Montague Island Vole: A Conservation Assessment

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Abstract

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Montague Island tundra voles were first described in the early 1900s. Based on their large size and dark coloration relative to other island and mainland populations, tundra voles from Montague Island were classified as a distinct subspecies. Research conducted in the 1990s revealed significant differences in the size and shape of Montague Island voles, but not significant genetic differentiation. Montague Island voles appeared abundant in the 1990s, although there was no attempt to estimate population size. Montague Island voles may be reproductively and genetically isolated. More sensitive genetic techniques now can be used to test genetic distinctiveness across populations. A conservation concern exists owing to the unknown population status and still questionable taxonomy of this island endemic subspecies, because it is unknown if land management practices affect this isolated population.

Keywords: Tundra vole, island endemics, *Microtus oeconomus elymocetes*, Montague Island, Montague Island vole, taxonomy.

Montague Island Vole

Contents

Figure 1—Montague Island is a large island, isolated by the deep, saltwater channels of Prince William Sound, south-central Alaska.

Background

A Brief History of the Taxonomic Classification of Montague Island Voles

Montague Island voles were first collected from Montague Island, Prince William Sound, Alaska, by Osgood in 1906. He described *Microtus elymocetes* as a new species based on their very large size and dark pelage. In 1910, Heller published an account of the Montague Island vole based on 30 specimens he collected during the Alexander expedition of 1908. He claimed "this species is easily distinguishable from any other member of the genus inhabiting the region by its larger size and much darker coloration" (Heller 1910).

Zimmermann (1942) grouped *M. elymocetes* with *M. oeconomus* based on the overall variability in skulls and uniformity in coloration of all tundra voles sampled, but assigned the island form subspecific status because of its relatively large size. Paradiso and Manville (1961) concurred with Zimmermann's revision of Montague Island vole after examining seven specimens from the type locality.

A Brief Description of Montague Island

Montague Island has been shaped by periods of glaciation and tectonic activity resulting from the collision of the Pacific and North American plates (Gehrels and Saleeby 1987, Lahr and Plafker 1980). Deep ocean channels, created by past glacial retreats, surround and isolate the island. It is the largest island (850 km^2) in Prince William Sound (fig. 1) (USDA Forest Service 1993). A long mountain range, extending north to south, divides the island, which ranges in elevation from sea level to more than 1000 m at its highest peak. The eastern coast is exposed to the Gulf of Alaska and is characterized by steep cliffs that abut the shoreline. One large drainage, the Nellie Martin

River, flows to the east. The western coast has many rivers and bays, which are protected from the violent storms and southeasterly winds from the Gulf of Alaska.

Current evidence suggests the climate of the region has remained relatively constant during the last 5,000 years (Heusser 1985). Anticyclone storms circulate over the Pacific Ocean most of the year. Cyclonic storms affect the Alaska coastline in autumn and winter producing semipermanent, low-pressure systems characterized by strong southerly or southeasterly winds and heavy precipitation (Mobley and others 1990).

The Prince William Sound region has generally heavy annual precipitation and cool mean annual temperatures. During a year of extremely high rainfall, 840 cm of precipitation was recorded from southeastern Montague Island, and mean annual precipitation in the Montague Island vicinity ranged from 236 cm at Latouche Island to 216 cm at Hinchinbrook Island (Brower and others 1988). In addition, mean annual maximum temperatures ranged from 7.3 ^{o}C at Latouche Island to 9.6 ^{o}C at Hinchinbrook Island, and mean annual minimum temperatures ranged from 3.1 ^{o}C at Latouche Island to 4.1 ^{o}C at Hinchinbrook Island (Brower and others 1988).

