can be used to keep cattle out of sensitive habitats. Shooting and dogs have been used to control feral cattle. A control effort in 1985 on Simeonof Island involved capturing as many individuals alive as possible, while the rest were shot; however, shooting received negative publicity and is generally met with public opposition (GISD 2007). The Alaska Maritime National Wildlife Refuge is drafting an Environmental Impact Statement for management options of cattle on Chirikof and Wosnesenski Islands (USFWS 2015).

Total for feasibility of control	**6/10**

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Acknowledgements

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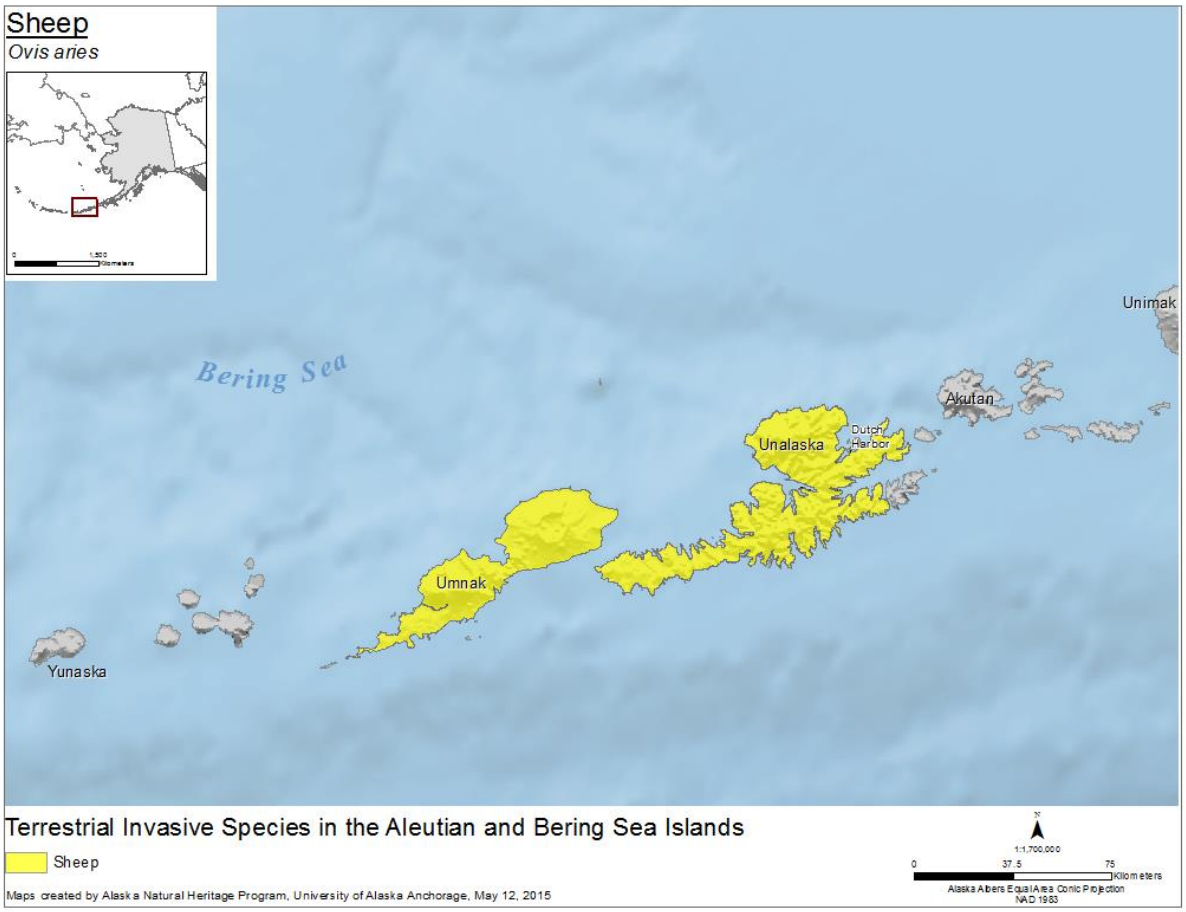
Reviewer(s): M. Ricca, United States Geological Survey

Scientific name: *Ovis aries* Common name: Sheep



Range Map

Alaska invasion/introduction history

Sheep were domesticated about 10,000 years ago from Eurasia and have since spread worldwide. There are present on Umnak and Unalaska Islands in Alaska (MacDonald and Cook 2009).

Ranking Summary		
	Potential Max	Score
Distribution	30	14
Biological Characteristics	25	16
Ecological Impact	30	21
Feasibility of Control	10	6
Total	95	57
Invasiveness (out of 100) = 60 Moderately invasive		

Distribution	Score
Current global distribution	***10/10***

The sheep was likely domesticated ca. 9000-11000 years ago, from mouflon sheep (*Ovis musimon*) from western and central Eurasia (Grzimek 1990; NatureServe 2015), although there is controversy around the origins of the modern domestic sheep. It has been introduced in Europe, Sweden, Norway, Crimea, Chile, USA, Canary and Kerguelen Islands, and islands off the coast of New Zealand and British Isles (Wilson and Reeder 1993).

Extent of the species US range and/or occurrence of formal state or provincial listings ***0/10***

Well established populations are found on multiple Hawaiian islands (Tomich 1986), islands off the coast of California (e.g. Santa Cruz Island; NatureServe 2015, DIISE 2015), and Umnak and Unalaska Islands in Alaska (MacDonald and Cook 2009).

Role of anthropogenic and natural disturbance in establishment ***2/5***

Initial introductions are implemented by humans, but once a population becomes feral they thrive in undisturbed habitats.

Climatic similarity between site of origin and release ***2/5***

Native to Eurasia, in places with similar climates (GISD 2010).

Total for distribution	**14/30**

Biological Characteristics and Dispersal	Score
Invasive elsewhere	***5/5***

Feral populations exist worldwide.

Dietary specialization ***5/5***

Sheep are forage generalist and will eat grasses, forbs, and shrubs (Van Vuren and Coblentz 1987). They have very little nutritional requirements and can digest extremely fibrous foods that other animals find inedible (Ensminger 1965, Hecker 1983, Reavill 2000).

Habitat specialization ***5/5***

Sheep are highly versatile, and worldwide they utilize a variety of habitats including deserts, grasslands, herbaceous meadows, scrublands, shrub lands, woodlands, forests, savannas, cliffs, talus slopes, alpine, disturbed and agricultural areas (GISD 2010, Grzimek 1990, MacDonald 1984).

Average number of reproductive events per adult female per year ***0/5***

Sheep reproduce once a year and give birth to one or two offspring (Ensminger 1965).

Potential to be spread by human activities ***1/5***

Although the sheep has been spread worldwide by humans in the past, now that the negative impact of feral populations is understood, new introductions are uncommon.

Innate potential for long distance dispersal ***u/5***

Unknown.

Total for biological characteristics	**16/25**

Ecological Impact	Score
Impact on population dynamics of other species	***7/10***

Introduced ungulates have great potential to cause damage on Aleutian and Bering Sea islands because there are no native species to provide intra-guild competition, no native predators to provide top-down control, and vegetation has evolved without large herbivores, therefore they have no natural defenses against them (Oksanen and Oksanen 2000, Ricca et al. 2012).

Introduced ungulates alter native vegetation by trampling, crushing, browsing, and over-grazing (Aston 1911, GISD 2010). Browsing on bark reduces tree and shrub health (Schott 2002). Soil disturbance and removal of native vegetation can potentially promote the establishment of nonnative plants (Ebbert and Byrd 2002).

Impact on natural community composition ***7/10***

Grazing and browsing causes changes in flora community composition, litter reduction, decreased seedling recruitment, and decreased plant species diversity (Van Vuren and Coblentz 1987). Changes to vegetation contribute to reduced diversity and numbers of birds, and trampling changes soil properties which can impact surface and burrow nesting birds (Ebbert and Byrd 2002, GISD 2010, Klinger et al. 2002). Studies have shown that sheep removal can result in increases in abundance and distribution of native flora and fauna (e.g. Skipper et al. 2013, Klinger et al. 2002).

Impact on natural ecosystem processes ***7/10***

Where large herbivores such as sheep have no natural predators, they can have extensive impacts on ecosystem (Oksanen and Oksanen 2000) and can cause disruptions to feedback loops that are responsible for maintaining intact native ecosystems and resiliency (Scheffer et al. 2001, Suding et al. 2004). For example, introduced herbivores change plant community structure, which in turn changes soil microbial communities, which affects nutrient cycling and overall island fertility, consequently creating positive feedback that perpetuates further changes (Renner et al. 2014). Specifically, sheep cause increased bare ground, erosion, and soil compaction, and also alter hydrologic regimes (Ebbert and Byrd 2002, Klinger et al. 2002).

Total for ecological impact	**21/30**

Feasibility of control	Score
Number of populations in Alaska	***1/3***

The population size on Unalaska is unknown but assumed to be less than 300. On Umnak Island there are only about six individuals (S. Ebbert pers. comm.).

Significance of the natural area(s) and native species threatened ***2/3***

Unalaska hosts the critically endangered Kittlitz's Murrelet and the endangered Marbled murrelet.

