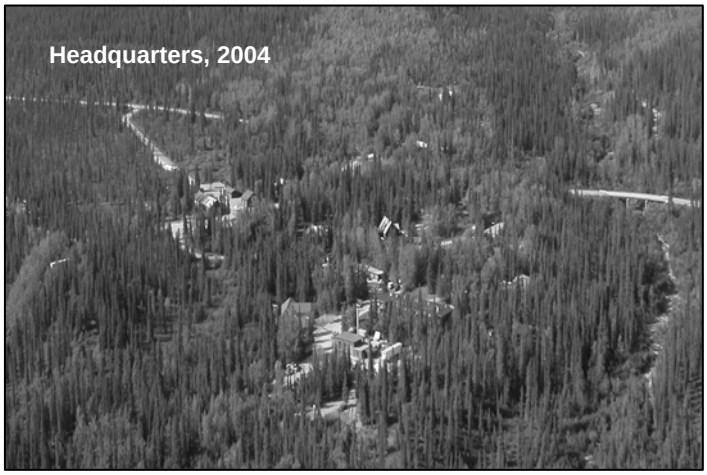
National Park Service
U.S. Department of the Interior

Denali National Park and Preserve

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

Courtesy of Harpers Ferry Center



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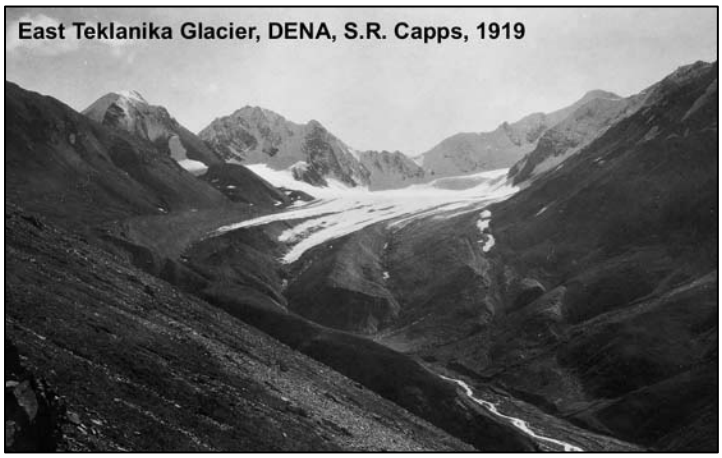

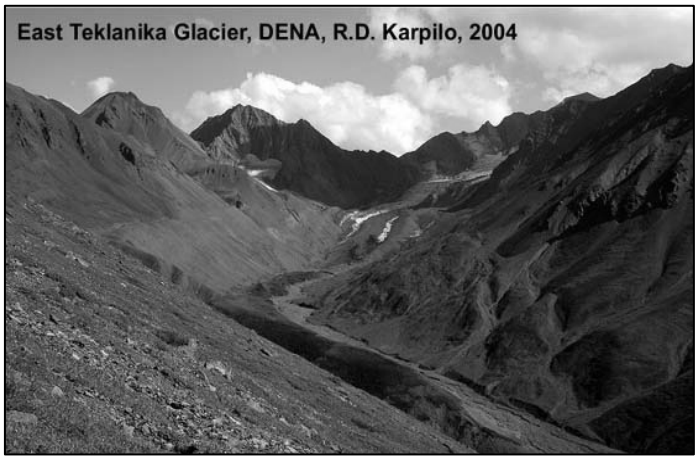

Summary of Current Resource Projects 2007

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

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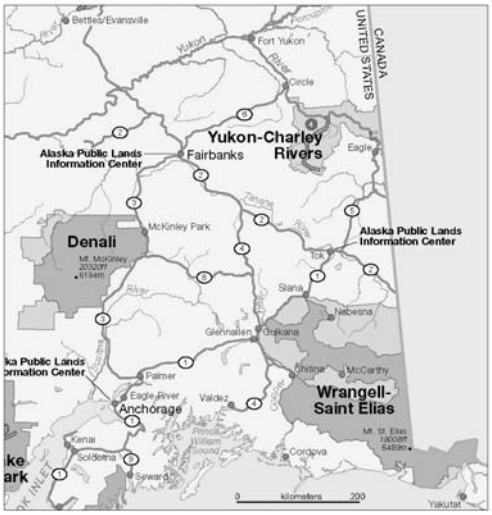
Integrated Programs and Findings

Central Alaska Network Inventory and Monitoring (I&M) at Denali

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.

The 2007 field season is the second year of program implementation after four years of planning and development.



Biological Inventories

Biological inventories were completed in 2005. These inventories documented the occurrence of 90 percent of the plant species, 90 percent of the small mammal species, and 90 percent of the freshwater fish species hypothesized to exist in Central Alaska Network parks. In 2005 the vascular plant inventory and small mammal inventory results were certified and all data have been transferred to NPSpecies and ANCS+.

Vital Signs Monitoring

The focus of the network until 2008 is bringing 11 of the 378 Vital Signs into full operation. This includes collecting field data, analyzing and reporting on the data to parks and the public.
As part of bringing the program into full operation, the network produced full protocols for the 11 initial Vital Signs (Climate, Air Quality, Snowpack, Vegetation, Water Quality, Macroinvertebrates, Passerines, Peregrine Falcons, Golden Eagles, Moose, and Wolves). After protocols are given scientific peer-review, they are revised as necessary before final approval from the Alaska Region Monitoring Coordinator. Currently, four Vital Signs protocols (Air Quality, Climate, Snow Pack, and Vegetation) have been given final approval. The remaining seven are in various stages of scientific review.

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

Recent Activities and Support

- "Near real-time" data from climate stations. Climate data from Denali, Wrangell-St. Elias and Yukon-Charley Rivers climate stations are transmitted hourly (hence "near real time") via satellite to the website http://www.wrcc.dri.edu/NPS.html. The website provides on-line tools for data summaries and data analysis.

- Vegetation monitoring underway in all 3 network parks. During 2006, vegetation monitoring was conducted in Denali and Yukon-Charley Rivers. Three crews of technicians conducted 10 day excursions to collect vegetation data across the park landscape. In 2007, vegetation monitoring will begin in Wrangell-St. Elias.

- Alaska Region Science Symposium and CAKN. The Alaska Park Science Symposium in 2006 focused on the three parks of the Central Alaska Network as well as of the neighboring Yukon in Canada. The organizers of the symposium held at Denali encouraged the presentation of scientific results on all aspects of park science including biological, physical, cultural, and social sciences, as well as park management. CAKN researchers presented seven papers and five posters about the Vital Signs monitoring program. More than 100 people attended the meeting, including park staff, managers, university scientists, and the general public. See also page 10.

- Interactive computer kiosks help educate park visitors about I&M data. The interactive computer kiosk program (see Vital Signs Monitoring above) has been updated. Park visitors can now view data on bird monitoring projects conducted throughout the network. Visitors may view maps of where the birds were observed, see pictures of characteristic habitats for each species, and view photos and hear audio-clips of each species.

- Investigating remote sensing for constructing vegetation maps. CAKN staff completed an analysis of three remote techniques to evaluate their usefulness in making large (regional) vegetation maps from plot data and in detecting changes in vegetation. The three techniques were unsupervised satellite image classification, supervised image classification, and photo-interpretation. The question was—can local-scale plot data collected according to the CAKN vegetation monitoring protocol be used to produce regional-scale maps of landscape change in Denali? Map accuracy is low for a map with nine classes of vegetation, but increases to ~80 percent when similar vegetation types with similar spectral characteristics are aggregated into a 6-class map. Classifications from remote techniques are reliable for detecting large changes in spectral characteristics only. For example, the invasion of spruce trees (conversion of Low Shrub–Tussock Scrub into Spruce Woodland) could not be detected reliably because of the similarity in spectral characteristics between the vegetation types.

- Shallow lake monitoring at Denali. In 2006, researchers implemented the shallow lake monitoring protocol at 30 lakes in Denali. Limnologists collected data on all the variables as outlined in the protocol except for vegetation. Based on a computer script that Dave Verbyla, a cooperator from the University of Alaska Fairbanks, created to automatically measure lake surface area, the team calculated the surface water area in Denali using RADARSAT imagery collected in early summer 2006. (See also pages 48, 60-61.)

- Small mammal monitoring reveals new understanding of population dynamics. For the 15th year, researchers monitored the abundance of small mammals in the Rock Creek watershed and the model produced explained 80 percent of variation in mammal abundance. (See page 26-27.)

Denali's Resource Stewardship Strategy

In 2001, the National Park Service instituted a new program document for resource management. Instead of having a Resource Management Plan, each park will develop a Resource Stewardship Strategy (RSS), a 15- to 20-year program planning document that serves as a bridge between the desired conditions as articulated in the park's General Management Plan and the implementation actions taken to protect park resources and values. The RSS will replace Denali's Resource Management Plan (1998). Existing specific park program plans (e.g., Subsistence Management Plan, Museum Management Plan, and Bear Management Plan) will continue to provide the details for day-to-day operations, but may need to be modified by the direction provided in the RSS.

A team has been formed at Denali (primarily resource staff) to complete Denali's RSS by the end of September 2007.

The park GMP specifies desired conditions for most of Denali's fundamental and "other" resources and values. Desired conditions are a qualitative description of the integrity and character for a set of resources and values, including visitor experiences, that the NPS has committed to achieve and maintain. Some of these desired conditions are articulated for the entire park and preserve, others apply only to specific management zones (also called "management areas" in some Denali plans). The RSS focuses on providing park managers with recommended comprehensive strategies to guide the National Park Service (NPS) in achieving and maintaining the desired conditions for the park's cultural and natural resources.

When most of the Denali GMP was crafted, articulating desired conditions was not an explicit objective of the planning process. As a result, although the desired conditions are present in the text they must be extracted and, in some cases, interpreted with reference to statutes. Desired park conditions fall into these categories:

1. Wildlife populations, wildlife habitat, and the processes and components of the park's natural ecosystem
2. Wilderness character, wilderness resource values, and wilderness recreational opportunities
3. Scenic and geologic values of Mount McKinley and surrounding mountain landscape
4. Visitor enjoyment and inspiration from observing wildlife in its natural habitat and other natural features
5. Historic, archaeological, and ethnographic resources
6. Paleontological resources
7. Air quality
8. Subsistence resources and opportunities

Indicators are being selected so they can be used to evaluate resource conditions and if management actions are effective at protecting park values. *Standards* for indicators may be different for different park zones.

Research *strategies* are being developed to (1) learn more about resources for which insufficient knowledge is available to select indicators for them, (2) measure resource indicators to make sure desired conditions are being achieved, and (3) carry out additional mandates about park resources. In January and February 2007, six informational meetings were held (2 in Anchorage, 1 in Talkeetna, 1 in Denali, 2 in Fairbanks) to share what is going on, and to gather suggestions from researchers and other subject matter experts about Denali resources.

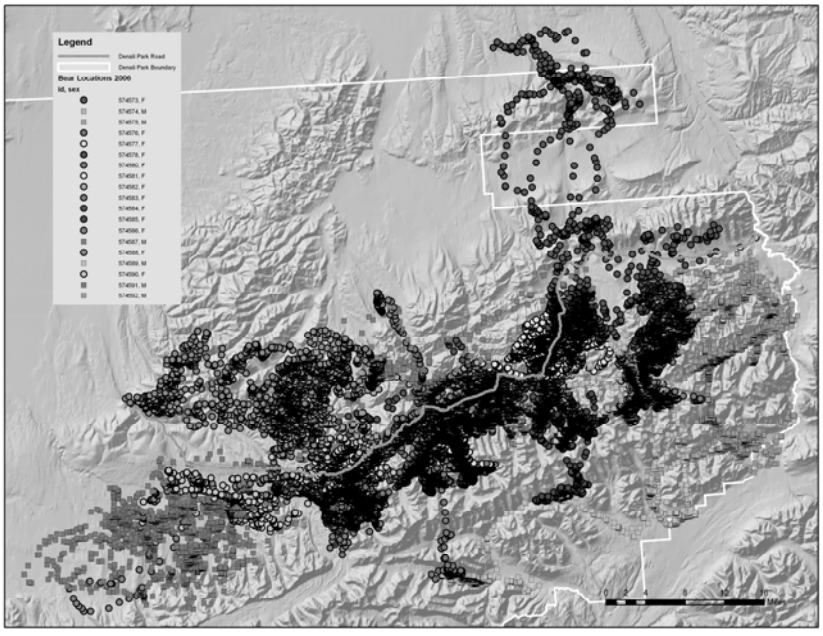
More information about the RSS will be posted on the website: nps.gov/dena.

