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 2011

All photos courtesy of National Park Service, unless otherwise indicated.

Table of Contents

Integrated Programs and Findings

Reporting about the Resource Stewardship Strategy

In 2010, Denali resources staff reviewed Denali's Resource Stewardship Strategy (RSS), which is the guiding document for the park's research and resource program for the next 15 to 20 years (2008-2027). 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.

Resources staff identified the current condition where possible for the 119 indicators of resource condition already identified (indicators related to visitor experience still need to be identified). A scorecard approach was used to report the status of the park's resource stewardship compared to a reference condition. The symbols used in the scorecard exercise combined a way to show trends (arrow up, down, steady), degree of management concern (color: red, yellow, green), confidence in the information (line: solid, dashed, dotted), and degree of control the park has over resource condition (shade of blue: dark, medium, light).

Indicator	Score
# Native vertebrate species losses	

The arrow is steady because there is no known losses of vertebrate species (status quo). There is not adequate monitoring information about all vertebrates species, hence the dashed line). Cautionary yellow is applied because of the potential future losses due to climate change and its effects on animal habitats, something that the park has little control over.

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

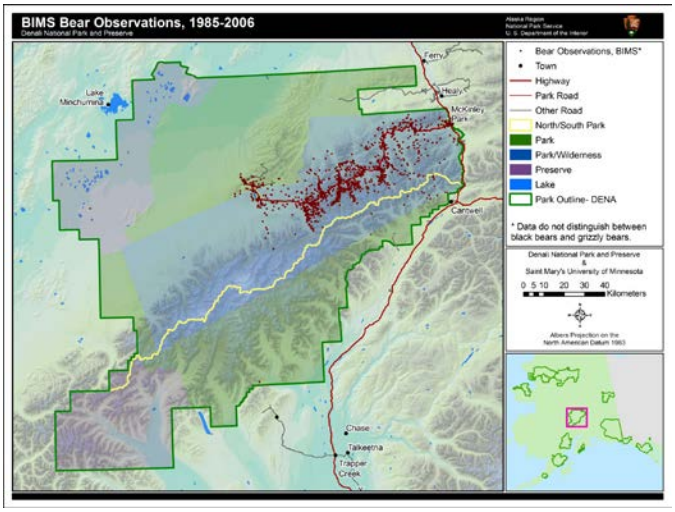
In 2009 Denali embarked on its Natural Resource Condition Assessment (NRCA) by setting up a Cooperative Ecosystem Studies Unit agreement with St. Mary's University of Minnesota to complete the assessment.

The NRCA program is part of the Natural Resource Challenge and mandates the development of park-specific assessments to help answer the question: What are current conditions for important park resources?

During 2010, Denali staff worked with St Mary's staff to develop resource summaries for a range of ecological indicators and to develop more focused analyses of existing data sets, including overflight impacts, fire history, water quality, infrastructure extent, bear observations from Bear Information Management System (BIMS) forms, and others.

The final product is expected in 2011 and will include: (1) spatial analyses of existing data on the condition of resources to present data in a pleasing way, (2) analyses of multiple data sets to answer condition questions, and (3) analyses of data that have been moved from non-digital form into GIS.

For a list of specific projects tackled by the NRCA in addition to the resource summaries for ecological indicators, consult the fact sheet on the NRCA at www.nps.gov/dena/naturescience/factsheets.htm



An example of a map product is the distribution of bear observations as reported on BIMS forms.

Digitizing Research Files

The Division is in the middle of a three-year project to convert to digital format many of the research records that currently reside in fireproof file cabinets in the Resources Conference Room. In the first year, most of the Technical Library's "reports" were converted to PDF format files. This scanning included many of the library's holdings of technical reports and grey literature, but did not include documents that were too difficult to dismantle for scanning purposes. Approximatley 1600 documents were digitized in that effort.

The second portion of the project focuses on the files pertaining to the numerous research projects that have taken place in the park since it was established. Over the winter, a graduate student from St. Mary's University went through the files and focused on a number of high priority projects. Those records were digitized as well as many large format maps and drawings. The scanned maps are being geo-referenced for use with the park's GIS database. The final portion of the project will complete the digitizing of the rest of the records and provide a framework for including records from research projects that happen in the future.

Denali Park Road Capacity Study

Provided here is an overview and a synopsis of the various facets of the road study (2006-2010) and a brief description of what is planned for 2011.

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 2010. 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 returned to Denali in summer 2010 to administer additional surveys designed to 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. From 2007 to 2010, 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). In 2010 bus driver wildlife observations were complimented with a new program that involves park staff riding buses with hand held computers with GPS capability. This program collected data on wildlife stops, including species, number of animals, distance from the road, behavior, and numbers and types of vehicles at each stop. Staff also noted numbers of vehicles at rest stop and at the Eielson Visitor Center which is a proposed indicator in the Vehicle Management Plan. Researchers gathered information about dust (2007 to 2009) and sound (2008 to 2010) 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 2011, researchers will continue to collect sheep and bear behavior data (observational) along the park road (this includes staff riding buses to note wildlife on hand-held computers). For 2011, GPS units will only be on buses with touch screen panels. In addition, a new satellite-based vehicle GPS system will be field tested on 4 buses and 2 NPS vehicles. Bus drivers are encouraged to enter wildlife sighting information into touch screen panels, as they have done in past years, 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.

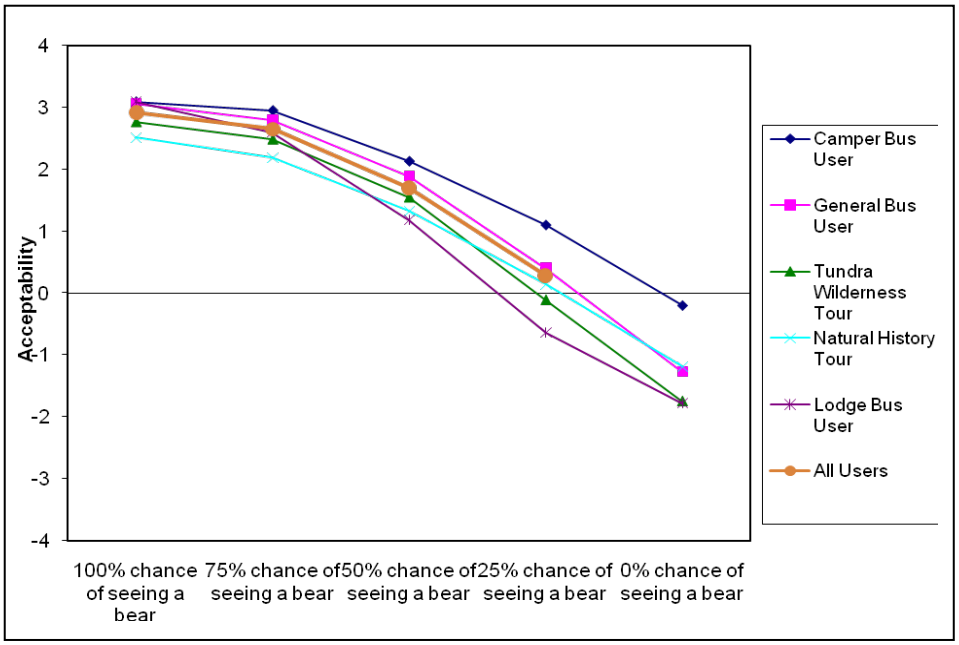
Road crossings by GPS-collared sheep occurred between Miles 33 to 38, 44 to 48, and 51 to 53 of park road, with the most crossings occurring between Miles 45 to 47.

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).

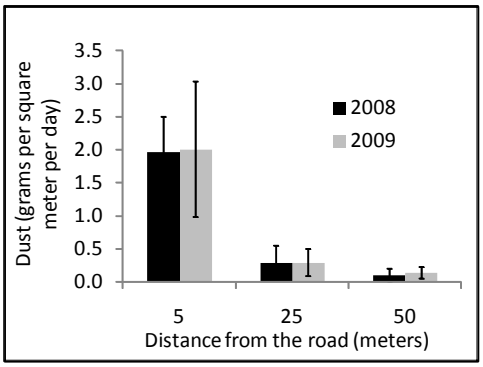
In the 2007 quantitative survey, visitors were asked to what extent they felt that certain issues were a problem on the park road. Respondents were asked to rate each question from 1 (not a problem) to 3 (big problem). The four most problematic issues were "not seeing enough wildlife close to the road," "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 from the University of Vermont administered a new survey that asked visitors how willing they were 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 were able to express their degree of interest in early morning or late evening tour departures; their desire for activities during a tour, such as hikes; and their interest in the ability to stop at a visitor center. A summary report on this survey is anticipated in summer 2011.

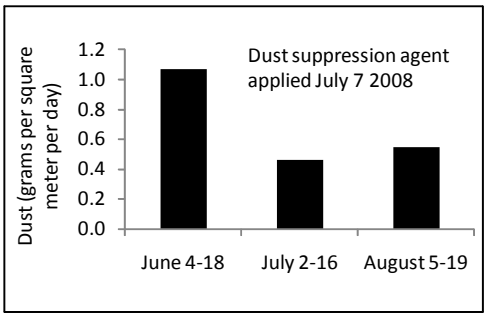
Dust

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 lower 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.

Soundscapes

As part of the road study, researchers studied levels of traffic-generated sounds near the park road. 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 data collected in 2009 at mile 28.1 and analyzed visually indicate that the daily average percent time audible (PA) for vehicle sounds are about 4 percent each hour during nonpeak hours (8:00 pm to 6:00 am) and about 10 percent of each hour at peak traffic hours (7:00 am to 7:00 pm). Overall, the daily average number of vehicle "events" was 162. Data collected in 2010 at mile 59.6 indicate that the average PA for vehicle sounds are 5.7 percent per hour during nonpeak hours and 21.6 percent per hour during peak hours. The daily average number of vehicle events was 177.

In 2010, researchers recorded sound measurements of bus pass-bys to determine the range and average decibel levels of buses by type, speed, and direction. Researchers set up a sound station at mile 59.9 for a period of 6 days in May andAugust 2010. During an average pass-by, Tundra Wilderness Tour buses produced a maximum decibel reading of 78.4 and Visitor Transportation Services buses produced a maximum decibel reading of 72.2. These data will be used as baseline measurements of bus noise that will be useful when considering new bus prototypes of hybrid models that might be deployed along the park road.

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). 2009 GPS data were used to update the model to be current with changes that have occurred on the park road since 2006, including the removel of the Polychrome rest stop, the new Kantishna Experience tour, and stops at the new Eielson Visitor Center.

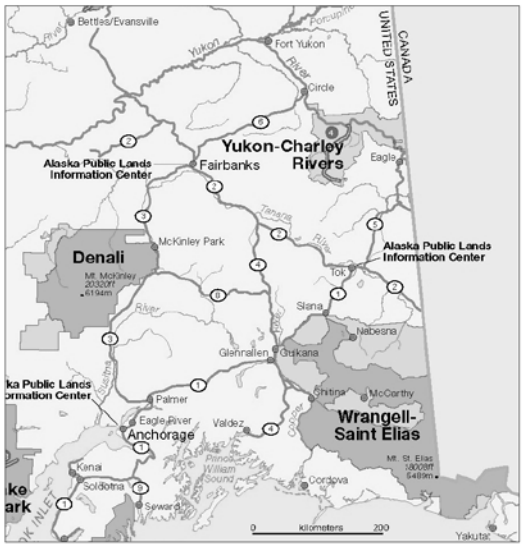
Data used in the model also came from touch screen panels installed in 20 buses (2007-2009) for bus drivers to record information about the location of stops made along the road for wildlife sightings, passenger pick-up and drop-off, and road maintenance. Data collected by drivers using the data panels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

The 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 ready for public comment in July 2011.

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 2011 field season is the sixth year of program implementation after four years of planning and development. The focus has been to bring more of the 34 Vital Signs into full operation with collecting field data and analyzing and reporting on the data to parks and the public. Originally, there were 37 Vital Signs, now there are 34. Forage Quality and Quantity were incorporated into the monitoring of animal species, and Water Quality and Macroinvertebrates are being studied as part of Shallow Lakes, and Rivers and Streams rather than as separate Vital Signs. 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 and the Denali Visitor Center (for Denali), the visitor centers in Copper Center (Wrangell-St. Elias), and the Fairbanks Administrative 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 and climate change in 10 resource briefs that are posted on the CAKN website http://science.nature.nps.gov/im/units/cakn/

Selected Updates

Vegetation Structure and Composition

During the tenth year (2010) of the Central Alaska Network vegetation monitoring program, four crews worked all summer doing project fieldwork in the three CAKN parks. The crews installed 187 permanent vegetation monitoring plots in Denali and another 136 plots in Yukon-Charley Rivers and Wrangell-St. Elias. Since 2001, about 1,626 permanent vegetation monitoring plots have been installed in the three network parks, 1112 of those plots are located in Denali.

Golden Eagles

Since 2007 the CAKN has worked 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 resulted in specific management recommendations for minimizing potential impacts of human disturbance on nesting Golden Eagles in Denali. Denali biologists and managers will continue to work with Dr. Nichols and Dr. Martin to implement an adaptive management strategy to minimize potential impacts of human disturbance at occupied Golden Eagle nests in the future.

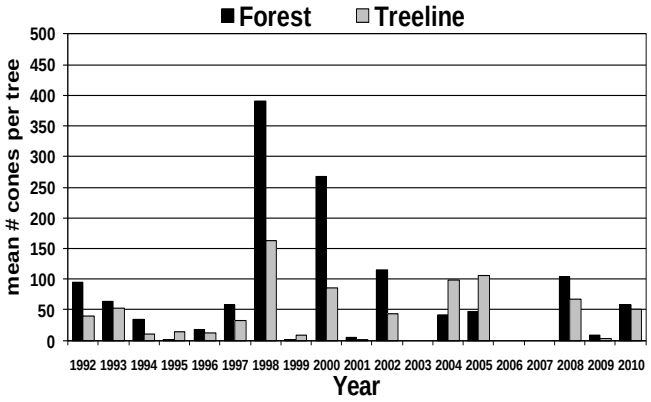
Plants/Vegetation

Long-term Vegetation Monitoring

Field work continued in 2010 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 1992-2010.

The spruce trees in this study produced an average of 58 cones per tree in the forested sites and almost 51 cones per tree in the treeline sites in 2010. This continues a trend that began in 2004 of the much smaller trees at treeline producing more than or at nearly as many cones as the larger lowland forest trees. This interesting trend may be related to water stress on the large lowland trees that are packed more closely together, and thus compete for resources more intensely than the trees growing in the open treeline sites. 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 2010, two vegetation crews completed sampling of the following mini-grids: Igloo Canyon, Kantishna River, Lower Moose Creek, Middle MnKinley River, Muddy River, Beaverlog Lakes, and Divide Mountain. 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 program successfully completed the first iteration of

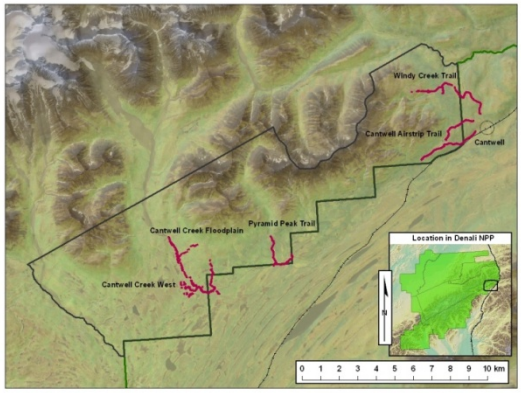
sampling of the Denali landscape-scale vegetation monitoring program (all the plots measured once). During the past decade, program staff have accomplished the following things, among many others:

- measured the diameter and other attributes of 50,319 trees
- counted 14,350 seedlings in plots
- collected nearly 20,000 plant specimens for identification and vouchering
- made field observations for and collected 1,603 soil samples (analyzed for pH, texture, moisture percent, carbon, and nitrogen content)
- documented plots and landscapes in approximately 28,299 photographs
- extracted 1,639 increment cores from trees (for measuring and counting of annual ring widths to characterize growth patterns)
- recorded species composition of vascular plants, mosses and lichens in 6,810 individual quadrats
- quantified the vegetation cover on 5,230 point transects

The data acquired through this decade of fieldwork represents a significant accomplishment in the life of this program. The next couple of years will be invested in analyzing and communicating the results from a variety of different angles (e.g., understanding the ecological controls over tree distributions, quantifying species diversity patterns across the park landscape). Stay tuned for results and updates emerging from the Denali Botany program!

Off-Road Vehicle (ORV) Impacts

In 2010, staff completed the fourth season of the ORV impacts 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 subsistence use of ORVs.

In the 2011 field season, Denali staff will continue to monitor the impacts of ORV use. Park staff have 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 2011 (the seventh time for this mapping). Staff will document 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 2010, researchers continued the detailed microscopic work that it takes to identify the several hundred nonvascular plants collected in 2007 and 2008. Field collections were made both north and south of the Alaska Range to inventory and voucher Denali's mosses, lichens, and liverworts. The researchers 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. Many new species have been added to Denali's nonvascular plant lists based on these field collections.

Nonvascular Plant Group	Known Taxa before CAKN Inventory & Monitoring Projects	Known Taxa After CAKN Inventory & Monitoring Projects	Increase in Known Species (Percentage) after I&M Projects
Mosses	**280** species in 118 genera	**387** species in 135 genera	+ 28%
Liverworts	**71** species in 30 genera	**124** species in 43 genera	+ 42%
Lichens	**280** species in 108 genera	**482** species in 150 genera	+ 42%

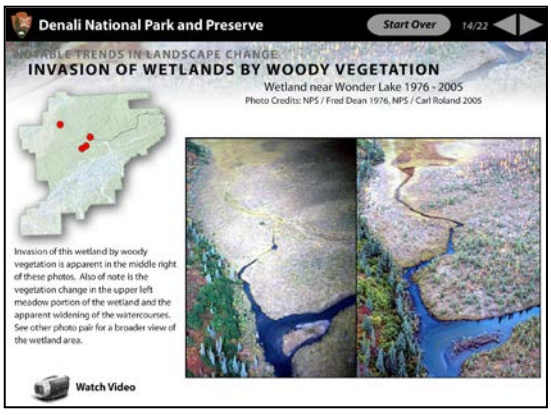
As detailed microscopic identification of voucher specimens continues in 2011, additional new taxa to the park and even to Alaska are expected.

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 has begun, and the project may have a working website within about a year.

Virtual Tour of Landscape Change in Denali

Visitors can now use interactive exhibit—the "Virtual tour of landscape change in Denali"—at the Murie Science and Learning Center to view photo pairs taken primarily in 1975-6 and 2005. This computer-based exhibit, installed in May 2010 connect visitors to the changing landscapes of Denali and around the world.



Paired photographs allow for 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.

The virtual tour of landscape change will also be available for download off the web (Denali and the Central Alaska Network) in 2011. Staff are also working to complete a narrated version of the tour in spring 2011.

Tons of Exotic (Non-native) Plants Removed

In 2010, as happens every year, several individuals and groups helped Biological Technician Wendy Mahovlic remove hundreds of pounds of non-native plants from the Denali Park Road corridor, the entrance area of the park, and the George Parks Highway near the park entrance.

Including the hours in which volunteers collected native seeds, 29 volunteers worked more than 2000 hours and pulled an amazing 5157 lbs of exotic plants. Removing exotics results in a reduced danger of these invaders displacing the park's native flora and disturbing ecosystems.

In 2011, for the 13th 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 2010 roster of non-native plants removed (in amounts of more than 50 lbs) in/near Denali:
  - * Dandelion (*Taraxacum officinale)*: 570 lbs
    (Denali Park Road corridor)
  - * White Sweet Clover (*Melilotus alba*): 101 lbs
    (Miles 232.5 and 238 Parks Hwy)
  - * Hawk's-Beard (*Crepis tectorum*): 117 lbs
    (Sewage lagoon; Mile 0 to 3 of the park road)
  - * Foxtail Barley (*Hordeum jubatum*) 1294 lbs
    (first two miles of the Park Road)

- **Other non-native species of plants**
  These additional non-native species, among others, were removed in 2010:
  - * *Vicia cracca* (bird vetch): 95 lbs (Mile 1 to 3 of the park road; also McKinley Village and McKinley Chalet)
  - * *Hieracium umbellatum* (narrowleaf hawkweed): 5 lbs (Parks Highway)
  - * *Tripleurospermum perforata* (scentless false mayweed): 20 lbs (Railroad Depot)
  - * *Linaria vulgaris* (yellow toadflax): 5 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 2010: near the east end of the Park Road (August 9-13), and at the west end of the Park Road (August 16-20). It was a good summer for wildflowers, and a total of 82 lbs. of native plant seeds were collected.