General management difficulty ***3/4***

Management techniques include fencing, sterilization, hunting, trapping, and culling, which can be carried out with or without the use of a Judas sheep. However, trapping and shooting is not always successful (e.g. Santa Cruz Island, California, in the 1900s, see Van Vuren 1981), and culling is often met with public opposition (Ebbert and Byrd 2002, GISD 2010).

Total for feasibility of control	**6/10**

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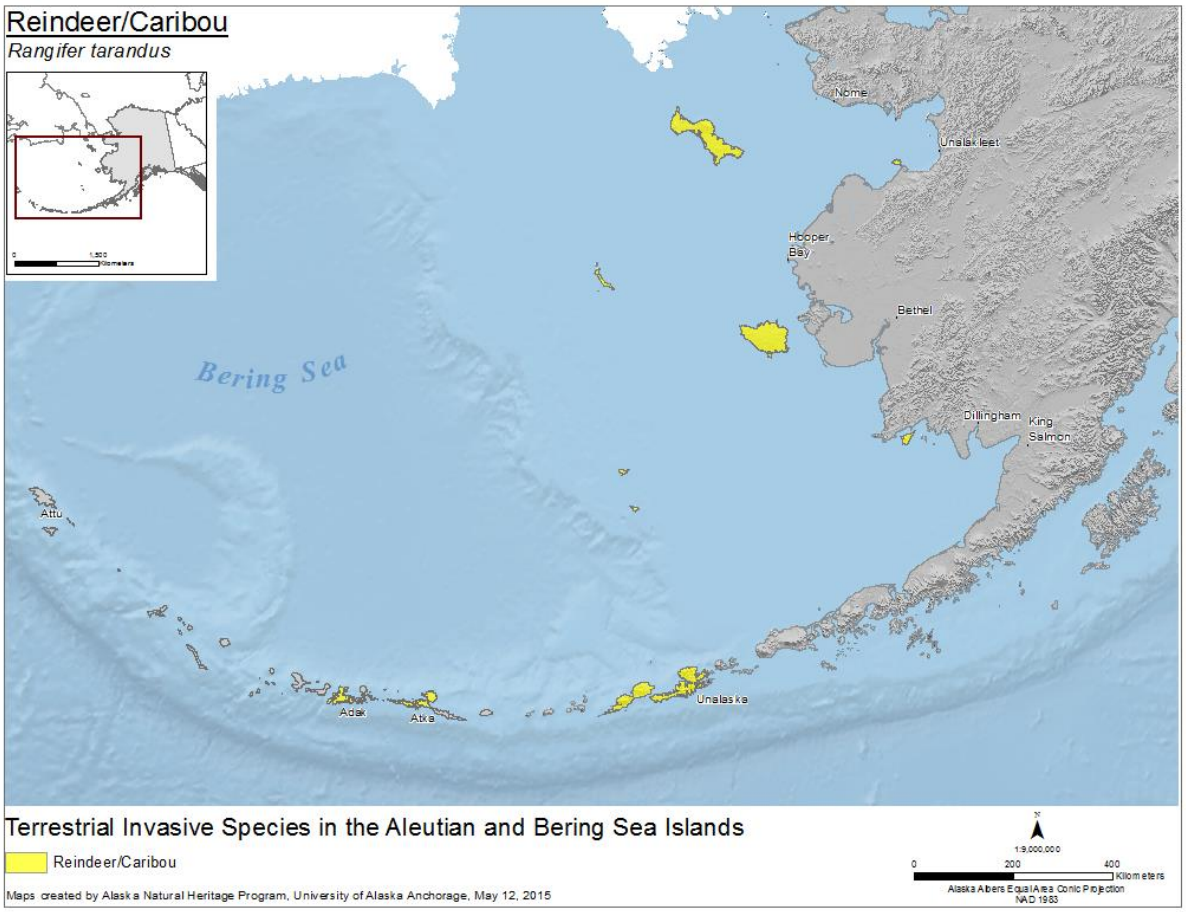
Scientific name: *Rangifer tarandus* Common name: Reindeer, Caribou



Range Map

Alaska invasion/introduction history

Reindeer were first introduced to Alaska from Siberia in 1891, and introductions continued throughout the early and mid-twentieth century. These introductions were catalyzed by U.S. Department of Education with the intention of providing native Alaskans an opportunity to develop an economy based around reindeer herding that would spur economic development of the region and provide an alternative food source for native populations (Ebbert and Byrd 2002, Jackson 1895, Swanson and Barker 1992). While caribou (*Rangifer tarandus arcticus*) are native to mainland Alaska, reindeer (*Rangifer tarandus asiaticus*) are native to Eurasia; both taxa have been introduced to many Bering Sea and Aleutian Islands (Ebbert and Byrd 2002, GISD 2010).

Historically reindeer or caribou were introduced on at least 12 Aleutian and Bering Sea islands: St. Matthew, Adak, Atka, Hagemeister, Kagalaska, Nunivak, St. George, St. Lawrence, St. Paul, Stuart, Umnak, and Unalaska. However, there have been instances in which introduced reindeer and caribou have starved or succumbed to harsh winters and their populations disappeared, as was the case on the Bering Sea Islands of St. Matthew (Klein 1968), St. Paul, and St. George (Scheffer 1951) in the mid 20th century.

Ranking Summary		
	Potential Max	Score
Distribution	30	17
Biological Characteristics	30	13
Ecological Impact	30	21
Feasibility of Control	10	8
Total	100	59
Invasiveness (out of 100) = 59 Modestly invasive		

Distribution **Score**

Current global distribution ***10/10***

Reindeer and caribou are found in circumboreal taiga and tundra habitats (NatureServe 2015). They are native to several northern countries, including northern Asia, Europe, Siberia, Alaska, Canada, and Greenland (Nowak 1999). They have been introduced to at least 31 islands worldwide (Leader-Williams 1988), including Iceland, the sub Antarctic islands of Kerguelen and South George, and other islands in the South Indian Ocean, North and South Atlantic, and North Pacific-Bering Sea (Leader-Williams 1988, Lesel 1967, Swanson and Barker 1992, Tyler 2010, Wilson and Reeder 2005).

Extent of the species US range and/or occurrence of formal state or provincial listings ***0/10***

There are native populations of caribou in Alaska, Canada, Washington, and northern Idaho (NatureServe 2015). In Alaska, caribou are native to the mainland and eastern-most Aleutian islands (Unimak; Ebbert and Byrd 2002). Reindeer are not native to North America. Both caribou and reindeer have been introduced on Aleutian and Bering Sea islands (GISD 2010).

Role of anthropogenic and natural disturbance in establishment ***2/5***

Both caribou and reindeer initially require translocation by humans to reach isolated islands, but once established, they can thrive in natural habitats. However, some introduced island populations have crashed to extinction following extreme population irruptions and harsh winters (Klein 1968).

Climatic similarity between site of origin and release ***5/5***

Reindeer and caribou are native to circumboreal taiga and tundra habitats (NatureServe 2015).

Total for distribution **17/30**

Biological Characteristics and Dispersal **Score**

Invasive elsewhere ***5/5***

Introduced to at least 3 islands worldwide and in Iceland (Leader-Williams 1988, Lesel 1967, Swanson and Barker 1992, Tyler 2010, Wilson and Reeder 2005).

Dietary specialization ***2/5***

Reindeer and caribou primarily feed on lichens, mosses, graminoids, forbs, ferns, and mushrooms; they will also eat bark, buds, leaves and shoots of deciduous trees and shrubs, particularly willow and

birch species (Hentonen and Tikhonov 2008, NatureServe 2015). Though overall diet breadth is broad, reindeer and caribou diets track phenological changes in forage quality across seasons, and many mainland populations rely heavily on fruticose lichens for winter forage (Klein 1990, Leader-Williams 1988).

Habitat specialization ***2/5***

Caribou and reindeer utilize tundra, boreal forests, open woodlands, alpine areas, rocky ridges, and high slopes up to 3000 m elevation; they also occasionally use bogs, fens, and riparia (GISD 2010, Henttonen and Tikhonov 2008, NatureServe 2015). In winter they have been observed alternating between lakes at low elevations and upland lichen sites, and also use west and south facing slopes of foothills where snow is relatively shallow due to wind and sublimation. In summer, reindeer prefer tidal flats, spits, beaches, thaw lakes, and river gravel due to the assemblage of plants these sites support. They may also graze in upland areas and spend time near snow fields in hot weather. Calving grounds are typically mid-upland and foothill zones (Swanson and Barker 1992).

Average number of reproductive events per adult female per year ***0/5***

One reproductive event per year, with one or two young born (GISD 2010). They may not reproduce every year if food is scarce (NatureServe 2015).

Potential to be spread by human activities ***1/5***

Transport by humans is the primary means of dispersal to islands; however, since the negative impact of introduced ungulates on islands has been observed, this action has ceased in Alaska.

Innate potential for long distance dispersal ***3/5***

On mainland, or where sea ice connects mainland to islands, caribou and reindeer can migrate long distances. Some herds migrate 1300 km between winter and summer ranges; in other cases, herds make elevational migrations (NatureServe 2015). They have been known to travel 5000 km a year (Fancy et al. 1989, Henttonen and Tikhonov 2008). Caribou are excellent swimmers that can traverse ice-free straits in the arctic (Miller 1995) and turbulent narrow straits between islands in the Aleutians (Ricca et al. 2012). In particular, caribou may swim up to three kilometers to reach accessible entry and exit points between Adak and Kagalaska (Ricca et al. 2012).

