National Park Service
U.S. Department of the Interior

Denali National Park and Preserve

Denali National Park and Preserve
Center for Resources, Science, and Learning




Photo Courtesy of Miki and Julie Collins

Summary of Current Resource Projects 2009

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Integrated Programs and Findings

Denali Park Road Capacity Study

Overview
In 2006, Denali began a multidisciplinary study designed to optimize visitor experience along the park road while protecting wildlife. Since 1972, traffic on the park road has been limited mostly to buses, and since 1986, a use limit of 10,512 vehicle trips annually has been in effect. Faced with increasing visitation and pressure to defend or change the limits to road traffic, park managers have designed a study to develop a greater understanding of the impacts of traffic volume and traffic patterns on the physical, biological, and social environment of the park.

Biologists studied wildlife movements in 2006 (20 collared bears) and 2007 (20 collared sheep). Traffic counters monitored road traffic at several locations in 2006. A "quiet night" (no traffic from 10 p.m. Sunday to 6 a.m. Monday) was instituted in 2007 and continued in 2008. Social scientists conducted surveys of park visitors about their park road experience (in 2006, they gathered qualitative information about visitor experiences, and used this information to ask specific questions in 2007, in order to select indicators and standards of an "acceptable" park road experience). Traffic patterns were monitored in 2006 by installing 130 GPS units on buses and 40 units in NPS vehicles traveling the park road. In 2007 and 2008, bus drivers on 20 buses used touch screen panels to record information about stops along the park road (e.g., wildlife, passenger drop off and pick up). Researchers gathered information about dust and sound along the park road in 2008. A comprehensive model of park road traffic has been developed to predict the effects of changes in traffic volume and timing on visitor experience and wildlife movements.

In summer 2009, researchers will continue to collect sheep and bear behavior data along the park road, GPS data on vehicle movements, and dust and sound data along the road. Bus drivers are encouraged to continue entering wildlife sighting information into touch screen panels for long-term monitoring of wildlife populations along the road.

Wildlife movement
To see the locations of the 16 GPS-collared grizzly bears during the summer of 2006, go to www.nps.gov/dena, click on Management, then Planning, then Road study, and select Wildlife Update February 2007. For an animation of how a bear moved over time, choose a bear number from the list on the same page. Alternatively, you can connect directly to: www.nps.gov/dena/naturescience/denali-park-road-capacity-study.htm

While 19 were collared, 3 were omitted from analysis because the young bears were associated with a female so movements were similar. The 16 grizzly bears crossed the park road 466 times between May and September 2006. Differences among bears (0-144 crossings) were primarily

due to the position of a bear's home range relative to the park road. The fewest crossings for all bears occurred in September.

Researchers considered a bear inactive when movement rates were less than 11 meters in one hour. The highest probability of being inactive was during early morning hours (especially between 3 and 4 am). On average, bears were inactive about 15 percent of the time (range 10 to 28 percent) across the entire season. Researchers found significant differences in the distance to the road of resting bear locations (relative to random points) for only five bears. In four of these cases, bears were resting closer to the road than would be expected. GPS-collared bears generally crossed the road most frequently between 8 and 10 a.m. and at 10 p.m. The low number of road crossings between midnight and 4 a.m. corresponds to the period during which collared bears were found to be the most inactive.

Based on the 60,000 hourly locations of Dall's sheep fitted with GPS collars in 2007, researchers learned that Dall sheep crossed the Denali park road 121 times during the study. Crossings occurred in the Igloo area (15 times) and the Polychrome area (106 times) by both sexes. Male sheep crossed the park road only during the spring season (15 May to 30 June), while females crossed in all seasons. Dall sheep crossed the park road during all hours of the day and night; but most (>80%) crossings occurred during the day when traffic volumes were highest on average. Road crossings by GPS-collared sheep occurred between Miles 33 to 38, 44 to 48, and 51 to 53 of park road with the most crossings occurring between Miles 45 to 47.

Average movement rates of both male and female sheep when crossing the park road were faster than movement rates when not crossing.

Visitor survey

In 2006, researchers conducted qualitative interviews with over 120 Denali Park visitors. Visitors were classified by user group—those who utilized (1) shuttle buses, (2) tour buses, (3) buses from lodges in Kantishna, and (4) their own recreational vehicle (RV) to access the park (Teklanika campers). Visitors were asked to identify and describe issues important to their experience on the Denali Park road.

In 2007, researchers conducted the second phase of the study—gathering data to set standards for indicator variables selected from results of the first phase. These variables included 1) number of buses on the road, 2) number of buses stopped at the same place to observe wildlife, 3) number of buses and people stopped at a rest area, 4) wait time at wildlife stops to see wildlife, and 5) percent chance of seeing a grizzly bear. The first three of these variables were addressed through a series of photographic simulations to depict a range of levels and associated impacts. For each series of photographs, respondents were asked a battery of evaluative questions. Respondents were asked to evaluate the acceptability of each of the study photographs from -4 ("Very unacceptable" to 4 "Very acceptable"), and then pick which photograph represented what they would prefer to see (preference), which showed the condition that most closely represents what they saw on the road (typically seen), which showed the condition that would be so unacceptable that they would no longer use the park road (displacement), and which photo represented the highest level of use the park service should allow (management action).

In the 2007 quantitative survey, visitors were asked to what extent they felt that certain issues were a problem on the park road. Respondents were asked to rate each question from 1 (not a problem) to 3 (big problem). The four most problematic issues were "not seeing enough wildlife close to the road," "too many buses on the Denali park road," too few animals along the road," and "dust generated by buses" (Fig. 1). Written quantitative surveys were completed by 707 park visitors who travelled the park road.

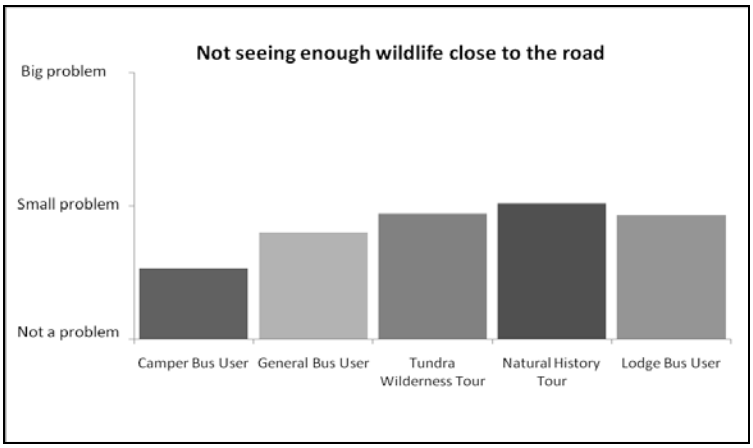


Figure 1. Respondents to the 2007 quanitative visitor survey found that not seeing wildlife close to the road was approaching the small problem level for some users. The values shown in the graph represent the average responses for various road user groups.

Traffic constraints

A comprehensive model of park road traffic has been developed to predict the effects of changes in traffic volume and timing on visitor experience and wildlife movements. Traffic patterns on the Denali Park Road are affected by locations of wildlife sightings, numbers and behavior of buses on the road each day, weather, and road maintenance. Researchers created the traffic model using the 2006 data collected from 130 GPS units installed on vehicles that use the park road on a regular basis (Joint Venture tour, shuttle, and camper buses) and 40 NPS vehicles (e.g., heavy equipment, road crew vehicles, and vehicles used on a regular basis). In addition, data used in the model was collected in 2007-2008 from touch screen panels on 20 buses (where drivers recorded information about the location of stops made along the road for wildlife sightings, passenger pick-up and drop-off, and road maintenance).

Data collected in 2007 and 2008 by drivers using the data panels (Fig. 2) provided some good data about stop time duration at stops for use in the traffic model. Stops made by drivers for grizzly bear sightings were generally longer on average than stops for other types of wildlife.

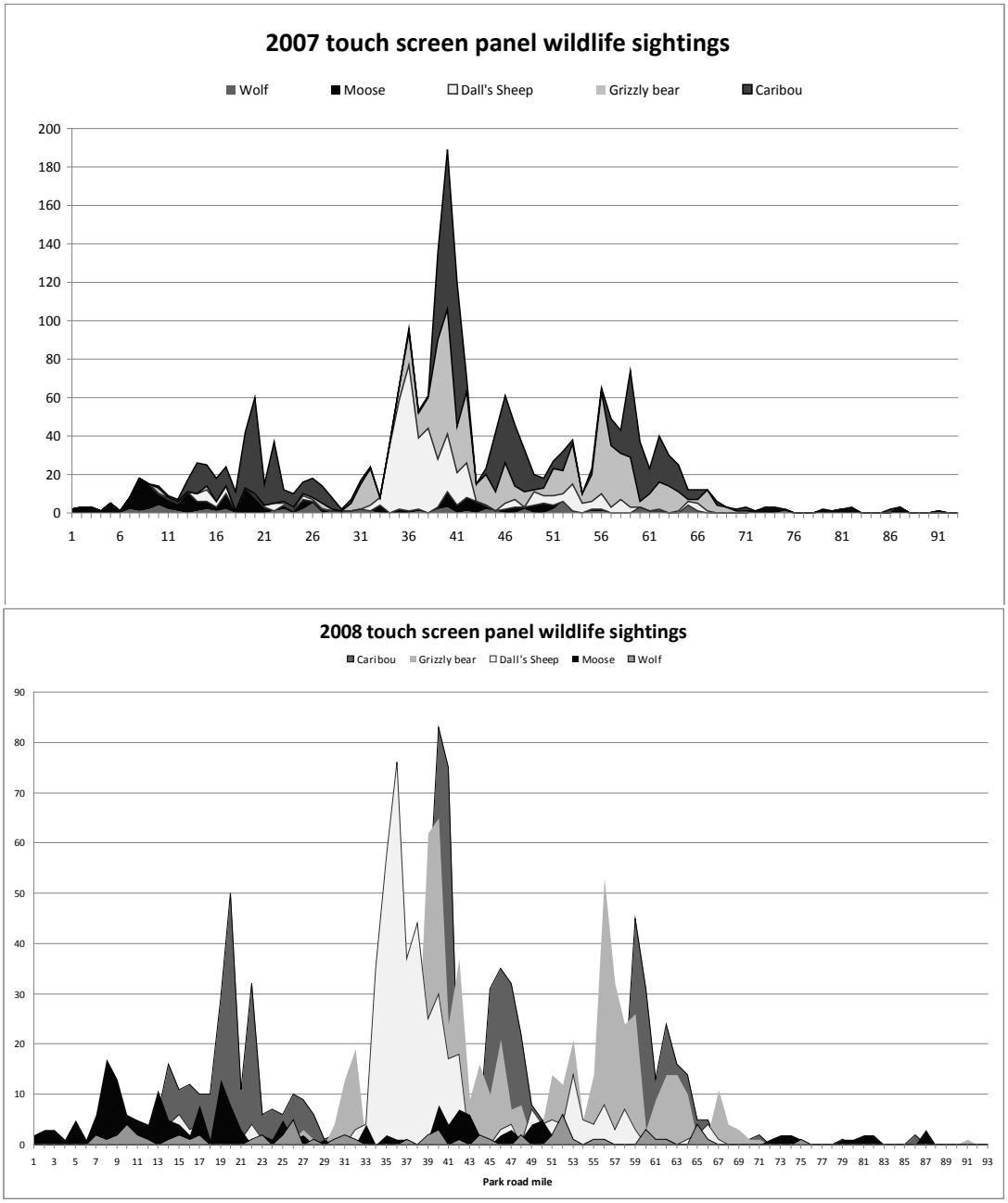


Figure 2. Number of wildlife sightings by mile reported by drivers with touch screen panels in 2007 and 2008. Note the y axis scale for number of wildlife is different for the two years.

The panel data were critical to the creation of the traffic model but will also be used to monitor long term trends in wildlife sightings and distribution along the Denali Park Road.

To understand how the current schedule of vehicles on the park road affects crowding standards created from the visitor survey, schedules representing the current base level of traffic and incremental 10 percent increases were run through the model. Early runs of the traffic model suggest that at the current base level of traffic on the park road we are violating the crowding standard for preferred number of buses at a wildlife stop calculated from the quantitative visitor

survey (1.75 buses) almost 70% of the time (Fig. 3). The next step for researchers will be to run alternative bus schedules through the model to see how they perform relative to crowding standards.

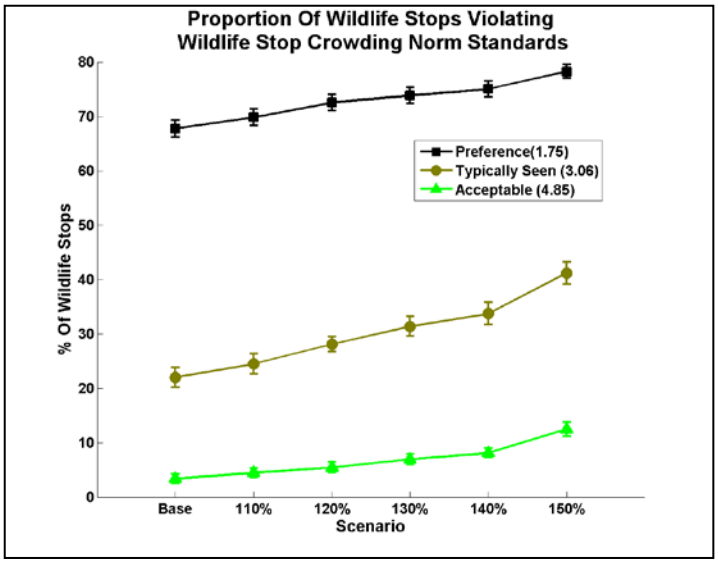


Figure 3. Proportion of wildlife stops violating each of the three normative standards.

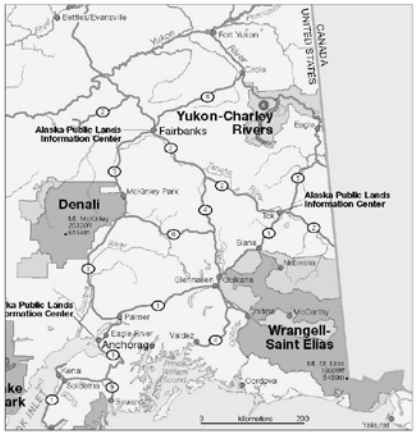
If the traffic simulation model and an environmental impact statement (EIS) suggest that an increase in traffic volume is feasible, an experimental increase in road traffic, timed to produce the greatest value in understanding impacts, will be undertaken as part of a Before-After-Control-Impact (BACI) study. The goal of the road study is to provide park managers with a tool to make the most well-informed decisions about the future of traffic on the park road. The EIS is currently underway in the Planning Division. A draft EIS is expected to be produced by December 2010.

Resource Stewardship Strategy

In 2009, Denali will complete its Resource Stewardship Strategy (RSS), which will guide its research and resource program for the next 15 to 20 years. The RSS document describes the desired conditions for park resources and values based on what the General Management Plan specifies, selects indicators to evaluate resource condition, and lists strategies and projects needed to maintain Denali's resource values. The complete RSS document will be posted on the park website and be available for viewing at Park Headquarters, and a shorter summary document with project highlights will be printed for distribution and be posted on the park website.

Central Alaska Network

The Central Alaska Network (CAKN) includes three national parks that encompass 21.7 million acres of land: Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve, and Yukon-Charley Rivers National Preserve.



Biological Inventories

Biological inventories were completed in 2005. These inventories documented the occurrence of 90 percent of the plant species, small mammal species, and freshwater fish species hypothesized to exist in Central Alaska Network parks.

Vital Signs Monitoring

The 2009 field season is the fourth year of program implementation after four years of planning and development. The focus has been to bring 11 of the 36 Vital Signs into full operation with collecting field data and analyzing and reporting on the data to parks and the public. The network produced full protocols for these 11 initial Vital Signs (Climate, Air Quality, Snowpack, Vegetation, Water Quality, Macroinvertebrates, Passerines, Peregrine Falcons, Golden Eagles, Moose, and Wolves). After protocols are given scientific peer-review, they are revised as necessary before final approval from the Alaska Region Monitoring Coordinator.

Kiosks

Interactive kiosks have been installed in four locations: the Murie Science and Learning Center (for Denali), the visitor centers in Slana (Wrangell-St. Elias), Copper Center (Wrangell-St. Elias, and the Fairbanks Public Lands Information Center. These kiosks encourage visitors to learn about the Vital Signs Monitoring Program, to view maps and graphs of the Biological Inventory data, and to see how parks utilize I&M data for management purposes.

Recent Findings

Combining data about vegetation and caribou – CAKN staff initiated a project integrating vegetation monitoring and caribou movement data for Denali. The project will result in a predictive model/map of caribou occurrence based on forage quality.

When does spring arrive? - The network began monitoring spring green-up in a cooperative project among interpretive staff in all three network parks and the network. This project allows interpreters to incorporate park visitors in the data collection process.

Current climate - In cooperation with Oregon State University and the PRISM (**P**arameter-elevation **R**egressions on **I**ndependent **S**lopes **M**odel) group, CAKN staff are in the process of updating the gridded climate maps for the Alaska region. Data from the new CAKN weather stations, which have been collecting data for 4 to 5 years, are being included in the analysis and will help refine the maps. In 2008, data were processed for inclusion in the model and the final station list will be reviewed by the National Weather Service, the Natural Resource Conservation Service, and other partners in this effort.

100 new lichen species documented in Denali - The network initiated a lichen survey in 2007 that resulted in as many as 100 new species to the park and will likely result in at least 3 new species for the state of Alaska. This survey will continue through 2009. (See also pages 12-13).

Range extensions for 3 anadromous fish species - Field efforts to sample remote streams in Wrangell – St. Elias and Denali resulted in extending the Alaska Department of Fish and Game's (ADF&G) Anadromous Waters Catalog. The presence of Chinook salmon in Moose Creek (Denali) was documented along with Coho salmon in a tributary of the Nizina River (Wrangell) approximately 5 miles upstream of their previous known extent, sockeye salmon in the Gilahina River (Wrangell), Coho salmon in Lake Creek (Wrangell), and the presence of pink and Coho salmon and Dolly Varden in 4 coastal streams (Wrangell). CAKN staff also documented the presence of Chinook and Coho salmon in Willow Creek, a tributary of the Tana River (Wrangell) that had not previously been known to support anadromous fish.

Volunteers aid small mammal field work - In the second year of the outreach program, local high-school, college, and Denali staff volunteers were invited to conduct small-mammal research in Denali with National Park Service biologists (see pages 28-29). CAKN plans to continue the program next year and to visit additional high-school classrooms to encourage more participation.

Website includes resource briefs - Read about CAKN activities and results for these vital signs: *Vegetation, Moose, Small Mammals, Climate, and Shallow Lakes* in resource briefs that are posted on the CAKN website http://science.nature.nps.gov/im/units/cakn/

Plants/Vegetation

Long-term Vegetation Monitoring

Field work continued in 2008 for the vegetation component of the long-term monitoring of park resources, including landscape monitoring of vegetation and white spruce cone production.

- **Monitoring white spruce growth and reproductive effort**

  The vegetation crew continues to monitor the permanent plots installed in 1992 within the Rock Creek drainage near Park Headquarters—observing the growth and cone and seed production of selected white spruce trees. Spruce cone production has been quite variable among years during this study, with especially high productivity observed in the years 1998, 2000, and high productivity in 2002, 2004, 2005, and 2008.

  The spruce sample population produced virtually no cones in 2006 and 2007 (no bar visible in Fig. 4), but 2008 marked a return to near-average cone production for these trees. On average, the trees in the forested sites have produced more cones per tree than did trees in the treeline plots over the course of this study, which was also the case in 2008.

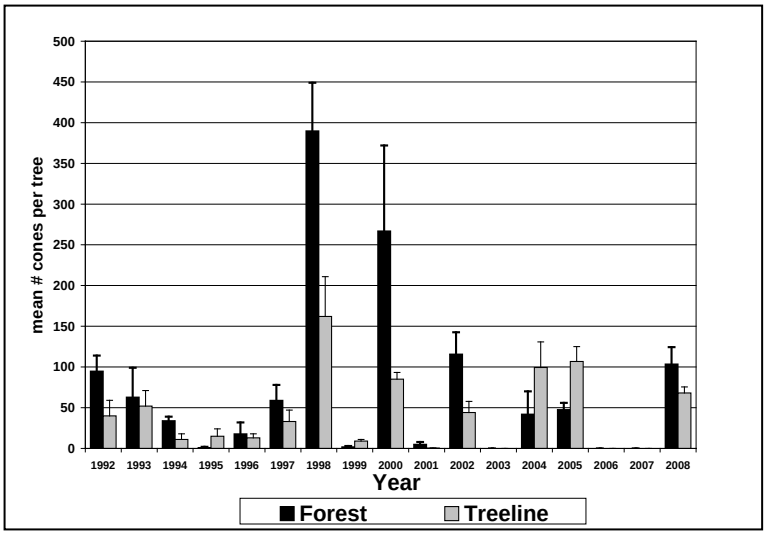


Figure 4. Average number of cones per white spruce tree observed in 3 treeline and 3 forest (valley bottom) plots in the Rock Creek drainage 1992-2008.

- **Landscape-scale vegetation monitoring project**

  The goal of this project is to detect changes in the fundamental properties of the vegetation cover of the park over long intervals of time. The design for this landscape-scale work is a systematic grid of sites at 20-km intervals laid out over the park landscape. For vegetation monitoring, parameters measured at the permanent plots include species composition and structure, abundance, tree density, tree size, tree vigor, and evidence of pathogens. The vegetation field crew also measures soil characteristics and landscape variables in these plots. The vegetation protocol for the Central Alaska Network vegetation monitoring has received a full peer-review, and the official implementation phase of the program began in 2006.

  In 2008, two vegetation crews completed sampling of the following mini-grids: Rock Creek, Middle Moose Creek, McKinley River, Upper Stony Creek, Sushanna River, Birch Creek Bend, and Middle Birch Creek. Sampling involved installing new plots and measuring vegetation in these seven mini-grid study areas, scattered across the northern part of the Park from Polychrome Glacier area to Broad Pass to the Stampede Corridor.

In 2009, the minigrids to be sampled are: Divide Mountain, Riley Creek, Double Mountain, Hult Creek, Slippery Creek, McKinley Bar, and Lower Muldrow Glacier.

A Ton of Exotic (Non-native) Plants Removed

In 2008, as happens every year, several individuals and groups helped Wendy Mahovlic remove hundreds of pounds of non-native plants from the Denali Park Road corridor, the Entrance Area of the park, and the Parks Highway near the park entrance. Counting volunteer hours for the native seed collection, 42 volunteers worked 2476 hours and pulled 2265 lbs of exotic plants.

- **Non-native plants with greatest biomass removed**
  Here's the roster of non-native plants removed in/near the park in 2008 (species with more than 50 lbs removed):
  * Dandelion (*Taraxacum officinale)*: 1485 lbs
    (Denali Park Road corridor)
  * White Sweet Clover (*Melilotus alba*): 100 lbs
    (Miles 232.5 and 238 Parks Hwy)
  * Hawk's-Beard (*Crepis tectorum*): 300 lbs
    (Sewage lagoon; Mile 0 to 3 of the park road)
  * Foxtail Grass (*Hordeum jubatum*): 350 lbs
    (Denali Visitor Center area)

- **Other non-native species of plants**
  Six additional non-native species other than dandelions were removed in 2008:
  * *Vicia cracca* (bird vetch): 10 lbs (Mile 1 to 3 of the park road)
  * *Lupinus polyphyllus* (bigleaf lupine): 5 lbs (Mile 1 to 3 of the park road)
  * *Leucanthemum vulgare* (oxeye daisy): a few plants (Nenana Canyon, near bus barn)
  * *Tripleurospermum perforata* (scentless false mayweed): 10 lbs (Railroad Depot)
  * *Linaria vulgaris* (yellow toadflax): 5 lbs (Railroad Depot; tracks near Triple Lakes Trail)

Revegetation of Construction/Disturbed Sites

- **Seed collections**

The summer of 2008 was a cool and rainy in Denali, as it was for much of Alaska. As a result, there were lower rates of flowering and delayed maturation of seeds, which impacted the ability of staff and volunteers to collect seeds. Because of Denali's far northern climate and location in the mountains, there are some summers where flowering and reproduction of plants is limited by the weather, and 2008 was such a year. Seeds were collected for sites along the park road where possible, but due to the poor crop, the major seed collection usually scheduled for August was cancelled.

- **Revegetation**

The big revegetation projects for the 2008 season were the revegetation of areas around the new Eielson Visitor Center and in the Toklat area, using vegetation mats and seeding in the fall*. Resources staff also assisted the trail crew in seeding areas in the Denali Visitor Center complex. Seeds from the following species were sown: *Oxytropis campestris, Hedysarum alpinum, Senecio lugens, Solidago multiradiata, Aster sibiricus*, and *Arnica frigida*.

*Note: The best time for harvesting and transplanting mats is when the mats are almost dormant (so little damage occurs to plants) when more plant energy is directed at root production (in spring and fall) than in leaf and fruit production (summer). Seeding in the fall mimics the natural dispersal of seeds at a time when the seeds won't germinate but will overwinter on site and be ready to germinate the following spring.

In 2009, for the eleventh consecutive year, volunteers will be enlisted to pull out non-native plants in the park and to collect wild native seeds for revegetation projects.

Off-Road Vehicle (ORV) Impacts

In 2008, park staff used mapping-grade GPS to map nearly 15.5 linear miles (25 linear kilometers) of tracks made by ORVs in the park. Staff recorded information about 13 trail attributes for each section of trail, including trail type (main active, secondary inactive, etc.), trail width, number of parallel paths along the trail segment, degree of vegetation stripping on the trail, depth of trail compared to adjacent areas, muddiness, and depth of damage to soil below the organic mat. The ORV tracks in this area were initially mapped in 2005.

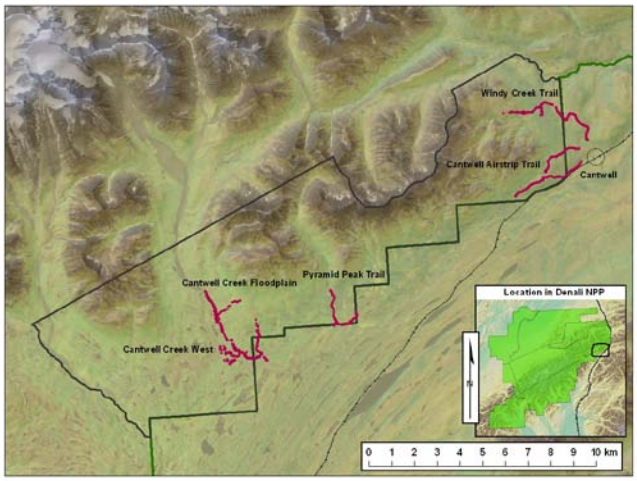


Figure 5. Sites for long-term monitoring of vegetation in areas now closed to ORV use.

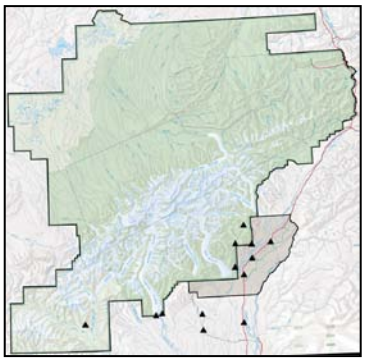
In the 2009 field season, Denali staff will continue to monitor the impacts of ORV use. Park staff has established seven long-term vegetation monitoring sites west of the Cantwell Creek Trail, in areas now closed to ORV use. Trail mapping using GPS will occur in 2009 (the fourth time such mapping has been done). Staff will be documenting changes in trail attributes of the Windy Creek, Cantwell Creek (Floodplain and West), Cantwell Airstrip, and Pyramid Peak trails (marked on Fig. 5), and collecting repeat photographs as another tool to look at changes over time.