❖ **Revegetation**

There were a variety of revegation projects accomplished during the summer of 2010. The revegetation technician supervised the replanting of areas at Mile 4 of the park roadand in the sewage lagoon entranceway with native seeds collected for this purpose in 2009. She also oversaw seeding efforts in the following locations: Teklanika Rest Stop; Igloo Sweet Smelling Toilet (SST); Igloo Canyon; Savage West Shelter; and the propane field (near Park Headquarters). Another big project in 2010 was watering the tundra mats and trees that were harvested and being stored to reuse in revegetation efforts after the completion of the Emergency Services Building and the Teklanika Rest Stop.

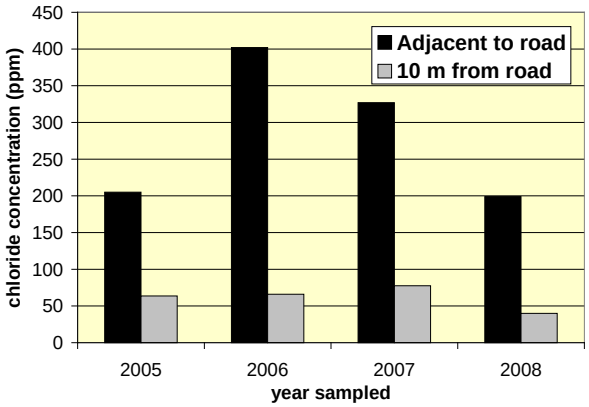
Monitoring Dust Palliatives on the Park Road

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.

A full sample was obtained in late summer 2010 but have not yet been analyzed. Due to the exceedingly dry weather, and then early snow in 2009, lysimeter samples were not taken that year.

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). Samples were not taken in 2009, and samples for 2010 are pending analysis.

Wildland Fire

Fire Highlights for 2010

The first fire in Denali in 2010 was discovered on June 17. Fire management personnel noticed smoke on the perimeter of the Foraker Pond Fire that had burned the previous year . The "new" fire was actually a "holdover" from a fire that retained enough heat over the winter to rekindle the next spring. The fire was burning deep on the edge of a thermokarst, a depression created by the collapse of ground after permafrost has thawed. Records show that this area had also burned in 1986.

Foraker River Fire (2010) was a holdover from the Foraker Pond Fire (2009)

On numerous occasions in 2010, the Western Area Fire Management staff at Denali cooperated with the Alaska Fire Service (BLM) and the State of Alaska's Division of Forestry. Managing fires inside and outside of the park was accomplished by implementing the "Closest Forces" concept: NPS personnel monitored wildfires in the greater Denali area and took suppression actions on nearby fires. For example, Denali fire personnel took initial suppression action on a fire that was caused by a plane crash near park headquarters and also responded outside of the park with an engine and helicopter to the Healy Fire. Denali Fire staff also supported the Toklat 2 fire near (but outside) the north boundary of the park. This fire was another holdover from 2009, which merged with a lightning-caused fire (ignited on May 27, 2010). Support for this fire consisted of providing personnel and a helicopter that was used for fire monitoring and personnel transport.

There were three wildland fires and one prescribed fire in Denali in 2010:

Fire Name	Burn Period	Acres	Fire Type	Comments
Foraker River	6/17/09-07/16/10	0.1	Wildland Fire	Holdover from the Foraker Pond Fire (2009)
Hines Creek	8/1/10 – 8/9/10	1.5	Wildfire	Fire ignited by plane crash; fire suppressed
White Creek	6/26/10-6/26/10	1	Wildland Fire	Burned area discovered by aircraft; fire was out upon discovery
Sewer Lagoon	12/28-1/4	1.1	Prescribed Fire[1]	Burning of biomass debris from roadside maintenance projects and 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.

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

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.

Prescribed Fires Planned for 2011

Several prescribed fires are planned for 2011:

Fire Name	Fire Date	Acres	Fire Type	Comments
Lower Savage Ranger Patrol Cabin	2/12/11-2/14/11	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
Admin Road 1	4/4/2011-4/7/2011	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects and hazard fuels treatment projects.
Toklat slash burn	2011	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
70 Mile Pit slash burn	2011	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
Kantishna Pit slash burn	2011	0.25	Prescribed Fire	Burn Biomass debris from roadside maintenance projects
New Thorofare Cabin slash burn	2011	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
New Birch Creek Cabin slash burn	2011	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment projects
Lower Windy Cabin slash burn	2011	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment project
Moose Creek Ranger Patrol Cabin	2011	1.0	Prescribed Fire	Burn Biomass debris from hazard fuels treatment project
Parker Cabin	2011	0.75	Prescribed Fire	Burn Biomass debris from hazard fuels treatment project

Creating Defensible Space Around Structures

Firewise is the name given to the creation of defensible space by thinning, limbing, or clearing space around structures.

Hazardous fuels around structures in the developed and backcountry areas of Denali have or are being reduced to create a "defensible space" around the structures. 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.

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.

The photos below show how firewising was needed at Park Headquarters after trees grew up between 1947 (left photo) and 2004 (right photo).

Left: Lowell Sumner Photo, #12508, Harpers Ferry Center 1947

Right: NPS Photo 2004

In 2010, fire management staff improved the defensible space (about 1.75 acres) at Park Headquarters and at cabins along the Denali Park Road by trimming branches to varying heights from the ground to give a natural appearance.

In 2011, staff will burn debris from past hazard fuels projects at the Moose Creek and Lower Windy Patrol Cabins, as well as the Parker, New Thorofare, and New Birch Creek cabins. Some cutting/thinning will be done at Moose Creek Cabin. The cutting and burns will complete the cycle for the initial treatment of these sites. These sites will then enter a maintenance cycle. The fire crew documents hazard fuels thinning around backcountry structures using photos.

Defensible Space Projects planned for 2011:

Project Name	Date	Acres	Project Type	Comments
Moose Creek Patrol Cabin	08/2011	0.25	Complete Initial Treatment	Finish cutting; burn existing piles
Wilderness Access Center	08/2011	.25	Initial Treatment	Create defensible space
Water Facility	2011	.30	Initial Treatment	Create/improve defensible space
Headquarters Historic District	2011	1.0	Evaluate and maintenance	Evaluate structures and improve defensible space if needed

Throughout the defensible space project, fire staff provides Denali employees with project updates and other fire information. Hazard fuel success stories are posted at: http://www.nps.gov/fire/public/pub_firestories2011.cfm

Denali Fire Management and Fire Ecology Program

To maintain and understand fire-adapted ecosystems, the Alaska NPS Fire Ecology program provides science-based information to guide fire planning, decisions, and fire management practices. The program focus areas are: provide effective evaluation of Alaska NPS fire management program activities and fire on the landscape through *monitoring*, (2) coordinate *research* and facilitating the use of scientific data, modeling, and technology to enhance the fire management program, and (3) provide fire ecology *information and outreach* to fire managers,

other park staff, and the public. The Alaska NPS fire monitoring program is designed to determine whether fire and resource management objectives are being met, as well as to document any unexpected consequences of fire management activities.

Fire effects are monitored by establishing vegetation/soil plots in front of active fires or after fires to evaluate the changes as a result of fire on vegetation, wildlife habitat, or soils. Similarly, *hazard fuels reduction (thinning) treatment* effects are monitored by establishing vegetation/soil plots prior to hazard fuels reduction treatments and evaluating them before and after hazard fuels treatments. The fire ecology monitoring fieldwork in Denali is largely accomplished by Western Area Fire Management seasonal technicians and permanent staff, under the guidance of the regional fire ecologists.

Below are descriptions of fire ecology projects that were accomplished in 2010 and plans for 2011 field season in Denali.

❖ **Burn severity at Bear Creek**

In summer 2010, Fire Management staff coordinated with the Central Alaska Network to assess the burn severity on the Bear Creek mini-grid vegetation plots. The 2009 Bear Creek Fire burned several plots located in highly flammable black spruce lowland forest. Some of these plots had already burned once in 1997.

Fire staff photographed and recorded plant and ground cover at each plot affected by fire (see lower photo at right). In 2006, Plot 16 was in mixed white and black spruce forest with feather moss ground cover. One year after the moderate-high severity Bear Creek fire, horsetails and grasses dominate the ground. Most of the spruce were killed by the fire, however the fertile soils will provide a good seed-bed for re-establishment.

The level of burn severity at the recently-burned plots will be correlated to post-fire vegetation recovery patterns in future years.

Bear Creek Plot 16
Top: 2006
Bottom: 2010 (1 year after Bear Creek Fire)

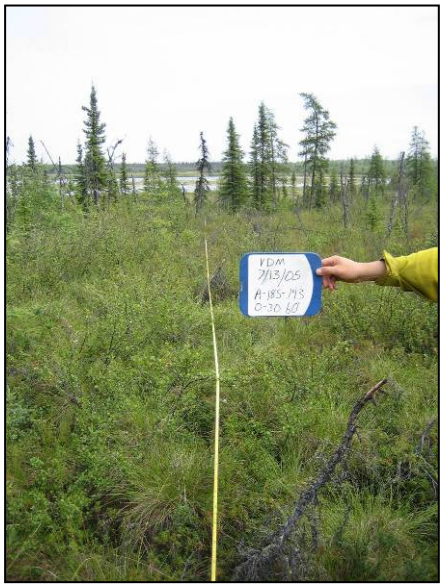
❖ **Effects of fire on landcover classification and vegetation browsed by moose**

One fire ecology project was established to meet multiple objectives: (1) update the recently-burned portions of the Denali Landcover Map, (2) test the use of videography as a method for landcover classification, (3) validate successional patterns in relationship to burn severity, and (4) 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. To determine the impacts of a short fire-return interval on vegetation, the vegetation and permafrost levels in these plots were re-measured in 2006. Understanding the natural variability related to

fire is necessary in order to identify potential effects associated with long-term climate change or management activities.

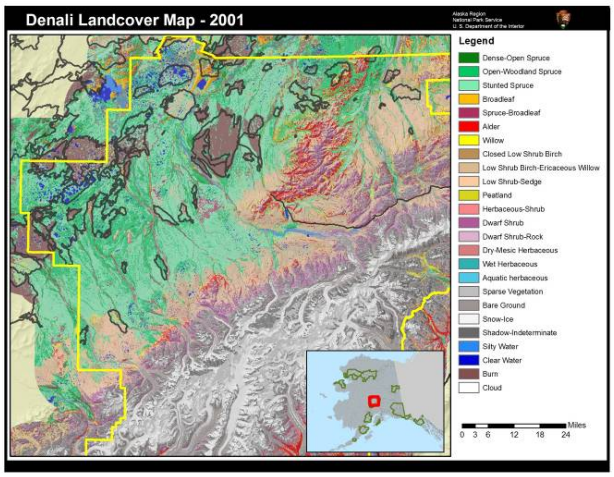
In 2011, fire management staff will remeasure 10 plots (including the one in photos below) that burned in 2005 (6 years post-fire) using the Alaska NPS Fire and Fuels Monitoring Protocol. The purpose is to assess impacts of a shortened fire-return interval (sites burned in 1986 or 1990 and again in 2005) on vegetation, fuels, wildlife browse, and permafrost.

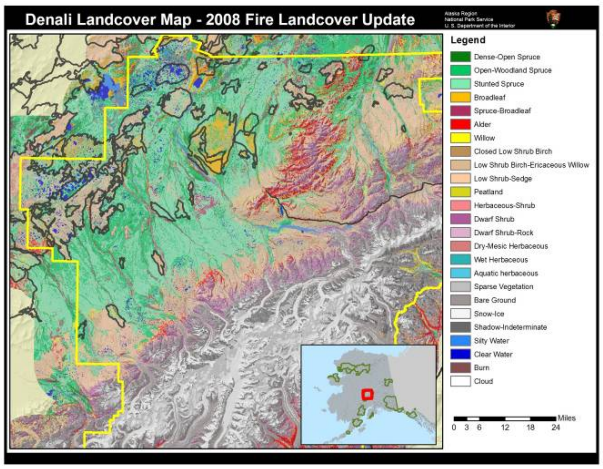


Left photo:
2005: 19 years after a 1986 fire, now dwarf birch and tussock tundra where it had presumably been woodland black spruce with tussock understory

2006: 1 year after the Highpower Creek Fire burned this plot again in 2005. The resilient tussocks have resprouted

The data from this study have been used to develop a landcover change matrix for vegetation that predicts changes in vegetation type based on pre-fire vegetation type, burn severity, and time since fire. The 2001 Denali Landcover map (below left) is outdated due to the large number of fires since 2001. To update the map (see 2008 map at right below), for each vegetation type that burned since 2001, a post-fire vegetation type was assigned based on burn severity and time since fire. Eighteen fires and approximately 400,000 acres were changed in the Landcover classification. The fire perimeters are shown as black outlines. Some areas that were spruce forest in the 2001 map are now classified low shrub-sedge or herbaceous vegetation types. Previously burned areas (brown in the 2001 map) have also been updated.





❖ **Hazard Fuels Treatment Monitoring**
Monitoring fire management fuels treatment projects is important for adaptive management. One of the first major hazard fuel reduction projects was conducted in at Park Headquarters, the Denali Visitor Center, Employee Housing, and the Toklat Roadcamp. The study to monitor these areas after they have been Firewised (reducing potential fuels for fires) is designed to (1) evaluate whether the hazard fuels prescription was implemented, (2) model the effects of the fuels treatment on potential fire behavior, and (3) monitor the effects of the fuels treatments on vegetation and fuels. Plots were established in 2003 (pre-thinning) and the thinning was completed in 2004. Re-measurements of the plots were taken in 2005 (1-year post thinning) and 2009 (5-years post thinning). A final report on this project will be completed in 2011.

Fire Education

✧ Western Area Fire Management, the Regional Fire Communication and Education Specialist, and MSLC staff will continue to incorporate wildland fire management messages in select presentations. In 2011, fire staff will provide fire ecology information during Denali Discover Camp.

✧ The Alaska Western Area fire staff will seek to promote the recently revised Alaska FIREWISE concept in 2011 and put on Firewise workshops that teach community members how to reduce the combustible material around their homes to reduce the risk of wildland fire.

✧ Each year Fire Management staff provides updated maps and informationon fires in and outside of the park. Fire danger information is also updated and posted at various locations. Two fact sheets are available—*Wildland Fire Rick and Response: Why are you cutting those trees?* and a new fact sheet *Where is all that smoke coming from?* that was produced in early 2011.

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 2010, staff distributed these materials around the park and will do so in 2011. 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 28 and September 28, 2010 from a helicopter, with fixed-wing aircraft support. Wildlife staff removed collars from 2 female grizzly bears in May and one in September. For the 2010 season, wildlife staff followed 7 collared bears (all female) for most of the season.

  At den emergence, out of 9 bears, three sows produced 7 cubs (2 litters of 2, one litter of three), and three sows started the season with 6 yearlings (litters of 3, 2, and 1). The remaining three sows did not have young. Only 2 cubs, in one litter, were alive, at the end of the season. Four of the 6 yearlings survived. The fate of the remaining 2 could not be determined since the sow's collar was removed in May. The oldest bear in the study is 22 years old.

  Plans for 2011 are to continue to remove radio collars as they come due for replacement. This part of the project is being phased out as the study shifts objectives and moves to a new area (North).

✧ **Grizzly bear monitoring – North**

The transition to a new grizzly bear monitoring study area was begun in 2009. The new study area in on the north side of the Outer Range mountains between the Kantishna Hills and the east end of the park. The objective of this study is to document ecology of grizzly bears and 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. GPS collars formerly used in the park's Road Studyare being deployed in this study as part of an effort to determine bear habitat use in relation to human activities, and possible climate-induced changes in vegetation patterns.

Bear capture was conducted from May 25 to 28, and September 28 to 29, 2010 from a helicopter, with fixed-wing aircraft support. A total of nineteen bears were captured, thirteen females and six males. Seven bears, captured for the first time, and 9 recaptured bears were fitted with GPS radio collars. Three bears were not collared, one because of incomplete sedation, and two because of sore necks from previous collars. One young male that had been collared in 2009 dropped his collar which was detected and picked up in May. Two male bears, one collared in May 2010 and one collared in May 2009, dropped collars in June and July. Four females produced a total of 8 cubs, all in litters of twins. One female had two 3-year olds, none had yearlings or 2-year olds. By late September only one cub remained. Neither of the two 3-year olds remained by season's end, but it could not be determined if they died or dispersed. Bears were radiotracked one to two times per month from May through November. No bears were located outside the park boundary on any flight. Finer resolution GPS data will not be available until September 2012 when GPS collars are scheduled to release. Travel by bears outside the park boundary will not be verified until after that time. There are currently 15 bears, all wearing GPS radio collars, in the study.

Plans for 2011 are to deploy 4 remaining GPS collars and check the fit of collars on young bears in May, and radio track all bears one to two times per month.

✧ **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 24, 2010 and September 13, 2010, 86 bear-human interactions were documented. These were classified 71 encounters and 15 incidents. The total of 86 BIMS this year marks a 12% decrease from the previous year's total of 98. Of those interactions rated as encounters, 17 occurred in the frontcountry and 54 occurred in the backcountry. Of the 15 interactions classified as incidents this season, four occurred in the front country while the other 11 occurred in backcountry (see table).

Interactions	FRONTCOUNTRY	BACKCOUNTRY	TOTAL
Observations	0	0	**0**
Encounters (when bear is aware of human and thus the bear's behavior is altered)	17	54	**71**
Incidents(when bear is involved in close charge, actual contact, or damage to human or property)	4	11	**15**
Control Actions	0	0	**0**
Total	**21**	**65**	**86**

Backcountry interactions between humans and bears increased from 59 in 2009 to 65 in 2010. This change is approximately a 10% increase. This marks the first increase in six years.

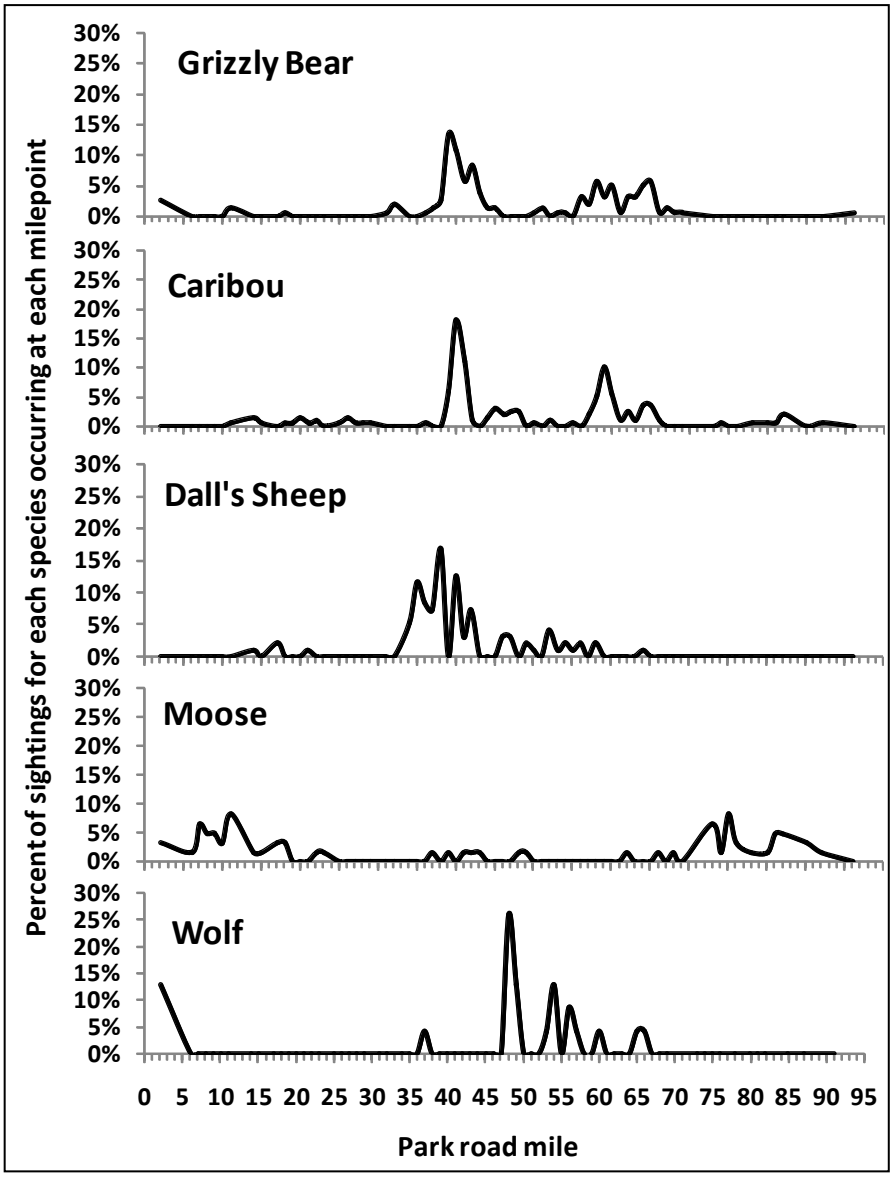
PLEASE HELP EMPHASIZE TO HIKERS AND VISITORS CAMPING IN CAMPGROUNDS AND BACKCOUNTRY AREAS the vital importance of preventing bears from obtaining human food.