Vegetation was described following Viereck and others (1992), and varies by altitude (Lance and Cook 1995, Weintraub and Cook 1991). Beach-rye (*Elymus arenarius* Linnaeus) dominates the shorelines and Sitka spruce (*Picea sitchensis* (Bongard) Carriere) and alder (*Alnus* spp. Mill) on alluvial deposits; sedge-moss bog meadows, sweetgale (*Myrica gale* Linnaeus) -graminoid bogs, and willow (*Salix* spp. Linnaeus) -graminoid shrub bogs are interspersed among Sitka spruce and western hemlock (*Tsuga heterophylla* (Rafinesque-Schmaltz) Sargent) forests at mid-elevation; and mountain hemlock (*Tsuga mertensiana* (Bongard) Sargent) and mountain-heath (*Phyllodoce aleutica* (Sprengel) Heller) tundra dominates high-elevation community types. (Species names are according to Hulten 1968.)

Where previous timber harvest has occurred, forest stands regenerate naturally and currently contain even-aged stands of western hemlock and Sitka spruce (USDA Forest Service 1989, Weintraub and Cook 1991).

A Brief History of Human Use of Montague Island

Historically, Montague Island supported small populations of humans from as early as 2000 years BP (Yarborough 1999). Local Eskimos used the southeastern coast of Montague Island as a hunting ground for sea otters. The Eskimos referred to Montague Island as Sukluk, which translates to the terrible island (Johnson 1999), presumably because of its violent eastern shoreline. Although a village at Zaikof Bay persisted for some unknown length of time (Johnson 1984), currently there are no human inhabitants on Montague Island.

Montague Island is largely federally owned (787 km^2) (USDA Forest Service 1993); however, 63 km^2 were conveyed to the Chugach Alaska Corporation, under the authority of the Alaska Native Claims Settlement Act (ANCSA 1971). A 56-km-long road constructed in 1993, which linked the deep-water port at McLeod Harbor to Chugach Alaska Corporation land at Patton Bay, was obliterated in 1997 (USDA Forest Service 1989). Public lands on Montague Island are managed by the USDA Forest Service, Chugach National Forest, Cordova Ranger District. Private lands are managed by the Chugach Alaska Corporation, Anchorage, Alaska.

Between 1947 and 1973, about 12 km^2 of high-volume timber was harvested along the western coast of Montague Island (USDA Forest Service 1989). Those stands regenerated naturally and currently contain uniform stands of western hemlock and Sitka spruce that are densely vegetated by salmonberry (*Rubus spectabilis* Pursh) (USDA Forest Service 1989, Weintraub and Cook 1991). In 1992, 55.5 km of road was constructed across public land to access about 48.5 km^2 of privately owned forest near Patton Bay. Within the 48.5 km^2, about 16 km^2 containing merchantable timber was clearcut during a 6-year period. Additionally, 3 million board feet of timber was harvested from the McLeod Harbor area in 1998 (Jandro 1999). Recreational cabins, maintained by the USDA Forest Service, are located at Port Chalmers, San Juan Bay, and Nellie Martin River.

Sitka black-tailed deer (*Odocoileus hemionus* Rafinesque), introduced to Prince William Sound in the early 1950s (Burris and McKnight 1973), b/and brown bear (*Ursus arctos* Linnaeus) have been hunted heavily on Montague Island. As a result, bear populations were seriously depleted. In 1990, the Alaska Department of Fish and Game closed the fall bear hunting season (Alaska Board of Game 1990) and in 1994 completely closed Montague Island to bear hunting by emergency order followed by an Alaska Board of Game ruling (Alaska Board of Game 1994). Bear hunting on Montague Island remains closed at this writing (Crowley 1999). Additionally, mink (*Mustela vison* Schreber) were introduced to Montague Island in the early 1950s and are present today at an unknown density (Burris and McKnight 1973).

Current Status of the Montague Island Vole

Population status—Currently, the Montague Island vole is designated a Sensitive Species (USDA Forest Service 1990) and Management Indicator Species for the Chugach National Forest (USDA Forest Service 1989), a population for which there is insufficient knowledge (IK) for the International Union for the Conservation of Nature (IUCN) (Lance and Cook 1998a), and G5T2/S2, a population of high ecological concern both in Alaska and nationally (West 1991). Additionally, the Montague Island vole was previously a U.S. Fish and Wildlife Service, Category II Candidate (58 FR 51144) for listing under the Endangered Species Act of 1973, as amended (U.S. Fish and Wildlife Service 1991).