Bryophyte and Lichen Inventory

As part of a multi-year project (2007-2009) to compile a rigorous, voucher-based inventory of Denali's nonvascular plants (mosses, lichens, liverworts) and to summarize current knowledge of these organisms in the park, during August 18-22, 2008, botany staff collected several hundred nonvascular plant specimens in 13 areas both north and south of the Alaska Range. They surveyed such habitat types as alpine heath tundra, alpine and lowland fen and wetland sites, granite outcrop areas, and lowland mixed hardwood and spruce forests. An initial rapid assessment of these collections has produced a provisional list of at least 15 taxa not previously listed on Denali's nonvascular cryptogam species list. (The botany staff also collected several hundred nonvascular plants in August and September 2007, producing a provisional list of at least 30 taxa not on Denali's nonvascular plant species list.) Several of these new taxa represent important range extensions and globally uncommon species status.

Also in 2008, researchers began the detailed microscopic work that it takes to identify the specimens collected in 2007 and 2008. As detailed microscopic identification of voucher specimens continues in 2009, additional new taxa to the park are expected.

Some significant species collected in during this project include:



- Boreal Felt Lichen (*Erioderma pedicellatum*) – Currently listed as Critically Endangered on the IUCN Red List of Threatened Species. This lichen was documented in the park in 2007 and more locales in the park and Denali State Park were documented in 2008 (see map). Previously it was known only from a very narrow range of sites in boreal eastern Canada and northern Europe.

- Waterfan Lichen (*Peltigera hydrothyria*) – Known only from North America, this lichen grows completely submerged in mountain streams. It is considered rare throughout its range in western North America.

- Methuselah's Beard Lichen (*Usnea longissima*) – An extremely pollution-sensitive species, this lichen is considered threatened or extirpated throughout much of its circumboreal range, due, in part, to deteriorating air quality.

Monitoring Dust Palliatives on the Park Road

To reduce road dust created by vehicular traffic, park maintenance crews apply an aqueous solution of calcium chloride ($CaCl_2$) to the surface of the park road. The application reduces dust and the need for replacing the fine materials constantly lost from the road as dust. However, adding this compound also has the potential for adversely affecting ecosystems adjacent to the road. NPS has developed a monitoring plan to assess and monitor the possible effects on soil, water, and vegetation of applying calcium chloride to the park road.

In 2005, park staff buried 15 pairs of lysimeters (instruments designed to sample water from within the topsoil) at Mile 15.2, 18.6, 22.2, 23.4, 26.9, 28.9, 31.2, 41.5, 49.1, 58.4, 60.4, 64.5, 71.3, 79.8, and 88.4—one lysimeter was buried near the road, and one about 10 meters away. Water samples are being taken annually from lysimeters and nearby water bodies to test for chloride ions.

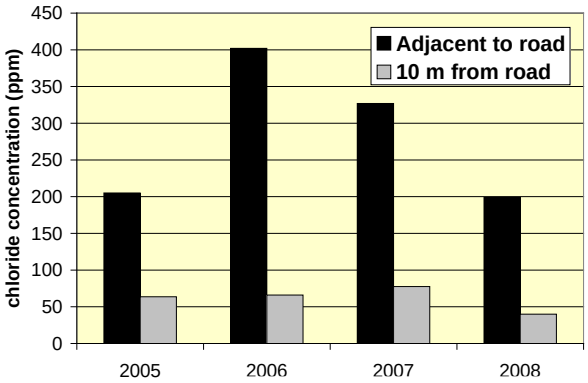


Figure 6. Chloride concentrations at sampling site at Mile 31.2 on the park road. Chloride concentrations are given for samples taken adjacent to road edge (black) and 30 feet (10 meters) from the road (gray).

The data from the first four years of sampling (2005 – 2008) show that there is little chloride reaching the water bodies. Two sites sampled on east end have shown high levels of Chloride (up to 402 ppm) adjacent to the road. The data from one of these sites (Mile 31.2) is shown in Figure 6. These levels of chloride represent levels that may begin to have biological effects and thus harm roadside vegetation, and botany staff will be monitoring the levels of chloride in these sites carefully. The lysimeters will be sampled again in late summer 2009.

Wildland Fire

Monitoring Wildland Fires

Denali National Park and Preserve has 3,359,449 acres (out of a total of 6+ million) that are covered by burnable vegetation. Eighty-nine percent of the burnable vegetation acres (2,983,460 acres) lies within "limited fire management options". These options allow fire to play its natural role in the ecosystem. Although some wildland fires are suppressed because they threaten natural or cultural values, the emphasis of the fire management program at Denali is on actively monitoring wildland fires while they burn and on protecting individual isolated structures in the fire's path.

One wildland fires and several prescribed fires occurred in Denali in 2008:

Fire Name	Burn Period	Acres	Fire Type	Comments
Sewer Lagoon slash burn	11/19 – 11/21/07	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
70 Mile Pit slash burn	5/11 – 5/13/08	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
Wigand Creek	6/15 – 6/21/08	107	Wildland Fire	Wildland Fire Use
Sushana Cabin slash burn	8/6 – 8/7/08	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
Stampede Mine slash burn	8/13 – 8/14/08	2.4	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
Upper Windy Cabin slash burn	8/18 – 8/20/08	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects

Several prescribed fires are completed or planned for fiscal year 2009:

Fire Name	Burn Period	Acres	Fire Type	Comments
Sewer Lagoon slash burn	11/19 – 11/21/08	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
Toklat slash burn	5/18 – 5/20/09	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
70 Mile Pit slash burn	5/20 – 5/22/09	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
Kantishna Pit slash burn	5/22 – 5/24/09	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
Lower Savage Cabin slash burn	8/10 – 8/12/09	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
Riley Creek Cabin slash burn	8/17 – 8/19/09	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
Lower Windy Cabin slash burn	9/14 – 9/16/09	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects

[1] Prescribed fire is a fire ignited by management actions under certain, predetermined conditions to meet specific objectives related to hazardous fuels or habitat improvement. Prior to a prescribed fire, a written, approved prescribed fire plan must exist and NEPA requirements must be met.

Fire monitoring includes observing a fire from aircraft, digitally photographing and mapping its progress, and keeping an updated narrative of the fire's status and behavior. Current and forecasted weather over the fire area is also monitored to ensure that the fire will continue to burn only where allowed. Protecting isolated structures that lie in the fire's path is generally accomplished by setting up a water pump and sprinkler system on or around the structure as most structures tend to be located adjacent to water sources.

Creating Defensible Space Around Structures

History has shown the devastating effects when wildland fire combines with a buildup of vegetation around structures. Hazardous fuels around structures in the developed and backcountry areas of Denali National Park and Preserve have or are being reduced to create a "defensible space" around the structures. Much of the built environment in Denali was constructed during the 1920s and 1930s. Structures were often built close to the forest edge or the forest has since grown back into the areas disturbed during construction.

Creating a defensible space includes clearing all flammable vegetation within 30', and thinning the vegetation that lies within 30' to 100' of the structure (cutting some trees, other vegetation; removing lower branches of trees). The defensible space reduces the risk of property damage in the event of a wildland fire and improves safety for visitors, residents, and firefighters. Once all the defensible spaces have been created, a maintenance and educational program will continue the benefits of this program. Firewise is the name given to the creation of defensible space by thinning, limbing, or clearing space around structures. Throughout the project, Denali employees receive project updates and other fire information. Two hazard fuel project success stories are posted at http://www.nps.gov/akso/Fire/firehome.htm

- **Developed areas**. In 2008, fire management staff improved the defensible space (about 0.4 acres) at Park Headquarters by trimming branches to varying heights from the ground to give a natural appearance. In 2009, fire management staff will treat additional areas as the need is identified in the maintenance cycle of previously created defensible space around buildings.

- **Cultural resource sites**. In 2008, staff burned debris that had accumulated from past hazard fuels projects at the Sushana and Upper Windy Creek Patrol Cabins and at the Stampede Mine, completing the cycle for the initial treatment of the sites. These sites are now entering a maintenance cycle. In 2009, staff will burn the unburned piles at the Lower Savage, Riley Creek, and Lower Windy Creek Patrol Cabins. The Sanctuary, Moose Creek and Igloo Ranger Patrol Cabins and the Parker Cabin are candidates for hazard fuels reduction initial and improvement treatments.

In 2009, the Fire Management Staff will revisit 24 of the 26 vegetation plots that were installed in 2003-2004 (as pre-treatment plots), and resampled in 2005 (one year post-treatment). The goal is to measure how the vegetation in the defensible space (treated) acres changes over time (this is the 5-year post-treatment sampling). By tracking the plots, managers can identify the recurring maintenance treatments needed to minimize the threat of wildland fire.

Videography Landcover Reclassification and Moose Browse Utilization

The purposes of this study are to reclassify the "burn" cover type (12.9 percent of the landcover) in the Landcover Classification that was produced from satellite images that were taken over several years (1985, 1988, 1991, 1996, 1999). The analysis and imagery that was used to develop the landcover classes are unable to detect non-burn classes of vegetation for up to 15 years after a fire.

To reclassify the burn areas in the short term, project staff needed to test the use of videography as a method for landcover reclassification. The project also can validate predictive fire models used by fire managers, validate successional patterns for areas of different burn severity, and identify fire effects on the level of moose browse observed under varying burn severity levels and age of burn.

Understanding the natural variability related to fire is also necessary in order to identify potential abnormal effects associated with long-term climate change or management activities.

A draft model to reclassify the Landcover Classes based on fire history was developed in early 2009. A coverage of this new Landcover Classified geospatial information system will be available by summer 2009. In the long term, fire managers would like to combine data about vegetation recovery after fires to model plant succession after a fire on a landscape scale, and apply this information to create maps. An example using this model for the area burned by the Hightower Fire is illustrated in Figures 7 to 9.

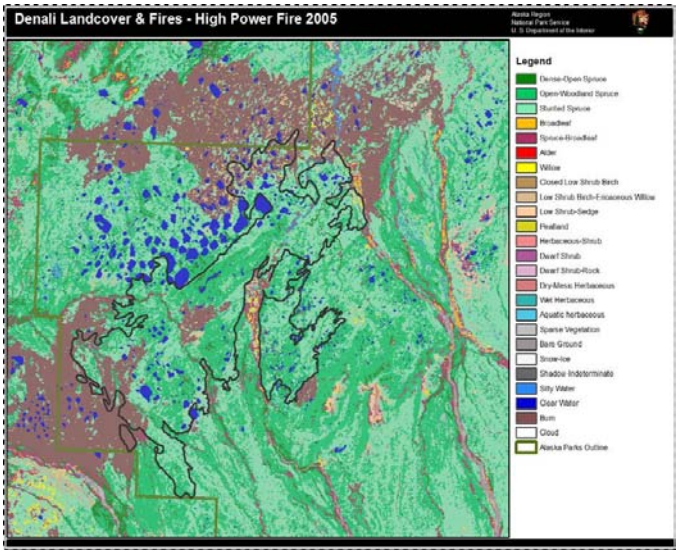


Figure 7.
Pre-fire Landcover Classification for 2005 Highpower Fire (outlined in black).
Note that medium-shaded areas to north and southeast (brown in color) are classified as "burn" in the landclassification.

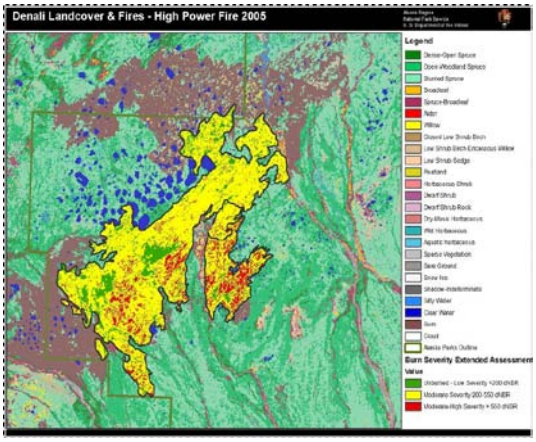


Figure 8.
Burn severity is mapped for the 2005 Highpower Burn. Three severity classes are indicated with different shadings (colors) (identified at the bottom of the key), for the Highpower Burn outlined in black.

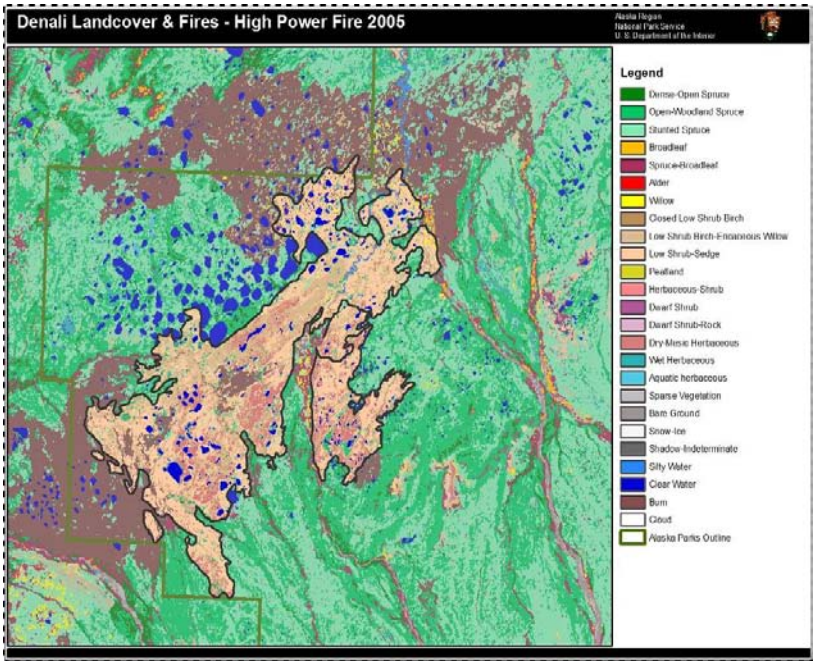


Figure 9.
New Landcover Classification (draft) for the 2005 Highpower Burn.
The current vegetation for the area burned in 2005 by the Hightower fire (area bounded by black line) is predicted based on what is known about how vegetation recovers after a fire and how this recovery or plant succession is different depending on the severity of the burn. Burn severity data were obtained from vegetation plots after the fire.

Analysis for this project is in progress and will continue in 2009 (no further field sampling).

Fire Education

- **Murie Science and Learning Center Science Series.** In 2008, after working with Western Area Fire Management and the Regional Fire Communication and Education Specialist, MSLC staff incorporated wildland fire management messages in select presentations.

- **Commercial Tour Bus Driver Orientation.** The Regional Fire Communication and Education Specialist, Regional Fire Ecologist, and Interagency Fire Cooperators gave fire ecology presentations to the Princess Tour Bus drivers. This was the first year that fire management presenters were incorporated into the tour bus orientation.

- **Firewise Workshops.** In 2008, no workshops took place in the Denali Area. The Alaska Western Area staff will seek opportunities to promote the recently revised Alaska FIREWISE concept in 2009. Firewise workshops teach community members how to reduce the combustible material around their homes in order to reduce the wildland fire risk.

- **Alaska Interagency Wildland Fire Key Messages.** To communicate clearly and consistently across all agencies and disciplines, the Interagency Wildland Fire Prevention, Education, and Awareness Committee has developed and continues to refine key messages about wildland fire.

Wildlife

Keep Wildlife Wild

Denali National Park and Preserve resource staff continue to educate people with the basic message: "Keep wildlife wild - do not approach or feed wildlife." Anecdotal observations continue to indicate that the program is successful. Fewer reports of human-wildlife conflict due to food conditioning have been reported each year the program has been in effect. The program includes bookmarks, brochures, and signs bearing a universal symbol "Do not feed the animals" with text explaining why this is important. Again in 2008, staff distributed these materials around the park and will do so in 2009. Signs appear on trash cans, picnic tables, and toilet stall doors. The message has also become part of every interpretive program.

The National Park Service recently formed a steering committee composed of representatives from each of the NPS regions to address the issue of wildlife habituation throughout NPS areas. The goal is to determine the extent of habituation and the species involved and to standardize our management methods for habituated wildlife throughout the service. Pat Owen, Wildlife Biologist, was selected to serve on the committee and will use the information compiled by the group to continue to improve on Denali's efforts to Keep Wildlife Wild.

The Keep Wildlife Wild program serves as a model for other parks. Wildlife staff encourages everyone working at the park to take every opportunity to discourage the feeding and subsequent habituation of wildlife.

Bears

- **Grizzly bear monitoring**
  This long-term study on the north side of the Alaska Range focuses on a sample of grizzly bears between the Muldrow Glacier and the Herron River. Radio-collared females are located from den emergence to the end of September to locate and follow the mortality of the sows and their cubs.

Bear capture was conducted on May 29 and 30, 2008 from a helicopter, with fixed-wing aircraft support. Bad weather and unavailability of a helicopter caused the capture effort to be shorter than planned. Wildlife staff replaced collars on four female grizzly bears, captured and collared one new three-year-old female, and retrieved one dropped collar. For the 2008 season, wildlife staff followed 13 collared bears (all female), which is below the target sample size of around 20 bears.

Following the sows through the 2008 season, at den emergence, five sows each had twin spring cubs, one sow had two yearlings, and the remaining seven sows did not have young. By September, three sows each had a single "spring" cub, but the remaining seven spring cubs could not be accounted for and were presumed dead. The two yearlings survived to the end of the season. The oldest bear in the study is 20 years old.

Plans for 2009 are to replace radio collars where necessary, increase the sample size by collaring new bears or locating those with failed collars, and investigate the mortalities/dropped collars.

- **Population estimates:**
  On the south side of the Alaska Range, the park cooperated with the Alaska Department of Fish and Game to estimate population numbers for both black and grizzly bears. The study was conducted in 2000, 2001, and 2003. A final report on this study has not yet been received. Preliminary results indicate that for the entire study area, the density for brown bears is approximately 28 bears/1000 km^2. This density is slightly higher than that documented on the north side. Density for black bears is predicted to be about 80 bears/ 1000 km^2.

Bear Management

Background: Bear problems at Denali escalated in the 1970's and 1980's. By 1982, Denali had the highest rate of backcountry bear incidents of any U.S. national park with a significant grizzly population and high backcountry use. Bears were getting food from backpackers and poorly-handled garbage, causing property damage, and injuring people. Between 1946 and 1983, 48 bears were relocated or destroyed in the park. Denali's Bear Management Plan (BMP) was developed to address bear problems and reduce bear-human conflicts.

By educating staff and visitors about bears and providing bear-resistant storage for food and trash, the park has dramatically reduced conflicts with bears and other wildlife. In 1984, Bear-Resistant Food Containers became mandatory for backcountry users. By 1985, incidents with bears in the backcountry had dropped nearly 90 percent. The last problem with a food-conditioned bear in one of the Denali campgrounds was in 1994. Since 1983, only four bears have been destroyed, one sent to a wildlife park, and two relocated by the National Park Service.

The success of the Bear Management Plan (BMP) is largely dependent on the cooperation of all NPS employees. Within the BMP, it states that all employees are responsible for reporting or correcting possible bear problems as they develop. Supervisors and liaisons are responsible for ensuring that their staff or crews get bear safety training and are aware of Denali's policy regarding bears and other wildlife.

To obtain more information, schedule bear-safety training, or borrow equipment (limited availability) for bear-proofing camps and worksites, contact Pat Owen (Wildlife Biologist) at 683-9547.

Between May 18, 2008 and September 7, 2008, 89 bear-human interactions were documented on Bear Information Management System (BIMS) forms, which is a 38 percent decrease from 142 interactions in 2007. The 2008 interactions were classified as three observations, 77 encounters, nine incidents, and one control action. For breakdown by frontcountry and backcountry, see the following table:

Interactions	FRONTCOUNTRY	BACKCOUNTRY	**TOTAL**
Observations	1	2	**3**
Encounters (when bear is aware of human(s) and thus the bear's behavior is altered)	25	52	**77**
Incidents (when bear is involved in close charge, actual contact, or damage to human or property)	1	8	**9**
Control Actions	1	0	**1**
Total	**28**	**62**	**90**

The most obvious change over past years is the increase of bears obtaining food. In the four years prior to 2008, there was only one incident reported of a bear obtaining food, while in 2008, there were three such incidents reported.

The importance of preventing bears from obtaining human food should be explained and emphasized to all hikers and visitors camping in Denali campgrounds and backcountry areas.

The one control action in 2008 involved NPS staff in a backcountry situation. Three seasonal NPS biological technicians were sampling vegetation along the remote river bar when a sub-adult black bear approached their field camp late at night. The team responded with aversive action including yelling, arm-waving, and throwing objects at the bear. After initially being chased off into dense brush, the bear circled back to the camp three or four times, and at one point, the animal clawed and destroyed one of the tents. On its final approach to the camp, the black bear aggressively charged the three researchers, hissing and pouncing at the ground. An attempt to divert the bear with pepper spray was ineffective.

In accordance with policy set forth in the park's Bear-Human Conflict Management Plan, one researcher made the decision to shoot the bear when it charged within 20 feet of the team and posed immediate hazard to human safety. The employee, who was qualified and authorized by the National Park Service to carry and use firearms in the park, hit the bear in its mid-section with a 12-gauge shotgun slug. Despite considerable blood loss, the wounded bear moved into dense vegetation and out of view.

The three employees immediately notified Denali's Communication Center via park radio. The following morning, the park wildlife biologist, along with two Law Enforcement rangers and one backcountry ranger, were flown to the camp in a park helicopter to investigate the situation and take further action if necessary. The group tracked the blood trail for 600 feet (200 meters), after which they lost the blood trail, and did not locate the wounded bear in the dense brush. Both the helicopter and a fixed wing aircraft searched from the air, but spotters were similarly unable to locate the bear. Park management issued a 5-day backcountry closure for the area, a remote unit that sees very limited visitor activity.

Wildlife Observations along the Park Road

This study, which relies on those bus drivers who volunteer to help monitor wildlife along the park road, continued in 2008 (and became part of the larger road capacity study). Drivers record the numbers of bears, moose, sheep, caribou, and wolves they see on their trips – instead of paper data sheets, bus drivers now use touch screen panels found in some buses. Numbers of sightings are summarized and compared to previous years to detect substantial changes. So far, differences in numbers from year-to-year are within the range expected due to natural variation.

Information about wildlife sightings on the Denali Park road serves an important function in long-term monitoring of wildlife populations along the road, as well as a very important component of a quality visitor experience in Denali that managers are tasked to maintain.

Based on the groups of wildlife observed per bus trip in the last 5 years (2004 through 2008), a visitor taking one bus trip into the park could expect (based only on averages) to see 2 groups of caribou, 2 groups of grizzlies, and 1 or 2 groups of Dall's sheep (Fig. 10).

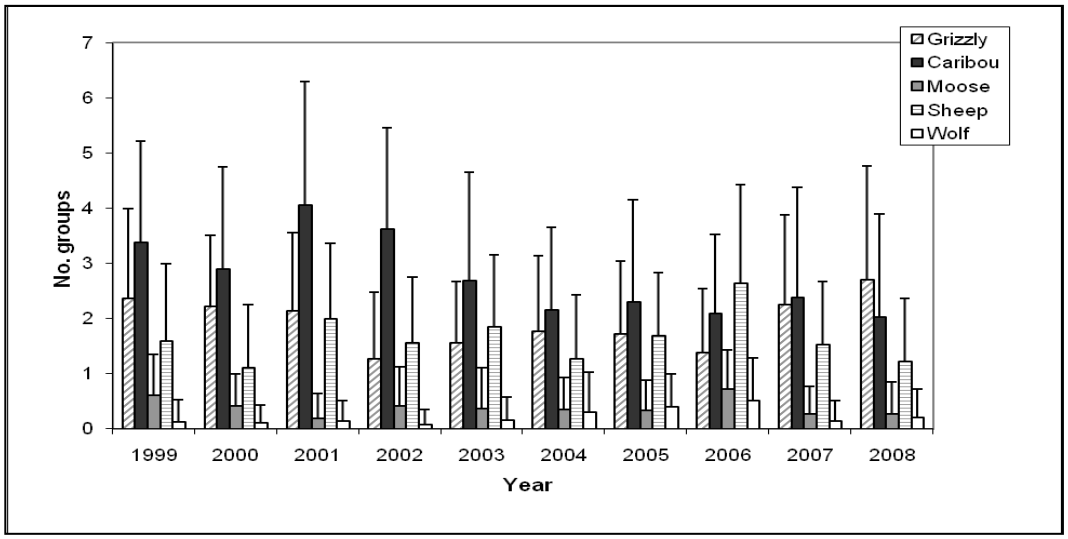


Figure 10. Number of groups of wildlife, by species, expected to be seen on a bus trip into the park.

Based on bus driver observation data from the last 5 years (2004 – 2008), a visitor taking 10 trips into the park would be expected to see a moose on 3 out of 10 trips, and a wolf on 2 or 3 out of 10 trips (Fig. 11).

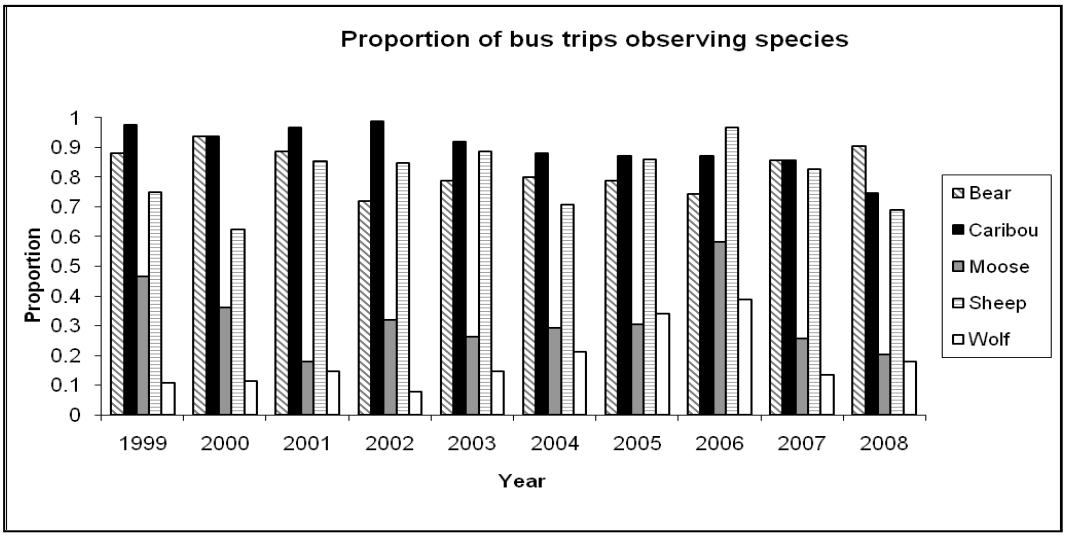
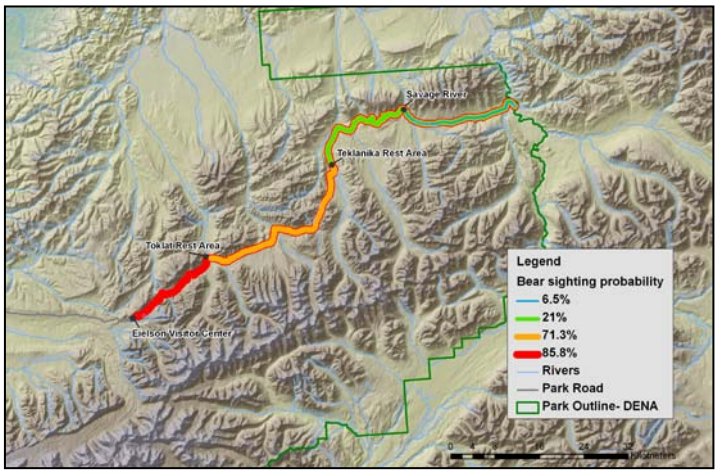


Figure 11. Proportion of bus trips expected to see see the "big five" based on bus driver observation data.

In summary, beyond the Savage River, the odds (based on averages over the last 5 years) of seeing the five large mammals are: caribou (84.5%), grizzly bear (81.8%), Dall sheep (81.0%), moose (32.8%), and wolf (25.1%). For wildlife viewing odds over the last 10 years, and for the variation among years, see Fig. 11 and note the height of the bars by species by year.

Recent data collected from touch screen panels (specifically the entries of bear sightings) have provided information about where the bear sightings occurred. From that information, it is possible to establish the probability of viewing grizzly bears for kinds of bus trips by destination. For example, the probability of seeing a bear on a bus trip increases from 21 percent to 71 percent by taking a bus to Toklat instead of to the Teklanika Rest Area (see map at right and table below).