Denali Park Road Capacity Study

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.

Wildlife movement

A GPS telemetry study of grizzly bears and Dall sheep is intended to detect impacts of traffic on animal movements near the road. Researchers captured 20 grizzly bears within the road corridor in the spring of 2006 and outfitted them with GPS collars for the season. The collars were programmed to calculate the position of the bears once every hour all summer, then fall off the bears automatically on September 20, 2006. Researchers captured 20 Dall sheep in March 2007 to follow their movements in the same way. Collars are programmed to fall off in September.



The movements of 16 bears in 2006 yielded a total of 45,370 locations (see Fig. 1). Three bears were censored from the analyses because they either did not have any locations within 3 km of the park road or were cubs whose behavior was autocorrelated with the mother's. The actual locations of the bears were assumed to be no more than about 9 meters (9 yards) away from the point reported by the GPS data.

Figure 1. Locations of 19 GPS collared grizzly bears during the summer of 2006.

To see Figure 1 in color, 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*

These 16 grizzly bears crossed the park road 466 times between May and September 2006 (Table 1). The number of crossings varied significantly among bears and ranged from 0 to 144 crossings. Differences among bears 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.

Table 1. Denali Park Road crossings by month of 16 GPS collared grizzly bears in 2006. A bear number is preceded by F (female) or M (male).

	Number of road crossings					
Bear ID	May	Jun	Jul	Aug	Sep	Total
F573	2	10	16	7	3	38
F576	0	0	0	0	0	0
F577	0	0	0	0	0	0
F578	10	0	0	0	0	10
F580	0	4	0	0	0	4
F581	8	13	8	26	4	59
F582	3	17	7	19	19	65
F584	33	43	17	39	12	144
F585	0	0	0	0	0	0
F586	3	6	4	21	8	42
M587	15	11	2	0	n/a	28
F588	1	0	2	1	0	4
M589	0	0	0	0	0	0
F590	14	20	11	6	11	62
M591	6	4	0	0	0	10
M592	0	0	0	0	0	0
Total	95	128	67	119	57	466
% of total	20.3	27.5	14.4	26.0	12.0	

Researchers considered a bear inactive when movement rates were less than 11meters in one hour. The highest probability of being inactive was during early morning hours. The height of inactivity (10 percent) occurred between 3 and 4 am. On average, bears were inactive about 15 percent (range 10 to 28 percent) of the time across the entire season.

Park staff installed traffic counters at intervals along the park road to record vehicle numbers to determine whether variation in the amount of traffic on segments of the park road affected bear behavior. Average daily traffic was 282 vehicles from Savage to mile 28; 222 vehicles from mile 28 to the Teklanika gate; 218 vehicles from the Teklanika gate to Toklat; 189 vehicles from Toklat to Grassy Pass; and 107 vehicles from Grassy to Wonder Lake. While study bears utilized habitats along the entire length of the park road, proximity to various road sections by a bear seemed to depend on home range location and not on what section of road a bear was near. There was no great variation among bears in distance to road by segment. Researchers then compared the distances of locations of inactive bears from the park road to random points along road segments. 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.

During the summer of 2006, the average number of vehicles on the Park Road peaked at 11am with over 17 vehicles per hour logged at traffic counters along the road (Figure 2). GPS collared bears generally crossed the road most frequently between 8 and 10 am and at 10 pm. The low number of road crossings between midnight and 4am corresponds to the period during which collared bears were found to be most inactive.

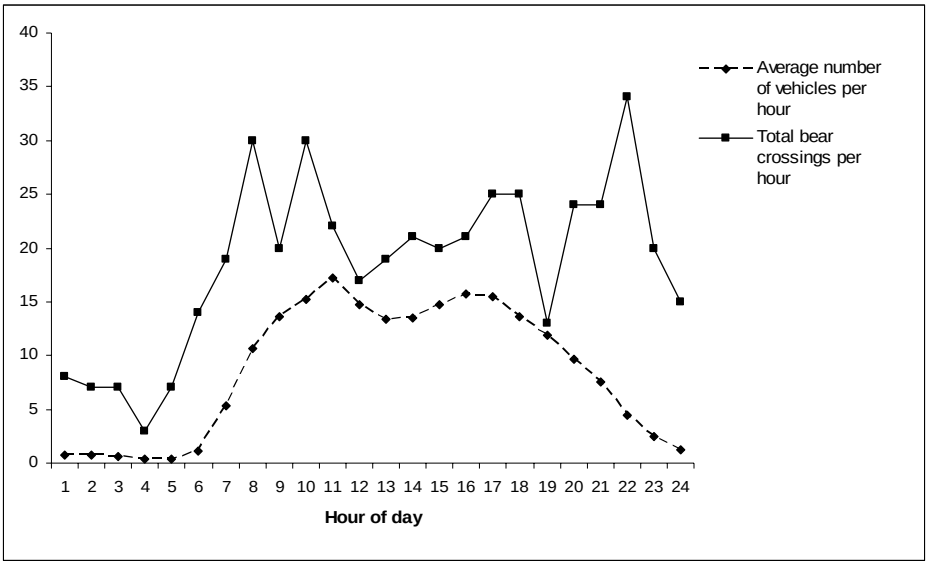


Figure 2. Hourly traffic and bear crossings on the park road averaged over the summer 2006 season.

Visitor survey

Researchers examining the expectations and quality of experiences of Denali Park Road vehicle users completed the first of two phases of the study 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.

Interviewers asked visitors questions about the quality of their experience on the park road, impacts to their experience, the number of vehicles on the road, and the management of vehicles using the road. Results from these interviews suggest a wide variety of potential indicators for the quality of a visitor's experience. These variables include the number of vehicles seen, number of encounters with other vehicles, frequency/duration of wildlife stops, distance of wildlife from the road, dust generated by vehicle traffic, number of visitors at rest stops, the condition and maintenance of buses, behavior/actions of other visitors while on buses, number/type of facilities along the road, vehicle congestion, and the quality of educational information provided by bus

drivers. Results also provide insights into *how* these variables affect visitor experiences and into potential differences among user groups. For example, seeing moving buses diminished the sense of "being in the wilderness" for some visitors, but seeing stopped buses positively affected the experience by indicating areas where wildlife might be viewed (Table 2).

Table 2. Coded responses to the question "Did you feel you were in the 'wilderness' during your trip along the road? Why or why not?" from last summer's visitor survey.

Code	Frequency
Yes, because	*6*
The road is surrounded by a vast, natural landscape	42
Not much traffic/use	18
Few buildings	15
Character of the road	11
The wildlife that was seen	10
No street signs, traffic signals, or power lines that would be found on other roads	7
Only buses, no cars on the road	5
Not much litter	2
Quiet	2
I walked along the road	1
Primitive or undeveloped rest areas	1
Character of the bus	1

Code	Frequency
No, because	*1*
The number of buses and people	31
Being on the bus detracted from a feeling of wilderness	27
The road	20
Facilities (rest stops) were present	7
Landscape (wasn't rugged or forested)	5
Construction activities	2
Human created noises	1

In 2007, researchers will begin the second phase of the study—gathering data that will help set standards for indicators selected from results of the first phase. Park managers will eventually use the resulting indicators and standards to evaluate and manage vehicle traffic by monitoring indicator variables and using a computer simulation model to estimate maximum acceptable vehicle use levels.

Traffic constraints

A study of logistical and physical constraints on traffic is examining vehicle behavior and determining factors that constrain traffic flow on the park road. In 2006, park staff, with assistance from Joint Venture, installed 130 GPS units on vehicles that use the park road on a

regular basis. GPS units were installed on all JV tour, shuttle, and camper buses. Approximately 40 NPS vehicles also had GPS units installed, including heavy equipment, road crew vehicles, and vehicles driving the park road on a regular basis. Park staff set up three base stations to remotely download vehicle data at the Denali Visitor Center, C-Camp, and Toklat. Remote downloads of vehicle GPS data worked very well once all the equipment was in place.

In 2007, bus drivers on 20 buses will be using LCD touch screen panels (Fig. 3) to record information about the location of stops made along the road for wildlife sightings, passenger pick-up and drop-off, and road maintenance. The information will be automatically downloaded to base stations along with the vehicle's GPS location data.

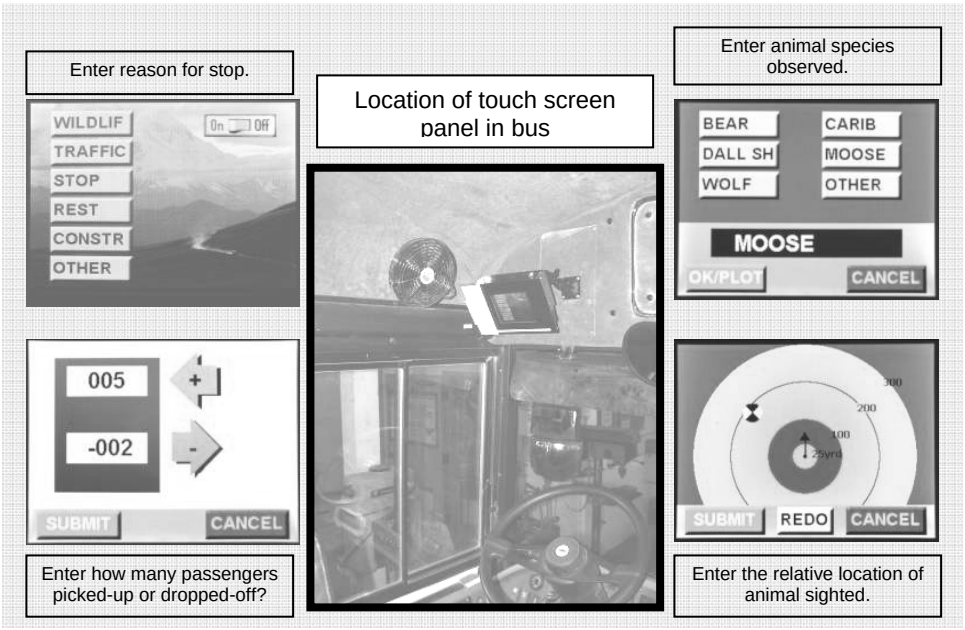


Figure 3. Touch panel data loggers will be installed on 20 buses in 2007 and will allow drivers to automatically geo-locate various reasons for stopping such as wildlife sighting or passenger pick-up locations.

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. To account for the effects of these various factors on traffic flow, researchers will use GPS and wildlife sighting data collected from vehicles driving the park road in 2006/2007 to create a traffic model capable of simulating location and vehicle-specific driving behaviors. Researchers can use the model to vary bus schedule scenarios, wildlife encounter probabilities, and other road logistic rules to quantify and visually analyze travel times, predicted bunching, and following distances of buses and of other vehicles along the road. The results can be used to predict and better study traffic related impacts on visitor experience and wildlife behavior.