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 2010. 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 2010, NPS staff rode buses with hand-held computers to record wildlife sightings. In total, 241 wildife stops were observed on westbound trips, west of Savage, going at least as far as the Eielson Visitor Center.

Based on these data, the percent chances of seeing at least one of the "big five" on a bus trip at least as far as Eielson Visitor Center in 2010 were:
100% for grizzly bears,
85% for caribou,
96% for Dall's sheep,
42% for moose, and
54% for wolves (the 2010 wolf sighting probability was the highest during 1999 – 2010; the second highest was 38% in 2005).

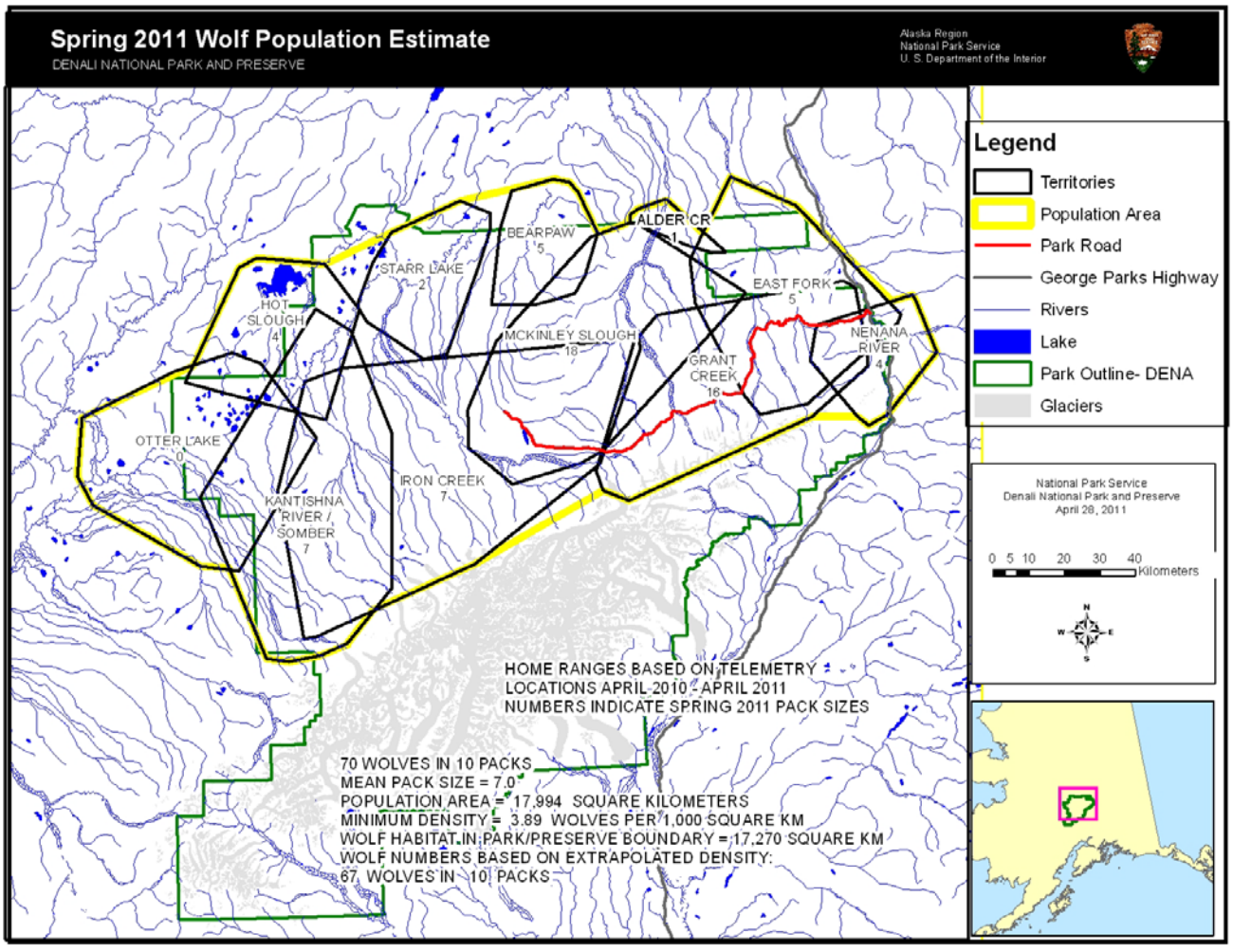
The average percent chances over the last 12 years (1999-2010) were
84% for grizzly bears,
91% for caribou,
82% for Dall's sheep,
40% for moose, and
23% for wolves.

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. Intensive research was concluded in 1993, but research and monitoring efforts continue.

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.



Spring 2011 wolf pack territories and population estimate for Denali.

As of April 15, 2011, there were 10 wolf packs in Denali with collared wolves in them. Eight wolves 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. In spring 2011, an additional 6 wolves were collared with GPS/ARGOS collars that determine the wolf's location every 3 hours and upload the data. These wolves were from three packs (East Fork, Grant Creek, and McKinley Slough) that live near the park road. These collars are programmed to detach from the wolves in fall 2012.

In April 2011, there were 70 wolves in the 10 packs being monitored by park biologists. The estimated density of wolves in Denali (about 10.07 wolves per 1000 square miles or 3.89 wolves per 1000 square kilometers) was an increase from last year's estimate of 9.0 wolves per 1000 square miles or 3.5 wolves per 1000 square kilometers.

Biologists captured and radio-collared 19 wolves during the winter 2010-2011. Four radio-collared wolves were killed by humans during the winter, in widely scattered locations ranging from Telida to Healy. Six collared wolves died of natural causes during the same period.

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 24 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 50 percent of the calves produced were recruited into the herd. With the onset of a period of severe winters in 1988, caribou numbers plateaued at about 3,200 in fall 1989 and then declined by over a third by fall 1992. 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 5 percent. During 1992-2003, with a return to moderate winter snowfall, the caribou herd continued to decline, but at a much slower rate of about 2.5 percent annually. Adult cow survival was comparable to the period of herd growth in the mid-1980s, but calf recruitment continued to be very low (13:100 during 1992-2003 compared to 35:100 during 1984-88).

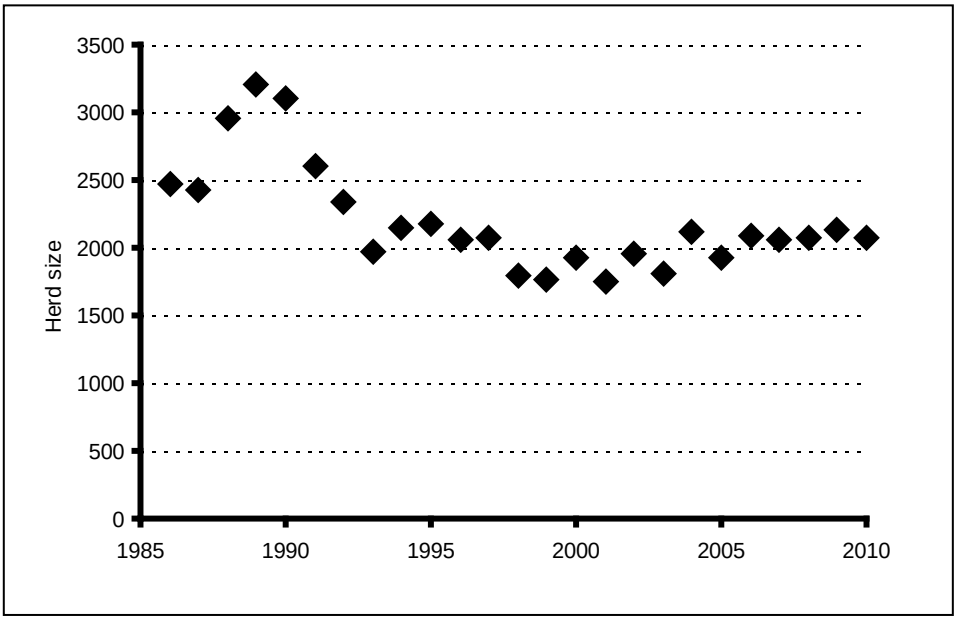
With the overall decline in calf recruitment during 1990-2003, the female age structure became heavily weighted towards older females. In May 2002, an estimated 24% of the females in the herd were $\geq$ 13 years old. As a result of these old females dying, adult female survival was low in the 2002-03 and 2003-04 winters (average = 83%) even though winter snowfalls were substantially below average. These survival rates are comparable to rates measured during the extreme winters of 1990-93. 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. During the last 7 years (2004-10), calf recruitment has increased to an average of 22 calves:100 cows in late September and recruitment of female calves has essentially balanced adult female mortality. The age structure is still weighted disproportionately to older females (15% females ≥ 13 years old in May 2010) and therefore susceptible to a large decline should the region experience a severe winter.

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.

Sixty-nine percent of the observed mortality of adult males occurring during August – November. However, it appears that much of this mortality may actually occur during an even narrower period. Layne Adams has increased radiotracking effort during that period to improve estimates of the timing of male mortality.

Herd size. A tentative estimate of herd size in late September 2010 was 2,070 caribou with little noticeable change during the last 7 years (see graph at right). During the last 7 years, there have been 22 calves for every 100 cows (calf:cow ratio), a 70 percent increase over the previous 14 years.



Adult Sex Ratios. During the September 2010 composition survey, there was a ratio of 42 bulls: 100 cows, the highest since 1992. 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 7 years, the sex ratio has averaged 37:100.

Calf Production And Survival. In mid-May 2009, Layne Adams estimated that 74 percent of cows one year or older produced young, based on observations of 66 radio-collared cows in the age-structured sample. Such birth (natality) rates have averaged 78 percent over the course of the study. Of the 17 non-pregnant radio-collared females, 8 were yearlings, and 6 were 2-year-olds (thus most non-pregnant cows were less than two-years-old). The remaining 3 non-pregnant individuals were 3, 5, and 8 years of age.

During the annual census and post-calving composition survey in early June 2010, Layne Adams observed a calf : cow ratio of 30 calves for every 100 cows. By late September, the calf:cow ratio had declined to 20:100, indicating that only 26 percent of the 2010 calf cohort had survived to September. The average of calf survival to fall (estimates) has been 28 percent over the last 7 years compared to 15 percent during 1991-2003. 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 (16 percent) over the previous year.

Female Survival and Age Structure. During the sampling year (October 2009 – September 2010), 11radio-collared cow caribou from the age-structured population died, resulting in an annual mortality rate of 16 percent, higher than the study average of 12 percent (range 2-23 percent). The female age structure in May 2010 reflected the improved recruitment of calves over the last 6 cohorts, as well as the losses of females ≥ 13 years old, and as a result the proportion of these older females has declined over the last few years.

Adult Bull Survival. During the three years that bull survival has been evaluated (September 2007-September 2010), of the 133 bulls that were collared (97 as adults: 45 in 2007 and 12 in 2008, 15 in 2009, 25 in 2010; plus 36 10-month old calves—12 each March since 2008), 45 have died. Suspected causes of death included wolves (21), bears (9), unknown large predator (7), unknown (6), and capture-related (2). The annual survival rate for adult bulls has averaged 0.74, substantially lower than 0.88, the long-term average estimated survival rate for adult females.

Bull Growth Patterns. Eighty-five (85) of the 97 adult bulls captured since 2007 were weighed and had body masses ranging from 205 to 581 lbs (93 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.

Antler length was strongly correlated with body mass and increased with age in a similar pattern to body mass. Average antler lengths averaged 120 cm (~4 feet) for bulls ≥ 5 years of age. Caribou antlers become wider (spread) and more complex (more points) with increasing age and body mass.

Planned Activities. In the 2010-2011 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 2007-2009 cohorts, and capture 12 10-month-old males (from the 2010 cohort) to assess age-specific growth and survival, and seasonal distribution.

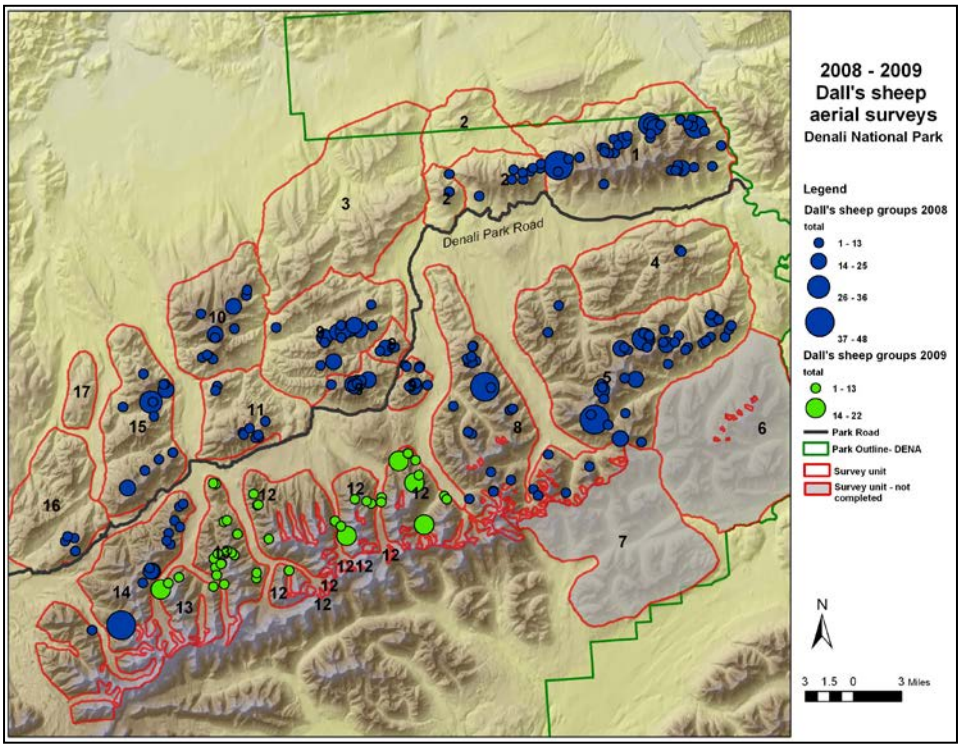
3. Locate all instrumented caribou in late November, late January, mid-March, late April, mid-May, early June, late July, and late September, or as needed to meet study objectives.

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.

Biologists from the Central Alaska and Arctic Monitoring Networks have worked to develop more economical and statistically reliable methods of surveying Dall's sheep. The method that has been developed involves surveying sheep along randomly generated altitudinal transects and

using distance sampling methods to estimate sheep numbers and composition. A survey using this method will be attempted in Denali in July 2011.

Ground-based surveys. In 2008, 2009, and 2010, 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 9, 2010 on Mt. Wright, Tatler Creek, Cathedral Mountain, Sable Mountain, Polychrome Mountain, and the East Branch of the Toklat River. These surveys classified 184 sheep. The lamb productivity estimate was 29 lambs per 100 ewes, somwhat lower than the estimates of 40 lambs per 100 ewes in 2008 and 38 lambs per 100 ewes in 2009.

Small Mammal Monitoring

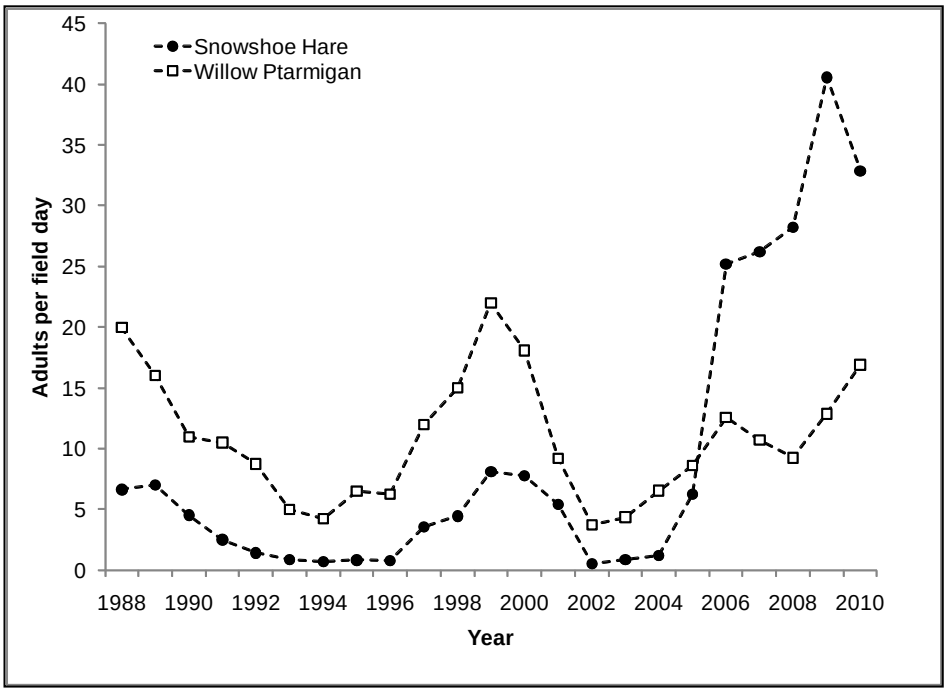
Vole populations of three species of voles in Denali have been monitored since 1992 using mark-recapture methods, and will continue to be monitored as part of the Central Alaska Network "Vital Signs" Monitoring Program. The three vole species are northern red-backed vole (*Myodes rutilus*), tundra vole (*Microtus oeconomus*), and singing vole (*Microtus miurus*). using mark-recapture methods. In 2010, Melanie Flamme, wildlife biologist with Yukon-Charley Rivers National Preserve (and with the Central Alaska Network Monitoring Program), coordinated the nineteenth 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 two forested ridge plots). 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 10-13, 2010. 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.

In 2010, Flamme detected a population crash at the Rock Creek legacy plots. Of the 5200 trap checks completed over the 4-day trapping session, there were only 84 total vole captures (both new and recaptures), including red-backed voles (n=58), singing voles (n= 10), and tundra voles (n=16). This is in contrast to the 1301 total vole captures in 2008 and to the 611 total vole captures in 2009. Conditions on the trapping plots were much dryer than in previous years with boggy areas being devoid of water, though blueberry crops were abundant. Unusually warm weather in May and dry summer weather may have contributed to the low population this year.

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 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.

Snowshoe Hare and Willow Ptarmigan

NPS biologists in Denali calculate annual indices of abundance for snowshoe hare and willow ptarmigan by recording the number of adults of each species observed during routine field activities from late April through June. These data allow biologists to identify the frequency and magnitude of the population cycles of each species over time. ADF&G biologists are conducting similar counts during Breeding Bird Surveys near Delta Junction and new efforts are underway to conduct similar counts across the road system in interior and northern Alaska.



Compared to 2009, the abundance of adult snowshoe hare decreased and the abundance of adult willow ptarmigan increased (see figure).

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 169 species of birds documented in Denali, 65 (38%) 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 and 2010, scientists tested a repeat-survey approach in Denali. This approach repeats a series of standardized surveys across the breeding season.

  On-road surveys. Have you ever wondered about those people who are standing along the Denali park road very early in the morning, clipboards in hand and binoculars held up to their eyes? These are the biologists conducting the on-road bird surveys for the Central Alaska Monitoring Network. From late April through June, 2010, these biologists

conducted standardized bird surveys along the three roadside survey routes in Denali (see table below). Each survey route contains 50 sampling points spaced approximately ½ mile apart. At each survey point, biologists conducted standardized 3-minute surveys and recorded all bird heard and all bird seen within ¼ mile of the point. The surveys start ½ hour before sunrise and end about five hours later.

Observers (and listeners) detected 63 species on the road-side surveys in 2010.

Route	Number of repeat surveys	First and last survey dates	Number of bird species detected for all surveys	Most commonly detected species
1	7	April 22 – June 21	40	American Robin, Orange-crowned Warbler, Wilson's Warbler, American Tree Sparrow, Fox Sparrow, White-crowned Sparrow, and Dark-eyed Junco
2	6	May 5 – June 23	39	Willow Ptarmigan, Orange-crowned Warbler, American Tree Sparrow, Fox Sparrow, White-crowned Sparrow, and Dark-eyed Junco
3	4	May 19 – June 24	45	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 instances, over the past 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.

In 2011, this project will continue with surveys in Denali, Wrangell-St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve.

- **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 15, 2010. The species with the most detections on the Savage BBS in 2010 included Wilson's Warbler, American Tree Sparrow, Fox Sparrow, and White-crowned Sparrow. The Toklat BBS route was completed on June 16, 2010. The species with the most detections on the Toklat BBS route in 2010 included

Orange-crowned Warbler, American Tree Sparrow, Savannah Sparrow, Fox Sparrow and White-crowned Sparrow.

National Park Service biologists will complete the two BBS routes in Denali in June 2011. 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) marking the 23rd 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 2010, the occupancy rate of Golden Eagle nesting territories (94%) 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 = 49) was higher than average (43.2), but short of the best years when 70 to 76 fledglings were produced.

  Park biologists monitored 9 Gyrfalcon nesting territories in 2010. 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 continued to note 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.

  This project will continue in 2011.