Bus Destination	Savage River	Teklanika Rest Area	Toklat Rest Area	Eielson Visitor Center
For 100 bus trips to this destination, during approximately how many trips would riders likely see a bear?	6 or 7	21	71	86

Wolves

Denali National Park and Preserve's wolves have been studied by researchers since 1939. Population estimates were not very accurate until 1986, when a large-scale wolf research project was initiated by David Mech and others. This project provided basic information necessary for effective wolf management. While the intensive research program was concluded in 1993, research and monitoring efforts have continued.

The current study consists of maintaining one to three radio-collared wolves in each known pack inhabiting the park north of the Alaska Range. Radio-collared wolves are located about twice per month, with additional locations during late September to early October to determine fall pack sizes and to count pups, and during March to determine late winter pack sizes.

Telemetry locations acquired over two years are used to determine the area of each pack territory. Areas of the combined pack territories and pack counts are used to estimate abundance and density of wolves. In addition, monitoring data have been used to determine wolf movements, den locations, mortality factors, behavior, and population dynamics.

As of April 1, 2009, 25 wolves in 17 packs in and around Denali wore conventional, VHF radio collars that are located from antennae-equipped aircraft. Another 8 wolves carried GPS collars that determine the animal's location once per day, store the data, and upload it through the ARGOS satellite system.

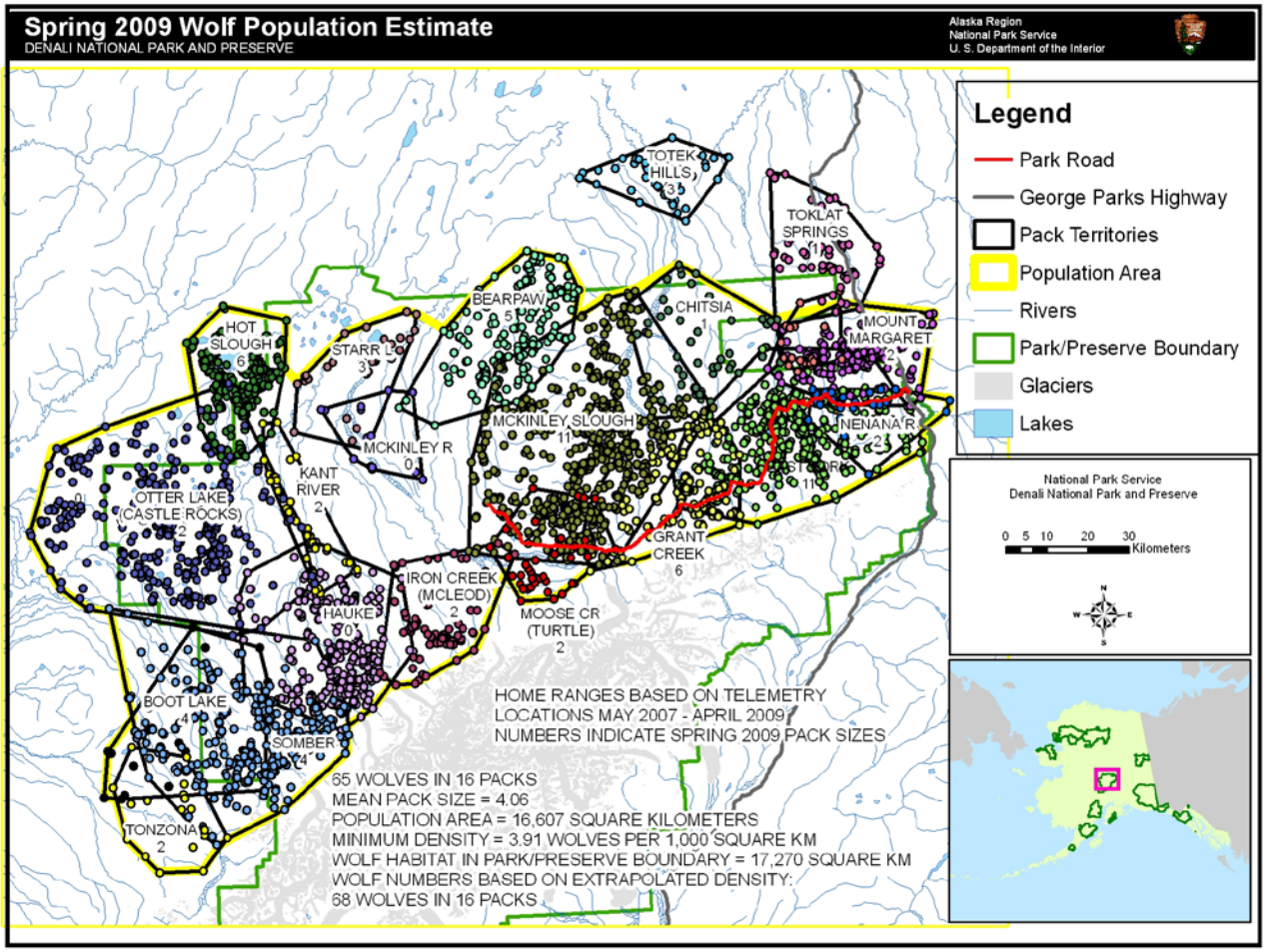


Figure 12. Spring 2009 wolf pack territories and population estimate for Denali.

In April 2009, there were approximately 65 wolves in the 16 packs being monitored by park biologists. The estimated density of wolves in Denali (about 9.9 wolves per 1000 square miles or 3.9 wolves per 1000 square kilometers) was 28 percent lower than last year's estimate of 14.1 wolves per 1000 square miles or 5.5 wolves per 1000 square kilometers.

Biologists captured and radio-collared 24 wolves during the winter 2008-2009. Two of those, both from the Mount Margaret Pack, appeared to have hair loss caused by infestation by lice. Wolves from several areas on the edges of the park have been found with hair loss and other coat problems in recent years. The Alaska Department of Fish and Game has diagnosed lice in wolves from the Tonzona and Toklat river areas near the park.

In May 2008, wildlife biologists captured a male wolf near Savage Campground in order to remove a broken snare from his neck. Although the snare had caused severe laceration and tissue damage, the wolf survived at least until December 2008, and appeared to be in good condition when last seen. At least one other wolf was observed carrying a broken snare in winter 2007-2008. Between April 2008 and March 2009, 10 collared wolves died of natural causes and 5 were killed by humans. Two non-collared wolves were killed by vehicles on the Parks Highway, in or near the park, in early winter 2008-2009. One was the mate of the wolf from which a snare had been removed earlier in the year.

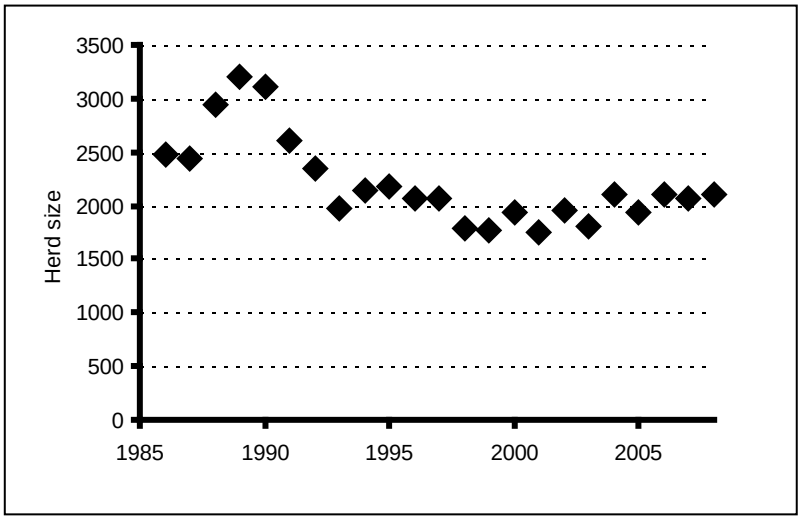
Caribou

The Denali Caribou Herd has been the focus of continuous, intensive research since 1984. Methods that are currently employed to monitor population trends and vital rates have been in place since September 1986 and probably represent the longest and most consistent effort of its kind on caribou in North America. A sample of 50-60 radiocollared females representative of the herd's age structure has been maintained since 1987, thus providing annual assessments of population vital rates that are faithful to the herd's age structure, and not influenced by biases common to radiotelemetry studies of long-lived animals. This age-structured sample is the only one of its kind ever attempted in a wildlife population, and has been maintained for 22 years.

To date, park biologists and cooperators have learned much about the interactions between predation and weather that drive the dynamics of the Denali Caribou Herd. When this study began, the caribou population was increasing at about 7 percent per year through a period of relatively mild winters in the mid-1980s. Winter survival of caribou cows was high (96 percent per year) and about 50 percent of the calves produced were recruited into the herd. With the onset of a period of severe winters in 1988, caribou numbers plateaued at about 3,200 in fall 1989 and then declined by over a third by fall 1993. During the period of decline, adult cow winter survival dropped substantially (85 percent per year) and calf recruitment dropped to a mere 5 percent. With a return to more average winter conditions after 1993, the herd trend has been essentially "flat" through 2008. During this period, adult cow survival was similar to that of the mid-1980s, but calf recruitment continued to be relatively low (35 calves per 100 cows during the fall from 1984 to 1989, versus 17 calves per 100 cows during each autumn since 1994). Calf recruitment has improved in the last 5 years (23 calves per 100 cows during each fall since 2004).

With the overall decline in calf recruitment since 1990, the female age structure became heavily weighted towards older females. Biologists expected that the loss of these old females over a few years would result in a noticeable decline in the herd. However, the loss of many of these old cows was offset by an increase in calf recruitment beginning in 2004. The female age structure is still weighted to older females compared to that at the beginning of the study; in 2008, 20 percent of the cows were 13-years old or older (several 13 and 14-year-olds).

In March 2008, USGS Alaska Science Center researcher Layne Adams and assistant placed or replaced radiocollars on 26 cows and 12 bull calves, and in September 2008, they captured and collared another 12 adult bulls, bringing the total of radio-collared caribou to 81 females and 47 males.



Herd size. A tentative estimate of herd size in late September 2008 was 2,100 caribou (see graph at right), with little noticeable change over the last 5 years. During this period, calf:cow ratios have averaged 23:100, a 65 percent increase over the previous decade. Herd trend over the next few years will largely depend on levels of calf recruitment.

Adult Sex Ratios. During the September 2008 composition survey, there was a ratio of 33 bulls: 100 cows. The number of bulls per 100 cows declined from an average of 56:100 during 1984-1989 to a low of 29:100 during 1997-98, as a result of increased mortality of males during severe winters in the late 1980s and early 1990s. Over the last 5 years, the sex ratio has averaged 36:100.

Calf Production And Survival. In mid-May 2008, Layne Adams estimated that 77 percent of cows one year or older produced young, based on observations of 69 radio-collared cows in the age-structured sample. Such natality rates have averaged 77 percent over the 22 years of the study. Of the 16 non-pregnant radio-collared females, 8 were yearlings, and 5 were 2-year-olds (most non-pregnant cows were less than two-years-old). The remaining 3 non-pregnant individuals were 5, 15, and 17 years of age.

During the annual census and post-calving composition survey in early June 2008, Layne Adams observed a calf : cow ratio of 30 calves for every 100 cows. By late September, the calf:cow ratio had declined to 22:100, indicating that only 28 percent of the 2008 calf cohort had survived to September. The average of calf survival to fall (estimates) has been 22.8 percent since 1987, with higher than average calf survival during the last 5 years. Approximately 15 female calves were recruited into the population (survived) per 100 older females, a ratio that is sufficient to offset the estimated losses of adult females over the previous year.

Female Survival and Age Structure. During the sampling year (October 2007 – September 2008), six radio-collared cow caribou from the age-structured population died, resulting in an annual mortality rate of 8.5 percent. Summer and winter survival were both slightly higher than the long-term averages (96.4 and 91.1 percent, respectively). As usual, cows that died tended to be old (12 to 20 years of age) and most (4 of 6) died in April and May.

The female age structure in May 2008 reflects (1) recruitment of a relatively large number of calves from the 2007 cohort that entered the age structure as yearlings and (2) a high proportion of old cows (≥ 13 years old) due to low overwinter mortality in the last 3 years and the relatively strong 1994 and 1995 cohorts that are now 13- and 14-years-old. The high proportion of old females in 2008 is surpassed only by the highest proportions observed in 2001 and 2002.

Adult Bull Survival. During the study year (October 2007 – September 2008), of the 42 bulls that were collared in September 2007, 11 died and 2 additional animals had their collars torn off during rutting interactions. Most (7) mortalities occurred during August – October; females die predominantly late in the winter. The annual survival rate for adult bulls was 0.73, substantially lower than 0.92, the estimated survival rate for adult females.

Bull Growth Patterns. Fifty-one caribou bulls captured in September 2007 and 2008 had body masses ranging from 220 to 581 lbs (100 to 264 kg). Body mass increased markedly with age from 1 to 5 years of age, gaining an average of 70 lbs (32 kg) each year. Weight reached a plateau once bulls were at least five year-old. When Layne Adams captured 24 10-month-old calves in March 2008 (12 of each sex), he noted that male calves were significantly heavier than female calves—average of 146 versus 133 lbs (66.5 vs. 60.3 kg), respectively.

Planned Activities. In the 2008-2009 study year, Layne Adams plans to continue the assessment of the population dynamics of the Denali Caribou Herd, including research on bulls, and investigate influences of environmental variation on those dynamics. Specifically, the plans include:

1. Capture and radiocollar caribou females as needed to maintain an age-structured sample of approximately 60 individuals for estimation of calf production, age structure, survival patterns and seasonal distribution, and to aid in population monitoring.

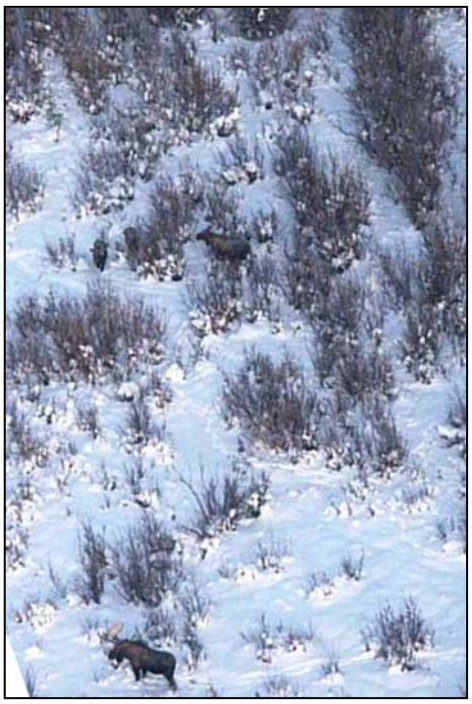
2. Maintain a sample of approximately 45 radio-collared adult bulls and surviving collared individuals from the 2007 cohort, and capture 12 10-month-old males to assess age-specific growth and survival, and seasonal distribution.

3. Locate all instrumented caribou in late November, late January, mid-March, late April, mid-May, early June, late July, and late September, or as needed to meet study objectives.

4. Conduct the post-calving census and composition survey and the fall composition survey to determine herd size, calf recruitment, and adult sex ratio.

Moose

Wildlife biologists conducted moose surveys in three separate areas of the Park in late October and November 2008.



CAKN Survey north of the Alaska Range. The large survey area on the north side of the Alaska Range is the Denali part of the larger Central Alaska Network (CAKN) monitoring program. Denali staff follows protocols developed by the CAKN program.

The 10,004-km^2 (3862-mi^2) area was surveyed November 3 – 25, 2008. Observers spotted 830 moose during the aerial survey and estimated there were 1279 $\pm$ 135 moose for the entire survey area. Overall density was 0.13 moose per km^2 (0.33 moose per mi^2), slightly higher than the 2004 estimate of 0.11 moose per km^2 (0.29 moose per mi^2) for the same area. The calf:bull:cow ratio in 2008 was 24:54:100. Of the cows observed, 77 percent were without calves, 22 percent had one calf, and 1 percent had twin calves.

Cantwell Survey south of the Alaska Range. In the area near the town of Cantwell, adjacent to the George Parks Highway and the Alaska Railroad, local residents are able to hunt moose in those parts of Denali National Park that were added by ANILCA in 1980. Residents of the Cantwell residence zone and other individuals with a history of subsistence hunting in the area must obtain federal registration permits in order to participate in this hunt. In this area of Game Management Unit (GMU) 13E, from 2 to 9 (average = 4) moose are harvested on park lands each year.

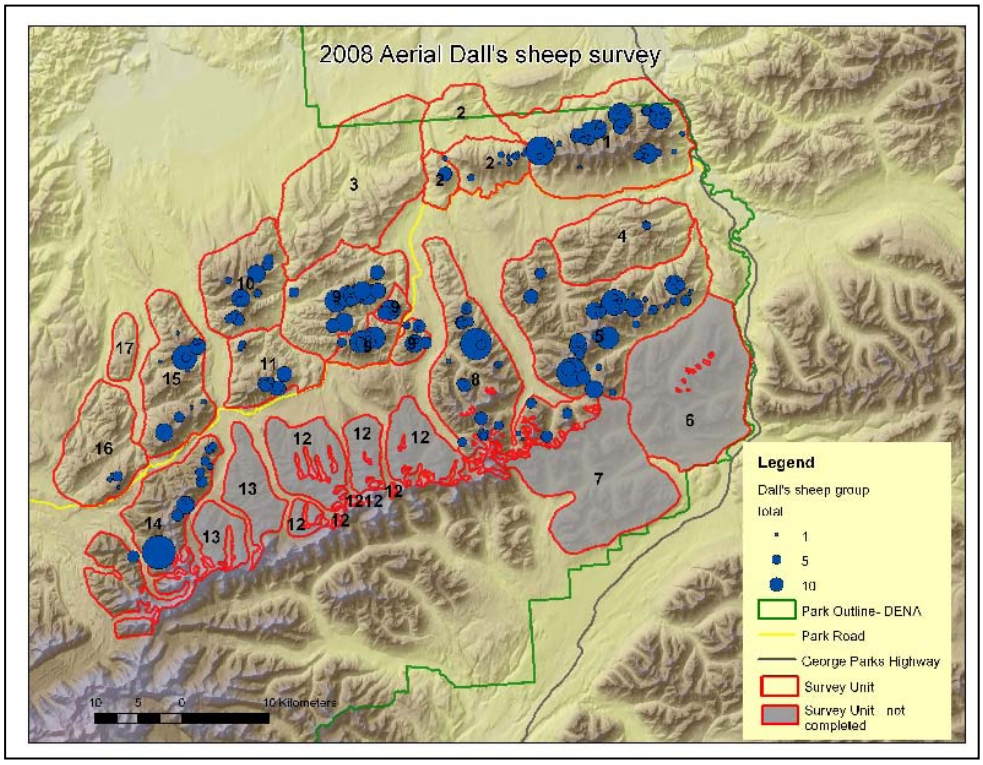
Observers counted moose from fixed-wing aircraft in the Cantwell area November 6-10, 2008. There was an actual count of 255 moose in this 1085-km^2 (419-mi^2) area (all units were surveyed, so if moose could be seen, they were counted). The overall density was 0.24 moose per km^2 (less than 1 moose—0.61—per square mile). The calf:bull:cow ratio was 28:40:100. Of the cows observed, 73 percent were without calves, 26 percent had 1 calf, and 1 percent had twin calves.

Upper Yentna River Survey south of the Alaska Range. In this area, both subsistence hunting by local residents and sport hunting under Alaskan state regulations are allowed. In 2006, Alaska's Department of Fish and Game (ADF&G) closed the general moose hunting season in GMU 16B, in which the Preserve is located, because of declining moose populations in the area. The only moose hunting allowed in GMU 16B under state regulations was a Tier II subsistence hunt, limited to 120 permits in the TM565 hunt area, which includes the Preserve. Many local, rural residents who are eligible to hunt in the Preserve under federal subsistence regulations are not able to get Tier II permits, so their only option for moose hunting is within the Preserve. A registration permit hunt was reinstated for federal subsistence hunting of moose in GMU 16B in 2008, in order to more closely track moose harvest numbers.

NPS provided funding to ADF&G to intensify their survey in the Yentna area of the Preserve (1885 km^2 or 728 mi^2) from October 29-31, 2008. They observed 50 moose during the aerial survey and estimated that there were 117 for that portion of the Preserve. Overall density was 0.06 moose per km^2 (0.16 moose per mi^2). The calf:bull:cow ratio was 18:57:100. Of the cows observed, 82 percent were without calves and 18 percent had 1 calf (none with twins).

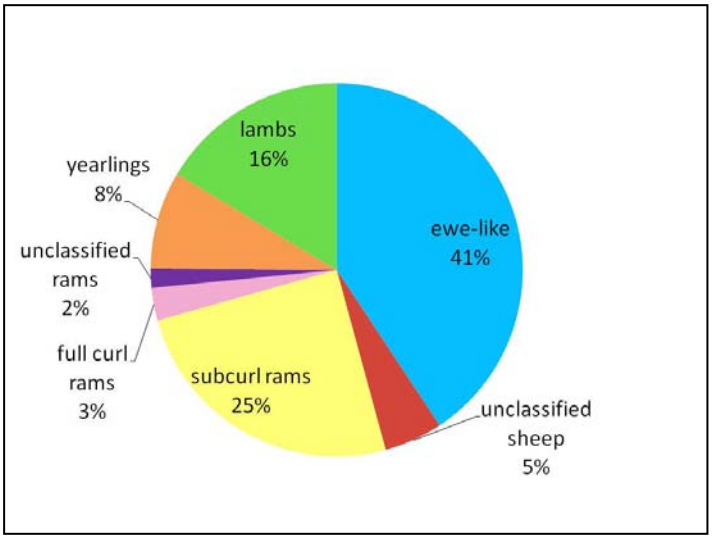
Sheep

Aerial survey. Between July 15 and August 25, 2008, Denali biologists conducted an aerial Dall's sheep survey in the area between the Muldrow Glacier and the Nenana River, the core sheep habitat in the park, and the area most often surveyed for sheep in the past. Of those 41 days, only 6 days provided adequate weather conditions for surveys to be conducted. On the other 25 days, poor visibility, high winds, or excessive snow cover prevented surveys. The area contains 17 survey units, but only 14 were flown in 2008 (see map at right). Biologists plan to fly the other 4 units (units 6, 7, 12, 13) in summer 2009, providing a baseline for sheep numbers and future surveys, despite the fact that sheep will have moved considerably between years.



A total of 1526 sheep were observed, including 898 ewe-like animals (ewes and yearling rams), 202 lambs, 281 immature rams with less than full-curl horns, and 66 full-curl rams. Another 65 rams could not be observed closely enough to determine whether they were full-curl, and 14 sheep could not be classified at all due to poor observing conditions.

Ground-based surveys. Ground surveys allow closer and more careful observation of sheep and provide more detailed and accurate composition data, but the areas that can be surveyed on foot are very limited. Staff had conducted ground-based surveys for many years prior to 1998, but summer 2008 was the first year the ground-based Dall's sheep surveys were reinstituted since 1998. NPS and volunteer crews hiked into eight areas reachable from the park road, counting 177 sheep and classifying them by age and sex (see figure at right).



The sex and age composition of Denali's Dall's sheep populations, as determined by 2008 ground-based surveys.

Small Mammal Monitoring

Voles (*Microtus* spp. and *Myodes* [formerly *Clethrionomys*] sp.) are not highly visible in the boreal forest, yet their collective biomass is a larger proportion of the animal community than that of grizzly bears. Within Denali's ecosystems, voles consume seeds, fungi and invertebrates, and provide a key prey source for raptors and carnivorous mammals. Voles play an important ecological role by having the ability to influence species above and below them in the food chain.

Since 1992, vole populations have been monitored in Denali and will continue to be monitored as part of the Central Alaska Network "Vital Signs" Monitoring Program. From these data and other studies, we know that populations of voles vary across the landscape and over years. Data from Denali suggest that annual fluctuations in small mammal populations are strongly related to abiotic factors like weather and timing of snowfall. Additionally, the relative abundance of small mammal species is directly related to local composition of plant species. Thus, any park-wide changes in weather or plant species composition will likely affect small mammal distribution and patterns of abundance. By monitoring populations of voles, we may detect effects of human-induced change (such as global warming).

In 2008, Melanie Flamme, wildlife biologist with Yukon - Charley Rivers National Preserve (and with the Central Alaska Network Monitoring Program), coordinated the seventeenth year of small mammal trapping in the Rock Creek study area in Denali. The trapping effort was busy and challenging because of high volumes and activity levels of small mammals.

The trapping effort relied on volunteers including 8 NPS staffers, 1 Denali-area resident, 2 college students, and 1 high school student (who contributed a total of 206 hours in 2008, the second year of the volunteer outreach program to assist the small mammal project). The students and other volunteers were trained and worked side-by-side with biologists—handling, trapping, and tagging small mammals in the field.

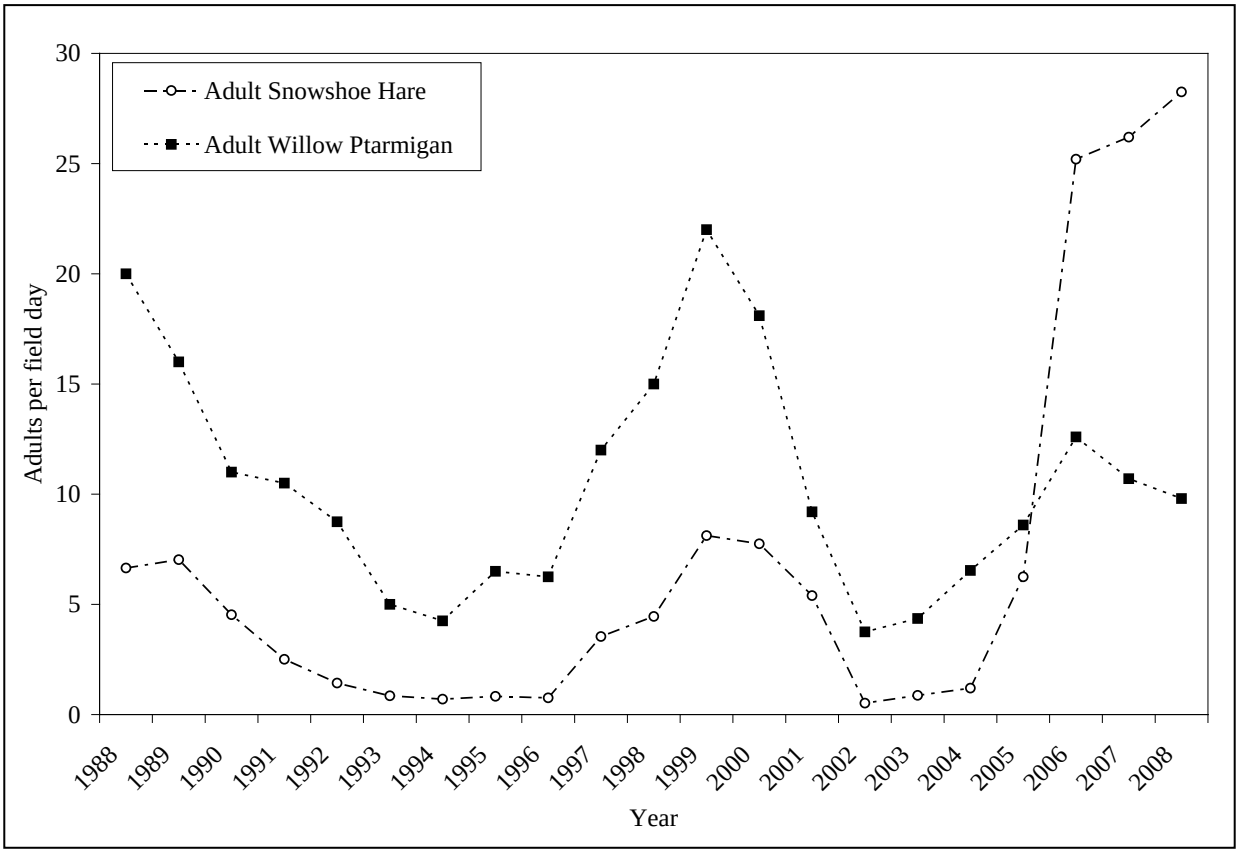
The biologists and volunteers set out 100 Sherman live traps on each of the four Rock Creek legacy plots and baited the traps with sterile sunflower seeds and bedding. The crews worked around the clock and checked the 400 traps three times daily from August 13-17. When crew members found a captured individual, they identified the small mammal by sex and species, determined reproductive status, and calculated net weight. Biologists marked previously unmarked individuals by implanting a passive integrated transponder (PIT) tag (approximately the size of a grain of rice) under the skin of the mammal. They then scanned the tag for its unique code, and released the small mammal. Using a "reader," biologists could identify every tagged individual and used these data about capture/recapture to produce estimates of population size.

