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




Summary of Current Resource Projects 2010

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Table of Contents

Integrated Programs and Findings

Resource Stewardship Strategy **NEW FACT SHEET AVAILABLE**

In 2009, Denali completed 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 RSS Team identified 119 indicators of resource condition, but recognized that indicators related to visitor experience still need to be identified. Targets were set for 80 of the 119 indicators; research and planning are needed to set the targets for the remaining indicators. The current condition for 73 of the indicators needs to be evaluated.

The complete RSS document and an RSS Summary document are posted at www.nps.gov/dena/naturescience/rss.htm . The summary document includes highlights from the 99 projects that are part of the RSS. Limited printed copies of the RSS Summary are available.

Natural Resource Condition Assessment **NEW FACT SHEET AVAILABLE**

A fairly new addition to the Natural Resource Challenge is the Natural Resource Condition Assessment (NRCA) Program. The NRCA Program mandates the development of park-specific assessments to help answer the question: what are current conditions for important park resources?

Each park's assessment is a snapshot-in-time evaluation of selected park natural resources. The assessment reports the overall condition of these resources by answering questions such as: What attributes and indicators can be used to assess whether resources are in a healthy condition? What factors exert influence on resource condition? Are there any critical data gaps?

Denali staff are working through a cooperative agreement with St. Mary's University of Minnesota to conduct the park's NRCA. Because the task of identifying key indicators for Denali's natural resources was completed through the development of the park's Resource Stewardship Strategy, Denali's NRCA product will include some in-depth assessments for specific areas of management and ecological concern (e.g., human influence, subsistence, fire, habitat). For a complete list of these specific areas, view the fact sheet about Denali's NRCA at www.nps.gov/dena/naturescience/factsheets.htm

Denali staff developed additional assessment projects for spatial analysis if time permits (e.g., timing of snow on-snow off, salmon distribution in relation to winter-open waters, bear-human interaction data).

Assessment results will be published and posted at www.nps.gov/dena/naturescience/nrca.htm .

Denali Park Road Capacity Study **NEW FACT SHEET AVAILABLE** (update for 2010)
Provided here is an overview and a synopsis of the various facets of the road study (2006-2009) and a brief description of what is planned for 2010.

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 from 2006 to 2009. 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. Researchers will return to Denali in summer 2010 to administer additional surveys that will further define visitor preferences regarding park road management. 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, 2008, and 2009, 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 (2007 to 2009) and sound (2008 and 2009) along the park road. 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 2010, researchers will continue to collect sheep and bear behavior observational data along the park road, GPS data on vehicle movements, 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 movements

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's 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's 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.

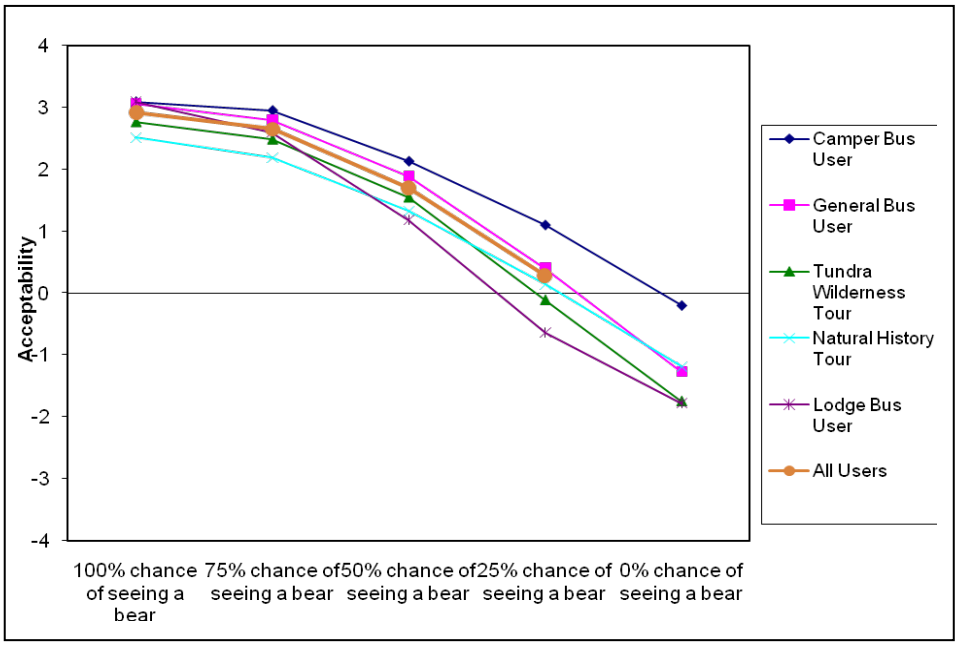
Road crossings by GPS-collared sheep occurred between Miles 33 to 38, 44 to 48, and 51 to 53 of park road with the most crossings occurring between Miles 45 to 47.

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

Visitor surveys

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 (see graph below).



Visitor response to part of the 2007 survey. Most visitors, regardless of bus type, indicated that they wanted to have at least a 25% chance of seeing a grizzly bear.

The first three of the five 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).

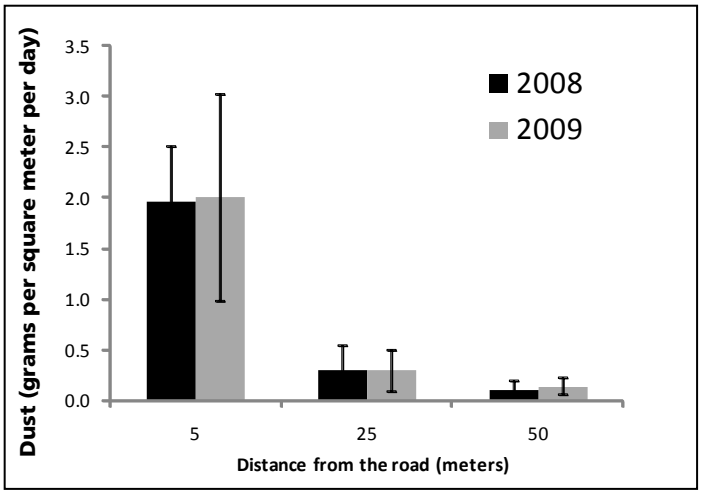
In the 2007 quantitative survey, visitors were asked to what extent they felt that certain issues were a problem on the park road. Respondents were asked to rate each question from 1 (not a problem) to 3 (big problem). The four most problematic issues were "not seeing enough wildlife close to the road,"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

In July and August of 2010, researchers will administer new surveys that will ask visitors how willing they are to trade-off features that were deemed important in previous surveys, such as duration of a tour vs. wildlife sightings, or ability to get on a bus at the time of your choosing vs. crowding at rest stops. In addition visitors will be able to express their degree of interest in early morning or late evening tour departures; desire for activities during a tour, such as hikes; and interest in the ability to stop at a visitor center.

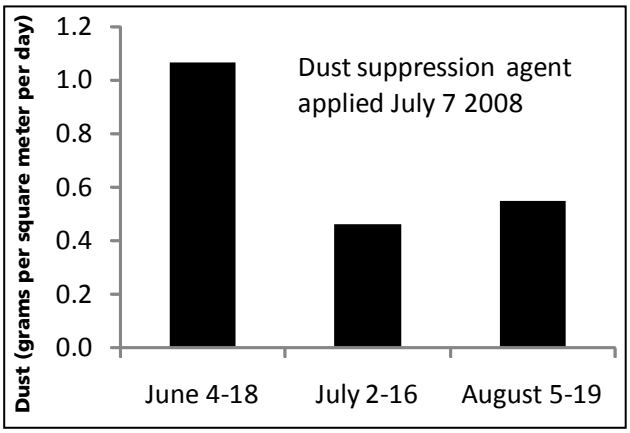
Dust

Placing dust "traps" (buckets) along the park road at five sites for periods of two weeks during June, July, and August in 2007-2009 has enabled researchers to: (1) quantify current levels of dust along the road corridor, (2) document how far from the road dust travels, and (3) determine how dust levels differ for sections of the park road that are paved, unpaved but treated with calcium chloride (a chemical dust suppressant), or unpaved and untreated. If changes in vehicle limits are instituted, repeating the dust study will determine if dust levels have changed in response to new traffic patterns. At each of the five sites, to document how far from the road dust travels, dust buckets were placed at distances of 5 meters (15 feet), 25 m (75 feet) and 50 m (150 feet) from the edge of the road. Buckets were placed along the road at Mile 11 (paved), at Mile 23.6 (Sanctuary)(unpaved, untreated) and Mile 29.5 (Teklanika) (unpaved, treated) and Mile 51.2 and Mile 55.5 (Toklat)(unpaved, untreated).

Dust deposition declined markedly with distance from the road (as seen in the graph at right) for Sanctuary (which does not receive a dust suppressant).



In 2008, the park road near Teklanika was treated with the dust suppression agent early in the July sampling period. See graph at right, where the effectiveness of this agent in limiting dust is illustrated (second and third bars are substantially lower after the July application of the dust suppressant).



In areas not treated for dust suppression, dust levels in buckets placed nearest the road increased predictably with increased traffic levels (over the season). Learning this relationship will allow managers to predict and mitigate for potential dust impacts from new traffic levels.

In 2010, park staff will be making visual observations of dust along the road corridor to assess how long dust plumes last under different weather and road conditions.

Soundscapes

As part of the road study, researchers are studying current levels of traffic-generated sounds near the park road. Natural sounds are part of the wilderness experience at Denali. Natural quiet is required by wildlife to hear and respond to sound cues for avoiding predators or perceiving the presence of food or mates.

Researchers set up sound stations at two sites (east of the Teklanika Rest Stop at Mile 28.1 and at Highway Pass, Mile 59.6). The stations were placed 50 m (150 feet) from road center to correspond to the wilderness boundary. Solar panels and batteries provided the capability to record sounds continuously for 6 days. Sounds were recorded for 6-day intervals in July and August in 2008 and 2009.

The recordings were analyzed to give the percentage of time that vehicles were audible, and the number of vehicle-noise "events" during each 6-day period of continuous sampling. An audibility analysis compared detection of sounds by staff listening to detection of sounds by visually analyzing the pattern of the sounds on a spectrogram. The preliminary data collected in 2009 at Teklanika and analyzed visually indicate that vehicle sounds are audible between 0 percent per hour in the early morning hours and 15 percent per hour at peak traffic levels. Overall there was an average of 162 events in a 24-hour period. The best methods for collecting and analyzing data will be applied to a third year of data collection in 2010. The goal is to model and predict potential sound impacts from a change in traffic volume or traffic pattern.

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).

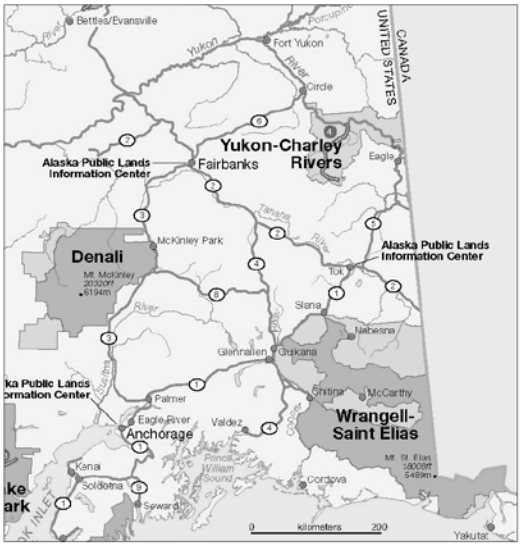
Data used in the model also came from touch screen panels installed in 20 buses (2007-2009) for bus drivers to record information about the location of stops made along the road for wildlife sightings, passenger pick-up and drop-off, and road maintenance. Data collected by drivers using the data panels also indicate that stops by drivers for grizzly bear sightings were generally longer on average than stops for other types of wildlife. The 2009 data were also used to model bus arrivals and departures at the new Eielson Visitor Center.

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.

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.

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 2010 field season is the fifth year of program implementation after four years of planning and development. The focus has been to bring more of the 36 Vital Signs into full operation with collecting field data and analyzing and reporting on the data to parks and the public. After protocols are given scientific peer-review, they are revised as necessary before final approval from the Alaska Region Monitoring Coordinator.

Kiosks
Interactive kiosks are 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.

Resource Briefs
Read about CAKN activities and results for selected vital signs in resource briefs that are posted on the CAKN website http://science.nature.nps.gov/im/units/cakn/

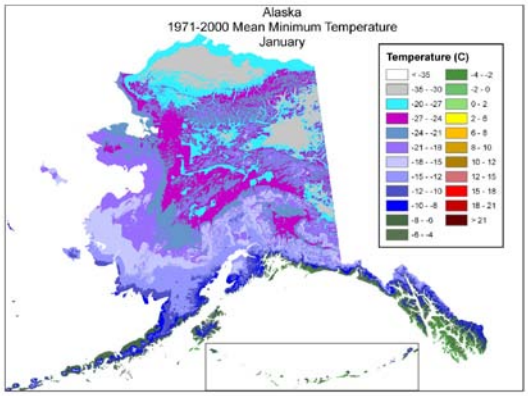
Updates

Climate

Climate is one of the primary drivers of ecological change in Alaska parks, but climate observations are often lacking in mountainous and remote regions of the state. In order to understand climate patterns and variation in Alaska parks, the National Park Service Alaska Region Inventory and Monitoring Program collaborated with Oregon State University's PRISM Climate Group to generate spatially-gridded average monthly and annual precipitation and temperature datasets for the 1971 – 2000 *climate normal period* (a thirty-year interval created every 10 years, which is the "normal" to which the current year's weather can be compared).

The digital climate maps are created using PRISM, an analytical tool that uses point data, a digital elevation model, and other parameters, such as precipitation, temperature, and dew point. PRISM is designed to map and update climate in difficult situations, including high mountains, rain shadows, temperature inversions, coastal regions, and other complex climatic regimes found in Alaska. The PRISM Climate Group produces and disseminates the most detailed and the highest quality spatial climate datasets currently available.

More information, including an atlas of the maps, can be found at www.nps.gov/dena/naturescience/climate-change.htm . The GIS datasets are available through the GIS Theme Manager in the NPS Alaska Region, or at the NPS Data Store. Information on these can be found on the NPS Alaska Region GIS Home Page (http://inpakroms03web/rgr/akgis) in the GIS Data Status/Climate Change section.



PRISM climate map of January mean minimum temperatures for the 1971-2000 climate normal period for the state of Alaska.

Golden Eagles

Since 2007 the CAKN has been working with USGS Senior Scientist, Dr. Jim Nichols and Dr. Julian Martin on a Structured Decision Making model for Golden Eagle management in Denali. The project for the network concluded in 2009 and has resulted in three published papers, and a webinar. A day-long workshop with the CAKN Board of Directors on Structured Decision Making and its application to park management was also held.

Vegetation Structure and Composition

During the ninth year (2009) of the Central Alaska Network vegetation monitoring program, approximately 300 permanent plots were installed across the three network parks by four field crews. Since 2001, nearly 1,000 permanent vegetation monitoring plots have been installed in Denali.

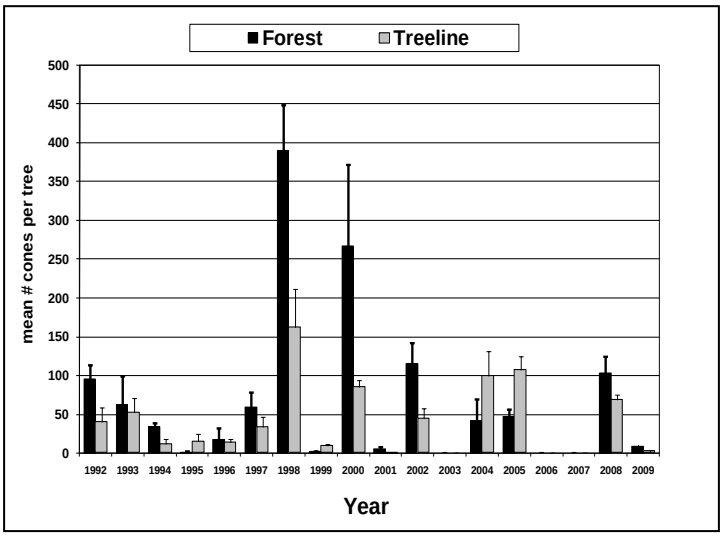
Plants/Vegetation

Long-term Vegetation Monitoring

Field work continued in 2009 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.



Average number of cones per white spruce tree observed in 3 treeline and 3 forest (valley bottom) plots in the Rock Creek drainage 1992-2009.

  The spruce sample population produced virtually no cones in 2006 and 2007 (no bar visible in figure), but 2008 marked a return to near-average cone production for these trees. Spruce trees in the park rarely have high cone production in consecutive years, and this pattern held true, with very few cones being produced in 2009. 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.

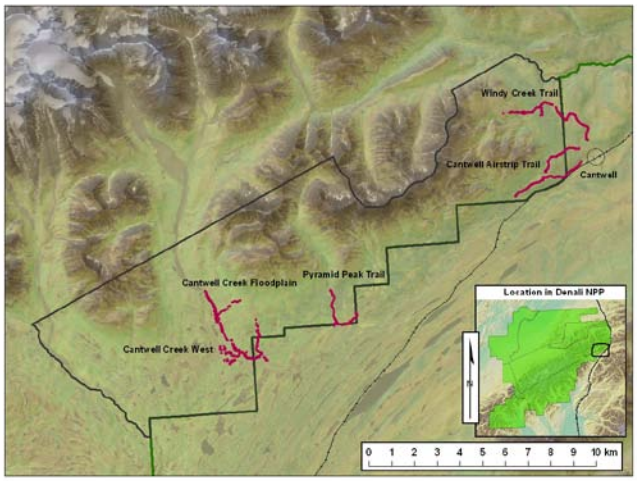
- **Landscape-scale vegetation monitoring project**

  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 2009, two vegetation crews completed sampling of the following mini-grids: Divide Mountain, Double Mountain, Riley Creek, Hult Creek, Slippery Creek, Lower Muldrow Glacier, and Thorofare River. Sampling involved installing new plots and measuring vegetation, soils, and site attributes in these seven mini-grid study areas, scattered across the northern part of the Park. In 2010, the minigrids to be sampled are: Igloo Canyon, Middle Moose Creek, McKinley River, Kantishna River, Muddy River, McKinley Delta and Beaverlog Lakes.

Off-Road Vehicle (ORV) Impacts

In 2009, staff completed the third full season of the ORV monitoring program. 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 during the inventory phase of the project in 2005.



Sites for long-term monitoring of vegetation and soils nin the Cantwell Traditional Use Area for subsitence use of ORVs.

In the 2010 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 2010 (the fifth 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 the map), and collecting repeat photographs as another tool to look at changes over time.

Bryophyte and Lichen Inventory

In 2009, researchers continued the detailed microscopic work that it takes to identify the several hundred nonvascular plants collected in 2007 and 2008 as part of a project to inventory and voucher Denali's mosses, lichens, and liverworts. As detailed microscopic identification of voucher specimens continues in 2010, additional new taxa to the park are expected.

During both 2007 and 2008, botany staff collected several hundred nonvascular plant specimens in 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 produced (in 2007) a provisional list of at least 30 taxa not previously listed on Denali's list of nonvascular plants. In 2008, 15 more taxa were added, and as mentioned above, additional species new to the park are expected. Some significant species collected in during this project include Boreal Felt Lichen (*Erioderma pedicellatum*), Waterfan Lichen (*Peltigera hydrothyria*), and Methuselah's Beard Lichen (*Usnea longissima*)—these represent important range extensions and globally uncommon species.

Web-based Ecological Atlas of Central Alaska's Flora

A website project, "An Ecological Atlas of Central Alaska's Flora," is under development in order to communicate the results of Denali's botany program to the scientific community and to the public. The goal of this website will be to synthesize species and plant community data that botany staff has gathered over the past 12 years (in many projects) and provide a variety of summaries of these data for those interested in Denali's flora and vegetation. The ecological atlas

will integrate data from inventory, monitoring, and research efforts and will provide detailed ecological, geographic, and community data summaries for both vascular and nonvascular elements of the flora. Data summaries will be accompanied by narrative material, photos, species descriptions, and maps. Planning, design, and construction of the website will begin in May 2010.

Virtual Tour of Landscape Change in Denali

Over the past five years, careful examination of paired historic and recent photographs by park staff has revealed dramatic and widespread landscape changes in and around Denali National Park and Preserve. Paired photographs are an excellent way to present landscape-scale information because they allow for self-paced visual comparison of landscape characters otherwise difficult to ascertain. Photographs are a familiar medium to most visitors, and therefore provide an effective tool for communicating ecological concepts and portraying landscape change. As public awareness of climate change related issues increases, interpretive products that put landscape change and its possible effects in context with an individual's everyday lives are becoming more necessary.

In winter 2009-2010, botany staff began to develop a computer-based virtual tour of landscape change in Denali. The tour is designed to connect a visitor to the landscapes of Denali and to changing landscapes around the world. The goal of this product is to share with the visiting public the matched photo pairs and the process by which park personnel acquired and analyzed them in order to:

(1) Demonstrate that a visit to Denali represents only a snapshot of the ecological conditions that may exist in the future or existed in the past
(2) Enrich public understanding of ecological change
(3) Encourage discussion of the consequences of human actions on the landscape in relation to human-induced climate change, park management policies, and day-to-day living – either in Denali or near a visitor's home.

Slated for deployment at a MSLC kiosk in May 2010, the virtual tour of landscape change will also be available for download off the web (Denali and the Central Alaska Network) in 2011.

A Ton of Exotic (Non-native) Plants Removed

In 2009, 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.

In 2010, for the 12th consecutive year, volunteers will be enlisted to pull out non-native plants in the park and to collect wild native seeds for revegetation projects.

- ❖ Here's the 2009 roster of non-native plants removed (more than 50 lbs) in/near Denali:
  - * Dandelion (*Taraxacum officinale)*: 225 lbs
    (Denali Park Road corridor)
  - * White Sweet Clover (*Melilotus alba*): 96 lbs
    (Miles 232.5 and 238 Parks Hwy)
  - * Hawk's-Beard (*Crepis tectorum*): 135 lbs
    (Sewage lagoon; Mile 0 to 3 of the park road)
  - * Wormseed mustard (*Erysimum cheiramthoides)*: 85 lbs
    (East Fork bridge area)

- ❖ **Other non-native species of plants**
  Four additional non-native species other than dandelions were removed in 2009:
  * *Vicia cracca* (bird vetch): 15 lbs (Mile 1 to 3 of the park road)
  * *Hieracium umbellatum* (narrowleaf hawkweed): 5 lbs (Parks Highway)
  * *Tripleurospermum perforata* (scentless false mayweed): 20 lbs (Railroad Depot)
  * *Linaria vulgaris* (yellow toadflax): 3 lbs (Railroad Depot; tracks near Triple Lakes Trail)

Revegetation of Construction/Disturbed Sites

- ❖ **Seed collections**
  Seeds were collected for purposes of revegetation during two periods in 2009: near the east end of the Park Road (August 10-14), and at the west end of the Park Road (August 17-21). It was a banner summer for wildflowers, and many seeds were collected.

- ❖ **Revegetation**
  During the summers of 2008 and 2009, a new section of road was built at at Mile 4 of the Park Road. Park staff and 20 volunteers seeded and raked the old roadbed on September 3, 2009. It was seeded with *Hedysarum alpinum*, *Oxytropis campestris*, and *Elymus* sp.

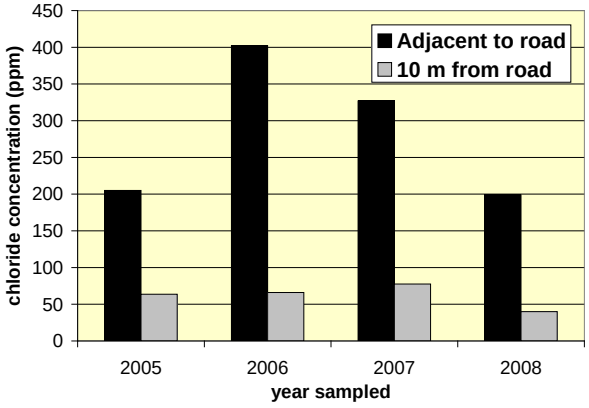
*Note: The best time for harvesting and transplanting mats is when the mats are almost dormant (so little damage occurs to plants) when more plant energy is directed at root production (in spring and fall) than in leaf and fruit production (summer). Seeding in the fall mimics the natural dispersal of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

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 installed 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.

