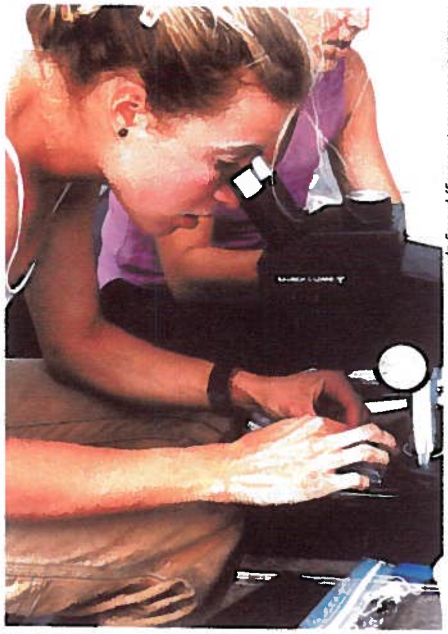


Museum of Southwestern Biology photograph

Figure 1. Doctoral student Natalie Dawson of the University of New Mexico uses a microscope to examine a diminutive shrew in our field laboratory.

Kurt Galbreath, a doctoral student at Cornell University, checks his sampling locality along the shores of Lake Clark.

Museum of Southwestern Biology photograph

Mammal Diversity: Inventories of Alaska National Parks Stimulate New Perspectives

by Joseph Cook, Natalie Dawson, Stephen MacDonald, and Amy Runck

Environmental conditions on earth have never been static, but an impressive series of indicators are now demonstrating that humans may be exacerbating rapid shifts in ecosystems on a global scale. Scientific investigations are focusing on the implications of environmental change in Alaska and elsewhere in the Arctic because, globally, high latitudes are particularly sensitive to these shifts. National park lands have become focal points of studies aimed at assessing changing environments because they are thought to reflect pristine areas that have been relatively unaltered by direct human influence.

Unfortunately, climate warming and related habitat shifts, increased pollutants on land and in the air, emerging diseases and pathogens, introduction of non-native species, and loss of biotic diversity now are likely impacting even our most pristine parks and preserves. To identify and track these and future perturbations, we need solid and extensive baseline information on environmental conditions, both past and present, in our national parks and preserves. Without rigorous documentation of the current status of organisms in these public lands, it will be impossible to predict how a future of unknown environmental change will affect the wildlife in these areas where so many people gather to appreciate, experience, and learn from the natural world.

One key element to understanding current conditions throughout the national parks is to catalog biotic diversity. Globally, losses of native organisms or additions of exotics have severely impacted our biosphere, so that changes in biotic composition are likely to have strong effects on the functioning of the world's ecosystems. The current global extinction rate is 100– to 1,000-fold greater than pre-human levels, and loss of local diversity can strongly affect ecosystem processes at both local and global scales *(Lawton and May 1995, Pimm et al. 1995).*

In Alaska, we are failing to adequately document and study these rapid changes in biodiversity, leaving us unable to assess causes and understand the often-complex dynamics. Without such information, we cannot develop functional policies that minimize negative biological and societal impacts. Climate warming is predicted to have amplified impacts in high-latitude ecosystems and is expected to influence the distribution of mammals and other organisms, including parasites, pathogens, and associated diseases. A baseline for wildlife and the pathogens that might impact wildlife (and human) health is vitally important so that we can rapidly track these emerging threats in the North.

Assessing change begins with modern inventory studies and long-term monitoring programs that can be used to develop rigorous databases. Ideally, these databases would be based on permanently archived museum specimens that have been collected regularly over many years and that contain representatives from all environmental gradients throughout a given region. The biological inventory program of the National Park Service (NPS) has begun to accomplish this task, but future work must continue if we hope to adequately represent all the distinctive biomes throughout