By the end of the sampling period, the crews had performed 5200 trap checks and processed 1301 total captures (400 new captures and 901 recaptures). Of the new captures, 86 percent were northern red-backed voles (*Myodes rutilus*), 9 percent were tundra voles (*Microtus oeconomus*) and 5 percent were singing voles (*Microtus miurus*).

Snowshoe Hare and Willow Ptarmigan

Broad scale indices of population size of snowshoe hare and willow ptarmigan are obtained by recording the number of each species observed during routine field activities. These data allow National Park Service biologists to track broad-scale abundance trends of both species over time.

The abundance of snowshoe hare increased slightly in 2008 and abundance of willow ptarmigan decreased slightly in 2008 (see graph below).



Birds

❖ **Monitoring abundance and distribution of passerines.** Biologists from the National Park Service and the Alaska Bird Observatory conducted ten-minute point transect surveys in Denali as part of the Central Alaska Network's Vital Signs monitoring program. The protocol for this project was peer-reviewed in 2005 and the project is in full implementation.

In 2008, a four-person field crew conducted all the surveys. The crew was trained in May (see photo) and conducted the surveys in June, between 0300 and 0900 hours. The crew recorded all birds detected (seen or heard) at each sampling point (there are 25 possible points in a minigrid) during a 10-minute sampling period in one of four time intervals (0 to 3 min, >3 ≤5 min, >5 ≤8 min, and >8 ≤10 min) and in one of 13 distance intervals (10-m intervals up to 100 m, 25-m intervals to 150 m, and >150-m).

The survey crew sampled 187 points on 8 minigrids in 2008 (see light colored minigrids, Fig. 13), and detected 1,217 birds (1,170 detection events). When birds detected for all points of a minigrid were combined, the crew detected 29 to 272 birds per minigrid and detected 10 to 20 species per minigrid.

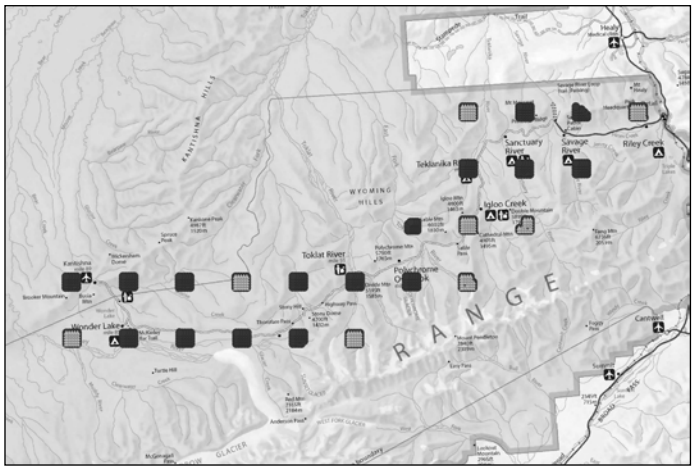


Figure 13. Map of minigrids used for the passerine monitoring project (Central Alaska Network) in Denali on the north side of the Alaska Range. There are 24 minigrids that are within 10 km of the Denali Park Road. Minigrids are located 10 km apart and each minigrid has a 5 x 5 array of potential sampling points (25 points located 500 m apart). The eight light-shaded minigrids were sampled in 2008.

The survey crew detected a total of 56 species on the 8 minigrids (46 species during the 10-minute counts, and 10 species on the minigrids but not during the 10-minute counts). Most detections (94 percent) were of members of the Order *Passeriformes*, and 74 percent of all detections were members of four families, *Emberizidae* (sparrow and kin) (57.2%), *Parulidae* (chickadees and kin) (12.8%), *Fingillidae* (finches and kin)(11.2%) and *Turdidae* (thrushes)(4.4%).

The most common birds on the 10-minute point transect counts were White-crowned Sparrow (*Zonotrichia leucophrys*) (detected on all grids; n= 260 detections, 21.4 percent of all detections) and Fox Sparrow (*P. iliaca*) (detected on 7 of the 8 minigrids; n= 149 detections, 12.3 percent of all detections) were the most common species detected on the 10-minute point transect surveys. Fewer species and fewer detections were made on higher elevation alpine minigrids that were dominated by dwarf vegetation, bare ground, and ice compared to lower elevation minigrids in forest or shrub tundra.

Point transect surveys will continue in June 2009; approximately 200 points will be sampled in 8 minigrids ().

Table 1. Summary statistics for birds detected on 10-minute point transect surveys in Denali by minigrid in 2008.

Minigrid name (in order surveyed)	Points surveyed	# Birds	# Species	Mean number of species per point
Nika Ridge	25	181	20	4.5
Rock Creek	25	211	18	5.1
East Fork East	22	65	12	1.6
Toklat West Branch	25	38	10	1.1
Igloo Canyon	25	196	16	4.4
Double Mountain*	18	29	12	1.0
Muddy River**	22	272	19	6.2
Moose Creek North Fork	25	225	15	5.6

*Seven points at the Double Mountain minigrid were not accessible due to extremely steep terrain.
** Three points at the Muddy River minigrid were not accessible because they were in the McKinley River.

- **Breeding Bird Survey (BBS):** The North American Breeding Bird Survey (BBS) is a large-scale survey of North American birds. Approximately 3,700 BBS routes are located in the U.S. and Canada and about 2,900 routes are surveyed annually. The BBS has accumulated over 30 years of data on the abundance, distribution, and population trends of more than 400 species. These data are useful for determining if changes of a species in certain states are related to a continental decline or merely represent population shifts within their breeding range. At Denali, park staff conduct two standardized Breeding Bird Survey (BBS) routes along the park road—the Savage BBS and the Toklat BBS. Each route contains 50 sampling points located 0.50 miles apart. At each point, the surveyor conducts a three-minute count and records all birds detected within 0.25 miles.

  The Savage BBS route was completed on June 17, 2008. The survey started at the west end of Savage River Bridge at 0300 and ended near Sable Pass at 0850. All 50 points were surveyed in 2008. Thirty species and 749 individual birds were detected in 2008. White-crowned Sparrow (n=1206) was the most commonly detected bird along the Savage BBS route followed by, American Tree Sparrow (n=115), and Orange-crowned Warbler (n=102).

  The Toklat BBS route was completed on June 18, 2008. The survey started at the Toklat Ranger Station at 0315 and ended at 0900. All 50 points were surveyed in 2008. Twenty-eight species and 650 individuals were detected in 2008. Wilson's Warbler (n = 126) was

the most commonly detected bird along the Toklat BBS route followed by Fox Sparrow (n = 91), and American Tree Sparrow (n = 87). This was the first year that Horned Grebe was observed on the Toklat BBS route.

National Park Service biologists will complete the two BBS routes in Denali in June 2009. Results from the Denali BBS routes are available at: http://www.pwrc.usgs.gov/bbs/retrieval/summary/stateform.cfm

- **Reproductive success of Golden Eagles and Gyrfalcons:** As part of the National Park Service's Central Alaska Network Vital Signs Monitoring Program, National Park Service (NPS) biologists monitored the occupancy of nesting territories and reproductive success of Golden Eagles and Gyrfalcons in the northeast region of Denali National Park and Preserve (Denali) in 2008. This marked the 21st consecutive year of this study. NPS biologists collected data using two standardized aerial surveys conducted from a Robinson R-44 helicopter, and additional ground observations and foot surveys. The occupancy survey was conducted in late April, additional foot surveys from May through July, and the productivity survey in late July 2008.

  In 2008, occupancy of Golden Eagle nesting areas (87%) was similar to the long-term mean. Despite high numbers of Snowshoe Hare (*Lepus americanus*), all measurements of Golden Eagle reproductive performance were lower in 2008 than in the previous two years including nesting rate (68%), success rate (67%), and fledgling production. Fledgling production (n = 52) was higher than average, but 25% lower than the previous two years.

  Denali biologist and many others noted higher than average numbers of non-territorial subadult Golden Eagles in the study area from June through August. Adult and subadult Bald Eagles (*Haliaeetus leucocephalus*) also were noted in the study area in June and July, apparently drawn to the area by the abundance of hare. Of additional interest in 2008 were sightings of subadult Golden Eagles with color-coded wing-tags. The wing-tagged eagles were captured in western Montana during autumn migration by two different organizations that used different color-coded wing tags in their studies. The Wildlife Research Institute used red and green wing-tags and Raptor View Inc. used blue wing-tags. The NPS does not use wing tags to study Golden Eagle movements; hence, any wing-tagged Golden Eagle observed in Denali was tagged outside of Denali. The NPS used satellite telemetry to study the movements of Denali's Golden Eagles and results of those studies are available in the *Auk*, issue 125, pages 214-224 or upon request.

  Gyrfalcon reproductive success in Denali was lower than most years despite apparently high numbers of Willow Ptarmigan in the study area. NPS biologists monitored 16 Gyrfalcon nesting territories in 2008; occupancy (38%) was lower than most years, but success rate (~ 80%) was high. Gyrfalcons at Marmot Rock along the Denali Park road produced three fledglings in 2008.

  Proposed activities for 2009 include (1) continuation of Golden Eagle and Gyrfalcon monitoring in the historic study area in Denali, (2) continuation of genetic studies of golden eagles in Denali, and (3) continued public education and outreach efforts.

- **Christmas Bird Count:** The National Audubon Society organizes the Christmas Bird Count (CBC) and each year more than 50,000 observers participate each year in this all-

day census of early-winter bird populations. The results of their efforts are compiled into the longest running database in ornithology, representing over a century of unbroken data on trends of early-winter bird populations across the Americas. The primary objective of the Christmas Bird Count is to monitor the status and distribution of bird populations across the Western Hemisphere. When data with Christmas Bird Counts and other surveys such as the Breeding Bird Survey are combined, scientists begin to see a clearer picture of how the continent's bird populations have changed in time and space over the past hundred years.

Local naturalist Nan Eagleson organizes and compiles the results of the Denali CBC which has been conducted every year since 1992. The 2008 Denali CBC was held on December 27, 2008. Sixteen participants recorded 15 species of birds including Spruce Grouse, Willow Ptarmigan, Northern Goshawk, Great-horned Owl, Northern Hawk Owl, Gray Jay, Black-billed Magpie, Common Raven, Black-capped Chickadee, Boreal Chickadee, Dark-eyed Junco, Pine Grosbeak, White-winged Crossbill, Hoary Redpoll, and Common Redpoll on the count day. White-winged Crossbill, with 319 individuals, was the most common bird species recorded on the 2008 Denali CBC.

To learn more about the Christmas Bird Count, visit: www.audubon.org/bird/cbc/

- **Surveillance sampling for Asian H5N1 avian influenza:** No surveillance sampling for Asian H5N1 avian influenza was conducted in Denali in 2008. As of this writing, the statewide U.S. Fish and Wildlife Service surveillance project in 2009 will focus on waterfowl and shorebirds, and no sampling will be conducted in Denali.

Please tell park visitors not to pick up dead birds; instead, park visitors should report dead birds and their location to NPS staff at the Denali Visitor Center, the Murie Science and Learning Center, or the Denali Center for Resources, Science, and Learning. To learn more about avian influenza in Alaska, visit the web site: http://alaska.fws.gov/media/avian_influenza/index.htm.

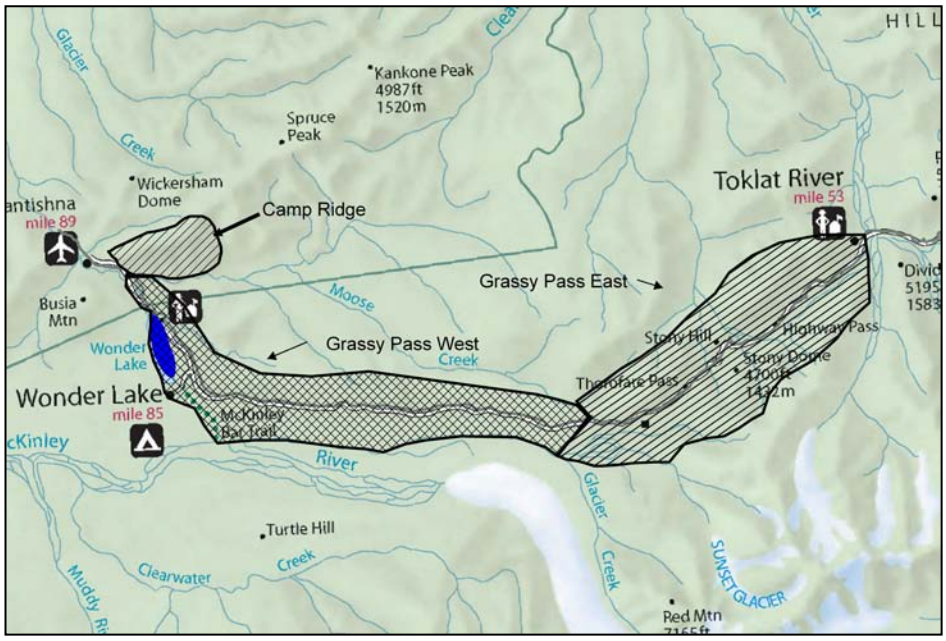
- **Bird Species of Conservation Concern:** Denali biologists and staff at Camp Denali and North Face Lodge initiated a pilot project to document the distribution and occurrence of a suite of 40 bird species of conservation concern (target species) in 2008.

  The target species included species with documented population declines such as Olive-sided Flycatcher and Rusty Blackbird and species that respond quickly to changes in their habitat such as Gray-cheeked Thrush and Golden-crowned Sparrow. Camp Staff recorded their observations of target species on standardized data forms from early June through mid-September in four geographically distinct study areas (see map on next page) that Camp Staff visited weekly during the 14-week study period.

  Thirty-three of 39 target species were detected during the study period. The number of target species detected in each survey area and in each sampling interval (week) varied across the study area and across the study period. More target species were seen in Grassy Pass West and Grassy Pass East than in the Camp Ridge study areas. The number of species detected each week varied and declined over the season. Two species, Scaup spp. and Long-tailed Duck, were observed in all study intervals. Six species of conservation

concern (Trumpeter Swan, Solitary Sandpiper, Upland Sandpiper, Baird's Sandpiper, Smith's Longspur, and Red-winged Blackbird) were not detected in any study area.

This project will continue in 2009.



Map of study areas in Denali being surveyed for bird species of conservation concern.

❖ **On the eBird Horizon; eBird and eBird Trail Trackers in Denali!**
eBird is an exciting new tool that enables anyone to enter their bird sightings in Denali directly into an interactive computerized database. eBird is a real-time online checklist system developed and operated by the Cornell Laboratory of Ornithology. eBird's goal is to maximize the utility and accessibility of the vast numbers of bird observations made each year by recreational and professional bird watchers. It is amassing one of the largest and fastest growing biodiversity data resources in existence. For example, in 2006, participants reported more than 4.3 million bird observations across North America. Anyone can set up their own eBird account and begin logging in their bird sightings. To set up your own eBird account or to learn more about eBird, visit their web site: http://ebird.org/content/ebird.

Denali biologists and staff at the Murie Science and Learning Center (MSLC) are working together to bring an eBird Trail Tracker to the MSLC and Denali's visitor centers. eBird Trail Tracker is an electronic gateway to information on bird sightings, and enables users to find out which birds are being reported and where in Denali and to record their own sightings. These observation records become part of eBird, an online checklist program that scientists, birders, and anyone with Internet access can use to review bird observation information from specific locations across North America.

Wood Frog Surveys

The wood frog is the only amphibian that occurs (or is expected to occur) in Denali National Park and Preserve. Information on the presence and habitat associations of the wood frog continues to be collected concurrently with many of the ongoing bird and vegetation projects, and backcountry ranger patrols.

Physical Resources

Parkwide Climate Monitoring

Climate monitoring continues at established locations around the park. These data are especially useful for weather forecasting related to fires and detecting ecological trends. There are a total of 17 climate stations distributed throughout the park. Most of these stations record air temperature, relative humidity, wind speed and direction, solar radiation, precipitation, and soil temperatures. From these stations, resource staff gains a park-wide perspective on the physical factors affecting Denali's ecosystems and can provide timely information on snow and weather conditions to park managers, the National Weather Service (NWS), researchers, and the public.

Climate monitoring at Denali is part of the vital signs monitoring of the Central Alaska Network (CAKN), which also includes Wrangell – St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve (Fig. 14). The main objective of the climate portion of the CAKN program is to monitor and record weather conditions at representative locations in order to quantify one of the drivers in Alaskan ecosystems (climate), identify long and short-term trends, provide reliable climate data to other researchers, and to participate in larger scale climate monitoring and modeling efforts.

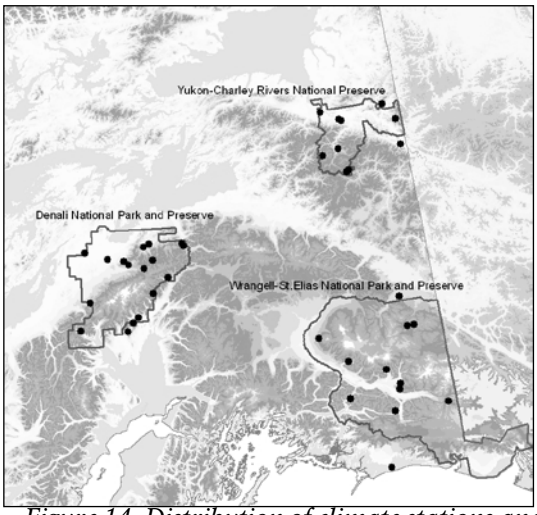
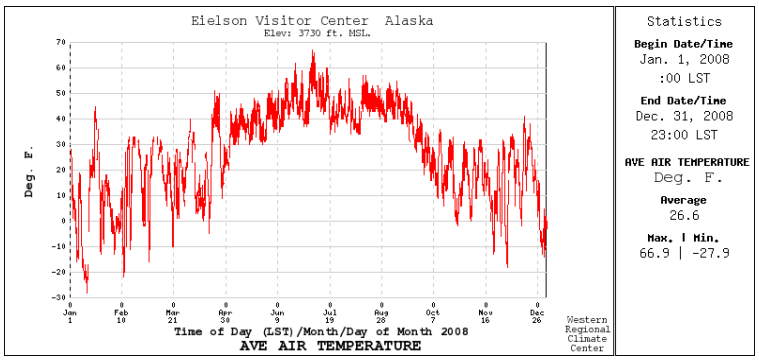
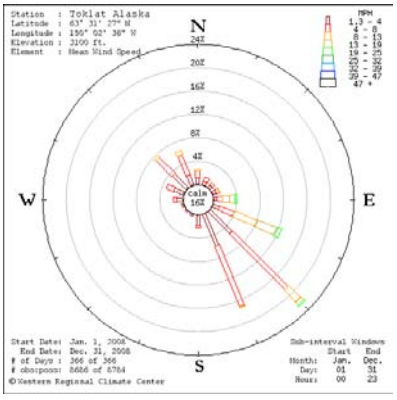


Figure 14. Distribution of climate stations and snow survey locations in the Central Alaska Network.

In 2008, all of the sites were visited for annual maintenance. The sensors on the station were swapped and calibrated and the data were downloaded. The comprehensive annual climate monitoring report will be available on the web in the spring of 2009 at http://www1.nature.nps.gov/im/units/cakn/monitoring.cfm.

Most of the stations are automated and send hourly data via satellite. Data summaries and data analysis tools are available at http://www.wrcc.dri.edu/NPS. Below are examples of the kind of data summaries that are available from the website:





Weather Monitoring at Park Headquarters

For more than 80 years, weather information has been collected at Park Headquarters. Long-term weather (climate) datasets provide valuable information for detecting and predicting changes or trends in both temperature and precipitation—both factors play a critical role in Denali's ecology.

Below are **summaries of the 2008 climate data** for temperature and precipitation collected at Park Headquarters and compared with averages from the long-term database. Weather data are summarized by the calendar year, so the data from 2008 are presented here.

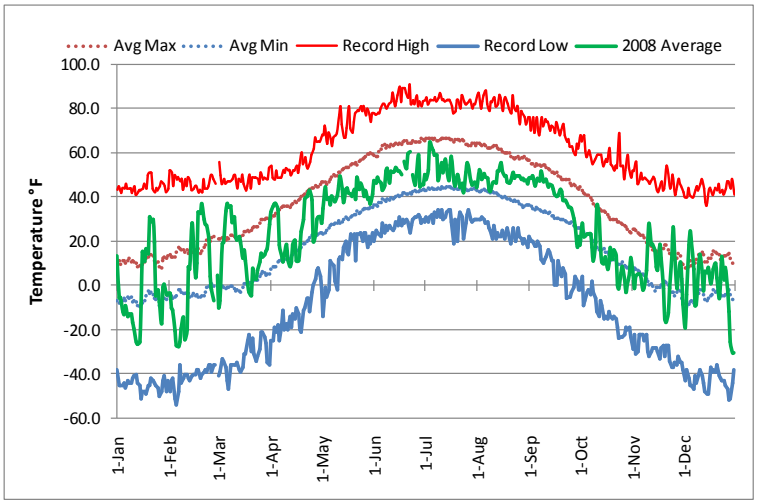
Weather Notes for 2008:

- The mean annual temperature was 3° F below normal—the coldest year since 1999
- The mean monthly temperatures were colder than normal for each month except March
- It was the fourth snowiest April on record with 21.4 inches of total snowfall
- July was wet; there were 2 inches more rain than normal

Temperature:

- Maximum temperature 79° F on July 5
- Minimum temperature -37°F on February 10
- Mean annual air temperature 24.6°F (colder than the historical average of 27.2°F)

Denali Headquarters **Average Monthly Temperatures** (°F)		
	2008	82-Year Historic Average
January	-2.1	*2.3*
February	2.9	*6.7*
March	15.2	*12.8*
April	25.1	*27.2*
May	41.3	*41.7*
June	50.2	*52.2*
July	51.7	*54.9*
August	48.6	*50.7*
September	41.1	*41.0*
October	14.0	*24.0*
November	6.6	*9.4*
December	0.4	*3.4*
Yearly Average	**24.6**	***27.2***



Precipitation

- Total Precipitation 16.56 inches
- Departure from Normal +1.53 inches
- Max. 24 hr precipitation 1.20 inches on August 1
- Total Snowfall 63.4 inches from July 1 to June 30
- Departure from normal -34.3 inches
- Maximum 24 hr snowfall 6.7 inches on April 14

Denali Headquarters Monthly **Precipitation** (in)		
	2008	Historic Average
January	0.55	*0.73*
February	0.95	*0.58*
March	0.24	*0.43*
April	1.29	*0.43*
May	0.25	*0.80*
June	1.43	*2.20*
July	4.92	*2.99*
August	3.32	*2.69*
September	1.06	*1.59*
October	0.95	*0.97*
November	1.02	*0.76*
December	0.58	*0.82*
Yearly Total	**16.56**	***15.03***

2008 Record-Breaking Weather at Denali Park Headquarters

February 20: 48° F maximum temperature (previous record 42° F 1977)
April 22, 23, 24: 55, 58, and 58°F, respectively (previous record 54, 53, 56°F in 1994, 1981, 2003)
April 14: 6.7 inches snowfall (record for the 24-hour period ending at 8 a.m.)
April 18: 4.5 inches snowfall (record for the 24-hour period ending at 8 a.m.)

Weather Station on Mt. McKinley

Denali Park staff, the International Arctic Research Center (IARC), and the Japanese Alpine Club have continued to work jointly planning the transmission of data from a weather station on Mt. McKinley. One objective of the project is to make near-summit weather information available in "real time" to the hundreds of climbers who attempt the summit each year, as well as to park rangers, who must plan and perform search-and-rescue operations in the vicinity of the South Summit. Researchers also find the data useful for their studies of the high-elevation environment.

It is extremely difficult and time consuming to engineer a station that will withstand the harsh weather at 19,000 feet, especially when the team can get there only once a year.

The 2008 expedition took place in June. The primary objective for this year was to bring down the remaining broken parts and pieces from the station that sustained wind damage in 2006. The team also scouted out sites around the high camp area at 17,000 feet for a potential new site. This new location is more protected from damaging high winds and has a clear view down to Talkeetna for data transmission. Pending compliance and permitting the team will attempt to install the new station during their 2009 climb scheduled for early June.

Information and data are available at: www.denali.gi.alaska.edu

Snow Surveys

In the winter of 2007-2008, park staff conducted snow surveys in Denali during the survey window (last 4 days of each month) during the winter season. Thirteen snow courses and aerial snow markers were surveyed throughout the season. The following narrative describes the 2007 – 2008 season:

North of the Alaska Range across the interior of Alaska, the first measurable snow was recorded during the first week of October. The Kantishna site recorded 1 inch of snow on October 1. The first measurable snow at the Tokositna Valley site on the south side of the range was on October 14, 2007. In November, interior Alaska was about 10 degrees warmer than normal and snowfall total was about 60 percent of normal. On November 30, 9 inches of snow was measured at Kantishna, the same amount as the past two years. The Denali Park Headquarters site had 4 inches of snow on November 30; the long-term average is 10 inches for this date. The early season measurements for the aerial snow markers on the south side were near normal with some slightly above normal.

By February, the Alaska interior snowpack was getting closer to normal conditions. There were 22 inches of snow on February 1 in Kantishna, which is 78 percent of normal. The Rock Creek sites and the Headquarters site in Denali were about 50 percent of normal. The same pattern persisted for March and April; the Denali sites were about 80 percent of normal. April of 2008 was a snowy month for Denali; at Park Headquarters, it was the fourth snowiest April on record with 21 inches of total snowfall. The McKinley Park National Weather Service total snowfall was 79 percent of normal for the year (32 percent of the total fell in April) with an annual total of 63.4 inches of snow for the season (the average annual snowfall is 80.1 inches). The April snowfall was higher than normal south of the Alaska Range as well, so, unlike in normal years where the snowpack peaks in March and starts to decrease through April, it continued to accumulate through the end of the snow survey period. The snowpack for the south side area was at 110 percent of normal for the last survey on May 1.

The Kantishna site recorded 6.1 inches of total winter precipitation (snow water equivalent) from October 1, 2007 through May 1, 2008, which is 29 percent of the total annual precipitation of 21.4 inches. The precipitation gauge at Tokositna Valley recorded 22.1 inches of winter precipitation from October 1, 2007 through May 1, 2008, 52 percent of the total annual precipitation of 42.6 inches.

Air Quality Monitoring

Continuous air quality monitoring has been conducted in the park since 1980 at a station near Park Headquarters. Sampling occurs through several nationwide air quality monitoring networks, which measure atmospheric deposition, ground-level ozone, sulfur and nitrogen oxides, fine particles, visibility, and associated meteorological parameters. A second station in Trapper Creek, established in 2001, also measures fine particles and visibility through the nationwide IMPROVE monitoring network (Interagency Monitoring of Protected Visual Environments).

While Denali has some of the cleanest air measured in the United States, small amounts of industrial and agricultural contaminants from other continents make their way into the park each year in a recurring seasonal pattern. The peak concentrations of international contaminants generally occur in the late winter and spring. Local and regional emissions are also measured in the park in small quantities each year. During summer, naturally-occurring wildfire smoke is the primary contributor to air quality degradation.

More information about the National Park Service air quality monitoring program can be found at the following web site: www.nature.nps.gov/air/.

Visibility Web Camera

The Denali visibility web camera is part of a nationwide network of webcams operated by the NPS Air Resources Division. During summer, the camera takes a picture of the Alaska Range once every 15 minutes, and the image is transmitted to the web via satellite. The webcam home page also displays current ozone and weather data from the air quality monitoring station near Park Headquarters. All images are archived throughout the summer for a long-term visual record of visibility, one of the air quality related values (AQRVs) protected under the Clean Air Act. The Denali visibility webcam can be found through an internet search on "Denali National Park webcam," or you can go to www.nature.nps.gov/air/WebCams/parks/denacam/denacam.cfm.