Population concerns—Species of *Microtus* tend to dominate their small mammal communities, both behaviorally and numerically (Cameron 1964, Pruitt 1968). They can potentially alter a plant community through selective harvest or plant growth stimulation through grazing (Rose and Birney 1985). In addition, they play an important role as prey to an array of carnivores, and in their ability to influence predator populations (Magoun and Johnson 1991).

Researchers have long been intrigued with annual fluctuations and multiannual cycles in *Microtus* population abundance (see Batzli 1992 for review). More populations of species of *Microtus* exhibit annual fluctuations than multiannual cycles, yet change in population abundance owing to multiannual cycles is more dramatic (Taitt and Krebs 1985).

Currently, there are no data available on population estimation for the Montague Island vole. Moreover, the U.S. Fish and Wildlife Service recommends further investigation of population trends before adopting further land use practices on Montague Island (Lance and Cook 1995).

Review of Technical Knowledge

Distribution

The tundra vole, *Microtus oeconomus* (Pallas) has a Holarctic distribution (Musser and Carleton 1993). Its Old World range extends from Scandinavia, the Netherlands, and Hungary, eastward and south to China and Mongolia, and throughout Siberia (Hoffmann and Koeppl 1985). Its New World range extends from St. Lawrence Island in the Bering Sea, throughout Alaska, and east to the Yukon and Northwest Territories (Musser and Carleton 1993). Although it was once believed that the Nearctic and Palearctic tundra voles were distinct groups, they now are considered conspecific based on morphologic and biochemical similarities (Lance 1995, Nadler and others 1978, Zimmermann 1942). Currently, there are 10 subspecies of tundra vole recognized in the New World (Hall 1981, Paradiso and Manville 1961).

Montague Island voles (*M. o. elymocetes*) are an endemic population to Montague Island in Prince William Sound, south-central Alaska. These voles occur throughout the island, and have been recorded from shoreline to alpine (Heller 1910, Lance 1995, Lance and Cook 1995).

Systematics

Large size and dark color, relative to other tundra voles, make the Montague Island vole population unique. In general, tundra voles are stocky mouse-like rodents with small ears and short tails. The body is dull brown with a grayish belly and the tail is bicolored (Burt and Grossenheider 1976). Montague Island voles were reported by Osgood (1906) as darker than other populations, with "upperparts cinnamon to clay color." Coat color comparisons of tundra vole collections housed at the University of Alaska Museum confirm this observation (Lance and Cook 1995). Coat color polymorphisms are well documented in species of *Microtus*; however, the mechanisms for their maintenance are poorly understood (Gaines 1985). This coat color difference may be an example of Gloger's Rule (Allaby 1994): animals living in warmer, humid areas generally exhibit darker pigmentation than those occurring in cool, dry areas. In addition, the large body size of adult Montague Island voles is conspicuous; total length ranges up to 225 mm, which is 35 mm larger than tundra voles from other populations (Lance and Cook 1995). This trend toward large body size is consistent with Foster's Rule, which states that insular rodents exhibit larger body size than their mainland relatives (Foster 1963).

Current analyses, of size and shape variation, substantiates findings previously described (Lance 1995). After removal of variation owing to size (age) alone, significant variation between Montague Island voles and other tundra voles remains (Lance 1995). These data suggest the differences distinguishing Montague Island voles from other tundra voles were related to both size and shape. However, body size and shape may have a strong nongenetic basis in rodents (Smith and Patton 1988), and chromosomal and biochemical evidence (Lance 1995; Lance and Cook 1995, 1998b) indicates there is no genetic differentiation between *M. o. elymocetes* and other subspecies of tundra vole.