Due to the exceedingly dry weather, and then snow in fall 2009, lysimeter samples were not taken last year, but they will be sampled again in late summer 2010. 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 the graph. 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.



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

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) lie 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.

Fire Highlights for 2009

The year 2009 was a long fire season for Denali. While a lot of acres burned, no known cultural resources were lost or damaged, and there were no injuries.

There was unprecedented Interagency coordination managing fires inside and outside Denali. For example, fire management implemented the "Closest Forces" concept by having NPS personnel monitor wildfires in the Greater Denali Area and taking suppression actions on a human-caused fire in Denali. The prior process was to call Alaska Fire Service based in Fairbanks, for any suppression activity. Although Alaska Fire Service had personnel in place closer than Fairbanks, Denali personnel were the "closest forces" to the fire (Sanctuary River Fire, see table below), and therefore park personnel took initial action. The Sanctuary River fire was the first fire in Denali to be suppressed in about 6 years.

Eight wildland fires and several prescribed fires occurred in Denali in 2009:

Fire Name	Burn Period	Acres	Fire Type	Comments
Sewer Lagoon slash burn	11/19 – 11/21/08	0.25	Prescribed Fire[1]	Burn Biomass debris from roadside maintenance projects
Toklat River #1 Fire	5/23 – 6/21/09	196	Wildland Fire	Wildland Fire
Toklat River #2 Fire	5/23 – 5/30/09	595	Wildland Fire	Wildland Fire
Live Trap Lake Fire	5/25 – 6/14/09	1665	Wildland Fire	Wildland Fire
70 Mile Pit slash burn	5/29 – 5/31/09	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
Kantishna slash burn	5/29 – 5/31/09	0.1	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
Bear Creek Fire	6/17 – 9/25/09	31360	Wildland Fire	Wildland Fire
Foraker Pond	6/17 – 9/25/09	9838	Wildland Fire	Wildland Fire
Ruth 1 Fire**	7/11 – 8/5/09	250.4	Wildland Fire	Wildland Fire
Ruth 2 Fire	7/11 – 7/14/09	0.1	Wildland Fire	Wildland Fire
Riley Creek Cabin slash burn	9/1 – 9/3/09	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
Sanctuary River Fire	9/5 – 9/6/09	5.10	Wildland Fire	Wildland Fire—Fire suppressed
Toklat slash burn	9/22 – 9/23/09	0.10	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

**Though initial suppression actions were taken, ultimately the wildfire was allowed fullfil its ecological role on the toe of the Ruth Glacier. This is the second time a fire was ignited on the toe of the Ruth Glacier in the last 13 years. A fire in 1996 was suppressed.

Several prescribed fires are completed or planned for fiscal year 2010:

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

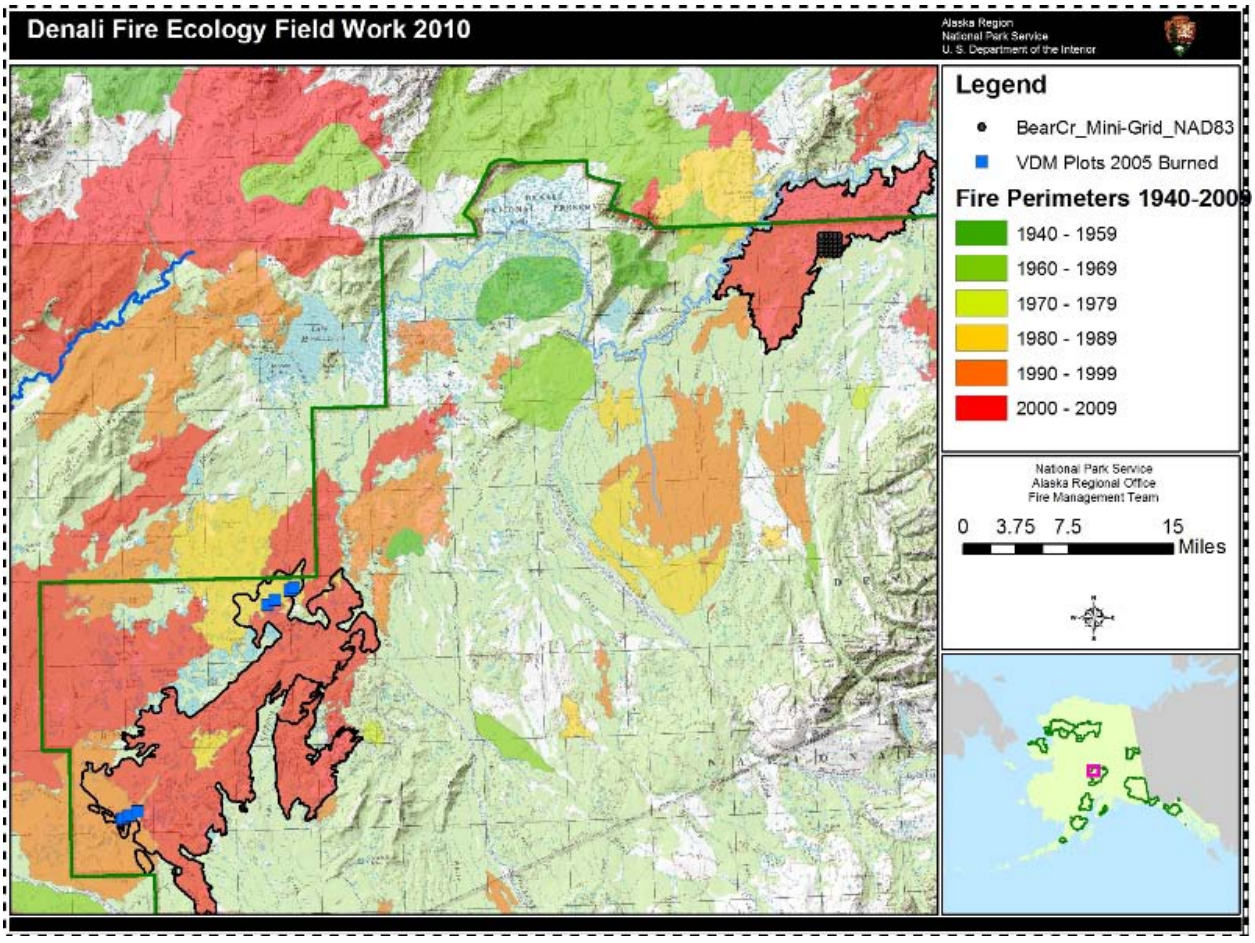
History has shown the devastating effects when wildland fire combines with a buildup of vegetation around structures. Hazardous fuels around structures in the developed and backcountry areas of Denali National Park and Preserve have or are being reduced to create a "defensible space" around the structures. 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 defensible space project, fire staff provides Denali employees with 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. Starting in 2009, fire management staff treated additional areas as identified in the maintenance cycle of previously created defensible space around buildings.

- **Cultural resource sites**. In 2009, staff burned debris that had accumulated from past hazard fuels projects at the Riley Creek and Upper Windy Creek Patrol Cabins, completing the cycle for the initial treatment of the sites. These sites are now entering a maintenance cycle. In 2010, staff will burn the unburned piles at the New Thorofare, New Birch 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).

Fire activites in 2010 will include assessing burn severity at Bear Creek minigrid (see black square at top right of map), and remeasuring plots for videography-moose analyses (squares near black outline at lower left of map). The two activities are further described below:



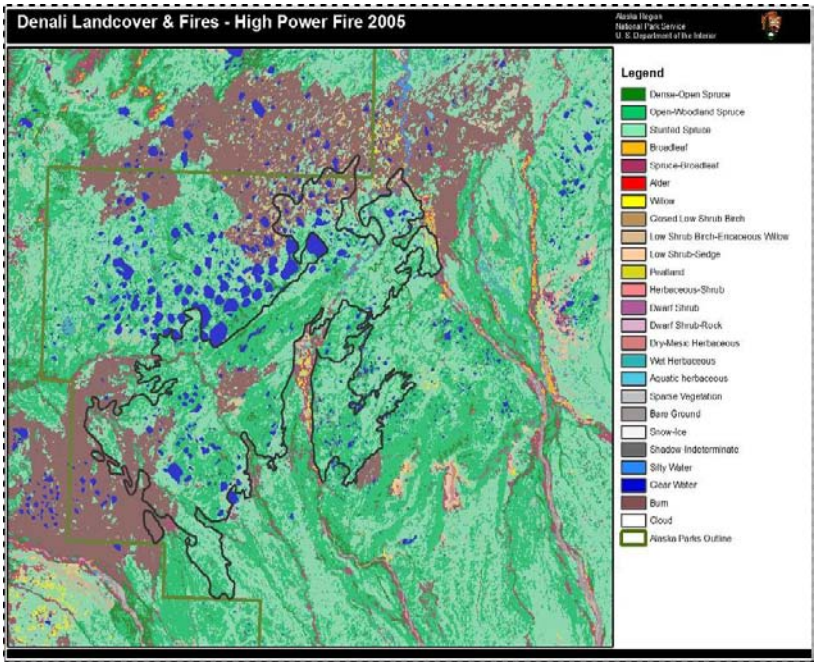
Assessing Burn Severity at Bear Creek Mini-grid

Fire Management staff is coordinating with Carl Roland to assess the burn severity on the Bear Creek mini-grid vegetation plots in 2010. The 2009 Bear Creek Fire burned through an established CAKN Inventory and Monitoring vegetation mini-grid (Bear Creek Mini-grid). This mini-grid had been established and measured using CAKN protocols in 2006. Portions of the plots were also burned in the Bear Fire (1997). The purpose of this work is to assess burn severity at each measured mini-grid plot (up to 25 plots) using standardized Composite Burn Index methods and additional estimates of severity. Fire staff will also photograph and record plant cover at each mini-grid plot affected by fire.

Denali Videography-Moose (VDM) Fire Plots

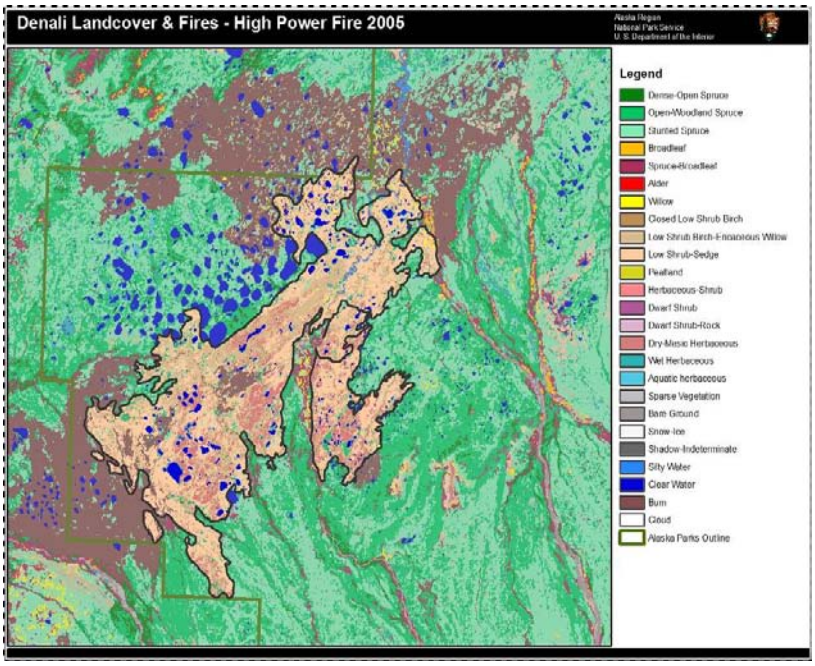
The Denali videography-moose fire pilot study was established to update the recently-burned portions of the Denali Landcover Map, to test the use of videography as a method for landcover classification, validate successional patterns in relationship to burn severity, and identify fire effects on moose browse for different intervals since last burn. In 2005, forty-three plots were established in 1-5 yr-old fires and 10-20 yr-old fires. During that summer, 10 of the plots were burned again by the 114,000 acre Highpower Creek fire. In order to determine the impacts of a short fire return intervals on vegetation, these plots were re-measured in 2006. Understanding the natural variability related to fire is necessary in order to identify potential abnormal effects associated with long-term climate change or management activities.

In 2010, fire management staff will measure the 10 plots that burned in 2005 (5 years post-fire) using the Alaska NPS Fire and Fuels Monitoring Protocol (formerly called Pre-Post Fire Protocol). The purpose is to assess impacts of shortened fire return intervals (sites burned in 1986 or 1990 and again in 2005) on vegetation, fuels, wildlife browse, and permafrost.



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.



New Landcover Classification (draft) for the area that includes 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.

Fire Education

- ✧ **Murie Science and Learning Center Science Series.** Starting 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. In 2009 staff participated in Denali Discover Camp covering fire ecology information.

- ✧ **Firewise Workshops.** In 2009, fire staff conducted no workshops but did complete a few home assessments in the greater Denali area. The Alaska Western Area fire staff will seek opportunities to promote the recently revised Alaska FIREWISE concept in 2010. Firewise workshops teach community members how to reduce the combustible material around their homes in order to reduce the risk of wildland fire.

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's resource staff continues 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 2009, staff distributed these materials around the park and will do so in 2010. 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 goals are 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 - West**

  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 26, 2009 from a helicopter, with fixed-wing aircraft support. Wildlife staff removed collars from 3 female grizzly bears and retrieved one dropped collar. For the 2009 season, wildlife staff followed the remaining 9 collared bears (all female).

  Following the sows through the 2009 season, at den emergence, two sows each had twin spring cubs, one sow had 3 spring cubs, and one sow had 2 three-year-olds. The remaining five sows did not have young, including two that each had been seen with their spring cub near the end of 2008. By September, one sow had her three and another had a single "spring" cub. The remaining five cubs could not be accounted for. The spring cubs were presumed dead and the three-year-olds had presumably dispersed. The oldest bear in the study is 21 years-old.

  Plans for 2010 are to continue to remove radio collars as they come due for replacement. This project is being phased out as the study moves to a new area with new objectives.

✧ **Grizzly bear monitoring – North**
Wildlife biologists began the transition to a new grizzly bear monitoring study in 2009. The new study area is on the north side of the Outer Range between the Kantishna Hills and the east end of the park. The objective of this study is to document the ecology of grizzly bears and their movements on the northeast side of the park especially outside the north park boundary where they may be subject to legal harvest and possible future predator control efforts by the State of Alaska.

During May 26-28 and June 9, 2009, biologists captured and fitted with radio collars eight females and five male bears (using a helicopter, with fixed-wing aircraft support). By early July, two males and one female managed to drop their collars. The collars were retrieved in mid-July and in September were redeployed on two new males and one new female. Capturing bears in late season enabled attaching the collars at the time that bears would be at their fattest. This allowed the collars to be tighter (and thus stay on better) than what would normally be acceptable during a spring capture when bears have the least amount of body fat.

At the time of capture, one female had two yearling cubs and one had two two-year-old cubs. By late September only the two-year-olds were alive and the yearlings were presumed dead. At least two bears, both male, traveled outside the park boundary to the north. Radio-tracking flights have been conducted in winter 2009-2010 to locate den sites.

Plans for 2010 are to increase the sample size by radio collaring additional bears and to continue radio tracking efforts. Staff is rebuilding several GPS collars formerly used in the park's Road Study, in order to use them in this study of bears (North) as part of an effort to determine bear habitat use in relation to human activities, and possible climate-induced changes in vegetation patterns.

✧ **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%. 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 15, 2009 and September 10, 2009, 98 bear-human interactions were documented. These were classified as one observation, 88 encounters, 8 incidents, and one control action. The total of 98 BIMS this year marks a 9% increase from the previous year's total of 90 (see table).

Type of Interaction	FRONTCOUNTRY	BACKCOUNTRY	**TOTAL**
Observations	0	1	**1**
Encounters (when bear is aware of human and thus the bear's behavior is altered)	35	52	**88**
Incidents (when bear is involved in close charge, actual contact, or damage to human or property)	3	5	**8**
Control Actions	1	0	**1**
Total	**39**	**59**	**98**

Both the number of reported backcountry interactions and incidents has decreased since last year, including a decrease in the number incidents involving bears causing property damage or receiving food rewards.

PLEASE HELP EMPHASIZE TO HIKERS AND VISITORS CAMPING IN CAMPGROUNDS AND BACKCOUNTRY AREAS the vital importance of preventing bears from obtaining human food.

Wildlife Observations along the Park Road

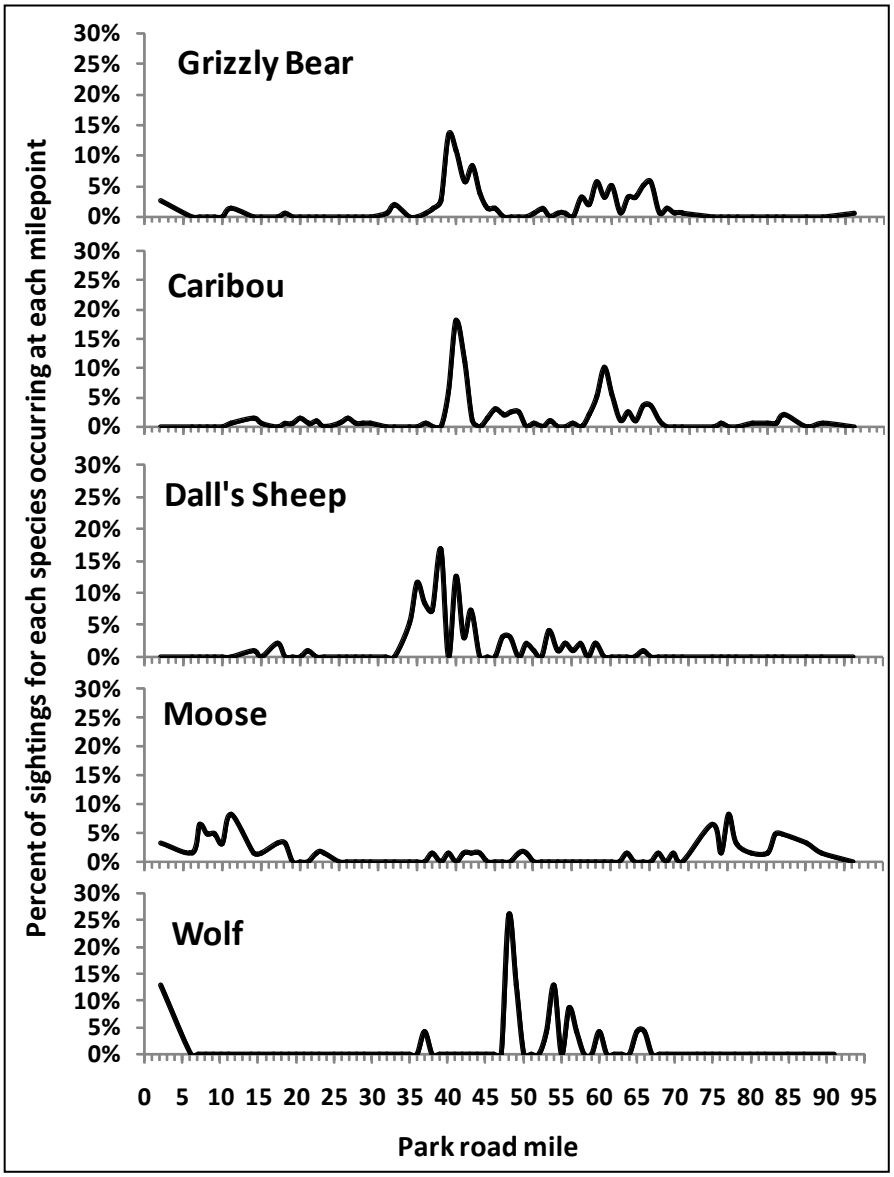
This study, which relies on those bus drivers who volunteer to help monitor wildlife along the park road, continued in 2009. Drivers record the numbers of bears, moose, sheep, caribou, and wolves they see on their trips – now, instead of paper data sheets, bus drivers use touch screen panels installed 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.

Data collected from bus driver wildlife observations indicate that over the last 10 years, 75-90% of visitors going at least as far as Eielson Visitor Center see at least one grizzly bear.

In 2009, the percent chances of seeing at least one of the "big five" on a bus trip at least as far as Eielson Visitor Center were:
78% for grizzly bears,
88% for caribou,
81% for Dall's sheep,
47% for moose, and
16 % for wolves.

The average percent chances over the last 11 years (1999-2009) were
83% for grizzly bears,
91% for caribou,
81% for Dall's sheep,
40% for moose, and
20% for wolves.



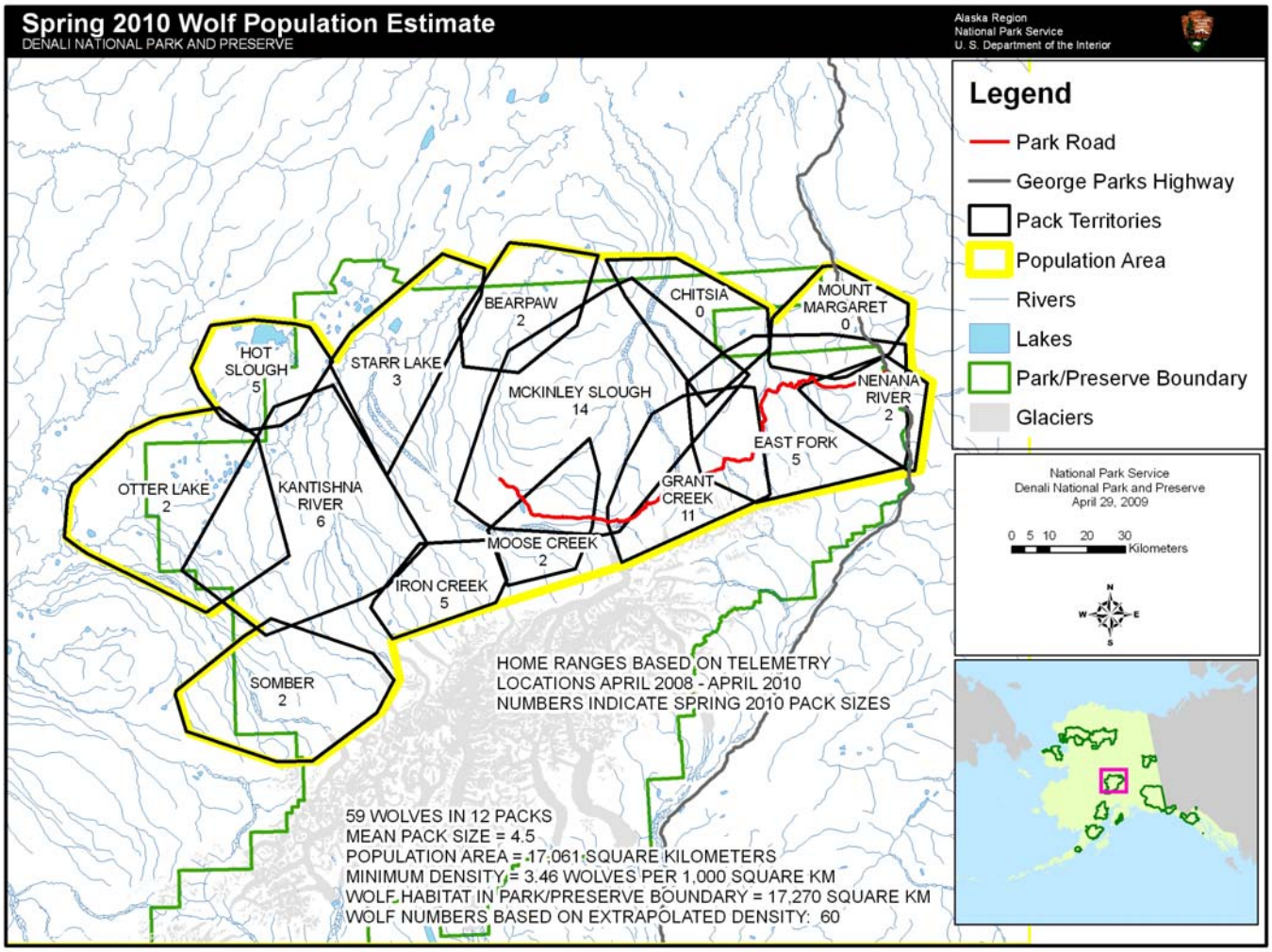
Wolves

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 or two 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. In recent years, the use of GPS/ARGOS collars that upload daily locations has greatly increased the number of locations available for most collared wolf packs.