Monitoring Landslide at Mile 45

At Mile 45 of the park road, survey stations were established in 1993 to monitor the rate of movement of a mass movement (landslide) surface—a classic rotational slump with a headwall scarp, subsiding basins, pressure ridges and fractures, and flow features. Park management and Federal Highways personnel are concerned about the threat that this movement poses to the park road.

Both horizontal and vertical movements have been monitored since 1993. Approximately 60 stations have been established over the entire period. Some have been lost due to surface fracturing or squeeze-out, and animal damage, and new ones are added almost every year, maintaining an average of 35 stations or data points.

The 2007 and 2008 data have demonstrated a slow decrease in the rate of downslope movement (see Fig. 15). However, the apex of the scarp headwall (the nearest point to the park road) has eroded back to within 27 feet of the road (as opposed to within 35 feet of the road based on 1999 data).

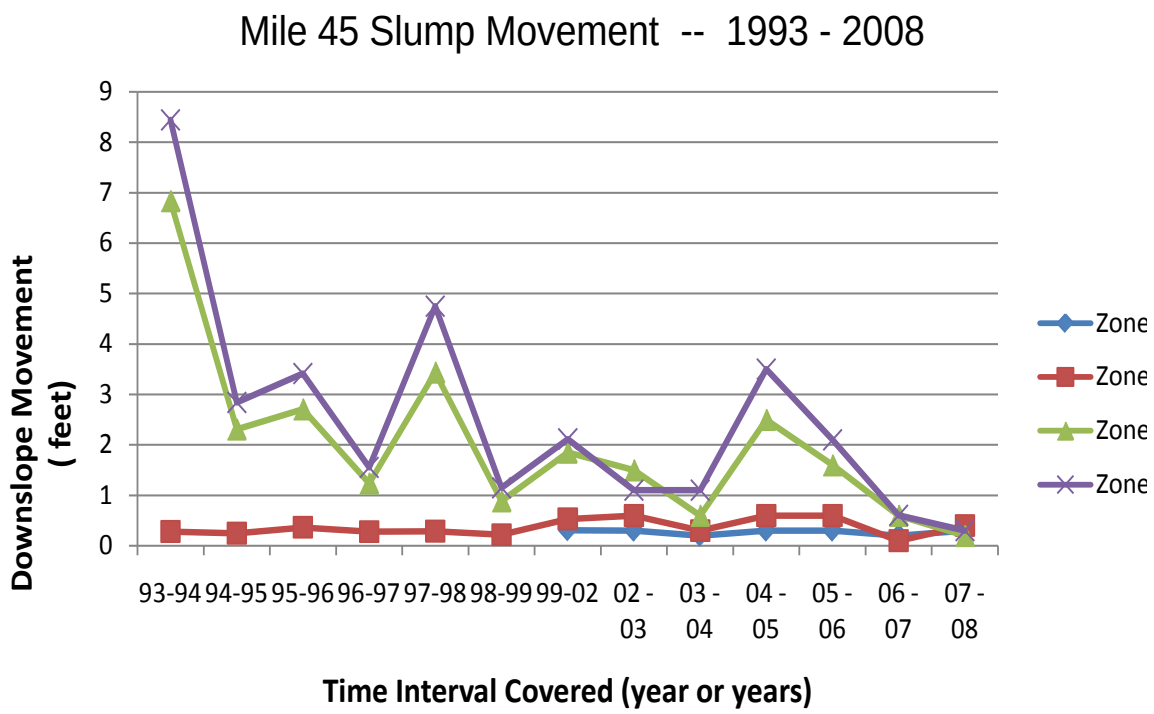


Figure 15. Movement of the Mile 45 over 15 years based on surveys in 4 zones. Zone 1 (diamond) and 2 (square) are above the slump and have been relatively stable, with less than a foot of average movement for the entire survey period. Zone 3 (triangles) and Zone 4 (indicated with x) are on the slump surface and show peaks in movement in the hydrologic years 1993-94, 1997-98, 1999-2002, and 2004-05, which were high precipitation years. The park road sits on relatively stable ground (so far) between Zones 1 and 2.

Although the downslope migration of the slump continues, the rates of movement by zone suggest no immediate threat to the park road for the next 5 to possibly10 years. Monitoring will continue in 2009 and beyond.

Paleontological Survey of the Lower Cantwell Formation

It has been well known for many years that the Cantwell Formation was formed in the right time period and partly under the correct terrestrial conditions for dinosaur fossil preservation. The first footprint discovered in 2005 (in Igloo Canyon—within 200 feet of the park road) was that of a theropod, a carnivorous dinosaur that walked upright and probably weighed some 200 pounds. This was the first evidence of dinosaurs in the interior of Alaska.

Since that park find, the NPS and other researchers have stepped up the search and geologic mapping efforts in the Igloo Creek and tributaries just north of the park road, and on buttress ridges on the north side of Double Mountain. The park road courses right through Cantwell Formation rocks in Igloo Canyon.

At the close of the 2008 field season, field parties had located dozens of additional dinosaur footprints including many sizes of hadrosaurs (duck-billed dinosaurs) theropods, a few ceratopsians, a pterosaur track (the first of such a find in Alaska—a journal article is in preparation), skin impressions, coprolites (dinosaur feces), bird tracks, numerous plant fossils or

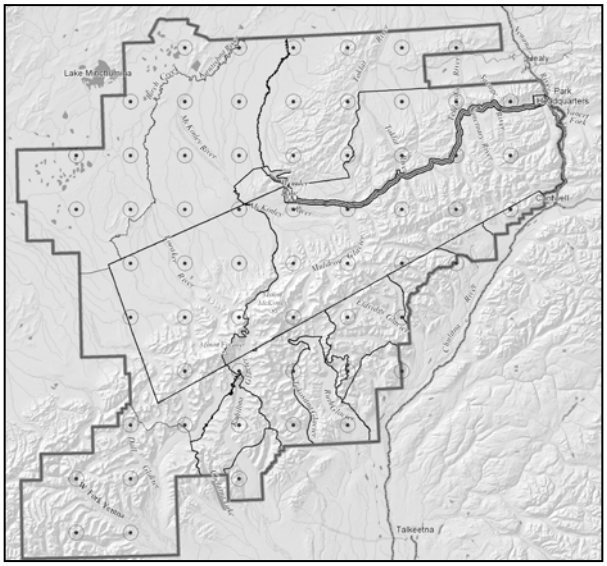
imprints, and other paleo-biotic features. Trace fossil material identified at Cabin Peak included both theropod and hadrosaur footprints with detailed foot morphology and skin impressions. Because some of the rock strata have numerous tracks on the same horizon or surface, researchers have come to call these sites "Cretaceous dance floors." The collective finds have provided insight into the paleoecology (plants, plant-eaters, animal-eaters) of the Late Cretaceous (65 to 145 million years ago).

The primary project work in 2008, led by Dr. Tony Fiorillo (Dallas Museum of Natural History), involved roughly two weeks of field time and assistance from two other researchers, Dr. Steve Hasiotis (University of Oklahoma), and Dr. Yoshi Kobayashi (Hokkaido University Museum, Japan). Field work will continue in 2009 with the same personnel mentioned above.

Soundscape Inventory and Monitoring Program

A soundscape research program has been underway at Denali since 2001. Natural and human-generated sounds have been inventoried at numerous locations around the park including along the park road, south of Broad Pass near Cantwell, at the Stampede Airstrip, in the Ruth Amphitheater, at Base Camp on the Kahiltna Glacier, on the Pika Glacier, and at the toe of the Tokositna Glacier. From the 7000+ hours of digital recordings and sound levels that have been documented in the park's three acoustical zones (alpine, sub-alpine, and scrub/forest), park staff can calculate for each audible sound the percentage of time and the number of times per day that it is audible. The sound level data is used to compare the levels of human-made sounds to the natural ambient levels.

The third sampling season of a newly-revised systematic (random) sampling plan was implemented in 2008. Five automated sound monitoring stations (see photo) were deployed and rotated among 9 locations in Denali. These included 1 winter-season site, 5 Long-term Ecological Monitoring (LTEM) grid points, 2 locations of interest in support of the Backcountry Management Plan, and 1 roadside site in support of the Park Road Study. Over a ten-year period, stations will be placed at six new locations each year—these stations will be randomly selected from a coarse grid of 60 points spread evenly throughout the park (see map at right).



From the sound data processed thus far (from 22 locations in Denali), wind is the most common natural sound, and aircraft overflights are the most common human-generated sound. At some locations, wind can be heard 24-hours a day. At locations with brush or trees, birds can also be heard throughout the day (and "night") during the spring breeding season.

At locations near common flightseeing routes, it is common to hear 30 overflights per day. At glacier landing strips, it is common to hear more than 100 overflights per day. At locations away from common flightseeing routes, the number of overflights heard per day rarely exceeds ten. At every site sampled, there are usually around five commercial jets heard per day.

The data collected with the sound stations can be used to quantify the impact from human-generated motorized noise without the aid of a human listener. Figure 16 shows a spectrogram of the sound levels recorded at Kahiltna Pass on June 26, 2007. Using this graphical representation, a trained technician can identify all overflights that occurred that day, and classify the type of aircraft (propeller plane, jet plane, or helicopter) that produced the sound. Software analysis can then automatically calculate the percentage of time for that day of monitoring in which audible and peak sound levels occurred.

In 2009, sound stations will be placed at six more minigrid points, a location at Broad Pass specifically to monitor noise from snow machine activity, and two points of management interest that will likely be placed in cooperation with the Denali Aircraft Overflights Committee. This committee is working to reduce the impact of overflight activity on Denali's backcountry users and relies heavily on data from the sound monitoring program to inform their recommendations.

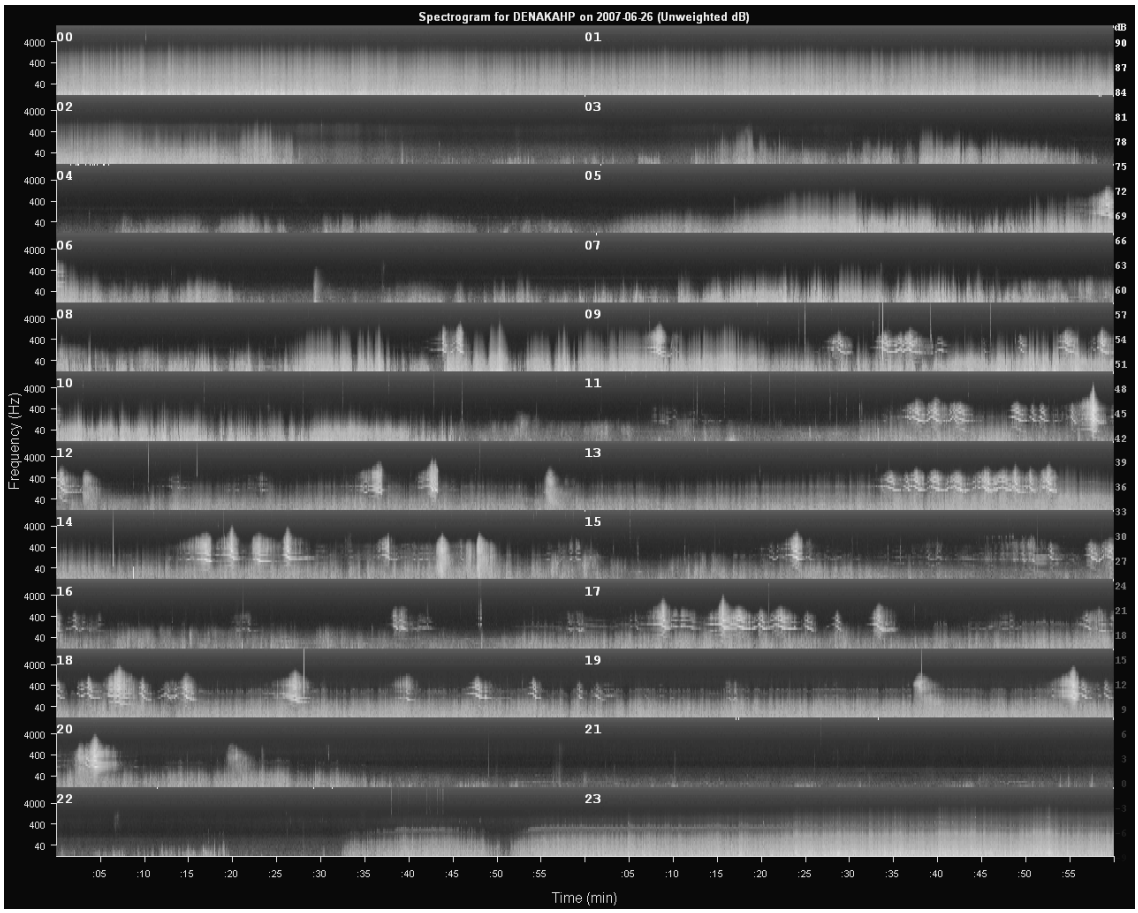


Figure 16. 24 hour spectrogram for June 26, 2007 from a monitoring site at Kahiltna Pass at elevation 10,300 ft. Each row contains 2 hours. The y-axis of each row delineates sound frequency and the shading indicates the sound level. The low frequency activity as seen in the first row is the sound of wind. The "blips" occurring between 8:45 and 20:05 are propeller plane overflights and show a Doppler frequency shift in their sound signature.

For those with interest in natural soundscapes in national parks and the National Park Service role in their protection, the NPS Natural Sounds Program Center website is www1.nrintra.nps.gov/naturalsounds/index.htm

Overflights Committee

The Denali Overflights Advisory Council, a FACA-chartered (Federal Advisory Committee Act) group, was established in 2007 with the task of advising the Superintendent, through the Secretary of the Interior, on mitigation of impacts from aircraft overflights on Denali National Park and Preserve. The Council is comprised of representatives from various user groups including air taxi operators, aviation interest groups, and backcountry and wilderness advocates. In 2008 the Council met at the park, and had an accoustical field trip in which participants listened to sounds, as well as having demonstrations of how the sound program equipment would record such sounds. In 2009, the Council has developed recommendations for revised flight paths that would reduce sound intrusions in certain backcountry zones while still maintaining safety, and help meet achieve the standards for soundscapes included in the 2006 Backcountry Management Plan. Denali's Sound Program has been working intensely to collect and interpret acoustic data so that the Council may make informed recommendations.

Field Class for Geologic Mapping

The University of Alaska Fairbanks under the direction of Rainer Newberry will conduct its Field Geology class in Denali Park from June 27 to July 7, 2009. Class objectives are: (1) to teach advanced undergraduate geology students how to use field geologic information in creating a geologic map and cross section and (2) to better understand the well-exposed, but geologically complex region that sits between two major strands of the Denali fault system.

The class will be based out of several campsites at the Teklanika Campground. Each day, 20 University of Alaska geology students (assisted by UAF faculty members and graduate Teaching Assistant) will conducted field traverses for geologic mapping in 3- to 4-person teams. Each group maps a different but overlapping 10-km^2 area. The objective by 2011 is to complete a detailed geologic map in the vicinity of the park road between Teklanika Campground and the Toklat River, by conducting the field class at Denali in alternate (odd) years. The field class was also held in 2003, 2005 and 2007. One field team discovered the dinosaur footprint near Igloo Creek in 2005.

Muldrow Glacier Monitoring

The Muldrow last surged in 1956-57 extending its terminus some 2.5 miles (four kilometers). Surges may occur at 50-year intervals, so another surge might be anticipated within a few years of 2007. The visual conditions that are characteristic of a glacier before surging were not present in 2008, so a surge may not be imminent. Monitoring efforts in the last few years have described the quiescent glacier between surges. The data can be compared to information collected during and after the next surge. Denali staff members have monitored ice elevations and flow rates of the Muldrow Glacier since 1992.

In 2008, park staff enlisted the cooperation of the Geophysical Institute at UAF and researcher Chris Larsen (also at UAF), to use laser altimetry from aircraft to develop high-precision elevation models of the Muldrow and compare them to the estimates of volume and thickness with on-the-ground surveys and topographic map photographs. The preliminary analysis of change since the

topographic map photographs were taken suggests about 1 cubic mile (4.5 km^3) of lost volume – a relatively small amount compared to other glaciers in Alaska.

In 2009, Denali staff plan to gather the same set of data that Bradford Washburn collected during a 1970's survey expedition on the Muldrow. These data will be used for a detailed analysis of long-term changes in glacier volume (how it is distributed from side to side and along its path), to better understand how the glacier is changing.

Long-term Glacier Monitoring

Traleika and Kahiltna. In 1991, Denali researchers established long-term glacier monitoring sites on the Traleika and Kahiltna Glaciers to monitor long-term glacier flow and mass balance changes. These glaciers were selected to compare glaciers on the north (Traleika) and south (Kahiltna) sides of the Alaska Range (dryer and wetter climates, respectively). The measuring sites for both glaciers are located at approximately 6000' (1830 m). The Kahiltna Glacier flows ~660 feet (200 meters) per year, while the Traleika Glacier moves ~165 feet (50 m) per year. The Traleika glacier has lost approximately 13 feet (4 m) of water-equivalent (if the change in ice/snow were water) in 11 years of monitoring (a negative mass balance), while the Kahiltna has gained ~7 feet (2 m) of water-equivalent. Interestingly, although the Traleika Glacier is experiencing negative mass balance, it has thickened 82 feet (25 m) in the past 11 years (the measurement station has risen by that amount), illustrating the complexity of glacier flow.

Southeast Fork of Kahiltna. In 2004, researchers added the Southeast Fork of the Kahiltna Glacier (the glacier fork that Mt. McKinley Base camp sits on) to the monitoring protocols to measure movement rates, winter accumulation, and summer ablation rates indefinitely into the future. In 2009, researchers will take the second set of ongoing measurements on the Southeast Fork.

In 2009, physical scientists at Denali, in cooperation with a researcher from Alaska Pacific University and his students, will attempt to better characterize the glacier flow around the Kahiltna Basecamp on the Southeast Fork. Student researchers will also attempt to locate historic Basecamp latrines (the ones with magnets installed) using a highly sensitive magnetometer and using projected movements to predict current position. Magnets are also placed in outhouse holes for determination of their movement rates. This study is part of an ongoing effort to mitigate impacts of climbers on Denali.

Straightaway Glacier. The surge that occurred on the Straightaway Glacier in 2007 (ended late in 2007) did not restart in 2008 (a repeat surge occasionally happens). The surface elevation of the middle glacier (see photo) lowered by about 200 vertical feet, as the surge redistributed ice from the upper glacier to the lower section of the glacier. The surging ice "wave" did not reach the terminus. The Straightaway Glacier has a history of relatively small, internal surges, as is evident in its folded medial moraine.

Shallow Lakes Monitoring

In 2008, as an addition to a Central Alaska Network shallow lakes monitoring program in Denali, Amy Larsen (Central Alaska Network Aquatic Ecologist) completed an inventory of approximately 90 lakes in the northwest portion of Denali. Shallow lakes are a major wetland feature in northwestern Denali and many of them are relatively free of direct human modification. They selected a wide range of lake types (more diversity in lake types than shown by the 30 lakes selected for long-term monitoring) to develop a quantitative classification of lakes into which the 30 lakes will fit.

The shallow lakes monitoring program at Denali began in 2006. Vital signs to be monitored in shallow lake ecosystems include water quality, water quantity (e.g., are lake levels falling?), vegetation, and macroinvertebrates. These vital signs were chosen because they represent important physical, chemical, and biological elements of healthy wetland ecosystems. Between 2006 and 2007 (when 28 of the 30 lakes sampled in 2006 were revisited), researchers observed that 27 lakes showed a significant drawdown (on average 6+ inches or 16 cm lower). This difference was explained by low winter snow pack and early melt.

In 2009, Amy Larsen plans to land on still-frozen lakes (Chilchukabena and Starr) to collect sediment cores beneath the ice/water. From an analysis of the cores (sediment dates, pollen, thickness of layers), researchers will gain information about historic lake conditions – allowing managers to better understand if the changes observed today are within the kind of range of natural variation expected over the long term.

Water Quality in Kantishna Streams

In 2008, USGS researcher Tim Brabets performed a comprehensive water quality analysis of previously mined streams in Kantishna to establish a baseline of water quality conditions. The mined sites that have or are undergoing reclamation were tested, along with Rock Creek (an unmined stream near Glen Creek). The streams were tested for standard water quality parameters, algae, and macroinvertebrates. The study will evaluate whether streams show a degraded condition, and will provide a foundation from which any successes of the overall mine reclamation program can be documented.

Early results suggest that Slate Creek has some of the highest concentrations of trace elements in the streambed sediments (compared to 1200 samples in the national water quality (NAWQA) data base). These high concentrations in turn may have affected Eldorado Creek (being sampled in photo).

Post-mining Creek Restoration

Glen Creek. A contract to restore placer-mined Glen Creek (in the Kantishna Hills) will begin in 2009. Contractors will concentrate on removing the last of the abandoned mining equipment, buildings, and support material/debris; removal of contaminated soils; re-contouring of tailings piles and floodplain reconstruction; and re-vegetation of the disturbed ground. This contract uses Centennial Challenge funds.

Slate and Upper Caribou Creek Restoration. Additional plans have been developed to restore Slate and Upper Caribou Creeks, but implementation is not scheduled for 2009. Both are listed as "impaired waterways" under the Clean Water Act due to stream geometries that have been altered by historic mining, creating highly variable sediment loads and resulting in impacts to aquatic habitat.

Permafrost Monitoring

The Central Alaska Inventory and Monitoring Network staff is developing a comprehensive permafrost monitoring program which will focus on the northern portions of the park where permafrost currently exists (see Fig. 17). The development of a monitoring protocol began in 2007, in coordination with Dr. Ted Schuur of the University of Florida, and is expected to be completed in 2009. His project, *Development of Monitoring Techniques to Detect Change in Carbon Cycling in Relation to Thermokarst in National Parks and Preserve*, begun in 2006 in partnership with NPS, will provide critical elements to the monitoring design. Recommendations from his project will be combined with those from a remote sensing interpretation project (identified the rates and nature of landscape change due to permafrost thaw), and a borehole monitoring study (measured temperatures in a borehole in permafrost near the park since 1991) to design the formal monitoring protocol.

Schuur's research is looking at areas of thawing permafrost outside the park to (1) quantitatively determine current plant species composition, growth, and biomass patterns, (2) provide an historical reconstruction of disturbance as a result of thermokarst, and (3) detect the contribution of old carbon to ecosystem carbon cycling. These three measurement approaches can be applied on a widespread scale to analyze change in northern ecosystems and to guide the monitoring of carbon cycle processes that can be affected by permafrost thawing and thermokarst.

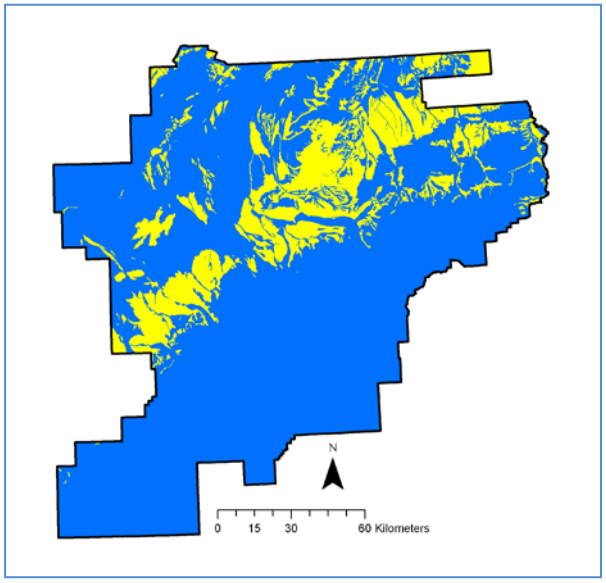


Figure 17.
Permafrost monitoring is expected to be focused on northern areas of the park that are considered to be at least moderately susceptible to climate change (see light colored areas on map, courtesy of Mark Clark, NRCS).

Toklat River Dynamics and Gravel Acquisition

The Denali Gravel Acquisition Plan authorizes gravel to be removed from the Toklat River Plain in order to support maintenance needs of the Denali Park Road. In 2008, approximately 20,000 cubic yards of gravel were removed from the Toklat River Plain by a "mirror channel method" whereby channels mirroring existing braids were cut. The method allows for minimum impact on the river system while providing a long-term sustainable gravel yield, without the need to transport gravel much longer distances if it were acquired from outside the park.

Park staff is monitoring floodplain dynamics, and in 2009 will begin a comprehensive analysis of the Toklat River system – assessing cumulative impacts from bank reinforcement along the Toklat access road, from the existing bridge lengths and causeway, and from gravel extraction.

⊲ Social Sciences ⊳

Visitor-related Projects

One project monitors visitation to Denali National Park and Preserve.

- ✧ **Monthly public use report:** This project documents visits to the park, including Park Road traffic, bus passengers, railroad passengers, climbers, and backcountry users, for both recreational and non-recreational purposes as well as visits to the Talkeetna Ranger Station and those who visit via aircraft landings. According to this report, there were 432,309 recreational visitors to the park in 2008, compared to 458,306 in 2007 and 415,935 in 2006. However, there have been some glitches in the program that formulates the representative numbers for Denali and reexamination of the formulas and input method is forecast for some time in 2009.

⊲ Subsistence ⊳

Denali Subsistence Resource Commission

Two meetings were scheduled with the Denali Subsistence Resource Commission (SRC) in 2008. However, the March meeting had to be cancelled due to a lack of a quorum. At their November 14 meeting, the Commission discussed the final rule published in the Federal Register that includes a provision on subsistence ORV use in the Cantwell traditional use area; and the status of the Environmental Assessment for the construction of replacement subsistence cabins. The Commission also reviewed upcoming funded subsistence proposals; criteria for 13.44 subsistence use permits (for those subsistence users living outside a resident zone community); and discussed the timeline for submitting proposals to the Federal Subsistence Board.

Other Advisory Councils and Board Participation

Amy Craver, Denali's program manager for Cultural Resources and Subsistence, represented Denali at the Eastern Interior Regional Advisory Council meeting (held in Nenana in fall 2008), and at the Denali Fish and Game Advisory Committee (held in Cantwell in fall 2008).

Amy Craver co-chaired the state-wide workgroup (Subsistence Advisory Council) during 10 (monthly) videoconferences and one session held in Anchorage with the subsistence managers from Alaska parks and the Alaska Regional Office, as well as chairs from the statewide Subsistence Resource Commission.

Federal Subsistence Registration Permit Hunts

Denali staff issue the Federal Registration Permits for subsistence hunting of moose and caribou on park lands in Game Management Unit (GMU) 13E (near Cantwell), and moose hunts on preserve lands in GMU 16B (near Skwentna). Park staff spent a day in Cantwell issuing these registration permits (60 caribou permits and 31 moose permits were issued) and a day in Skentna (5 moose permits were issued). Staff issued others from the Denali office throughout the remainder of the season. When subsistence users received their permit, park staff also provided copies of the Subsistence Users Guide, land status maps of GMU 13E.

Hand-filled permit applications were advanced to the U. S. Fish and Wildlife Service where they were entered into a statewide database. Park staff and the Denali SRC utilized this information to evaluate wildlife regulatory proposals.

Managing Timber Resources in the Windy Creek Area of Denali National Park

Currently, Denali National Park and Preserve does not have a subsistence firewood and log management program. To date, no formal assessments have been made of timber resources, local management practices, or timber use strategies. The NPS regulations in 36 CRF 13.20 "Preservation of natural features" and 13.49 "Subsistence use of timber and plant material" guides harvest and use of timber resources. Subsistence users are required to obtain a permit from the park superintendent to harvest live standing timber resources with a diameter greater than three inches at ground height. For live standing timber of diameter less than three inches, cutting is permitted unless restricted by the superintendent. The demand for and use of subsistence timber

resources by qualified subsistence users in the Cantwell area is likely to increase in the future due to the escalating price of fuel oil and the increasing number of qualified subsistence users in Cantwell.

In 2009, Amy Craver will contract with a Forestry consultant to conduct a timber inventory of the ANILCA additions to Denali National Park in the Windy Creek area. This timber inventory will be part of the information needed to develop and draft a comprehensive Windy Creek Firewood/Log Management Plan for qualified subsistence users that would be implemented at Denali.