- **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 2010 Denali CBC was held on December

18, 2010 and 13 participants enjoyed warm temperatures (1° to 5° F) and recorded 9 species plus one unidentified woodpecker on the count day including Spruce Grouse, Black-backed OR Three-toed Woodpecker, Gray Jay, Black-billed Magpie, Common Raven, Black-capped Chickadee, Boreal Chickadee, Pine Grosbeak, White-winged Crossbill, and Common Redpoll.
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 2010. 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 2010 the distribution and occurrence of a suite of 34 bird species of conservation concern. Several park rangers also participated in the study in 2010. 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 2011.

- **Abundance and distribution of boreal forest wetland birds:** NPS biologists started a new field study in June 2010 in the northwestern region of Denali to 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. Boreal forest wetlands 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.

In 2010, NPS biologists surveyed wetlands near Somber and Barren Creek. In 2011, NPS biologists will survey wetlands in the upper Foraker River area and the Clearwater Creek area near Turtle Hill.

- **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. In 2010, the FWS conducted the statewide trumpeter swan surveys using a new sampling approach. This approach allowed the FWS to continue monitoring the abundance and distribution of trumpeter swans in Alaska.

  In and near Denali, the numbers of trumpeter swans increased along with the statewide population – from about 43 in 1968 to over 1000 in 2010. Over the last 40 years, trumpeter swans have dispersed across the vast wetlands in the northwest and southwest regions of Denali and as their population grew and dispersed, swans started to use higher elevation ponds and lakes across Denali. For instance, in 2010, a pair of non-breeding trumpeter swans spent most of the summer on a large lake on the east side of the Sanctuary River, just east of Double Mountain.

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.

Physical Resources

Changes in Physical Resources Leadership

There have been major personnel changes in the Physical Sciences Branch of the Denali's Resources Division. Guy Adema, Physical Sciences Program Manager, accepted a position as Natural Resources Team Manager at the NPS Alaska Regional Office, beginning in early 2011. To continue the commitment to physical sciences at Denali:

- Denny Capps was hired as the new Park Geologist. Denny's past university degree emphases have been in environmental geology, Quaternary geology and geomorphology, and geologic hazards. Denny has worked in Yellowstone, Glacier, and Klondike and has also conducted research in Glacier Bay and Wrangell-St. Elias before coming to Denali. He is excited to bring his experience as a university educator to the park.
- Rob Burrows was hired as a term Physical Sciences Technician to conduct glacier monitoring and permafrost monitoring. Before coming to Denali, Rob was at North Cascades for nine years in resource management (including glacier monitoring for North Cascades and for Mount Rainier) and as a backcountry ranger.
- Guy Adema's former position will be filled sometime in 2011.

Parkwide Climate Monitoring

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. Climate monitoring continues at 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 (especially helpful for weather forecasting related to fires), the National Weather Service (NWS), researchers, and the public.

Several large scale climate patterns affect the air temperatures in Denali:

(1) Pacific Ocean indices

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 between warmer and cooler occurring approximately every 20 – 30 years. A sudden shift occurred in 1976 from the cooler regime to a warmer regime. There is speculation that the PDO has entered another cool phase that may have started back in late 1998. The shift has not been as clear as the one in 1976. There have been several shorter duration cool and warm phases since 1998, but negative (cooler) values have dominated. A lack of PDO understanding makes it impossible to determine true PDO reversals soon after they occur.

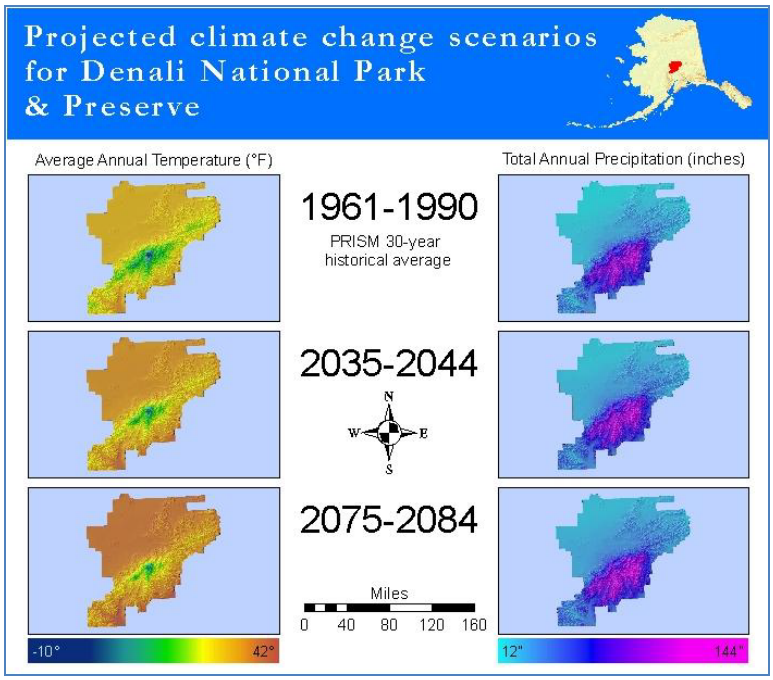
(2) Extent of sea ice in the Arctic Ocean
The Arctic Ocean, and, in particular, the extent of sea ice plays a crucial role in the Arctic climate. Reduction of ice extent leads to warming due to increased absorption of solar radiation at the surface. Over the past few years there has been significant 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.

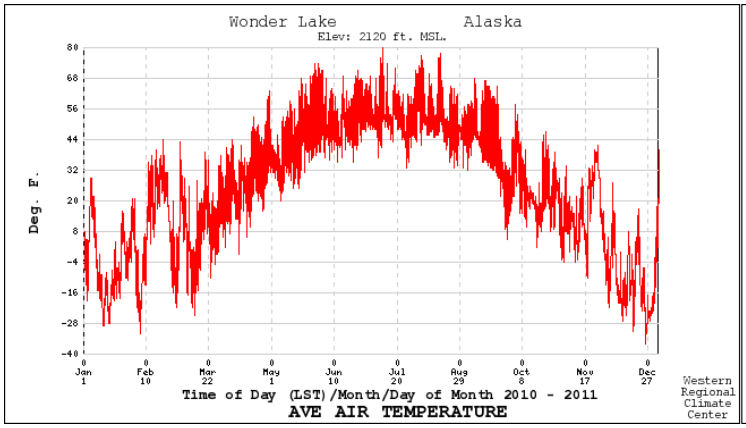
Annual data reports are available from the Central Alaska Network website at http://science.nature.nps.gov/im/units/cakn/reportpubs.cfm. Most of the stations are automated and send hourly data via satellite.

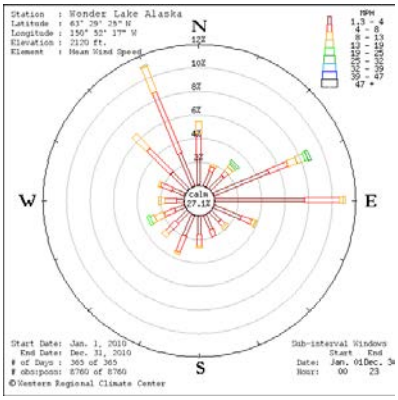
Climate data from NPS sites provide critical observations that contribute to, refine, and validate regional climate models that have been down-scaled from global circulation models. These models can be used to estimate future temperature and precipitation values within the park. According to the model below, which assumes a steady increase in CO_2 emissions over the next several decades, Denali is projected to become warmer and drier over the next century.

The challenges associated with climate change science transcend political and jurisdictional boundaries and require a more networked approach to conservation. The NPS is partnering with other state and federal agencies through newly formed Landscape Conservation Cooperatives (LCCs) that leverage resources and strategically target science to inform conservation decisions and actions. These LCC partnerships can accomplish more together than any single agency or organization alone.



Data summaries and data analysis tools are available at http://www.wrcc.dri.edu/NPS. Below are examples of the kind of data summaries that are available from the website:





Weather Monitoring at Park Headquarters

Weather information has been collected at Park Headquarters for more than eight decades. This long-term weather station was upgraded in June 2010 (see before and after photos below) with a new fence, new instrument shelters, and an interpretive sign. The National Weather Service was interested in giving the site the recognition and attention it deserved. It is one of the longest and most valuable climate records we have for the Central Alaska Network.

Below are **summaries of the 2010 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 2010 data.

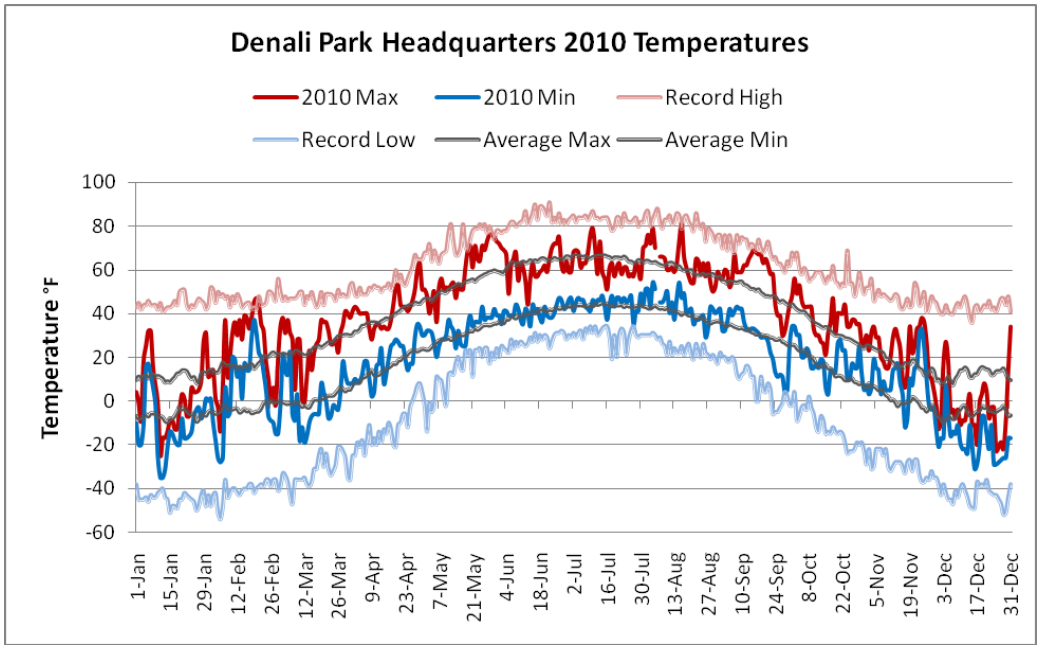
Weather Notes for 2010:

- The mean annual temperature was 0.5° F above the long-term average
- February 2010 was 6.6°F warmer than normal; November was 6.2°F warmer than normal
- December was 14.1°F colder than normal, the 7th coldest on record
- Every month was drier than normal in 2010, except July
- October 2010 was the 4th driest on record

Temperature:

- Maximum temperature 81° F on August 16; an all time record for this date
- Minimum temperature -35°F on January 12
- Mean annual air temperature 27.7°F (0.5° above historical average of 27.2°F)

Denali Headquarters **Average Monthly Temperatures** (°F)		
	2010	Historic Average
January	-4.2	*2.1*
February	13.3	*6.7*
March	13.0	*13.1*
April	31.0	*27.3*
May	45.5	*41.7*
June	51.4	*52.1*
July	53.6	*54.9*
August	53.2	*50.7*
September	42.3	*41.0*
October	28.0	*24.1*
November	15.6	*9.4*
December	-10.8	*3.3*
Yearly Average	**27.7**	***27.2***



Precipitation

- Total Precipitation 10.75 inches
- Departure from Normal -4.25 inches
- Max. 24 hr precipitation 0.69 inches on June 13
- Total Snowfall 47.0 inches from July 1 to June 30
- Departure from normal -32.5 inches
- Maximum 24 hr snowfall 3.4 inches on March 9

Denali Headquarters Monthly **Precipitation** (in)		
	2010	Historic Average
January	0.33	*0.73*
February	0.20	*0.58*
March	0.38	*0.43*
April	0.26	*0.44*
May	0.67	*0.79*
June	3.23	*2.21*
July	2.38	*2.99*
August	1.94	*2.72*
September	0.50	*1.58*
October	0.18	*0.96*
November	0.67	*0.76*
December	0.64	*0.82*
Yearly Total	**10.75**	***15.00***

2010 Record-Breaking Weather at Denali Park Headquarters

February 19, 20: High temperatures of 45° and 47°F, respectively
(previous records were 43° and 42° in 1934, 2008 respectively)
May 30: High temperature of 75°F (previous record 74°F in 1981)

Snow Surveys

In the winter of 2009-2010, 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 2009–2010 season:

At Denali Park Headquarters, the day of the first persistent snow was October 27, a few weeks later than normal. On December 1, there was 6 inches of snow at park headquarters, which is 60 percent of normal. The first measurable snow that persisted on the south side of the Alaska Range in the Tokositna Valley was on October 19, 2009. On December 1, the Tokositna SNOTEL reported 21 inches of snow with 3.2 inches of water content, which is 80 percent of average.

By February 1, the snowpack north of the Alaska Range was well below normal, Kantishna had 13 inches of snow with a snow water content of 1.9 inches, normal is 26 inches of snow with a water content of 4.5 inches. The Lake Minchumina snow course, which has been in operation since 1967, recorded 1.0 inch of snow water content for February 1, a record low for that location. The sites at and around Denali Park headquarters were between 50-75percent of normal with depths around 12 inches and snow water content ranging from 32-43 percent of normal. Throughout March and April the conditions remained about the same. As temperatures warmed in April the snowpack decreased; on May 1 most of the sites sampled in the region recorded 0 inches of snow.

The snowpack also remained below normal on the south side of the Alaska Range for the season, with little additional snow accumulation in February and March. By April 1, the aerial snow

markers in this area were about 59 percent of average. Nugget Bench was at 67 percent of average and Dutch Hills had 45 inches of snow with an estimated 14 inches of water content, 51 percent of average. This is a record low water content for this location. These two sites are located between the Peters and Dutch Hills on the south side. This area had some snow accumulation in April, and by the May 1 survey the snow courses were about 68 percent of average.

The Kantishna SNOTEL site recorded 3.0 inches of total winter precipitation (snow water equivalent) from October 1, 2009 through May 1, 2010, 12.5 percent of the total annual precipitation of 24.0 inches. The McKinley Park long-term NWS site was 60 percent of normal for the year with an annual total of 47.0 inches of snow, the average snowfall is 79.5 inches. The precipitation gage at Tokositna Valley recorded 15.8 inches of precipitation from October 1, 2009 through May 1, 2010, which is 6.3 inches below the 1971-2000 normal. This is 39 percent of the total annual precipitation of 40.2 inches for the 2010 water year.

Air Quality Monitoring

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

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

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

Over the next three to four years, park staff will be working with Cathy Cahill, an atmospheric chemist from the University of Alaska Fairbanks, and Josh Schmidt, a statistician working for the Central Alaska Vital Signs Monitoring Network, to analyze thirty years of air quality monitoring data from Denali to provide a comprehensive analysis of air quality status and trends.

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 at www.nature.nps.gov/air/WebCams/parks/denacam/denacam.cfm.

Monitoring Landslide at Mile 45

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 at Mile 45 of the park road. The annual survey of the slump (landslide) at Milepost 45 did not occur in 2009 or 2010. A re-survey is slated for summer 2011.

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. 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 possibly 10 years.

Paleontological Survey of the Lower Cantwell Formation

There were three exciting new finds during 2010 paleontological inventory efforts, all in the Lower Cantwell Formation, a geologic unit which contains significant dinosaur fossils.

(1) During a trip to the Sable Mountain area (reconnaissance for a Murie Science and Learning Center field course), David Tomeo (MSLC) and Chad Hults (NPS, USGS) discovered a new type of dinosaur track. Although it appears similar to a theropod with long, thin toes, the track undoubtedly has four toes. Dr. Anthony Fiorillo of the Museum of Nature and Science in Dallas, Texas is researching what species made this track.

(2) Alex de Moor, a GeoCorps intern, found another Cretaceous bivalve site near the East Fork Toklat River when on a field excursion with other GeoCorps interns, park staff, and UAF researchers. An abundance of wood and plant debris near the bivalves is an indication of a freshwater ecosystem.

(3) Field teams discovered two new hadrosaur trackways—one poorly preserved trackway in vertically bedded strata on Cabin Peak and another near Sable Mountain.

In addition to these finds, geologists found hundreds of plant specimens, including abundant angiosperm leaves and gymnosperm needles.

The paleontological surveys involved over a month of fieldwork by GeoCorps paleontology interns, made available through a partnership between the National Park Service and the Geological Society of America; Dr. Tony Fiorillo (see also page 70); Todd Jacobus and Susana Salazar, graduate students at the University of Alaska Fairbanks; and Chad Hults, USGS. The field work focused mostly in the Polychrome, East Fork Toklat, and Sable regions.

During 2010, paleontological staff created a digital database for recording and organizing paleontological resources. The Microsoft Access database now incorporates over 210 fossil sites and 345 fossil specimens in the Cantwell Formation alone. Data from the 2006 through 2010 field seasons was recorded, including condition evaluation, location, notes, and linked photos. Data can be easily exported for GIS mapping of sites. The database will be useful for monitoring sensitive paleontological resources and tracking the inventory's progress. The inventory effort will continue in 2011 with GeoCorps paleo interns focusing on reconnaissance style field work to Mt Galen, Mt Sheldon, Double Mountain, and areas farther from the park road. Some time will be spent reviewing documented sites and providing updated evaluations of site condition.

Taking Photos at Cabin Peak for 3-D Dino-Footprints

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). The surface is unfortunately breaking up as it slumps down the side of Cabin Peak. The slumping is advanced enough that the fault scarps are visible from the air and it is possible that someday this unique site will slide down the mountain. This project will generate detailed 3D-digital images of the panels.

In August 2010, a field team of 2-4 people was slated to arrive at the park to obtain photogrammetry of these panels. Field details and methodologies were not worked out for 2010, and the project will take place in 2011 instead. The team will consist of a pair of experts from UNAVCO coordinating with Tony Fiorillo's paleontological team.

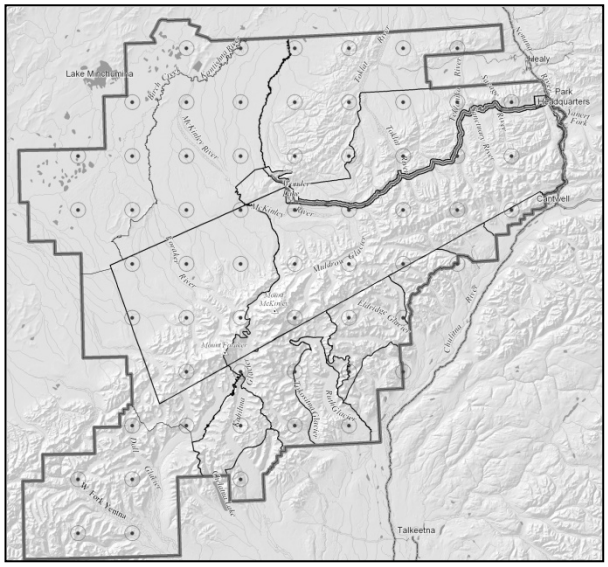
The work will be coordinated through UNAVCO, a non-profit consortium (based in Boulder, Colorado) that facilitates geoscience research and education using geodesy. Two staff from UNAVCO will use Terrestrial Laser Scanning to generate LiDAR (light detection and ranging) point clouds for the surface at Cabin Peak. LiDAR uses light to detect the distances to an object, making it possible to create a surface "map" of the panels. LiDAR will provide the ability to capture the larger-scale features of the entire surface in digital format. It won't be able to capture the fine details such as the invertebrate traces that tell about climate and time of year of formation, or the small bird tracks—because the data storage for capturing the equally important fine details of the surface is prohibitive due to file size.

Thus the best approach will combine UNAVCO's LiDAR with the making of larger molds of representative sections of the surface. Tony Fiorillo will make these molds to record the fine details. After the field work, Fiorillo will work with a local company in Dallas, Texas that can generate high-resolution digital files of casts made from these molds. The combination of the two methods will provide the Park a detailed datum recording the current state of preservation of this very important resource.

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.

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 12000+ 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 a sound 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 fifth season of a revised systematic sampling plan in 2010, deploying six automated sound monitoring stations (see photo) and rotating them among 10 locations. These locations were: 1 winter-season site, 6 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 41 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 software package developed by the NPS Natural Sounds Program Center 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, Denali developed two additional tools to visualize the timing and regularity of acoustic events.

In 2011, sound stations will be placed at six more Inventory & Montoring grid points, as well as two additional points of management interest which will correspond to the 2011 Soundscapes Social Survey. The Social Survey stations will be deployed at 7800 foot camp on the Kahiltna Glacier and the North end of the Triple Lakes Trail. The I&M grid point off the McKinley Bar Trail will satisfy three separate purposes – as part of the baseline inventory, the Social Survey, and by repeating measurements collected in 2005. A winterized station was installed in January of

2011 on the Stampede Airstrip with assistance from the Park Kennels. The station will inventory aircraft and snowmobile events in the area.