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 15, 2010, 13 wolves in 12 packs in and around Denali wore conventional, VHF radio collars that are located from antennae-equipped aircraft. Another 7 wolves carried GPS collars that determine the animal's location once per day, store the data, and upload it through the ARGOS satellite system.



Spring 2010 wolf pack territories and population estimate for Denali.

In April 2010, there were 59 wolves in the 12 packs being monitored by park biologists. The estimated density of wolves in Denali (about 9.0 wolves per 1000 square miles or 3.5 wolves per 1000 square kilometers) was a further decline from last year's estimate of 10.0 wolves per 1000 square miles or 3.9 wolves per 1000 square kilometers. These wolf densities are the lowest in more than 20 years of wolf monitoring in Denali.

Biologists captured and radio-collared 5 wolves during the winter 2009-2010. A lack of available helicopter pilots prevented more capture work, but the coverage of radio collars was complete enough to provide accurate counts of wolf numbers.

At the March 2010 meeting of the Alaska Board of Game, the board voted to eliminate the Stampede and Nenana Canyon Closed Areas, which had been in place for 10 years to protect wolves that live near the Denali Park Road from being hunted or trapped when they leave the park. The National Park Service had submitted a proposal to enlarge the Stampede Closed Area to include all of the "wolf townships" that form a notch in the park boundary.

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 23 years.

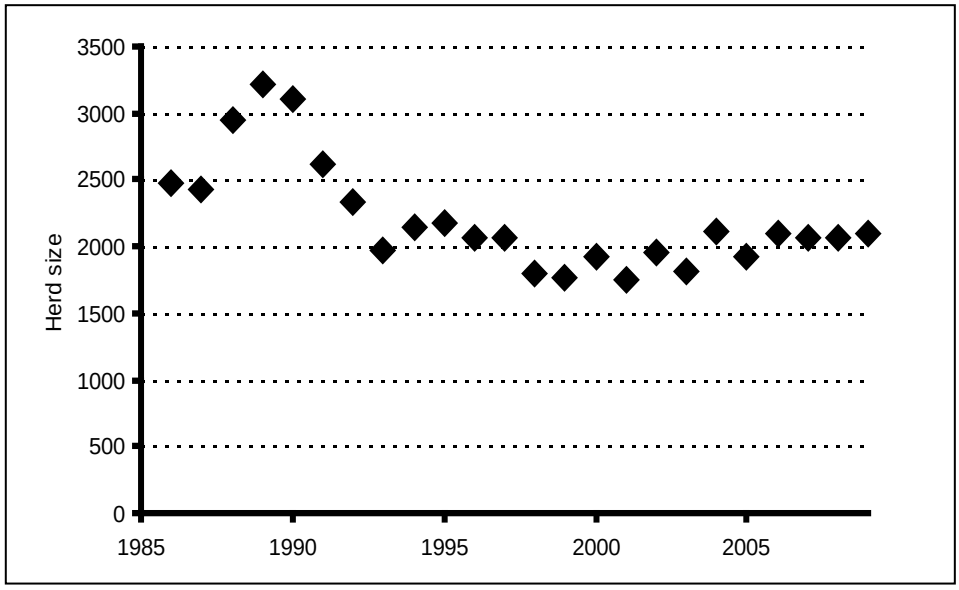
To date, park biologists, Layne Adams of U.S.G.S, Alaska Science Center and co-cooperators have learned much about the interactions between predation and weather that drive the dynamics of the Denali Caribou Herd. When this study began, the caribou population was increasing at about 7 percent per year through a period of relatively mild winters in the mid-1980s. Winter survival of caribou cows was high (96 percent per year) and about 47 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 (from 96 percent to 85 percent per year) and calf recruitment dropped to a mere 12 percent. With a return to more average winter conditions after 1993, the herd trend has been essentially "flat" through 2009. 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 6 years (23 calves per 100 cows during each fall since 2004), but without a detectable increase in population numbers.

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 2009, 20 percent of the cows were 13-years old or older, compared to 6% in this age group during 1987-89.

In September 2007, a new component of the study was initiated to investigate the survival, growth and seasonal distribution of bull caribou within the Denali Herd. Information on bull survival patterns is lacking from the scientific literature, even though bulls generally constitute the majority of the take in harvested populations. Prior to this study very little was known about bull mortality in Denali, but two interesting and unexpected patterns arose from investigations of wolf kills in Denali during 1986-1993.

First, large bull caribou were killed by wolves primarily in August and September prior to the annual rut, when the caribou should have been in peak condition. Generally, studies of northern ungulates document high mortality for males *following* the rut, resulting from their depleted nutritional condition. Also, the wolf kill data indicated that mortality of caribou bulls unexpectedly ended by early December rather than continuing through the winter. Thus, it was suspected that mature Denali bulls may have moved outside the range of radio-collared wolf packs and thus have not been included in the kill data. If that is the case then they are largely outside the park boundaries for much of the winter. Late winter composition surveys of Denali Caribou Herd show that most of the bulls are not associated with the cows or utilizing similar habitats in March.

Herd size. A tentative estimate of herd size in late September 2009 was 2,070 caribou with little noticeable change during the last 6 years (see graph at right). During the last 6 years, there have been 23 calves for every 100 cows (calf:cow ratio), a 65 percent increase over the previous decade. Herd trend over the next few years will largely depend on levels of calf recruitment into the adult population.



Adult Sex Ratios. During the September 2009 composition survey, there was a ratio of 36 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 2009, Layne Adams estimated that 73 percent of cows one year or older produced young, based on observations of 71radio-collared cows in the age-structured sample. Such birth (natality) rates have averaged 77 percent over the course of the study. Of the 19 non-pregnant radio-collared females, 8 were yearlings, and 8 were 2-year-olds (thus most non-pregnant cows were less than two-years-old). The remaining 3 non-pregnant individuals were 4, 16, and 18 years of age.

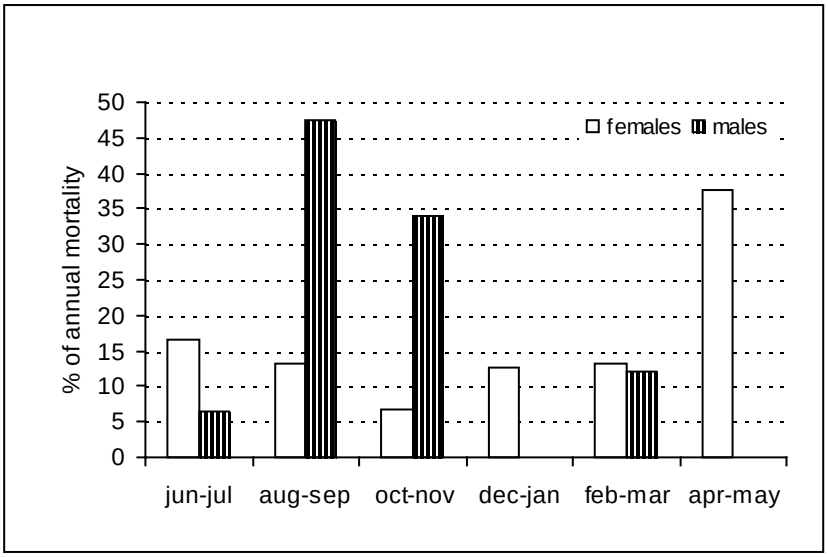
During the annual census and post-calving composition survey in early June 2009, Layne Adams observed a calf : cow ratio of 35 calves for every 100 cows. By late September, the calf:cow ratio had declined to 23:100, indicating that only 29 percent of the 2009 calf cohort had survived to September. The average of calf survival to fall (estimates) has been 23 percent since 1987, with higher than average calf survival during the last 6 years. Approximately 13 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 (9 percent) over the previous year.

Female Survival and Age Structure. During the sampling year (October 2008 – September 2009), eight radio-collared cow caribou from the age-structured population died, resulting in an annual mortality rate of 8.9 percent. Summer and winter survival were both slightly higher than the long-term averages (96.3 and 91.6 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 2009 reflects the recruitment of calves from the 2008 cohort that entered the age structure as yearlings. However the proportion of old cows (≥ 13 years old) continues to be relatively high (due to low overwinter mortality in the last few years and the relatively strong 1994 and 1995 cohorts that are now 13- and 14-years-old).

Seasonal Distribution of Females. The spatial distribution of the Denali Caribou Herd changes throughout the year as females move to calving ranges predominantly in the foothills to the north and northwest of Mt. McKinley, remaining in the higher elevation areas through much of the summer and into the rut. With the onset of winter, caribou move to winter ranges at lower elevations encompassing much of the north side of Alaska Range from the lower Savage to the forested Foraker River, Birch Creek, Slippery Creek flats, with the predominant concentration in the foothills and flats directly north of the Wyoming Hills.

Winter distributions of the caribou have varied substantially during the 22 years of caribou monitoring. While caribou generally congregate in north of the Wyoming Hills, few caribou occur there in some winters. In particular winters, primary concentrations have been noted further east along the lower Savage (e.g. 1989, 1991, 1994), in the upper Moose Creek-Clearwater Fork region (e.g. 1987, 1998, 2007), the Kantishna Hills (e.g., 1989, 1990, 1997), or west along treeline and in woodland areas in the Birch Creek and Slippery Creek drainages (e.g. 1996, 1997, 2000). The 1992 winter was particularly unusual when caribou left the park in late September following an extreme snowfall and scattered as far as the White Mountains and northern Tanana Flats.



Timing of annual mortality for adult caribou by sex in the Denali Caribou Herd, based on radiotelemetry data collected during October 1986-September 2009 for females, and October 2007 – September 2009 for males.

Adult Bull Survival. During the two years that bull survival has been evaluated (September 2007-September 2009), of the 57 bulls that were collared (45 in 2007 and 12 in 2008), 17 have died with most deaths occurring 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 long-term average estimated survival rate for adult females.

Bull Growth Patterns. Sixty-three of 72 caribou bulls captured in September 2007, 2008, and 2009 were weighed and 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 64 lbs (29 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 2009-2010 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.

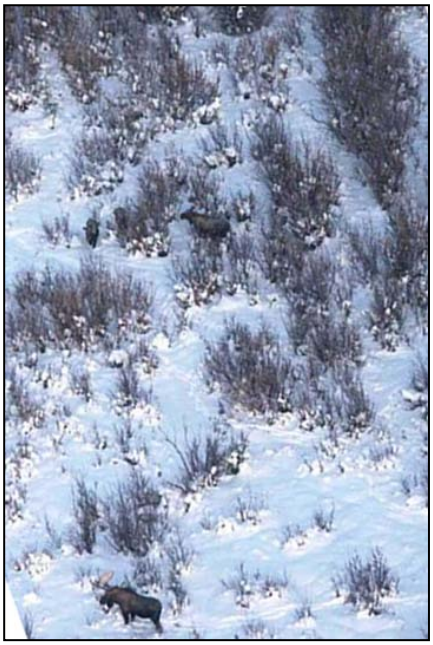
2. Maintain a sample of approximately 45 radio-collared adult bulls and surviving collared individuals from the 2007 and 2008 cohorts, and capture 12 10-month-old males (from the 2009 cohort) to assess age-specific growth and survival, and seasonal distribution.

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.

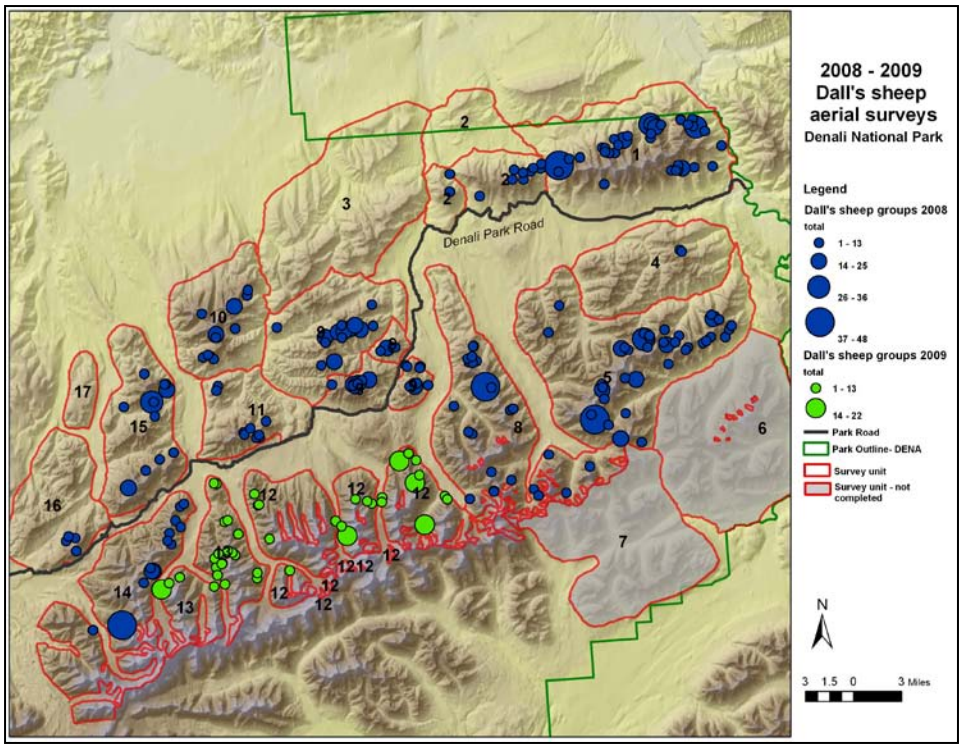
4. Conduct the post-calving census and composition survey and the fall composition survey to determine herd size, calf recruitment, and adult sex ratio.

Moose

Denali is one of three parks that make up the Central Alaska Network (CAKN). Based on protocol developed as part of the CAKN monitoring program, surveys to estimate moose numbers are conducted in Denali every three years. A large survey area on the north side of the Alaska Range is Denali's part of the larger CAKN monitoring program for moose. Wildlife biologists conducted moose surveys in this area and two additional areas (Cantwell and the Yentna Valley) of the park in late October and November 2008. Moose surveys are scheduled to be repeated in Denali in late Fall 2011.



Dall's Sheep



Aerial survey. Denali biologists conducted Dall's sheep surveys on July 13 and 17, 2009 and surveyed units 12, 13 (which had not been surveyed in 2008) and unit 9 (incompletely surveyed in 2008) (see map). Observers counted a total of 527 sheep in 75 groups, with a breakdown of sheep as: 313 ewe-like, 85 lambs, and 129 rams. On average, there were 7 sheep in a group. In units 12 and 13 (not surveyed in 2008), observers counted 198 sheep in 42 groups. These sheep were tallied as 132 ewe-like, 29 lambs, and 37 rams. There were more ewes but fewer lambs tallied in unit 9 in 2008 compared to 2009. In comparison, in 2008, observers tallied a total of 1,526 sheep (898 ewe-like, 202 lambs, 412 rams, and 14 unknown sheep) in 197 groups for an average group size of 7.7 sheep.

Combining the counts from 2008 and 2009—Unit 9 was surveyed in both 2008 (367 sheep in 36 groups) and 2009 (329 sheep in 33 groups) and the larger number from 2008 was included in the combined tally of years—there were 1724 sheep observed in the traditional survey units north of the Alaska Range. Units 6 and 7 were not included in this tally.

Ground-based surveys. In both 2008 and 2009, park staff conducted ground-based Dall's sheep surveys in Denali. 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.

Denali staff conducted ground-based Dall's sheep surveys on June 29-30, 2009 on Primrose Ridge, Mt. Wright, Cathedral Mt., Igloo Mt., and Sable Mt. The 2008 ground-based surveys included the west end of Polychrome Mt. above the Toklat bridge, and areas in the Alaska Range along the east branch of the Toklat River in addition to the locations listed for 2009.

Ground-based counts classified 177 sheep in 2008 and 136 sheep in 2009. Productivity estimates (expressed as ratios) from these counts are 40 lambs per 100 ewes in 2008 and 38.6 lambs per 100 ewes in 2009. While comparisons with past survey results should be made with caution, results of the 2008-2009 survey suggest that sheep numbers within the traditional units east of the Muldrow Glacier have not changed significantly since the mid-1990's.

Biologists recommend that park managers develop a survey methodology for Dall's sheep in the eastern portion of the park that can be more feasibly completed within a reasonable time frame and that provides more accurate estimates of sheep abundance that can be compared across years.

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. Population numbers of small mammals are reflective of local conditions because of their short life spans, high reproductive rates, and movements restricted to less than 2 miles (4km). Small-mammal populations are excellent candidates for detecting change in boreal ecosystems over time and thus small mammals were selected for long-term monitoring by CAKN.

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. In 2009, Melanie Flamme, wildlife biologist with Yukon-Charley Rivers National Preserve (and with the Central Alaska Network Monitoring Program), coordinated the eighteenth year of small mammal trapping in the Rock Creek study area in Denali. One hundred Sherman live traps were deployed on each of the four Rock Creek legacy plots (two riparian plots and and two forested ridge plot. All traps were baited with irradiated (can't sprout) sunflower seeds and biodegradable bedding. All 400 traps were checked 3 times daily (6 am, 1 pm, and 8 pm) from August 13-16, 2009. Captured individuals were identified by sex and species. Reproductive status was determined, and net weight was calculated. Researchers inserted rice-grain-sized tags under the skin of previously unmarked individuals. These tags are called passive integrated transponder (PIT) tags. Each tag has a unique code and once implanted can be scanned to read the code. The tagged animals were scanned and released. By the end of the sampling period, 5200 trap checks [(400 traps x 3 checks x 4 days)] yielded 611 captures (244 new captures and 367 recaptures). Of the new captures, 175 (71.72%) comprised northern red-backed voles (*Myodes rutilus*), 46 (18.85%) comprised tundra voles (*Microtus oeconomus*) and 23 (9.43%) comprised singing voles (*Microtus miurus*).

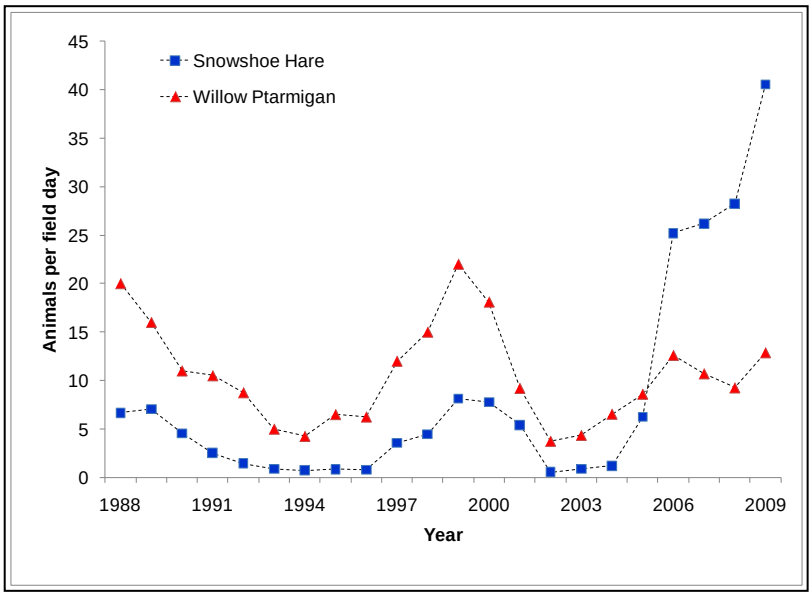
Red-backed voles had an estimated density of about 15-18 voles per hectare (for the forested plots and 18-39 voles per hectare for the riparian plots (more variable between the two plots). No singing voles were captured on the riparian plots. In general, density estimates were consistent with those over the past 17 years.

In 2009, the Central Alaska Network's small-mammal monitoring outreach program (in its third year) recruited three high-school students from Fairbanks to join the fieldwork for small mammal monitoring in Denali. Volunteers participated in the seven days of field work at the Rock Creek legacy plots. The volunteers worked side-by-side with the biologists and gained hands-on experience handling and trapping small mammals. The volunteers contributed a total of 224 hours towards the Central Alaska Network's small-mammal monitoring project for 2009.

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. This project will continue in 2010.

In 2009, the abundance of adult snowshoe hare continued to increase and the abundance of adult male willow ptarmigan was similar to the last three years (see figure at right).



Vegetation browsed by snowshoe hare was very easy to see across many areas of Denali in 2009.

Birds

- **Monitoring abundance and distribution of passerines.** Passerine (perching) bird monitoring programs started in Denali in 1992. Denali was one of four prototype parks selected for this initial Long-term Ecological Monitoring Program. This program eventually became the NPS Vital Signs Inventory and Monitoring program, as Denali joined two other parks in the Central Alaska Network (CAKN). Passerine birds is one of the components being monitored in the CAKN I&M Program. The Order Passeriformes (passerines or perching birds) is the single largest order of birds, comprising over 50 percent of avian species diversity.

Of the 168 species of birds documented in Denali, 65 (39%) are in the order Passeriformes. One of the major CAKN objectives in monitoring passerine birds is to detect changes and trends in bird abundance. The current protocol for monitoring passerine birds, instituted in 2002, is undergoing extensive revisions to incorporate new survey and analyses methods. In 2009, scientists tested a repeat-survey approach in Denali. This approach repeats a series of standardized surveys across the breeding season.

On-road surveys. From early May through June, 2009, park biologists conducted 50 3-minute surveys for birds along each of three 24.5-mile survey routes along the Denali park road (sample points spaced about ½ mile apart from mile 0 to 24.5 (route 1), from mile 25 to 49.5 (route 2), and from mile 50 to 74.5 (route 3). These road-side survey routes were initially developed and surveyed repeatedly each year by the Alaska Bird Observatory in the mid-1990s. The surveys are very similar to the Breeding Bird Surveys (see below), but each route is surveyed more than once during the breeding season (May and June). The surveys start ½ hour before sunrise and end about five hours later. In June, the surveys start by 3:00 a.m. and end by 9:00 a.m. At each sampling point, the biologist records all the birds detected within ¼ mile of the sampling point within a 3-minute period. Six repeated surveys were conducted along the first route from May through June, and three repeated surveys were conducted along the second and third routes in June. This is the best time of day to hear and see many passerines, and also a great time to enjoy colorful sunrises.

Observers (and listeners) detected 65 species were detected on the road-side surveys in 2009 (see table below for breakdown by route number). Species diversity varied across routes, but American Tree Sparrow, Fox Sparrow, and White-crowned Sparrow were detected on all surveys regardless of date.

During June (peak breeding season), birds detected on all surveys were the above three species plus Orange-crowned Warbler, Wilson's Warbler, and Savannah Sparrow.

Route	Number of repeat surveys	Number of bird species detected for all surveys	Range of detected species for one survey	Most commonly detected species
1	6	43	17-30	American Robin, Orange-crowned Warbler, Wilson's Warbler, American Tree Sparrow, Fox Sparrow, White-crowned Sparrow, and Dark-eyed Junco
2	3	38	20-28	Willow Ptarmigan, Orange-crowned Warbler, American Tree Sparrow, Fox Sparrow, White-crowned Sparrow, and Dark-eyed Junco
3	3	35	20-31	Orange-crowned Warbler, Wilson's Warbler, American Tree Sparrow, Savannah Sparrow, Fox Sparrow, and White-crowned Sparrow

This repeat survey method will allow the detection in trends in abundance of a suite of common passerine birds in Denali. For instance, over the last 15 years, the number of Wilson's Warblers detected on these survey routes has decreased by 50 percent, while the number of Fox Sparrow detected on these surveys has increased by more than 50 percent.

This project will continue in 2010, and will be conducted in Wrangell-St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve as well.