Total for biological characteristics	**13/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***7/10***

Introduced reindeer and caribou have great potential to alter population dynamics of species native to Aleutian and Bering Sea islands due to the lack of interspecific competition for forage resources and top-down control from native predators (Ebbert and Byrd 2002, Ricca 2013), yet numerical effects on native populations are sparsely quantified. Most visible impacts include alteration of native vegetation by trampling, crushing, browsing, over-grazing, and cratering into soil (Aston 1911, GISD 2010). Soil disturbance and removal of native vegetation could promote the establishment of nonnative plants. Additionally, ungulates harm bird populations by trampling surface and burrow nesting birds and altering soil properties that affect burrowing birds (Ebbert and Byrd 2002).

Impact on natural community composition ***7/10***

Most populations of reindeer and caribou introduced to islands undergo four stages of irruptive dynamics, characterized by: 1) an initial irruption that exceeds carrying capacity and is fueled by ample forage; 2) a brief slowdown as density-dependence begins to compensate; 3) a subsequent decline (that can be precipitous and lead to extinction); and 4) re-equilibration to a lower carrying capacity (Caughley 1970, Ricca et al. 2014). These dynamics can have strong direct and indirect impacts on native plant community composition. In particular, slow growing fruiticose lichens (e.g. *Cladonia rangiferina*) are easily over-grazed at high herbivore densities. Once depleted, these lichen communities can take 20-40 years to fully recover (Klein 1968), and can be outcompeted by fast growing vascular flora, of both native and introduced species (Swanson and Barker 1992). Over time, plant communities may shift away from those naturally characterized by lichens, mosses, and dwarf-shrubs to herbivory tolerant graminoid communities. Trampling and compaction of the moss and dwarf-shrub mat combined with nitrogen input from feces and urine helps creates conditions more favorable to graminoids. Biomass of highly palatable but less herbivory-tolerant forbs and deciduous dwarf shrubs (*Salix, Vaccinium*) also becomes reduced as grazing intensity and duration increase (Bråthen et al. 2010, Klein 1987, Leader-Williams 1988, Oloffson et al. 2004, Ricca et al. in press, van der Wal 2006). This shift to a graminoid dominated community that is resilient to repeat grazing has been proposed as the likely mechanism that allows caribou and reindeer to persist on islands over winter after lichens have been depleted (Klein 1968, Klein 1987, Leader-Williams 1988, Ricca et al. in press). In addition, soil cratering uproots and dislodges plants, and in combination with trampling and overgrazing, can cause erosion, degraded vegetation communities, and in extreme cases causes desert-like conditions (Ebbert and Byrd 2002, Swanson and Barker 1992).

Impact on natural ecosystem processes ***7/10***

The aforementioned irruptive population dynamics and related changes to plant community structure can have cascading effects on ecosystem function, and may ultimately drive a shift towards an alternative ecosystem state (Suding et al. 2004). For example, a positive feedback for herbivore induced ecosystem changes may be created by grazing that changes plant community structure, which then alters decomposition processes and nutrient cycling (Oloffson et al. 2004, van der Wal 2006). Changes to a graminoid dominated community can promote greater nitrogen cycling (van der Wal 2006), but Ricca et al. (in press) found that grazed island in the Aleutians had lower rates of N-mineralization and smaller nitrogen pools. More recent studies illustrate how grazing by caribou and reindeer can also alter complex soil microbial and fungal communities that strongly influence nutrient cycling (Bråthen et al. 2015, Stark et al. 2015), but these processes have not been studied well in the Aleutians. Soil erosion caused by overgrazing likely leads to nutrient loss and altered hydrology.

Total for ecological impact	**21/30**

Feasibility of control	**Score**

Number of populations in Alaska ***2/3***

Historically, reindeer or caribou were introduced on at least 12 Aleutian and Bering Sea islands. However, there have been instances in which introduced reindeer and caribou have starved or succumbed to harsh winters and their populations disappeared, as was the case on the Bering Sea Islands of St. Matthew (Klein 1968), St. Paul, and St. George (Scheffer 1951) in the mid 20th century.

Significance of the natural area(s) and native species threatened ***3/3***

Reindeer or caribou co-occur with listed species on a number of islands. Adak and Atka host ground nesting seabird species of concern such as the Kittlitz's Murrelet and Marbled Murrelet; Kagalaska also hosts the latter. Ground nesting upland birds such as rock ptarmigan and Lapland longspur may also be affected (USFWS-AMNWR pers. comm.). Bering Sea Islands of St. George and St. Paul support the vulnerable Red-legged kittiwake, and St. Paul also has the endangered Pribilof Island shrew (TIB 2015). All of these islands also support additional introduced species that can have compounding effects on listed species (e.g. arctic fox, Norway rat, house mouse, and feral domestic dogs and cats; TIB 2015). Additionally, several AMNWR islands with introduced ungulates also support USFWS Region 7 priority species, and those taxa affected include the Tufted puffin, Fork-tailed storm petrels, Harlequin duck, Emperor geese, and Steller's eiders (USFWS-AMNWR pers. comm.). The only known populations of federally endangered Aleutian shield fern occur on Adak Island, and suitable habitat exists on other ungulate occupied islands (Duarte et al. 2012).

General management difficulty ***3/4***

Boom and bust cycles are typical of caribou and reindeer on islands where they are introduced. The result is that reindeer and caribou have a somewhat self-regulating population dynamic, and after an initial irruption and subsequent die-off, it is unlikely that the herd will regain its large size again. However, this trend does not always hold true. For example, caribou were introduced to Adak in the 1950s while there was an active military base there (Jones 1966); the population was kept in check by hunting, but after the military base closed in the mid-1990s the population exploded (Williams and Tutiakoff 2005). As of 2012 population growth has slowed due to a likely combination of increased hunting pressure, density dependent reductions in calf survival and recruitment, and winter conditions (Ricca et al. 2014). However, the irruption also had the negative consequence of the herd migrating to nearby Kagalaska Island which was previously free of introduced ungulates. Hence, Adak caribou have gone from being introduced to being invasive (Ricca et al. 2012).

Culling of reindeer and caribou can be met with public opposition, as was the case when this technique was used – in combination with live capture – to remove reindeer from Hagemeister Island (Swanson and LaPlant 1987). Management is more complicated on lands with mixed-ownership where stakeholders have different interests. For example, the State of Alaska or an Alaska Native Corporation may maintain reindeer for sport hunting, and meat and byproduct markets, and consider them a commodity, while USFWS or other land management agencies want to treat them as introduced species that should be eradicated, as is the case on Adak (Ebbert and Byrd 2002, Ricca et al. 2014). In these situations, maintaining adequate hunting pressure from sport and subsistence harvest can be an effective management strategy and may halt population irruptions. This can be challenging on remote islands with little or no human settlements, or where access is difficult (Ricca et al. 2012, 2014). Another option is herd size reduction coupled with grazing management systems (Swanson and Barker 1992).

Total for feasibility of control **8/10**

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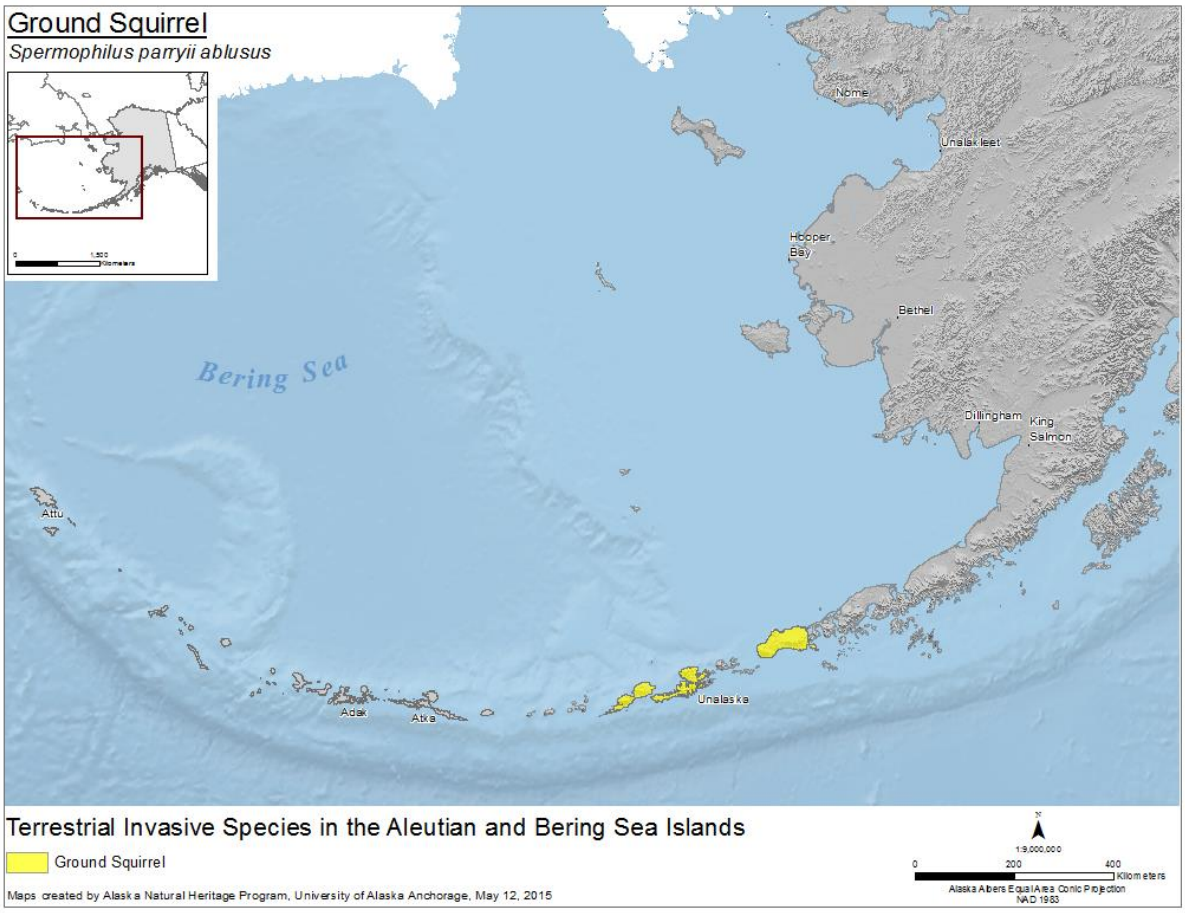
Reviewer(s): M. Ricca, United States Geological Survey