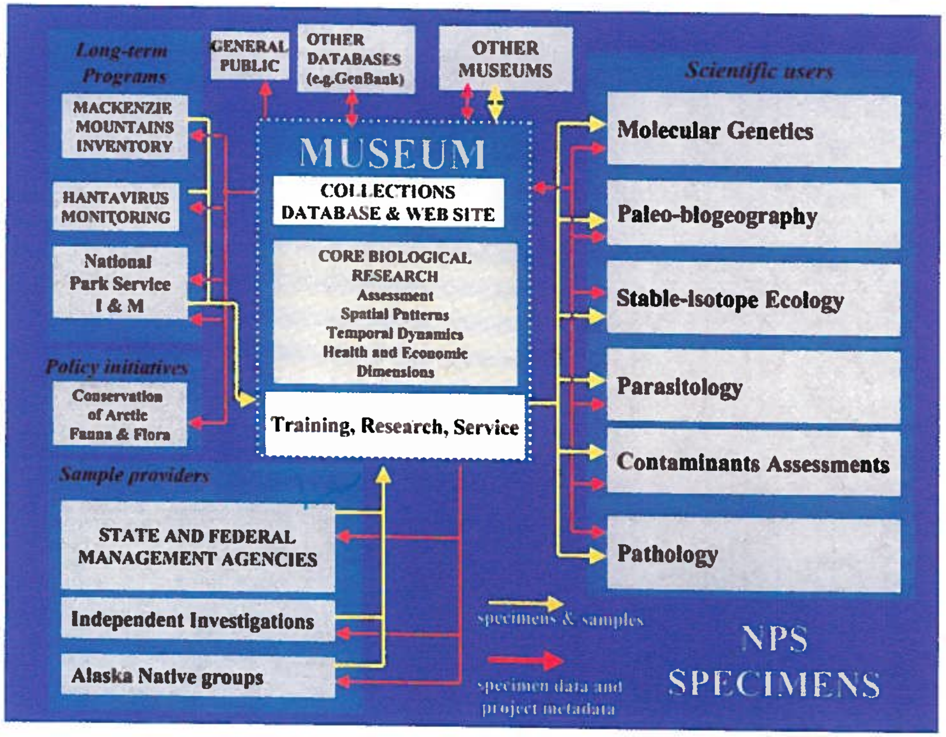


Figure 2. Schematic that demonstrates the many connections among the many providers, projects, and users of specimens that will arise from NPS inventory efforts.

Alaska and if we hope to effectively address temporal change. This inventory has brought together scientists, teachers, and students from around Alaska and the world to participate in establishing baseline information on mammals in arctic regions. These inventory materials and databases have been, and will continue to be, used in diverse scientific studies.

One of the important lessons learned from the 1989 *Exxon Valdez* disaster in Prince William Sound was that baseline inventory data, so critical to interpretation of the impacts of catastrophic events, were unavailable for that incredibly productive ecosystem. In short, it was difficult in many cases to assess the damage of the oil spill. Regular sampling and preservation of select museum specimens will prove invaluable as we attempt to monitor temporal change in the biotic diversity of Alaska national parks.

Field Inventories Provide Material for Diverse Studies

During the past four years, the Beringian Co-evolution Project (BCP), an international effort sponsored by the National Science Foundation, has teamed with the NPS Alaska Region Inventory and Monitoring Program to inventory the mammals and associated parasites in 11 of Alaska's national parks, monuments, and preserves. Our focus was on little known small mammals: shrews, bats, rodents, pika, hares, and weasels.

In some ways, these field studies of small mammals have not changed substantially over the past 100 years. We still camp at remote and beautiful sites to sample small mammals and spend long hours trying to learn about their habits and habitats. The methods used to investigate mammals, however, have evolved considerably. Our camps are now portable laboratories *(Figure 1)*. They allow us to create a variety of special preparations that are sent to specialists worldwide for analysis. We now haul liquid nitrogen tanks to ultrafreeze tissue samples, microscopes to sample and prepare tiny parasites, numerous vials to sort and preserve all the material, Global Positioning System (GPS) units to precisely georeference samples, and solar powered electric fences to keep the bears at bay.