Off-road. From June 1-30, 2010, park biologists and the staff of the Alaska Bird Observatory conducted 10-minute point counts to sample for birds at 161 sampling points along three survey routes in the northeast portion of Denali. Route 1 ran from Jenny Creek to the Sanctuary River valley, Route 2 ran from the Teklanika River, across Big Creek and to the Polychrome area, and Route 3 ran north of the Denali park road from Moose Creek to lower Stony Creek. The biologists repeated surveys with two 2-person teams. Forty-nine species were detected on the off-road routes in 2009. The number of species detected per route ranged from 30 on route three to 41 on Route 1. Species diversity varied by route, but the species with most detections on all routes were Wilson's Warbler, American Tree Sparrow, Fox Sparrow, and White-crowned Sparrow. High numbers (more than 20) of Whimbrels were detected on Routes 1and 3.

The off-road passerine surveys will not be conducted in Denali in 2010. The sampling design for these surveys is being revised and incorporated into the larger CAKN passerine monitoring project. Under the new design, off-road surveys will be conducted on the minigrids (see vegetation section) rotated among the three CAKN parks over a three-year period and then repeated (Wrangell-St. Elias in 2011, Yukon-Charley Rivers in 2012, and in Denali in 2013).

- **Breeding Bird Survey (BBS):** The North American Breeding Bird Survey (BBS) is a large-scale survey of North American birds. Nearly 4,100 BBS routes are located in the U.S. and Canada and about 2,900 routes are surveyed annually. The BBS has accumulated over 40 years of data on the abundance, distribution, and population trends of more than 420 species. These data are useful for assessing if changes of a species in certain states are related to a continental decline or merely represent population shifts within their breeding range.

  Park biologists survey two BBS routes in Denali in June each year: the Savage BBS and the Toklat BBS. Each route contains 50 sampling points located ½ mile apart. At each point, the observer conducts a three-minute count and records all birds detected within ¼ mile of the sampling point.

  The Savage BBS route was completed on June 16, 2009. Observers detected 31 species and 554 individuals. The species with the most detections on the Savage BBS in 2009 included Wilson's Warbler, American Tree Sparrow, Fox Sparrow, and White-crowned Sparrow. The number of species detected on the Savage BBS each survey year ranged from 18 to 33, with 56 species detected over the 21 years (since 1986) when the route was surveyed. Several species were detected on this route in 2009 that had not been detected in previous years including Bald Eagle, Northern Harrier, and Surfbird.

  The Toklat BBS route was completed on June 17, 2009. Observers detected 34 species and 545 individuals. The species with the most detections on the Toklat BBS route in 2009

included Orange-crowned Warbler, American Tree Sparrow, Savannah Sparrow, Fox Sparrow and White-crowned Sparrow. The number of species detected on the Toklat BBS each survey year ranged from 24 to 43, with 76 species detected over the 22 years (since 1982) when the route was surveyed. No new species were detected on the Toklat BBS route in 2009.

National Park Service biologists will complete the two BBS routes in Denali in June 2010. Results from the Denali BBS routes are available at: http://www.pwrc.usgs.gov/bbs/RawData/Choose-Method.cfm

- **Reproductive success of Golden Eagles and Gyrfalcons:** As part of the Central Alaska Network (CAKN) Vital Signs Inventory and Monitoring (I&M) Program, 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) again in 2009. This marked the 22nd consecutive year of this study. Park biologists collected data using two standardized aerial surveys conducted from a helicopter, and additional ground observations and foot surveys. The survey to document occupancy of nesting areas and breeding activities was conducted in late April, additional foot surveys were conducted from May through July, and the survey to document fledgling production and reproductive success was conducted in late July.

  In 2009, occupancy of Golden Eagle nesting areas (93%) was higher than the long-term mean (86%). Despite high numbers of snowshoe hare (*Lepus americanus*), all measurements of Golden Eagle reproductive performance were lower than expected. Fledgling production (n = 67) was higher than average, but short of the best years.

  Park biologists monitored 16 Gyrfalcon nesting territories in 2009. Gyrfalcon reproductive success in Denali was lower than most years despite apparently high numbers of Willow Ptarmigan in the study area.

  Park biologists and many other park employees and visitors noted many subadult Golden Eagles and adult and subadult Bald Eagles (*Haliaeetus leucocephalus*) in the study area from late May through early September. Biologists hypothesized that these non-territorial eagles were drawn to the area by the abundance of snowshoe hare. Also, many people reported seeing the subadult Golden Eagle with bright blue wing-tags along the Denali park road from June through August. This eagle was captured in western Montana during autumn migration in 2008 by Raptor View Inc. The National Park Service 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 journal *Auk* 125: 214-224, or upon request.

  This project will continue in 2010.

- **Christmas Bird Count:** The Christmas Bird Count (CBC) is a long-standing program of the National Audubon Society, with over 100 years of citizen science involvement. It is an early-winter bird census, where thousands of volunteers across the US, Canada and 19 countries in the Western Hemisphere, go out over a 24 hour period to count birds through a designated 15-mile (24-km) diameter circle, counting every bird they see or hear all day. 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 CBC is to monitor the status and distribution of bird populations across the Western Hemisphere. When CBC data are combined with data from other surveys such as the Breeding Bird Survey, 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 2009 Denali CBC was held on December 29, 2009. Seven participants enjoyed warm temperatures (23° to 32° F) and recorded 14 species on the count day including Spruce Grouse, Willow Ptarmigan, Northern Goshawk, Great Horned Owl, Northern Hawk Owl, Hairy Woodpecker, American Three-toed Woodpecker, Gray Jay, Black-billed Magpie, Common Raven, Black-capped Chickadee, Boreal Chickadee, Pine Grosbeak, and Common Redpoll. Willow Ptarmigan was the most commonly detected species in 2009, with 100 individuals detected in the count circle. This was the highest number of Willow Ptarmigan detected on the count in 18 years. No White-winged Crossbills were detected on the 2009 count; this is not surprising given the poor white spruce seed crop in the local area in 2009.

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 2009. As of this writing, the statewide U.S. Fish and Wildlife Service surveillance project in 2010 will focus on waterfowl and shorebirds, and no sampling will be conducted in Denali.

Park visitors should not pick up dead birds. Park visitors should report the locations of dead birds 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.

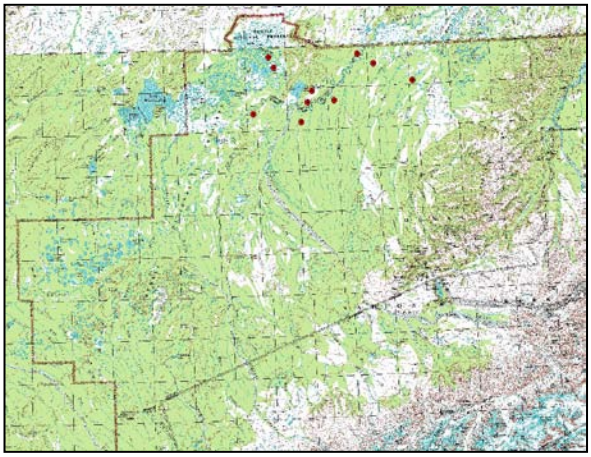
- **Bird Species of Conservation Concern:** Denali biologists and staff at Camp Denali and North Face Lodge continued to document in 2009 the distribution and occurrence of a suite of 34 bird species of conservation concern. Four park rangers also participated in the study in 2009. Species included in this project are those with documented population declines such as Olive-sided Flycatcher and Rusty Blackbird and those that respond quickly to changes in their habitat such as Gray-cheeked Thrush and Golden-crowned Sparrow. The project was conducted from early June through mid-September in two study areas: Grassy Pass east to Toklat and Grassy Pass west to Kantishna. Observers recorded their first detections of each species during their routine daily activities. Denali scientists are using these data on the presence of these birds along the western portion of the Denali park road to help assess changes in bird distribution over time. This project is also helping naturalists and rangers provide park visitors with current information about birds and their conservation issues.

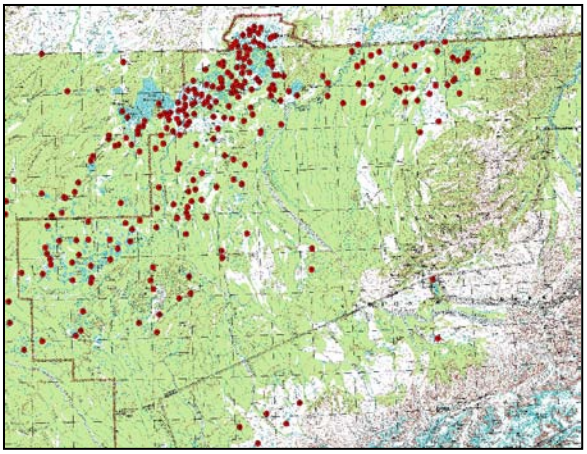
  This project will continue in 2010.

- **Abundance and distribution of boreal forest wetland birds:** Park biologist, Carol McIntyre, is starting a two-year field study in June 2010 in the northwestern region of Denali. The study will provide new information on the presence, relative abundance, and distribution of a suite of birds that nest in boreal forest wetlands. The study will provide a reference point for measuring change in these bird attributes in relation to a changing climate. The vast expanse of boreal forest wetlands in the northwestern portion of Denali (see photo) was added to the park in 1980 . These wetlands are among Denali's most productive ecosystems, but they also are one of the least studied ecosystems in Denali. Many of the birds that nest in boreal forest wetlands are considered habitat specialists, some of these species are among the most vulnerable to habitat loss, and some of these species are already experiencing declining population trends. For instance, Lesser Yellowlegs and Rusty Blackbirds have experienced 98% population declines over the last 40 years. This project is being conducting in collaboration with the CAKN Shallow Lakes Monitoring Program that is monitoring the physical and chemical features of Denali's wetlands.

- **Statewide Trumpeter Swan Survey:** The Migratory Bird Management Division of the U.S. Fish and Wildlife Service (FWS) is responsible for monitoring populations of trumpeter swans and other waterfowl species in Alaska. FWS biologists conducted the first statewide trumpeter swan census in Alaska in 1968 as part of an assessment of this species, which was listed as threatened under the Endangered Species Act of 1966. To estimate the population size of trumpeter swans in the remote and vast areas of Alaska, the FWS developed aerial survey methods that could be duplicated by competent observers to collect comparative data over time. This foresight paid off, as the same survey methods have been used by the FWS for conducting the statewide trumpeter swan census in Alaska ever since. FWS personnel have conducted a statewide trumpeter swan census every five years since 1975 across all trumpeter swan nesting habitat in Alaska. The increase in the number of trumpeter swans detected on the five-year census is striking, with an increase from 4,170 swans in 1975 to 23,692 swans in 2005.

The numbers of trumpeter swans in Denali increased along with the statewide population – from 43 in 1968 (left dot map) to over 700 in 2005 (right dot map). Over the last 40 years, trumpeter swans have dispersed across the vast wetlands in the northwest portion of Denali and swans are starting to use higher elevation ponds and lakes in this region.





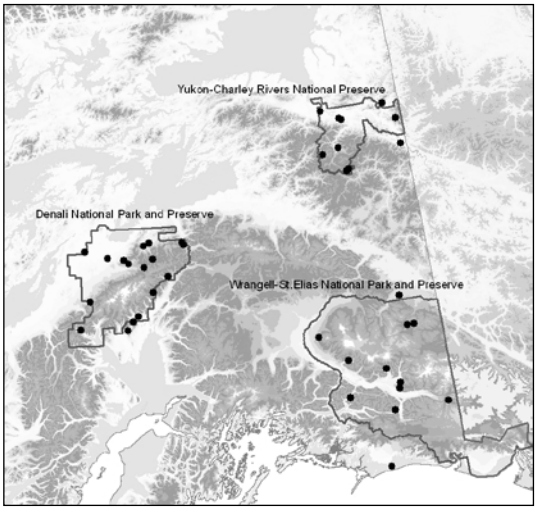
The standardized FWS census data are an invaluable resource for biologists and land managers to document changes in the distribution and abundance of trumpeter swans across their range in many national parks and refuges. The FWS will conduct the statewide trumpeter swan survey in 2010.

Wood Frog Surveys

The wood frog is the only amphibian that occurs (or is expected to occur) in Denali. 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.

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.



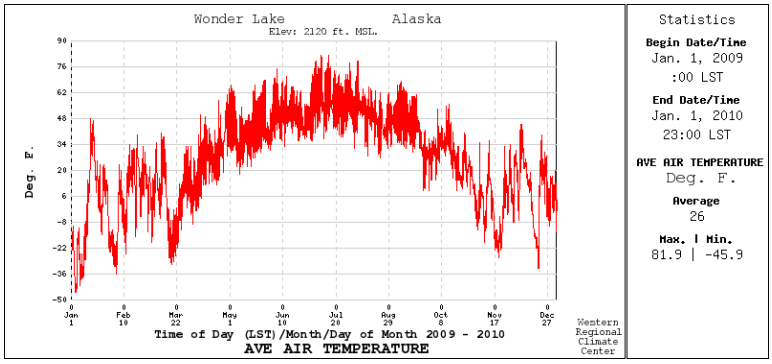
Climate monitoring at Denali is part of the vital signs monitoring of the Central Alaska Network (CAKN), which also includes Wrangell – St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve. The main objective of the climate portion of the CAKN program is to monitor and record 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.

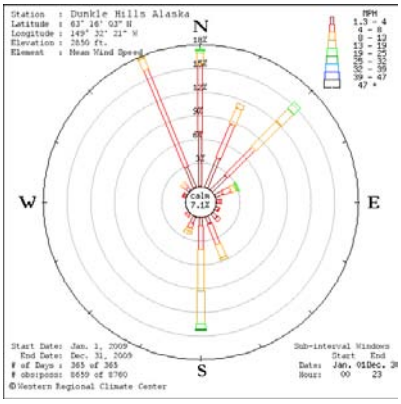
Recent analysis has shown that there are several large scale climate patterns that affect the air temperatures in Denali. The strongest and most consistent of the observed correlations is between annual, and especially winter, temperatures and the two indices related to the atmospheric and oceanic circulations of the North Pacific Ocean: the Pacific Decadal Oscillation (PDO) and the North Pacific Index. Typical winter sea surface temperatures during the warm phase of the PDO are warmer off of the Gulf Coast of Alaska moderating air temperatures over interior Alaska. There seems to be a pattern to this cycle with regime shifts occurring approximately every 20 – 30 years. Temperature trends that have shown climatic warming tend to be strongly biased by a sudden shift in 1976 from the cooler regime to a warmer regime. The PDO remained in a negative phase for 23 consecutive months ending in August of 2009, the longest continuous run since the last negative phase in 1976.

While the north Pacific seems to explain some of the temperature trends in the region, the Arctic Ocean, and, in particular, the extent of sea ice plays a crucial role in the Arctic climate. Reduction of ice extent leads to warming due to increased absorption of solar radiation at the surface. Over the past few years there has been significant reduction in the extent of the summer sea ice cover and the decrease in the amount of relatively older, thicker ice. These are complex processes that have confounding effects, which means that sometimes what is expected to happen doesn't, even if models predict a certain outcome, which is why weather observations in the parks are so important.

Annual data reports are available from the Central Alaska Network website at http://science.nature.nps.gov/im/units/cakn/reportpubs.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:





Eruption of Mt. Redoubt

A notable event in 2009 was the eruption of Mt. Redoubt in south central Alaska. The eruption was characterized by powerful ash explosions with plumes between 30,000 to 60,000 feet (9,000 to 18,000 m) above sea level. There were 11major explosive events during the first week, and a total of 19 events over the two week period in March and early April. Volcanic eruptions have the potential to affect temperatures throughout the region, and while it is difficult to attribute monthly weather variations, it is important to note significant events for future analysis.

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 2009 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, hence the presentation of 2009 data.

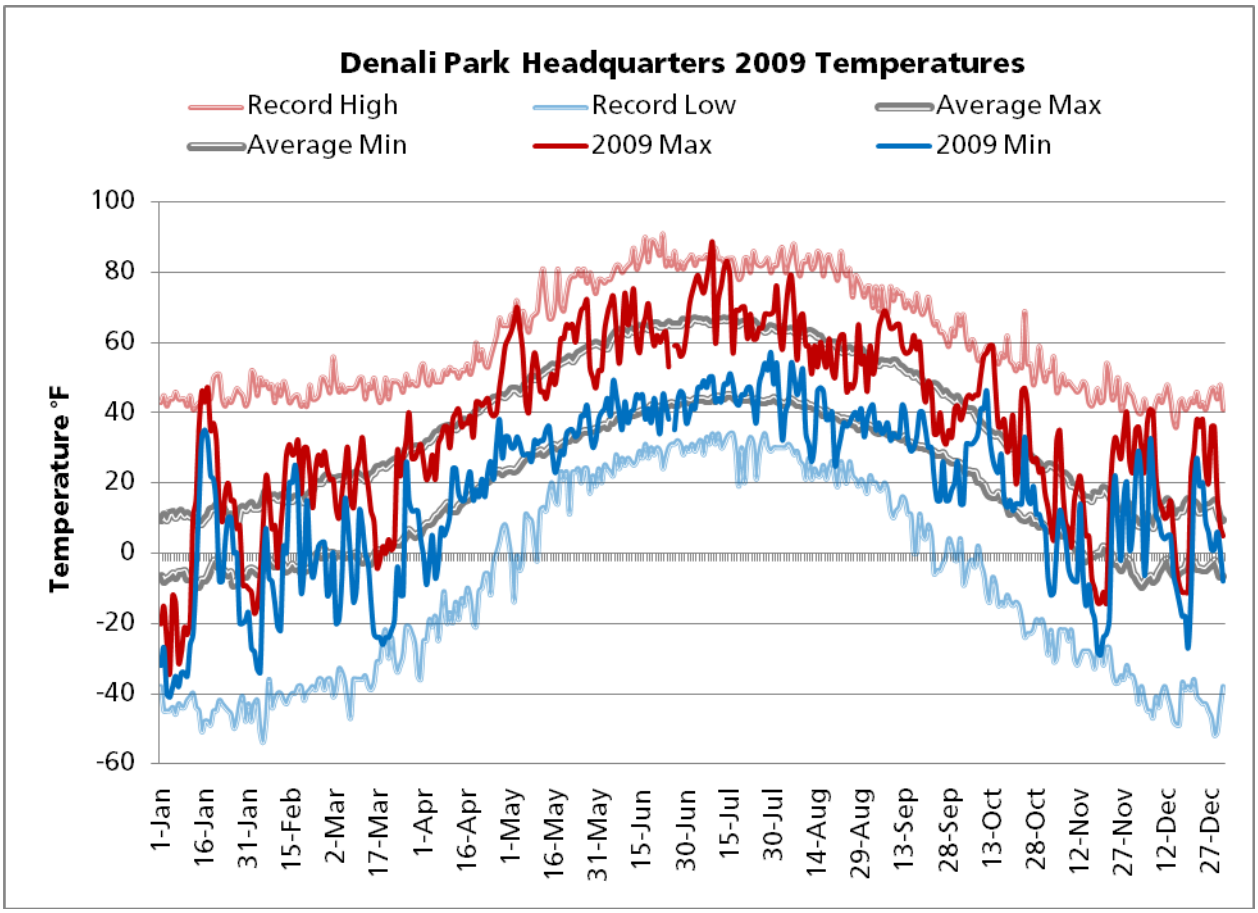
Weather Notes for 2009:

- The mean annual temperature was 0.2° F above the long-term average
- July was
  - the **second warmest July on record**
  - 4.1°F warmer than the 83-year long-term average
  - at or above 70 degrees (as maximum temperature) for 17 days (on average there are 10.3 days in July above 70)
- Record high temperatures were recorded in mid January, late April, mid July and mid October
- Record low temperatures were recorded in mid March, mid August, and mid November
- January, March, and November were quite a bit cooler than normal
- May, July, October and December were much warmer than normal
- Annual precipitation was 3.72 inches below normal
- June and July had 40-50% less rainfall than normal, while August totals were an inch more than normal

Temperature:

- Maximum temperature 88° F on July 9
- Minimum temperature -41°F on January 4
- Mean annual air temperature 27.4°F (just about at the historical average of 27.2°F)

Denali Headquarters **Average Monthly Temperatures** (°F)		
	2009	83-Year Historic Average
January	-2.8	*2.2*
February	5.5	*6.6*
March	6.1	*12.7*
April	26.8	*27.2*
May	44.3	*41.7*
June	52.0	*52.1*
July	59.1	*55.0*
August	48.7	*50.7*
September	41.5	*41.0*
October	30.6	*24.1*
November	4.5	*9.4*
December	12.2	*3.5*
Yearly Average	**27.4**	***27.2***



Precipitation

- Total Precipitation 11.28 inches
- Departure from Normal -3.72 inches
- Max. 24 hr precipitation 1.23 inches on August 31
- Total Snowfall 70.1 inches from July 1 to June 30
- Departure from normal -9.8 inches
- Maximum 24 hr snowfall 4.4 inches on December 17

Denali Headquarters Monthly **Precipitation** (in)		
	2009	Historic Average
January	1.18	*0.73*
February	0.35	*0.58*
March	0.43	*0.43*
April	0.09	*0.44*
May	0.76	*0.79*
June	1.14	*2.18*
July	1.27	*2.99*
August	3.74	*2.72*
September	0.92	*1.58*
October	0.18	*0.96*
November	0.55	*0.76*
December	0.67	*0.82*
Yearly Total	**11.28**	***15.00***

2009 Record-Breaking Weather at Denali Park Headquarters

January 15, 17:	High temperatures of 46° and 47°F, respectively (previous records were 43° and 46° in 1981, 1938)
July 9:	88°F (previous record 85°F in 1927)
March 18, 19:	Low temperatures -26° and -24°F, respectively (previous records were -25° and -22° in 1966, 1973)
August 31:	1.23 inches of rain (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. Information and data are available at: www.denali.gi.alaska.edu

Snow Surveys

In the winter of 2008-2009, 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 2008–2009 season:

At Denali Park Headquarters, the day of the first persistent snow was September 28. The snowpack developed through the early season and for the December 1 survey, sites around the park had near normal to above normal snowpacks. By February, the snowpack in the western portion of the Tanana Basin was slipping below normal. The Denali Park Headquarters site was at 75 percent of normal with 8 inches of snow on the ground. The first measurable snow that persisted on the south side in the Tokositna Valley was on October 7, 2008. The early season measurements for the aerial snow markers in the western part of the Susitna Valley were at or below normal with the Tokositna SNOTEL reporting 35 inches of snow with 5.3 inches of water content for December 1, which is 63 percent of average.

The northwestern areas of the park continued to get some snow throughout the winter. This region had snowpacks that were above normal for the year with snow depths at Lake Minchumina at 27 inches for April, which is 128 percent of normal and 23 inches at Purkeypile or about 110 percent of normal. Minchumina still had 12 inches on the ground for the May 1 survey which is 240 percent of normal. For the eastern areas of the park including park headquarters, the snowpack decreased more rapidly and by the May 1 survey were about 70 to 75 percent of normal.

On the south side of the Alaska Range there was some additional accumulation for January and February, and the March 1 surveys indicated a snowpack near normal for most of the snow markers in the Peters and Dutch Hills area. This pattern persisted into late spring with most of the sites having near normal snowpack for the May 1 survey.

The Kantishna SNOTEL site recorded 7.8 inches of total winter precipitation (snow water equivalent) from October 1, 2008 through May 1, 2009, 42 percent of the total annual precipitation of 18.5 inches. The McKinley Park long-term NWS site was 88 percent of normal for the year with an annual total of 70.1 inches of snow, the average snowfall is 79.9 inches. The precipitation gage at Tokositna Valley recorded 24.3 inches of precipitation from October 1, 2008 through May 1, 2009, which is about 2 inches more than the 1971-2000 normal. This is 55 percent of the total annual precipitation of 44.4 inches for the 2009 water year.

Mount Redoubt, a volcano in south central Alaska, erupted multiple times in March and there was widespread ash cover in the region. Additional snow accumulation quickly covered up the dark-colored ash, and thus the ash did not cause an accelerated melt.

Air Quality Monitoring

2010 marks the 30th anniversary of continuous air quality monitoring in the park at the 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 for "Denali 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 zones above the slump have been relatively stable, with less than a foot of average movement for the entire survey period. The zones on the slump surface show peaks in movement in high precipitation years. The park road sits on relatively stable ground (so far) between the two zones above the slump. 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.