Scientific name: *Spermophilus parryii* Common name: Ground squirrel



Range Map

Alaska invasion/introduction history

The ground squirrel (*Spermophilus parryii*) is naturally occurring on the mainland and some Alaskan islands. However, they were introduced to additional islands by native Alaskans and early Russians who were using the squirrels for clothing and food. Some island introductions were also performed by ranchers who were using them as a food source for foxes after seabird populations began to decline (described in Ebbert and Byrd 2002). Introduced populations may still persist on Amaknak, Cherni, Kavalga, Umnak, and Unalaska Islands; a native population is present on Unimak Island (Bailey 1993, Cook et al. 2010, MacDonald and Cook 2009, Murie 1959).

Ranking Summary		
	Potential Max	Score
Distribution	30	10
Biological Characteristics	30	11
Ecological Impact	30	20
Feasibility of Control	10	6
Total	100	47
Invasiveness (out of 100) = 47 Weakly invasive		

Distribution	**Score**
Current global distribution	***0/10***

The ground squirrel is found throughout northern Canada, Alaska and Siberia (Linzey 2008).

Extent of the species US range and/or occurrence of formal state or provincial listings ***0/10***

In North America, the ground squirrel is native to Alaska, all Canadian territories (Yukon, Northwest Territories, Nunavut), and the northern portion of three provinces (British Columbia, Saskatchewan, and Manitoba; NatureServe 2015). It is introduced on some Aleutian Islands (Cook et al. 2010, Ebbert and Byrd 2002, Linzey 2008).

Role of anthropogenic and natural disturbance in establishment ***5/5***

The ground squirrel is well established in natural areas throughout its range.

Climatic similarity between site of origin and release ***5/5***

The ground squirrel is native to much of Alaska and also inhabits numerous Alaskan islands including Kodiak, St. Lawrence, and the Shumagin Islands (AKNHP 2015), which are climatically similar to the Aleutian Islands.

Total for distribution	**10/30**

Biological Characteristics and Dispersal	**Score**
Invasive elsewhere	***0/5***

Considered indigenous on mainland Alaska and in Canada and Siberia (Cook et al. 2010, Eddingsaas et al. 2004).

Dietary specialization ***5/5***

Generalist omnivore, typically feeding on graminoids, stems, leaves, seeds, fruits, woody plants, and mushrooms (AKNHP 2015). The ground squirrel will also prey on collared lemmings and young snowshoe hares (Boonstra et al. 1990, O'Donoghue and Stuart 1993), and it will scavenge a variety of animals when available (Hibbard et al. 1951). It is also known to feed on food scraps at human camps, which may act as an additional food source in resource-poor areas (Hibbard et al. 1951).

Habitat specialization ***5/5***

The ground squirrel is found in a variety of habitat types, including boreal forests, alpine, sandbanks, and tundra (AKNHP 2015, Hik et al. 2001), and are also known to use human structures (Mayer 1953). It typically prefers south facing slopes, which are warmer and drier than other slopes (Price 1971). They require soil that thaws deeply (>80 cm) by mid-summer to construct their burrows (Batzli and Sobaski 1980).

Average number of reproductive events per adult female per year ***0/5***

Females produce one litter per year of 5 to 10 young (Nagorsen 2005).

Potential to be spread by human activities ***1/5***

Historically, humans intentionally introduced the ground squirrel to islands as a prey source for foxes (Ebbert and Byrd 2002). In modern times humans are not directly transporting ground squirrels, and indirect dispersal mechanisms are unlikely.

Innate potential for long distance dispersal ***0/5***

Adult ground squirrels are typically philopatric, and dispersal distances of juvenile ground squirrels are small, averaging 100-500 meters, with high mortality associated with dispersal (Byrom and Krebs 1999).

Total for biological characteristics	**11/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***10/10***

The ground squirrel may prey on eggs and chicks of waterfowl and seabirds (Ebbert and Byrd 2002). Presently, birds such as Storm Petrels and other burrow nesters are not present on islands with ground squirrels, but are present on neighboring islands, suggesting that these species are unable to co-exist (Ebbert and Byrd 2002).

Impact on natural community composition ***7/10***

Foraging by the ground squirrel contributes to overgrazing, removal of vegetation, reduction in lichen cover, and changes to plant community composition (Ebbert and Byrd 2002, Mallory and Heffernan 1987, McKendrick et al. 1980, Price 1971).

Impact on natural ecosystem processes ***3/10***

Tunneling and burrowing, as well as foraging, change vegetation and soil properties, consequently affecting nutrient cycling, erosion, soil properties, and hydrology (Ebbert and Byrd 2002, Mallory and Hefernan 1987, McKendrick et al. 1980, Price 1971).

Total for ecological impact	**20/30**

Feasibility of control	**Score**

Number of populations in Alaska ***1/3***

The ground squirrel naturally occurs throughout mainland Alaska and on Unimak Island in the Aleutians. It is considered to be invasive on five Aleutian Islands: Amaknak, Cherni, Kavalga, Umnak and Unalaska (Cook et al. 2010).

Significance of the natural area(s) and native species threatened ***3/3***

The ground squirrel is considered introduced on five Aleutian Islands; of these, Unalaska supports the critically endangered Kittlitz's Murrelet and the endangered Marbled Murrelet (TIB 2010).

General management difficulty ***2/4***

Ground squirrels can be controlled using poison baits, trapping, and shooting. The former option is relatively inexpensive but may cause secondary poisoning to non-target species, including bald eagles, gulls, and ravens (Ebbert and Byrd 2002).

Total for feasibility of control	**6/10**

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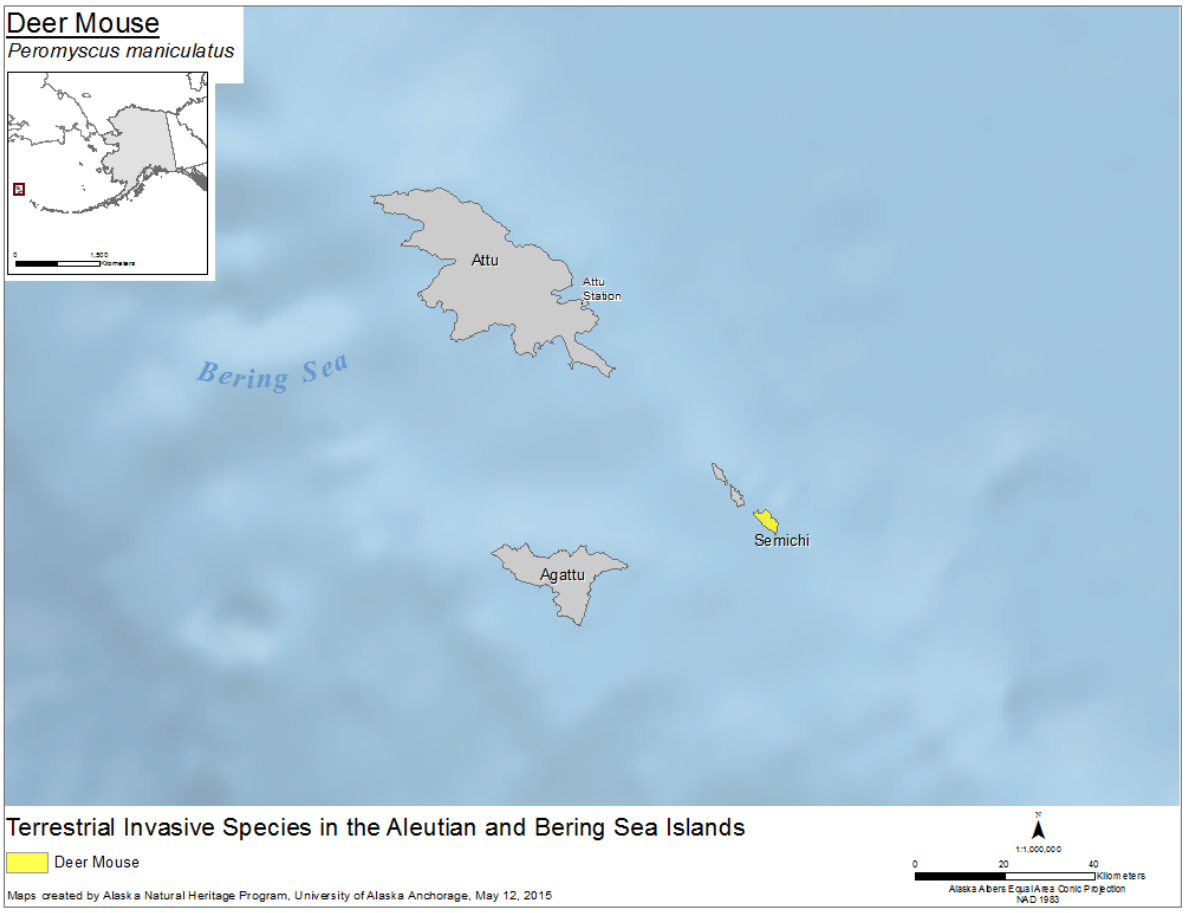
Scientific name: *Peromyscus maniculatus* Common name: Deer mouse