Simulation experiment. During the winter 2006/2007, researchers developed a simulation experiment to evaluate model rules about driver behavior (travel time, stop time) especially in relation to wildlife stops. Using the rules, the model can predict changes in total travel and stop time related to traffic congestion on the park road. Researcher modeled the park road from the

Wilderness Access Center to Stony Overlook west of the Toklat River. "Wildlife sightings" near the road at six hypothetical but predetermined locations during early morning, mid-morning, and afternoon were added to the model at one hour intervals over a nine-hour period. These locations and time periods for encounters were based on actual observations over a single day in 2006. The stop and speed characteristics for all bus routes – Visitor/Camper Shuttle Buses, Denali Natural History Tours (DNHT), and Tundra Wildlife Tours (TWT) – were considered identical for this experiment. In 2006, 76 buses departed daily from the Wilderness Access Center. This bus schedule was used as a 'control' for other management strategies that were tested. One of these strategies included varying the stop times at wildlife encounters to average either 5 or 15 minutes.

The change in average stop times for wildlife viewing resulted in responses in total travel and stop times (Fig. 4). Five minute viewing times decreased the number of unintended stops made by all buses by 7 percent and decreased the overall travel time by over an hour on average.

Data collected in 2007 along with a comparative analysis of 2006 data will be used to fine-tune the traffic models for each type of bus routes (DNHT, TWT, Shuttle).

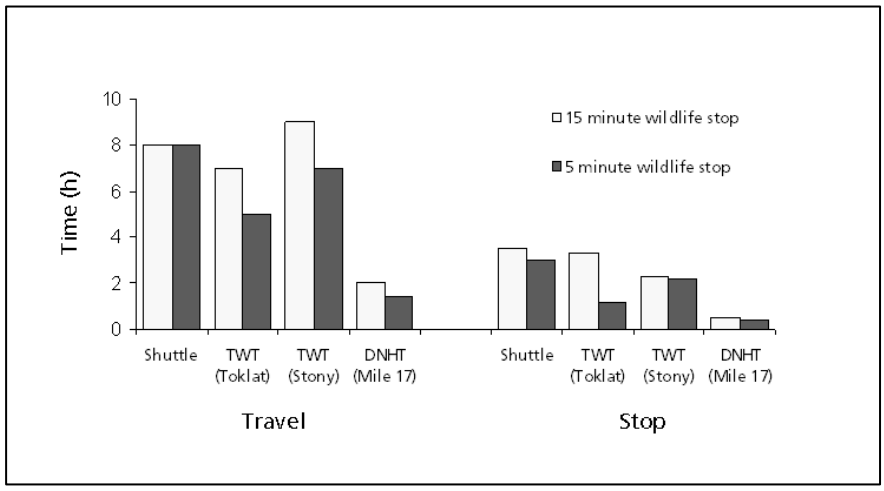


Figure 4. Simulated effects of changes in wildlife encounter stop times travel and stop time of Shuttle, Tundra Wildlife Tour (TWT) and Denali Natural History Tour (DNHT) buses driving the Denali Park Road. These are preliminary results based on a subset of vehicle GPS data collected in 2006.

Ultimately, a comprehensive model of park road traffic will be developed to predict the effects of changes in traffic volume and timing on visitor experience and wildlife movements. If the model and an environmental impact statement 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.

International Polar Year (IPY) Activities at Denali

The International Polar Year 2007 – 2009 is a huge, exciting scientific campaign focusing on the polar regions – both the Arctic and Antarctic regions. The official IPY launch date was March 1, 2007. For the next two years, scientists from around the world will focus their efforts on understanding the role of the polar ecosystems on global climate systems.

Current programs and research at Denali will contribute to this effort. In particular, the vital signs monitoring program (Central Alaska Network), and data from long-term studies will be highly supportive of Alaska efforts. Denali's contributions will include some of the longest running climate and biological monitoring records in the region. It is anticipated that Denali resource staff will work with UAF scientists on IPY projects related to climate change, permafrost, glaciers, vegetation changes, and wildlife. One example is Martin Jeffries, University of Alaska Fairbanks, who continues measurements of lake ice and snow at Horseshoe Lake as part of the Alaska Lake Ice and Snow Observatory Network (ALISON). He has enlisted the help of Tri-Valley students and teaches, as well as park staff and the Murie Science and Learning Center.

The website for the International Polar Year Alaska is http://www.alaska.edu/ipy/.

Alaska Park Science Symposium Held at Denali

More than 150 scientists, park managers, community members, students, and educators gathered at the Denali Visitor Center and the Murie Science and Learning Center for the 2006 Alaska Park Science Symposium that took place in September. The bi-annual event had as its theme "Park Science in Central Alaska: Crossing Boundaries in a Changing Environment." Presentations focused research in Denali, Wrangell-St. Elias, Yukon-Charley Rivers, and the adjacent lands and waters of Central Alaska and the Western Yukon. The schedule included fifty presentations and thirty-five posters on topics including geology, monitoring a changing environment, landscape ecology, vertebrate ecology, profiles in history, educational strategies, evaluating the visitor experience and subsistence management. The conference was broadcast live over the Internet, allowing people from all over the country to view sessions in real time. A published Symposium Proceedings is planned in 2007.

Effects of Climate Change at Denali

Denali's natural resources are responding to climate change. Some of these changes are easily visible and others are more subtle:

- **Wildfire Size and Duration.** Fire statistics over the last five years show an increase in fire size and duration. The Moose Lake Fire in 2002 (see photo at left) was the largest single fire on record for Denali (117,920 acres) and the Highpower Creek Fire (2005) lasted 81 days – well beyond the average of 24 days. There has not yet been an increase in the average numbers of fires per year, but lightning activity levels have increased. There were a record number of lightning strikes in June 2005 in Interior Alaska. 2005 was the second largest fire season on record – 4 million acres burned with widespread smoke in June and July.

- **Shrinking Glaciers.** Denali glaciers continue to show negative balance and steady thinning. (See photos on front cover; see pages 46-47.)

- **Warming of permafrost.** Permafrost temperature profiles measured in boreholes near Healy show consistent warming since 1991. The borehole temperatures are very close to 0°C. At the point when borehole temperatures reach 0°C, there is the potential for significant landscape change. (See page 45.)

- **Snow free days and length of growing season.** Weather observations have been recorded at Denali for 80 years (since 1925). In recent years, the number of snow free days has increased and the growing season has lengthened. Average warming over the past century has been 0.5°F. (See weather information on pages 36-38.)

- **Vegetation and landscape change.** Over a 30-year period, based on visual comparison of aerial photography (1976, 2005), spruce has expanded its range across the landscape, open water areas are smaller, "pond-drying" is common, and woody vegetation has invaded open wetland sites. An example of the invasion of open wetland sites is shown below—notice the extent of woody vegetation, including shrubs and spruce trees (likely *Picea glauca*), that has established in the same meadow between 1976 (left) and 2005.

1976

2005

- **Shifts in Bird Distribution.**
  - Trumpeter Swans increased in numbers; their distribution enlarged to include higher elevation lakes (2005 survey)
  - Orange-crowned Warblers, Golden-crowned Sparrows, and Lincoln's Sparrows are much more common in Denali than they were 75 years ago (based on bird surveys in 2001 to 2005).

Long-term Vegetation Monitoring

Field work continues in 2007 for the vegetation component of the long-term monitoring of park resources, including landscape monitoring of vegetation and white spruce cone production.

- **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 these mini-grid sites 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 2006, two vegetation crews completed sampling of the following mini-grids: Wonder Lake, Mount Healy Ridge, Primrose Ridge, Kankone Peak, Bearpaw River, Sandless Lake and Bear Creek. During the 2007 season, the vegetation crew will be installing new plots and measuring vegetation in seven mini-grid study areas, which are scattered across the northern part of the Park from Polychrome Glacier area to Broad Pass to the Stampede Corridor.

- **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 2002.

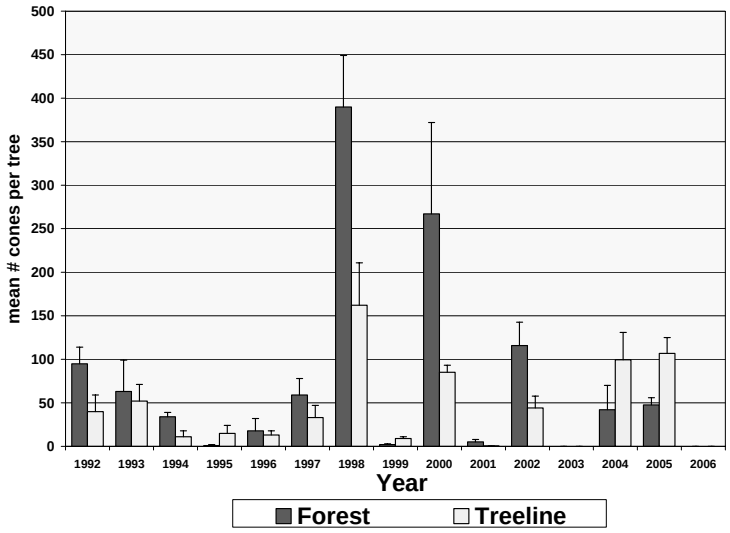


Figure 5. Average number of cones per white spruce tree observed in 3 treeline and 3 forest (valley bottom) plots in the Rock Creek drainage.

The spruce sample population produced virtually no cones in 2006 (no bar visible in Fig. 5), which is not surprising considering 2004 and 2005 were two consecutive years of sizable cone production that depleted the trees' reserves.

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, but in 2004 and 2005 there were more cones per

tree in the higher elevation treeline sites. In general, trees at treeline are considerably smaller than the spruce trees in the low elevation forested site.

❖ **Repeat photography**

The repeat photography project is part of vegetation monitoring in the Central Alaska Network. Approximately 2,500 slides of Denali taken in 1976 have been scanned and metadata on each picture recorded in an Access database. A number of repeat photographs (a subset of the entire aerial photos of park landscapes taken in the mid-1970's) were taken in 2005 to document qualitative changes in Denali's landscape. The original photographs were taken to prepare the first vegetation map of the park by Fred Dean, long-time researcher in Denali. Dean's early photos are a treasure trove of ecological information about the park at an earlier time and what changes are evident on the landscape over a 30-year span of time.

The CAKN is working on ways to objectively quantify the vegetation change. While there was no repeat photography taken in 2006, and there are no plans for any in 2007, additional repeat photography will be done in the future.

Removal of Exotic (Non-native) Plants

Several individuals and groups helped Wendy Mahovlic and "the exotic plant management team" remove hundreds of pounds of non-native plants from the Denali Park Road corridor, the Entrance Area of the park, and the Parks Highway near the park entrance. Counting the native seed collection volunteering (see next section), sixty-eight volunteers worked 1351 hours.

❖ **Non-native plants with greatest biomass removed**

Here's the 2006 roster of non-native plants removed in/ near the park (more than 50 lbs):

* Dandelion (*Taraxacum officinale)*: 756 lbs
* White Sweet Clover (*Melilotus alba*): 173 lbs
  (Miles 239 to 227 Parks Hwy; Miles 0 – 3 Park Road)
* Hawk's-Beard (*Crepis tectorum*): 350 lbs
  (Sewage lagoon; Miles 0 – 3 Park Road)
* Mustard (*Erysimum cheiranthoides*): 70 lbs
  (Toklat area; Miles 41 and 43.4 Park Road)

❖ **Other non-native species of plants**

Six additional non-native species other than dandelions were removed in 2006:

* *Vicia cracca* (bird vetch): 5 lbs. (Miles 1 – 3 of Park Road)
* *Lupinus polyphyllus* (bigleaf lupine): 3 lbs. (Mile 7 pull-out)
* *Trifolium repens*, *T. pretense* (red and white clover): 20 lbs. (Miles 0 – 3 Park Road)
* *Leucanthemum vulgare* (oxeye daisy): a few plants (Nenana Canyon, near bus barn)
* *Tripleurospermum perforata* (scentless false mayweed): a few plants (Railroad Depot)
* *Linaria vulgaris* (yellow toadflax): several plants (Railroad Depot)

In 2007, for the ninth consecutive year, volunteers will be enlisted to pull dandelions and other non-native plants in the park.