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.

Glacier Monitoring

Rob Burrows arrived in Spring 2011 as a new Physical Science Technician and will take the lead for Denali's glacier monitoring program. Although Guy Adema is now in the NPS Alaska Regional Office in Anchorage as the Natural Resources Team Manager, he will continue to be involved with Denali's glaciers. Denny Capps, the new Park Geologist, will be closely involved too.

Glacier Monitoring Protocol for Central Alaska Network.

In 2010, Guy and Rob produced a new protocol for monitoring glaciers to be used in the two "glacier parks" in the Central Alaska Network (CAKN)—both Denali and Wrangell-St. Elias have glaciers. The document is currently out for peer review.

A summary article on Denali's glaciers (monitoring and research) will be published in *Park Science* sometime in 2011. The first CAKN glacier monitoring annual report is available at http://science.nature.nps.gov/im/units/cakn/Documents/2010reports/CAKN_Glacier_Annual_Report_2010_nrpc.pdf

Gigapixel Panorama Photography for Monitoring.

As part of glacier monitoring, park glaciologists will continue use repeat photography of Denali's glaciers to show dramatic and subtle changes over time. Panoramic photos have been taken at the glaciers with index station (Kahiltna and Traleika) every fall and spring, and at other select glaciers that have a repeat photography record or are of interest and should have a record captured in photography.

Beginning in 2010, new detailed panoramic photos of gigapixel size will be taken of glaciers as part of glacier monitoring. These photos are accomplished with a camera mounted on a tripod with a rotating robotic head and a motorized arm to trigger the shutter button. When the robotic

head starts its work, the robot moves the camera in small increments and triggers the shutter for a new photo at each small incremental move. The camera is zoomed in on the glacial landscape to get the most detailed view possible. With a slight overlap of frames, the multiple photos are "stitched" together into a gigapixel image using appropriate software. The photos provide fine detail because each photo takes only a fraction of the view at very high resolution. Once lots of photos are stitchedtogether, details of the bedrock, ice, and morainal features near glaciers can be seen by zooming in on the panoramic photo.

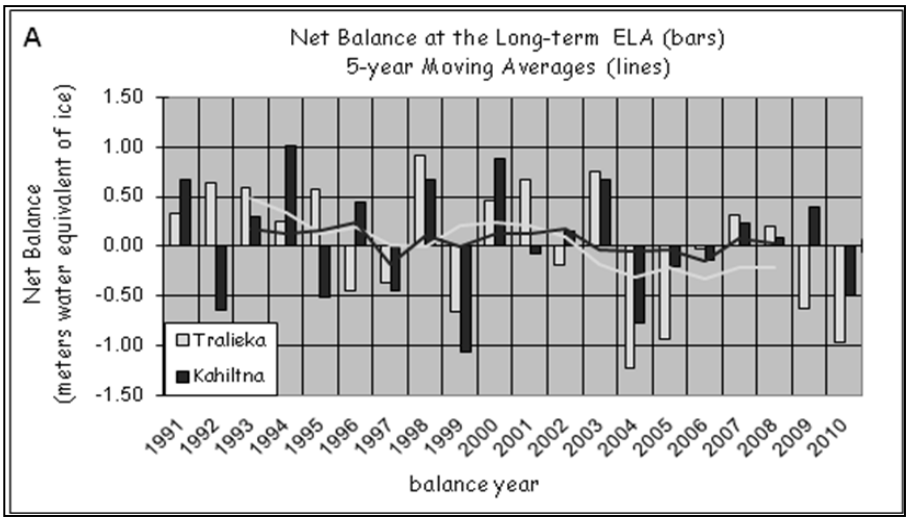
The gigapixel panoramas taken in the park in 2010 can be viewed at http://www.gigapan.org/profiles/27054/ More photos are planned and will be added to the site.

A gigapixel panorama of the Muldrow Glacier from Oastler Pass in May 2010. The view spans approximately 180 degrees. Note the zoomed views of the helicopter on the lower left and the Traleika Index Site on the lower right.

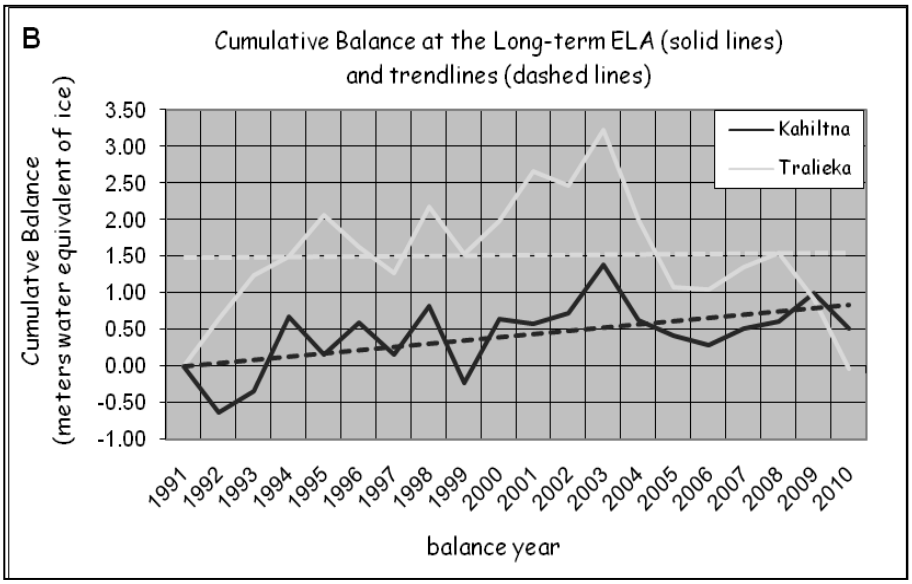
Traleika and Kahiltna Glaciers (Index Sites). In 1991, Denali researchers established long-term glacier monitoring sites on the Traleika and Kahiltna Glaciers to monitor long-term glacier flow and mass balance changes. These glaciers were selected to compare glaciers on the north (Traleika) and south (Kahiltna) sides of the Alaska Range (drier and wetter climates, respectively).

Measurements of snow depth and snow/ice loss are taken during a spring visit and a fall visit at a single "index" stake placed vertically into the ice. Each stake is located on each glacier near the long-term equilibrium line altitude (ELA). This location can be used to approximate the balance of the entire glacier. The measurements track the snow water equivalent of total winter snowfall (winter balance) and the water equivalent of summer melt (summer balance). The difference is the net balance. In the case of a positive net balance year, snow is leftover at the end of the summer melt season and the site has gained mass. In a negative net balance year, additional firn and ice melt away and the site loses mass.

Based on how net balance measurements change with elevation, the values determined at Denali's index stakes can be used to estimate the balance of the entire glacier. Given the huge areas of these glaciers, these estimates carry quite a bit of uncertainty. The best estimates are shown in the graphs below.



The Kahiltna and Traleika net balance values (graph a) often track the same direction (positive or negative) in a given year, but not always, demonstrating the distinction between the climate zones on the north and south side of the Alaska Range.



Both glaciers show similar short-term cumulative trends (graph b), but the Kahiltna (lower graph) has an overall positive trend and Traleika (upper graph) has an overall neutral trend.

How can these glaciers (Kahiltna and Tralieka) be accumulating snow and ice, or at least not losing ice, in the face of a warming climate? These local Denali trends may be surprising given the trends of glaciers further south in Alaska and all over the world. These two glaciers originate from the highest peak in North America which sits in a cold continental climate, thus they may be expected to be "hold outs." Climate data for Interior subarctic Alaska is also different than the trend seen in the Gulf of Alaska region and in the Arctic.

Monitoring Other Glaciers with GPS Surveys and Comparative Photography. The glaciers that exist at lower elevations in Denali are not faring as well as Traleika and Kahiltna. All of the glaciers monitored by repeat GPS surveys and comparative photography show significant retreat and thinning. The latest survey of East Fork Toklat Glacier on September 21, 2010 shows 50 to 120 m (160 to 400 feet) of ice loss since 1954 from near the top to the terminus of the glacier, respectively. Many other glaciers surveyed or photographed in the last decade show this persistent trend such as Middle Fork Toklat, West Fork Cantwell, Sunrise, Sunset, Hidden Creek, Polychrome, Herron, and Foraker Glaciers.

Surging Glaciers. No glaciers in Denali are known to be surging as of April 2011.

Monitoring the Muldrow Glacier. The Muldrow Glacier 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 baseline of what a glacier is like in the quiescent phase.

Denali staff have monitored ice elevations and flow rates of the Muldrow Glacier since 1992. The average annual flow rate of Muldrow has varied from 40 to 140 meters/year (130 to 460 feet/year). The highest value of 140 meters/year was measured between September 1, 2009 and May 18, 2010. Checking the monument in 2011 will confirm whether this is an anomalously high rate, or whether the wind may have blown the monument down glacier.

To further analyze where the Muldrow Glacier ice volume is changing, St. Mary's University of Minnesota digitized and created a new digital elevation model of Bradford Washburn's 1970 mapping survey of the glacier surface. This model will facilitate comparison with the 1950s mapping and the 2006 LiDAR map of the glacier.

* * *

Long-term monitoring of glaciers will continue in 2011 following and refining the protocol and standard operating procedures that we developed this past year. We will obtain gigapixel photography on a new suite of glaciers; possible visits this year include the Kahiltna Glacier terminus, Middle Fork Toklat Glacier, Polychrome Glacier. Along with the photography, we plan to resurvey the termini of these glaciers and, if possible, completely re-map the Polychrome Glaciers.

Glacier Research

Spatial Patterns of Mass Balance on the Kahiltna. Joanna Young, a M.S. student working under Dr. Anthony Arendt at University of Alaska Fairbanks is assessing spatial patterns of mass balance on the Kahiltna Glacier. For her second and final field season (2011), she is placing balance stakes on the lower glacier in the spring and will check them again in late August. She also set up a weather station on the lower glacier. The balance and meteorological data will help to validate a mass balance model for the area glaciers, and generate glacier runoff estimates. (See also page 67.)

How has glacial extent changed from 1952? Dr. Arendt and Sam Herreid are currently working on a glacier extent inventory of the park. Using satellite imagery for park glaciers (taken in a range of years from 2003 to 2010), they are mapping glacier extents "now" to compare with glacier extents mapped in 1952 by the USGS for the Alaska 15-minute quadrangle map series. The total area of all glaciers in 1952 was 4126 km^2 (1590 square miles). In the 2000s, the total was 3779 km^2 (1460 square miles) for a net area loss of 347 km^2 (130 square miles). This project will also break out the boundaries of individual glaciers, something that has not been done for park glaciers previously.

Glacier Profiles. Dr. Chris Larsen of the University of Alaska Fairbanks collected topographic profiles of selected glaciers in 2010 using airborne laser altimetry/LiDAR swath mapping technology. Using the same technology, he mapped the summit of Mount McKinley to within $\pm$ 2 meters. (See also page 74.)

Waste Monitoring on the Southeast Fork of Kahiltna. What are the potential effects of human waste deposited in crevasses while climbers are on Mt. McKinley? 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 answer this question. A three-year cooperative agreement with APU allows the researcher and his students to assess different aspects of glacier dynamics in relation to climber-generated 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, Katie Goodwin (graduate student) and Michael Loso conducted a preliminary study of the level of fecal contamination along the West Buttress Route, as well as in the Kahiltna River down glacier from the popular climbing route. Trace levels of fecal contamination were detected both on the surface of the glacier as well as in the head waters of the Kahiltna River. She also assessed the physical and chemical breakdown and fate of human waste in glacial environments and nearby, and reviewed existing published literature and best management practices regarding human waste disposal in remote arctic environments. Additional studies related to human waste on the Kahiltna are planned for 2011-2012. (See also page 71-72.)

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 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.

Lake sampling will resume in Denali in 2013.

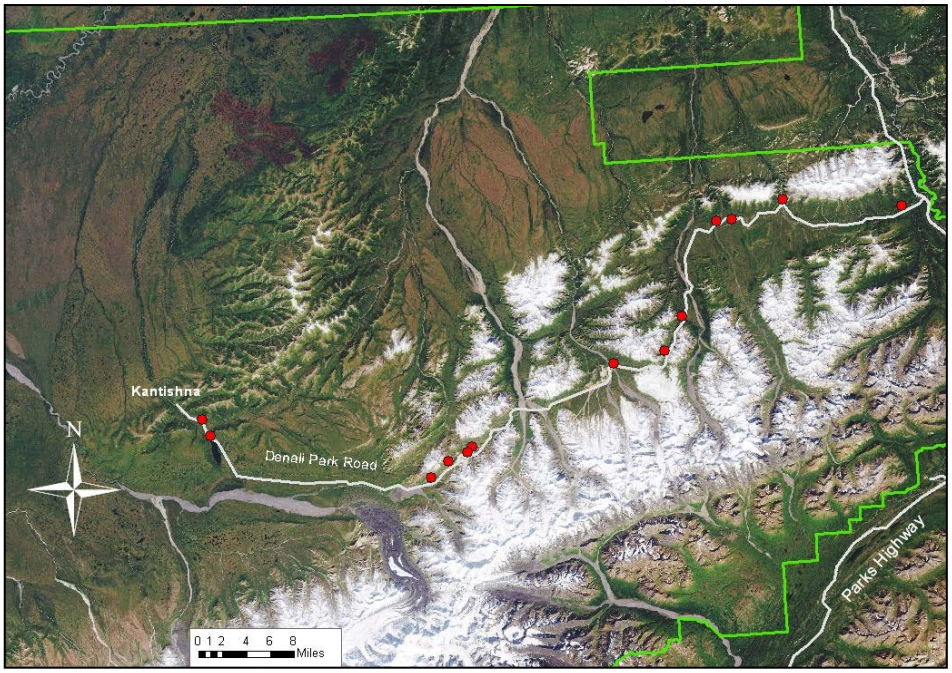
Long-term Stream Monitoring

Trey Simmons began collecting data from Denali streams in 2007 as part of the Central Alaska Network (CAKN) long-term stream monitoring program. The CAKN program collects a variety of data, including aquatic insects, diatoms, fish, water chemistry, and geomorphology data.

Including sites sampled in 2010, Simmons has sampled 34 sites, mostly along the park road. Eighteen sites were sampled in 2010 during 35 visits to sites (some sites are visited multiple times in a season). For the first time in 2010, sampling occurred in the backcountry (four sites visited by helicopter) as part of the implementation of site selection using a GRTS (generalized random tessellation stratified) algorithm. Stream sites that are sampled can be representative of other streams throughout the park, if the sites for sampling are selected at random. GRTS picks a random sample, but can select a sample to be biased in some way. Biasing selection to be near the park road makes access easier. That bias allows randomized sites to be used, even if helicopter access isn't available.

There are three types of sampled sites: Sentinel sites (picked by hand, not randomly selected), synoptic sites picked by computer near the park road, and synoptic sites picked by computer in the backcountry. Many of the sentinel sites have been sampled annually since 1994, originally as part of the Denali LTEM program. Serendipitously, the computer picked eight sites that were very close to long-term sites that Trey was already sampling near the road, so these eight sentinel sites have become synoptic (randomly selected) or probabilistic sites. Sampling near-road computer-selected sites and far-from-the-road computer-selected sites over time will allow a comparison of these two types of sites. If there is no difference in results, then it is much more practical to sample the random sites near the park road.

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. Simmons also plans to develop a way to monitor stream channel properties and land cover changes for stream reaches using remotely-sensed imagery. Repeated data collection at sentinel sites will allow for the detection of trends in important indicators of ecological condition (e.g., water quality, biodiversity), whereas comparisons across all sites can be used to assess the current status of park streams.This year, in collaboration with researchers from Utah and the University of Alaska, Simmons began developing biological assessment tools to quantify water quality. These tools, collectively referred to as RIVPACS models, use the species composition of aquatic insects to evaluate the ecological condition (and hence water quality) of streams in Alaskan National Parks, including Denali. (See also page 76.)



Sentinel stream sites are indicated with dots (from Rock Creek, the most eastern site, to Moose Creek, the most western sampled site.

Water Quality in Kantishna Streams

In 2008, USGS researcher Tim Brabets began a comprehensive water quality analysis of previously mined streams in Kantishna to establish a baseline of water quality conditions. Fifteen sites were selected for water quality and biology monitoring in the Kantishna Hills. Most of the monitoring sites are located on streams that have been mined with the exception of Rock Creek, which serves as a control or reference site. Sites on Moose Creek also serve as integrator sites in that a number of the mined streams - Glen Creek, Eldorado Creek, Eureka Creek, and Friday Creek – drain into this stream. A wide range of water quality and biology constituents such as pH, suspended sediment, trace elements, and macroinvertebrates are being collected at these sites to provide a complete "picture" of water quality of these streams. The study will evaluate whether streams show a degraded condition, and will provide a foundation from which any successes of the overall mine reclamation program can be monitored.

Beginning with the 2009 field season, the number of sites sampled was reduced from 15 to 8 in order to collect "continuous on-site data." Six sites were instrumented with YSI sondes that continuously record water temperature, specific conductance, and turbidity. Based on the 2009 data, a significant finding is that high turbidity levels in Caribou Creek and Glen Creek (mined watersheds) occur only at the same time as high turbidity levels in Rock Creek (unmined watershed). These high periods are due to rainfall events, when stage and flow increases in streams, not from mining activities. This finding suggests that through the natural re-vegetation (mining ceased in 1985) and through man-made reclamation work done by Denali, turbidity (and hence suspended sediment) have decreased in streams that were mined in Kantishna.

Working with the Alaska Department of Environmental Conservation (AKDEC), Denali and the USGS have developed a water quality monitoring plan for streams in Kantishna Hills.

Post-mining Creek Restoration

Slate and Upper Caribou Creek Restoration. Slate and Caribou Creek were restored during summer 2010. Recontouring of the stream and adjacent tailing piles, construction of bank reinforcement structures, and revegetation were installed according to a design intended to restore riparian and floodplain function. It is expected that a result of the restoration, Caribou Creek will be removed from the impaired waterways list, and Slate Creek will be recategorized.

Moose Creek. Design work for restoration of Moose Creek in the vicinity of downtown Kantishna is underway. A design completed in response to the Denali Gravel Acquisition Plan was deemed obsolete due to a park decision to not use gravel reclaimed from the Moose/Taybo claims for park operations due to elevated levels of heavy metals in the gravel.Final design alternatives are expected to be completed in the first half of 2011.

Comstock Mine Closure. In 2010, NPS staff closed the adit with a foam plug (see photo at right), that allows future re-entry if necessary, and scarified the tailings platform at the adit entry.

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 even years, (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 enlisted help from USGS (Chuck Podolak) 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. In 2011 a camera is slated to be installed overlooking the river to document changes in river flow and channels. (See also page 76.)

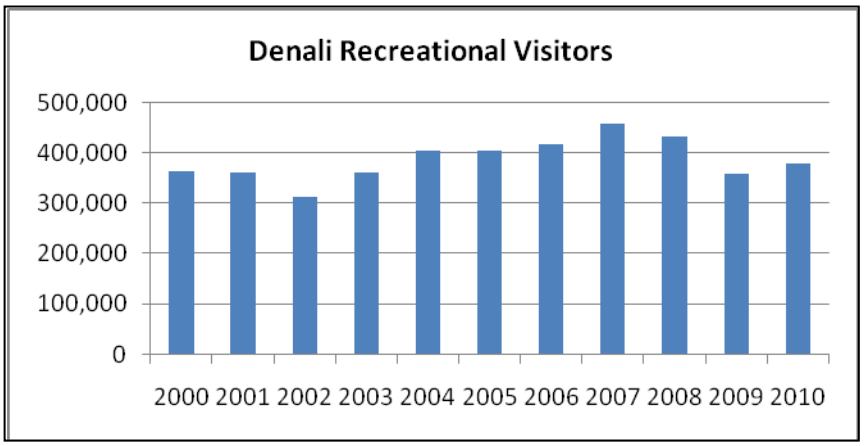
Night Sky Survey

In September 2010, Chad Moore and Dan Duriscoe from the NPS Night Sky Team conducted an assessment of night sky conditions in Denali. They surveyed six sites, collecting full-sky photographic data to quantify light pollution and night sky brightness. Initial results indicate that although the night sky is relatively pristine throughout most of the park, artificial light encroaches on some locations. While they were here, the night sky researchers gave a presentation to park staff, addressing night sky interpretation and better design of outdoor lighting.

◂ Social Science ▸

Park Visitation

Park visitation increased in 2010 compared to 2009 (see graph). There were just under 379,000 recreational visitors, as reported in the Monthly Public Use Report. Most of this increase, however, can be attributed to an adjustment in the formula, which computes monthly use, to include a portion of non-bus visitors that were previously not counted.



However, visitation is no longer declining and early indications are that the numbers may increase again in 2011. When decade averages are graphed, visitor numbers are still trending upwards, albeit at a slower rate that the averages for years earlier this decade.