Range Map

Alaska invasion/introduction history

The deer mouse and its over 50 subspecies is native to most of North America and is the most widespread North American rodent (Linzey 2008). The deer mouse has been found in the Copper River Basin where nativity is questionable; this population may have been introduced or may reflect a range extension from nearby parts of Canada (MacDonald et al. 2009). The only definitively exotic population is on Shemya Island, where it was introduced in 1978 (Fritts 2007, MacDonald and Cook 2009).

Ranking Summary		
	Potential Max	Score
Distribution	25	2
Biological Characteristics	25	13
Ecological Impact	10	7

Feasibility of Control	3	1
Total	63	23
Invasiveness (out of 100) = 42 Weakly invasive		

Distribution	**Score**
Current global distribution	***0/10***

Established and native in the USA, Canada, and Mexico; introduced in parts of Mexico and on the Aleutian Island of Shemya (Linzey 2008).

Extent of the species US range and/or occurrence of formal state or provincial listings ***0/10***

The deer mouse is the most widespread rodent in North America, ranging from southern Canada to central Mexico, eastward to Texas (Linzey 2008). It is not present in western and southeastern Mexico, southeastern US and Atlantic coastal states, northern Canada, and most of Alaska (NatureServe 2015). The deer mouse is believed to have been introduced from California to Shemya Island in 1978 through military activities (Fritts 2007, MacDonald and Cook 2009). The nearest native population is in the southwestern Yukon Territory. It is possible the deer mouse was introduced to conterminous Alaska during the construction of the trans-Alaskan pipeline in the 1970s; it was found in the Copper River Basin in 2008, where it had previously been undetected. However, the Copper River Basin population may be a range extension, making the nativity, and potentially the taxonomy, of this population unclear (MacDonald et al. 2009).

Role of anthropogenic and natural disturbance in establishment ***u/5***

Unknown.

Climatic similarity between site of origin and release ***2/5***

A similar climate is found in the deer mouse's native range of Northwest US and parts of Canada.

Total for distribution	**2/25**

Biological Characteristics and Dispersal	**Score**
Invasive elsewhere	***1/5***

Introduced in parts of Mexico, otherwise there is no documentation of the deer mouse occurring outside its native range in North America.

Dietary specialization ***5/5***

Generalist omnivore; will eat fungi, plant material, nuts, seeds, fruit, arthropods and other invertebrates, and bird eggs. Snails, worms, and insects are an important food source in the summer. The deer mouse will sometimes store food for the winter (Ebbert and Byrd 2002, Wolfe et al. 1985).

Habitat specialization ***5/5***

There are 57 subspecies that make up two ecotypes of the deer mouse. One is a forest inhabitant with large ears and long tail, the other inhabits open areas and has small ears and a short tail. Between these two ecotypes, it can be found in many habitats, including scrublands, shrub lands,

alpine, deserts, prairie, grasslands, savannas, bogs, swamps, riparia, forests, woodlands, taiga, tundra, orchards, croplands, hedgerows, and suburban areas. Nest sites include fallen logs and debris, tree cavities, underground burrows, thick vegetation, and buildings (Linzey 2008, NatureServe 2015).

Average number of reproductive events per adult female per year ***2/5***

The deer mouse breeding season is shorter at high elevations and in northern portions of its range. At northern latitudes one or two litters per year, with five to six young per litter is average. This mouse reaches sexual maturity at two months and gestation lasts 23 days (Kirkland and Layne 1989).

Potential to be spread by human activities ***u/5***

Unknown.

Innate potential for long distance dispersal ***0/5***

The deer mouse's home range is typically a few hundred to a few thousand square meters, averaging one hectare or less, and it does not migrate (NatureServe 2015). Bowman et al. (1999) captured a subadult male in New Brunswick at sites 1.77 km apart. Another study in Kansas captured a deer mouse at sites 1.32 km apart (Rehmeier et al. 2004). Individuals displaced by three km return to their home site within a few days (Maier 2002).

Total for biological characteristics	**13/25**

Ecological Impact	**Score**

Impact on population dynamics of other species ***7/10***

Outside of Alaska, the deer mouse has caused declines in the vulnerable species Craveri's Murrelet (*Synthliboramphus craveri*; BirdLife International 2010). The deer mouse preys on eggs and greatly inhibits the reproduction of Xantus murrelets (*Synthliboramphus hypoleucus*) on California's Santa Barbara Island (Murray et al. 1983), as well as elsewhere (Maxon and Oring 1978).

Impact on natural community composition ***u/10***

Unknown.

Impact on natural ecosystem processes ***u/10***

Unknown.

Total for ecological impact	**7/10**

Feasibility of control	**Score**

Number of populations in Alaska ***1/3***

Only known from Shemya Island and the Copper River Basin.

Significance of the natural area(s) and native species threatened ***u/3***

Unknown.

General management difficulty ***u/4***

Unknown.

Total for feasibility of control	**1/3**

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Acknowledgements

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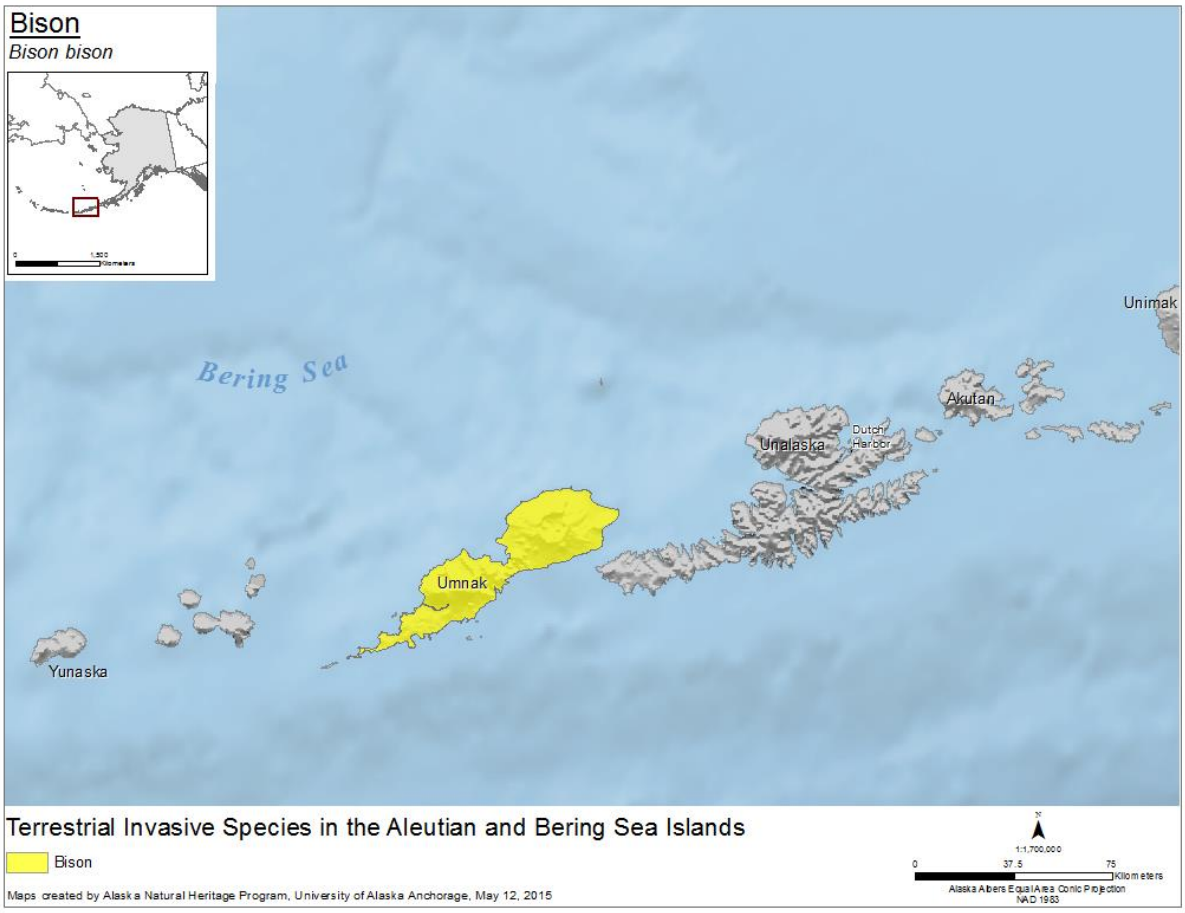
Scientific name: *Bison bison* Common name: Bison



Range Map

Alaska invasion/introduction history

The bison (*Bison bison*) was once widespread across North America, ranging from Alaska to the east coast and into parts of northern Mexico. Before European colonization, the bison population of North America was estimated to be 30-60 million, but by 1903 had been reduced to about 1650 individuals as a result of overhunting. After decades of reintroduction and management, the North American bison population reached 75,000 animals in 1983 (Meagher 1986). The bison is currently limited to isolated pockets both within and outside of its historic native range. A few native, wild populations still exist in Canadian and US National Parks, but most current populations are of reintroduced animals (NatureServe 2015). The IUCN Red List considers bison to be *Near Threatened*, due to having only five viable populations (herds of over 1000), small population sizes, and dependence on conservation management for persistence (Gates and Aune 2008).