Revegetation of Construction/Disturbed Sites

❖ Seed collections

In anticipation of the need for native seeds to revegetate areas after development and construction, resource staff, 13 volunteers, and the Denali trails crew again conducted a "Need for Seed" collection in 2006. Approximately 328 person-hours were spent collecting 30 pounds of uncleaned seeds in mid-August 2006.

Collections were made in the East (near the park entrance) and West (at Toklat, Eielson, and Kantishna) of early successional species. These successional species are ones that will grow well on any newly-graded and bare soil sites being created by construction. The species include Eskimo potato (*Hedysarum* spp.), Oxytropis (*Oxytropis campestris*), Arnica (*Arnica* spp), and native grasses (*Elymus* spp).

Once the seeds are collected, they are cleaned (removing seeds from pods or leafy sheaths and removing plant stalks and stems). Seed collections will continue in 2007 for revegetation of present and future construction projects.

❖ Revegetation

The big revegetation projects for the 2007 season are the revegetation of areas around the new Eielson Visitor Center and in the Toklat area, using vegetation mats and seeding in the fall.

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

Off-Road Vehicle (ORV) Impacts

In 2005, park staff used GPS to map nearly 45 linear km of tracks made by ORVs in the park (see Fig. 6). 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.

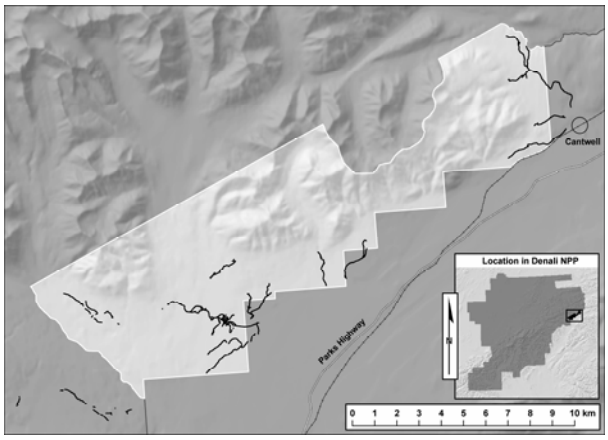


Figure 6. ORV trails mapped in 2005. The lighter area is the Cantwell Traditional Use Area.

In 2006 and continuing in 2007, park staff members are incorporating the field data about the impacts of ORV's into the Environmental Assessment (as part of the NEPA process) being written to develop alternatives for managing ORV use for subsistence activities in the Cantwell Traditional Use area of Denali.

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 as a dust palliative on the park road.

On August 23–24, 2005, park staff buried 30 lysimeters (instruments designed to sample water from within the topsoil). At Miles 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, 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. The data from 2005 and 2006 (preliminary results) show that beyond Mile 31.2 there is little to no chloride in the water bodies. Two sites on east end had high levels of Cl (180 ppm) right next to road. The lysimeters will be sampled again in fall 2007.

Wildland Fire

Monitoring Wildland Fires

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

No wildland fires occurred in Denali in 2006, but prescribed fires were used to burn slash piles (Table 3).

Table 3. Fires in or near Denali National Park and Preserve in 2006

Fire Name	Burn Period	Acres	Action Taken	Comments
Toklat slash burn	May 1-3, 2006	0.1	Burn biomass debris from general maintenance projects and Toklat Hazard Fuels Reduction Project	Prescribed fire[1]
70 Mile Pit slash burn	May 18-19, 2006	0.1	Burn biomass debris from roadside maintenance projects	Prescribed fire
Kantishna slash burn	May 18-20, 2006	0.1	Burn biomass debris from roadside maintenance projects	Prescribed fire

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

Fire monitoring includes observing a fire from aircraft, digitally photographing and mapping its progress, and keeping an updated narrative of the fire's status and behavior. Current and forecasted

weather over the fire area is also monitored to ensure that the fire will continue to burn only where allowed. Protecting isolated structures that lie in the fire's path is generally accomplished by setting up a water pump and sprinkler system on or around the structure as most structures tend to be located adjacent to water sources.

Creating Defensible Space Around Structures

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

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

- ✧ **Developed areas**. In 2006, defensible space totaling ~ 9 acres was improved at Toklat Road Camp, trimming branches to varying heights from the ground to give a natural appearance.

- ✧ **Cultural resource sites**. In 2006, the Sushana and Upper Riley Creek Patrol Cabins were "Firewised". Of the sites to be cleared in 2007, the ones most visible from the park road are the Toklat Patrol Cabin, the Pearson Cabin, and the East Fork Research and Patrol Cabins.

In 2006, the Fire Management staff resampled tree characteristics in selected plots that were installed and sampled in 2003 (pre-treatment). Tracking the plots is done to measure how the vegetation in the defensible space (treated areas) changes over time to identify what recurring maintenance is needed to minimize the threat of wildfire.

Utilizing Satellite Imagery to Estimate Burn Severity

To more efficiently and safely monitor the severity and associated effects of wildland fire on the vegetation within Denali National Park and Preserve, an exciting new technology that utilizes

satellite imagery is being developed. If it proves to be accurate, precise, and reliable, this technology will substantially increase firefighter safety by reducing the amount of time spent in aircraft flying over fires to collect data about fire severity.

Fire specialists have compared pre- and post-fire Landsat (satellite) imagery to develop this new index of burn severity called the Normalized Burn Ratio (NBR). This continuous index relies on the fact that vegetation reflects light in different ways if it is unburned or burned to various degrees. [For any satellite image "techies", NBR is calculated in a manner similar to the Normalized Difference Vegetation Index (NDVI), but uses Landsat bands 4 and 7 (not 3 and 4 as NDVI does).]

To be confident that the NBR system works for Denali or elsewhere, the satellite image NBR index has to agree consistently with ground observations. The NBR method has been applied to Landsat imagery for Denali and other Western Area parks to produce GIS maps showing the mosaic of fire effects (NBR index).

Fire Management staff did not install any plots in Denali during 2006 but plans to install plots in 2007 in the area of the Highpower Fire that burned in 2005.

Videography Landcover Reclassification and Moose Browse Utilization

The purposes of this study are to reclassify the "burn" portions of the Landcover Classification, test the use of videography as a method for landcover reclassification, validate predictive fire models used by fire managers, validate successional patterns compared to burn severity, and identify fire effects on the level of moose browse observed under varying burn severity levels and age of burn. Understanding the natural variability related to fire is also necessary in order to identify potential abnormal effects associated with long-term climate change or management activities.

The current fire fuels map for Denali is based on LANDSAT imagery compiled from scenes over several years. Approximately 12.9 percent of the park, which is prone to natural ignitions, is classified as "burn" on the current map or has burned since the Landcover Classification map was made. The analysis and imagery used to develop the landcover classes are unable to detect other classes of vegetation for up to 15 years after a fire. In the short term, these "burn" areas need to be reclassified into another Landcover classification other than "burn" to update maps so fire managers can predict fire behavior with some confidence. In the long term, fire managers would like to combine data about vegetation recovery after fires to model plant succession after a fire on a landscape scale, then apply this information to create maps.

Post-fire plant succession depends on the site's fire severity, climate, surviving flora and seed sources, proximity to early successional colonizing seed sources, and the substrate (rock, soil). Fire severity is the degree of ecological change (setback) due to fire. In general, the greater the fire severity, the further the plant succession is reduced to its earlier stages and the longer recovery will take to its pre-fire condition.

Fire is a major disturbance of boreal forests in Denali and interior Alaska, but how the age and fire severity of fires affects the density and distribution of moose on a landscape scale is poorly understood. Moose play a major role in the dynamics of boreal forest ecosystems and are an

important resource for subsistence users. In much of the natural fire-prone portion of Denali, if the fire severity encourages shrub development, then browsing by moose (moose browse utilization) may increase. Extremely high fire severity may delay shrubs development and extremely low fire severity may induce little change in species composition and structure.

Courtesy of Tom Walker

In 2005, field crews ground-truthed areas in the northwestern (most fire-prone) portion of the park that were flown with videography equipment in 2004. The field crews sampled vegetation in 46 plots established along the two 100-km transects, recording whether browsing by moose was low, moderate, or high. Transects were chosen to span burned areas ranging from 3-to 50 years ago. Data from this portion of the study will (1) provide ground-verified data to reclassify the "burn" landcover classification to a vegetated class and (2) establish baseline information on the extent of shrubs (browse) utilized by moose for areas where fire age and satellite-derived (Normalized Burn Ratio) burn severity are known.

Ten plots that had been established in early summer 2005 burned in mid-summer 2005 during the Highpower Fire, and were resampled in 2006. Analysis for this project is in progress and will continue in 2007.

Fire Education

- **Fire! In Alaska Workshops.** Fire! In Alaska workshops are intensive workshops that include hands-on lesson modeling, computer simulations, and interdisciplinary activites. Teachers and educators not only gain access to a "fire trunk" full of knowledge and tools to teach a curriculum about fire ecology, behavior, management, and Firewise, but they also receive one credit. Alaska Fish and Game and NPS staff plan to present a workshop in April 2007.

- **Denali Discovery Camp.** As part of the annual Denali Discovery Camp in June 2006, the Fire Management staff participated in short hikes and taught several students about the wildland fire triangle, fire behavior, firefighter tools, and the range of work a firefighter does. Staff plan to participate again this year

- **Susitna Exploration Camp.** As part of the annual Susitna Exploration Camp in late July and early August, the fire staff participated in hikes with several students and taught concepts about wildland fire and forest succession. Staff plan to participate again this year.

- **Alaska Interagency Wildland Fire Key Messages.** Wildland fire management agencies and organizations share common goals—to enhance personal safety and reduce loss of life while preserving and enhancing the health of forests and wetlands. To communicate clearly and consistently across all agencies and disciplines, the Wildland Fire Prevention, Education, and Awareness Committee developed key messages about wildland fire during the winter of 2006/7. Morgan Miller is chair of this committee and can be reached at Morgan_Miller@nps.gov for more information.

Wildlife

Keep Wildlife Wild

Denali National Park and Preserve resource staff continue to educate people with the basic message: "Keep wildlife wild - do not approach or feed wildlife". Anecdotal observations continue to indicate that the program is successful. Fewer reports of human-wildlife conflict due to food conditioning have been reported each year the program has been in effect. The program includes bookmarks, buttons, brochures, and signs bearing a universal symbol "Do not feed the animals" with text explaining why this is important. In 2007, staff will again distribute these materials around the park. Signs appear on trash cans, picnic tables, and toilet stall doors.

The message has also become part of every interpretive program. The "Keep Wildlife Wild" program serves as a model for other parks. Wildlife staff encourage everyone working at the park to take every opportunity to discourage the feeding and subsequent habituation of wildlife.

Bears

- **Grizzly bear monitoring**

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

  Bear capture was conducted on May 31 and June 1, 2006. Collars were replaced on four female grizzly bears. Three new three-year-old females were captured and collared. Four dropped collars were retrieved. Captures were conducted from a helicopter with fixed wing support. The number of collared bears in the study is 13, all female. The oldest study bear is 18 yrs old.

  At den emergence, only one sow had any spring cubs (one cub). By the end of September the cub could not be accounted for and was presumed dead. One sow had a single yearling that was alive at the season's end. Four sows had a total of 4 two-year-olds, two of which survived to the season's end. The third likely died and the fate of the fourth could not be determined after the death of its mother. Two sows had a total of 4 three-year-olds, three of which were radio collared and were alive at the end of the season. The fourth could not be accounted for after May and likely dispersed.