The annual survey of the slump (landslide) at Milepost 45 did not occur in the 2009 field season. A re-survey is slated for summer 2010.

Paleontological Survey of the Lower Cantwell Formation

Dr. Tony Fiorillo of the Museum of Science and Nature, Dallas, along with colleagues Dr. Steve Hasiotis (University of Kansas) and Yoshi Kobayashi (Japan's Hokkaido University Museum) returned again to Denali in 2009.

During their weeks in the park, they expanded searches within the Cantwell Formation both east and west of previous searches. The fruitful sites seem to be located in an east-west zone or broad transect within the Cantwell formation. In 2009, Fiorillo and colleagues "expanded the transect" some 50 km (about 31 miles) in 2009, adding site investigations in areas north of Eielson Visitor Center (west), areas around Fang Mountain (east), and the time-honored Sable Mountain and Tattler Creek localities.

New trackways have been discovered in the north Galen vicinity—these are poorly-preserved theropod and hadrosaur footprints on nearly vertical rock strata. At Fang Mountain, the discovery of fresh water clams has further refined an understanding of the Cretaceous ecosystem, as has the recognition of crayfish burrows at Fang, North Galen, and Tattler Creek. The crayfish finds are the farthest north occurrence of such creatures (even today they are not found north of southern Canada). Additionally, the park staff and seasonal paleontology inventory crew documented 33 new sites including footprints, fossil flora, and other trace fossil material.

Cabin Peak Dino-Footprint Photo Acquisition

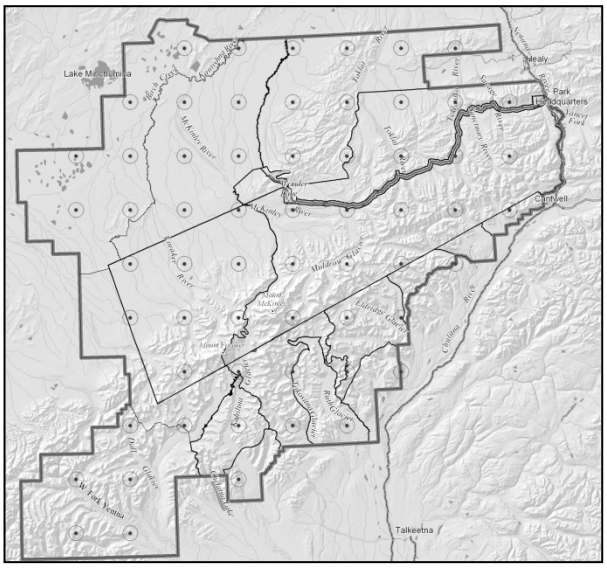
A large surface of rock with fossil tracks at Cabin Peak appears to have been fractured into four large faces of rock known informally as trackway panels. The panels are slightly askew from one another and range from a steep 30-degree angle to nearly vertical. The panel surfaces measure approximately 60-m high x 160-m long (180 feet x 480 feet). In August 2010, a field team of 2-4 people is slated to arrive at the park to obtain photogrammetry of these panels. Field details and methodologies have not been completely worked out, but the team will likely spend at least a week at the site. They may use climbing ropes or set up light aerial scaffolding to approach the very steep surfaces closely in order to acquire detailed 3D-digital images of the panels. The resulting image data files will be at a resolution of both 1 mm (1/25 inch) and 2 cm (< 1 inch), with an even higher resolution (less than 1 mm) for some small areas of the panels.

The digital information will be used for detailed studies of the trackway surface. There is also the potential to use small (report-sized) to large (mural-sized) reproduced images for such outlets as science articles and public displays. The visiting personnel include Neffra Matthews from the Bureau of Land Management, Office of Photogrammetric Applications at the National Science and Technology Center, Denver, Colorado, and Brent Breithaupt of the University of Wyoming Geological Museum. NPS personnel will provide assistance.

Soundscape Inventory and Monitoring Program

A soundscape research program has been underway at Denali since 2001. Natural and human-generated sounds are being systematically inventoried across the entire landscape of the park, including popular backpacking areas, glacial lowlands, high alpine, Mt. McKinley climbing routes, and along the park road. From the 9000+ 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 the percentage of time and the number of times per day that it is audible as well as the calibrated sound level of important events. The sound-level data are used to compare the levels of human-made sounds to the natural ambient levels.

Soundscape staff implemented the fourth season of a revised systematic sampling plan in 2009, deploying five automated sound monitoring stations (see photo) and rotating them among 10 locations. These locations were: 1 winter-season site, 7 Central Alaska Network (CAKN) Inventory & Monitoring grid points, and 2 locations of interest in support of implementing the Backcountry Management Plan. 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).

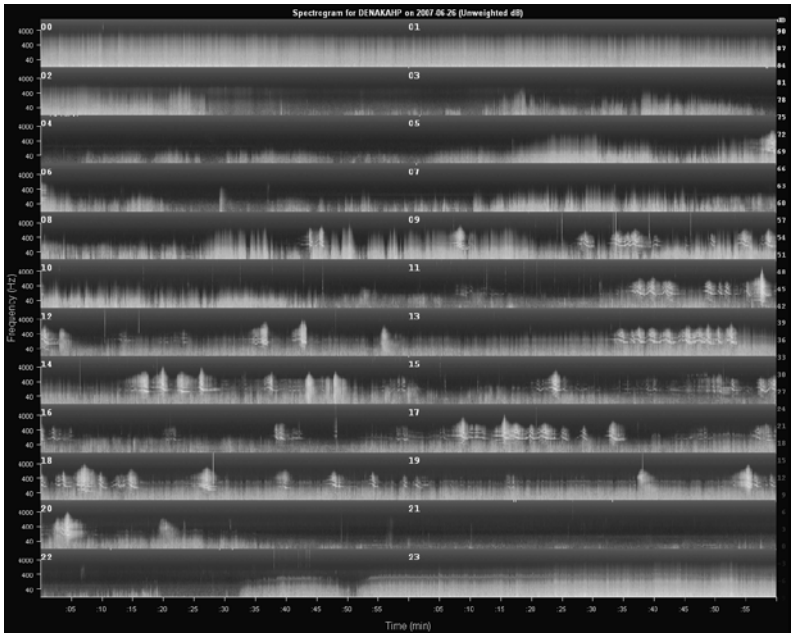


From the acoustic data processed since 2006 (from 32 locations in Denali), wind is the most common natural sound and aircraft overflights are the most common human-generated sound. At some locations, wind can be heard 24 hours a day. At locations with brush or trees, birds can also be heard throughout the day (and "night") during the spring breeding season.

At locations near common flightseeing routes, it is typical 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 converted to a spectrogram of the sound levels recorded (see next page for a spectrogram at Kahiltna Pass on June 26, 2007). A trained technician can identify overflights and classify the type of aircraft (propeller plane, jet plane, or helicopter) by visually examining the spectrogram. The soundscape program is using a newly developed software package to analyze for "acoustic events" (sounds) the percentage of time they are audible, and how loud (maximum sound pressure level) they can be.

In 2010, sound stations will be placed at six more Inventory & Montoring grid points, a location in the Tokositna Valley specifically to monitor noise from snow machine activity, and two points of management interest, which will likely be selected to sample areas of interest to the Denali Aircraft Overflights council. The Overflights council 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. An article outlining this cooperation was published in 2010 (Park Science): http://www.nature.nps.gov/ParkScience/index.cfm?ArticleID=350



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 park user groups including air taxi operators, aviation interest groups, and backcountry and wilderness advocates. In 2009, the Council developed recommendations for revised flight paths that would reduce sound intrusions in certain backcountry zones while maintaining safety, and would help to achieve the standards for soundscapes included in the 2006 Backcountry Management Plan. Also in 2009, the council successfully coordinated a field session to familiarize the committee with what aircraft sound like to listeners on the ground when a range of aircraft fly over at varying altitudes. Flights were arranged so the council members standing on the ground could listen to these aircraft flying overhead at known altitudes. Denali's Soundscape Program has been working intensely to collect and interpret acoustic data that the Council can use to make informed recommendations.

Surging Glaciers

Park Glaciers were monitored in early 2010, and no glaciers in Denali appear to be surging.

Muldrow Glacier Monitoring

The Muldrow last surged in 1956-57. Surges may occur at 50-year intervals, so while another surge might be anticipated within a few years of 2007, as of now, the Muldrow is still a quiescent glacier between surges. Thus, monitoring in the last few years, adds to the base of what a glacier is like in the quiescent phase.

Denali staff has monitored ice elevations and flow rates of the Muldrow Glacier since 1992.

Lost volume. In 2009, researcher Chris Larsen of the University of Alaska Fairbanks provided a preliminary analysis of glacier volume and thickness change between 1950s (topographic map photographs) and 2008 (high-precision elevation models he developed from laser altimetry from aircraft and on-the-ground surveys). The analysis suggests that during this time interval the Muldrow has lost about 4.5 km^3 (~1 cubic mile) of its ice volume, a relatively small amount compared to other glaciers in Alaska.

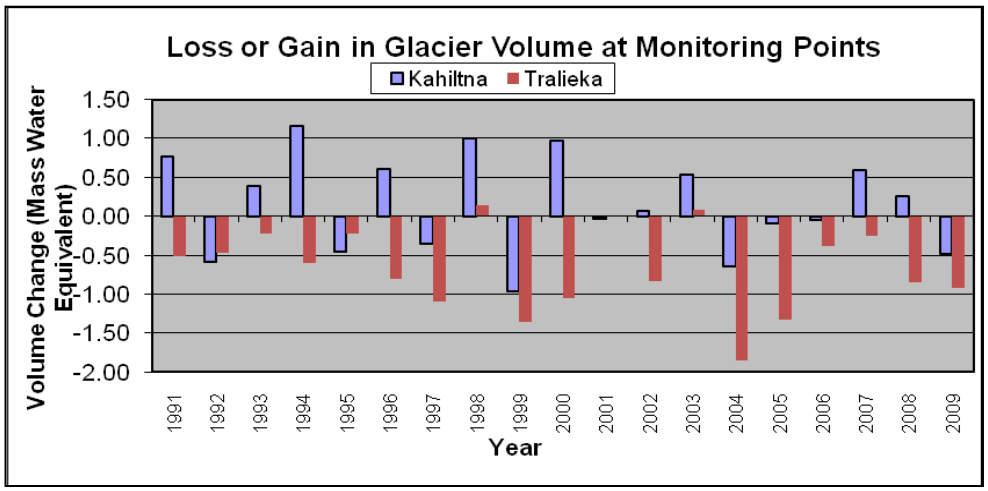
Elevation change of glacier surface. Larsen's preliminary analysis of the elevation change of the Muldrow surface indicates that the greatest change in volume since the 1950s is occurring in the lower elevations of the Muldrow, at less than 2000 m (about 6500 feet) above sea level. The data also show that the glacier is not thickening substantially at higher elevations as is often expected on surge-type glaciers. Larsen's analysis is comparing lidar measurements (2006), laser measurements (2008), and ground measurements (1950s).

To further analyze where the glacier ice volume is changing, during 2010 St. Mary's University of Minnesota will complete a detailed comparative analysis of the current glacier surface with a Bradford Washburn 1970 glacier surface mapping survey (once the Washburn data are digitized).

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.

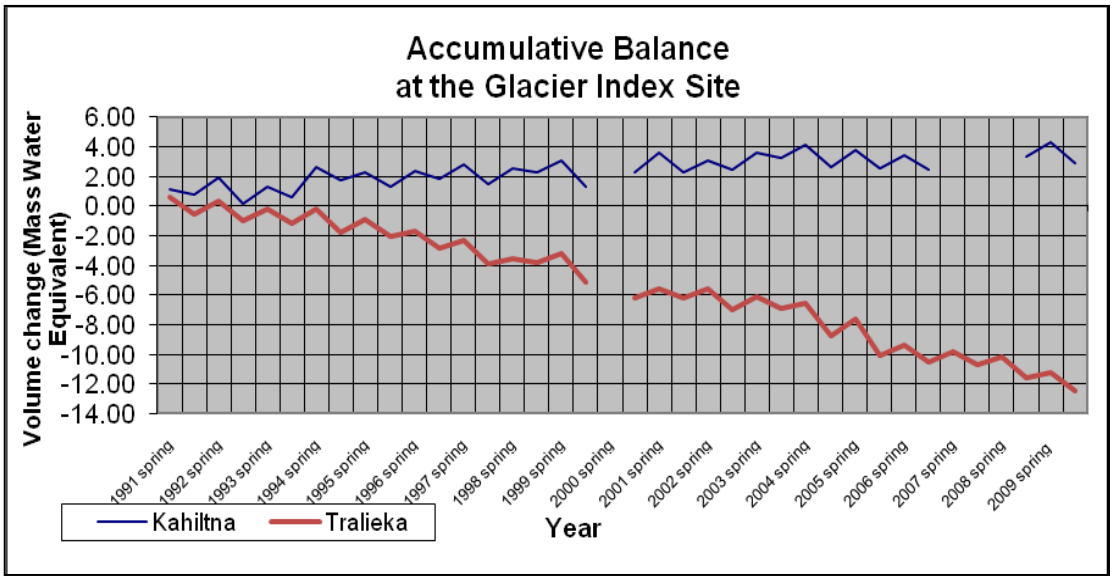
The Kahiltna has been gaining glacial volume (mass water equivalent) while the Tralieka has been losing glacial volume (see graph below for the amount of ice (water equivalent) that the Kahiltna and Tralieka have either gained (above the horizontal zero line) or lost (below the horizontal zero line) since 1991, and the next graph for the cumulative gains or losses over time.



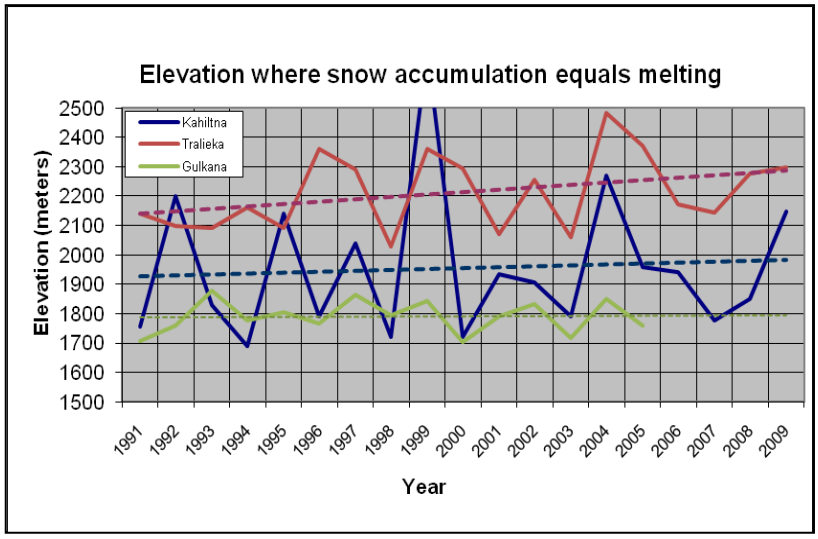
The Kahiltna bars are outlined and are primarily glacier volume gains (above the horizontal), while the Tralieka bars are not outlined and are primarily losses (below the horizontal).

The Kahiltna Glacier has been accumulating glacier volume since 1991 (upper thinner ascending line).

The Tralieka Glacier has been losing volume (lower thicker descending line).



Each year the elevation where snow accumulation equals melting (called the equilibrium line) for these two glaciers has been documented. This graph demonstrates that the equilibrium line for both the Kahiltna and Traleika Glaciers has been increasing in elevation (the upper line is the Tralieka, the middle line is the Kahiltna). The graph also includes an intensively-studied Gulkana Glacier, a USGS Benchmark Glacier. In 2010, Denali staff will arrange in-depth analyses of these trends, to summarize the conditions of these two glaciers at Denali and to put them in perspective with regional trends for glaciers.



Waste Monitoring on the Southeast Fork of Kahiltna. Alaska Pacific University (APU) researcher Dr. Michael Loso and his graduate students are characterizing the glacier flow around Kahiltna Basecamp on the Southeast Fork of the Kahiltna Glacier, in order to assess the potential effects of human waste deposited in crevasses while climbers are on Mt. McKinley. This three-year cooperative agreement is assessing glacier dynamics of human waste and the associated biological risk to backcountry visitors and local watershed, in order to inform mountain waste management practices. In 2009, Loso and students created a preliminary flow map for the base camp area and located a buried latrine using a magnetometer (a magnet was installed in the latrine anticipating the tracking of its movement). In 2010, the APU researchers will characterize the glacier's mass balance and ice dynamics around key waste disposal sites and aircraft landing zones on the Kahiltna and other glaciers, assess the physical and chemical breakdown and fate of human waste in glacial environments and nearby, and review existing published literature and best management practices regarding human waste disposal in remote arctic environments. One sub-product of the investigation will be a compilation of all known research results about the Kahiltna Glacier.

Shallow Lakes Monitoring

In 2006, the CAKN initiated the shallow lakes monitoring project in Denali. To date, Amy Larsen (CAKN aquatic biologist) has studied a total of 128 lakes in the park. In 2006, the crew installed permanent benchmarks on 30 lakes (lakes that will be monitored over time). These 30 lakes were sampled again in 2007, to estimate inter-annual variation. The remaining 99 lakes were inventoried in 2008.

The 30 lakes (for monitoring) were sampled intensively and data were collected on: surface area, physical morphology, water quality, macroinvertebrates, wetland vegetation, and thaw depth. Data will be used to track changes in: lake number and surface area, water quality, macroinvertebrate composition, and plant composition. The remaining lakes (for inventory and lake classification purposes) were sampled less intensively (fewer replicates) and for a reduced suite of parameters. The inventory lake data will be used to evaluate *spatial coherence* and to develop a lake classification for the park.

Preliminary data analysis suggests that lake surface area has decreased significantly in the Eolian Lowlands Subsection of the park. Lake drying in this region is due to sandy soils, limited distribution of permafrost, and a thin layer of organic material. Water levels were significantly more stable in the Minchumina Basin Lowlands Subsection of the park where fine particle silt prevails, permafrost is more dominant, and there is a thick layer of organic material that protects permafrost from degradation.

Amy Larsen began analyzing the entire dataset for Denali in 2009. In 2010, she is continuing the analysis and developing a lake classification system. Lake sampling will resume in Denali in 2013.

Long-term Stream Monitoring

Trey Simmons began collecting data from Denali streams in 2007 as part of the Central Alaska Network (CAKN) long-term stream monitoring program. Through 2009, the program has sampled 25 sites, most along the park road. Nine sites have been sampled in all three years, and another 8 sites have been sampled in 2 of the 3 years. Many of the sites have been sampled annually since 1994, originally as part of the Denali LTEM program. The CAKN program collects a variety of data, including aquatic insects, diatoms, fish, water chemistry, and geomorphology data. Starting in 2008, data loggers that collect continuous water temperature data have been installed in a number of streams along the park road for the summer season. All the data will be measured repeatedly to monitor the status and trends in indicators (e.g., water quality, biodiversity) of whether Denali's streams and river ecosystems are in a healthy condition. Simmons also plans to develop a way to monitor stream channel properties and land cover changes for stream reaches using remotely-sensed imagery.

Aquatic macroinvertebrates. Aquatic macroinvertebrates (mostly insects) are widely used as indicators of stream condition and water quality. Thus aquatic macroinvertebrates are an important focus of the CAKN stream monitoring program in Denali. Simmons has documented 82 macroinvertebrate taxa during the first two years of data collection but expects this number to increase once the 2009 collections have been identified. In 2007 and 2008, Simmons has collected at least 27 aquatic insect taxa not previously reported from Denali, as well as four families of freshwater mollusks not formally documented). In 2007 and 2008, the richness and density of aquatic insects varied tremendously among the sampled streams (e.g., East Fork Toklat River had 3 taxa compared to Moose Creek which had 33 taxa). Density of insects varied from 7 individuals/m^2 (East Fork Toklat River) to over 10,000/m^2 (upper Igloo Creek).

Simmons also plans to develop a tool for assessing the water quality of Denali streams using aquatic macroinvertebrates (biological assessment of water quality).

Diatoms. Prior to the initiation of the CAKN stream monitoring program, little was known about Denali's benthic diatoms (a kind of alga found in the bottom of streams). Benthic diatoms constitute the base of the food chain in most streams. They have also been shown to be sensitive indicators of water quality.

Through 2009, Simmons has documented the presence of 278 diatom species in Denali's streams (total species documented was 127 in 2007, 226 in 2008, and 278 in 2009). Of these, only 62 species (22 percent) were collected in all 3 years. A previously-undescribed diatom species (species new to science) was collected in both 2008 and 2009 from a number of streams. Simmons is following the accepted procedure for getting this species formally described and documented. In general, diatom richness is significantly higher than aquatic insect richness in Alaskan streams; this pattern holds in Denali too. Observed diatom species richness in Denali streams varies from 18 species (East Fork Toklat River) to 78 species (spring stream on McKinley Bar).

Fish. Simmons caught fish in 13 of 21 streams sampled in 2007 and 2008, using a combination of electrofishing, minnow traps, and angling. He conducted electrofishing at a few sites (noted on the list below by #). Because different capture methods are biased toward different species, these results are illustrative rather than definitive of what fish are found in Denali streams. Fish collected by river in 2007 and 2008 (with number captured) are as follows:

Savage River - Arctic grayling (5)
#Sanctuary River - Slimy sculpin (29), Arctic grayling (7)
East Fork Toklat River - Arctic grayling (15)
East Fork Toklat (tributary) - Arctic grayling (17)
Igloo Creek - Arctic grayling (4), slimy sculpin (2)
#Igloo Creek (above Tattler) - Arctic grayling (15), slimy sculpin (3)
#Tattler Creek – Arctic grayling (1), slimy sculpin (2)
Little Stony Creek - Arctic grayling (15)
Moose Creek - Chinook salmon *(3), Arctic grayling (1), slimy sculpin (15)
McKinley Bar (spring) - Arctic grayling (~25**)
McKinley Bar (south creek) - Arctic grayling (~11**)
McKinley Bar (center creek) - Arctic grayling (~10**)
McKinley Bar (north creek) - Arctic grayling (~40**), slimy sculpin (1)
#Lake Creek - lake trout (6), slimy sculpin (40), burbot (1)

* The capture of juvenile Chinook salmon at the Moose Creek site constitutes a substantial expansion of its known range in the drainage (some 40 km upstream of its previously documented extent).

**The high concentrations of juvenile Arctic grayling observed in the spring-fed creeks along the McKinley Bar Trail (the only places in the park we observed large numbers of juveniles) suggests that these sites may be important rearing areas for this species.

Water Quality in Kantishna Streams

USGS researcher Tim Brabets sampled water and biological components as measures of the water-quality at 14 sites on previously-mined streams in the Kantishna Hill (plus one on Rock Creek near Headquarters, to serve as a control) during 2008 and 2009. These data established a baseline of post-mining water-quality conditions.A number of the mined streams (Glen Creek, Eldorado Creek, Eureka Creek, and Friday Creek) drain into Moose Creek, so the Moose Creek site is an "integrator" site because Moose Creek integrates the readings from its tributaries.

A wide range of water quality and biological measures (e.g., pH, suspended sediment, trace elements, and macroinvertebrates) are being collected at each site to provide a complete picture of water quality of these streams. The study will evaluate whether streams show a degraded condition now, and will provide a baseline for comparison following mine reclamation, as it is hoped that reclamation will speed up water quality improvement over time.

Preliminary reesults indicate dissolved oxygen and pH are within a "normal" range at all sampling times and locations. Turbidity (water cloudiness) and suspended sediment concentrations were low for samples collected during average stream flow periods (not flooding), indicating that these streams may have naturally recovered with regard to sediment as new vegetation has gotten established. To monitor the restoration of Glen Creek that took place in 2009, three sites on Glen Creek downstream of the reclamation have been instrumented to continuously record turbidity.

Water samples have been analyzed for 23 trace elements. Most concentrations of these elements are within the "safe" limits of published EPA guidelines for drinking water. However, antimony concentrations in Slate Creek, Eldorado Creek, and Eureka Creek, exceeded the EPA drinking water guideline (6 micrograms per liter). Concentrations of arsenic and lead were elevated at these same sites but did not exceed the drinking water guidelines. Rock Creek and the two Moose Creek sites show the lowest concentrations of these two elements.