Monitoring Subsistence Fisheries in Northwest Denali

Local residents near the northwest portion of Denali have noted declines in a number of fish species that are important for subsistence use. They have also noticed increasing numbers of beaver, widespread pond and lake drying, and changes in water quality. These changes concern local rural residents and resource managers, yet to date no monitoring programs have been initiated to examine status and trends of the subsistence fish species in this area. Similarly, there are few data regarding trends in beaver activity or lake surface area dynamics, or addressing possible linkages among these phenomena.

This project, a collaboration between the Denali's subsistence manager, the Central Alaska Network aquatic ecologist, a USGS ecologist, USFWS anthropologists, and a USGS geographer, will seek to fill these gaps using a combination of traditional ecological knowledge, aerial surveys, remote sensing, and on-the-ground field work. Fieldwork will begin July 2009.

Documenting Trapping Activities in Denali and Wrangell-Saint Elias

Drawing on the collection of harvest data, key informant interviews, and ethnographic fieldwork, this multi-park study will document the historic and current active trapline trails and associated activities at Denali National Park and Preserve and Wrangell-St Elias National Park and Preserve. The goal of this multi-park project is to provide data to help inform a trapline management plan for each park. The first year of the project (2009) will focus on Denali National Park and Preserve and the second year will document the trapping activities in Wrangell-St Elias National Park and Preserve.

On February 19, park staff flew to Minchumina for a community meeting to introduce the trapline project (see photo at right). The purpose of this meeting was to solicit feedback from the community about the project's proposed methodology. The meeting was well attended, and the six trappers who attended supported and valued the importance of the project.

Minchumina Residents reviewing map of trapline trails.

Park staff will continue collecting data culminating in a Denali Trapline Management Plan. After the Trapline Plan is completed, park staff will seek additional funding to initiate a Furbearer Harvest Monitoring Program.

◂ Cultural Resources ▸

Comprehensive Archeological Survey and Inventory

In 2006, Brian Wygal was hired in a 4-year term position as park archeologist and began a park archeological survey. He wraps up the final year of the survey in 2009. The archeological survey and the development of an archeology management plan are being performed in accordance with the NPS Systemwide Archeological Inventory Program (SAIP) as outlined in the *Archeological Survey Implementation Plan, Denali National Park and Preserve* prepared by Alaska Regional Office archeologists.

The overall project goals are to identify and inventory previously unknown cultural resources and to retrieve information that could date these sites. Additionally, Brian Wygal has been revisiting previously recorded sites and conducting condition assessments that will aid in the management and preservation of these resources. The data collected during the course of this project will contribute to the development of a comprehensive cultural chronology for Denali.

More than 1200 lithic artifacts have been catalogued and analyzed over the course of the past two years and these have recently been returned to the Denali Museum Collections facility for curation.

In 2008, the archeologist (with archeology crew):

- Intensively surveyed a total of 7,220 acres of Denali including remote regions along Hauke Creek (a small tributary of Birch Creek) and along Somber Creek (a tributary of the Highpower River). Work was also conducted in the Windy Creek region west of Cantwell.
- Discovered four new prehistoric sites.
- Prepared condition assessments on 11 previously documented sites that had not been revisited in some time.
- Hired students through the STEPP program, involved volunteers, and secured outside research funds from the University of Nevada, Reno, in order to complete several projects resulting in a series of presentations and reports.

Archeology crew sets up camp.
Note electric bear-proofing fence.

Native Place Name Mapping Project

The Native Place Names project for Denali was begun in the 1990s. Working with Athabaskan elders in the Denali area, Dr. James Kari identified and collected around 1,600 names that Native Alaskans apply to places associated with Denali (see Fig. 18). The current component of this project involves the layout, production, and publication of a Native Place Names Map for Denali. Sam Coffin a graduate student at University of Alaska Fairbanks recently finished GIS mapping all the Native Place names from Kari's 1990s report. A total of 1,600 documented place names are now mapped (168 are within the park boundary). Of the 168 Athabaskan places names in the park, 99 are of the Koyukon dialect, 28 of the Lower Tanana dialect, 20 of the Dena'ina dialect, 14 of the Upper Kuskowim dialect, and 7 of the Ahtna dialect.

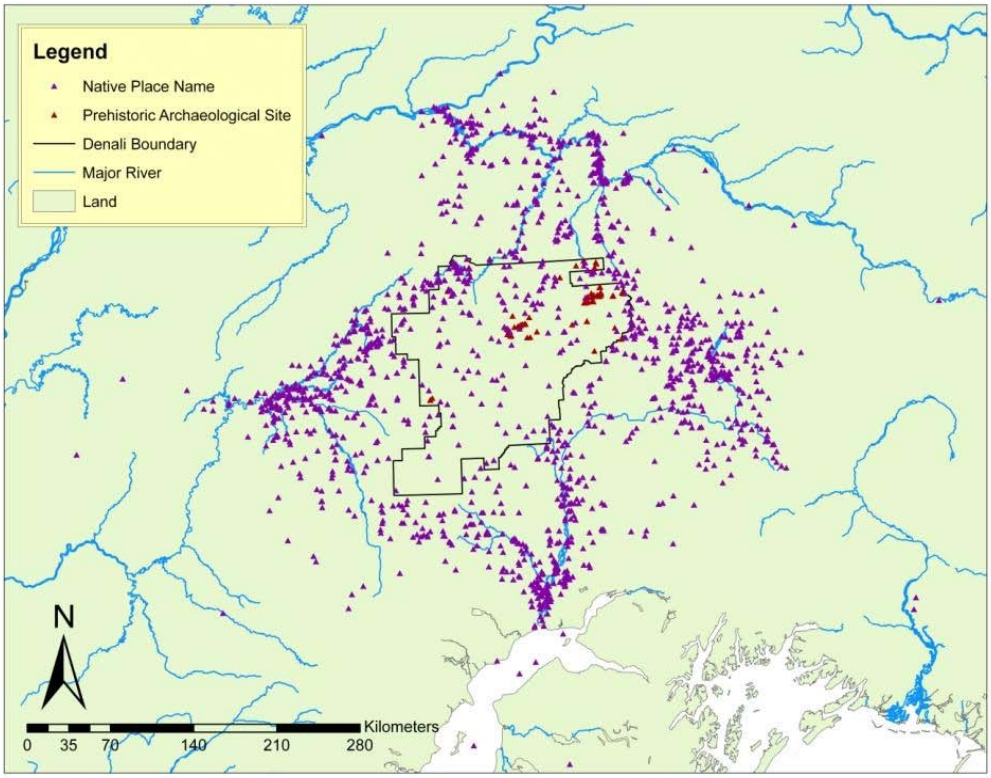


Figure 18: Location of Alaska Native Place Name sites, and prehistoric archeological sites near or in Denali.

In summer 2009, an intern will be hired to develop an interactive map with the place names for both park staff and visitors to Denali. Publication of this map will help park staff and visitors to better understand the relationship between the native Athabaskans and the resources of Denali (Native uses of the park's resources).

Kantishna Cultural Landscape Report

In September 2008, Denali Cultural Resources staff met with members of the Olmsted Center for Landscape Preservation to discuss the scope of a Cultural Landscape Report for the Kantishna and Wonder Lake areas (see Fig. 19). Olmsted, a NPS landscape preservation program based in Boston, completed a Cultural Landscape Report for the Park Headquarters in 2008. The final report will provide information needed to inform a park master planning and environmental compliance effort directed at the western terminus of the main park road.

Olmsted and Denali Cultural Resources staff drove to Friday Creek and took a helicopter flight over the greater Kantishna Mining District and Wonder Lake areas. Jane Bryant led the group by identifying and describing significant historic structures in the proposed study area. One of the main purposes of the visit was to determine the scope of a potential cultural landscape report. A cultural landscape report serves several important functions for cultural landscape management: it documents the history and significance of a landscape; it documents existing landscape conditions and provides treatment guidelines; and, taking cues from planning documents guiding the entire park, serves as the primary tool for long-term landscape management.

The proposed *Kantishna-Wonder Lake Frontcountry Visitor Use, Administration and Interpretation Area Cultural Landscape Report* will provide Site History, Existing Conditions, Analysis, and Landscape Treatment chapters. The Site History and Existing Conditions sections document in narrative and graphic form the physical evolution of the landscape through the present. The Analysis section provides a concise discussion of the property's historic significance according to the National Register criteria, and an evaluation of the landscape characteristics and associated features that contribute to that significance. The Treatment chapter provides recommendations on how to preserve, restore, or rehabilitate landscape features in support of long-term management objectives, accompanied by guidance as to how to accommodate changes in order to facilitate continued use.

Denali approved Olmsted's draft proposal for completing the report in February 2009, and work will commence this fiscal year and phased over a three-year period with a planned 2011 completion date.

Figure 19. Olmsted Center for Landscape Preservation staff and Denali Cultural Resources staff at the historic Kantishna Roadhouse in September 2008.

Servicewide Programmatic Agreement

The National Park Service has signed a new Nationwide Programmatic Agreement (PA) to address compliance with Section 106 of the National Historic Preservation Act and associated implementing regulations. The principal signatories of this nationwide PA are the Advisory Council on Historic Preservation, the National Conference of State Historic Preservation Officers (SHPO), and the NPS. This agreement supersedes the Nationwide Programmatic Agreement signed in 1995.

The PA addresses activities within the national parks that may affect properties of historic or cultural significance on both tribal and non-tribal lands within parks. This document provides a

way to "streamline" the consultation process for actions taken on historic resources by providing a specific list of acceptable actions that will not adversely affect historic resources. This PA will radically change the way in which the NPS conducts both SHPO and Tribal consultation by requiring a greater level of involvement of both the SHPO and appropriate Native Tribes and Corporations. WASO guidance regarding the implantation of this PA is expected by November 2009.

In accordance with the new PA, Steve Peterson and Jeremy Karchut have started SHPO consultation on several projects including historic cabin rehabilitation proposed for the Pearson Cabin, Lower Toklat Cabin, Lower Windy Cabin, and the Sushana Cabin. Steve Peterson and Jeremy Karchut are also organizing a site visit with the SHPO and SHPO staff sometime in late April 2009 to begin consultation for projects proposed at Park Headquarters and along the park road. Tribal consultation will begin this spring with the notification of proposed undertakings at Denali for fiscal year 2009. This consultation process will seek comments or concerns regarding proposed undertakings at Denali from tribes and tribal corporations culturally affiliated with the park.

Historical Research and Oral History

Cultural resource staff continues to participate in planning for interpretive exhibits and programs; produce educational programs interpreting park history for staff and visitors; acquire historic photos; and conduct oral history interviews with park "elders," i.e., park staff, former employees, local residents, and others to document conditions and experiences in the park.

Current and recent work included the following projects:

- The second volume of the park's administrative history, *Crown Jewel of the North: An Administrative History of Denali National Park and Preserve, Volume 2*, written by Alaska Regional Office Historian Frank Norris, was published in December 2008. It is available from the Center for Resources, Science, and Learning.

- In 2008, cultural staff provided information and assistance for park projects including planning for a new Savage River Reststop, Kantishna Reclamation projects, and restoration work at the Toklat Pearson cabin.

- Cultural staff is researching and writing a guide to park history through sites visible from the park road. Historic photographs and interpretive text will illustrate the themes of park history, including transportation, tourism, park administration, mining, and significant place names.

Museum Collections

The primary tasks of the park's Museum Curator are caring for the park's museum collections, updating the collections database, and providing customer service to all park staff as well as the public. To this end, the Museum Curator in 2008:

- Contracted the writing of an Integrated Pest Management Plan for the museum collections, which is now being implemented.

- Updated the Scope of Collections Statement.

- Reviewed Denali's historic photograph collection.

- Added 4550 objects/specimens to the museum database (part of addressing Denali's backlog of cataloging (assisted by seasonal museum technician Barbara Brease). Newly cataloged specimens include a mammoth tooth, a projectile point, microfiche copies of reports, and photographic prints and negatives.

- Completed inventories of all storage cabinets, herbarium specimens, bryophyte specimens, 16 mm film, and binder boxes of historic photographs stored in the Collections vault.

- Provided collection tours for 157 visitors including researchers and park visitors.

- Responded to 92 requests for information about, or use of, Denali Museum Collections—58 requests came from within the park and 34 requests came from outside the park.

- Arranged first Open House of Museum Collections.

Museum Curator Jane Lakeman continued to make many organizational changes to the secure collections vault during fiscal year 2008. A Collections Storage Plan was written for the park suggesting the best possible use of the space given the material currently being stored. Flexible park base funding for a Museum Standards project through the Centennial Challenge Initiative enabled the purchase of three new herbarium cabinets, twelve new object storage cabinets, three new flat file units, and a flammable storage cabinet. Additionally, new 4-post and shelf units were installed allowing for the storage of many more archival collections, the fastest growing component of museum collections.

In 2009 there will be even more changes to the park's Museum Collections. Projects to be undertaken include:

- Reduce Denali's backlog cataloging (continuing effort).

- Complete cataloging of all archeological artifacts collected during the 2007 Archeological Field Survey.

- Write Emergency Operations Plan for Denali's museum collections.

- Initiate rehousing of all Museum Collections, using archival quality material to ensure preservation and protection of this valuable resource.

◂ Research Support ▸

Geographic Information System

A Geographic Information System (GIS) is a computer-based database system for storing, analyzing, and displaying spatial information. Anything that can be depicted on a map can be incorporated into a GIS.

Denali's GIS is used by all functions in the park for analysis of park resources, preparing maps for planning purposes, and public displays. Engineering drawings for construction, mining site rehabilitation, and design work are also produced by the GIS. Denali's GIS includes several hundred layers or themes of information (hydrology, elevations, buildings, roads, etc.) that can be overlain by the computer to form composite maps. In addition to producing maps and other visual products, the associated databases can be queried in an unlimited variety of ways to analyze the features appearing in the maps. The system is managed on a central workstation and used by park staff on their desktop computers, laptops and other mobile devices. Efforts are on-going to make the technology and/or products more useful and available. A simplified interface called ArcReader requires no GIS background makes much of the information available to casual users. Applications such as Google Earth have brought GIS technology to anyone with an internet connection.

One notable addition to the park's GIS dataset involves an on-going project to collect high-resolution (1 meter) satellite imagery of the park. The project was started in 2005 and to date the portion encompassing the road corridor and south to the Alaska Range as well as a portion in the southwest corner has been collected. On-going problems with cloud cover during the summer months have hindered the data collection. It is hoped that eventually the entire park will be collected as clear images become available resulting in a base map far more accurate than the existing USGS Topo Quads.

The park maintains a copy of the entire NPS GIS dataset for the state of Alaska locally (over 600gb of data and over 18,000 coverages). Many additional layers of information have been added. The dataset is kept current through updates that are conducted nightly over the internet. Major infrastructure layers are updated to reflect changes as a result of work accomplished in the summer season.

A select set of GIS layers are available for easy public viewing (trails, backcountry units, animal movements) using freely available software such as Google Earth. The data files can be downloaded from the park's website (www.nps.gov/dena). Recently, the high resolution satellite imagery viewable in Google Earth has been upgraded to include much of the eastern half of the park.

GPS (Global Positioning System) has become a valuable tool for park managers in all disciplines. As receivers have become smaller, cheaper, and more precise, the number of units in use in the park has grown dramatically. The tool has become a common addition to backpacks along with the first aid kit and map. The latest high-end handheld GPS collects positions as precise as 8 inches. The park glaciologist uses Survey-Grade GPS to measure movements of glaciers within 0.1 meter. Biologists use GPS to document sample site and observation locations within 2 to 5 meters. The backcountry staff uses small, recreation-grade GPSs to document patrol routes,

campsite locations and for search and rescue. The maintenance Division uses GPS to document infrastructure such as culvert locations and for laying out construction projects. In the future this tool will increasingly be useful for precisely locating park infrastructure and documenting management activities.

Research and Resource Communications

Several more color fact sheets about Denali resources and scientific findings were produced in 2008 and early 2009. Additional fact sheets will be developed in 2009 and future years. These fact sheets are also available at http://www.nps.gov/dena/naturescience/factsheets.htm

- Air Quality Monitoring NEW
- Beavers Across Denali's Hydrologic Landscape NEW
- Central Alaska Network: Inventory & Monitoring Program
- Climate Change
- Climate-related Vegetation Changes
- Dinosaur Track Found in Denali
- Ecology of Upwelling Areas in the Toklat River
- An Integrated Study of Park Road Capacity –2006, 2007, 2008
- Large Lakes and Landscape Limnology
- Large Mammals…How many are there? (annual update NEW)
- Moose Surveys
- Painted Fossil Bison Skull: When, how, and why was it painted?
- Paleoecology of Denali's Dinosaurs NEW
- Permafrost Landscapes
- Population Biology of the Wood Frog
- Reconstructing Ecosystems of the Lower Cantwell: Plants in the Age of Dinosaurs
- Resource Stewardship Strategy
- Rivers and Streams (4-pages)
- Soil Survey and Ecological Classification
- Soundscapes
- Stampede Creek and the Legacy of Mining: Antimony Movement in Stream Water and Sediment NEW
- Surveying Dall's Sheep Populations NEW
- Treeline Shifts in Denali: Influences of Climate Change and Local Site Conditions NEW
- Wildland Fire Risk and Response: Why are you cutting those trees?
- Wolf Monitoring 1986 – 2009 NEW

Research Administration

As of March 1, 2009, 791 study numbers have been assigned to scientific and scholarly studies (some continuing and some have taken place in the park over the years). Each year there are approximately 50-75 studies that are ongoing or recently completed.

These projects are either conducted by Denali staff (described at length in this document) and park cooperators (e.g., U.S. Geological Survey, Biological Resources Division, and the Alaska State Department of Fish and Game), or by other investigators (e.g., from universities and other agencies and institutions). Appropriate research gathers information while making minimal impacts to park resources. Scientific research on arctic and subarctic ecosystems has been integral to the understanding, management, and protection of resources at Denali National Park and Preserve since the early 1900's.

Any scientist wanting to conduct research must submit a study proposal and fill out an application. To expedite this process, the National Park Service developed a Research Permit and Reporting System (RPRS). Beginning in 2001, scientists file an application using the RPRS website (http://science.nature.nps.gov/research).

There are new and revised pages and documents for researchers now posted on the park's website (access the Information for Researchers page via the Nature and Science page) http://www.nps.gov/dena/naturescience/research.htm

Denali Park staff review the application and study plan for any administrative, scientific, or compliance concerns, assess how the proposed project fits in with the overall science goals of the park, and set the conditions of the research permit, if approved and issued. Collecting permits may be granted for limited collecting of objects, whole organisms, or parts of organisms (e.g., leaves). Some samples may be destroyed while being analyzed. Some animals may be collected and released after they have been measured or tagged.

Each researcher reports his/her results in an Investigator Annual Report (IAR). Anyone can access and read the Investigator Annual Reports for projects conducted in Denali and all national parks by going to the website http://science.nature.nps.gov/research. Beginning in 2002, each researcher at Denali is expected to include an educational component to their project, in addition to filing an IAR.

Study files about each research project are kept in fireproof file cabinets in the resources building. Reports, dissertations, and publications resulting from scientific studies become part of Denali's resources technical library. Arrangements can be made to use these materials by contacting the Lucy Tyrrell, Research Administrator at (907) 683-6352. Computer databases are maintained about the research studies and the library volumes. Archived documents and collections are housed in the Denali National Park Museum or are loaned temporarily to other institutions.

◂ Brief Synopsis of Research Findings in 2008 ▸

The following researchers (non-Denali staff) held research permits in 2008. This table provides brief information about their findings. (Some research is reported in more detail elsewhere in *Current Resource Projects*.)

Each researcher is required to submit an Investigator's Annual Report (IAR) to the National Park Service. To view IARs for research conducted in Denali and in other parks (and to search IARs by park, year, investigator, or key words), visit the website: http://science.nature.nps.gov/research.

Researcher	Affiliation	Project
Adams	USGS-Alaska Science Center	Population dynamics of wolves and their prey in a subarctic ecosystem (caribou only)
Information about this caribou project is reported on page 24-26.		
Akasofu	International Arctic Research Center, UAF	Weather conditions on Mt. McKinley
Dr. Akasofu is retired, and the new principal investigator for this project is Larry Hinzman (see below).		
Andersen	Anchorage Forestry Sciences Laboratory	Using the ICESAT-GLAS lidar to estimate the amount, spatial distribution, and statistical uncertainty of aboveground carbon stocks of the North American boreal forest
No IAR has been filed as of April 15, 2009.		
Arp	USGS-Alaska Science Center	Using beaver colonies as a model for ecosystem land use and recovery in Denali National Park and Preserve, Alaska
An aerial survey to locate beaver works (lodges and dams) was done on August 10, 2007 from a Cessna 185 float plane piloted by Jim Webster of Fairbanks starting at Summit Lake, crossing the Alaska Range northeast of Mount McKinley, proceeding over the Muldrow Glacier and Wonder Lake, out to Lakes Minchumina and Chilchukabena, and returning to Summit Lake flying south around the Alaska Range. After reviewing photographs time-linked to GPS points, it was determined that 239 individual beaver works were observed along this 700-km track. Based on the low flying height and good conditions, it was estimated the surveyors could adequate spot beaver works within 1 km of the plane and thus covered approximately 6% of Denali land area. The most interesting initial finding was that a few areas in the park had very high beaver work densities, particular along the mountain front south of the Alaska Range, around Wonder Lake and Moose River in the Kantishna Hills, and between Lakes Minchumina and Chilchukabena, while other very similar appearing parts of the hydrologic landscape were devoid of any beaver activity. Its noted here that some beavers use bank dens rather than lodges and would be very hard to locate from a plane. Beaver locations were classified by hydrologic conditions, which indicated that nearly half of works were found along streams and rivers (49%) compared with lakes and ponds (18%), springs (15%), and floodplains (18%) that appeared to be less frequently used.		

Researcher	Affiliation	Project
Arp (cont'd)		

Additional questions of interest were, "How many of these beaver works are currently inhabitated by beaver families?" and "How many abandoned beaver dams and lodges were not seen because of degradation and plant growth?" To better answer these questions, researchers spent several days prior to the air survey working at one large beaver complex on Lake Creek near the Wonder Lake ranger station. A segment of the stream here had both active and abandoned beaver dams and lodges, with one such abandonment dated by the park rangers as occuring in 2005. Researchers conducted a topographic survey of this segment to develop a detailed map of the area; they compared this map to their observations from photographs taken days later. This comparison was used to better determine which beaver works were active or abandoned throughout the flightline. Using this method, research suggests that 47% of observed sites were active and 53% were abandoned. However, 12 dams and 3 lodges were mapped while surveying on the ground, while only 5 of the 12 dams and 2 of the three lodges could be observed from air photographs. Thus estimates of the total number of beaver works from a plane, particularly abandoned sites was likely underestimated.

Brabets	USGS-Alaska Science Center	Water quality from streams draining abandoned and reclaimed mined lands in the Kantishna Hills area, Denali National Park and Preserve, Alaska

Fifteen streams were sampled 4 times in 2008 for trace elements in bed sediment, major ions, and dissolved trace elements. Seven sites were sampled for macroinvertebrates and algae. (See also page 46.)

Brennan	Purdue University	A park visitors view of the growth of a continent

The transition from the thick (40-45 km thick) crustal root of the Alaska Range to thin (25-30 km thick) crust of the Paleozoic Yukon-Tanana terrane to the north coincides with the surficial trace of the northern-most strand of the Denali fault system (the Hines Creek fault). Another transition in crustal thickness is observed along the southern side of the Alaska Range as the crustal root thickness thins to approximately 35 km which coincides with the surficial trace of the southern most strand of the Denali fault system (the Talkeetna fault). These observed changes in crustal thickness bounding the Alaska Range also occur at the termination of several mid-crustal arrivals noted beneath the Alaska Range. Changes in the characteristics of the lithosphere, as observed by receiver function analysis, are also observed by similar changes in p-wave tomography (Eberhart-Phillips et al., 2006). Earthquake seismicity is distributed throughout the upper crust (10-15 km) along both cross-sections, but of note is a swarm of seismicity just west of the Hines Creek fault as the crust thins from ~ 45 km thick to ~33 km in thickness.

We interpret the lack of significant changes or boundaries in the lithosphere across the McKinley fault as the result of relatively recent deformation along this portion of the fault system. The first-order structures that bound the lithospheric and crustal geometry of the orogen appear to be the Hines Creek fault to the north and the Talkeetna fault to the south. It is likely that these faults represent the boundaries of an older phase of deformation (relative to the McKinley fault) that were prominent in the uplift of the Alaska Range. The concurrence of these lithospheric-scale boundaries at the edges of geologic terranes is not surprising as these older crustal heterogeneities have likely been reactivated during the deformational phase related to the uplift of the Alaska Range.

Researcher	Affiliation	Project
Brown	University of Alaska Fairbanks	Developing a multiyear trend model for habitat use of wood frogs in Denali National Park and Preserve

During the summer of 2008 (May 29-June 26), 84 lentic wetland sites were surveyed in the Wonder Lake region of Denali National Park and Preserve as part of a project funded by the Discover Denali Fellowship program. Some sites had been previously surveyed in 2004. Incidental observations were recorded as well as data for vocal surveys . The wetlands were classified with habitat variables using a data form provided by the Montana Natural Heritage Program. Species classification information was collected for *Rana sylvatica* and UTM coordinates were recorded for each of the observations. Overall, 37 additional sites were added to the wetland monitoring of *Rana sylvatica;* 47 of the 84 sites surveyed in 2008 were occupied by *Rana sylvatica*.

Wood frog observations were classified into 5 classes (egg group, larvae, metamorph, juvenile, and adult classes). The egg group class was observed between May 31 and June 19 at 10 sites, 7 of those were previously surveyed in 2004. The larvae class was further classified into 5-20 mm larvae and 20-50 mm larvae. Between June 15 and June 25 larvae were observed at 20 sites with 18 of those classified as 5-20 mm and 6 classified as 20-50 mm larvae. Of those 18 larvae sites observed in 2008, 16 were previously surveyed in 2004. There were two metamorph observations made on June 20 and June 21. Juveniles were observed between June 4 and June 25 at 5 sites. Adults were observed at 19 sites between May 31 and June 21 (10 sites previously surveyed in 2004, 9 new sites).
The vocal and incidental surveys were conducted during varying times of the overall survey between May 29 and June 26. Overall, 103 *Rana sylvatica* observations were recorded with 37 egg group sightings and 77 adult observations. Of the 77 adult observations, 62 were vocal surveys and were not direct observations.
In conclusion, *Rana sylvatica* observation data indicate that a landscape predictive model would provide a valuable addition to the monitoring of *Rana sylvatica* populations within Denali National Park and Preserve as well as statewide. Furthermore, precise timing of adult observations would enable a diet analysis to be performed on the population in order to greater understand the environmental factors that affect the freeze-tolerance mechanism.

Cable	University of Wyoming	The consequences of permafrost degradation and plant water use strategies for plant community composition

A field campaign was successfully completed in July 2008, where I collected plant stems, leaves, active layer (soil and organic material), and permafrost (down to 0.25-0.5 m depth) from 5 locations on a well-drained tussock tundra ecosystem. This was done outside the park boundaries near the Stampede Road, where the ecosystems and landscape are identical to those in Denali. I was unable to measure plant water loss (transpiration) because it was raining and too humid. The equipment cannot be used in these conditions. In the fall of 2008 at the University of Wyoming Stable Isotope Facility, I cryogenically extracted water from the plant stems, leaves, active layer, and permafrost. I submitted the samples for stable isotope analysis (^{18}O and ^{2}H) at the University of Wyoming and am awaiting the results. I also ground the leaves to a powder and submitted them for ^{13}C analysis, which will tell us about the relative water stress of the plants. The analysis equipment for the water samples is under repair, but they expect to give me isotope results by the end of February 2009. I have been working on the model that will quantify the use of permafrost thaw water by the different plant species. Lastly, while I was at Denali Park, I gave a public lecture to a group of Elderhostelers at the Denali Education Center.