2006	Sows with spring cubs	Sows / yearlings	Sows / two-year-olds	Sows / three-year-olds
Den emergence	1 / 1*	1 / 1	4 / 4	2 / 4
End of September	1 / 0	1 / 1	2 / 2	2 / 3

* number of sows / total number of cubs

Plans for 2007 are to replace radio collars where necessary, increase the sample size by collaring some new bears or locating those with failed collars, and investigate mortalities/dropped collars.

- **Population estimates:**
  On the south side of the Alaska Range, the park is cooperating 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

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 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 get further information or to schedule bear training, contact Pat Owen (Wildlife Biologist) at 683-9547. Information and some equipment can also be provided for bear-proofing camps and worksites.

Between April 26, 2006 and September 18, 2006, 185 bear-human interactions were documented through the Bear Incident Management System (BIMS) forms. The interactions were classified as 7 observations, 149 encounters, 12 incidents, and 17 control actions. The total of 185 BIMS this year is more than a 22 percent decrease from the previous year's total of 238. Of those interactions rated as encounters, 49 occurred in frontcountry areas and 100 occurred in the backcountry. There were 12 interactions classified as incidents this season, split evenly between front and backcountry with 6 in each setting. This is a decrease of 13 incidents from the previous year. All control actions took place in front country settings in 2006.

Interactions	FRONTCOUNTRY	BACKCOUNTRY	TOTAL
Observations	3	4	**7**
Encounters	49	100	**149**
Incidents	6	6	**12**
Control Actions	17*	0	**17**
Total	**75**	**110**	**185**

Backcountry and frontcountry incidents involved property damage and close approaches to people.

There were 17 control actions in 2006 compared with 14 in 2005. Of these control actions, eight involved a pair of sub-adult bears frequenting the Savage River area and seven were directed at a sow with two two-year-olds frequenting developed areas around Wonder Lake and Kantishna Lodges. Nine control actions included in 2006 totals were not conducted by NPS staff. These included one action by Kantishna Roadhouse staff, five actions by Camp Denali employees, two actions by the Savage River Campground Host, and one action by a Joint Venture Bus Driver at Wonder Lake Campground.

Aerial Moose Survey

Moose (*Alces alces*) surveys in Denali National Park and Preserve are part of the Central Alaska Network (CAKN) monitoring program and follow program protocols to conduct moose surveys in the northern part of the park every 3 years. The last north side survey was conducted in 2004. Additional surveys are occasionally conducted to determine moose densities in specific areas of the park. In 2006, a survey in Game Management Unit 16B (upper Yenta valley on the south side) was planned in conjunction with an Alaska Department of Fish and Game moose survey in the same unit outside the park, in order to provide moose densities for an area that may experience increased pressure from subsistence moose hunters. Due to lack of adequate snow cover, the surveys were not conducted.

Road Wildlife Study

This study relies on those bus drivers who volunteer to help monitor wildlife along the park road and will continue in 2007 and become part of the larger road capacity study. Drivers record the numbers of bears, moose, sheep, caribou, and wolves they see on their trips (westbound only). These numbers 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.

Laura Phillips, the ecologist hired to work on many aspects of the road study, has begun some preliminary analysis of several recent years of data collected by bus drivers but not yet analyzed. She is restricting the analysis to observations made after the Savage check station at mile 15 on the Park Road, so some numbers such as the number of moose observations may be different from previous years.

Based on the groups of wildlife observed per bus trip from 1999 through 2006, a visitor taking one bus trip into the park could expect (based only on averages) to see 3 groups of caribou, 2 groups of grizzlies, and 1 or 2 groups of Dall's sheep (Fig. 7).

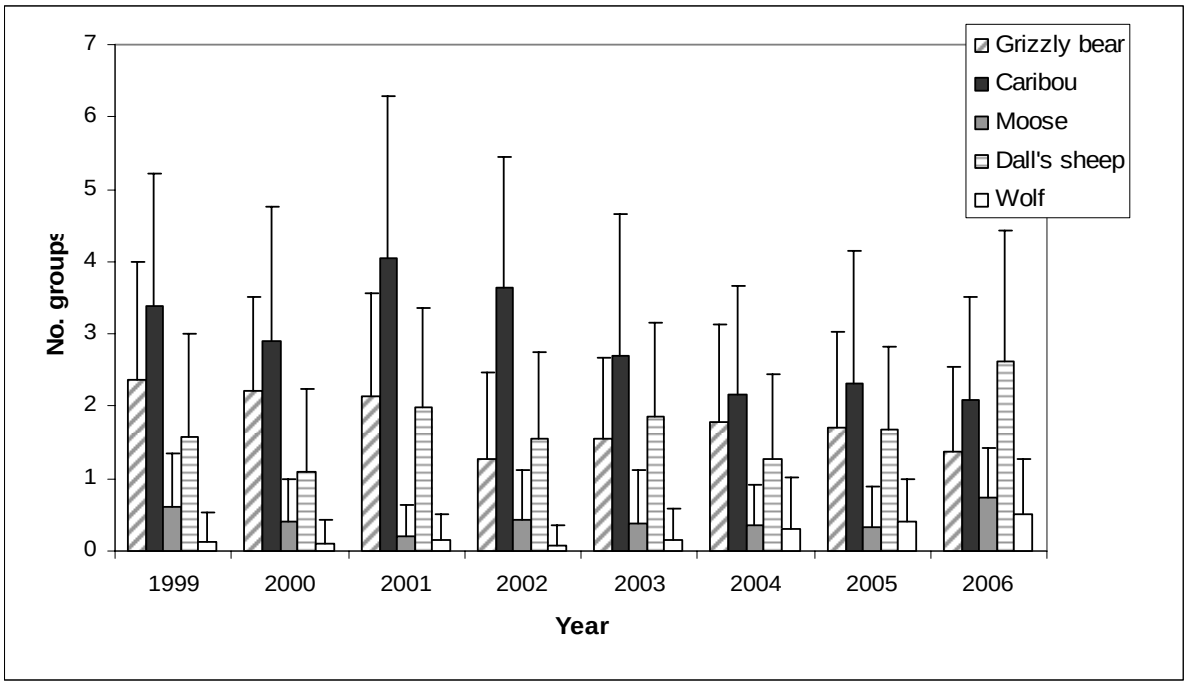


Figure 7. The average number of groups (+ SD) observed per trip on the Denali Park Road, 1999-2006.

Based on bus driver observation data from 1999 – 2006, a visitor taking 10 trips into the park would be expected to see a moose on 3 out of 10 trips, and a wolf on 2 out of 10 trips (Fig. 8).

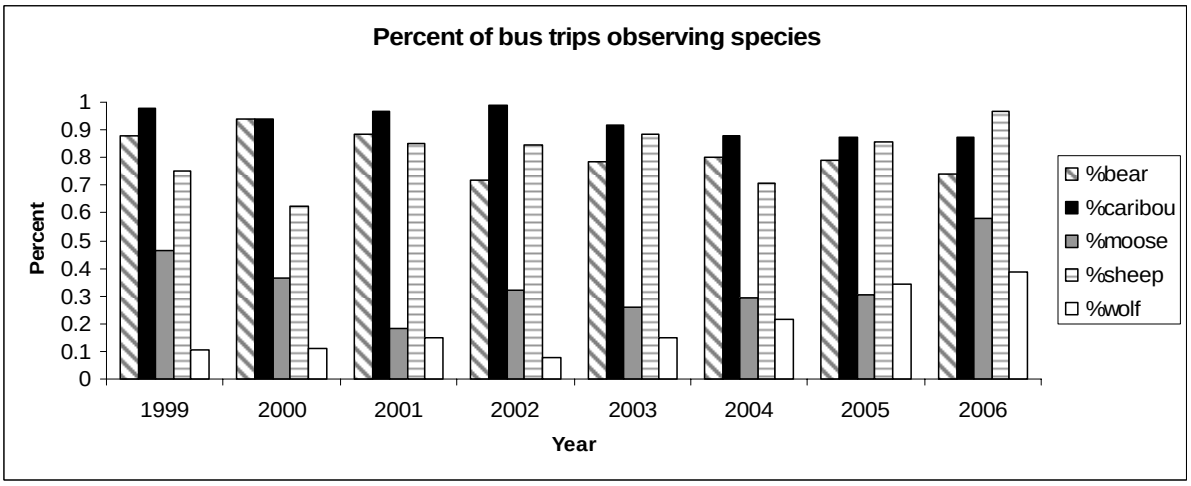


Figure 8. The percentage of bus trips during which different species of large mammals were observed on the Denali Park Road, 1999-2006.

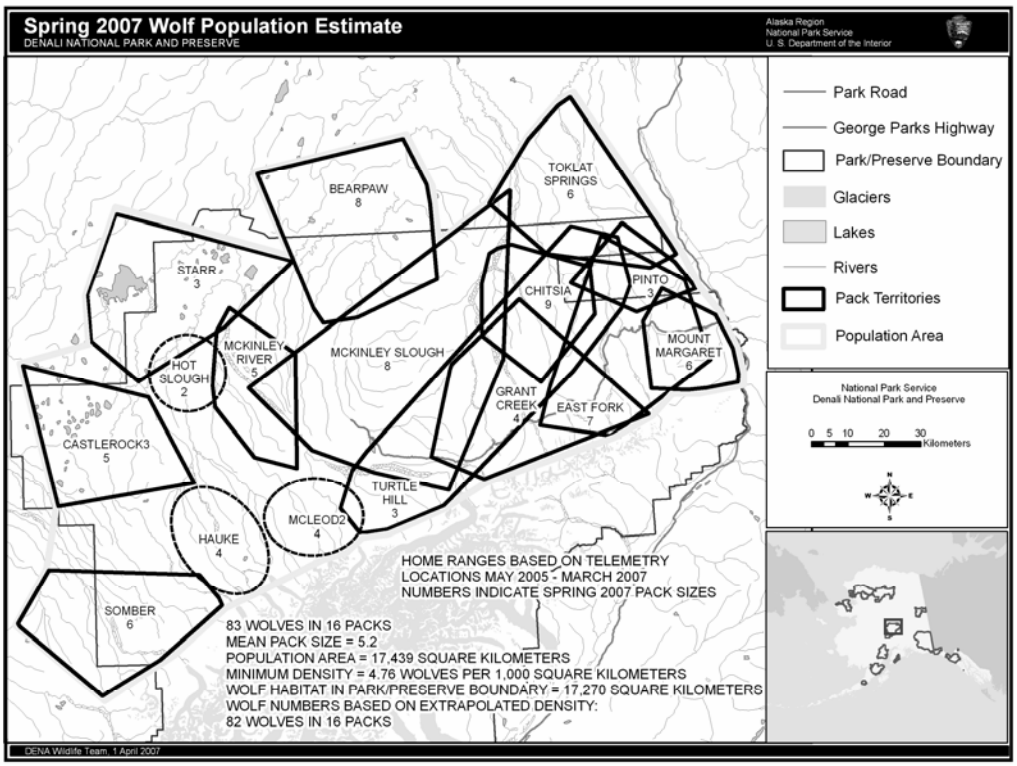
In summary, beyond the Savage River, the odds (based on averages over the last 8 years) of seeing the five large mammals are: caribou (92%), grizzly bear (82%), Dall sheep (81%), moose (35%), and wolf (19%). For wildlife viewing odds in more recent years, see Fig. 8 and note the height of the bars by species for 2005 and 2006 (Fig. 8).

Wolves

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

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

Telemetry locations acquired over two biological years (a biological year runs May 1 – April 30) 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, mortality factors, behavior, and population dynamics.



As of April 1, 30 wolves in 16 packs in Denali wore conventional, VHF radio collars that are located from antennae-equipped airplane. Another 9 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 April 2007, there were approximately 83 wolves in the 16 packs being monitored by park biologists. The estimated density of wolves in Denali (about 4.8 wolves per 1000 square kilometers) was significantly lower than the 2006 estimate (6.7 wolves per 1000 square kilometers), probably because more wolves dispersed from their packs during the previous year. Track observations and sightings in spring 2007 indicated that many wolves were traveling alone. High densities of snowshoe hares during the winter of 2006-2007 probably contributed to the ability of dispersing wolves to live alone before pairing up or joining a pack.