Mining in the Kantishna Hills has caused increased metal concentrations in streambed sediments. Streambed sediments have been sampled for 34 trace elements at 14 of the sites. Metals such as arsenic in streambed sediment can be harmful to aquatic life. The probable effect level (PEL) at which arsenic exposure would cause adverse effects to aquatic life is 17.0 milligrams per kilogram dry weight. The concentration of arsenic for Slate Creek was 3,900 milligrams per kilogram (way over PEL) while the Moose Creek and Rock Creek sites were only slightly over the PEL limit.

Macroinvertebrates were collected from riffle habitats for community assessment at seven sites. Stream mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Tricoptera), referred to as "EPT", are taxa that only live in water-quality conditions that are "good". Not surprisingly, the site on Caribou Creek farthest downstream from mining effects, and the Rock Creek control site, had the highest numbers of EPT. The number of taxa (species, genera, or families) known as richness (RICH), as a measure of biological diversity, was also highest at these two sites. The mined sites had lower EPT and RICH (Slate Creek had the lowest).

Post-mining Creek Restoration **NEW FACT SHEET AVAILABLE**

Glen Creek. Work began in late June 2009 on the reclamation of Glen Creek and Moose Creek in the Kantishna Hills vicinity. Glen Creek has been a site of placer mining activity since the early 1900s, and the accumulation of abandoned equipment, as well as a heavily-disturbed floodplain, has represented one of the most impacted and unsightly stream valleys in the park.

The contractors, Environmental Compliance Consultants (ECC) and Oasis Environmental, brought in a D6 dozer, 955 loader, a 160C Deere excavator, a Case backhoe/loader, two 40-ft trailers, two Ford 450 flatbed trucks, and two ATVs to complete the job. Staging took place at Friday Creek Camp, Eureka Creek crossing, and the North Face pull-out areas. The camp and field operations centered out of Glen Creek camp.

Work accomplished on Glen Creek included: 1) removing approximately 50 tons of abandoned mining equipment and supplies (washplants, trailers or Atcos, cabins, miscellaneous generators and medium heavy equipment, a railroad boxcar, and a D6 cat), 2) contouring nine tailing piles (3.1 acres) located on both east and west forks, as well as the main stem of Glen Creek, 3) reconstructing 900 feet of stream channel requiring the installation of 300 linear feet of *gabion baskets and reno mattresses*, and the associated slope reductions, 4) harvesting and planting willow cuttings and transplanting willow or alder plugs, as well as hydro-seeding steep, barren slopes (spraying seed in a stream of water) and hand seeding flatter slopes after harvesting seeds from nearby , and 5) scarification of (breaking up hard pack to accelerate plant growth) portions of the mining camp roads and most of the access road from the Glen-Moose airstrip to the upper Glen mining camp.

Moose Creek. Similar work occurred on Moose Creek at one location where a single tailings pile was reduced, with some material used to reinforce a mucky portion of the access road, and cuttings and plantings were placed on the barren tailings and surrounding area.

Comstock Mine Closure. In 2010, NPS staff will close the adit with a foam plug (allows future re-entry if necessary) and scarify the tailings platform at the adit entry.

Upper Caribou Creek. Post-mining floodplain restoration work will begin this summer on the uppermost and last remaining un-reclaimed portion of Caribou Creek in the Kantishna Hills. Project tasks include the reconstruction of several channels of Caribou Creek, the redistribution of tailings piles, the reinforcement of existing and constructed banks along the course of the stream, and revegetation of barren areas. The work, which should take about one month, is being performed by the same contractor that was on Glen Creek last year, and will involve heavy equipment trips in and out on Skyline Drive.

Slate Creek. Contract preparations have been made for restoration work to be completed at Slate Creek in the Kantishna Hills in 2010. This work involves the transport and redistribution of tailings material, the clean-off and coating of ore faces with an impermeable veneer to arrest acid and chemical leaching and run-off, the reconstruction and reinforcement of stream channels, and the revegetation of the site. The contract is expected to be advertised in spring 2010, and will require about one month to accomplish.

"Downtown" Kantishna. Preparations are also being made for contract work on the old Moose Creek and Taybo claims in the central valley across from the Kantishna Roadhouse. The priority is to remove the remaining mining equipment and camp debris, with some clean-up of possibly contaminated soils. If funded, this project could be completed this field season.

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

The Alaska Region Inventory &Monitoring Program received additional funding in 2010 to better assess changes in response to climate change. Denali staff is working with the Arctic Inventory and Monitoring Network (specifically Gates of the Arctic, and Western Parklands) to develop a comprehensive permafrost monitoring strategy which may meet the needs of all parks and produce a landscape-scale assessment of permafrost change.

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 (gravel extracted every other year) 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 began a comprehensive analysis of the Toklat River system – assessing cumulative impacts on the floodplain from bank reinforcement along the Toklat access road, from the existing bridge lengths and causeway, and from gravel extraction. Using a high-precision topographic map and aerial photography of the Toklat floodplain, changes are being monitored, in order to assess potential impacts. While Hydraulic Mapping and Modeling reported an increase in the difference between highest and lowest elevations of the cross-section of the Toklat in 2008 (a sign that the river might be channelizing), in 2009, the cross-sections were distributed in a manner that indicated that channelization might not be happening.

During 2010, Denali will partner with an academic institution or contractor to evaluate the potential cumulative effects of gravel extraction, Denali road maintenance, bank hardening near the Toklat rest area, and the causeway/bridges on the fluvial geomorphology of the Toklat River.

New Landslide at Sable Pass

While not a resources project per se, the landslide that occurred at Sable Pass last summer is of general interest to many. The landslide is a "block landslide" that has disturbed approximately 0.11 acre (less than 5, 000 sq ft) of tundra surface about a quarter-mile south of the park road. During the second week in June 2009, a fracture line appeared in the tundra on the south side of the road at approximately Mile 40. The landslide "release" occurred during the night of June 12, 2009, when several major blocks of tundra and underlying gravels and sediments slid down slope some 30-40 feet. The traveled as units, remaining relatively intact in arriving at their current resting place.

Additional minor fracturing may continue, and all vertical faces will slowly down waste, ultimately becoming a patch of hummocky terrain. The lower two-thirds of the blocks on the left (facing south) seem to be frozen gravels (permafrost), which will enhance the down waste and erosion process. The stream running along the toe or base of the slide probably contributes to the undermining action as new material is transported out and away, destabilizing the area. Additionally, frozen materials can add water weight to the blocks, and may lubricate a slip plane surface just beneath the blocks.

Geology.

The slide appears to consist of two different materials:

(1) The whitish Suntrana Formation silica-rich sandstones of the Usibelli Group are the less fractured material on the right (facing south) and are 5-20 million years old**. This is** one of types mined for coal in Healy and, where it underlies the glacial/fluvial gravels in the West Sable Pass area, it was also mined for coal in the 1920's (where the drainage empties into the East Fork Toklat River near the East Fork bridge). These sandstones do not retain water well (possibly the reason why the right side materials are not as broken into polygonal blocks with vertical sides as the left side materials). Additionally, these white sandstones are not "weeping" water from the newly exposed surfaces.

(2) The left side materials are more **recent glacial/fluvial** gravels that probably contain fine-grained clay or silts that absorb and hold water much better, and thus display more polygonal block fracturing, and weeping surfaces.

◃ Social Sciences ▹

Hiring Park Social Scientist

Andrew Ackerman was hired as the park's first social scientist in September 2009 and moved to Denali with his family from Moscow, Idaho. In Moscow, he completed a Master of Science from the University of Idaho (in Bioregional Planning and in Conservation Social Science, i.e. how people recreate/use and perceive their environment). His thesis described how land-grant universities and host communities can collaborate to achieve community development outcomes. In 2008, he was a visitor use researcher in Yosemite National Park studying the levels, types, and timing of recreational use. While at the University of Idaho, he also taught a course in public involvement in natural resource management. Prior to graduate school, he was the Assistant Director of Community Development for Moscow.

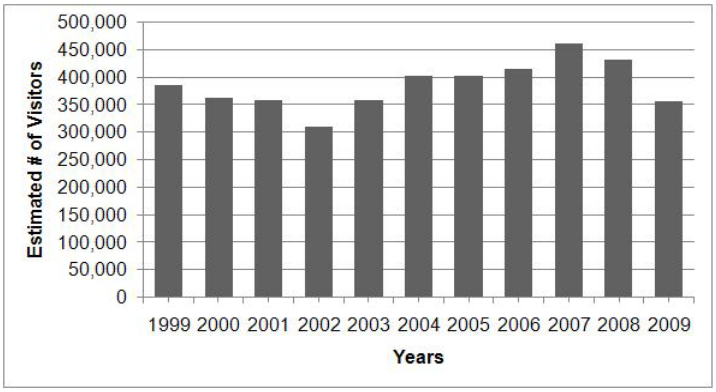
Monthly Public Use Reporting Statistics

Several divisions are involved in collecting data that are plugged into the monthly public use statistics (estimate of visitation during the month). This past year, progress has been made in assessing existing data collection and storage methods across these divisions. In addition, there have been improved communications with the NPS Public Use Statistics Office and improved understanding of how Denali's statistics relate to the bigger picture.

Revisions have been made to the reporting instructions and minor changes have been made to the methodology in order to improve data inputs about visitation and to more accurately account for park use. Andrew Ackerman is pursuing significant changes for improving data collection (e.g., methods use at Savage Checkbox).

Additionally, he is assessing and pilot-testing a variety of visitor data collection tools. For example, a Trafx infrared automated trail counter has been placed on the park road winter gate and there are plans to set up additional non-intrusive counters on trails around headquarters for testing this summer. Staff will observe visitors in the frontcountry this summer (in the entrance area as well as at other locations) in order to better understand visitor use patterns and distributions.

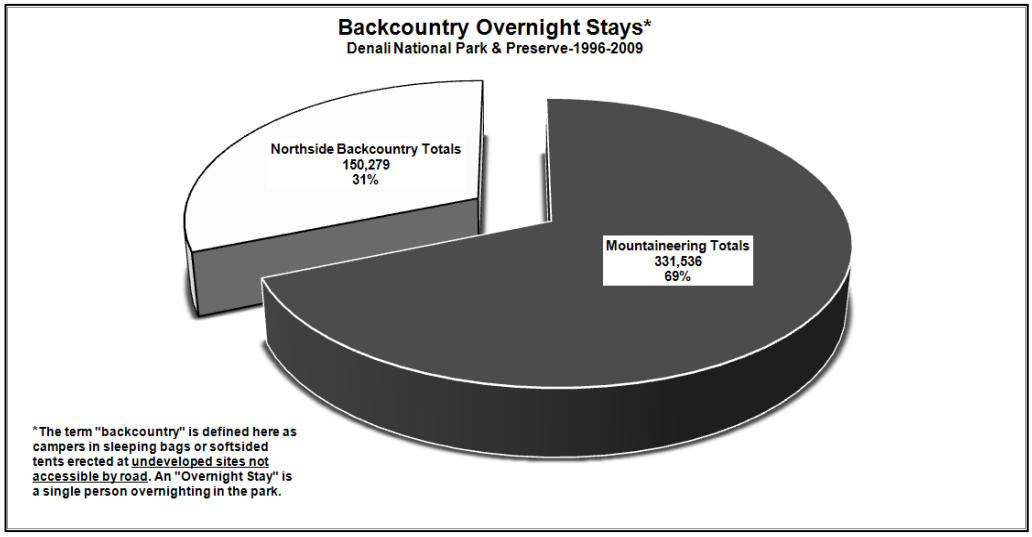
Park visitation in 2009 was down considerably from previous years (see graph), and, at just over 370,000 recreational visitors, is one of the lowest visitation years over the last decade. However, the visitation averaged by decade is still trending upwards, albeit at a slower rate than earlier this decade.



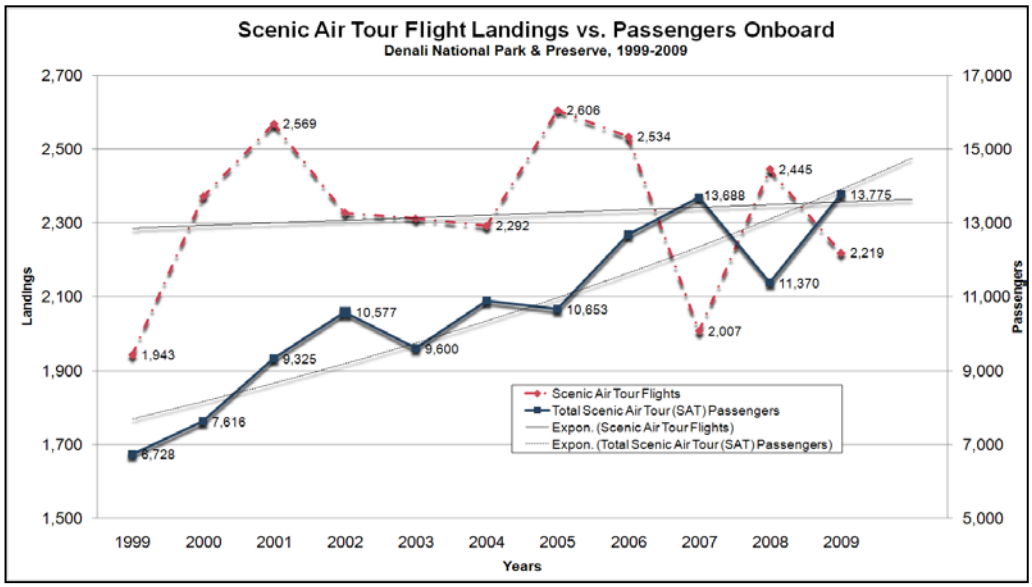
Total number of "recreational visitors" to Denali annually (during 1999-2009), as reported in the Monthly Public Use Report.

Other Visitation Statistics and Trends

An Excel workbook about park visitation (initiated in 2006 by the planning division using data going back to 1996) has been updated through 2009. The workbook includes 56 tabs of data in spread sheets, and charts generated from the data. The tabs (worksheets) include such things as: backcountry overnight stays (see pie chart below), scenic air tour flight landings and passengers aboard (see line graph), flights with landings, McKinley climbers, Alaska Railroad passengers, and bus ridership.



Proportion of Backcountry Overnight Stays by Type (1996-2009).



Trends in Scenic Flight Numbers and Passengers

The entire workbook is available by contacting Andrew_Ackeman@nps.gov (the park's social scientist). [For Denali staff, the workbook is posted at M:\Visitor Statistics on the shared network drive.]

Soundscape Social Norms Study

The park social scientist is collaborating with the park Soundscape Program to develop a proposal to study visitor perceptions of mechanized noise. The goal of the study is to assist park managers with understanding a range of visitors perceptions related to both natural sounds and human-generated sounds, to develop noise preference/sensitivity norms for various user groups, and to refine monitoring efforts, including those set out in the Backcountry Management Plan (2006). Denali was awarded a technical assistance grant from the NPS Natural Sounds Program to assist with the study. The study is planned for 2011-2012.

Economic Impact Model

Denali staff has been working with Dr. Dan Stynes, of the Department of Community, Agriculture, Recreation, and Resource Studies at Michigan State University to study the economic benefits of the park to the local economy and to develop a detailed, Denali-specific model of these impacts (benefits). The model is being refined and a report on the results will likely be out this summer.

Backcountry Hiker Survey

Dr. Peter Fix of University of Alaska-Fairbanks and his research assistant will be conducting a survey of overnight and day hikers in the Denali backcountry this summer (June to August) to better understand day and overnight hiker characteristics, use patterns, and preferences. The Backcountry Management Plan (2006) lists five indicators of resource condition (e.g., litter and human waste) and five indicators of social conditions or visitor experience (e.g., encounters with other groups) and indicates that action to manage visitor use would be taken if the thresholds describe by standards would be exceeded. The survey that Fix will conduct in 2010 is the first time that the park will collect information on whether the types of things that backcountry hikers encounter in the backcountry are within these standards. The park social scientist will play a support role to ensure that sufficient data are collected in such a way that they are valid and can be used to support future management direction.

Visitor Surveys

See pages 5-6 for a description of the social science research that is part of the Denali Park Road Capacity Study.

≺ Subsistence ≻

Denali Subsistence Resource Commission

Subsistence staff held two Subsistence Resource Commission (SRC) meetings. The first SRC meeting was held on November 4, 2009 at the Murie Science and Learning Center. During the meeting, the SRC discussed the upcoming Federal Subsistence Program review, SRC vacancies, and Federal subsistence proposals and upcoming projects.

The spring SRC meeting was held in Lake Minchumina at the Denali West Lodge. Most of Minchumina's entire scattered community attended the Saturday potluck dinner and returned for Sunday's meeting and second potluck. Saturday evening provided time for informal talk of trapping, berry-picking, flying and other local interests. Meeting highlights included: updates on the horns, antlers, bones and plants subsistence use permits; and a review of the three wildlife proposals to the Federal Subsistence Board that address issues related to Denali. The first proposal was to reduce the harvest of wolves in Kantishna (Game Management Unit 13) during August 10 to April 30 from 10 wolves to one wolf, and during November 1 to April 30 to five wolves. The second proposal is to add a hunting season for 25 muskrat for Denali National Park and Preserve between November 1 and June 10. The final proposal was to request an individual customary and traditional use determination for a resident living in Game Management Unit 20A for hunting moose in Game Management Unit13E.

Other Advisory Councils and Board Participation

Amy Craver, Denali's program manager for Cultural Resources and Subsistence, represented Denali at the Eastern Interior and South Central Regional Advisory Council meetings (held in Anchorage and Fairbanks in Spring 2010).

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 managed the Federal Registration Permits for subsistence hunting of moose and caribou on park lands in Wildlife Management Unit 13E near Cantwell, and moose hunts on preserve lands in Unit 16B. A total of 66 caribou permits and 32 moose permits were issued for 13E, and 7 moose permits were issued in Skwentna for 16B. Permit applications were advanced to the Fish and Wildlife Service and permit data was stored in a park database. Park staff updated and revised the Kantishna Hunting Guidelines and ensured that enforcement of regulations were consistent with information given to subsistence users utilizing the park road by the subsistence manager.

Subsistence Projects

Managing Timber Resources in the Windy Creek Area of Denali National Park. Sanders Forestry Consulting (Sanders) based in Sutton, Alaska was contracted by the Alaska Regional Office (ARO), Denali National Park and Preserve to conduct a timber inventory of forest stands within designated ANILCA additions to the park in the Windy Creek Area.

The Windy Creek Inventory Area was divided into three sub-units:

Area "A" Windy Creek	-	T17S, R8W, Sections 23, 24, 26
Area "B" Summit	-	T18S, R8W, Section 3 and north half Section 2
Area "C" Pyramid	-	T18S, R8W, Sections 13, 22, 23, 24

Denali managers will use the results from this inventory to develop a forest management program for subsistence use of timber products in the Windy Creek Area. The project deliverables include a timber cruise report of a statistically-based field timber cruise and the associated GIS maps and data files.

Monitoring Subsistence Fisheries in Northwest Denali. The goal of this two-year project is to generate data for fish distribution and abundance, beaver dam density, and regional lake surface area dynamics. To date no monitoring programs have been initiated to examine status and trends in beaver activity or lake surface area dynamics in the northwest portion of Denali National Park and Preserve. The objectives of this project are to fill these data gaps using a combination of traditional ecological knowledge, aerial surveys, remote sensing, and fish sampling. The objectives for 2009 fiscal year were partially accomplished. Gillnet fish sampling will be delayed to 2010 to staffing issues and a delay in receiving a fish sampling permit from the state.

In July 2009, Denali staff flew to Nikolai to visit a family fish camp along the Blackwater River to collect traditional ecological knowledge about historical fish locations and populations from local subsistence fishers and to interview an extended family about their subsistence fishing activities for a video. The subsistence fish monitoring and video project was introduced to the community during a community wide NPS-sponsored picnic in Nikolai (attended by 76 adults and children).

Initial outcomes include eight video-taped traditional ecological interviews with local residents identifying spatial and temporal trends in subsistence fish harvesting, beaver activity in fish bearing lakes, and extensive aerial photographs of eight lakes. Future work will include examining Mosaics and identifying beaver dams and then rectifying current aerial photos to recent satellite imagery (already collected by USGS) to see if the same features can be identified. The next phase will be to compare these satellite images to older images (1980's) and try to quantify both lake surface area change and changes in beaver dam density.

Documenting Traplines and Associated Activities. In 2009, Denali received funding from NRAC to provide data to inform trapline management plans for Denali National Park and Preserve. The objectives for 2009 were to conduct mapping and ethnographic fieldwork at Denali National Park and Preserve. Initial outcomes include: a GIS map inventorying the historic traplines trails, information on the species trapped and approximate numbers of animals harvested, and data based on associated trapline activities derived from interviews and archival research. In February 2009, park staff organized a potluck/community meeting in Lake Minchumina to introduce the Trapline project and to get community feedback on project methods. The meeting was well attended by local trappers who gave input into the project design.
In winter 2009-2010, the subsistence manager traveled to Michumina and spent time with Miki and Julie Collins documenting associated trapline activities. The result of this project will be a report that will inform a trapline management plan for Denali.

Diversity Outreach**.** Subsistence staff worked to bring together Alaskan urban youth and Ken Burn's America's Best Idea. Staff participated and assisted with an orientation in Anchorage for urban youth (Cook Inlet Tribal Youth) prior to bringing a group of youth to the MSLC Field Camp. Subsistence staff worked with MSLC staff to recruit and hire two elders from Minto (a couple) to come to the camp to talk with urban students about their traditional values and subsistence lifestyle. The group also learned about archeology at Teklanika from the park's archeologist.

◂ Cultural Resources ▸

Archeology Survey

A four-year archeology survey project concluded in 2009. A crew of four archeologists spent the month of June in the backcountry near the Swift Fork of the Kuskokwim surveying and testing one prehistoric site. Condition assessments on 23 previously recorded sites were completed on sites near the park road. A final report by Brian Wygal is being peer reviewed. This project concluded with more than 16,000 acres of the park receiving intensive archeological survey, resulting in the documentation of 30 previously unrecorded sites.

Investigation at Teklanika West Archeological Site

Archeologists from the University of Alaska Fairbanks (Dr. Ben Potter, graduate student Sam Coffman, other graduate students, and 14 volunteers) re-investigated the Teklanika West archeological site in the summer of 2009. This project was conducted in order to determine the extent, age, and cultural activities at the site in order to update the National Register of Historic Places nomination (for the Teklanika Archeological District), and to develop a long-term management plan for the District. The project was funded through a CESU agreement (Potter) and an MSLC fellowship (Coffman). The project was also incorporated into the NPS Alaska Region Archeology Mentorship Program organized by archeologist Becky Saleeby of the Alaska Regional Office. Through the regional office involvement, three students participated in the excavation, including two Alaska Native high school students from Anchorage and one high school student from Russia.

Several presentations in 2009 shared information about Teklanika West (Brian Wygal, Sam Coffman, and Jeremy Karchut (Denali's former archeologist). Jeremy also spoke about Teklanika at the 17th annual Arctic Conference at the Institute of Arctic and Alpine Research (INSTAAR) in Boulder, Colorado.

Additional public outreach involving the park's archeology program included presentations and a walking tour of the Teklanika West archeological site in July. The audience included a group of Alaska Native high school students from Anchorage. In addition, a film crew with the National Geographic Channel filmed at DENA during two archeology fieldwork projects for a television show entitled "Surviving Prehistoric Alaska" that was aired on January 28, 2010.

Ice Patch Archeology **NEW FACT SHEET**

An archeological survey of alpine ice-patches was conducted in mid August by then archeologist Jeremy Karchut, Dr. Craig Lee (University of Colorado INSTAAR), and Jim Dixon of the University of New Mexico. Ice patches have exposed prehistoric artifacts and other organic material in many places in Alaska, Yukon, and North America. Researchers did not locate any artifacts in Denali's survey of six ice-patch locations. More sites could be accessed due to inclement weather (low cloud ceiling). This survey did establish baseline data involving current ice-patch locations, size, and associated faunal remains. Additional ice-patch surveys will be considered in the future if funding allows. Lee gave two presentations on this research including at the 9th Biennial Rocky Mountain Anthropological Conference in Gunnison, Colorado.