There are two North American subspecies of bison: *Bison bison bison* (plains bison) and *Bison bison athabascae* (wood bison; Gates and Aune 2008). The former are native from northern Mexico into central Alberta and the latter are native from central Alberta into Alaska (Sanderson et al. 2008). Wild populations of wood bison have been extirpated from their native range in Alaska (Gates and

Aune 2008), and it currently has a limited distribution in the state. There is a managed population at the Alaska Wildlife Conservation Center (AWCC) in Portage, and individuals from the AWCC have been translocated to Umnak for hunting, and also to Stevens Village. Popof Island had an accidental introduction in the 1950 that has recently been augmented with calves from the AWCC (ADN 2008, Juneau Empire 2009, KIAL news 2007). They were historically present around Delta Junction (Juneau Empire 2009, UAF undated).

Ranking Summary		
	Potential Max	Score
Distribution	30	8
Biological Characteristics	30	16
Ecological Impact	30	13
Feasibility of Control	7	1
Total	97	38
Invasiveness (out of 100) = 39 Weakly invasive		

Distribution	**Score**
Current global distribution	***0/10***

Bison are native to North America. Bison have been introduced to islands in Indonesia, India, and on Santa Catalina off the California coast (TIB 2015).

Extent of the species US range and/or occurrence of formal state or provincial listings ***3/10***

Bison have been extirpated throughout the majority of US states. They are considered critically imperiled (S1) in Wyoming; Imperiled (S2) in Utah, Montana, the Yukon, and Northwest Territories; Vulnerable (S3) in South Dakota, British Columbia, and Saskatchewan; and introduced in Arizona (NatureServe 2015). Populations in Alaska have been intentionally introduced and are managed.

Role of anthropogenic and natural disturbance in establishment ***0/5***

The bison is native to Alaska and the rest of North America and was once widespread. Current land use limits their migration and population sizes. Modern introductions to Aleutian Islands have been intentional and require a great deal of planning and expense.

Climatic similarity between site of origin and release ***5/5***

Native to parts of Alaska.

Total for distribution	**8/30**

Biological Characteristics and Dispersal	**Score**
Invasive elsewhere	***5/5***

Bison have been introduced on islands in Indonesia, India, and on Santa Catalina off the California coast (TIB 2015).

Dietary specialization ***2/5***

Bison primarily feed on grasses and sedges, but when these are scarce they also eat forbs, leaves of woody plants, and lichens (Gates and Aune 2008).

Habitat specialization ***5/5***

In southern parts of their native range bison primarily utilize grasslands and open plains. In northern parts of their range they use boreal forest woodlands and openings, river valleys, and meadows (NatureServe 2015). They primarily graze in grasslands and meadows, but will additionally utilize herbaceous wetlands, riparian meadows, woodlands, and savanna; they range from arid regions to places with deep snow (Gates and Aune 2008, NatureServe 2015). Like other ungulates, they will visit recently burned areas with new vegetation (Shaw and Carter 1990).

Average number of reproductive events per adult female per year ***0/5***

The bison typically has one calf per year (NatureServe 2015).

Potential to be spread by human activities ***1/5***

Modern introductions to Aleutian Islands are intentional, infrequent, and require a great deal of planning and expense.

Innate potential for long distance dispersal ***3/5***

Historically, before European settlement, the plains bison made long, mass migrations of up to several hundred kilometers in the spring and fall, and also made elevational migrations. This is no longer the case, due to land use changes and smaller population sizes, and modern herds are now restricted to protected parks and adjacent lands. The wood bison is not a migrant. Both species aggregate during breeding and calving in the spring and summer (Gates and Aune 2008, NatureServe 2015). In the Northwest Territories bison home range is typically several hundred square kilometers (Larter and Gates 1990). Although bison are good swimmers, large expanses of ocean likely act as a barrier to dispersal on islands where they have been introduced.

Total for biological characteristics	**16/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***3/10***

Introduced ungulates alter population dynamics of species native to Aleutian and Bering Sea islands owing to the lack of interspecific competition for forage resources and top-down control from native predators (Ebbert and Byrd 2002, Ricca et al. 2012). Introduced ungulates alter native vegetation by trampling, crushing, browsing, and over-grazing (Aston 1911, GISD 2010). Soil disturbance and removal of native vegetation can potentially promote the establishment of nonnative plants. Ungulates, such as bison, can harm bird populations by trampling surface and burrow nesting birds and altering soil properties that affect burrowing birds (Ebbert and Byrd 2002). Additionally, bison can harbor diseases that can potentially affect other species (NatureServe 2015).

Impact on natural community composition ***7/10***

Little vegetation data exists for Umnak and Popof Islands where bison have been introduced, but their impacts are likely not trivial in areas where they forage heavily. Among ruminant ungulates, larger animals can subsist on lower quality forage, owing to lower mass-specific metabolic rates, but

need to consume more of it (Demment and Van Soest 1985). Larger bison may have greater per-capita impacts on plant communities in comparison to smaller ungulates such as sheep, reindeer, and caribou.In mid-continental habitats, bison grazing strongly favors the formation and maintenance of grassland habitats (Frank and McNaughton 1993) and accordingly has been described as a keystone herbivore (Knapp et al. 1999).

Impact on natural ecosystem processes ***3/10***

Impacts on ecosystem function on islands where bison have been introduced are largely unknown. However, in mid-continental habitats bison grazing can have strong cascading effects on below-ground processes, such as increasing rates of nitrogen mineralization and pool size, and altering soil quality by increasing organic matter and labile carbon (Frank and Groffman 1998, Knapp et al. 1999). How these effects might manifest themselves in insular Aleutian habitats is unknown.

Total for ecological impact	**13/30**

Feasibility of control	**Score**

Number of populations in Alaska ***1/3***

Bison have a limited distribution in Alaska. There is a managed population at the Alaska Wildlife Conservation Center (AWCC) in Portage, and between 2006 and 2009 plains bison have been translocated from there to Umnak and Popof Islands, and Stevens Village (ADN 2008, Juneau Empire 2009, KIAL news 2007). They were historically present around Delta Junction (Juneau Empire 2009, UAF undated).

In 2007 the first three bison calves were sent to Umnak Island from the AWCC, three more were introduced in January 2008, and another three were transported there in December 2008, with the hope of growing the heard to 50 individuals. This project was carried out by the Aleutian Pribilof Island Community Development Association (APICDA), the local village corporation Chaluka Corp., and the AWCC. The former agency runs a hunting lodge in the village of Nikolski, previously catering to reindeer hunting. This project was intended to expand their business to bison hunting, as well, to draw more hunters and promote tourism. The land on which the bison are introduced is privately owned by the native Chaluka Corp. Umnak also hosts cattle on a ranch on the eastern part of the Island; reindeer, feral sheep, and horses have been abandoned by past ranchers and persist on the island (KIAL News 2007). The current population of bison on Umnak is unknown.

An accidental introduction of plains bison to Popof Island occurred in 1951, when two females and one male jumped off a barge. The male didn't make it to shore, but the females did, and one subsequently gave birth to a bull calf which led to the establishment of a herd numbering 150-180 as of 2009. In September of 2009 two female bison from the AWCC were added to the Popof Island population for genetic diversity. Presently, the herd is managed by the Shumagin Village Corporation (Juneau Empire 2009, UAF undated).

Elsewhere in Alaska, there was historically a bison population off the Richardson Highway and along the Delta River, near the villages of Delta Junction and Big Delta, between 1925 and 1969 (UAF undated).

Significance of the natural area(s) and native species threatened ***u/3***

Unknown.

General management difficulty ***0/4***

Introductions of bison on Aleutian Islands has occurred on privately owned lands and has been intentional and costly. These herds are being managed to grow and maintain their populations, and management for control or eradication purposes is highly unlikely. However, it may be worth monitoring insular Alaskan bison to determine if reintroductions have detrimental impacts to on native species or ecosystem processes, as is common with other introduced ungulates.