Caribou

The National Park Service has supported intensive caribou research at Denali since 1983. Since 1986, this research program has consistently applied the same methodology to census the population annually and to estimate calf production, calf recruitment, adult female survival, and herd composition. This Denali study is the longest and most consistent caribou census anywhere in North America. Despite the general acceptance of the importance of age on productivity and survival, the Denali's age-structured sample is the only one of its kind ever attempted in a wildlife population and it has been maintained for 20 years. Since 1986, a sample of approximately 50 radiocollared females has been maintained, providing an annual assessment of population vital rates faithful to the herd's age structure.

Much has been learned about the interactions between predation and weather and the dynamics of the Denali Caribou Herd (Fig. 9). 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 were recruited into the herd. With the onset of a period of severe winters in 1988, caribou numbers reached a plateau of about 3,200 in fall 1989, then declined and dropped to about 2,300 caribou by fall 1992. During the period of decline, adult cow winter survival dropped (85%) and calf recruitment

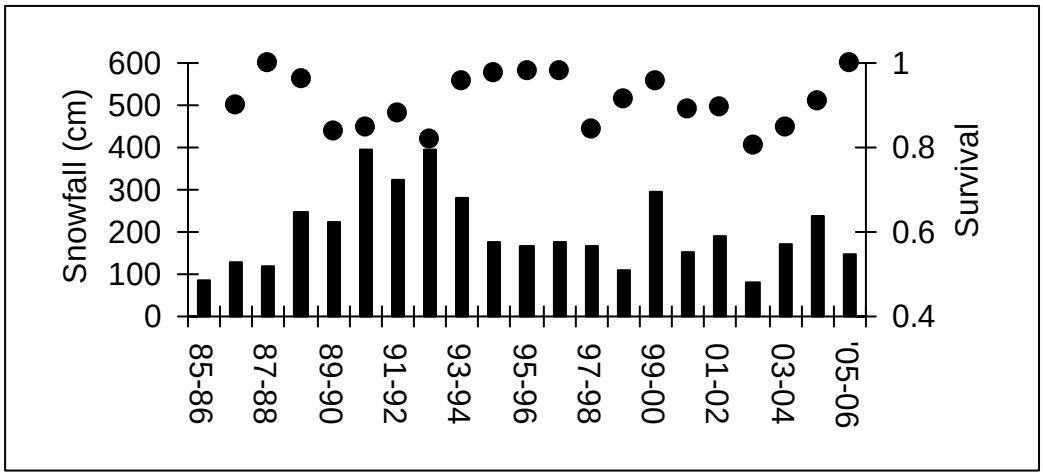


Figure 9. Estimated winter survival rates (October – May) of caribou cows in the Denali Caribou Herd, Alaska relative to winter snowfall during 1987-2005.

dropped to a mere 5 percent (i.e., 95 percent of calves did not make it to adulthood). Since1992, winter snowfall has been moderate and the caribou herd has declined slowly at about 2 percent annually. Adult cow survival has been comparable to the mid-1980s, but calf recruitment has continued to be relatively low.

With a decline in calf recruitment since 1990, and the female age structure heavily weighted towards older females who would be lost over a few years, it was expected that another period of decline would exist for the herd, particularly that the poorest adult female survival recorded in this study occurred in winter 2002-03 coincident with the lowest snowfall on record for the park.

However, calf recruitment has been somewhat improved the last 3 years and the herd has shown some slight growth. Although the female age structure of the herd is still somewhat weighted to older females, compared to that at the beginning of the study, the situation has improved and we expect the herd to maintain its numbers, particularly if the increase in calf recruitment continues.

During capture operations in March 2006, researchers replaced radiocollars on 11 cows, removed a collar from one cow, collared 12 female calves from the 2005 cohort (adding them to the age-structured sample). During the year ending in March 2006, 9 radioed caribou died. As of September 30, 2006, 76 Denali Herd female caribou (including 60 in the age-structured sample) were wearing radiocollars.

Herd size. The tentative estimate of 2,150 caribou in the Denali Herd in late September 2006. Herd size has increased during 2005-2006 (see Fig. 10) primarily as a result of increased calf recruitment. During the last three years, calf:cow ratios and estimated calf numbers have averaged about twice what was observed in 1998-2003. Trends for the herd size over the next few years will depend largely on whether the increases in calf recruitment continue.

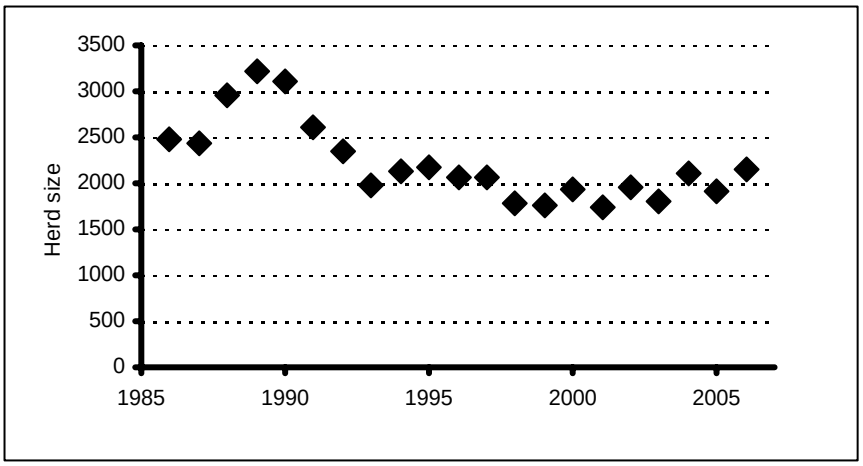
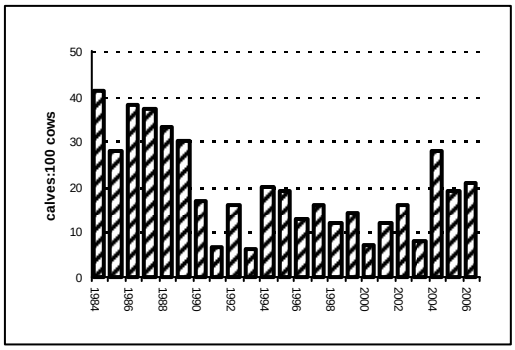


Figure 10. Population estimates (late September) for the Denali Caribou Herd,Denali National Park, 1986-2006. The estimate for 2006 is tentative.

Adult Sex Ratios. In September 2006, the adult sex ratio recorded was 39 bulls:100 cows. Bull numbers declined from an average of 56:100 during 1984-1989 to a low of 29:100 during 1997-1998 (increased mortality of males during severe winters). It has averaged 37:100 over the last four years.

Calf Production And Survival. The natality rate (how many ≥ 1 year old in mid-May have calves) was 70 percent, based on observations of 63 radiocollared cows in the age-structured sample in May 2006. Natality rates have averaged 78 percent over the 20 years of the study. The lower rate in 2006 was largely due to the high number of yearlings and 2-year-olds in the population recruited in 2004 and 2005. These age-classes accounted for 13 of the 19 non-pregnant females in the radioed sample. Productivity of 2-year-olds was high (4 of 12 radiocollared individuals producing calves).



Between early June 2006 and late September, the calf:cow ratio had declined from 38:100 to 21:100 (see Fig. 11), indicating 29 percent survival of the 2006 calf cohort. Approximately 13 female calves were recruited per 100 older females.

Figure. 11. Calf:cow ratios for the Denali Caribou Herd, late September, 1984-2006.

Adult Female Survival. During October 2005 – September 2006, 2 radiocollared caribou from the age-structured sample died, for an annual mortality rate of 3.2%. Interestingly, these mortalities all occurred during the summer. Thus summer survival was comparable to the long-term average of 96.4%, while overwinter survival was higher than the average (91.1%).

Female Age Structure. As with last year, changes in the female age structure in 2006 were largely due to recruitment of a relatively large number of individuals from the cohort that entered the age structure as yearlings in 2005. The proportion of old cows (≥ 13 years old) in the population differed little from the last few years (Fig. 12). Although the proportion of old cows in the herd has declined markedly since 2001-2002, it is still nearly double that of 1987-1989 when calf recruitment was high and the herd was growing at about 8% per year.

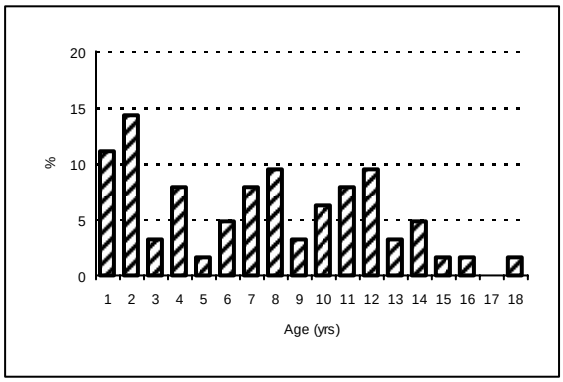


Figure 12. Estimated age structure for cows in the Denali Caribou Herd, May 2006 (n = 63).

Small Mammal Monitoring

Voles (*Microtus* spp. and *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 another important ecological role by having the ability to influence species above and below them in the food chain.

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

The 2006 field season of small mammal sampling in Rock Creek added a fifteenth year to the data series begun in 1992. Sampling occurred at the trapping grids in the Rock Creek drainage—four study plots include two forested areas and two areas along Rock Creek. Sherman live traps were deployed on the plots for a 4-day period. Traps were baited with sunflower seeds and bedding, and checked 3 times per day. Captured individuals were identified by sex and species, reproductive status was determined, and net weight was calculated. Unmarked individuals were implanted with passive integrated transponder (PIT) tags approximately the size of a grain of rice and released. Every individual can then be identified with a "reader" for capture/recapture estimates of population size.

In 2005, small mammal abundance was the highest ever observed in Rock Creek, but in 2006 population sizes dropped to more "typical" levels. Eighty percent of the variation in small mammal abundance could be explained by a population model that incorporates date of spring onset, and the amount of spring and summer moisture (or lack of moisture), along with an interaction of spring onset and summer moisture (dryness). As far as is known, this study is the first of its kind to explain (model) so much of the variation in small mammal abundance.

Small Mammal Inventory

At this time all 25 species of *small* mammals (100 percent of those expected to occur in Denali) have been documented (observed in the park and specimens collected) (Table 4). Denali's three most common species (based on inventory collections) are northern red-backed voles, tundra voles, and the cinereus shrews.

Table 4. Checklist of the **small** mammals of Denali National Park and Preserve, Alaska
All species listed have been substantiated with a vouchered specimen.