Age Structure and Sex Ratio

Age ratio (adult to subadult), as determined by the shape of the skull and suture closure (Choate and Williams 1978, Lance 1995, Lance and Cook 1995) was reportedly 65:24. Sex ratio (male to female) was 36:53 (Lance and Cook 1995).

Reproductive Potential

Age at sexual maturity and length of the breeding season may be highly variable in microtine rodents (Keller 1985). Sexual maturity is determined by weight, which is regulated by environmental conditions (that is, weather, forage availability, and quality) and not necessarily by age (Kaikusalo and Tast 1984, Nadeau 1985, Tast 1984). During the summer months of 1991 and 1992 on Montague Island, 66 percent of adult females and no subadult female tundra voles were reproductive (Lance and Cook 1995). Additionally, 58 percent of adult males were reproductive, compared with 31 percent of subadult males.

Breeding spans from May through September, but can be highly variable based on environmental cues (Keller 1985, Tast and Kaikusalo 1976, Whitney 1976). Additionally, breeding may occur year-round if environmental conditions are good (Kaikusalo and Tast 1984, Tast 1984). Mean gestation period is 20.5 days (Dieterich and Preston 1977, Morrison and others 1976).

Tundra voles potentially can breed three times annually, twice during the warm summer months and once in winter (Kaikusalo and Tast 1984). This ecological strategy of high productivity is attributable to existence in uncertain environments (MacArthur and Wilson 1967).

Litter Size

Environmental factors cue the onset and duration of breeding and the age of the female may affect litter size. Reproductive data for 89 individuals, collected June through August 1991 and 1992, from Prince William Sound indicate that mean number of embryos is 6.5 (s.d. 1.29, N=18; Lance and Cook 1995). Additionally, the following data on litter size (number of embryos) were collected from other subspecies of tundra vole: 7.8 in late June to 5.0 in late August (Bee and Hall 1956), 6.1 in July to 5.2 in August (Youngman 1975), 7.1 in summer to 3.5 in winter (Kaikusalo and Tast 1984), and a mean of 6.9 for all months combined (Whitney 1977).

Breeding Biology

Multiannual cycles in abundance are known to occur in tundra voles (Whitney 1976). Tundra vole populations, studied on the Kenai Peninsula between 1968 and 1971, were reportedly cyclic, peaking at 70 to 80 animals per hectare (Whitney 1976). Typically, there is no spring decline in population density during years of cyclic peak densities (Taitt and Krebs 1985). Spacing behavior, operating through differential dispersal and territory size, may play an important role in adjustment of densities. These phenomena may be controlled both phenotypically and genotypically, that is, determined partly by genetic predisposition and partly by behavioral adjustments (Taitt and Krebs 1985).

Movements

Tundra voles disperse from their home range when (1) the habitat is saturated and essential resources are limited and (2) low density areas occur. Tast (1966) reports that tundra voles seasonally re-invade flooded areas, not suitable for habitation at certain times of the year. Some species of *Microtus* are known to "wander," that is, leave their home range but return thereafter, and others are nomads, never establishing a home range (Lidicker 1985).

Dispersal

Dispersal among *Microtus* is positively correlated with population density (Gaines and McClenaghan 1980) and has an impact on the population's age structure, natality and mortality rates, and sex ratios (Lidicker 1985). Saturation dispersal tends to be unbiased in the sex of the disperser. Moreover, increases in vole population numbers could prompt dispersal and occupation of suboptimal habitats (Tast 1984).

Seasonal dispersal at the onset of breeding season tends to be favored by subadult males (Lidicker 1985). Colonizing dispersal, in which animals establish home ranges in areas of lower density, has been reported in tundra voles (Buchalczyk and Pucek 1978, Tast 1966), and reproductive females seem to be most successful at this type of dispersal (Lidicker 1985).