Materials collected in these recent efforts represent geographically extensive and site intensive collections of unprecedented depth and scope. Each mammal we collect is assigned a unique field identifier, and all tissues, parasites, and other subsamples are linked to the original specimen. Thus all samples can be associated with a specific animal, GPS locality, and date of collection *(Figure 2)*. All mammals sampled are preserved as scientific specimens (vouchers), usually as cleaned skeletons or whole bodied in alcohol. Survey crews preserve tissues (heart, liver, kidney, spleen, and lung), and embryos in liquid nitrogen. These samples are deposited in cryogenic archives, such as the Alaska Frozen Tissue Collection at the University of Alaska Museum of the North. Searchable databases at the University of Alaska Museum of the North provide ready access to these collections (http://arctos.database.museum/SpecimenSearch.cfm).

Modern Collections Help Establish Baseline Environmental Conditions

Museum specimens provide a critical historical baseline for assessment of change caused by natural or human perturbations. Each carefully prepared specimen documents environmental conditions at a particular locality on a specific date. We cannot go back in time and recollect a particular specimen at a particular location. As they represent historical populations, the value of these specimens increases through time, particularly as the diversity of many localities is degraded. We have lost the opportunity to document environmental change in many areas because no baseline inventory was ever conducted.

One of the benefits of museum specimens is the ability to track diseases through time. For example, the discovery of deadly Hantavirus in the Southwestern U.S. was largely based on archived tissue samples associated with museum specimens at the Museum of Southwestern Biology. Because of inventories and museum collections, we now know that this "new" disease has existed for a long time, that it is widespread in western North America, and that closely related strains are found throughout the New World. Hantavirus is likely in Alaska, although we have yet to thoroughly survey for its existence.

In addition to vouchering each mammal captured, researchers process, preserve, and archive the many fleas, ticks, mites, tapeworms, roundworms, and other parasites that make a mammal's body their home. Viruses are screened at several labs. These materials are dispersed to international experts and to major collections such as Louisiana State University, Indiana State University, Georgia Southern University, Harvard School of Public Health, and University of Wyoming. Species lists and preliminary assessments of host associations and biogeographic distribution are in progress for respective components of the parasite fauna. Assessments of parasite diversity (e.g., numerical diversity, abundance, species richness, and overall geographic distribution) will soon be followed by extensive DNA analyses.

An Expanded View of the Mammals of Alaska

Alaska is home to slightly over 100 species of mammals, of which nearly half fit into the small mammal category. Among these, 32 species have been documented in national parks through voucher specimens as a direct result of this inventory *(Table 1)*.

The NPS/BCP inventory has produced a number of new and exciting insights into Alaska's mammals, including the tiny shrew, *Sorex yukonicus*, one of the newest mammals described for North America. While reviewing museum collections at the University of Alaska in 1993, one of our Russian colleagues, Dr. Nikolai Dokuchaev, recognized a new shrew species from collections made in the 1980s. This shrew is among the smallest mammals in the world, weighing less than a nickel. Since Dr. Dokuchaev's discovery *(Dokuchaev 1997)*, our inventories have documented that this "rare" species is actually widespread throughout Alaska, with a total of 37 specimens now known to science *(Figure 3)*. The tiny shrew probably occurs in neighboring Yukon Territory, but has not yet been documented in Canada.

Our work also significantly extends and clarifies the range of the singing vole, *Microtus miurus*, a vocal (as its common name implies), semi-colonial species of the mountains in Alaska and adjacent Canada. The vole had been previously recorded in Denali National Park and Preserve (DENA). The discovery of this highly social rodent at the southwest end of the Alaska Range in Lake Clark National Park and Preserve and in the Nutzotin Mountains in northern Wrangell-St. Elias National Park and Preserve extends the range over 185 miles (300 km) to the southwest and 125 miles (200 km) to the east of DENA. In addition, the inventory provided an opportunity to re-examine several preserved specimens listed as *Microtus miurus* from the Yukon-Tanana Highlands in and near Yukon-Charley Rivers National Preserve that are housed in the collections of the U.S. National Museum (Smithsonian Institution), Washington, D.C., and the Slater Museum, University of Puget Sound. All proved to be misidentified originally and are now identified as tundra voles, *Microtus oeconomus*. Because these specimens had been archived, we were able to make a significant correction to our understanding of the distribution of the singing vole.