Improving Visitor Estimates and Understanding Segments

Several park divisions are involved in collecting the data that are plugged into the monthly public use statistics (estimate of visitation during each month). In 2010, staff from these division continued to improve data inputs to the monthly recreation visitor formula and made improvements to the formula itself based upon known inputs.

The calculation for the percentage of visitors that do not take a bus trip past the Savage Check Station continues to use assumptions from a brief study of park visitors in 1999. To increase the confidence in total park visitor estimates, it is critical to improve the estimate for the percentage of Denali visitors that enter via the Denali Park Road but do not go past the Savage Check Station and how this percentage varies seasonally, including throughout the peak visitor season. Park managers are also interested in better understanding park visitation via Talkeetna, the primary south side destination.

Through a cooperative agreement, Denali's social scientist has enlisted the help of Peter Fix, University of Alaska Fairbanks, to conduct a social science survey in 2010. This survey is designed to (1) determine how many visitors access the park via the Talkeetna Airport but do not register with the park, (2)improve counts of visitors arriving by vehicle and driving into the park (but not taking a bus beyond the Savage Check Station).

In addition to gaining a better understanding of recreational visitation, in the process, the survey will gather information about where Denali visitors are going and what they are doing during their visit. The project is underway as of April 6, 2011. Visitors will be asked to participate in the survey at the park road pullout east of the Mountain Vista Trailhead, at the post office road, or at the Jonesville Trail (depending on the timeframe during the season), as well as at the Talkeetna airstrip.

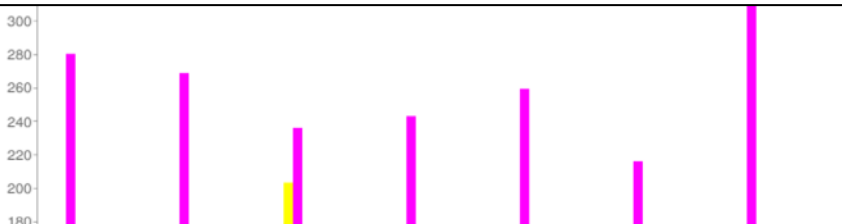
Improving Visitor Data at Savage Check Station

Working closely with the park social scientist, the Commercial Services Division purchased a "ruggedized handheld tablet pc" in 2010 (see photo at right) to be piloted by visitor use assistants working the Savage Check Station in 2011.

The goal of this project is to increase efficiency and accuracy in data collection of vehicles and associated visitors passing the Savage Check Station. Because total park visitor estimates are based upon a formula that uses the number of visitors past Savage as a primary input, it was determined that any improvement to the collection methods may increase the accuracy of estimates. Additionally, the tablet and new streamlined form fields have the potential to significantly reduce the time needed for data entry, allowing for better data capture as well as more time for the ranger to interact with the visitors.

Counting Visitors Who Use Trails

In 2010, infrared automated trail counters (Trafx counters) were placed on trails around headquarters (summer months) and at the Headquarters gate (winter months). The daily average number of hikers for 11 of the park's maintained trails segments are shown below. The traffic was highest on the Horseshoe Lake Trail, the Hines Creek Bridge, and the trail to the Mt. Healy bench overlook:



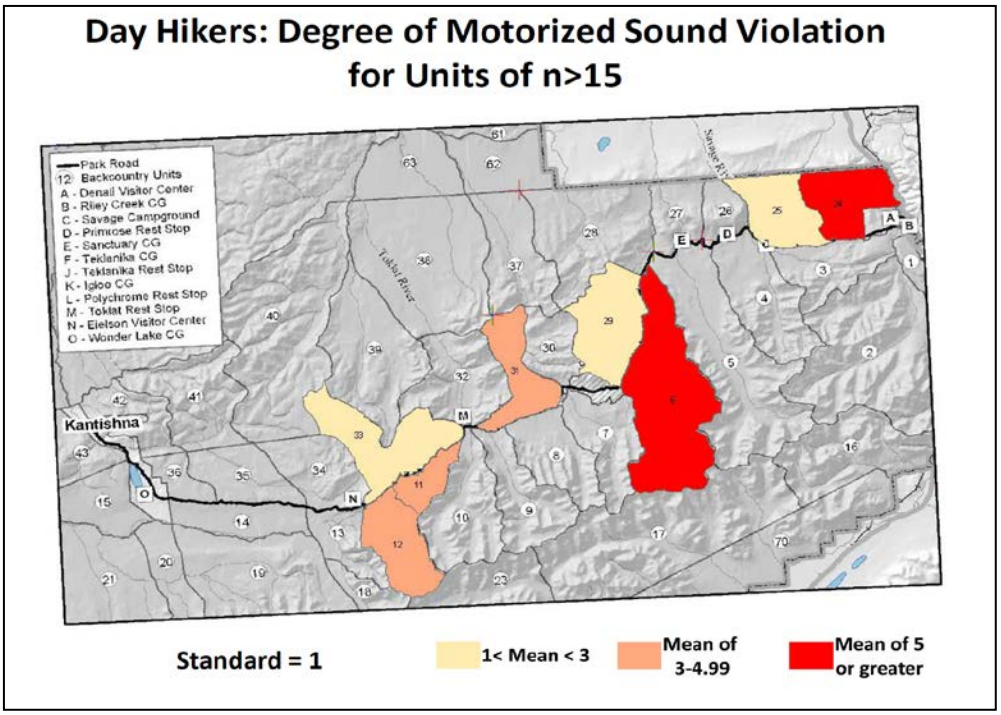
Site Name	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Alpine Trail-Thorofare (AD)	27.1	9.0	12.6	25.9	39.2	28.7	28.6
Bison Gulch (D)	1.0	0.0	0.0	4.0	17.0	2.5	4.0
Hines Creek Bridge (AD)	140.5	63.7	203.0	74.3	55.0	74.0	98.5
Horseshoe Lake (AD)	280.0	268.7	235.7	242.8	259.3	215.8	312.8
HQ Winter Gate (ADF)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mckinley Bar (D)	28.6	27.1	30.0	32.1	21.9	39.1	31.9
Mt Healy-High (D)	30.0	46.0	42.0	53.0	48.0	44.0	35.0
Mt Healy-Low (D)	88.8	73.5	57.3	61.8	90.2	85.3	81.7
Roadside	50.0	130.0	32.0	43.0	48.0	41.0	31.0
Savage Canyon (AD)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
test site	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Triple Lakes (AD)	32.0	69.5	41.5	28.5	35.0	65.5	44.0
Daily Averages	57	57	55	47	51	50	56

A = adjustment applied, D = divide by 2 applied, F = filtering applied

Backcountry Visitor Study

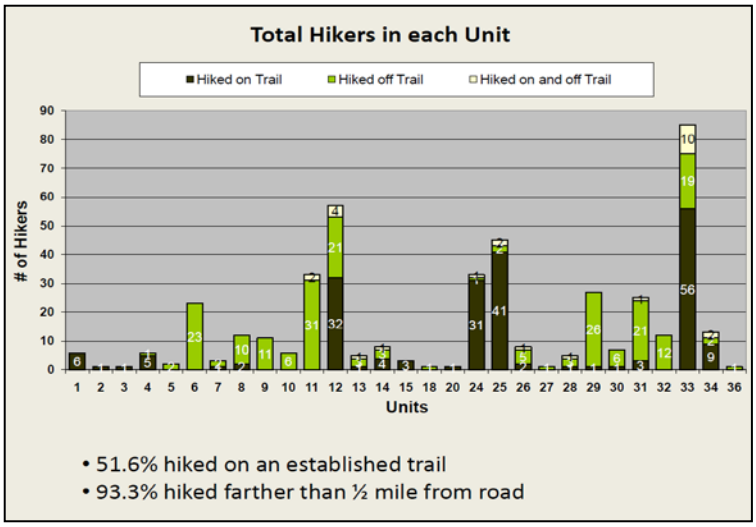
Dr. Peter Fix of University of Alaska-Fairbanks collaborated with the park social scientist to conduct a survey (questions and interviews) of day and overnight backcountry visitors to the park in 2010.

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 described by plan standards are exceeded.



The main purpose of the study was to assess existing backcountry indicators and determine to what degree standards were being met or exceeded.

As an example of findings, the backcountry units colored on the map above were those in which the day hikers reported that the number of motorized noises heard in the unit exceeded the standard (standard = 1). The darker the shading the greater the sound violation of the backcountry plan standard.



Results in another part of the study, indicate that more hikers hiked in units 12 and 33 (below and above Eielson, respectively) than in any other units.

Ninety-three percent of hikers in the backcountry hiked farther than one-half mile from the park road.

(See also page 70-71.)

The project team presented findings to park staff in late 2010.

Social Norms about Soundscapes

The park social scientist has collaborated with the Soundscape Program and Dr. Peter Newman of the University of Colorado Boulder to develop a study of visitor perceptions of mechanized sound (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 what is known as "noise preference/sensitivity norms" for various user groups, and to refine monitoring efforts, including those set out in the Backcountry Management Plan.

Dr. Peter Newman (U. of Colorado Boulder) and several graduate students will survey visitors at three park locations in 2011 to find out what sounds visitors notice and what their perceptions of the sounds are. The survey will be conducted near Kahiltna Basecamp during the early season, and at both Triple Lakes Trail and McKinley Bar Trail during three weeks in June/July 2011. Sound stations will also be temporarily located at each sampling site to compare what sounds are recorded by the sound stations to what visitors notice.

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.

≺ Subsistence ≻

Successful Federal Subsistence Regulatory Changes

- *WP10-31 – Individual Customary and Traditional Use Determination for Moose and Caribou for GMU 13E.* This regulatory change provides for an individual customary and traditional use determination for a resident living in Game Management Unit 20A for hunting moose in Game Management Unit13E.

- *WP10-95- Limit harvest of wolf hunting in Units GMU 20C – that portion within Denali National Park and Preserve.* This regulation will 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.

- *WP10-96 – Reinstate Federal hunting season for muskrat on Federal public lands within Unit 20 remainder.* This regulation will be to add a hunting season for 25 muskrat for Denali National Park and Preserve between November 1 and June 10.

Denali Subsistence Resource Commission

Due to weather conditions and lack of a quorum, Subsistence staff had to cancel two Subsistence Resource Commission (SRC) meetings. The first SRC meeting was scheduled on November 4, 2009 at the Murie Science and Learning Center and the second meeting was scheduled for February26, 2010.

Other Advisory Councils and Board Participation

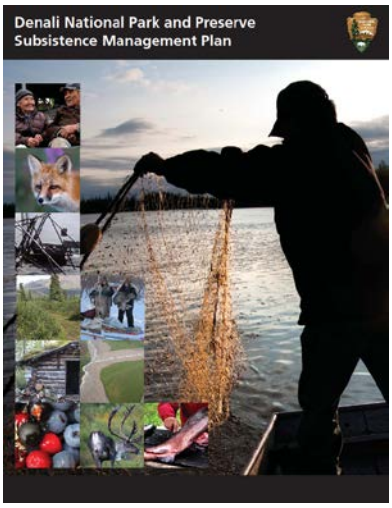
Amy Craver, Denali's program manager for Cultural Resources and Subsistence, represented Denali at the Eastern Interior and South Central Regional Advisory Council meetings (held in Anchorage and Fairbanks in Spring 2010 and 2011).

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 62 caribou permits and 34 moose permits were issued for 13E, and no 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.

Updating the Denali Subsistence Management Plan



Amy Craver obtained funding from the regional subsistence program to update Denali's Subsistence Management Plan. Meeting minutes will be used to update the documentation of actions proposed or taken by the Denali Subsistence Resource Commission. A revised electronic format will allow adding new materials more easily. Lucy Tyrrell, research administrator at Denali, has been working to draft a new layout and format for the plan.

The format will be shared with other parks. Amy Craver and Lucy Tyrrell will complete the update in 2011, and Lucy will begin working with other parks to revise their Subsistence Management Plans based on the Denali template created.

Subsistence Projects

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. No monitoring programs had 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. Outcomes for 2010 included aerial surveys of five fishing locations that local subsistence users have noted that fish abundance has declined. Additionally beaver dams were located and mapped. The final report will be completed in 2011.

Documenting Traplines and Associated Activities. The purpose of this study is to provide data to inform trapline management plans for Denali and for Wrangell-Saint Elias National Park and Preserve. The objectives for 2010 were to conduct mapping and ethnographic fieldwork at Wrangell-Saint Elias 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.

Cultural Resources

New Archaeologist

The park's new archaeologist is Penelope Del Bene, who was hired in June 2010. She holds a Bachelor's Degree from the University of Oregon and a Master's Degree from the University of California, Northridge. Her Master's Thesis focused on spatial analysis of archaeological sites in the Sierra Nevada Mountains. She has worked as an archaeologist for the U.S. Forest Service in California and the Bureau of Land Management in Wyoming. These experiences have provided a breadth of knowledge applying heritage resource law to a variety of cultural resource types including trails, historic sites, traditional cultural properties, and prehistoric sites.

Parkwide Archeology Survey

A four-year archeology survey project concluded in 2010. 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.

National Historic Preservation Act (NHPA) Compliance

Denali's archaeologist is responsible for National Preservation Act compliance (including Section 106 and Section 110). With the assistance of eight volunteers, the park archaeologist conducted Section 110 activities, including the completion of 35 cultural resource condition assessments; and the Section 106 compliance obligations for more than 68 federal undertakings.

In summer 2010, the Olmstead Group for Historic Preservation in Boston spent a week in Kantishna gathering field data for the Kantishna Cultural Landscape Report. The Cultural Landscape Report will be submitted for peer review in 2011.

Historical Research and Historical Outreach

Cultural staff facilitated the collection of historic photographs, documents, and data from private sources, provided cultural resource programs , and provided historic site information to other park divisions, for ongoing cultural resource projects, and for project compliance. Historic film footage of the 1932 Lindley-Liek Mt. McKinley climbing expedition was preserved digitally and pared with a narration by expedition member Grant Pearson, to create a 40-minute program. Historic film footage taken in Mt. McKinley National Park by NPS ranger Bill Nancarrow between 1949 and 1952 was preserved digitally and Bill Nancarrow's narration of the footage was added to create an interesting presentation of early park activities including large caribou migrations and travel by snow jeep. Cultural staff continues to prepare a roadside guide to park history, expecting a publication date in summer 2011. Historic photographs and interpretive text will illustrate the themes of park history, including transportation, tourism, park administration, and mining.

Archaeological Investigations

Several archaeological investigations are planned for 2011:

- Investigations in the Lake Minchumina region will include the archaeological survey of relic shorelines of ancient Lake Minchumina to identify archaeological sites.

- Investigations in the Windy Creek region will include archaeological survey and limited subsurface excavation of previously identified sites.

- A planned parking lot development near the Talkeetna Ranger Station will require National Historic Preservation Act Section 106 compliance. The investigation into the historic artifacts and features present at the location will entail a detailed historic background investigation, oral interviews with some of Talkeetna's long-term inhabitants, and subsurface testing and mapping of the proposed project location.

Museum Collections

Denali National Park and Preserve hired a new Museum Curator, Kirk Dietz, in December of 2010. Kirk comes from the Department of the Interior Museum in Washington, D.C. In the past, he has worked in cultural resources for the National Park Service, Bureau of Land Management, and the State of Utah. Kirk's experience includes collections management, exhibitions, and interpretation of collections.

Denali's previous Museum Curator, Jane Lakeman, transferred to the Alaska Regional Office to serve as Registrar in March 2010.

Two major projects to be undertaken by the Curator in 2011 include (1) a 100% inventory of collections (both object and archival) and (2) oversight of planning to address the backlog of cataloging 100+ linear feet of archival material. The Curator will also develop and implement the policy and program for researcher access to Denali's historic photograph collections and fee-based reproduction services. A narrative regarding researcher access to such materials will be provided to the public through the park's official website.

The Curator will also serve as lead in planning, writing, and producing a museum exhibition celebrating the centennial anniversary of the first summit of Mount McKinley. All annual reporting requirements (Collections Management Report, Random Sample and Controlled Property Inventories) will be conducted in summer of 2011 and submitted to the Alaska Regional Curator for review.

◂ 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. Most of the park has imagery although significant portions are cloud-obscured. 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 1.30tb 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/planyourvisit/gis_gps_data.htm). 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

Research Administrator, Lucy Tyrrell, worked with researchers and resources staff to produce more than 20 new or revised color fact sheets about Denali resources and scientific findings in 2010 and early 2011, bringing the total number of fact sheets she has created to 50. Additional fact sheets will be developed in 2011 and future years. These fact sheets are also available at http://www.nps.gov/dena/naturescience/factsheets.htm

- Air Quality Monitoring
- Ancient Hunters near the Teklanika River NEW
- Are Wolf Viewing Opportunities at Risk?
- Beavers Across Denali's Hydrologic Landscape
- Central Alaska Network Inventory and Monitoring Program
- Climate-related Vegetation Changes
- Dinosaur Track Found in Denali
- Ecology of Golden Eagles
- Ecology of Upwelling Areas in the Toklat River
- How are permafrost landscapes changing?
- How old are the spruce?
- Ice Patch Archeology
- Implementing Denali's Resource Stewardship Strategy
- An Integrated Study of Park Road Capacity 2006
- An Integrated Study of Park Road Capacity 2007
- An Integrated Study of Park Road Capacity 2008
- An Integrated Study of Park Road Capacity 2010
- Large Lakes and Landscape Limnology
- Large Mammals…How many are there? UPDATED FOR 2011
- Long-term Monitoring after Restoration of Kantishna's Placer-Mined Streams
- Measuring Movements along the Denali Fault
- Melting Glaciers in the Kichatna Mountains NEW
- Monitoring Climate Change
- Monitoring Contaminants
- Moose Rut
- Moose Surveys
- Museum Collections: Preserving Denali's Stories
- Natural Resource Condition Assessment
- Painted Fossil Bison Skull: When, how, and why was it painted?
- Paleoecology of Denali's Dinosaurs
- Permafrost Landscapes
- Permafrost Thaw and Carbon Balance
- Population Biology of the Wood Frog
- Prehistoric Upland Hunting Site
- Preservation of Cultural Resources

- Reconstructing Ecosystems of the Lower Cantwell: Plants in the Age of Dinosaurs
- Restoration of Mined Lands in Kantishna
- Rivers and Streams (4-pages)
- Sharing Research
- Soil Survey and Ecological Classification
- Soundscapes
- Stampede Creek and the Legacy of Mining: Antimony Movement in Stream Water and Sediment
- Subsistence
- Surveying Dall's Sheep Populations
- Treeline Shifts in Denali: Influences of Climate Change and Local Site Conditions
- Understanding Park Visitor Characteristics
- Where is all that smoke coming from? NEW
- Wildland Fire Risk and Response: Why are you cutting those trees?
- Wolf Monitoring 1986 – 2010

Research Administration

As of May 1, 2011, 835 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, 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 2010

The following researchers (non-Denali staff) held research permits in 2010. This table provides information about their findings based on the researcher's 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. Some research is reported also elsewhere in *Current Resource Projects*.

Researcher	Affiliation	Project
Adams	USGS-Alaska Science Center	Population dynamics of wolves and their prey in a subarctic ecosystem (caribou only)

Information about this caribou project is reported on page 27-29.

Herd Size: For late September 2010, I derived a preliminary herd size estimate of 2,070 caribou. The Denali Herd has been relatively stable over the last 7 years, corresponding with higher recruitment averaging 22 calves:100 cows during this period, a 70% increase over the previous 14-years of markedly poor recruitment.

Adult Sex Ratio: The herd's adult sex ratio of 42 bulls:100 cows in September 2010 was the highest noted since 1992. Adult sex ratios 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. Bull:cow ratios have increased slowly since 1998 to an average of 37:100 during 2004-2010, but are a still well below levels at the beginning of the study.

Calf Production and Survival: Productivity of cows ≥ 1 year old was estimated at 74% in mid-May 2010, based on 66 radiocollared females in the age-structured sample, or near the 24-year average of 78%. During the early-June 2010 postcalving composition survey, we noted 30 calves:100 cows. By the late September composition count, the calf:cow ratios had declined to 20:100. Accounting for the adult female mortality rate, the decline from the natality rate to the fall calf:cow ratio equates to 26% survival of the 2010 cohort to September. Calf survival has averaged 28% over the last 7 years, compared to 15% during 1991-2003.

Female Survival and Age Structure: During October 2009 – September 2010, 11 radiocollared females from the age-structured sampled died for an annual mortality rate of 16%, higher than the study average of 12% (range 2-23%). The higher rate during this study period can be attributed in part to the preponderance of older females in the population in that 4 of 11 caribou that died were ≥ 14 years old. The female age structure in May 2010 exhibits the effects of improved recruitment over the last 6 cohorts, as well as the losses of females ≥ 13 years old, and as a result the proportion of these older females has declined over the last few years.