INSECTIVORA - Shrews

Family **Soricidae**
- *Sorex cinereus*, cinereus shrew
- *S. hoyi*, pygmy shrew
- *S. monticolus*, montane shrew
- *S. palustris*, water shrew
- *S. tundrensis*, tundra shrew
- *S. yukonicus*, tiny shrew

CHIROPTERA - Bats

Family **Vespertilionidae**
- *Myotis lucifugus*, little brown bat

CARNIVORA - Carnivores

Family **Mustelidae**
- *Mustela erminea*, ermine
- *M. nivalis*, least weasel

RODENTIA - Rodents

Family **Sciuridae**
- *Glaucomys sabrinus*, northern flying squirrel
- *Marmota caligata*, hoary marmot
- *Spermophilus parryii*, arctic ground squirrel
- *Tamiasciurus hudsonicus*, red squirrel

Family **Dipodidae**
- *Zapus hudsonius*, meadow jumping mouse

Family **Muridae**
- *Clethrionomys rutilus*, northern red-backed vole
- *Lemmus trimucronatus*, brown lemming
- *Microtus miurus*, singing vole
- *M. oeconomus*, tundra vole
- *M. pennsylvanicus*, meadow vole
- *M. xanthognathus*, yellow-cheeked (taiga) vole
- *Ondatra zibethicus*, muskrat
- *Synaptomys borealis*, northern bog lemming

Family **Erethizontidae**
- *Erethizon dorsatum*, North American porcupine

LAGOMORPHA - Pikas & Hares

Family **Ochotonidae**
- *Ochotona collaris*, collared pika

Family **Leporidae**
- *Lepus americanus*, snowshoe hare

Birds

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

  Surveys were conducted between June 1-21, 2006 between 0300 and 0900 hours. All birds detected (seen or heard) at each sampling point were recorded during a 10-minute sampling period in one of four time intervals (0 to 3 min, >3 ≤5 min, >5 ≤8 min, and >8 ≤10 min) and one of 13 distance intervals (10-m intervals up to 100 m, 25-m intervals to 150 m, and >150-m). The survey crew sampled 194 points on 8 minigrids in 2006 and detected 1859 birds at 1782 detection events, including 167 to 300 birds per minigrid and 6.7 to 12.0 birds per point. Species richness ranged from 14 to 25 species per minigrid and 3.8 to 6.7 species per point.

  Seventy-two species were detected on minigrids (54 species during 10-minute counts and 18 species outside the counting period). Most detections (75 percent) were of members of three families, *Emberizidae* (Sparrows), *Turdidae* (Thrushes), and *Parulidea* (Warblers). White-crowned Sparrow was the most commonly detected species on the 10-minute counts (n = 413 detections, 22.2% of all detections).

  Point transect surveys will continue in June 2007; approximately 200 to 250 points will be sampled.

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

  The Savage BBS route was completed on June 14, 2006. The surveyed started at the west end of Savage River Bridge at 0300 and ended near Sable Pass at 0813. All 50 points were surveyed in 2006. Thirty-three species and 758 individuals were detected in 2006. White-crowned Sparrow (n=119) was the most commonly detected bird along the Savage BBS route followed by Orange-crowned Warbler (n=102), American Tree Sparrow (n=93) and Wilson's Warbler (n=90).

  The Toklat BBS route was completed on June 15, 2006. The survey started at the Toklat Ranger Station at 0325 and ended at 0917. All 50 points were surveyed in 2006. Thirty-

five species and 738 individuals were detected in 2006. White-crowned Sparrow (n=111) was the most commonly detected bird along the Savage BBS route followed by American Tree Sparrow (n=100), Fox Sparrow (n=95) and Savannah Sparrow (n=90). This was the first year that Least Sandpiper was detected on the Toklat BBS route.

National Park Service biologists will complete the two BBS routes in Denali in June 2007. Results from the Denali BBS routes are available at: http://www.pwrc.usgs.gov/bbs/retrieval/summary/stateform.cfm

- **Reproductive success of Golden Eagles and Gyrfalcons:** As part of the National Park Service's Central Alaska Network Vital Signs Monitoring Program, National Park Service (NPS) biologists monitored the occupancy of nesting territories and reproductive success of Golden Eagles and Gyrfalcons in the northeast region of Denali National Park and Preserve (Denali) in 2006. This marked the 19th consecutive year of this study. NPS biologists collected data using two standardized aerial surveys conducted from a Robinson R-44 helicopter, and additional ground observations and foot surveys. The occupancy survey was conducted in late April, additional foot surveys from May through July, and the productivity survey in mid-July 2006. NPS biologists also visited a sample of occupied Golden Eagle nesting territories in early July to collect shed feathers for ongoing DNA analyses.

  It was a banner year for Golden Eagles in Denali in 2006; 64 of the 75 territories that were monitored were occupied (85 percent occupancy rate) and rates of laying (94 percent), nest success (83 percent), and production of fledglings (n = 75; fledglings per occupied territory = 1.17; mean brood size = 1.50) were among the highest recorded in study's history. NPS biologists attributed the high eagle reproductive success to high numbers of snowshoe hare in the study area.

  Gyrfalcon reproductive success in Denali was lower than most years despite apparently high numbers of Willow Ptarmigan in the study area. NPS biologists monitored 15 Gyrfalcon nesting territories in 2006, and occupancy (47%), success rate (43%), and production of fledglings (n = 9) were lower than most years.

  Proposed activities for 2007 include (1) continuation of Golden Eagle and Gyrfalcon monitoring in the historic study area in Denali, (2) continuation of genetic studies of golden eagles in Denali, and (3) continued public education and outreach efforts.

Notable eagle observations in the Golden Eagle study area:

- unusually high number of non-territorial subadult Golden Eagles (June – August)
- many interactions between the subadults and the breeding adult Golden Eagles (July and August)
- an adult eagle hitting a subadult eagle in midair and driving it to the ground
- observation of a wing-tagged subadult Golden Eagle in the Igloo Creek and Sable Pass region (late June and early August) [Note: Researchers with the Research Wildlife Institute tagged this eagle in Montana during autumn migration between 2002 and 2005]
- observations of several adult and subadult Bald Eagles (June and July) apparently hunting snowshoe hare

Notable observations of raptors and owls in or near the Golden Eagle study area:

- at least 18 nesting pairs of Great-horned Owls including one successful pair in a cliff-nest historically used by Golden Eagles and one successful pair at the entrance to the Savage River campground
- three new occupied Peregrine Falcon nesting areas bringing the total documented to six
- frequent observations of Northern Harriers and Short-eared Owls
- 12 Northern Harrier nests (only 2-3 found annually in the last 19 years)
- four Short-eared Owl nests (rarely found in other years)

❖ **Developing indices of trends in willow ptarmigan (and snowshoe hare):** Indices of population size of snowshoe hare and willow ptarmigan on a broad scale are obtained by recording the number of each species observed during routine field activities. These data allow National Park Service biologists to track broad-scale abundance trends of both species over time. The abundance of snowshoe hare and willow ptarmigan was higher in 2006 than in the past 20 years.

❖ **Christmas Bird Count:** The National Audubon Society organizes the Christmas Bird Count (CBC) and each year more than 50,000 observers participate each year in this all-day census of early-winter bird populations. The results of their efforts are compiled into the longest running database in ornithology, representing over a century of unbroken data on trends of early-winter bird populations across the Americas. The primary objective of the Christmas Bird Count is to monitor the status and distribution of bird populations across the Western Hemisphere. When data with Christmas Bird Counts and other surveys such as the Breeding Bird Survey are combined, scientists begin to see a clearer picture of how the continent's bird populations have changed in time and space over the past hundred years.

Local naturalist Nan Eagleson organizes and compiles the results of the Denali CBC which has been conducted every year since 1992. The 2006 Denali CBC was held on December 30, 2006. Fourteen participants recorded 13 species of birds including Spruce Grouse, Willow Ptarmigan, Northern Goshawk, Great-horned Owl, Three-toed Woodpecker, Gray Jay, Black-billed Magpie, Common Raven, Black-capped Chickadee, Boreal Chickadee, American Dipper, Pine Grosbeak, and Common Redpoll. Common Redpoll, with 217 individuals, was the most common bird species recorded on the 2006 Denali CBC.

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

❖ **Surveillance sampling of Arctic Wablers, for Asian H5N1 avian influenza:** The Alaska subspecies of Arctic Warbler is the second highest-ranking bird for early detection of Asian H5N1 in North America. This species overwinters in the epicenter of Asian H5N1 outbreaks in Southeast Asia and Indonesia, where it is abundant in shrub and forest habitats around farms and homes. In response to the recent concern over the highly pathogenic avian influenza virus, H5N1, the United States Fish and Wildlife Service (FWS) developed a screening effort to capture and collect samples from migrant birds.

FWS or contracted personnel sampled 19,947 individual birds in Alaska (including 154 birds is Denali in 2006. No H5N1 Avian Influenza was detected in any of these birds and has not been documented in North America.

At Denali, Alaska Bird Observatory (ABO) researchers operated banding stations and captured Arctic Warblers in mist nets in suitable habitat from June- early August. They worked in upper Savage River, Igloo Canyon, and near the Polychrome Glaciers. They caught 319 individuals of 17 species and collected cloacal swabs or fecal samples from 68 Arctic Warblers and 86 other birds. Species and numbers captured included: Hammond's Flycatcher: 3, Alder Flycatcher: 1, Western Wood Peewee: 1, Arctic Warbler: 69, Hermit Thrush: 9, American Robin: 1, Northern Shrike: 1, Orange-crowned Warbler: 22, Yellow Warbler: 1, Blackpoll Warbler: 1, Wilson's Warbler: 13, American Tree Sparrow: 78, Savannah Sparrow: 3, Fox Sparrow: 11, White-crowned Sparrow: 83, Dark-eyed Junco: 2, Common Redpoll: 20.

As of this writing, the FWS surveillance project in 2007 will focus on waterfowl and shorebirds, and Arctic Warbler sampling will not occur in Denali.

Please tell park visitors not to pick up dead birds; instead, park visitors should report dead birds and their location to NPS staff at the Denali Visitor Center, the Murie Science and Learning Center, or the Denali Center for Resources, Science, and Learning. For more information about avian influenza, visit the web site: www.nwhc.usgs.gov/disease_information/avian_influenza/index.jsp.

- **Two new species added to Denali National Park and Preserve bird checklist in 2006.**
  Two new species of birds, Ruddy Duck (*Oxyura jamaicensis)* and Mourning Dove (*Zenaida macroura*), were added to the Denali National Park and Preserve bird checklist in 2006.
  - Bill Thompson observed three Ruddy Ducks (considered casual in Alaska) during an 11-day backpacking trip near upper Hauke Creek on July 5
  - Alan Seegert observed a Mourning Dove (considered rare in Alaska) near the Riley Creek campground on July 28.

- **Moose Creek Migration Station**
  For the ninth consecutive year, the Alaska Natural History Institutes, along with the Alaska Bird Observatory (ABO) and Alaska Wilderness Centers, operated a fall songbird migration monitoring station at Camp Denali/North Face Lodge in the Moose Creek drainage from mid-July to early September. The goals of the Station are to capture and band migrating passerines to examine population dynamics and the timing (phenology) of life history events (e.g. migration, reproduction, molt, juvenile dispersal, and seasonal differences in body condition). In addition, the Station provides public education programs about avian ecology and conservation, and contributes data to the Alaska-Yukon Migration Monitoring Network.

The station of 12 mist nets was operated daily by a four-person banding crew from July 16 to September 9, weather permitting, for seven hours beginning at sunrise. Nets were open on 45 days, with 11 days cancelled due to weather for a total of ~3,421 net hours. Nets were checked and birds were removed from nets at 15- to 40-minute intervals, based primarily on weather conditions and capture rate. Net locations used in previous seasons remained unchanged. All birds captured were banded with U.S. Fish and Wildlife Service aluminum leg bands and processed according to the protocol established by the ABO. Data recorded included: species, age, sex, amount of skull ossification, wing chord and tail length, size of fat deposits, breeding condition (presence of brood patch or cloacal protuberance), molt condition, proportion of juvenal plumage, mass, and date, time, and location of capture (which net). New in 2006, two species (Arctic Warbler and Gray-cheeked Thrush) were sampled (cloacal swabs) to test for Asian H5N1 Avian Influenza.

In 2006, the crew banded a total of 889 individuals of 31 species. Comparing numbers of birds captured for the effort (net hours), 2006 had the lowest capture rates in the history of the migration station. Cold temperatures in June (two deep freezes) may account for this low capture rate. In 2006, the most abundant species captured were: Wilson's Warbler (24% of all birds), Dark-eyed Junco, White-crowned Sparrow, Swainson's Thrush, Yellow-rumped Warbler, and Ruby-crowned Kinglet. The return rate was 2 percent, i.e., 19 birds were captured in 2006 that had been banded in previous seasons at Moose Creek. Peak numbers of captures in nets occurred in late August (see Fig. 13). For the first time in the history of the Moose Creek Migration Station, two Pine Siskins were netted. On a weekly basis, the capture tallies were displayed at the Murie Science and Learning Center.