New Parasites Discovered that Reflect Distinctive Geologic History

Our Finnish colleagues already have found and described a new parasitic worm species from our studies in Gates of the Arctic National Park in 2002 *(Haukisalmi et al. 2004)*. Other parasite work *(Figure 4)* through the renowned National Parasite Laboratory in Beltsville, Maryland, has also uncovered a phenomenal number of new species. These new forms provide a strong signal that their mammalian hosts likely are relicts of unglaciated refugia that existed at high latitudes during previous ice ages *(Hoberg et al. 2003)*.

Climate Change Can Be Tracked Using DNA Technology

DNA studies indicate a close genetic relationship between populations of small mammals in northwest Alaska and far eastern Russia. These findings reflect the past geologic history of the

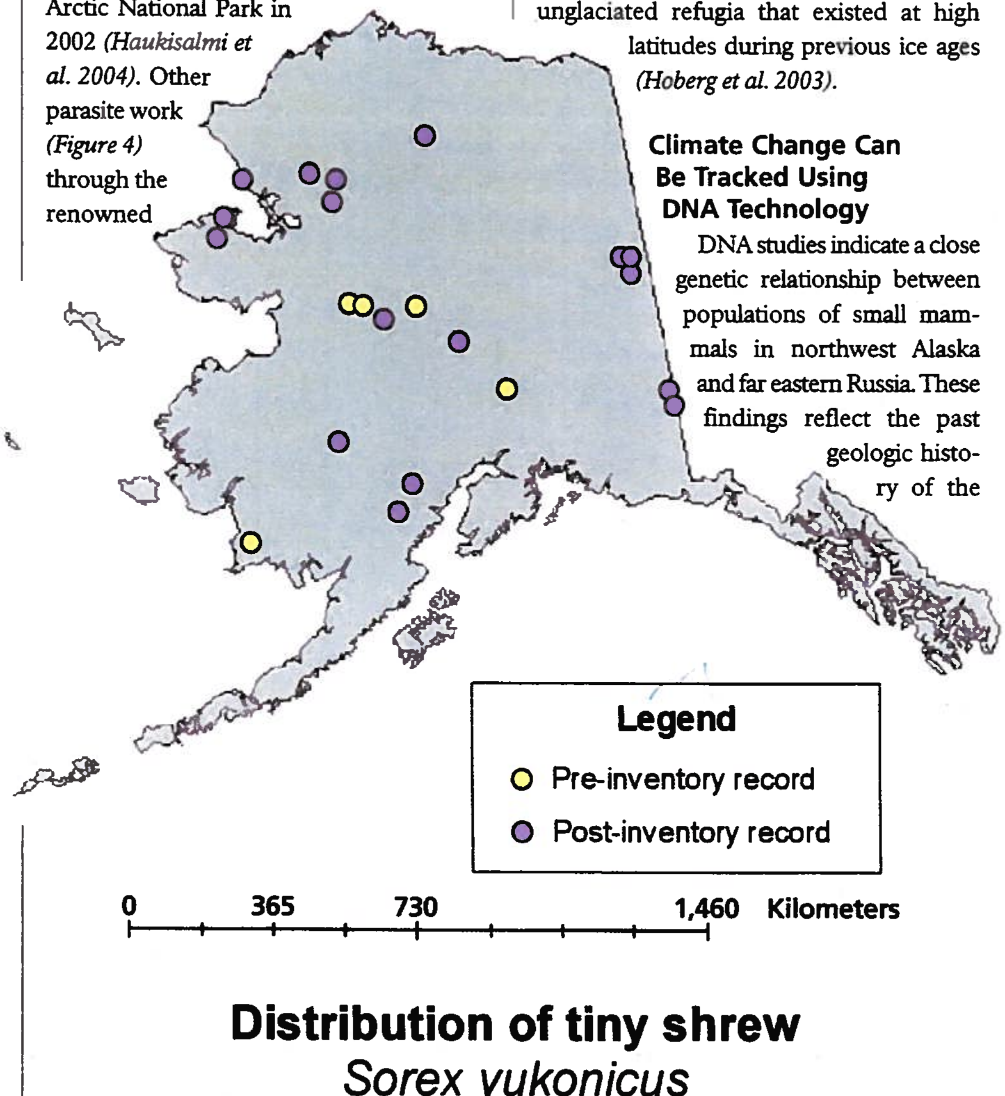


Figure 3. Thanks to the BCP/NPS inventory, we now know that the new shrew species for North America, *Sorex yukonicus*, has a much wider range than originally suspected.

	Central Alaska Network			Southwest Alaska Network*		Arctic Alaska Network				
Key to Abbreviations: N=National P=Park Pr=Preserve M=Monument	Denali NPPr	Yukon-Charley Rivers NPr	Wrangell-St. Elias NPPr	Kenai Fjords NP	Lake Clark NPPr	Bering Land Bridge NPr	Cape Krusenstern NM	Gates of the Arctic NPPr	Kobuk Valley NP	Noatak NPr
Shrews										
cinereus shrew	●	●	●	●	●	●	●	●	●	●
pygmy shrew	●	●	●		●		●	●	●	
montane shrew	●	●	●	●	●	●	●	●	●	●
water shrew	●		●							
tundra shrew	●	●	●		●	●	●	●	●	●
barren ground shrew						●	●	●	●	●
tiny shrew	●	●	●		●	●	●	●	●	
Bats										
little brown bat			●		●					
Carnivores										
American marten	●	●	●		●			●		
ermine	●	●			●			●		●
least weasel	●					●		●		●
Rodents										
Alaska marmot								●		
hoary marmot	●	●	●							
arctic ground squirrel	●	●	●		●	●	●	●	●	●
northern flying squirrel	●									
red squirrel	●	●	●		●			●	●	