National Historic Preservation Act (NHPA) Compliance NEW FACT SHEET

Denali's Archeology Program is responsible for National Historic Preservation Act compliance (including Section 106 and Section 110). A GS-5 archeological technician (Sam Coffman) and a total of twenty volunteers assisted the park in fulfilling its compliance obligations, including completing Section 106 on more than 50 projects.

A *Determination of Eligibility* for the Denali Park Road was completed in 2009. The Park Road has been officially determined eligible for listing on the National Register of Historic Places. The Alaska State Historic Preservation Officer concurred with this determination.

Finally, the Kantishna Cultural Landscape Report is in progress. This project involves a contract with the Olmsted Group for Historic Preservation, Boston. In fiscal year 2009, one Olmsted representative traveled to the National Archives for research on this project. The group has scheduled a final visit to Denali in August 2010, and is scheduled to complete the final Cultural Landscape Report next year.

Historical Research and Historical Outreach

Cultural staff facilitated the collection of historic photographs, documents, and data from private sources. One previously unknown historic structure was investigated and documented. Specific information and history programs were provided to other park divisions, the MSLC and other groups.

Cultural staff continues to research and draft 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 NEW FACT SHEET

Denali's Museum Curator fulfilled the objectives for the second year of the Museum Standards project including oversight for (1) a Collections Survey and Assessment of Paper Material by a paper conservator, and (2) a review of all archival holdings, and research for a Museum Collections Emergency Operations Plan to outline the special needs of museum objects and records in all emergency situations. The curator also used flexible park base funding to purchase archival-quality supplies to appropriately re-house all collections, insuring that preservation standards are met, and to purchase museum-dedicated hard drive space and backup on the park's computer server. Finally, the curator completely reorganized the collections vault after the installation of new museum storage cabinets and 4-post shelf units. These additional storage cabinets and units have increased storage of natural history and cultural specimens/objects by 40% and archival storage by 300%. Museum Curator, Jane Lakeman, departed Denali in March to take a position in the Alaska Regional Office, and a new museum curator is being hired.

◂ 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, including preparing maps for planning, public displays, drawings for construction, mining site rehabilitation, and design work. 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.

The park's GIS dataset involves an on-going project begun in 2005 to collect high-resolution (1 meter) satellite imagery of the park. It is hoped that eventually the entire park will be collected as clear (cloudless) 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 2009 and early 2010. Additional fact sheets will be developed in 2010 and future years. These fact sheets are also available at http://www.nps.gov/dena/naturescience/factsheets.htm

- Air Quality Monitoring
- Beavers Across Denali's Hydrologic Landscape Central Alaska Network: Inventory & Monitoring Program
- Central Alaska Network Inventory and Monitoring Program
- Climate Change
- Climate-related Vegetation Changes
- Dinosaur Track Found in Denali
- Ecology of Upwelling Areas in the Toklat River
- Ice Patch Archeology NEW
- Implementing Denali's Resource Stewardship Strategy: achieving desired conditions for park resources NEW
- An Integrated Study of Park Road Capacity –2006, 2007, 2008 NEW update for 2010
- Large Lakes and Landscape Limnology
- Large Mammals…How many are there? (annual update NEW)
- Long-term Monitoring after Restoration of Kantishna's Placer-Mined Streams NEW
- Moose Surveys
- Museum Collections: Preserving Denali's Stories NEW
- Natural Resource Condition Assessment NEW
- Painted Fossil Bison Skull: When, how, and why was it painted?
- Paleoecology of Denali's Dinosaurs
- Permafrost Landscapes
- Permafrost Thaw and Carbon Balance NEW
- Population Biology of the Wood Frog
- Preservation of Cultural Resources NEW
- Reconstructing Ecosystems of the Lower Cantwell: Plants in the Age of Dinosaurs
- Resource Stewardship Strategy NEW
- Restoration of Mined Lands in Kantishna NEW
- 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
- Surveying Dall's Sheep Populations
- Treeline Shifts in Denali: Influences of Climate Change and Local Site Conditions
- Understanding Park Visitor Characteristics NEW
- Wildland Fire Risk and Response: Why are you cutting those trees?
- Wolf Monitoring 1986 – 2009

Research Administration

As of April 10, 2010, 809 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 2009

The following researchers (non-Denali staff) held research permits in 2009. 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 also reported on page 26-29. We tentatively estimated herd size in late September 2009 at 2,070 caribou with little noticeable change over the last 6 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. We estimated a natality rate of 73% for cows ≥ 1 year old in mid-May 2009. Natality rates have averaged 77% over the 22 years of the study. During October 2008 – September 2009, 8 radiocollared females from the age-structured sampled died for an annual mortality rate of 8.9%. Changes in the female age structure in May 2009 were primarily due to recruitment of the 2008 cohort. However, the proportion of old cows (≥ 13 years old) in the population continues to be relatively high.During the 2 years we have been evaluating bull survival (September 2007 – September 2009), we have monitored 57 individuals (45 and 12 collared in September 2007 and 2008, respectively). Of those, 17 have died with most deaths occurring during August-November, compared to females that die predominantly late in the winter. The annual survival rate for adult bulls to date was 0.73, substantially lower than the long term average estimated for adult females (0.92). We have weighed 63 of 72 adult bulls captured in September 2007, 2008, and 2009 recording masses ranging from 99.5 kg to 264.1 kg. Body masses increased markedly with age from 1 to 5 years of age, gaining an average of 29 kg each year, and plateaued at full adult size for bulls ≥ 5 years old. The bull size classes we employ for composition surveys (S, M, L) differ significantly by body mass with mean masses of 120 kg, 160 kg, and 226 kg, respectively. These size classes include individuals of 1-3 (median = 1), 1-5 (median = 3), and 4-10 (median = 6) years of age, respectively.		
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 2009 for trace elements in bed sediment, major ions, and dissolved trace elements. Seven sites were sampled for macroinvertebrates and algae. (See also page 51.) Preliminary analysis of water quality data indicate that concentrations of most trace elements in water are less than published EPA guidelines for drinking water. However, antimony concentrations in Slate Creek, Eldorado Creek, and Eureka Creek exceeded the EPA drinking water guideline of 6 micrograms per liter. Mining in the Kantishna Hills has caused increased metal concentrations in streambed sediments. Concentrations of arsenic at 11 sites have exceeded a probable effect level (PEL) at which arsenic exposure would cause adverse effects to aquatic life. Macroinvertebrates have been collected from riffle habitats for community asessment at seven sites. A site on Caribou Creek farthest downstream from mining effects and Rock Creek (a control site), had the highest numbet of mayflies, stoneflies, and caddisflies, which indicates good water quality conditions while mined sites such as Slate Creek showed the lowest number of these taxa. Similarly, the sites on Caribou Creek and Rock Creek had the highest number of individual taxa while Slate Creek had lower numbers of individual taxa. In-situ turbidity meters were installed at 6 locations in 2009. Preliminary analysis of the turbidity data indicate high values only during rainfall events at Rock Creek (the control site), and other sites that have beeen mined.		

Researcher	Affiliation	Project
Chestnut	Washington State University	Distribution and prevalence of the amphibian chytrid fungus
Sampling occurred in the Wonder Lake vicinity between June 20 and June 26. Wood frogs were detected at 14 of 17 ponds where they were previously known to occur. The most common life stage encountered was larvae. One hundred sixty-six samples were collected from wood frogs and 27 water samples were collected from nine ponds. Samples are being tested for Bd DNA using molecular techniques.		
Concienne	University of Colorado at Boulder	Microbial succession in soils at retreating glaciers
Soils, including carbon, organic matter, N, and plants, were studied at various distances from the retreating Middle Fork Glacier (a chronosequence where distance from glacier is a proxy for soil age--from younger (nearer) to older (further away)). Microbial biomass carbon (MC) was measured in soils collected in June 2009. In 2009 MC remained relatively constant for the first 700m (0-50yrs exposed), averaging 94Î¼gC/g ds and then beyond 2000m (>100yrs exposed) MC increased significantly (p=0.05) with distance averaging 124 Î¼gC/g ds, with the highest levels (49-1122 Î¼gC/g ds) found in the region of the end moraine (>100 years exposed). These results indicate that the Middle Fork is different from other locations which have similar abiotic factors. The change in MC along the chronosequence does however support the occurrence of primary succession and further suggests that something other than abiotic factors could be affecting community assembly in the proglacial zone of the MTG. Total plants increased significantly ($p<0.01$) along the chronosequence (2008 and 2009 data). The first colonizers were *Epilobium latifolium* and *Saxifraga oppositifolia*. *Dryas octopetala* and *Astragalus* sp., plants with N-fixing symbionts, were not found until beyond 1100m (>50 years exposed) and 2800m (>100yrs exposed) respectively. Plant cover remainedsparse until soils were exposed for >100 years, with 0 plants recorded in the first 800m, an average of 5 pl/m2 recorded from 800m to 2800m (50-100 years exposed), and an average of 52 pl/m2 recorded from 2800m-3000m. Water holding capacity also increased significantly ($p<0.01$) with distance along the chronosequence.		
Densmore	USGS-Alaska Science Center	Long-term monitoring of restoration of placer-mined watersheds in Denali
Monitoring 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. 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. Findings were published in journal and as a Denali fact sheet.		
English	Alaska Pacific University	“Understanding movement dynamics of the Southeast Fork of the Kahiltna Glacier
The primary objective of this year's study—relocating the 2002/2003 latrine pits—was unsuccessful. Extensive searching for the magnets buried in the latrines revealed high background magnetism (due probably to the granitic rocks in the Southeast Fork) but no clear signal of the buried magnets. Our hypothesis, at the conclusion of the summer fieldwork, was that the signal of the deeply buried magnets was too weak to be detected over the high background noise. Other elements of the study were successful, however, and these will prove useful in coming years. Among these elements was the goal of establishing and monitoring ten new velocity stakes on the Southeast Fork. These "stakes" (really just PVC poles) were arrayed transverse to the glacier flowline in two lines of 5 stakes each. One line was upstream of the airstrip and the other downstream. Velocities on these stakes ranged from 0.194 meters per day to 0.306 meters per day. More importantly, these stakes improved our understanding of the variability of glacier flow direction from place to place on the Southeast Fork. Trajectories ranged from 213-276° WSW, and in our final analysis of the data provided good evidence for the TRUE reason we didn't find the magnet/latrine.		

Researcher	Affiliation	Project
English (cont'd)		
Our best guess at where to search for the magnets in 2009 was based on an extrapolation of the known velocity and trajectory of ice at the latrine site. But the results of the velocity work show clearly (as will be demonstrated in figures to be submitted shortly for inclusion in a park fact sheet) that the ice bends southward (downstream) well before contacting the main fork of the Kahiltna. Thus the latrine pit's trajectory as it traveled with the ice between 2002 and the present would have thus taken it far to the south of where we were searching. On the basis of this useful result, we will be hunting for the magnets again in the summer of 2010. In addition, a snowpit dug at base camp was used to establish an accumulation value for the previous winter (2008-2009) of 250 cm snow, 101.7 cm weq).		
Fiorillo	Dallas Museum of Natural History	Paleontological survey of the lower Cantwell Formation, Denali National Park and Preserve
Field investigations documented dozens of new fossil localities in the Cantwell Formation. The findings of this reporting year, in combination with discoveries of recent years have highlighted the complexity of the remarkable ancient ecosystem recorded within the Cantwell Formation of Denali National Park. The known distribution of vertebrate and invertebrate trace fossils, and fossil plants in Denali now extends from the Fang Mountain area to the area just north of Mount Galen. In addition to previously reported trace fossils, crayfish burrows are now recognized in the park. The occurrence of these paleotemperature indicators is consistent with previous qualitative estimates of mean annual temperatures during the deposition of the Cantwell Formation. Mean annual temperature for Denali National Park during the latest Cretaceous was likely similar to that of southernmost Canada. Additional invertebrate trace fossils recognized during surveys this year are attributed to unionid clams. The presence of these trace fossils in some channel deposits indicates that at least some paleorivers ran with clear water. A pterosaur track was recently reported from the Cantwell Formation in Denali (Fiorillo et al., 2009. A pterosaur manus track from Denali National Park, Alaska Range, Alaska, USA. PALAIOS, 24:466-472). An additional track was found in the Tattler Creek drainage in 2009. In addition to the tracks of fishes, pterosaurs, saurischian, and ornithischian dinosaurs, the Cantwell Formation also contains a great diversity in fossil bird tracks. This diversity is one of the greatest that can be observed anywhere in the world, second only perhaps to the fossil bird track record of South Korea. Several types of tracks can be attributed to previously recognized ichnotaxa. But study of the Denali tracks has revealed the presence of perhaps two distinct types of fossil bird tracks as well. Public lectures reporting on this work were provided to the Murie Science and Learning Center and at the Denali Education Center.		
Freymueller	University of Alaska Fairbanks	Repeated Global Positioning System (GPS) and absolute gravity measurements to measure active crustal deformation in southern Alaska
In 2009, we repeated surveys of the seven survey marks along the Denali Park Road. I made one trip by car along the road on June 16 to set up the sites, and a second trip to pick them up on June 20. Both trips went smoothly, with no serious problems, and enough data was recorded at all of the sites (cable failures caused by small, chewing animals have been a problem in several other years, but not this time). In addition to the fieldwork, I also gave a lecture at the Murie Science and Learning Center, which was timed to coincide with my setup trip. There was a good audience that seemed to be engaged and asked a lot of questions.		

Researcher	Affiliation	Project
Freymueller (cont'd)		

Findings to Date:
Because the post-earthquake measurements combine a steady long-term signal with a short-term, transient response to the earthquake, one of the key questions we face is how to separate these two. Comparison of the post-earthquake series of measurements of sites in the park and along the Parks Highway to the pre-earthquake series suggests that the 2005- 2009 measurements are consistent with the pre-earthquake trend in the north-south component, but they move faster to the west than before the earthquake. Thus a transient component related to the post-seismic deformation following the earthquake remains. More time will be needed to untangle this signal from the strain associated with the Denali fault. However, with the addition of the 2009 survey we are now able to draw some tentative conclusions about the observed motions.

The site at Wonder Lake (WOND) has always displayed a southward motion relative to North America that has been hard to explain. This southward motion continues through 2009, at an apparently steady rate. However, the site A127 to the southeast of Wonder Lake and the UNAVCO site WIKR to the north both show much slower southward motion. This makes it seem likely that the Wonder Lake site has an anomalous and localized southward motion, cause unknown but most likely not representative of the regional tectonics. In the north-south component, the remaining sites show a gradual change from velocities oriented slightly to the northward at the Parks Highway to slightly southward at the Kantishna/Wonder Lake area. This gradual change is easier to explain and is most likely a consequence of postseismic deformation from the 1964 earthquake. The east-west component appears to continue to be dominated by postseismic deformation following the 2002 earthquake, and these data are being analyzed along with a broader set of data from around southern Alaska.

It also appears that the site B124 may have shifted by ~10 mm between the 2007 and 2008 surveys. The site is located on a large boulder, and a shift of the boulder could explain this. With the upcoming 2010 survey we should have enough data to confirm this hypothesis, and we could then correct for the shift.

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

This research began in 1966 and focused on groups rather than populations.
Gordon Haber was killed in a plane crash in the park on October 14, 2009.
The last report for this research, covering biological years 2007 and 2008, i.e., May 2007 - April 2008 and May 2008 - April 2009 was provided to the park in May 2009. Go to www.alaskawolves.org for this report, previous annual reports and other reports (see Reports and Reports2 pages) as well as photos and commentary from field observations (Blog section).

Researcher	Affiliation	Project
Haeussler	USGS Alaska Science Center	Behavior of the Denali Fault, Central Alaska Range

The primary goal of this research is to construct a model of how the Denali fault works in time and in space. We are trying to understand how often large earthquakes occur, whether or not distinct sections of the fault break repeatedly in earthquakes of the same size, if earthquake recurrence intervals are generally periodic or variable, and when the most recent earthquake occurred on the sections of the fault that did not rupture in 2002. In 2009, geomorphic features that cross the Denali fault, and are offset by the fault, were identified just west of the park boundary. Samples were collected for cosmogenic isotopic dating, and sample preparation is underway. This work should constrain the Denali fault slip rate for the western part of the park.

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 four seismic stations, three telemetry sites.
From west to east, the seismic stations are: “CAST” at Castle Rocks (63 N 25.16, 152 W 4.92) (since 2006); “KTH” located on top of Wickersham Dome near Kantishna (63 N 33.19; 150 W 55.26) (since 1988); "TRF" on top of Thorofare Mountain (63 N 27.06; 150 W 17.24)(since 1988); and "MCK", located near the entrance of the park (63 N 43.94; 148 W 56.10) (since 1964, upgraded in 1998). 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 Alaska Earthquake Information Center. 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.

On April 6, we upgraded the seismometer and digitizer at MCK and the telemetry at the Murie Science Learning Center in order to receive the MCK data.
On April 22, we restored the telemetry at KTH and installed a strong motion sensor at CAST.
On July 27, we upgraded the seismometer and digitizer at KTH.
August 26, we re-leveled the seismometer at CAST.

Future plans:
In 2010, we will remove remaining analog equipment at TRF and replace the seismometer at CAST.
In the future, we hope to add a seismometer at Double Mountain. This would be necessary to obtain a better resolution on the source of the 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.

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.

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. During the 2009 climbing season, routine maintenance work was done on the weather station. Older equipment broken from previous years were brought down off of the mountain, and new thermisters and anemometers were placed on the weather station. The transmission system is currently not in operational condition and data from the sensors are being stored in a data logger on site. The data logger will be retrieved during the next climbing season in 2010.

Researcher	Affiliation	Project
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 is located at Tokosha COMMS facility. WICK was accessed on April 20 and 22 by helicopter. AC33 was accessed on Sept 16 by helicopter.		
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). For the 2009-2010 freeze-up/break-up season, the Alaska Lake Ice and Snow Observatory Network (ALISON) study site on Horseshoe Lake was set up inDecember. Dorothy DeBlauw's grades 4-5 class (about 19 students) at Tri-Valley School (Healy, AK) made 4 trips (December 11, 2009 January 25, February 26, and April 1, 2010). During each trip, they made scientific measurements along a 100m transect that was established on the lake once the ice was safe to walk on: 21 snow depth measurements and snow bottom (ice surface) temperatures (taken at 5m intervals along the transect); 3 bulk snow samples (for determination of snow density in the classroom); 2 snow surface temperatures at the beginning and end of the transect; and 1 ice thickness measurement at the thermal wire ice thickness gauge (TWIT). The snow depth, density and temperatures were used to calculate the heat fluxes from the lake water, through the ice, to the atmosphere. This data set is the most recent addition to what is now a 7 year time series. The Tri-Valley School data set at Horseshoe Lake is one of the longest in the ALISON project. 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. Data can be downloaded from http://www.gi.alaska.edu/alison/ALISON_data.html.		
Johnson	U.S. Fish and Wildlife Service	Assessing migratory movements of short-eared owls nesting in Alaska
No activity was conducted in Denali this report year.		

Researcher	Affiliation	Project
Kedrowski	Texas State University	Climber's perceptions on Denali: crowding concerns, hazards…

310 surveys were distributed at Kahiltna Basecamp to climbers attempting the West Buttress, or routes on the southwest side of McKinley (i.e. West Rib). 97 surveys were returned (31.3% return rate), 25 surveys were returned blank (one survey was thrown out for lack of congruency between skill level and actual climbing experiences). 72 surveys (23.2% response rate) were completed, 66 male (91.6%), 6 female (8.3%), average age 37.3 years. The oldest climber was 64 years, the youngest 22 years.

Climbing *experience* was self rated by climbers (n = 72) into 4 categories: beginner (n = 4, 5.6%), novice (n = 30, 41.7%), intermediate (n = 24, 33.3%), advanced (n = 14, 19.4%). Climbing *skill* level (self rated) placed climbers into novice (n = 22, 30.6%), intermediate (n = 24, 33.3%), and expert (n = 26, 36.1%) groups.

The relationship between mountaineering experience and skills were assessed using correlation analysis (Kendall's Tau). A favorable p-value (.647, 99% confidence level, $\alpha = .01$) showed that respondent climbers are fairly congruent with their past climbing experience and level of perceived skills. Thus, reliable placement of the Mount McKinley climbers into three individual levels of overall mountaineering experience classification is possible: novice (novice and beginner, n = 18, 25.0%), intermediate (n = 28, 38.9%), and advanced (n = 26, 26.1%). Further data from surveys showed a negative correlation ($p = -.361$, $\alpha = .01$) between overall mountaineering experience classification and number of years since the respondent listed their first experience climbing to the top of a 'real' mountain. This indicates in the the surveyed sample of Mount McKinley climbers that in addition to a majority of them being classified as intermediate and advanced, the climbers also have relatively few years of experience in the mountains since their first time on a peak.

23 variables were analyzed in order to predict the most common risk perception concerns of climbers across the three overall mountaineering experience level groups. The data was normally distributed prior to analysis, and generated one significant function, "Health and Environment Influencing Making the Summit" $\Lambda = .842$, $\chi 2(2, N=72)=14.86$, $p<.001$, indicating that the function of predictors significantly differentiated between mountaineering experience level groups and their perceptions of particular risk perception variables "before" and "after" their climb of Mount McKinley. These results suggest that climbers with high fears of AMS, dehydration, HAPE, and not making it to the top were most associated with the function "before" attempting McKinley are more likely to be classified as intermediate. Novice climbers may also be concerned but not to the degree of the intermediate climbers. These values indicate that "after" a Mount McKinley climb, intermediate classified climbers were most impacted and concerned with dehydration, not making it to the top, high winds, and sunburn/snow blindness on their summit bid.

Most of the climbers surveyed indicated that the level of crowding on the peak remains within acceptable limits (n = 56, 77.7%) for the permit system that currently in place. 66 of 72 responding climbers (91.6%) indicated that the current permit system used by the NPS is adequate and should continue to be used. 14 of 72 surveyed climbers (19.4%)indicated that permits issued should be decreased, while four climbers (5.5%) wanted an increase.

Before the start of the climb from Basecamp, success only meant making it to the summit (n = 6, 8.4%) while other climbers stated that their expedition would be successful regardless of getting to the top (n = 66, 91.6%). These views changed slightly after the trip was over, as all (n =72, 100.0%) stated that their entire trip was a success.

Through these findings, the number of permits granted to camp and climb Mount McKinley is deemed adequate.

Researcher	Affiliation	Project
Lachniet	University of Nevado – Reno	Stable isotope hydrology and climate of Denali National Park
In the summer of 2009, we completed our first reconnaissance-level visit to Denali. We collected about 10 water samples from flowing streams along the Parks Highway and the Savage River. Those samples have recently been analyzed for stable oxygen and hydrogen isotope values at the Las Vegas Isotope Science Lab at the University of Nevada, Las Vegas. The data form part of a larger ~300 sample data set that we have collected from surface waters across Alaska. The data will be used in the Ph.D. dissertation of Alison Sloat at UNLV.		
Larsen, A.	Central Alaska Network	Central Alaska Network shallow lake monitoring project
(See also page 49.) We collected lake cores from Chilchukabena Lake (in Denali), as well as Long Lake (Wrangell-St. Elias) and Six-Mile Lake. Cores have been divided and laboratory investigations have been initiated.		
Larsen, C.	Geophysical Institute, UAF	Airborne surveying of glacier surface elevation change
No activity was conducted this report year.		
Molly Lee (and Amy Wiita)	University of Alaska Fairbanks	Artists' Sense of Place: The Connection of Art and Environment
I continued to observe various aspects of the Denali artist-in-residence (AIR) program from June to September 2009. I made four trips to Denali and attended the three public presentations by the 2009 artists-in-residence. I collected data during these presentations for analysis and preparation of the artists' ethnographic interviews. I completed two interviews with Denali artists-in-residence. Three additional artist interviews are pending. I continued to interview park staff in 2009 and completed 4 interviews with park staff at the federal level or at other parks with artists-in-residence programs. I also interviewed a consultant to the NPS working on AIR research. I also made 2 trips to the park to experience the park in a structured way. One trip was as a student in an Alaska Geographic sponsored class entitled Knowledge Informs Art. I spent 3 days in the park with other artists as classmates under the instruction of a 2009 Denali AIR. The class allowed us to experience the park and draw knowledge from the landscape and use that knowledge to inform creativity and art. This allowed me the opportunity to participate alongside other artists as they experienced the Denali environment and observe how they used this experience to inform their art. It also provided me with the opportunity to observe a Denali AIR teaching within the Denali landscape and delve deeper into how she experiences the park. During another trip to the park I was able to stay at a small rustic scientific research cabin that was within a few hundred yards of the Murie cabin where the artists-in-residence stay. I was able to experience the park in a similar fashion as the AIRs; riding the bus system to explore the park on day trips and hiking the area surrounding the cabin. This trip coincided with an AIR's residency at the Murie cabin. By invitation of the artist, I was able to see how the AIR used the Murie cabin and briefly talk about the artist's experience while on location. This provided background on and a foundational understanding of the artist's-in-residence experience at the Murie cabin and in the park.		