Carlson	University of Alaska Anchorage	Flower color evolution in the arctic: integrating genomic research and undergraduate education in polar environments

To examine how pigmentation might be correlated with abiotic drivers of natural selection, particularly climate, we collected data on the frequencies of pigmented and unpigmented individuals of the same species across a very broad latitudinal gradient. We collected data on populations from the southern tip of the Alaska Peninsula to the North Slope, including one from Denali. We also collected data on the species ecology (e.g., presence of pollinators and herbivores).

Researcher	Affiliation	Project
Carlson (cont'd)		

We located a population of *Parrya nudicaulis* and *Cardamine purpurea* (Brassicaceae) along the Savage River that contained individuals expressing very different levels of floral and vegetative pigments. We censused the population of *Parrya* (1139 individual plants) and recorded the frequencies of unpigmented, very light pink, light pink, and dark pink to purple colored individuals: Nearly all (97 percent) of plants showed some level of pigmentation, with 42% of the plants being very lightly pigmented, 42% being light pink, and roughly 13% being dark pink. For a broad transect from 63N to 71N at roughly 140 degrees longitude, we see a weak positive correlation in the frequency of pigmented individuals with increasing latitude. This supports our prediction that the frequency of white morphs (those not producing anthocyanins) should decrease with increasing latitude.

We also collected data on the latitude, longitude, and elevation of the site. This spatial information will be used to acquire PRISM climate data so we can correlate pigmentation frequencies to climate factors such as minimum summer and winter temperatures.

Additional herbivory data was collected for the *Parrya* plants (herbivory by *Pieris napi* butterfly larvae). We observed young caterpillars and a number of eggs on the undersides of leaves. Too few observations were made to determine if oviposition preferences were related to anthocyanin concentrations (anthocyanins and their flavinoid precursors are known to have anti-herbivory qualities).

We collected some leaf and flower tissue from 20 white, 20 light pink, and 20 dark pink *Parrya nudicaulis* individuals. The tissue was frozen and metabolimic research to determine anthocyanin concentrations is scheduled in May in Dr. Kleibenstein's lab UC Davis. RNA was extracted from 20 individuals and we have 5 of 6 genes in the anthocyanin biosynthetic pathway sequenced. Data from these analyses will be used to address our other predictions.

Coble	Stephen F. Austin State University	Interpreting the Alaska National Park experience

No IAR received as of April 15, 2009.

Concienne	University of Colorado at Boulder	Microbial succession in soils at retreating glaciers

Nitrogen pools in the soils at the Middle Fork Toklat Glacier (MFTG) are extremely low. Four zones were sampled, with approximate age ranges of 0-6 years in zone 1, 6-16 years in zone 2, 16-54 years in zone 3 and 4. Levels of microbial biomass N increased from non-detectable levels to 4 μgN/g soil. Although not statistically significant, this demonstrates a trend in increasing microbial activity. Further measurements of functional attributes in the soil microbial community, plant community, and climate were taken: N fixation increased from non-detectable levels to 0.27 ng/cm2/h along the chronosequence. Total plant individuals increased along the chronosequence from 0 to 135 individuals.

Within newly deglaciated ecosystems, the only source of N is from the fixation of atmospheric N_2 and, therefore, N-fixing microbes are the first colonizers. N-fixing plants contain bacterial symbionts within the roots to facilitate N assimilation and are the first vegetative invaders within disturbed ecosystems. Vegetative primary succession at the Middle Fork site includes the invasion of N-fixing plants such as *Epilobium latifolium* and *Astragalus nutzontinensis*; however, plant individuals were sparsely evident along most of the chronosequence, indicating that not only is N the limiting factor to plant invasion, but that there may be some other competitive factors. Studies of newly deglaciated ecosystems elsewhere indicate that microorganisms colonize newly deglaciated ecosystems before plants. Microbial biomass N (MBN) is indicative of the total size of the microbial community and is good measure of the potential timing of

Researcher	Affiliation	Project
Concienne (cont'd)		
plant invasion. The MFTG chronosequence shows very low levels of N-fixation or MBN, and the levels of both only become detectable in the oldest soils. N-fixing heterotrophic microbes colonize soils when conditions are favorable, i.e. when the N-fixers can out compete the other heterotrophic microbes for nutrients. The limestone that makes up the mountains around the Middle Fork is most likely high in C, therefore further studies are necessary to fully understand the reasons for the apparent late colonization of N-fixing microbes and plants. In addition, because the MFTG is a "dirty" glacier, nutrient cycling along the chronosequence needs further investigation (taking samples further up on the glacier and analyzing them for C, N, and P content as well as microbial community structure and function. Further studies are also needed to better access the C:N and N:P levels and how these impact soil formation and vegetative succession along the entire chronosequence. A better understanding of N (as well as C and P) cycling within these little understood newly-deglaciated ecosystems could be vital to monitoring the effects of climate change on nutrient cycling.		
Densmore	USGS-Alaska Science Center	Long-term monitoring of restoration of placer-mined watersheds in Denali
The monitoring methods used for this phase of the project included surveyed stream cross-sections, vegetation plots, and aerial, ground, and satellite photos. Recent work focused on the effects of a major (25-year) flood that occurred in 2000. Research addressed the immediate flood effects on the stream and floodplain geometry and riparian vegetation, evolution of the stream from annual flooding and recovery of riparian vegetation for six years after the flood, and adaptive management strategies that would benefit this and future restoration projects in this region. In 2008, we analysed results and submitted a manuscript to NPS and a professional journal. Our results illustrated design flaws, particularly in regard to identification and analysis of sediment sources and the dominant processes of channel adjustment. Significant unanticipated channel widening occurred following the flood, likely caused by excessive upstream sediment loading.		
Densmore	USGS-Alaska Science Center	Factors controlling establishment and growth of *Taraxacum officinale* in Alaskan national parks
Exotic annual plants that had colonized both study sites had disappeared by 2008. After four years, no exotic plants, including Taraxacum officinale, were present on the roadside study site 85 miles from the park entrance. After five years, T. officinale had colonized only one of three replicate blocks in the study site near the visitor center, and density did not vary among revegetation treatments.		
Fehrmann	Alaska Pacific University	When tectonics give rise, streams respond: using longitudinal steam profiles to determine areas of tectonic activity
Field plans were made, but the study activity ended up being based on spatial data using GIS. Findings did conclude that variations in longitudinal stream profiles did coincide with variations in bedrock type and glacial influence, as well as regions of possible tectonic activity where no other known possible sources of stream profile variations were expected. Ground-truthing of this study is recommended in order to conclude any findings.		

Researcher	Affiliation	Project
Fiorillo	Dallas Museum of Natural History	Paleontological survey of the lower Cantwell Formation, Denali National Park and Preserve

This is an ongoing project. Inclement weather curtailed much of the original work plan. However, accomplishments for 2008 include significant mapping at an extraordinary dinosaur track site found near Cabin Peak. Details of this site were presented at the 2008 annual meeting of the Society of Vertebrate Paleontology. Continued investigation of fossil resources in the Tattler Creek area produced a hand impression of a pterosaur, the first record of these animals in all of northern North America. A description of this specimen was submitted for publication in the international paleontological journal *PALAIOS*.

Researcher	Affiliation	
Fix	University of Alaska Fairbanks	Effects of survey timing on the measurement of current social and resource conditions

This study conducted a sample of 262 day visitors hiking in the Denali backcountry (111 visitors waiting for the bus (pre-trip), 68 visitors departing the bus after they returned from their trip (post-trip), 45 visitors at the Savage River rest area and 38 visitors at the Eielson Visitor Center). Key findings include: 1) sampling visitors post trip would result in the highest rate of completed surveys, 2) item non-response does not appear to be an issue between pre-trip and post trip samples, 3) mean levels of indicators were similar between pre and post trip samples, 4) and sampling at the Wilderness Access Center post trip and at the Savage River rest area will provide a representative sample of day hikers. It is recommended that any future research to measure indicators related in day hikers in Denali National Park and Preserve sample visitors post trip at the WAC and at the Savage River rest area.

Fix	University of Alaska Fairbanks	Monitoring indicators of visitors' backcountry experience in Denali National Park

The Denali National Park and Preserve Backcountry Management Plan (BCMP) identified ten indicators related to the visitor experience, and set standards for those indicators. The BCMP explicitly stated six of the indicators would be monitored, by visitor survey, at least once every five years. This study will measure levels of these six indicators so comparisons to the standards can be made. In addition, the BCMP calls for the evaluation of the usefulness of the indicators as a measure of the visitors' backcountry experience. This study will also assess the usefulness of the indicators as an important measure of the visitors' backcountry experience.

Study sites were assessed in 2008, but data were not gathered.

Freymueller	University of Alaska Fairbanks	Repeated Global Positioning System (GPS) and absolute gravity measurements to measure active crustal deformation in southern Alaska

No IAR was received by April 15, 2009.

Haber		Dynamics of wolf-prey systems and wolf societies in the Denali Region, Alaska

This research, which began in 1966, focuses on groups rather than populations. The report for this research, covering biological years 2007 and 2008, i.e., May 2007 - April 2008 and May 2008 - April 2009, will be available in May 2009. Go to www.alaskawolves.org for the previous annual report and other reports (Reports and Reports2 pages) and ongoing excerpts, with photos, from the field observations (Blog section).

Researcher	Affiliation	Project
Hansen	University of Alaska Fairbanks	Denali Seismic Monitoring Sites (including repeater on Double Mountain)

Site description: The seismic network in Denali Park consists of eight sites; four seismic stations, three telemetry sites and a display at Eielson Visitor's Center (EVC). However, the display was removed in early 2005 in preparation of the demolition of EVC.

From west to east, the seismic stations are: "CAST" at Castle Rocks (63 N 25.16, 152 W 4.92); "KTH" located on top of Wickersham Dome near Kantishna (63 N 33.19; 150 W 55.26); "TRF" on top of Thorofare Mountain (63 N 27.06; 150 W 17.24); and "MCK", located near the entrance of the park (63 N 43.94; 148 W 56.10). Data from "MCK" is available in near-real-time on the internet at: http://quake.wr.usgs.gov/waveforms/crest/indexc.html Telemetry repeaters are located on the sides of Double Mt., and Mount Healy near the park entrance. A receiving site was established in 2005 at the Murie Science and Learning Center (MSLC) to relay data from the radio links via a leased DSL phone line to AEIC. Station "MCK" was first installed in July 1964 after the Great Alaska Earthquake of March 28, 1964. It was most recently upgraded with a state-of-the-art digital broadband instrument in August 1998. The seismic stations "KTH" and "TRF" were originally installed on August 15, 1988 and were upgraded in June 2003. Finally "CAST" was installed in August 2006.

These stations are part of the regional seismic network of about 450 seismic stations in the State of Alaska. Most of Alaska's earthquakes are caused by the extremely active plate boundary between the North American and the Pacific tectonic plates. One of the problems of interest is the deep seismicity beneath Mt McKinley and its relation to the deep root of the mountain, and how deep seismicity relates to the shallow Kantishna cluster of seismicity.

On November 3, 2002 at 1:12 PM Alaska time, the largest earthquake to occur in the world in the year 2002 struck central Alaska. The epicenter was located approximately 68 km east of Denali National Park. This major activity on the Denali fault system increases concern that the western portion of the Denali fault, the part that that bisects Denali National Park, may have increased likelihood of rupture.

What was done in 2008:

We spent one day, August 15, in the park performing routine maintenance in 2008. The crew was Steve Estes and Tammy Viggato from the Alaska Earthquake Information Center accompanied by Larissa Yocum of Denali National Park and Shane, helicopter pilot.
• Castle Rocks, we rewired the solar panels, checked out site, leveled seismometer and planed for addition of strong motion instrument;
• Double Mt. Repeater, we inspected site. Everything looked well. NPS has removed nearly all of their equipment.
• Healy Mt. Repeater the door was locked. We had no key. Took photos, inspected antenna.
• Kantishna (Wickersham Dome) we remove remains of old short period analog station. Check out the broadband sensor and looked at the communication link which has no been functioning well. It looked okay
• Thorofare Mt., we found the door locked. We had no key so we inspected vault,. Everthing was okay.
• We did not visit the MCK site or MSLC.

Future plans:
• continue removing the older analog seismic stations, now that the new digital stations are stable
• add a strong-motion sensor at Castle Rocks to allow for on-scale recording of large earthquakes that may occur on the western portion of the Denali fault.
• add a seismometer at Double Mountain (sometime in the future). These would be necessary to obtain a better resolution on the source of that very active zone of seismicity located roughly between Mount McKinley and Wonder Lake at a shallow depth. This would also provide valuable insight to the rupture process should the western portion of the Denali Fault rupture.

Researcher	Affiliation	Project
Hinzman	International Arctic Research Center, UAF	Weather conditions on Mt. McKinley

The goal of this project is to measure high altitude meteorological data and to maintain a near real time data stream from the mountain. The transmitted Mt.McKinley weather data will be displayed on the Internet so the public may view the most current mountain condition.

The attempt to reach the weather station in 2008 was met with harsh weather conditions and many snow days. The team was held at 14K camp, then at High Camp for extended days due to dangerous weather and was only able to reach the weather station for a very limited time. During their brief visit to the station, the team was only able to work on the temperature sensors, batteries and buried the data logger in the snow. The thermistors are measuring the air, snow, and rock temperatures. The anemometer could not be mounted securely to the weather station and was brought back.

Preliminary observation at the High Camp area indicates this may be a possible location for a weather station site. Moving the weather station to a more readily accessible location, which is not as exposed as the current location, will most likely increase the time that the technicians can work on the weather station. However, it is unknown if the data transmission from this location is possible.

For 2009, we hope to put all the sensors on the weather station for continuous data recording and also bring back the damaged weather station mounting poles. Currently, we would like to aim for the relocation of the weather station to High Camp area in 2010.
[See also information reported on page 38-39.]

Jackson	UNAVCO Inc.	Plate Boundary Observatory (PBO) component in Denali National Park to monitor tectonic and magmatic process using high precision Global Positioning Systems (GPS)--Reconnaissance of sites south of the Alaska Range

Site AC56/WICK was built on August 30, 2008 at 63.55278, -150.92222 near Wonder Lake Ranger Station.

Site AC33 at Tokosha COMMS facility was visited on August 31, 2008 for routine maintenance.

Jeffries	University of Alaska Fairbanks	Lake ice and snow studies at Horseshoe Lake, Denali National Park and Preserve: scientific research contributing to science education

One objective of this study is to learn about the variability (within a year, and among years) of lake ice thickness, snow depth and density on the ice, and the conductive heat flow through the ice and snow to the atmosphere throughout Alaska. A second objective is to contribute to science education by involving K-12 teachers and students in a scientific inquiry that involves hands-on participation in the Alaska Lake Ice and Snow Observatory (ALISON).

The Alaska Lake Ice and Snow Observatory Network (ALISON) study site on Horseshoe Lake was set up on 10 December 2008. This is the sixth year that ALISON measurements have been made at this site.

This year Dorothy DeBlauw, a 5th grade teacher at Tri-Valley School, and her class have been making measurements during the winter. These measurements include ice thickness and snow depth, density and top-and bottom temperatures. The heat flux from the lake is calculated from these measurements. The class is has been going to the site about once a month. Kristen Friesen (NPS employee) has been helping Ms. DeBlauw with this project.

Researcher	Affiliation	Project
Jeffries (cont'd)		
The ice thickness as of 17 February 2009 (0.65m) is similar to the ice thickness from the previous year (0.68m on 21 February 2008). The snow depth is also similar (0.066m in 2009 compared to 0.081m in 2008). However, the snow density is lower in February 2009 (~155 kg m3) than last year (~250 kg m3). Nevertheless, heat flux appears to be in line with previous years' data. The Tri-Valley School data set at Horseshoe Lake is one of the longest in the ALISON project. These data are unique in that no other group is doing these kinds of measurements in the immediate area. These data represent an important contribution to the understanding of Alaska's changing environment. The data acquired during the 2008-2009 ice season represents a contribution to the International Polar Year (IPY) effort that began in March 2007 and ends in March 2009. The current Horseshoe Lake data are posted at http://www.gi.alaska.edu/alison/HLY_CURRENT_Graph.html. All of the previous years' data are posted at http://www.gi.alaska.edu/alison/HLY_PAST_Graph.html. The data from 2003-2008 can be downloaded from http://www.gi.alaska.edu/alison/ALISON_data.html.		
Larsen, A.	Central Alaska Network	Central Alaska Network shallow lake monitoring project
In summer 2008 we sampled 98 lakes north of the Alaska Range in Denali National Park and Preserve. Sampling followed the standard operating procedures outlined in draft monitoring protocols for shallow lake monitoring (Larsen et al. 2005). Samples were collected for analysis of water, vegetation, thaw depth and peat thickness. Bathymetric surveys were also conducted on each lake. Data have been entered into the NPS Alaska Shallow Lakes database. Historic analysis of remote sensed images suggests that lake surface area in the Minchumina Lowlands has decreased by 16%. A complete data analysis will continue through 2009 analysis products include a map of lake districts, a classification of lake types and age classification system. We will also complete a comparative analysis of lake types in relation to fire, permafrost degradation, lake type, age and geographic position.		
Larsen, C.	Geophysical Institute, UAF	Airborne surveying of glacier surface elevation change
Surveys were conducted over several glaciers within Denali, including the Muldrow, Kahiltna and others. These surface elevation data are being compared to earlier surveys to determine the rate of mass balance of these glaciers. Preliminary results indicate that the highest elevation glaciers may not be losing mass as fast as in the past, while the lowest elevations have accelerated in mass loss.		
Molly Lee (and Amy Wiita)	University of Alaska Fairbanks	Artists' Sense of Place: The Connection of Art and Environment
I observed various aspects of the Denali artist-in-residence (AIR) program over the year including the artist selection process and artists' public presentations. I made four trips to Denali and attended the three public presentations by artists-in-residence. I collected data during these presentations for analysis and preparation of the artists' ethnographic interviews. Two artist interviews were completed with 2008 Denali artists-in-residence. I revised the process for one interview to meet the participant's needs and it is in progress. Two additional artist interviews are pending. I continued to interview park staff in 2008 and completed 2 additional staff interviews.		

Researcher	Affiliation	Project
Lee / Wiita (cont'd)		
All interviews have been ethnographic and have focused on obtaining information on themes and categories. To ensure the best data collection possible I have individualized the interviewing process to each participant's needs while maintaining rigor in the data collection process. A great deal of flexibility has been required for the interviewing and interaction process with participants. Data collection has required personalized attention to how to best engage each participant. This has meant revising the data collection process to include written responses and attendance at art shows. I took a trip to Eielson Visitor Center to observe the art in the new visitor center and to get a better perspective on the areas available to the AIRs and the cabin where they stay in the park. I attended art shows of artists-in-residence in Anchorage and Fairbanks and began data compilation.		
MacCluskie	Central Alaska Network (NPS)	Small mammal monitoring at the landscape scale and synthesis of monitoring data in Denali NPP
See page 28-29.		
Manning	University of Vermont	A predictive study of use impacts on the Denali park Road: a study plan to support analysis and management of carrying capacity
Data collectd in the summer of 2007 were analyzed and presented to the park through a workshop and report. Standards of quality for relevant indicators of quality were determined. These findings were coordinated with research on the effects of park road vehicle traffic on wildlife, and a computer simulation model of park road bus traffic.		
Marion	Patuxent Wildlife Research Center, USGS	Developing monitoring protocols for assessing the extent and condition of informal trails within Denali National Park
Alternative methodologies for assessing and monitoring trail conditions within backcountry park environments were developed, field tested, and revised. Evaluations of alternative protocols were conducted to assess their accuracy and precision. The application of sub-meter and sub-foot Trimble GPS units was assessed for data collection.		
Martin	Whitman College	Climate change communication in the facte of public uncertainty
My project has proceeded, but not in the direction I had expected--instead of limiting my research to Denali and the interpretive staff's approach to climate change, I broadened my research to a "journalistic" narrative-driven study of climate change opinion in Fairbanks. I did interview one individual from Alaska's NPS office about climate change, and his testimony may end up in my final thesis project. I believe I can still share the final project with Denali's staff--all names and identities will be kept confidential. This work was partly inspired by the time I spent working in Denali and the challenging process of putting together a program on climate change for the public.		

Researcher	Affiliation	Project
McCarthy / Tomsich	University of Alaska Fairbanks	Integrated paleoenvironmental reconstruction of the lower Cantwell Formation near Sable Mountain, Denali National Park, Alaska

Results

The majority of the sediments are fine-grained overbank and lacustrine deposits, gravelly channel fill, massive sheet sandstones and debris flows. Paleosols identified in thin-section are only weakly developed. Infrequently occurring trace fossil data comprises beetle, snail, ostracode and worm traces, algal mats, possible crayfish burrows, burrowed and heat-fractured wood, root and tuber casts, 1 theropod and 12 hadrosaur footprints, numerous dinosaur-made load casts, and 3 different types of large bird tracks. A rich plant compression fossil assemblage consisting of taxodiaceous conifer shoots, cones and seeds, diverse fern fronds, horsetail rhizomes and a variety of angiospermous leaves belonging to platanoid, trochodendroid and higher hamamelid groups was recovered from a range of facies. Plant macrofossil assemblages including tree stump impressions and rare burrowed wood were more diverse in crevasse splay and overbank deposits. A climate analysis (CLAMP) using dicotyledonous leaf fossil data indicates a mean annual temperature of 10.6°C, a warmest monthly mean of 20.6°C and a coldest monthly mean of 1.5°C. Length of growing season was calculated as 6.4 months.

Interpretation

Because this study is still continuing, interpretations of the sedimentary environments and the paleoecology are preliminary. The heterogenic lithologies indicate a floodplain with a shallow, axially braided major channel, numerous smaller channels, and a variety of closely spaced proximal floodplain subenvironments. Debris flows indicate influence of distal alluvial fan sedimentation. Sedimentary facies, incipient paleosols and sporadic burrows and poorly-shaped dinosaur footprints (load casts) point to wet floodplain environments. Conversely the burrowed and heat-fractured wood and the well-formed dinosaur tracks interpreted to have been made into firmer sediment are indicative of periodically drier episodes. Short breaks in deposition due to river migration allowed for brief intervals of soil formation. But the many overbank and sheet sandstones suggest that this river was never far from the site and is responsible for the repeated interruptions of soil development and disturbances of riparian fauna and flora. As a result, the structure of the floodplain forest was likely immature. Plant fossil assemblages and tree stump impressions from crevasse splay and overbank deposits suggest that plants were growing near the site of deposition. Consequently, the floodplain was covered by open-canopy forest consisting of deciduous conifers (bald cypress and swamp cypress), diverse shrub-like angiosperms and several fern types. The taxodiaceous conifers and hamamelid angiosperms association is interpreted as a polar mixed conifer and broad-leaved deciduous forest flora. This paleoflora, characterized by a low familial diversity, was common in the high Arctic of late Cretaceous time (Wolfe, 1987). Analysis of dicot leaves showed that climate was temperate with mild winters, but that the growing season was relatively short. Some betulaceous angiosperm taxa also known from mid to late Maastrichtian floras of northeastern Russia indicate a mid-Maastrichtian age for the Sable Mountain deposits.

Future work

The rocks and fossils of the lower Cantwell Formation offer a rare glimpse into the late Cretaceous sedimentary environments and the ecology of Arctic regions. The plant macrofossils correspond with those known from other Arctic paleoenvironments and reflect Panberingian species expansion in a habitat that is not found in our modern world: temperate climate conditions under the polar light regime (Wolfe, 1987). A more complete collection of dicot leaf fossils could refine climate and paleofloristic results. Because the plant macrofossils are fragmented, the chance for error is significant. More angiosperm leaf samples are needed in order to reduce effects of preservational bias and determine the full scope of the diversity.

Researcher	Affiliation	Project
Mcdonald	Jet Propulsion Laboratory under contract to NASA	Monitoring freeze/thaw transition on a regional scale in boreal forests using the ADEOS Satellite

This study assesses how well space-borne microwave remote sensors can monitor the seasonal freeze/thaw dynamics within boreal forest ecosystems. Two of the eight ground validation stations, arranged along a latitudinal gradient from the Brooks Range to the Kenai Peninsula, are in Denali. One station is at tree-line (near Savage) and one in closed spruce-hardwood forest (Rock Creek). These stations monitor land surface state (freeze, thaw) and vegetation biophysical function (sap flow) in several trees. Temperature is monitored with thermistors implanted in the vegetation tissue and at various depths in the soil. Xylem sap flow is inferred though monitoring the heat dissipation within a small volume of hydroactive tissue surrounding a heated needle-like probe implanted into the tree trunk. This work was conducted at the Jet Propulsion Laboratory, California Institute of Technology, under contract to the National Aeronautics and Space Administration.

No IAR for 2008 work was submitted as of April 15, 2008.

Milner	University of Alaska Fairbanks	Long-term ecological monitoring of streams in Denali NPP

In both July and August 2008, six Surber samples for macroinvertebrates were collected at 10 of the 14 long term study sites (not Rock Creek, S1 or Moose). In addition, the turbid channel of the East Fork of the Tolkat was not sampled due to high flows and Highway Pass Creek was sampled further up the watershed due to a bear closure. These samples are in storage presently being sorted and identified. We have been working with Trey Simmons of the NPS, who sampled at the same sites but using a D-net approach in 2007, about the comparison of techniques, and with Maggie MacCluskie about joint analysis of data sets.

Milner	University of Alaska Fairbanks	Hydroecology of upwelling zones in a glacierized catchment

Upwelling channels are characterised by interaction points between waters of different pathways and faunal communities. In 2008 we continued our study of a series of upwelling channels on the Toklat River floodplain. These areas are potentially 'hotspots' of biodiversity, whereby the mixing of different water sources combines components, interacting to increase productivity and hence biodiversity. This project aims to follow an integrated hydro-ecological approach at the Toklat River to investigate interactions between physical and ecological processes operating within these 'biodiversity hotspots', at a sufficiently small scale so as to generate a fuller understanding of the mechanisms operating between the two fields. Nested piezometers and pressure transducers were used for determining hydraulic head/water pressure at a variety of depths (15, 30, 50 and 100cm). In some cases these were attached to data loggers (minitrolls) for continual water level monitoring to estimate discharges. Periodic samples of surface water taken in sample vials, and of ground water from piezometers using tubing and hand pump were collected for isotope and anion/cation content to characterize water sources. Thermistors were attached to dataloggers to allow comparisons between surface and subsurface water temperature fluctuations, and between upwellings and glacial sites. An EDM was used to enable extensive mapping of the area, to provide a comprehensive picture of the system. Samples of hyporheic fauna were collected both weekly (using water removed from the piezometer tubes) and bi-seasonally, using colonization pots buried at 15 and 30cm, and left for six weeks, in six of the 12 upwelling sites. Some vegetative transects were undertaken in 2008.