American beaver	●	●						●		
meadow jumping mouse	●				●					
northern red-backed vole	●	●	●	●	●	●	●	●	●	●
collared lemming						●	●	●	●	●
brown lemming	●	●	●			●	●	●	●	●
long-tailed vole		●	●							
singing vole	●		●		●	●	●	●	●	●
tundra vole	●	●	●	●	●	●	●	●	●	●
meadow vole	●	●	●		●			●		
taiga vole	●	●						●	●	
muskrat	●	●			●	●	●	●		●
northern bog lemming	●	●	●		●			●		
NA porcupine	●	●	●					●	●	●
Lagomorphs										
collard pika	●	●	●		●					
snowshoe hare	●		●		●			●		●
Alaskan hare						●				

** The inventory of Katmai Park & Preserve will be completed by autumn 2004*

Table 1. Preliminary checklist of vouchered small mammal species from selected Alaska park lands. Other mammal species are present or probably present within parks shown here, but have not been substantiated with a voucher specimen.

region when these areas were connected by the Bering Land Bridge, up to about 10,000 years ago. Similarly, the parasites we have examined are closely related across this region. Such discoveries provide a much more powerful and predictive framework for understanding wildlife relationships across larger landscapes.

DNA analyses also can reveal when species have recently colonized a new area. Kurt Galbreath provided evidence for the recent invasion of Alaska by the tundra vole *(Galbreath and Cook 2004)*. Other technologies, such as stable isotope analyses, have tremendous promise for providing insight into changing environmental conditions, but specimens must be preserved and available for such investigations.

Vouchers in the Future

The voucher specimen-based inventory of National Park Service lands in Alaska establishes a framework for tracking change in northern environments. Already, a diverse set of publications (more than 50 peer-reviewed papers) based on BCP/NPS collections has set the stage for more comprehensive assessments of high latitude environments (http://www.msb.unm.edu/mammals/Cook/CurrentProjects/0051.html).