Habitat Use

High populations of *Microtus* typically are associated with early stages of plant succession (Rose and Birney 1985), when grasses and woody perennials dominate the plant community (Wetzel 1958). Montague Island voles have been found most frequently in beach fringe zones consisting of beach rye and beach pea (*Lathyrus maritimus* Linnaeus), and often are found in association with riparian vegetation, such as skunk cabbage (*Lysichiton americanum* Schott) (Weintraub and Cook 1992). They build extensive runway systems in moss and sand under thick, matted layers of dead stalks of beach rye. They also have been captured in wet muskeg and subalpine meadows. Historically, they have been reported in every vegetation type from shoreline to alpine, including forest (Heller 1910).

Food Habits

The gastrointestinal tracts of *Microtus* appear to be adapted for high-fiber, low-protein, and low-mineral diets (Batzli 1985). Microtine rodents are primarily vegetarians, and the genus *Microtus* has adapted to a highly fibrous and siliceous diet by evolving rootless molars that continue to grow through their life (Batzli 1985). In some species of *Microtus*, diet during breeding season consists of mostly fresh stems and leaves, gradually shifting to seeds, stem bases, and roots as the above-ground parts of the plants age and die (Batzli 1985). Summer diets of tundra voles in Alaska may consist of sedges (*Carex*) and cottongrass (*Eriophorum angustifolium* Honckeny) (Cornely 1999). Provisioning of high-quality food can maintain breeding during winter (Cole and Batzli 1978). Indeed persistence of reproduction, litter size, body growth, and survival rates must depend on nutrient content of forage (Batzi 1985).

Habitat Availability

Beach fringe habitat, as described by Weintraub and Cook (1991, 1992), is commonly encountered along Montague Island's extensive coastline and appears to be the main plant community used by Montague Island voles. However, during peak periods of population cycles, "surplus" animals may be pushed into less preferred habitat (Getz 1985).

Home Ranges

Territory size and spacing behavior may be dependent on sex and age, genetic predisposition, and behavioral adjustments to local population densities (Taitt and Krebs 1985). They are polygynous (Heske and Ostfeld 1990, Lambin and others 1992); males hold mutually exclusive breeding territories containing the home ranges of one to several females. The relation between density and home range of tundra voles is parabolic and is expressed as:

$$S = 0.11 + (3.55/d) \ ,$$

where S = the home range size in hectare and d is the density in voles per hectare (Madison 1985).

Seasonal Differences

During the winter months, Montague Island voles may move to higher elevations where snow conditions are more conducive to subnivean living. However, little is known about then habitats used by Montague Island voles during winter. Microtine rodents use subnivean environments in winter, when snow cover is deep. In June 1991, a vole nest was found buried in snow in an alpine meadow above Port Chalmers (150 m) (Weintraub and Cook 1991). Snow conditions along the beach vary annually (Youkey 1999) and may be unsuitable for subnivean living owing to wet conditions or lack of snow in some winter months. Alternatively, voles preferentially may use forests in the winter months, where they may be more protected from winter elements; the forest canopy intercepts snow (Hanley and Rose 1987), and dead and down timber or root wads may provide natural shelter. In general, snow depth on Montague Island increases as elevation increases, and decreases with increased timber volume (Youkey 1992).

Movement Patterns

Male tundra voles move farther and more often than females during the reproductive period, and move similarly to females during winter (Madison 1985, Whitney 1976). During winter, tundra voles are social (Kaikusalo and Tast 1984, Tast 1966). There are no data about the seasonal movements of Montague Island voles.

Relation to Spatial Scale

Male tundra voles may range 7300 m^2, and females 3000 m^2 in summer (Karulin and others 1976). Tundra voles can swim, but it is unknown how far a wandering or dispersing individual will travel (Lidicker 1985).

Relation to Food Sources

Increased body size of Montague Island voles may be related to differences in nutrition, as demonstrated for pocket gophers (*Thomomys bottae* Huey) (Patton and Brylski 1987), or a result of increased resource availability owing to decreased predation or competition (Case 1978). However, Lance (1995) found that competitive release did not explain large body size in Montague Island voles.