Hydrological data from 2007 indicated that rises and falls in glacial channel stage due to peaks and troughs in glacial melt were mirrored by the upwelling channels, with a significant time lag, suggesting that upwelling channels are fed at least partially by glacial meltwater. Increases in glacial stage following heavy rainfall, were reflected in the groundwater channel, supporting the glacial channel as the major source, but which might also be indicative of additions by rainwater from valley sides. More detailed study in 2008 revealed there to be differing degrees of glacial-fed, valley run-off and deeper groundwater flow

Researcher	Affiliation	Project
Milner (cont'd)		
sourcing each individual upwelling, which affected the variability of temperature and discharge of the sites. Hydrochemical analysis of water samples will give further insights. Upwelling channels were significantly warmer than the glacial channel and with more stable flow regimes. Macroinvertebrate studies in 2008 examined the hyporheic zone, looking at differences between upwellings. There was a significantly greater species diversity in the upwelling sites sourced predominantly from deeper groundwater sources, as opposed to those fed by glacier-fed streams or valley-runoff. In addition a Detrended Correspondence Analysis was performed in order to identify the key influential physical variables behind macroinvertebrate movement within the hyporheic zone. The variables measured were oxidation reduction potential, Pfankuch Stability Index (PSI), temperature and discharge variability, pH, hydraulic gradient (HG), and conductivity, all measured at the surface. At 15cm it was determined that discharge variability, HG, PSI and conductivity were the dominant influential variables. At 30cm only discharge variability, PSI and temperature variability were identified. Initial analyses suggest that some macroinvertebrates at both depths respond to increases in discharge variance in decreases in stability by seeking refuge in the hyporheic zone, e.g. Zapada, Nemouridae and Empididae. For macroinvertebrates found at 30cm it would appear that water temperature is an additional driving factor.		
Newberry	University of Alaska Fairbanks	Geological mapping exercises in Central Denali Park
The UAF Geology field mapping exercises are scheduled for alternate years, and will occur in 2009, but did not occur in 2008. See page 44 .		
Newman	University of North Dakota	Population biology of the wood frog in a rapidly changing environment: Site 1 Denali National Park
During the reporting year I analyzed occupancy patterns based on presence-absence of breeding activity at each surveyed wetlands, and egg counts, which provide an index of the number of reproductively active females in each wetlands. For both response variables, I used a model selection approach to identify environmental predictors of population status. In addition, I estimated patterns of spatial autocorrelation in both response and predictor variables to improve parameter estimation and assess the contributions of spatial processes that may be acting independently of measured environmental predictors. I also briefly summarize the status of a skeletochronological assessment of ages of frogs from Alaska, although most of these samples did not come from the park. However, they provide some insight into the life history of wood frogs in the northern portion of its range. Finally, I provide a brief update on the status of population genetic work on Denali wood frogs. Together, these studies lay the foundation for understanding the ecology of this environmentally sensitive amphibian in a relatively undisturbed setting, and provide a baseline for measuring impacts of environmental change, particularly those associated with climate and landscape alteration. I will deliver a written report detailing the results of the above analyses.		
Pfeifer	U.S. Geological Survey, Arizona	Effects of climate change, glacial retreat, and snowfield loss on habitat condition and the effect on wild sheep populations and distribution in polar and high mountain ecosystems in Alaska, Russia, and Asia.
Quickbird imagery of the Denali study site ordered for high resolution vegetation analysis. Preliminary classification of glacial materials completed and extent of glacial reduction in study area in progress. Climate data have been acquired for the area and will be incorporated into the study and modeling effort.		

Researcher	Affiliation	Project
Pfeifer (cont'd)		

In terms of field work, 16 Dall's sheep feces samples were collected for nutrient analysis and 4 water samples were collected and sent to USGS water quality lab for nutrient analysis. Results have been received. 2 vegetation transects were run on woody plant "islands". Analysis results of feces samples for Fecal FN and Fecal DAPA were received from WSU wildlife lab. Food groups analysis are in progress by WSU.

Feces, and water samples were also collected at several other study sites outside of Denali (Headwaters of the Wood River, Wrangell Mountains, Chucach Mountains, and St. Elias Mountains. The results for these other study sites will be coupled with results from the Denali National Park and Preserve samples to detect any differences in nutrient levels among ites. This data will be input into habitat models.

Shain	Rutgers University	Evolution of glacier ice worms (*Mesenchytraeus solifugus*)

After consulting with several people, including Roger Robinson at the NPS, our team decided to explore the region near "Little Switzerland", as there seems to have been ice worms there ~20 years ago. We noted that several low elevation glaciers in the area had receded dramatically, and we found no evidence of ice worm populations. Our general conclusion is that ice worms may have inhabited this region in the recent past, by glacial melting has probably led to their local extinction.

Shaw		Long term trends and spatial variability in arctic haze at four sites in western Alaska

We upgraded air pump, flow control and plumbing for the aerosol collection program. A poster entitled Aerosols in Alaska, describing this work, will be given at AGU meeting in San Francisco on December 15, 2008. Regular sampling continues at the DEnali station. Andrea Blakesley is the park contact person who operates the sampling station.

Simmons	Central Alaska Network	Implementation of a long term monitoring program for the streams and rivers of Denali National Park and Preserve

Biological (macroinvertebrates, fish and diatoms), physical and chemical data were collected from 19 sites in DENA. Laboratory processing of biological and chemical samples has not yet been completed. Fish data are as follows:

Sanctuary River - 16 sculpin, 5 grayling
Moose Creek at bridge - 14 sculpin, 1 grayling
Little Stony Creek - 7 grayling
McKinley Bar spring - 2 grayling
McKinley Bar trail creek - 1 sculpin, 6 grayling
Igloo Creek - 2 sculpin, 3 grayling
Tattler Creek - 2 sculpin, 1 grayling
Igloo Creek above Tattler - 4 sculpin, 5 grayling
E.F. Toklat trib - 7 grayling
Moose Creek at airstrip - 2 grayling

Researcher	Affiliation	Project
Simmons (cont'd)		

Lake Creek - 6 lake trout, 1 burbot, 40 sculpin

No fish were captured at E.F. Toklat, Hogan Creek, Gorge Creek, Gorge Creek spring, upper Moose Creek, Moose Creek at crossing, or Cantwell Creek.

Continuous temperature recorders were installed in early June and successfully retrieved in late September from 7 sites. One recorder failed after 15 days. Severe flooding caused substantial reworking of the Hogan Creek channel, with the result that the deep pool where the temperature recorder was installed was transformed into a sandbar. Significant bank erosion was evident.

Temperature statistics (in degrees Celsius)
Site Seasonal min Seasonal mean Seasonal max
Moose Creek 1.453 6.888 14.529
Hogan Creek -0.059 2.995 7.77
Igloo Creek -0.031 5.119 13.353
Lake Creek 3.932 11.44 18.247
Sanctuary River 0.19 5.988 14.266
Savage River 1.017 5.29 14.385

Spalinger	USGS	Proteins and tannins in summer browse may limit productivity of moose

No field work was conducted in Denali in 2008.

Stueve	Texas A&M University	Spatial patterns of tree establishment at the alpine treeline ecotone

Clouds and poor image quality necessitated the use of a 1953 aerial photograph and 2005 IKONOS satellite image. The primary changes observed were (1) infilling of spruce near established trees and (2) patchy upslope advancement of spruce into the alpine tundra. In some cases, newly established trees "advanced" over 150 meters (490 feet) upslope into tundra. The field study confirmed that the majority of these trees became established in a few discrete time periods after 1953. Some trees also became established prior to that year but were not discernible on the 1953 photo and others became established after 1953 but were not discernible on the 2005 image. Overall, these changes are consistent with other findings elsewhere in Denali over the last 30 years.

Theoretically, treeline should advance upslope uniformly in the presence of warmer temperatures, but the cumulative influence of local site conditions—both physical (abiotic) and biological (biotic) often prevent this from occurring in a linear fashion—or possibly even hinder tree growth.

Local site conditions were mapped in relation to the patterns of tree establishment observed between 1953 and 2005. Logistic regression within the hierarchical partitioning framework was used to determine what local site conditions exerted the most control over patterns of tree establishment.

Although the abiotic factors of elevation, winter sun exposure, proximity to streams, slope angle, snowpack, moisture availability, and summer sun exposure

Researcher	Affiliation	Project
Stueve (cont'd)		
were influential (descending order of importance), proximity to existing trees (biotic factor) was the most important variable affecting patterns of tree establishment. Because treeline in this part of Denali is relatively undisturbed, these results challenge the ecological assumption that the vegetation (trees) near treeline is in equilibrium or balance with its abiotic environment. These findings could mean that: (1) treeline reacts too slowly to climate change and is never in equilibrium with the physical environment, (2) climatic warming in Interior Alaska over the last several decades has been so pronounced that tree establishment lags behind newly suitable conditions near the current treeline, or (3) existing trees modify their surroundings, making conditions in the adjacent tundra suitable for tree seedlings, and upslope advance and/or lateral infilling continues until such time as a major disturbance (e.g. fi re or severe climatic cooling event) sets treeline back to a lower elevation. Regardless of which explanation is true, treeline will likely keep advancing upslope and experience infilling, even if warming trends are tempered in Interior Alaska.		
Trost		Alaska transboundary regional haze monitoring project
The study is still ongoing, sampling is intended to continue through May 2009. No data analysis will be available until early 2010.		
Underbakke	University of Alaska Fairbanks	Evaluation of palliative performance for rural Alaska dust control
No IAR for 2008 was received as of April 15, 2009.		
Van Ballenberghe		Ecology of Moose in Denali National Park and Preserve
Fieldwork occurred from 27 May to 10 June and from 18 August to 30 September 2008, the 29th year of the study. Data on production and survival of calves were gathered during spring. For the seventh year, few instances of predation on neonates were reported in the area east of Sanctuary River. This correlates with fewer observations of bears and their signs in this area during both spring and fall. This is in marked contrast to events occurring in the 1980s and 1990s when bear sightings and predation on moose calves were common. Radioed cows produced calves at rates similar to previous years. Predation on calves in this area has been the major cause of calf mortality for the past 30 years. During spring 2008, a radioed cow again had a calf near Riley Creek Campground and occupied the area for several weeks but, unlike prior years, the calf did not survive. We closely monitored her interactions with people and dogs. During autumn, data were gathered on behavioral ecology, mainly on rutting behavior, traditional use of rutting areas, mating success, sparring, fighting, and antler breakage. Moose were distributed in traditional rutting areas similar to previous years, with much activity in the mile 9-10 area, but for the first time in the history of the study, no stable rutting groups formed. Data on mating success and mate choice were gathered on radioed females. Calves were again relatively abundant in roadside areas during autumn compared to the 1980s and 1990s. Calf survival from May to September was estimated at about 25 percent in 2008, higher than in recent years. The moose population in the eastern part of Denali National Park appears stable following a sharp decline 1970-1990. This was due to low recruitment as a result of high predation rates on young calves, primarily as a result of predation by bears. Current population stability is correlated with less bear predation on neonates.		

Researcher	Affiliation	Project
Wake	University of New Hampshire	Drillsite reconnaissance and snow chemistry survey in Denali National Park

During May 2008, a collaborative team of seven scientists (two from the University of New Hampshire, three from the University of Maine, one from Dartmouth College, and one from Data North Consulting) conducted a field program in DNP consisting of reconnaissance flights over most of the Alaska Range and the northern reaches of the Talkeetna Range, installation of an automatic weather station at Kahiltna Base Camp (7,800'), the collection of snowpit samples and firn cores for glaciochemical analysis, and ground profiling radar surveys at two sites (Kahiltna Pass [9,500'; Figure 1] and Mount Russell Plateau/Upper Yenta Glacier [8,400']).

Annual layers in the snowpack at both sites have been identified based on the location of ice layers and seasonal fluctuations in stable isotope ratios (Fig. 2). Comparison of the stable isotope records from Kahiltna Pass and Russell Plateau show strong regional coherence (Fig. 2b), suggesting that an isotope-based paleoclimate record from Kahiltna Pass will represent regional conditions. Our analysis indicates that the 23.12 m long record (13.14 m water equivalent) from Kahiltna Pass extends back to the summer of 2003, while the 18.33 m Mount Russell Plateau (8500') record (9.70 m water equivalent) extends back to the summer of 2006. From this preliminary analysis, we have identified annual snow accumulation and annual percent melt for both records. The Kahiltna Pass melt percent record is strongly correlated ($r>0.9$) with the number of warm summer days at Talkeetna, Cantwell, and Fairbanks (Fig. 3). This suggests that we will be able to develop a robust record of summer warmth back in time from stratigraphic analysis of a series of cores from this site.
Trace element analyses of snow pit samples from Kahiltna Pass and Russell Plateau reveal elevated concentrations of Cd, Pb, Bi, As, Cu and Zn relative to crustal reference element concentrations (e.g. Al, Fe). These toxic metal(oid)s have crustal enrichment factors ranging from 30-612, indicating that greater than 90% of each represents anthropogenic pollution. We do not see any evidence for local contamination of the Kahiltna Pass site by mountaineers, as trace metal concentrations and enrichment factors from the two sites are nearly identical over the last year (snowpit data). This is significant because Kahiltna Pass is close to the main route for climbers on Denali, whereas Russell Plateau is rarely visited. Thus, we are confident that trace metal records from Kahiltna Pass will represent regional atmospheric concentrations rather than local contamination.
Ground penetrating radar (GPR) profiles were collected at Kahiltna Pass and Russell Plateau to assess the subsurface flow regime and determine glacier thickness for optimal drill site selection. These high-resolution profiles reveal convergent ice flow in the south-east region of Kahiltna Pass, but conformable horizontal layering suitable for ice core drilling in the north-west region. Dipping bedrock was observed at a depth of 250 m on the edge of one GPR profile #4 (not shown). Extrapolating the bedrock slope beneath the suitable drill site indicates that ~350 m of ice is present.

◂ Murie Science and Learning Center ▸

Background

The Murie Science and Learning Center (MSLC), hosted at Denali National Park and Preserve, consists of many strong partnerships focused on ultimately increasing the effectiveness and communication of research and science results in the national parks. Specifically, the MSLC focuses its mission on providing research, discovery, and learning opportunities within arctic and subarctic parks to promote appreciation and caring for our national and cultural heritage. This is the fifth season of operation for the center. Visit the MSLC website at http://www.murieslc.org

Partners

The MSLC consists of a primary partnership between the National Park Service and Alaska Geographic. Although based in Denali, the MSLC also serves seven other national parks across two NPS Inventory & Monitoring Networks. Partner parks are Cape Krusenstern National Monument, Noatak National Preserve, Kobuk Valley National Park, Wrangell-St. Elias National Park and Preserve, Yukon-Charley Rivers National Preserve, Bering Land Bridge National Preserve, and Gates of the Arctic National Park and Preserve. The area covered by these parks represents more than 50 percent of the lands administered by the NPService nationwide.

Other partners include:

- Denali Education Center (partners on educational programs, provides housing for researchers (as available), and assists with the Discover Denali Research Fellowship Program)

- Doyon-Aramark Joint Venture (park concessioner who operates the Murie Dining Hall jointly with their employee dining room)

- Denali Borough School District (provides technical support and equipment to the center and partners on several education programs and in the development of the Wireless Network)

Facilities, Services, and Programming
The MSLC main facility provides a classroom, exhibit area and office space for staff and visiting researchers. The Murie Dining Hall (next door) is shared with the park concessioner. The MSLC field camp is now located within the park by the Teklanika River (Mile 29) and consists of five tent cabins, a yurt and a food & equipment storage shed. Services provided by the MSLC and partners are the following: providing space for both educational programs and events, and office space and resources for visiting researchers; internet access and data transmission capabilities; wireless network capabilities along the first 35 miles of the park road; video-conferencing; in-park transportation coordination and food service.

In 2008, the MSLC programming included citizen science programs; curriculum-based education programs for K-12 grades; school-to-work experiential learning programs; internships; multi-day accredited field seminars and teacher trainings; youth camps; science presentations; and research fellowship grants.

Services Specifically for Researchers
The MSLC facilitates science across all the parks it serves in a variety of ways. For example, requests for proposals were solicited from all eight MSLC partner parks. Approximately $30,000 was awarded researchers in 2008 and $24,400 in 2009 (see page 81, "Research Awards"). Access to office space, housing, internet, data sets, equipment, and subject matter expertise are other ways the MSLC assists researchers in the ultimate goal of increasing science-informed decision-making in national parks.

Programs

Citizen Science

ALISON Project. Throughout the 2008-2009 winter, students from Denali Borough School District hiked to Horseshoe Lake twice monthly to measure and record lake ice and snow data. The Horseshoe Lake site is one of sixteen sites across the state that make up the Alaska Lake Ice and Snow Observatory Network (ALISON), a project under the direction of Dr. Martin Jeffries at the Geophysical Institute, University of Alaska Fairbanks. Tri-Valley students, teachers and the education specialist were only turned back on occasion by temperatures colder than -10ºF and extremely icy trail conditions. Students provide data that may help detect changes in the ice and snow levels throughout the state over time through this ALISON citizen science program. Prior to making 2008-2009 measurements, the cooperators focused on consolidating protocols and creating educational outreach tools.

Youth Camps

Denali Backcountry Adventures. This week-long learning camp for high school students was developed in partnership with the Denali Education Center, with the support of the Denali Borough School District. The program develops participants' outdoor and leadership skills while they conduct impact monitoring activities in the Denali backcountry. Information collected is entered by participants into the current park database. Indicators selected for monitoring in the park's new Backcountry Management Plan are: soundscape qualities, visitor observations and contacts, wildlife observations, and backcountry impacts. Backcountry Adventure group size is

limited to 12 participants and two instructors and the group spends three nights in Denali's backcountry. Areas for exploration and monitoring are identified by park managers. In 2009, the MSLC will offer the Denali Backcountry Adventures camp July 27-31, with a skill building workshop on July 24.

Denali Discovery Camp. This five-day camp seeks to offer quality outdoor experiences to local youths in grades one through eight. Developed in partnership with the Denali Education Center, the camp curriculum engages participants in hands-on activities as they learn about sub-arctic ecology, the national park mission, and preservation and protection of park resources. Many park resource staff members meet with groups of campers in the field to talk about ongoing research projects. Depending on their ages, participants will spend one to three nights in the park during camp week (June 22-26, 2009).

Denali-Susitna Exploration Camp. This camp offers local youth from the Northern Susitna Valley the opportunity to explore the natural and cultural history of the area utilizing technology. Developed in partnership with Kigluait Educational Adventures and Upper Susitna Soil and Water Conservation District, the camp also seeks to foster leadership skills in local high school students who serve as youth leaders for the participants in grades four through seven. Camp participants and youth leaders culminate their knowledge through the creation of technology-based products and a play that will be presented to the community. In 2009 this camp will be offered in August.

Alaska Summer Research Academy. The Alaska Summer Research Academy (ASRA) will offer two programs in Denali for students grades 8-12 who are interested in working with university faculty and industry professionals. "All Shook Up in Denali: Earthquakes Module" will explore seismic activity. The "Photography Module" will include photo documentation of landscapes in the park. ASRA is sponsored by the University of Alaska Fairbanks in partnership with the National Park Service, the MSLC and other partners. For more information visit: www.uaf.edu/asra. Dates for the portion of this program that occurs through the MSLC are July 27-31, 2009.

Field Seminars and Teacher Training

Field Seminars. The MSLC will be offering 23 field seminars in the 2009 season, including one at Yukon-Charley Rivers National Preserve. These multi-day seminars are active learning experiences that cover a range of topics including geology, wildflowers, birds, large mammals, Dall's sheep, bears, science of fly fishing, and field journaling. Most courses are based out of the MSLC field camp, located within the park near the Teklanika River at Mile 29 of the park road. Many park research staff members serve as content experts for the seminars. All field seminars are available for optional university credit through the University of Alaska - Anchorage.

Teacher Training. The MSLC will offer three teacher trainings in July 2009. These three- to four-day programs are "courses" focusing on science writing; world of wolves; and subarctic science, sustainability, and students. All teacher trainings include one to three credits through the University of Alaska - Anchorage or the University of Alaska - Southeast.

Day Programming

Experience Denali Excursion. This MSLC program is offered up to 3 days per week to help Princess Tours visitors explore wildlife and wildlife research in Denali through small-group outdoor-based activities with MSLC science instructors, funded by Alaska Geographic. Participants learn about different habitats as they travel by bus to the Savage River area, where they take a short walk and participate in hands-on activities. This program coordinated by the Alaska Geographic returns all proceeds to the Murie Science and Learning Center operations, approximately $207,500 annually.

Discover Denali. Developed to provide a meaningful park experience for Royal-Celebrity Tours passengers, this fee-based program is offered several times a week, May – September in partnership with the Denali Education Center. The program consists of a lecture in the MSLC classroom, a skins-and-skulls hands-on session, interpretive walk through an area significant in early park history, and a ranger-introduced viewing of the new park film. A portion of the proceeds support the Discover Denali Research Fellowship Program (approximately $30,000 annually).

Science Series Presentations. The MSLC staff, funded by the Alaska Geographic, also offer free science presentations to the public. These one hour presentations in the classroom provide park visitors with an in-depth glimpse into current research areas in Denali and expose them to content not otherwise being shared with the public. The programs are offered approximately three times per week, depending on staffing.

Evening Speaker Series. The MSLC and Alaska Geographic hosts guest speakers throughout the summer as the opportunities arise. Guest speakers include; park researchers, visiting researchers and conservationists, writers, artists, and adventure travelers.

Special Programming

Education Internships. Whenever possible, the MSLC offers summer education internships. These 14-18-week internships expose interns to all facets of education programming, experiential education, research, and park management.

Custom Education and Facility Services. The MSLC coordinates the needs for visiting science and education groups. The MSLC arranges short education programs, food services, transportation services and meeting space to these groups.

Research Awards

Discover Denali Research Fellowship Program

2009 is the fourth year of the Discover Denali Research Fellowship Program. Recipients are awarded grants up to approximately $5,000 for research, especially for projects that will assist park managers with critical resource issues. Research is conducted in or near Denali. Discover Denali Research Fellowships are made possibly by the Denali Education Center through the MSLC.

Fellowships (a total of $12,500) were awarded in 2009 to the following researchers (listed alphabetically), conditional on their obtaining a research and collecting permit, as with any research project in Denali:

- Elizabeth (Fay) Belshe, University of Florida (graduate student)
  "Remotely sensing the effects of permafrost thaw on tundra carbon balance"

- Tara Chestnut, Portland State University (graduate student)
  "Distribution and prevalence of the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) in the northern range of the Wood Frog (*Rana* [*Lithobates*] *sylvatica*)

- Barbara-Lynn Concienne, University of Colorado at Boulder (graduate student)
  "Microbial succession in newly deglaciated soils"

- Craig Lee, University of Colorado
  "Ice on the edge: global warming and a new archeological/paleontological research frontier in Denali National Park and Preserve"

In 2008, the following Discover Denali Research Fellowships were awarded:

- Patrick Brennan, Purdue University (graduate student)
  "A park visitor's view of the growth of a continent" [Hines Creek fault]

- Dr. Jessica Cable, University of Wyoming
  "The consequence of permafrost degradation and plant water use strategies for plant community composition"

- Dr. Alexander Milner, Institute of Arctic Biology, University of Alaska
  "Hydroecology of upwelling zones in a glacierized catchment: pinpointing water sources and spatial extent"

- Kirk Stueve, Texas A&M University (graduate student)
  "Spatial patterns of tree establishment at the alpine treeline ecotone: Denali National Park"

- Susi Tomsich, University of Alaska Fairbanks (graduate student)
  "Integrated paleoenvironmental reconstruction of the lower Cantwell Formation in the Sable Mountain area, Denali National Park, Alaska"

Murie Science and Learning Center – Research Awards

For the second year (initial year was 2008), financial support is available for research projects in any of the eight northern Alaska national parks (across two NPS Inventory & Monitoring Networks—Central Alaska Network or Arctic Network). These research awards are provided by Alaska Geographic through the Murie Science and Learning Center. One of the researchers awarded funding in 2009 will be working in Denali. The awards are conditional on obtaining a research and collecting permit, if working within a national park:

In 2009, the following are recipients of Murie Science and Learning Center Research Fellowship Awards (a total of $11,900 awarded):

- Chris Houlette, University of Alaska Museum of the North
  "Prehistoric obsidian procurement and use in **Gates of the Arctic** National Park"

- Zachary Meyers, University of Alaska Fairbanks (graduate student)
  "Documenting genetic diversity in *Oxytropis kokrinenesis* from **Kobuk Valley National Park**"

- Ben Potter, University of Alaska Fairbanks
  "Understanding site formation and cultural activities at Teklanika West (HEA—001)" [Denali National Park and Preserve]

In 2008, Murie Science and Learning Center Researchers Fellowships were awarded to three researchers for projects at Denali and to three researchers with projects at other northern parks:

- Andrew Brown, University of Alaska Fairbanks (graduate student)
  Denali National Park and Preserve
  "Developing a multi-year trend model for habitat use of wood frogs in Denali"

- Barbara-Lynn Concienne, University of Colorado, Boulder (graduate student)
  Denali National Park and Preserve
  "Microbial succession in soils at retreating glaciers"

- Hanna Lee, University of Florida (graduate student)
  Denali National Park and Preserve
  "Monitoring effects of climate change and permafrost carbon in Denali National Park"

- Gretchen Roffler, USGS, Alaska Science Center, Anchorage
  Wrangell – St. Elias National Park and Preserve
  "Evaluating the genetic structure of Dall's sheep in Wrangell – St. Elias National Park and Preserve"

- Dr. Patrick Sullivan, University of Alaska Anchorage
  Noatak National Preserve
  "Microtopographic controls on treeline advance in Noatak National Preserve, Alaska"

- Andrew Tremayne, University of Wyoming (graduate student)
  Gates of the Arctic National Park and Preserve
  "Dating the Denbigh Flint Complex in Alaska's Brooks Range"

For more information about research fellowships, contact Denali's Research Administrator, Lucy_Tyrrell@nps.gov or the MSLC Education Coordinator, Christie_Anastasia@nps.gov.

⊲ E-Resources ⊳

Links to Information

The following links provide more information about Denali's natural and cultural resources and recent research results.

Denali's Nature and Science Webpage
http://www.nps.gov/dena/naturescience/
This page provides access to many other useful pages, including the other links listed here.

Current Resource Projects
http://www.nps.gov/dena/naturescience/researchresults.htm
This page links to the electronic version of *Current Resource Projects 2009*, as well as to archives from previous years.

Fact Sheets about Denali Science
http://www.nps.gov/dena/naturescience/factsheets.htm
More than two dozen two-page printable color fact sheets about research, monitoring, and resource management at Denali (see list of fact sheets on page 58).

Alaska Park Science
http://www.nps.gov/dena/naturescience/park-science.htm
The special Denali issue of Alaska Park Science, plus links to other issues that include Denali articles.

Climate Data
http://www.wrcc.dri.edu/NPS
Data summaries and data analysis tools about Denali's weather and climate.

Fire Information
http://www.nps.gov/akso/Fire/firehome.htm
Links to current fire information, fire ecology, fire weather and danger, and more about fire management in Alaska.

Podcasts about Denali Science
http://www.nps.gov/dena/photosmultimedia/dne.htm
Several podcasts are now available in the "Denali: New Expeditions" series.

Central Alaska Network
http://science.nature.nps.gov/im/units/cakn/
Links to resource briefs (for Denali and the other CAKN parks), monitoring reports, and more information about the Inventory and Monitoring Program.

Murie Science and Learning Center
http://www.murieslc.org
More about the Murie Science and Learning Center and its northern Alaska parks, partners, and programs.

Selected Resource Highlights from 2008

Sheep Surveys

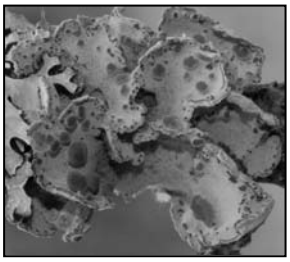
Sheep surveys were last conducted in the mid-1990's. In 2008, both aerial surveys (see photo at right) and ground-based surveys were conducted to gather information about population size, and estimates of sex and age composition for the areas surveyed. (See pages 27-28).

Moose Surveys

Moose surveys were last conducted in 2004. In addition to the traditional survey on the north side of the Alaska Range, in 2008, spotters aloft in planes counted moose in units in the Yentna and Cantwell areas. (See pages 26-27).

More Dinosaur Discoveries

Field work by research teams and Denali park staff added tracks of two new dinosaurs—a four-toed track of a possible Ceratopsian (beaked dinosaur) and a hand print of a Pterosaur (winged dinosaur—see photo at right), plus confirmed tracks of baby hadrosaurs (plant-eating dinosaur). Researchers are using the array of fossil finds to reconstruct the ecosystems at the end of the Cretaceous. (See pages 41-42, 65).



More Rare Lichen Localities

By the end of 2008, there were 13 known localities for the rare lichen, *Erioderma pedicillatum* south of the Alaska Range (7 sites in Denali, 3 sites in Denali State Park and 3 additional sites). This lichen was first "discovered" and documented in the Denali area in 2007. (See page 12.)

Looking Ahead – 2009 and Beyond

- **Road Study Data Informs Road Capacity EIS**—Research data gathered 2006 – 2008 (integrated study of traffic, wildlife, and visitor experience, with several research collaborators) have been shared with the planning group which is developing the Road Capacity Environmental Impact Statement, with alternatives for changes in traffic patterns.
- **Implementation of Denali's Resource Stewardship Strategy**—In 2009, Denali will complete its Resource Stewardship Strategy (RSS), which will guide its research and resource program for the next 15 to 20 years. The RSS document describes the desired conditions for park resources and values based on what the General Management Plan specifies, selects indicators to evaluate resource condition, and lists strategies and projects needed to maintain Denali's resource values.