The new museum collections will continue to provide material for a large number of scientific investigations well into the future. Accessible collections are among the finest resources available to environmental scientists and educators today as specimens provide insight into the many tough questions facing society and its relationship to the natural world. Without a rigorous doc-

Museum of Southwestern Biology photograph

Figure 4. Kayce Bell, an undergraduate student at Idaho State University, explores the guts of a small vole in search of parasite specimens.

umentation of the resources we have available in our national parks, it is impossible to predict how these national treasures may change in the future. Dramatic environmental change on several levels has made future conditions in these northern ecosystems unpredictable. Knowledge is the key to facing the future with the certainty and clarity that will be necessary to deal with environmental change.

Acknowledgments

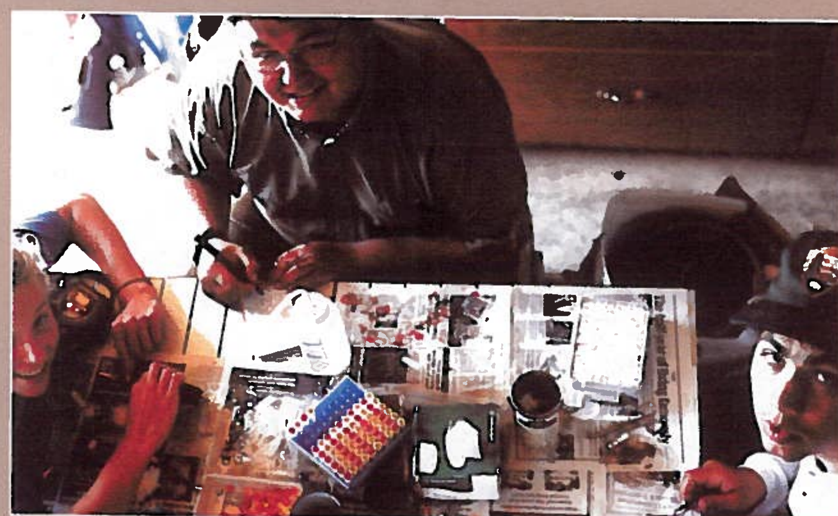
A project of this kind involved the hard work and diverse talents of many individuals and institutions. The enthusiastic support of many dedicated employees of the National Park Service is recognized. Special thanks to our field crews, our foreign collaborators, and the staff of the University of Alaska Museum of the North, especially Brandy Jacobsen, Gordon Jarrell, and Dusty McDonald. Dr. Jarrell, in particular, has worked tirelessly to establish web accessible databases for the University of Alaska Museum of the North.

Inventories Jumpstart Future Scientists

In addition to stimulating new discoveries in mammal diversity, the project sought to inspire future biologists and scientists. Four high school students (two Native Americans), ten undergraduate college students (three Native Americans), 13 graduate students, and four postdoctoral associates (two Russians, one Canadian) participated in the inventory fieldwork from 2001–2004. The Native American students came from Noorvik (Inupiat) and Dillingham (Yup'ik) in Alaska, and from Idaho (Shoshone).

Students and collaborators learned modern methods for field inventory in parasitology and mammalogy. Seasoned biologists provided field training to students at all levels. Museum and laboratory training continued at the University of Alaska Museum of the North, Museum of Southwestern Biology-Albuquerque, and U.S. National Parasite Collection-USDA in Maryland once the field season had ended. At these sites, students explored the role of museums in natural resource management.

We also helped design and execute small mammal field projects with high school teacher, Mike Sellers, and his students at Noorvik, Alaska. These students won competitions in the Alaska Native High School Science Symposium in 1999, and then, attended the National Conference in Minneapolis, where their project placed second in 2000. Two of these students were members of our field crews in northwestern and central Alaska.



Museum of Southwestern Biology photograph

Natalie Dawson, Tim Dyasuk, and Tazhay Jones at Amalik Bay in Katmai National Park and Preserve. Tim is an undergraduate student from Dillingham, Alaska.

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