Total for feasibility of control	**1/7**

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Acknowledgements

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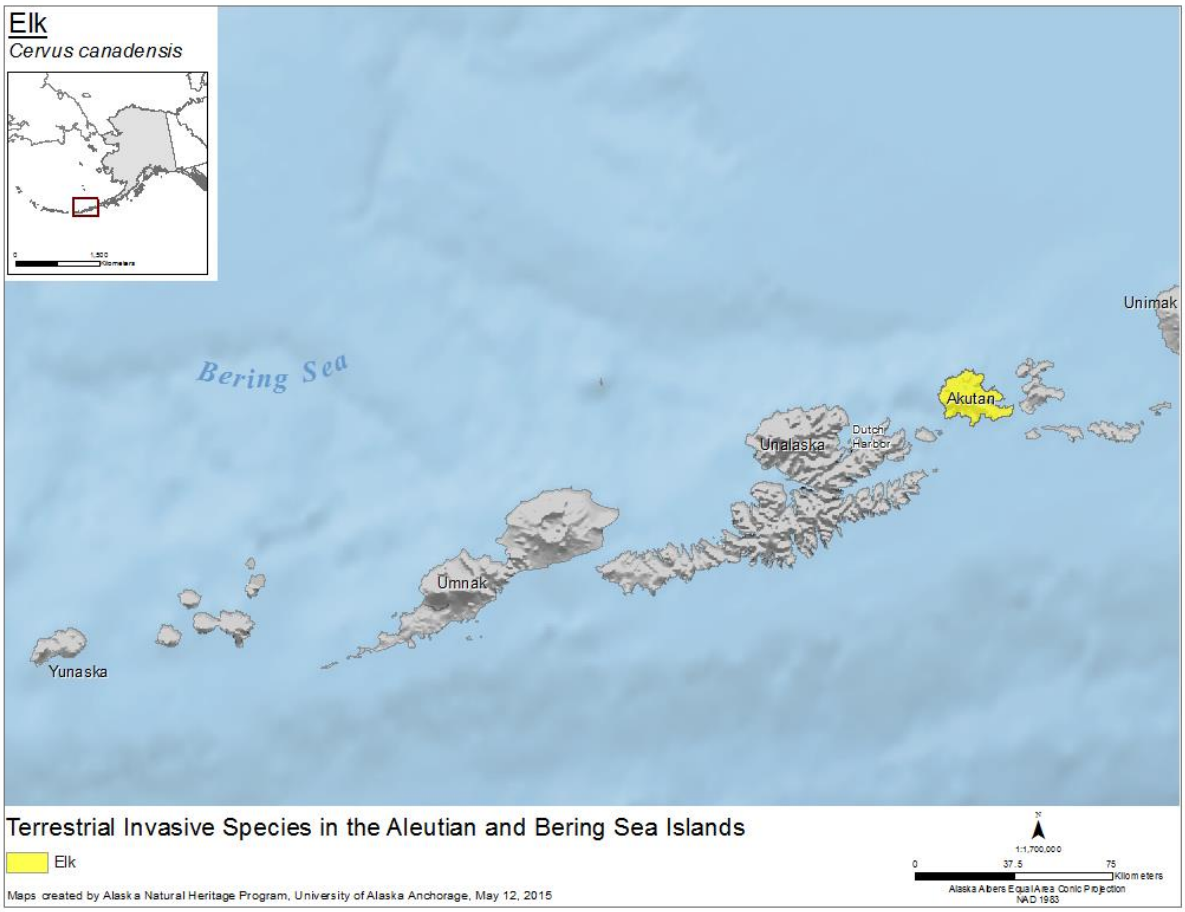
Reviewer(s): M. Ricca, United States Geological Survey

Scientific name: *Cervus elaphus* Common name: Elk



Range Map

Alaska invasion/introduction history

Two species of elk have been introduced in Alaska: Rocky Mountain elk (*Cervus elaphus nelsoni*) and Roosevelt elk (*Cervus elaphus roosevelti*). All elk in Alaska have been introduced in the last hundred years from the Pacific Northwest (ADF&G 2014). Eight Roosevelt elk were introduced to Afognak Island in the 1920's from Washington (Batchlelor 1965), and are now established both on Afognak and nearby Raspberry Islands. This population grew to 1400 then crashed by 70% in the 1970s due to a series of harsh winters. The population rebounded to previous size and is stable as of 2010s (Hundertmark and Van Daele 2010). In 1987 seventeen Rocky Mountain elk and 33 Roosevelt elk were introduced to Etolin Island in Southeast Alaska from Oregon (ADF&G 1999). These elk now also occupy nearby Zarembo Island (ADF&G 2014). Another eight Rocky Mountain elk adults, plus one recently born at the Alaska Wildlife Conservation Center (AWCC), were sent to Akun Island in the 2010s, as part of a program to populate the Aleutian Islands with game (Klint 2013). The AWCC is working in partnership with the Aleutian Pribilof Island Community Development Association to move another 21 elk to Akun Island in the fall of 2015. They will be managed by the Akutan Native Association for subsistence and economic opportunities (AWCC 2015).

Ranking Summary		
	Potential Max	Score
Distribution	30	17
Biological Characteristics	30	9
Ecological Impact	30	9
Feasibility of Control	10	4
Total	100	39
Invasiveness (out of 100) = 39 Very weakly invasive		

Distribution	**Score**
Current global distribution	***0/10***

Elk occur in regions of the conterminous U.S., Canada, and Mexico (Nowak 1991).

Extent of the species US range and/or occurrence of formal state or provincial listings ***7/10***

The elk occurs in approximately 30% of US states and at least five Canadian provinces. The majority of the elk's range is along the Rocky Mountains and western coast of the United States (Patterson et al. 2003, NatureServe 2009).

Role of anthropogenic and natural disturbance in establishment ***5/5***

Once introduced to an area elk are thrive in natural areas (Troyer 1960, ADF&G 2008).

Climatic similarity between site of origin and release ***5/5***

Elk are native in the Rocky Mountains, including Colorado, Wyoming, Montana, Alberta, and British Columbia (O'Gara and Dundas 2002), which experience low temperatures similar to coastal Alaska (Cathey 1990).

Total for distribution	**17/30**

Biological Characteristics and Dispersal	**Score**
Invasive elsewhere	***0/5***

Although elk have been extensively translocated outside of their native range, this species is not considered invasive because introductions are intentional, and it does not appear to cause ecologic or economic harm.

Dietary specialization ***2/5***

Elk feed on a variety of grasses, sedges, forbs, and shrubs (MacDonald and Cook 2009). The diet of elk varies with season and the availability of food resources (Troyer 1960). On Afognak Island, elk are dependent on willow and elderberry in the winter (Troyer 1960), and in Southeast Alaska species of huckleberry, western redcedar, and salal are important components of their diet (Kirchhoff and Larsen 1998).

Habitat specialization ***5/5***

Elk utilize habitat types in both lowland and mountainous regions (Nowak 1991). In British

Columbia, elk utilize conifer and deciduous forests, wetlands, rock outcrops, and vegetation slides (Quayle and Brunt 2003).

Average number of reproductive events per adult female per year ***0/5***

Cows typically give birth to once calf per year; twins are rare (Raedeke et al. 2002).

Potential to be spread by human activities ***1/5***

The accidental transport of elk to new locations does not typically occur; however, elk have been translocated by humans to create additional hunting opportunities (O'Gara and Dundas 2002, ADF&G 2008).

Innate potential for long distance dispersal ***1/5***

Elk display a high fidelity to their home ranges during seasonal migrations; however, if conditions are unfavorable, elk may move outside their home range and establish elsewhere (Irwin 2002, NatureServe 2009). In Southeast Alaska elk have dispersed to islands adjacent to their site of release (ADF&G 2008).

Total for biological characteristics	**9/30**

Ecological Impact	**Score**

Impact on population dynamics of other species ***3/10***

In Southeast Alaska, Sitka black-tailed deer and elk have a high degree of dietary overlap. This overlap has potential to cause competition between elk and deer during severe winters or as more areas are clearcut (Kirchhoff and Larsen 1998). It is unlikely that deer will be completely displaced by elk, but deer may have to exploit foraging patches that are not accessible to elk (Hanley 1984, Jenkins and Wright 1988). Additionally, introduced elk can potentially transport disease to black tailed deer and can alter predator-prey dynamics (Tynan 2010).

Introduced ungulates alter native vegetation by trampling, crushing, and over-grazing; browsing on bark reduces tree and shrub health (Aston 1911, GISD 2010). Additionally, soil disturbance and removal of native vegetation can potentially promote the establishment of nonnative plants (Ebbert and Byrd 2002).

Impact on natural community composition ***3/10***

In other states elk populations have heavily grazed and trampled plant communities (Lyon and Christensen 2002). Literature does not report heavy feeding as a problem in Alaska yet. However, if food resources become sparse due to logging, competition may occur between elk and Sitka black-tailed deer, and vegetation communities may become degraded from over-browsing by both species (Kirchhoff and Larsen 1998, ADF&G 1999).

Impact on natural ecosystem processes ***3/10***

Grazing by elk can lower the biomass produced by plants and cause changes in carbon and nitrogen dynamics in willow communities. However, these changes in ecosystem processes are not well understood and conflicting results have been obtained by different studies (Schoenecker et al. 2004).