Conservation Concerns

Population Density

No data are currently available about population vigor or density. Heller (1910) describes Montague Island voles as abundant wherever he landed on the island, and in all vegetation types. In 1991, 70 Montague Island voles were trapped, by using Sherman live traps and museum special snap traps, in 7,314 trap nights (Weintraub and Cook 1991). In 1992, 25 Montague Island voles were trapped in 304 trap nights (Weintraub and Cook 1992). Trap success between the two years are not comparable, however, because trap effort was distributed among all habitat types on the island in 1991 and concentrated in beach fringe habitat in 1992.

Mortality

Naturally occurring predators on Montague Island include raptors, brown bears, river otters (*Lontra canadensis* Schreber), mink, and dusky shrews (*Sorex monticolus* Merriam). Bald eagles (*Haliaeetus leucocephalus* Linnaeus) are common on Montague Island, and great horned owls (*Bubo virginianus* Gmelin) are known to be present (Lance and Cook 1995). Other raptor species that may be present include peregrine falcon (*Falco peregrinus* Tunstall), goshawk (*Accipiter gentilis* Linnaeus), sharp-shinned hawk (*Accipiter striatus* Vieillot), short-eared owl (*Asio flammeus* Pontoppidan), boreal owl (*Aegolius funereus* Linnaeus), screech owl (*Otus kennicottii* Elliot), and saw-whet owl (*Aegolius acadicus* Gmelin). Of these species, the boreal owl and saw-whet owl specialize in year-round capture of mice (Snyder and Wiley 1976).

Brown bears from mainland Alaska are not known to feed on voles as a primary food source (Pearson 1985). Likewise, brown bears found on Montague Island are not likely to rely on tundra voles as a primary food source, because they feed heavily on the salmon (*Oncorhynchus* spp. Walbaum) that return to their natal freshwater streams. However, predation on tundra voles may occur in spring before the first salmon runs. This protein source may be vital to bear survival when they arise from winter denning.

Other species that may affect survival of Montague Island voles include mink and river otter that are known for killing, stockpiling, and eating tundra voles (Pearson 1985). Moreover, because of their small size, shrews are able to follow voles through their runways into their nest. Although there is little information about how effective shrews are at preying on voles in the wild, *Sorex monticolus* probably eat newborn tundra voles (Pearson 1985).

Parasites and diseases also may play an important role in the life cycle of Montague Island voles (Lance 1995, Lance and Cook 1995). Spleen enlargement was noted in 93 percent (N=44) of Montague Island voles examined (Lance and Cook 1995). Splenic weights averaged 5.4 percent of the total body weight of adult females and males. Previous work noted similar symptoms in microtines, including *M. oeconomus*, and identified a protozoan blood-parasite (*Babesia* spp.) as the cause of the disease (Fay and Rausch 1969, Ristic 1988, Ristic and Kreier 1981). The usual vector of babesias in nondomesticated animals is the Ixodid tick (Ristic 1988), and, perhaps non-coincidentally, the occurrence of *Babesia microti* in Alaska microtines parallels the geographic distribution of *Ixodes angustus* (Fay and Rausch 1969). The parasitemia, known as babesiosis, is not known to be lethal to its natural hosts, but persists in the chronic stage for the duration of the life of the animal (Fay and Rausch 1969). However, it is unknown how it affects individual host fitness. Reproductive output data suggest the number of embryos per breeding female was lower when splenomegaly was present; average number of embryos produced by animals exhibiting the splenomegaly was 5.75 (s.d. 0.975, N=4) compared to an average of 7.25 (s.d. 0.975, N=4) embryos produced by adult females that did not exhibit spleen enlargement (Lance and Cook 1995).

Tundra voles are known to survive and even breed in cold temperatures, above and below snow cover, as long as food conditions are good (Tast 1984). No mortality from direct human influences is known.