Adult Bull Survival: During September 2007- September 10, we have captured, radiocollared and monitored 133 male caribou including 97 captured as adults (≥ 1 year old; 45, 12, 15, and 25 captured in September 2007-10, respectively) and 36 captured as 10-month-old calves (12 each March 2008-10). As of 30 September 2010, 70 were still alive with functioning radios, 45 have died, 9 had their collars torn off during the rut, and 9 radiocollars have failed prematurely. During the 3 years we have evaluated survival of males (October 2007 – September 2010), annual survival has averaged 0.74, substantially lower than the average 0.88 estimated for adult females throughout the study. Although sample sizes for individual ages for are small, age-specific survival appears to be highest through to about 5 years of age, averaging 0.84, then clearly declines for older age-classes. Mortalities predominantly occur during August – November, with

Researcher	Affiliation	Project
Adams (cont'd)		

very few mortalities during February – July.

Bull Growth Patterns: We have weighed 85 of 97 adult bulls captured in September 2007-10 recording masses ranging from 93 kg to 264 kg. Body masses increased markedly with age from 1 to 5 years of age, gaining an average of 26 kg each year, and plateaued an average of 230 kg for ≥ 5 years of age. The bull size classes we employ for composition surveys (S, M, L) differed significantly by body mass ($F = 205.7$, $df = 2,82$, $P < 0.001$) with mean masses of 117 kg, 161 kg, and 227 kg, respectively. These size classes included individuals of 1-3 (median = 1), 1-5 (median = 3), and 4-12 (median = 6) years of age, respectively, based on cementum analyses.

Arendt	University of Alaska Fairbanks	The effects of changing climate on Denali glaciers: a case study on the Kahiltna Glacier

Three trips were made to the glacier during the 2010 summer field season: April 30 - May 3, August 26, and September 22. During the May campaign we drilled ten 3/4" diameter PVC pipes into the ice surface to act as reference markers (ablation stakes), against which future measurements of snow/ice surface location could be compared to assess glacier mass changes. We positioned the stakes along a centerline transect spaced approximately equally between 820 – 1430 m elevation. At every second ablation stake we installed temperature and relative humidity (RH) sensors that logged data every 10 minutes. During the transect installation we collected snow depth information by probing through the snowpack to the 2009 summer surface using a graduated snow probe. Seventy measurements were made to characterize spatial patterns in snow accumulation. Finally, we dug 3 snow pits to determine density, temperature and snow crystal variations with depth at different elevations.

During the August trip we visited the ablation stakes to measure the amount of summer melt. We also downloaded data from the temperature/RH sensors installed on five of the stakes. The sensors were set at a height of 1.4 m above the surface on a system that was designed to allow the sensors to slide vertically down an aluminum pipe and remain at a fixed height above the melting surface. The sliding system unfortunately failed at most sites, so that the sensors were several meters above the surface when retrieved. The data are being corrected based on assumed temperature gradients above the ice surface.

During the September trip we installed an Automated Weather Station (AWS) at 62deg45'35.30"N and 151deg18'26.51"E, 1280 m elevation. We drilled a 1" aluminum pipe vertically 3 m into the ice surface and affixed a temperature/RH probe. On a crossarm we attached a sonic ranger to provide a measure of snow accumulation rates. Three high accuracy Platinum resistance thermometers were affixed to the lower section of the mast at 0.15m, 0.55m, 0.95m above the ice surface. Once buried, the sensors will measure variations in snow temperature. They will also be used to assess timing of snowpack warming and melting in spring 2011. The data are being logged at 10-minute intervals and telemetered via a satellite iridium system, and are available in near-real time at https://datagarrison.com/users/300034012159720/300034012159720/plots.php. All data are being archived at the University of Alaska for eventual distribution to NPS and other interested agencies.

Preliminary analysis of the mass balance data shows that 2010 was a strongly negative mass balance year. Summer mass balances are well approximated by a linear function of elevation in the ablation zone, and account for most of the spatial variability in mass balance. Summer temperatures at all elevations were above freezing from mid-May to the end of August. Temperatures at different elevations on the glacier were highly correlated, and the seasonal average gradient of temperature with elevation was within the range of published lapse rates found in other glacier studies. Mass balance and temperature measurements are being compared to nearby locations in the Central Alaska Range, including mass balance data from a National Park Service (NPS) index site, and temperature data from the National Oceanic and Atmospheric Administration (NOAA) and Remote Automated Weather Stations (RAWS). The goal of these comparisons is to determine factors for scaling remote observations to local conditions at the Kahiltna Glacier.

Researcher	Affiliation	Project
Bickley	unaffiliated	Glacier terminus surveys and photo documentation

The accomplishments of the 2010 field season's research included taking baseline (initial) GPS measurements of the termini (ends) and centerlines of the Cul-de-sac and Tatina Glaciers in the Kichatna Mountains of Denali National Park and Preserve and establishing precise photo points from which repeat photography of the same two glaciers may occur in subsequent year's research. Lead investigator Joseph Bickley and assistant Odin Miller conducted GPS measurements on foot while utilizing glacial mountaineering skills to traverse the Cul-de-sac and Tatina Glaciers. Both researchers flew into a remote airstrip located outside preserve boundaries in order to minimize impacts to preserve resources.

The researchers successfully mapped the complete terminus and centerline (below snowline) of the Cul-de-sac Glacier. Comparison of the baseline GPS measurements to subsequent year's measurements of the same parameters will allow researchers and park managers to quantify certain parameters of the melting rate of the glacier. The Cul-de-sac Glacier has a large outflow creek that flows nearly parallel to the terminus. Unable to cross the creek on foot at all points to reach the actual face of the glacier, the researchers took GPS measurements along the creek whenever the actual glacier terminus was inaccessible. Both waypoints and a GPS track of the terminus and centerline were obtained. The centerline survey continued up to the snowline, which was at approximately 5100 feet elevation in the last week of August 2010.

The researchers also took GPS measurements of the terminus and centerline of the Tatina glacier in the Kichatna Mountains of Denali. Not shown on the 1967 USGS topographic map used to navigate to the area, a large glacial lake now exists at the Tatina Glacier terminus and makes the terminus itself inaccessible on foot except at the far southeastern corner. As a result, the researchers took a single waypoint of the terminus location at this corner. The Tatina Glacier is also much steeper and more crevassed than the Cul-de-sac glacier. Low fog made visibility extremely poor while the researchers conducted the centerline survey of the Tatina Glacier. Consequently, the centerline survey ended at an estimated halfway distance to the actual snowline from the terminus. Limited time and funding prevented the researchers from revisiting the Tatina glacier to complete the centerline survey in 2010.

Although some potential ash fall was observed on both glaciers, distinguishing between ash and mineral soil blown off adjacent slopes proved impossible in the field for researchers without specific knowledge and training in drawing such distinctions. No collections of ash fall were proposed or obtained in the 2010 research permit so no collections of the potential ash were made for laboratory analysis. Future year's research aimed at identifying the role of ash fall in increasing the melting rates of glaciers would greatly benefit from such collections and analysis.

Joseph Bickley also established precise photo points and took initial photos from the photo points for both the Cul-de-sac and Tatina Glaciers. Each photo point itself was also photographed and marked with a GPS waypoint in order to aid other researchers to revisit the same photo point locations in the future for repeat photography.

Due to limited time and funding, no attempt was made in 2010 to locate the points from which historical photographs were taken by A.H. Brooks of unknown glaciers in the Kichatna Mountains. Prior to going to the field, lead investigator learned from past research by Bruce Molnia that the unknown glaciers are most likely located in the southern Kichatna Mountains, far from the 2010 field work site.

Researcher	Affiliation	Project
Blong	Texas A&M University	Prehistoric upland use in Denali National Park: a proposal…

This report presents the results of archaeological fieldwork conducted summer 2010 in the Savage River basin, Denali National Park and Preserve. This fieldwork is part of a long-term research program investigating prehistoric human use of upland landscapes in central Alaska, and it was designed to help Denali meet management goals and 2009 Denali Resource Stewardship Strategy recommendations. John Blong and Ted Goebel co-directed the project and were

Researcher	Affiliation	Project
Blong (cont'd)		

assisted by Mike Waters, Thomas Jennings, Heather Smith, and Angela Gore of the Center for the Study of the First Americans at Texas A&M University.

The Savage River project focused on prehistoric sites in the uplands of the Alaska Range dating from the earliest human occupation to less than 1,000 years ago. The archaeological record of the central Alaska Range uplands potentially plays a crucial role in evaluating seasonal landscape use hypotheses explaining central Alaskan lithic assemblage variability. The Savage River project was separated into two parts: (1) upper Savage basin survey, a reconnaissance survey for unrecorded sites and relocation of recorded sites in the drainage south of the Park Road; and (2) Ewe Creek assessment, subsurface test excavations at recorded sites near the confluence of Ewe Creek and Savage River, north of the Park Road.

The upper Savage basin survey focused on the relocation of nine previously recorded prehistoric sites in the Savage basin (HEA-136, HEA-155, HEA-156, HEA-157, HEA-161, HEA-162, HEA-165, HEA-166, and HEA-173). This portion of the project was successful in locating four recorded sites (HEA-136, HEA-155, HEA-165, and HEA-166). However, we could not relocate five previously recorded sites (HEA-152, HEA-156, HEA-161, HEA-167, and HEA-173). In addition to this, reconnaissance survey covered 26 high probability surface exposures on elevated landforms and identified five unrecorded prehistoric sites and one unrecorded historic site in the upper Savage basin. Eighty lithic artifacts were analyzed in the field during this portion of the project, informing our understanding of upland lithic technological activities throughout prehistory.

The Ewe Creek assessment focused on mapping, surface collecting, and subsurface testing at cultural resource sites near the confluence of the Savage River and Ewe Creek, in order to evaluate the condition and significance of three previously recorded sites (HEA-263, HEA-264, and HEA-265). In this portion of the project, we collected topographic landform data and recorded detailed site location data for all three sites. Further, we collected precise spatial data on 52 lithic artifacts from surface contexts and collected these specimens for laboratory analysis. In addition to this, we excavated one 1m2 test unit at HEA-264 and two 1m2 test units at HEA-265. We recovered 6 lithic artifacts and charcoal for radiocarbon dating from subsurface contexts at HEA-265 and HEA-264. We submitted a charcoal sample from the lowest cultural horizon at HEA-265 and received a radiocarbon date of 4,150 ± 40 14C BP (4,830 – 4,350 cal BP). This date likely represents the earliest date of occupation for the three Ewe Creek sites.

The 2010 Savage River project generated preliminary data on lithic assemblages from upland contexts in the Alaska Range. This data will be combined with future uplands research to reach our goal of characterizing prehistoric upland lithic assemblages in order to further evaluate landscape models explaining lithic assemblage variability in central Alaska.

The scientific study conducted under this permit has been completed for this permit year, and there is no further work planned at this time.

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

1)The overall water quality of streams in the Kantishna Hills area is good. However, three streams - Slate Creek, Eldorado Creek, and Eureka Creek - have concentrations of arsenic and antimony that exceed USEPA recommended levels for drinking water.

2)Trace element analysis of streambed sediments at 14 sites showed several sites to have concentrations of arsenic and lead that exceed probably effect levels that could be toxic to aquatic habitat.

Researcher	Affiliation	Project
Brabets (cont'd)		
3)All mining stopped in the Kantishan Hills in 1985. Since that time(25 years)natural re-vegetation has occurred in many areas. This re-vegetation, in addition to Denali's reclamation work has resulted in lower suspended sediment concentrations (as measured by turbidity)in all streams. Higher suspended sediment concentrations are now only noted during rainfall runoff events.		
Bruederle	University of Colorado	Systematic investigations of the Federally Threatened Eutrema penlandii emphasizing the conservation of genetic and species diversity
No activity was conducted this report year.		
Fiorillo	Museum of Nature and Science, Dallas	Paleontological survey of the lower Cantwell Formation, Denali National Park and Preserve
During the 2010 field season, work took place in several locations within the park: upper Riley Creek, Double Mountain, Mt. Sheldon, and Tattler Creek. In the stretches of upper Riley Creek we continued reconnaissance of exposures for paleontological significance and began sedimentological work. The area had been deemed of interest because our earlier work had found climatically significant crayfish burrows and fossil bird tracks such as *Aquatilavipes swiboldae*, as well as duck-billed dinosaur tracks. Continuing our work demonstrated that the area is more rich in fossil bird tracks than previous realized further supporting the contention that the Cantwell Formation of Denali National Park is one of, if not the richest source of information anywhere in the world for studying latest Cretaceous fossil bird diversity. Therefore we measured a preliminary section of 50 m of Lower Cantwell fluvial sedimentary rocks. Our work strongly suggests that this is an area that will need additional detailed investigation. Similarly the Double Mountain work showed abundant dinosaur tracks. The rocks of this area represent a much different depositional setting than found elsewhere in the park. A significant part of the section here suggests a much lower energy system than elsewhere in the Cantwell Formation. Our time at Mt. Sheldon was truncated by a family of problematic bears. But in the short time we were there we did find fossil wood and other plant debris suggesting that this area may contain significant fossil resources. We coordinated with the Murie Science and Learning Center class that was in Tattler Creek and served as a resource for class participants. Tattler Creek remains a rich source of information for this study. For example, we discovered two more horizons containing tracks attributable to *Magnoavipes denaliensis*. We also found additional tracks attributable to pterosaurs, animals not yet recognized elsewhere in the park. We found other tracks of unknown origin in the area of the divide between Tattler Creek and Big Creek that warrant further investigation.		
Fix	University of Alaska Fairbanks	Monitoring indicators of visitors' backcountry experiences in Denali National Park
During summer 2010, 581 day hikers and 403 overnight backpackers were contacted. Four hundred and fifty two day hikers completed the survey (78% response rate) and 191 backpackers completed the survey. A non response test was conducted. Respondents and non-respondents differed by group size for day hikers and residency for backpackers; however, analysis did not reveal differences of concern. Residency of the day hikers in the sample was as follows: local to Denali, 4.6%; AK resident not local to Denali, 10.4%; other United States, 74.2%; and foreign, 10.7%. Residency of the backpackers in the sample was as follows: local to Denali, 16%; AK resident not local to Denali, 14%; other United States, 56%; and foreign, 14%. The measurement of the indicators included		

Researcher	Affiliation	Project
Fix (cont'd)		
impacts originating in the park road corridor, e.g., bus noise, the park road itself. The standards in the Denali Backcountry Management Plan were intended to only include impacts originating from within the wilderness area. Thus, comparing the measured values to the standards is difficult. Data analysis is in progress. Preliminary results show the following mean levels, per day, for the indicators. For day hikers: natural sound disturbance, 3.18; encounters with modern equipment, 2.02; encounters with landscape modification, 1.94; encounters with other park visitors, 5.88; encounters with groups larger than six, 0.68; and encounters with NPS rangers or researchers, 0.60. Fourteen percent of the day hikers encountered litter and/or human waste. For backpackers: natural sound disturbance, 3.21; encounters with modern equipment, 1.00; encounters with landscape modification, 1.04; encounters with other park visitors, 0.77; encounters with groups larger than six, 0.04; and encounters with NPS rangers or researchers, 0.03. Eleven percent of the backpackers encountered litter and/or human waste and there were 32 nights in which backpackers could not camp out of site or sound of others. The final report will be complete in spring 2011.		
Freymueller	University of Alaska Fairbanks	Repeated Global Positioning System (GPS) and absolute gravity measurements to measure active crustal deformation in southern Alaska
No IAR received as of May 1, 2011.		
Goodwin	Alaska Pacific University	Impacts of historic and future human waste disposal on Kahiltna Glacier
The following questions were addressed through fieldwork and laboratory experiments conducted throughout the spring, summer and fall of 2010. •What is the current location of the base camp latrine pits that were marked with magnets? The buried magnet in the 2002 latrine pit was not located. A large search grid set on the expected location of the magnet and latrine pit yielded inconsistent readings. It is suspected the main source of magnetic noise was attributed to the presence of a one inch volcanic ash layer approximately two meters down in the snow from the 2009 Mt. Redoubt eruption. •Is there evidence of surfaced waste immediately down glacier from the Base Camp Airstrip? Evidence of surface human waste further down glacier towards the glacier terminus? An aerial survey from a helicopter on August 26, 2010, followed a visible line of ice from the Base camp located on the South East fork of the Kahiltna Glacier down to the terminus of the Kahiltna Glacier. A second aerial survey from a helicopter followed a visible line of ice from the 7,800 ft. Ski hill camp on the main fork of the Kahiltna Glacier down to the terminus of the Kahiltna Glacier. No visible signs of surfaced human waste or trash from the above climbing route were seen on the ice. The firn line on the Kahiltna was between 6,800-6,600 ft. in elevation, just above the great icefalls on the main fork. •Is there evidence of surfaced waste along the main climbing route? A fecal sample collected from 18,800 ft. was analyzed for total coliform and E. coli. The sample came back positive for total coliform and E. coli. The results of this analysis indicate the harmful bacteria in human feces was still viable after being left exposed at 18,800 ft. on Mt. McKinley for a full calendar year. Snow samples were collected twice along the West Buttress climbing route during the 2010 climbing season. The first set of snow samples were analyzed for the presence of total coliform and E. coli; all samples tested negative for the presence of E. coli and total coliform, indicating there was no human waste contaminating the snow surface along the route, pre-climbing season. The second set of snow samples were analyzed for the presence of total coliform and E.coli. The presence of total coliform was detected in one snow sample at the 11,200 ft. camp and in one snow sample collected at Base camp. The presence of total coliform and E. coli was detected in a snow sample collected at the 9,500 ft. camp; all three positive samples were collected from the designated pee holes at each camp, where climbers also use their CMC's •Is there evidence of waste at the headwaters of the Kahiltna River?		

Researcher	Affiliation	Project
Goodwin (cont'd)		

Four water samples were collected near the terminus of the Kahiltna Glacier by helicopter. No fecal contamination was detected in the water samples collected from the control side tributary or from the west fork of the Kahiltna River. Trace evidence of fecal contamination was detected in a glacial pond at the toe of the glacier and in the east fork of the Kahiltna River.

•What concentration of fecal coliform or E. coli is present in the freeze/thaw experiment waste

In custom designed cold chamber 240 fecal samples underwent 121 consecutive days of 24-hour freeze-thaw cycles, ranging from -5 to 6 ± 2 degrees Celsius. Half of the samples were exposed to continuous UV light exposure while the other half remained protected from all UV light. No mortality of total coliform, E. coli or fecal streptococci was detected in any of the samples throughout the course of the experiment. The results of our laboratory experiments lead us to believe the harmful bacteria and pathogens in human waste can persist for at least one full climbing season if not longer. Special consideration should be taken when disposing of waste along the main climbing route to limit outbreaks of gastroenteritis among climbers.

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.

Work done in 2010:

At TRF, we performed routine maintenance of the power and telemetry systems (April 18).

At CAST, we replaced the STS-2 sensor with a Trillium 240 (April 18).

At KTH, we replaced the Q330 digitizer and installed a Guralp 5T compact strong motion instrument (August 28).

Future plans:

In 2011, we will remove the old S13 sensor at TRF. We are also considering adding a seismometer at Double Mt. sometime in the future to obtain a better resolution on the source of that very active zone of seismicity located roughly between Mount McKinley and Wonder Lake at a shallow depth. This would also provide valuable insight to the rupture process should the western portion of the Denali Fault rupture.

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

The goal of this project was to measure high altitude meteorological data and to maintain a near real time data stream from the mountain.

The team can only reach the weather station during the summer climbing season. During this short window of opportunity, batteries and data loggers are replaced each year, sensors if necessary.

Typically field season was June, and the team would climb the West Buttress to reach the weather station at 19,200 ft (5,715 m). The Talkeetna Park Rangers assisted with carrying most of the sensors, batteries and tools to 14,000 ft camp (Medical Camp) during their regular re-supply missions to the camp.

Our goal was to build a system that will successfully transmit data from the mountain year round, and to make the information available to the public in near real time. With trial and error with satellite telemetry system and radio transmissions, we were able to send the data from the mountain every hour until early spring. The transmission stopped mainly because of broken cables, failed computer processors, or the collapse of the supporting framework due to extremely strong winds, icing, and windblown rocks.

Due to the limited time the technicians can actually work on the weather station at the current location, a new site for the weather station was being proposed. Especially after the main supports for the weather station was found broken in 2007.

In 2008, efforts to reestablish the weather station was not successful due to strong winds, but most of the bent poles were brought down from the weather station site.

During the 2009 and 2010 cleanup efforts, scouting missions for a new site around High Camp started. The west end of the High Camp was found to be the best location.

Unfortunately in late 2010, instead of establishing a new weather station it was decided to terminate the IARC McKinley Weather Station Project, due to lack of appropriate funding.

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

During the 2010 calendar year, UNAVCO made no onsite visits to the GPS sites located in DENA.

Jacobus	University of Alaska Fairbanks	Late Cretaceous paleoclimate and ecological change preserved in the Cantwell Formation, Central Alaska Range

No IAR was submitted as of May 1, 2011.

Researcher	Affiliation	Project
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 2010-2011 freeze-up/break-up season, the Alaska Lake Ice and Snow Observatory Network (ALISON) study site on Horseshoe Lake was set up in January 2011. Dorothy DeBlauw's grades 4-5 class at Tri-Valley School (Healy, AK) made several trips to collect data. 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 8 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.