Total for ecological impact	9/30

Feasibility of control	Score
Number of populations in Alaska	***1/3***

Populations of elk exist on Afognak, Raspberry, Etolin, and Zarembo islands, and possibly on neighboring islands in Southeast Alaska (ADF&G 2008).

Significance of the natural area(s) and native species threatened ***1/3***

Elk have the potential to compete with native Sitka black-tailed deer, which are of value to recreational hunters. However, reduction in deer hunting and/ or complete displacement by elk is unlikely (Kirchhoff and Larsen 1998, ADF&G 1999).

General management difficulty ***2/4***

Management of elk in Alaska does not include eradication of the species, but managing abundances at healthy levels to provide hunting opportunities on Afognak, Raspberry, Etolin, Zarembo, and Akun islands, while limiting the dispersal of individuals to adjoining islands and the mainland (ADF&G 2008). There are a number of factors that naturally limit populations of elk, including harsh winters, starvation disease, predation, and lowered birth rate due to habitat inadequacies or population density (Tynan 2010).

Total for feasibility of control	4/10

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Acknowledgements

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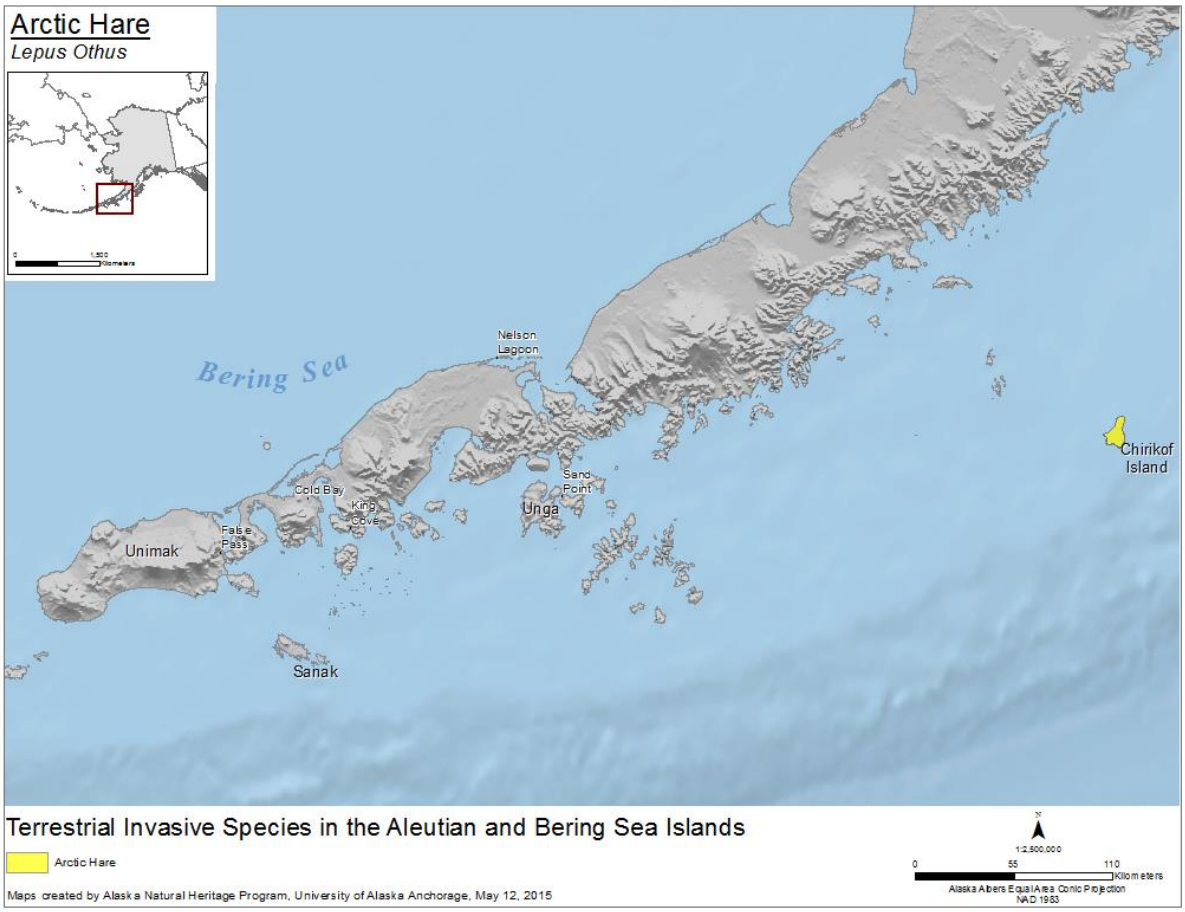
Reviewer(s): L. van Daele, Alaska Department of Fish and Game; M. Ricca, United States Geological Survey

Scientific name: *Lepus othus* Common name: Alaskan (Arctic) hare



Range Map – ABSI LCC Region (former range, no longer present)

Alaska invasion/introduction history

The Alaskan hare (*Lepus othus*) is native to western and southwestern Alaska, including the eastern Aleutian Islands (NatureServe 2015). It is similar to *Lepus arcticus* and *L. timidus* but is geographically isolated and endemic only to Alaska (DeBruine 2000). The Alaskan hare was intentionally introduced on Chirikof Island in 1891 but has since disappeared (Bailey 1993). It was also introduced on ten or more Alaska Maritime National Wildlife Refuge islands but only persists on a few (Ebbert and Byrd 2002).

Ranking Summary		
	Potential Max	Score
Distribution	25	5
Biological Characteristics	20	10
Ecological Impact	20	6
Feasibility of Control	3	0
Total	68	21
Invasiveness (out of 100) = 31 Very weakly invasive		

Distribution	**Score**
Current global distribution	***0/10***

Native to Alaska. The taxonomy of species in eastern Asia is unclear; they are sometimes considered to be *Lepus othus* or *L. timidus* (Waltari et al. 2004).

Extent of the species US range and/or occurrence of formal state or provincial listings ***0/10***

The Alaskan hare has a limited distribution in western and southwestern Alaska, including the eastern Aleutian Islands (Flux and Angermann 1990, Murray and Smith 2008, NatureServe 2015).

Role of anthropogenic and natural disturbance in establishment ***u/5***

Unknown.

Climatic similarity between site of origin and release ***5/5***

Native to Alaska including some Aleutian Islands.

Total for distribution	**5/25**

Biological Characteristics and Dispersal	**Score**
Invasive elsewhere	***0/5***

Not known to be invasive anywhere.

Dietary specialization ***5/5***

Feeds on green vegetation in the summer, and bark, shoots, roots, and twigs of woody plants in the winter and spring (Best and Henry 1994, Whitaker 1980). Specifically, it is known to eat plants in the heath family, sedges, grasses, flowers, and dwarf willow (DeBruine 2000, NatureServe 2015, Murray and Smith 2008).

Habitat specialization ***5/5***

The Alaskan hare prefers areas with brush, but also often occupies open tundra and rocky slopes. Other habitats used include wet meadows, sedge flats, alder thickets, coastal lowlands, and alluvial plains (Best and Henry 1994, Flux and Angermann 1990). Where cover is available, young are born under the shelter of alder or willow, but where there are no shrubs it will use small depressions in the open (Best and Henry 1994). The majority of its native distribution is nearly all north of treeline

(Murray and Smith 2008), and it ranges from 0-660 meters elevation (Flux and Angermann 1990). The Alaskan tic hare does not burrow (DeBruine 2000).

Average number of reproductive events per adult female per year ***0/5***

One litter per year of 5-7 young (Best and Henry 1994, NatureServe 2015).

Potential to be spread by human activities ***u/5***

Unknown.

Innate potential for long distance dispersal ***u/5***

Unknown.

Total for biological characteristics	**10/20**

Ecological Impact	**Score**

Impact on population dynamics of other species ***3/10***

Both hares and rabbits can destroy habitat and cause defoliation and erosion. (McChesney and Tershy 1998). They potentially compete with native snowshoe hares (*Lepus americanus*) for food (Klein 1995, Svendsen 1990).

Impact on natural community composition ***3/10***

Alaskan hare populations tend to fluctuate greatly (NatureServe 2015). It is possible that the Alaskan hare faced declines in Alaska after the native snowshoe hare (*Lepus americanus*) was locally introduced to parts of the arctic hare's range in the early twentieth century. This could be attributable to a direct relationship (e.g. disease, parasites, food competition) or indirectly caused by increasing populations of predator species. Their population appears to have peaked in the 1970s and has since been decreasing (Klein 1995). Numbers may be cyclical, with declines following high predator populations caused by peak in snowshoe hare populations (NatureServe 2015).

Impact on natural ecosystem processes ***u/10***

Unknown.

Total for ecological impact	**6/20**

Feasibility of control	**Score**

Number of populations in Alaska ***0/3***

The Alaskan hare is native throughout western and southwestern Alaska (NatureServe 2015). It was intentionally introduced on Chirikof Island in 1891 but has since disappeared (Bailey 1993). It was also introduced on ten or more Alaska Maritime National Wildlife Refuge islands but only persists on a few, and has unknown or minor impacts (Ebbert and Byrd 2002).

Significance of the natural area(s) and native species threatened ***u/3***

Unknown.

General management difficulty ***u/4***

Unknown.

Total for feasibility of control	**0/3**

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