Effects of Land Management Activities

Species of *Microtus* that occur in forest areas generally are restricted to grassy clearings or sites where understory grasses or sedges proliferate; however, island populations of *Microtus* have been found in wooded habitats (Cameron 1958, Grant 1971). Habitat reduction for microtine rodents has resulted primarily from conversion of grasslands for farming and grazing (Getz 1985). Wet areas, drained and filled for farming, have been left unavailable to some populations of *Microtus*. Conversely, grassy edges along road-sides have provided extensive habitats for some species of *Microtus*. Moreover, *Microtus oregoni* often is found in early successional stages of clearcut forest sites (Getz 1985).

Management Issues

Relation to Human Activities and Management Actions

Depletion of forest habitat on Montague Island is of concern because of the lack of knowledge about seasonal habitat use and habitat use during high population densities by the Montague Island vole. Other plant communities on Montague Island are relatively unmodified by humans.

Landscape Structure

There are no data to address the landscape features that might impede a dispersing or traveling tundra vole.

Montague Island Vole Response to Management Actions

Because seasonal movements and dispersal patterns have not been investigated, Montague Island vole response to timber harvest, road building, and hunting regulations cannot be assessed at this time. Currently, there is little evidence to suggest that Montague Island voles have been adversely affected by deforestation or road construction. If, however, voles depend on closed-canopy forests for protection from winter elements or expand into forest habitats during high population densities, depletion of forest habitat could affect the health of the population.

Introduction of mink to Montague Island may affect vole populations through predation pressure. It is unclear, however, that a sustainable population of mink still exists on Montague Island (Crowley 1999).

Risk Assessment

Predators could have a negative impact following a "crash" in the tundra vole population. Heavy predation pressures on waning population densities could result in population extirpation (Rose and Birney 1985); however, given the current distribution and availability of good habitat for voles on Montague Island, this seems a remote possibility. It is unknown if the Montague Island vole population is cyclic, or what constitutes the boundaries of a population.

Approaches to Montague Island Vole Conservation

The taxonomic evidence regarding the subspecific validity of Montague Island vole is equivocal, and the potential effects that disease, predation, and management practices may have on the population is unknown at this time. Because beach fringe habitats may be necessary to maintain population viability of the tundra vole populations on Montague Island, the habitat relation should be more clearly understood. Moreover, the distribution of populations should be mapped so that critical habitat can be identified.

Information Needs

Information about population trends, seasonal habitat use, and effects of the disease, babesiosis, on Montague Island voles and tundra voles from adjacent islands and the mainland is lacking. Indexing is a cost-effective technique for monitoring the health of a population through time. Small-mammal population trends can be assessed relatively easily through removal trapping along lines or arrays set in specific vegetation types. In addition, data carefully collected through this type of sampling would be useful in identifying and assessing causes and progression of disease, such as babesiosis.

A large series of tissue and skeletal samples from Montague Island voles and tundra voles from other island and mainland populations in south coastal Alaska currently is housed at the University of Alaska Museum. Sensitive genetic techniques, such as nuclear DNA sequencing, could be used to further assess the potential differentiation of the Montague Island vole.

Investigation into the extent of infection and effects of babesiosis on the demography of Montague Island voles is necessary to effectively assess their population status. Moreover, because the squirrel tick (*Ixodes angustus*), which carries the *Babesia microti* blood parasite, can use numerous animals to complete its life cycle, other mammals should be surveyed for the presence of this tick and blood parasite. This can be accomplished through coordination with the Alaska Department of Fish and Game in Cordova, Alaska, during hunting and trapping seasons.

Factors that may negatively affect the beach fringe, which supports most of the tundra vole population on Montague Island, should be identified. Critical tundra vole habitat on Montague Island should be mapped. Snowfall data should be collected concurrent with population index data to reduce the risk of misinterpretation of population trends.

English Equivalents

When you know:	**Multiply by:**	**To find:**
Centimeters (cm)	0.39	Inches
Meters (m)	3.28	Feet
Kilometers (km)	0.62	Miles
Square kilometers (km^2)	0.38	Square miles
Hectares (ha)	2.47	Acres
Square meters (m^2)	10.76	Square feet
Celsius (°C)	1.8 and add 32	Fahrenheit

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