Lachniet	University of Nevado – Reno	Stable isotope hydrology and climate of Denali National Park

No activity was completed in Denali National Park pursuant to the approved proposal. Because permission was not granted to enter the park with a private vehicle, we determined the sampling was not time-efficient given the available duration of our field time. Instead, we elected to complete our sampling outside of Park boundaries.

Larsen, C.	Geophysical Institute, UAF	Airborne surveying of glacier surface elevation change

No IAR was submitted by May 1, 2011. See page 49.

MacCluskie	Central Alaska Network (NPS)	Small mammal monitoring at the landscape scale and synthesis of monitoring data in Denali NPP

No IRA was submitted by May 1, 2011. See page 31.

Manning	University of Vermont	A predictive study of use impacts on the Denali park Road: a study plan to support analysis and management of carrying capacity

Data collection for the stated choice portion of this study has been collected and is being analyzed. The study report is being written and a draft will be submitted to the park for review.

Researcher	Affiliation	Project
Miller	Wright State University	The bones of Denali: historical ecological insight and the identification of past caribou calving grounds

The 2010 field season was a very important preliminary venture into Denali. I became acquainted with the ecosystem, terrain, logistics, and bone assemblage of the Park and Preserve. Much of my time was spent searching for carcasses with known dates-of-death (known postmortem duration). Due to a combination of the nature of the available data (largely lat/longs from maps) and the terrain (very rich understory and thick tundra), these recovery options did not go as well as hoped. Further efforts to find previously mapped carcasses will likely not be pursued with any large-scale efforts.

My time in Denali, however, provided excellent insights into the nature of the death assemblage and informed future research plans. Bones were absolutely recoverable from the landscape, and the next step in this research is to explore the caribou calving grounds (and wintering areas) and moose wintering grounds for skeletal markers. This work will provide valuable insight into the capacity of bone assemblages to capture ecological patterns for ecosystems in high-latitudes with low ungulate biomass.

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

Macroinvertebrate sampling was carried out at the study streams during August 2010 - these samples have been stored prior to securing funds for sorting and identification. However this does maintain the long term record which is important.

A paper has been accepted in Arctic, Antarctic and Alpine Research entitled "Water flow dynamics of groundwater-fed streams and their ecological significance in a glacierised catchment" by Jill Crossman, Chris Bradley, and Alexander Milner.

Moore	Colorado State University	Collect baseline inventory of night sky quality

No IAR was submitted by May 1, 2011. See page 53.

Newberry	University of Alaska Fairbanks	Geological mapping exercises in Central Denali Park

The UAF Geology field mapping exercises are scheduled for alternate years, and did not occur in 2010.

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.

Dall's feces samples weer collected on Cathedral Mountain, Igloo Mountain,and Sable Mountain. These samples were sent to the Washington State University for anlaysis by the Wildlife Laboratory for FN, Fecal DAPA, and all samples were corrected for ash content. 23 samples were collected and analyzed. These samples added to an historical database of fecal pellet analysis for years 2007 - 2009. The purpose of the analysis of fecal pellets is to develop a historical database FN, and DAPA for evaluation of nutriant levels in Dall's sheep in the study area. These results will be compared with collections and analysis of pellets from the Wood River Drainage SE of Fairbanks and pellets collected in the Wrangell Mointains.

Researcher	Affiliation	Project
Pfeifer (cont'd)		
Water samples were also collected for analysis of nutriant levels in seeps, permafrost melt, and glacial streams. Thes data will be compared with water nutriant levels from water samples collected in prior years. Ewe/Lamb Counts were made in the study area in 2009, and again in 2010 to determine ewe/lamb as an indicator of herd health. These counts will continue. A project website was developed in 2010 (http://sgst.wr.usgs.gov/alaska/ A USGS Open File Report was prepared and approved documenting research and findings to date. (URL: http://pubs.usgs.gov/of/2010/1135/index.html)		
Podolak	USGS	Geomorphic evaluation of the Toklat River, AK near Mile 53 of the park road, Denali National Park
No IAR was submitted as of May 1, 2011. See page 53.		
Shaw	University of Alaska Fairbanks	Long term trends and spatial variability in arctic haze at four sites in western Alaska
Samples of aerosol were collected weekly at air sampling site near Park Headquarters by Andrea Blakesley. These samples were mailed to Patricia Quinn, PMEL, NOAA, Seattle for chemical analysis.		
Simmons	Central Alaska Network	Implementation of a long term monitoring program for the streams and rivers of Denali National Park and Preserve
In 2010 35 sampling visits were conducted at 18 unique site locations in Denali. Habitat, water chemistry, macroinvertebrate and diatom data were collected at each site. Some sites were visited multiple times during the year. 12 of the sites were selected using a probabilistic algorithm (GRTS) for inclusion in the large-scale probability survey; the remaining site are sentinel sites sampled annually. See also page 50-51		
Spalinger	USGS	Proteins and tannins in summer browse may limit productivity of moose
No field work was conducted in Denali in 2010.		
Trost	Alaska Department of Environmental Conservation	Alaska transboundary regional haze monitoring project
The sampling campaign was completed in 2009, chemical and particulate analyses of the samples are mostly done (all DRUM sample strips have been analyzed but FRM Partisol filters have not been analyzed yet) and the data analysis is progressing. Preliminary results presented here show that the aerosol concentrations are very low. The reconstructed mass according to DRUM samplers is 0.85 ug m-3 plus/minus 0.06 ug m-3. The unknown fraction is assumed to be mostly carbon and water. The concentrations of different species and PM2.5 are fairly similar for DNPP and Trapper Creek, with slightly lower concentrations for McGrath. The predominant measured component of PM2.5 mass is ammonium sulfate with an average concentration of 0.59ug m-3 plus/minus 0.03 ug m-3. Ammonium sulfate primarily is found in the 1.15 um to 0.34 um size fraction while SOIL primarily is found in the 2.5-1.15 um size fraction. Once the last few QA/QC checks are completed on the DRUM data, we, in cooperation with UAF, will finish the temporal and spatial analyses of the elemental		

Researcher	Affiliation	Project
Trost (cont'd)		

concentrations. We will use that data to: 1) produce time series plots of all elemental and constructed (e.g., RCON, NHSO, etc.) variables, 2) compare the data from the periods of collocated samplers at Trapper Creek to determine the reproducibility and effectiveness of the DRUM sampler, 3) identify elemental concentration peaks for comparison with the HYSPLIT trajectories to determine the origins of the aerosols associated with the peaks (all of the HYSPLIT trajectories have been run and characterized by which potential source regions they have crossed in the last 310 hours), 4) determine what fraction of aerosol concentration is from local versus distant sources, 5) determine the changes in elemental and mass concentrations as the aerosols transport across two sites in the network to determine if there are sources of aerosols between the sites, 6) compare the results of this study to the IMPROVE aerosol data that have been released this year and 7) ensure that all of the data, once they have passed QA/QC checks are available for use by modelers and other scientists as well as Denali National Park and Preserve.

Van Ballenberghe		Ecology of Moose in Denali National Park and Preserve

Fieldwork occurred from 25 May to 10 June and from 18 August to 2 October in 2010, the 31st year of the study.

Data on production and survival of calves were gathered during spring. For the eighth year, few instances of predation on neonates were reported in the area east of Sanctuary River. This correlates with fewer observations of bears and their signs in this area during both spring and fall. This is in marked contrast to events occurring in the 1980s and 1990s when bear sightings and predation on moose calves were common. Radioed cows produced calves at rates similar to previous years. Predation on calves in this area has been the major cause of calf mortality for the past 30 years. During spring 2010, we again monitored cows with calves in the entrance area and near Riley Creek Campground. We closely monitored interactions between moose, people, and dogs.

During autumn, data were gathered on behavioral ecology, mainly on rutting behavior, traditional use of rutting areas, mating success, sparring, fighting, and antler breakage. Moose were distributed in traditional rutting areas similar to previous years, with much activity in the mile 9-10 area, but following the trend of recent years, no stable rutting groups formed. Data on mating success and mate choice were gathered on radioed females and uncollared but identifiable bulls. Calves were again relatively abundant in roadside areas during autumn compared to the 1980s and 1990s. Calf survival from May to September was estimated at about 25 percent in 2010, higher than in recent years. The moose population in the eastern part of Denali National Park appears stable to slowly increasing following a sharp decline 1970-1990. This was due to low recruitment as a result of high predation rates on young calves, primarily as a result of predation by bears. Current population trends are correlated with less bear predation on neonates.

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

Data from the AWS shows that the average annual temperature at KBC from May 7, 2009 to May 7, 2010 was -6.6˚C (20.1˚F), which was 2.3˚C (4.1˚F) warmer than the average of -8.9˚C (16.0˚F) from May 7, 2008 to May 7, 2009. The maximum (hourly average) temperature from May 7, 2009 to May 7, 2010 was 12.0˚C (53.6˚F) on June 27, 2009 from 3-4 pm, and the minimum temperature was -28.0˚C (-18.4˚F) on December 17, 2009 from 8-9 pm. These were both warmer than the maximum (11.3˚C) and minimum (-29.2˚C) hourly average temperatures from the previous year (May 7, 2008-May 7, 2009). Based on the local lapse rate of 6.2˚C/km, we estimate a mean annual temperature at Mt. Hunter plateau (3900 m) of approximately -17˚C (~1.4˚F), indicating that the Mt. Hunter plateau glacier is frozen to its bed.

Researcher	Affiliation	Project
Wake (cont'd)		

The Mt. Hunter chemistry data display the clearest annual signals (from seasonal oscillations in firn chemistry) that we have yet seen at any of the DNP candidate ice core sites, most likely due to less influence of summer meltwater percolation at this higher and colder site. The team noted only one small (<2 cm thick) melt layer in the 10 m-long Mt. Hunter firn core, whereas 5-10% of the annual snowpack at Kahiltna Pass consists of refrozen melt. Thus, the transition from the percolation zone to the dry snow zone is just above the elevation of Mt. Hunter plateau (~13,000 ft). Pollutants such as lead and arsenic are found at similar enrichments (>90% of each is pollution) on Mt. Hunter plateau as at KBC, Kahiltna Pass Basin, and Mt. Russell, supporting our previous hypothesis that the atmospheric pollution is primarily the result of long-range transport from upwind regions including Asia. The March, 2009 Mt. Redoubt volcanic eruption proved to be a valuable time horizon, leading us to revise our previous accumulation rate estimates for KBC and Kahiltna Pass Basin to 0.95 m w.e. and 0.85 m w.e., respectively. On Mt. Hunter plateau, we estimate an average annual accumulation rate of 0.7 m w.e.

GPR profiles collected in 2008-2009 indicated that Kahiltna Pass basin has a maximum depth of 300 m and surface conformable strata within at least the top 75 meters of ice, appropriate for extraction of a surface-to-bottom ice core. However, data collected with lower frequency GPR in 2010 reveal complex (deformed) strata underlying 150-170 meters of surface conformable firn/ice at Kahiltna Pass. Based on our measured accumulation rates and flow model estimates from GPS surface velocity measurements, we estimate that only ~100 years of surface conformable ice exists at Kahiltna Pass, well below our goal of obtaining a ≥1000 year unaltered climate record.

We also collected a centerline GPR profile on the Kahiltna Glacier from Motorcycle Hill (11000 fasl) to below Camp 1 (6800 fasl). Significant radar signal attenuation from melt occurs in the GPR profile just above ski hill (8530 fasl). Surface velocity measurements collected in 2009 and 2010 show a 300-400% velocity increases at the base of ski hill relative to regions up-glacier. This new centerline GPR profile supports a previous hypothesis that the Kahiltna Glacier has a melted or lubricated bed at and down-glacier from Camp 1. These data also suggest that the boundary between the wet and percolation snow zones occurs at the top of ski hill (~8500 fasl).

Results from GPR profiles collected on the Mount Hunter plateau reveal between 200-270 meters of surface conformable ice, and minimal signs of ice deformation. Combined with our annual accumulation estimate of 0.7 m w.e., our ice flow models project that we will be able to collect a paleoclimate record spanning over 1000 years from this location. The combination of a >1000 year climate record, the minimal influence of meltwater on snow chemistry, and the favorable glaciological dynamics make the Mt. Hunter Plateau the most optimal deep ice core site yet identified in DNP.

◂ 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 natural and cultural heritage. This is the seventh 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 National Park Service nationwide.

Other partners include:
Denali Education Center
Doyon- ARAMARK Joint Venture
Denali Borough School District
University of Alaska

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 is shared with the park concessioner. The MSLC field camp is located at the Teklanika River (Mile 29) and consists of six tent cabins (24 beds), a yurt, and a food and equipment storage shed. The MSLC Guest Housing (yurt), located near the MSLC Dining Hall, provides housing for guest researchers and educators.

Services provided by the MSLC and partners are the following:

(1) space for both educational programs and events
(2) office space and resources for visiting researchers
(3) internet access and data transmission capabilities
(4) videoconferencing
(5) in-park transportation coordination and food service

In 2011, the MSLC programming includs citizen science programs; curriculum-based education programs for K-12 grades; school-to-work experiential learning programs; electronic field trips; internships; multi-day accredited field seminars and teacher trainings; youth camps; science presentations; and research fellowships.

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 82-84, "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 decisionmaking in national parks.

Programs

Citizen Science

Alaska Lake Ice and Snow Observatory Network (ALISON) Project. Throughout the 2010-2011 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.

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 Denali Backcountry Adventures includes monitoring 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 2011, the MSLC will offer the Denali Backcountry Adventures July 11-15, with a skill building workshop on July 11.

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 13-17, 2011).

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 2011, this camp will be offered July 11- 15.

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. This year two modules :"Alaska Paleo" and "Denali Rocks" are being offered. 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 18-29, 2011.

Field Seminars and Teacher Training

Field Seminars. The MSLC will be offering 15 field seminars in Denali and sponsoring two in Wrangell St.-Elias in the 2011 season. 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.

Teacher Training. The MSLC will offer three teacher trainings in Denali and sponsoring one in Wrangell St.-Elias in 2011. 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.

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. 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 returns all proceeds to the Murie Science and Learning Center operations, approximately $100,000-55,000 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, an interpretive walk through an area significant in early park history, and a ranger-introduced viewing of the film *Heartbeats of Denali*. A portion of the proceeds support the Discover Denali Research Fellowship Program (approximately $30,000 annually).

Running with the Pack: Family Excursion. This MSLC 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 returns all proceeds to the Murie Science and Learning Center operations, approximately $7,000 annually.

Climate Change in Alaska's Parklands Evening Presentation. Climate Change in Denali Presentation. In 2011 Alaska Geographic will offer a new presentation to park visitors. The science-based presentation about climate change in Denali looks at the current observations and trends and discusses how the National Park Service is responding to these changes. This free program is offered twice weekly at the MSLC facility.

Evening Speaker Series. The MSLC and Alaska Geographic host guest speakers throughout the summer. Guest speakers include park researchers, visiting researchers and conservationists, writers, artists, and adventure travelers. This free program is offered twice weekly at the MSLC facility, usually on Monday and Thursday evenings at 7 pm.

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

<u>Discover Denali Research Fellowship Program</u>
2011 is the sixth year of the Discover Denali Research Fellowship Program. Recipients are awarded grants up to approximately $8,000 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 possible by the Denali Education Center through the MSLC and Alaska Geographic. The fellowships are contingent on the researcher's obtaining a research and collecting permit, if working in the park, as with any research project.

Six fellowships (a total of $21,600) have been awarded in 2011 to the following researchers:

- Matthew Campbell, UAF
  Population genetics of Denali National Park blackfish

- Tamara Harms, UAF and Michelle McCrackin, Washington State University
  Climate change underfoot: permafrost thaw and nitrogen dynamics

- Rachel Isaacs, The Pennsylvania State University
  Mechanism of treeline shifts in climate change

- Justin Teisberg, Washington State University
  Developing a more efficient and reliable immobilization protocol for grizzly bear managers and researchers

- Colby Wright, UAF
  Fang Mountain paleoenvironmental reconstruction of Cantwell Formation

For more information about these research project and the researchers, see the Denali website: http://www.nps.gov/dena/naturescience/fellows.htm

In 2010, the following Discover Denali Research Fellows conducted their studies 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

Murie Science and Learning Center – Research Fellowship Program

In 2011, for the fourth year, 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. The awards are conditional on obtaining a research and collecting permit, if working within a national park:

In 2011, the following fi ve researchers are recipients of Murie Science and Learning Center Research Fellowship Awards (a total of $20,000 awarded):

- Leif Anderson, University of Colorado Boulder
  Contributions of sub-debris melt and ice wall retreat to the rapid deflation of the debris-covered Kennicott Glacier terminus

- Seth Campbell, University of Maine
  SAR techniques for spatial and temporal estimation of velocity and glacier surface melt variability in the Alaska Range

- H. River Gates, UAF and USFWS
  Migratory connectivity of dunlin breeding at Cape Krusenstern NM

- Ron Karpilo, Colorado State University
  Reconstructing and mapping the historic geoscience exploration of Stephen R. Capps in Denali National Park and Preserve, Alaska

- Stephany Jeffers, UAF University of Alaska Museum of the North
  A new species of Claytonia from Feniak Lake: Assessing morphological variation, niche space, and genetics

- Colby Wright, UAF
  Paleoenvironmental reconstruction of the Late Cretaceous Cantwell Formation near Fang Mountain, Denali National Park, Alaska

For more information about these research project and the researchers, see the Denali website: http://www.nps.gov/dena/naturescience/fellows.htm

In 2010, these Murie Science and Learning Center Research Fellowship recipients conducted their projects [location in brackets]:

- 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]

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

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 2011*, 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.

DENALI NATIONAL PARK AND PRESERVE

Resources Staff FY2011

≺ In Memorium ≻

Phil Brease – Park Geologist from 1986 to 2010

Denali suffered an enormous loss last summer when Phil Brease, the park's geologist, passed away while doing what he loved, sharing his knowledge of geology with students. Phil started his career as a professional musician, but was quickly sidetracked by his love of geology, graduating from Central Washington University and working for multiple agencies before coming to Denali in 1986 to work on mining evaluation.Phil's work with mining in the park transitioned over time from the contentious job of evaluating mining plans and claims to the significant challenges of restoring mined lands. Phil excelled at developing cooperative research relationships and throughout his career facilitated research with a wide network of educators, geologists, and paleontologists.

Phil's contributions to park geology and paleontology were many. His efforts to improve understanding of park geology and his fostering of the park's newly recognized paleontological resources were especially important. His exceptional wit and excitement were infectious as he communicated a colorful geologic story to countless and diverse audiences.

Phil developed park science and communicated that science to a broad range of the public. Phil's name will live on in the minds of many researchers, park staff, visitors and school children, as well as in the Devonian brachiopod named in Phil's honor, *Myriospirifer breasei.*

Selected Resource Highlights from 2010 - 2011

Comprehensive Land Restoration

Denali has completed the most comprehensive riparian and wetland land restoration effort in its history in Kantishna. Funded in part by a $2.4 million flexible park base allocation, major restoration work has greatly increased the natural character and habitat value of several Kantishna properties: Slate Creek, Caribou Creek, Moose Creek, Comstock Mine, Glen Creek, and Skyline Drive. Major equipment and hazardous waste removal occurred at Glen Creek and Moose Creek. (see page 52)

Science-based Management

Denali has taken a leading role in implementing science-based management, exemplified by:

- Denali Park Road Capacity Study. This comprehensive study has examined the impacts of road traffic on a variety of social, biological, physical and logistical indicators. Results are being used to prepare a Vehicle Management Plan EIS, to guide future efforts related to road traffic (see pages 4-9)

- Comprehensive Geomorphic Study of the Toklat River. This study may save the park many hundred thousand dollars per year if gravel extraction from the Toklat River can be maintained without adverse impacts on the hydrology. (see page 53)

Looking Ahead – 2011 and Beyond

- □ **Natural Resource Condition Assessment** Denali expects St. Mary's University of Minnesota to complete the park's Natural Resource Condition Assessment in 2011 (page 3)
- □ **Viewability of Wolves Study** GPS/ARGOS collars were added to six wolves to study wolves in packs that live near the park road (page 26-27)
- □ **Sheep and Moose Surveys** Scheduled for 2011 (page 30)
- □ **Climate Change Models** How well do climate change models predict for Denali? (page 38)
- □ **Air Quality Retrospective** Analyzing 30 years of air quality data (page 42)
- □ **3-D Images of Dinosaur Trackways** Specialists will create 3-D images of dinosaur footprints at Cabin Peak for use in research, publications, and displays. (page 44)
- □ **Development of Sound Norms from Visitor Perceptions** A social science survey will ask visitors to note what sounds they hear and how they perceive those sounds (page 57)
- □ **Research Fellowships** $40,000 in fellowship funding in 2011 allows 11 researchers to pursue a variety of research topics in Denali and elsewhere (page 82-84)