Researcher	Affiliation	Project
Lee / Wiita (cont'd)		
I continue to compile data from my observations and interviews and the analysis is on-going. Interim observations include: --artists experience the environment in individual ways that build on their past experiences; --artists experience the environment differently from others based on their purpose and focus; --artists' experiences include the ability to make use of spontaneous and planned opportunities; --various collaborations can take place between artists and others, including scientists, as a means of experiencing the environment; --there are consistencies in the basic aspects of how artists process their experiences of the environment, e.g., recording, analyzing/absorbing, reporting and producing; --artists use their experience of the environment in their own way to meet their individual needs—across a group, individual use is a common theme.		
MacCluskie	Central Alaska Network (NPS)	Small mammal monitoring at the landscape scale and synthesis of monitoring data in Denali NPP
See page 30.		
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
No activity was conducted this report year.		
Milner	University of Alaska Fairbanks	Long-term ecological monitoring of streams in Denali NPP
Macroinvertebrates were collected in early July at Savage River, Sanctuary River, Hogan Creek, Igloo Creek, Tattler Creek, East Fork tributary, Main Tolkat, Highway Pass Creek, Little Stoney Creek West and Moose River. Six Surber samples were collected and these are now being stored awaiting analysis. Work continued with personnel with USGS in Seattle and Tacoma looking at long-term data sets from pristine wilderness areas including Denali National Park and a draft manuscript has been prepared for submission.		
Milner	University of Alaska Fairbanks	Hydroecology of upwelling zones in a glacierized catchment
The study was not carried out this year.		
Newberry	University of Alaska Fairbanks	Geological mapping exercises in Central Denali Park
The UAF Geology field mapping exercises are scheduled for alternate years, and occurred in 2009. No IAR was received as of April 15, 2010.		

Researcher	Affiliation	Project
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.

Research activities in fiscal year 2009 included analysis of changes in glacial extent within the study area. A very complex technique was developed to evaluate changes in the ablation and accumulation zone, using Landsat imagery and evaluation of changes in glacial extent over the period 1979 - 2008. Results indicate that the mean elevation of the ablation/accumulation zone has increased from 1821.8 m to 1862.3 m, an increase of 40.5 meters over the period. During this same time, the surface area of the studied glaciers experienced a 47 percent decline from 1979 - 2008. In addition, 49 samples of Dall's sheep feces were collected during fieldwork and sent to the WSU Wildlife Lab for analysis of FN, Fecal DAPA, and corrected for ash. This analysis of feces will be used to evaluate nutritional status of forage in the study area. The analysis of these current samples are being added to the existing database of 2007 and 2008 sample collections. Additional water samples were collected and analyzed for nutrients in 2009 and added to the water sample database. Ewe/lamb count were initiated in the study area for the first time to provide an indicator of herd health in the study area.
Phenological analysis of the study area began late in 2009 and will continue in 2010.
Development of a project website documenting research activities and results to daty is in progress, and a USGS Open File report is currently going through review and will be published in the spring of 2010.

Potter	University of Alaska Fairbanks	Understanding site formation and cultural activities at Teklanika West (HEA-1)

The 2009 excavations concentrated on understanding the stratigraphic variation across the site, as well as mapping the landform the site occupies. A total of five blocks were excavated, totaling 12.5 square meters. Excavation blocks were placed, on average, five meters apart maximizing our understanding of the stratigraphic variability across the site. Units were established in areas that did not show signs of previous disturbance or excavation. These excavations confirmed multiple occupations at the site. More than 1500 artifacts were recovered from these excavations, of which, 1097 were found in in situ. Lithic artifacts dominate the assemblage, n=960; 87.1% (28 tools; 932 debitage pieces). Most importantly, our excavations recovered fairly-well preserved fauna remains, ranging from identifiable elements to numerous fragments, n=115; 10.4%. Currently, identifiable species range from either bison/moose, to caribou, and Dall's sheep. Many of the fauna and lithic analyses are ongoing. Additionally, this study was able to confirm the presence of two tephras (volcanic ashes), one likely early Holocene in age and the other being a late Holocene ash. These are still being identified at the tephra lab located at the University of Alaska, Fairbanks.

Dissemination of preliminary results have, or will be, made to the following:
The 75th annual meetings for the Society for American Archaeologist, St. Louis, MO. Archaeological Investigations at Teklanika West, Central Alaska. April 2010; 37th Annual Meeting of the Alaska Anthropological Association. Paper title: The Holocene Archaeology of Teklanika West, Central Alaska, by S. Coffman and B.A. Potter. Anchorage, AK. March 2010; 17th Annual Arctic Conference. Paper title: Archaeological Investigations at Teklanika West, Central Alaska: Preliminary Results, by S. Coffman and B.A. Potter. Boulder, CO. November 2009; Coffman, S. (2009) Archaeology in Denali National Park and Preserve. Murie Science and Learning Center Summer Lecture Series. Denali Park, Alaska; Murie Science and Learning Center, summary report for excavations at Teklanika West (2010); Understanding Site Formation and Cultural Activities at Teklanika West: report submitted to the Otto Geist Fund at the University of Alaska Museum of the North (2010); Understanding Site Formation and Cultural Activities at Teklanika West (HEA-001) in Denali National Park and Preserve: A Preliminary Report. Cooperative Agreement Number H9911080028 (2010); and ARPA Report: Understanding Site Formation and Cultural Activities at Teklanika West (2010).

Researcher	Affiliation	Project
Rice	Iowa State University	Niche preference of coprophagous Coleoptera associated with moose dung

During 7-9 August 2009, the taiga at Savage River Campground was searched for animal dung and the associated insect fauna. Of the two major herbivore species in Denali, only moose dung was found at this location. Dung was categorized as either summer moose dung or winter moose dung. Summer moose dung was examined for insects by manually breaking the dung and cutting it with a knife into small pieces over a sheet of white paper. The observed coprophagous larvae, pupae, or adults were then counted. When winter moose dung pellets were found, only those that appeared to be "fresh" and deposited during the previous winter or spring were examined. Fifty of the largest pellets from each pile were inspected for external indications of insect egress, broken into two pieces, and examined for either insects or their tunneling activity. An equal number (n=13) of winter moose dung piles and summer moose dung pats were examined. All dung was examined in the field except for three pats of summer moose dung, which were transported and held indoors to allow for adult emergence. Adults emerged from these pats on 18-23 August.

Winter moose dung contained no evidence of insects or their activity. The winter dung was heavily compacted with twig and bark fragments, and resembled course compressed sawdust. Moisture was present in the dung but this likely came from recent rains as opposed to originating from the defecating moose. It is unlikely that winter dung would retain moisture levels necessary for coprophagous larval development because of the relatively small mass per pellet.

Summer moose dung frequently contained larvae, pupae, or adults of coprophagous (dung-eating) beetles. Collected adults were later identified as *Aphodius* (*Planolinoides*) *borealis* Gyllenhal and 10 of 13 summer moose dung pats contained this species. Two dung pats had high insect (larval, pupal, and adult stages) densities of 55 and 151 individuals, but these were the exceptions as the range of *A. borealis* in all other pats was at much smaller densities of 0-11 insects. There were an average of 18 insects (*A. borealis)* per summer moose dung.

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

Collection of aerosol data at McKinley Park is taking place all year with weekly filter changes conducted by Andrea Blakesley.

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

(See also page 49-50.)

In 2009, the CAKN program sampled 13 sites in Denali, including 11 that were sampled in previous years. Two sites were revisited in the fall. In 2009 the program changed the way we collected diatom and invertebrate samples to facilitate the development of models that quantify detectability. Four replicate samples were collected at each site rather than a single composite sample. These data have not yet been analyzed and water chemistry data have not yet been received.

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

No field work was conducted in Denali in 2009.

Researcher	Affiliation	Project
Trost		Alaska transboundary regional haze monitoring project
The following sites were chosen to augment the two IMPROVE sites at Denali: Lake Minchumina and McGrath. The two IMPROVE sites are at Trapper Creek and at Park Headquarters. The two augmentation sites were supplied with a Federal Reference Method (FRM) partisol 2000 sampler in order to have an independent measure to act as the IMPROVE samplers at the Park Headquarters and Trapper Creek. In addition, all four sites were installed with a DRUM sampler which runs for six weeks at a time and collects particulate on a three strips that can be analyzed for different elements using synchrotron XRF. Samples were collected every three days for the FRM partisol 2000 and continually (barring mechanical problems and staffing shortages) for the DRUM samplers from February 2008 to May 2009. A total of 102 strips were sent to the University of Alaska Fairbanks for analyses. The chemical analyses are being carried out at the University of California Davis and the data will be returned to UAF for final analysis. The data are expected to be available for our analyses in 2010. IMPROVE data are expected to be available in 2010 as well.		
Van Ballenberghe		Ecology of Moose in Denali National Park and Preserve
Spring fieldwork was conducted from May 27 to June 10 to monitor moose calf production and neonate survival. Calf production was unchanged from recent years; twins comprised about 50% of births. Neonate survival was higher than prior to 2000 when bear predation was heavy. Autumn fieldwork was conducted from August 17 to October 3 to collect data on rutting behavior. Traditional rutting areas in the Mile 7-10 area were used by moose in 2009 as in previous years. The peak of the rut was earlier in 2009 compared to that for years prior to 2005. Data on mate choice, sparring, fighting, and antler breakage were collected to add to a long-term data set begun in 1980.		
Wake	University of New Hampshire	Drillsite reconnaissance and snow chemistry survey in Denali National Park
Data from the Automated Weather Station reveal that the average annual temperature at Kahiltna Base Camp from May 2008 to May 2009 was -8.9C (16.0F). The maximum temperature was 17.4C (63.3F) on August 23, 2008 at 2:25 pm, and the minimum temperature was -31.1C (-24.0F) on February 4, 2009 at 10:55 pm. The average wind speed was 3.6 knots, and the maximum (hourly average) wind speed was 28.5 knots on January 17, 2009 at 4 pm. We used temperature data from the UAF-NPS Denali Pass weather station (~19,000') to estimate the local lapse rate (6.2 C/km), providing a mean annual temperature at Kahiltna Pass (3050 m) of approximately -13C (~8.5F). Based on this temperature, we are confident that the Kahiltna Glacier is frozen to its bed at Kahiltna Pass. Our chemistry data from 2009 show the March 22-23, 2009 Mt. Redoubt eruption clearly. The visible ash layer is associated with an order-of-magnitude increase above background levels for every chemical compound we measure (Na+, Ca2+, Mg2+, K+, Cl-, NO32-, SO42-). Our data also differentiate between the explosive phase of the eruption in late March and more diffuse (non-explosive) volcanic emissions later in April and May. The surface snow shows elevated concentrations of sulfate and chloride (which are gaseous), but low concentrations of calcium and magnesium (solid). This is the fingerprint of non-explosive volcanic emissions that we would expect. Elevated concentrations of calcium and other solids are only observed during the explosive phase of the eruption associated with the ash layer. This clear chemical fingerprint of the Redoubt ash will allow us to identify it in the deeper ice core we propose to develop in the future, providing a clear time marker to help in developing the ice core paleoclimate time series. A total of 18 ground penetrating radar (GPR) profiles and 37 GPS ice velocity points were collected in 2008 and 2009 to determine the depth, stratigraphy, and dynamics of the upper Kahiltna Glacier. At the Kahiltna Pass candidate ice core site, the ice thickness to bedrock was measured to depths exceeding 300 m. By		

Researcher	Affiliation	Project
Wake (cont'd)		

tracing the bedrock reflector across multiple GPR profiles, we developed a contour map of ice thickness at Kahiltna Pass, revealing the >300 m deep ice down the axis of the glacier flanked to the west and southeast by ice of 100-150 m thickness.

Our 2009 GPR profiles also reveal a complex flow regime in the eastern half of Kahiltna Pass, with ice flowing into Kahiltna Pass from the east being deformed as it flows down the Motorcycle Hill icefall. This ice intersects a second flow regime that originates in the northwest corner of Kahiltna Pass, characterized by lower surface velocities and surface-conformable internal stratigraphy. The intersection of these two flow regimes at Kahiltna Pass is clearly imaged on the GPR profiles as a westward-dipping horizon separating the deformed and surface-conformable stratigraphy. Surface velocity GPS measurements support the hypothesis of two flow regimes at Kahiltna Pass. High velocities of 32-60 m/s are observed flowing down from Motorcycle Hill and counter-clockwise around the Kahlitna Pass bend, whereas low velocities of 7-26 m/s are observed in ice flowing SW from its apparent origin in the northwest corner of Kahiltna Pass.

GPS surface velocity measurements were also made at 12 locations between Kahiltna Base Camp and Kahiltna Pass, revealing a ~300% velocity increase only 4 km down-glacier (61-170 m/yr) from Kahiltna Pass, and a 400% increase 7 km down glacier (61-248 m/yr). The significant velocity increase occurs at Camp 1 following the steep terrain associated with Ski Hill, indicating that Ski Hill represents the transition zone between a frozen bed and melted bed.

Wallace	Alaska Volcano Observatory	Timing, distribution, and character of tephra fall from the Mt. Redoubt

During the two days of flying with NPS staff David Kruetzer and the NPS contract helicopter, we were able to sample Redoubt ash fall from the March 23, 2009 explosion at 13 locations within the Park. The collaboration between the NPS and the USGS was well served and fully successful as both agencies were able to achieve their intended missions working together with a single helicopter. Time was saved having NPS staff on board for our mission because David Kruetzer and the pilot were very familiar with the geography and we able to land us at excellent sampling sites with zero reconnaissance flying. We collected a total of 11 volcanic ash samples from the 13 visited sites. Although Redoubt ash was identified at all visited locations, only 11 of the 13 sites were suitable for sampling (i.e. not reworked). All samples were collected using measured-area methods which includes sampling a 20 x 20 cm area at each site. The small, fine-grained samples are being used to construct an isomass map of ash fall from the 2009 eruption of Redoubt Volcano. The individual dried masses of each sample are plotted on a map and lines of equal mass are contoured. These data are then used to calculate a mass and volume of erupted tephra fall (volcanic ash) both for each individual explosion (in this case event 5 on March 23, 2009) and for the entire eruption (March 22-April 4, 2009). Samples from the most distal portions of the plume are very important in order to make accurate volume calculations but also because these fine-grained, diffuse materials are difficult to see in satellite imagery so field verification of satellite imagery helps to calibrate our monitoring equipment as well as improve ash fall models. We estimate the volume of ash fall erupted on March 23, event 5 to be 3.5 million cubic meters. This is similar to ash fall volumes from individual events during the 1989-90 eruption of Redoubt. This amount is about 15 percent of the total erupted ash fall from the 2009 eruption with a total eruption ash fall volume estimated at 22.3 million cubic meters. In total we have collected over 400 samples of ash fall from the 2009 eruption in other areas. Other USGS and Italian colleagues are using our ash sample data (including the 11 samples collected in the Park) to improve and calibrate ash fall models so that during future eruptions we may be able to adequately model ash fall locations and amounts. In addition to creating an isomass map and calculating eruption volumes, we are having particle size data analyses done on the samples to understand particle-size distribution and calibrate ash fall models.

Researcher	Affiliation	Project
Wilmking	Greifswald University	Unraveling the divergence riddle: linking local tree growth …

We sampled two locations close to Rock Creek (one closed canopy forest plot and one plot near treeline), taking penetrating cores of 20 white spruce trees at each plot and measuring important tree parameters, such as height, diameter, dominance, infestation by budworm, needle characteristics, etc. We could confirm opposite climate-growth responses in white spruce at the site at Rock Creek.

We examined the change in tree growth since 1975 (shift in climatic regime in Alaska from cold and moist to warm and dry climate) and found that about 30% of the trees showed a decrease in growth (negative responders) and 70% showed an increase in growth (positive responders). Change in mean growth ranged from decrease by 1/3 to increase by 2.5 times compared to the period before (1950-1975). This diverging growth response is very likely due to stand density, with single standing trees at the treeline plot comprising a high percentage (90%) of positive responders, and trees at the closed canopy forest plot comprising 50% positive and 50% negative responders. However, this could also be attributed to the elevational gradient: treeline trees growing higher up on the slope (above 850m a.s.l.) suffer less from high temperature induced drought stress than trees in the closed canopy forest further downslope, hence, leading to diverging growth trends on the site level. Furthermore, we found that trees older than 150 years tend to respond with decreased growth and trees younger than 150 years with increased growth.

However, further analyses need to be done on the plant physiology of white spruce (Vaganov-Shaskin-Model) and on the dependency of white spruce growth on different microsite conditions. Also, other underlying ecological mechanisms, such as competition or mutual facilitation by the surrounding vegetation, should be analyzed to better explain within-site variability of white spruce growth responses to climate change.

◃ 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 sixth 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)
- University of Alaska (provides accreditation on many education programs, oversees many research efforts in the MSLC parks)

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 six 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; and video-conferencing; in-park transportation coordination and food service.

In 2009, 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 $24,400 was awarded to researchers in 2009 and $15,384 in 2010 (see page 84, "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 2009-2010 winter, students from Denali Borough School District hiked to Horseshoe Lake monthly to measure and record lake ice and snow data. The Horseshoe Lake site is one of many 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 School students, teachers, and the education specialist were only turned back on occasion by temperatures colder than -10°F 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 2009-20010 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 (including two instructors) and the group spends three nights in Denali's backcountry. Areas for exploration and monitoring are identified by park managers. In 2010, the MSLC will offer the Denali Backcountry Adventures camp July 28-30, with a skill building camp out on July 26-27.

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 21-25, 2010).

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 2010, this camp will be offered in July or 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 full program are July 19-30, 2010.

Field Seminars and Teacher Training

Field Seminars. The MSLC will be offering 20 field seminars in the 2010 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, 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 2010. These three- to four-day programs are "courses" focusing on science writing; geology of Denali; and movie making and podcasting. 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 7 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 $100,000 annually.

Discover Denali. Developed to provide a meaningful park experience for Royal-Celebrity Tours passengers, this fee-based program is offered up to 5 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).

Running with the Pack: Family Excursion. This Murie Science and Learning Center program was developed to meet the needs of family groups visiting Denali with Adventures By Disney and Alaska Premier Tours. This fee-based program is offered every Friday, June through August. The program consists of a guided hike in the entrance area with a focus on wolf ecology and current research. The program is operated by Alaska Geographic and all proceeds are returned to the Murie Science and Learning Center operations, approximately $7,000 annually.

Climate Change in Alaska's Parklands Evening Presentation. In 2010 Alaska Geographic will give this new evening dinner presentation to guests of Cruise West Tours. The program is operated in partnership with Doyon/ARAMARK Joint Venture. The science-based presentation about climate change in our northern Alaska park lands will look at the current observations and trends and discuss how the National Park Service is responding to these changes. All of the proceeds from this program are returned to the Murie Science and Learning Center operations, estimated at $4,000 annually.

Evening Speaker Series. The MSLC and Alaska Geographic host guest speakers throughout the summer on a bi-weekly basis. 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 special programs, food services, transportation services and meeting space to these groups.

Research Awards

Discover Denali Research Fellowship Program

2010 is the fifth 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.

Two fellowships (a total of $7566) have been awarded in 2010 to the following researchers (listed alphabetically), conditional on their obtaining a research and collecting permit if working in the park, as with any research project in Denali:

- Joe Bickley, Alaska Backcountry
  Glacier terminus surveys and photo documentation in the Kichatna Mountains, Denali National Park and Preserve, Alaska

- John Blong, Texas A&M University (graduate student)
  Prehistoric upland use in Denali National Park: a proposal to conduct archaeological field research along the Savage River

In 2009, the following Discover Denali Research Fellows conducted their studies in or near 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

Murie Science and Learning Center – Research Awards

For the third year (initial year was 2008), financial support is available for research projects in any of the eight arctic and subarctic 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 2010 will be working in Denali. The awards are conditional on obtaining a research and collecting permit, if working within a national park:

In 2010, the following two researchers are recipients of Murie Science and Learning Center Research Fellowship Awards (a total of $7818 awarded):

- Caitlin Hicks, University of Florida (graduate student)
  Carbon cycle changes in warming Alaska: Do plants or soil microbes drive changes in ecosystem respiration? [near Denali National Park and Preserve]

- Shelby Anderson, University of Washington (graduate student)
  Late prehistoric social change in northwest Alaska: A study of ceramic procurement, production, and distribution in the Arctic [Western Arctic Parklands]

In 2009, Murie Science and Learning Center Research Fellowships were awarded to these three researchers who conducted their projects in Denali or in other arctic or subarctic parks:

- 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]

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

Researcher in Residence Program

The MSLC is hosting a Researcher-in-Residence Program in partnership with the North and West Alaska Cooperative Ecosystem Studies Unit (http://www.uaf.edu/snras/cesu/) over the course of the next four years. This program is designed to increase the opportunities for researchers to work in the park and increase the opportunities for visitors to learn about current science occurring in the park. It is anticipated that the MSLC will host up to three separate researchers. For more information on this program visit http://murieslc.org/static/1615/researcher-in-residence-program

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 2009 - 2010

Completion and Implementation of Denali's Resource Stewardship Strategy
In 2009, Denali completed its Resource Stewardship Strategy (RSS), which will guide its research and resource program for the next 15 to 20 years. (see page 3)

Glen Creek Post-mining Restoration
Fifty tons of abandoned mining equipment and supplies were removed as part of the massive restoration of the post-mining stream and floodplain areas at Glen Creek. (see page 52)

Wolf Populations and Wildlife Viewability
The low density of wolves in 2009 and 2010 and the Board of Game's vote to remove the Stampede and Nenana River closed areas may change the chances of seeing a wolf along the Denali Park Road. (see pages 23-25)

Natural Resource Condition Assessment (NRCA) Underway
Denali staff are working through a cooperative agreement with St. Mary's University of Minnesota to conduct the park's Natural Resource Condition Assessment. Each park's assessment is a snapshot-in-time evaluation of selected park natural resources. (see page 3)

PRISM Climate Maps
In 2009, the Oregon State's PRISM group completed its two-year modeling project to create annual and monthly temperature and precipitation maps for all of Alaska for the 30-year period 1971-2000, as extrapolated from hundreds of weather stations in Alaska. The Central Alaska Network and Denali helped fund this project. (see page 9)

Long Fire Season in 2009
Fire management staff managed multiple fires over a very long season (by Denali standards). There was unprecedented Interagency coordination managing fires inside/outside Denali. A wildfire was allowed to fulfill its ecological role on the toe of the Ruth Glacier (there was a fire there in 1996 that was suppressed). (see page 15)

Looking Ahead – 2010 and Beyond

- **Road Study Data Informs Road Capacity EIS**—Research data gathered 2006 – 2008 (integrated study of traffic, wildlife, and visitor experience) have been shared with the planning group which is developing the Road Capacity Environmental Impact Statement, with alternatives for changes in traffic patterns. (see pages 4-8)
- **3-D Images of Dinosaur Trackways**—Specialists in 3-D photography are slated to take images of panels of dinosaur footprints at Cabin Peak in order to create 3-D images for use in research, publications, and display murals. (see page 44)
- **Follow the Mountain Waste**—Researchers at Alaska Pacific University are studying glacier movement near the Southeast Fork of the Kahiltna, and are recovering previously crevassed human waste to analyze it for harmful bacteria and assess impacts to local water systems. (see page 48)