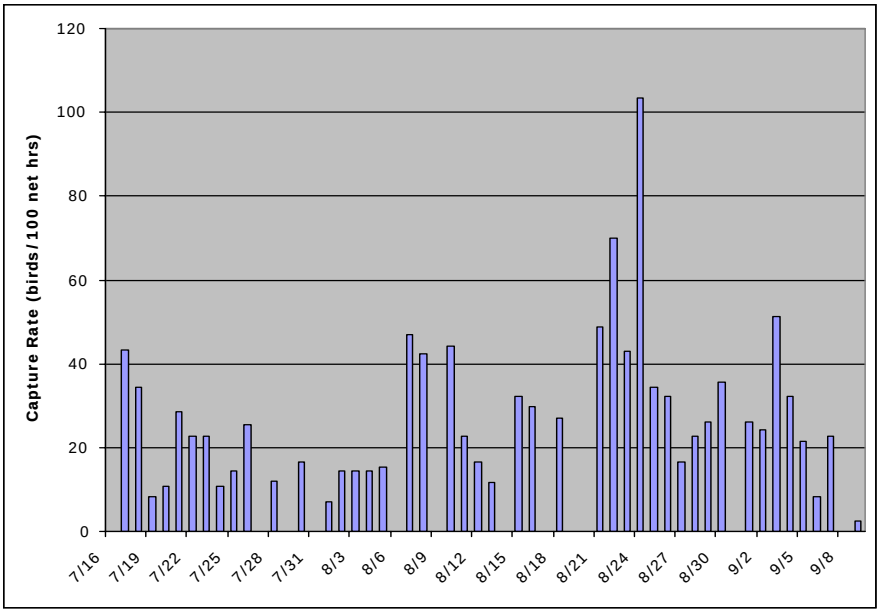


Figure 13. Daily capture rate at Moose Creek Migration Station, July - September 2006.

Freshwater Fish Inventory

Freshwater fish inventories were conducted in 2003 completing the CAKN inventory of fish. The only fish that was "expected" to occur in Denali but not sampled in 2003 was the inconnu. The total number of fish species documented in Denali to 14 (Table 5).

Table 5. Species of fish expected or documented in Denali

Species Category	Common Name	Scientific Name	Status *
Lampreys	Arctic lamprey	*Lampetra japonica*	2003
Pikes	northern pike	*Esox lucius*	E, 2003
Suckers	longnose sucker	*Catastomus catastomus*	E, 2003
Mudminnows	Alaska blackfish	*Dallia pectoralis*	2003
Whitefishes	inconnu	*Stenodus leucichthys*	E
Whitefishes	round whitefish	*Prosopium cylindraceum*	P
Whitefishes	humpback whitefish	*Coregonus pidschian*	2003
Trouts and Salmon	lake trout	*Salvelinus namaycush*	P
Trouts and Salmon	Dolly varden	*Salvelinus malma*	P
Trouts and Salmon	Chinook salmon	*Oncorhynchus tshawytscha*	P
Trouts and Salmon	chum salmon	*Oncorhynchus keta*	P
Trouts and Salmon	coho salmon	*Oncorhynchus kisutch*	P
Grayling	Arctic grayling	*Thymallus arcticus*	P
Codfishes	burbot	*Lota lota*	P
Sculpins	slimy sculpin	*Cottus cognatus*	P

* P - Present or previously documented, E - Expected but not previously documented
2003 - Newly Documented in 2003 E, 2003 – Expected and documented in 2003

Wood Frog Surveys

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

Dr. Grant Hokit (Carroll College, Montana) conducted extensive surveys for wood frogs (2004) from Grassy Pass to the south end of Wonder Lake. He looked for frogs in all still-water sites inside randomly-located 1-km circular plots. By describing habitat information and recording where they found frogs, they learned what features are positively or negatively correlated with use by wood frogs. Wood frogs were observed at 106 sites (48 percent), breeding activity (the presence of eggs and/or larvae) was observed at 98 sites (45 percent), and adults and/or juveniles were observed at 17 sites (8 percent).

Breeding activity occurred more frequently than expected at larger sites that were not isolated from other sites characterized by: 1) maximum water depth between 1 to 2 meters, 2) no connection to moving water, 3) 51-75% of the site less than 50 cm deep, 4) 76-100% of the riparian zone covered with woody vegetation, 5) from one quarter to three-quarters (26 to 75%) of the site covered with emergent vegetation, 6) alder or spruce present in the riparian zone, and 7) no sign of beaver activity. Sites with signs of beaver activity were negatively associated with frog breeding activity. No breeding activity was observed at bog sites dominated by sphagnum mats. Breeding activity of wood frogs was *not* associated with elevation or distance to boreal forest.

In 2007, Robert Newman of the University of North Dakota plans to conduct a study of the population biology of wood frogs as one of the Discover Denali Research Fellows.

Physical Resources

Parkwide Climate Monitoring

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

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

In 2007, each of the sites will be visited for annual maintenance. The sensors on the station will be swapped and calibrated and the data will be downloaded. The 2006 annual climate monitoring report is available on the web at http://www1.nature.nps.gov/im/units/cakn/monitoring.cfm.

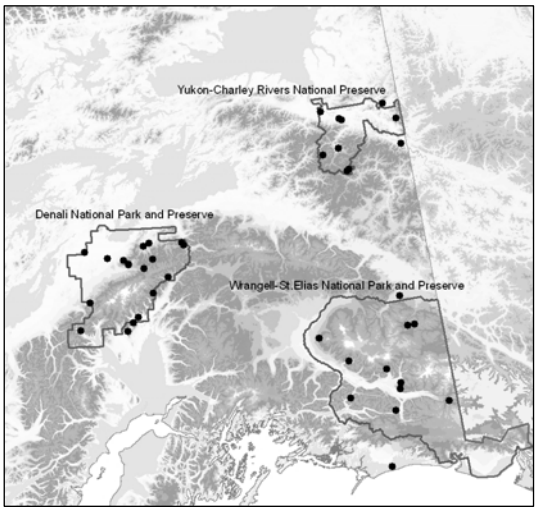
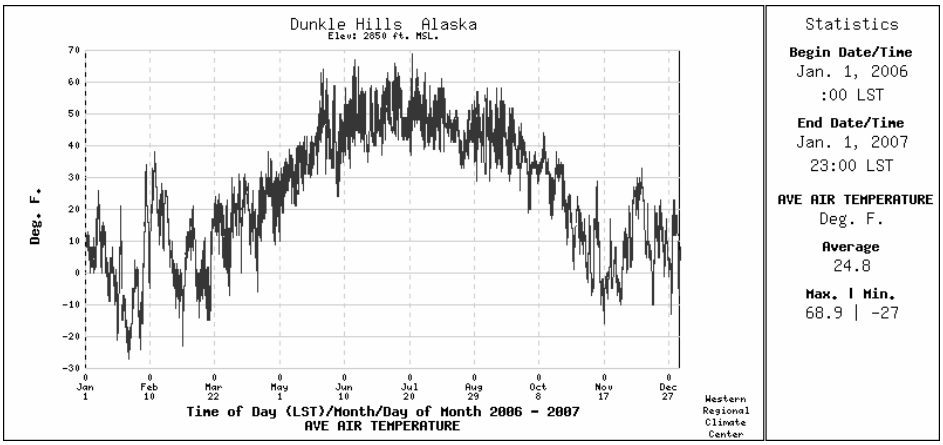
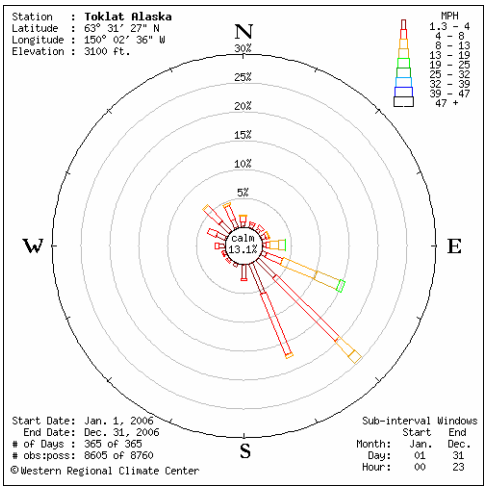


Figure 14. Distribution of climate stations and snow survey locations in the Central Alaska Network.

Most of the stations are automated and send hourly data via satellite. Data summaries and data analysis tools are available at http://www.wrcc.dri.edu/NPS. See examples of 2006 data summaries below:





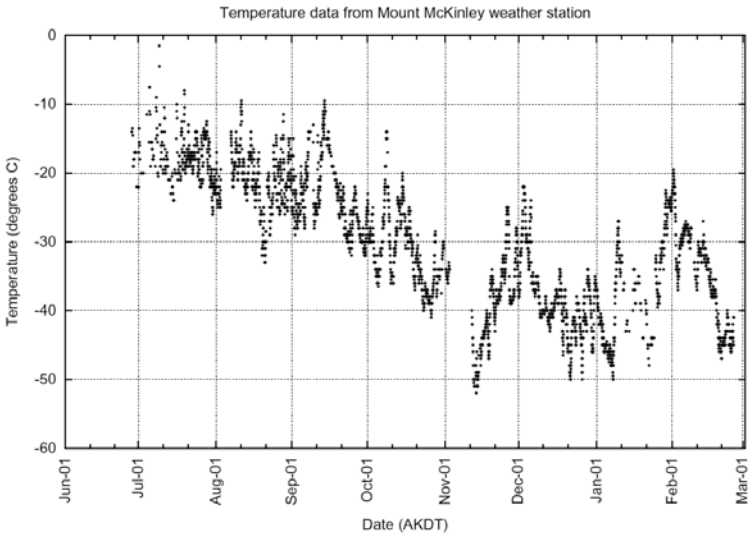
Weather Station on Mt. McKinley

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

Originally, the Japanese Mountain Club installed a weather station in 1990 in memory of four Japanese climbers (including the famous mountaineer and adventurer Naomi Uemura) who, in independent climbing events, are all believed to have been literally blown off the mountain by gusts of wind. The Club donated the weather instrumentation to the International Arctic Research Center at the time of its opening ceremony in 1999. Since that time expeditions ranging from 2-3 weeks in duration have been organized each year in attempts to improve the station.

It is extremely difficult and time consuming to engineer a station that will withstand the harsh weather at 19,000 feet, especially when the team can get there only once a year. The 2006 expedition took place in June. This past year has been highly successful for data transmissions from the site. Since June 28, when the climbing team successfully installed new equipment at Denali Pass (see photo), until present day (March 1) the data has been transmitting. The temperature sensors seem to be working fine, but the anemometers have had glitches. Both the ultrasonic sensors and the cup anemometers have not been recording wind speeds. The team has been working on designs for these sensors trying to come up with something that will withstand the harsh winds at this extreme elevation.

Information and data (e.g., at right) are available at: www.denali.gi.alaska.edu



Weather Monitoring at Park Headquarters

For more than 80 years, weather information has been collected at Park Headquarters. Beginning in 1922, Alaska Railroad personnel collected weather information in their camp near Riley Creek. In 1924, the National Park Service took over operation of the weather station. In 1925, the station was moved from the old headquarters site near the confluence of Hines and Riley Creek to the current Headquarters area (near the Kennels). Long-term weather (climate) datasets provide valuable information for detecting and predicting changes or trends in both temperature and precipitation, both factors that play a critical role in the ecology of Denali.

Below are **summaries of the 2006 climate data** for temperature and precipitation collected at Park Headquarters and compared with averages from the long-term database.

Temperature

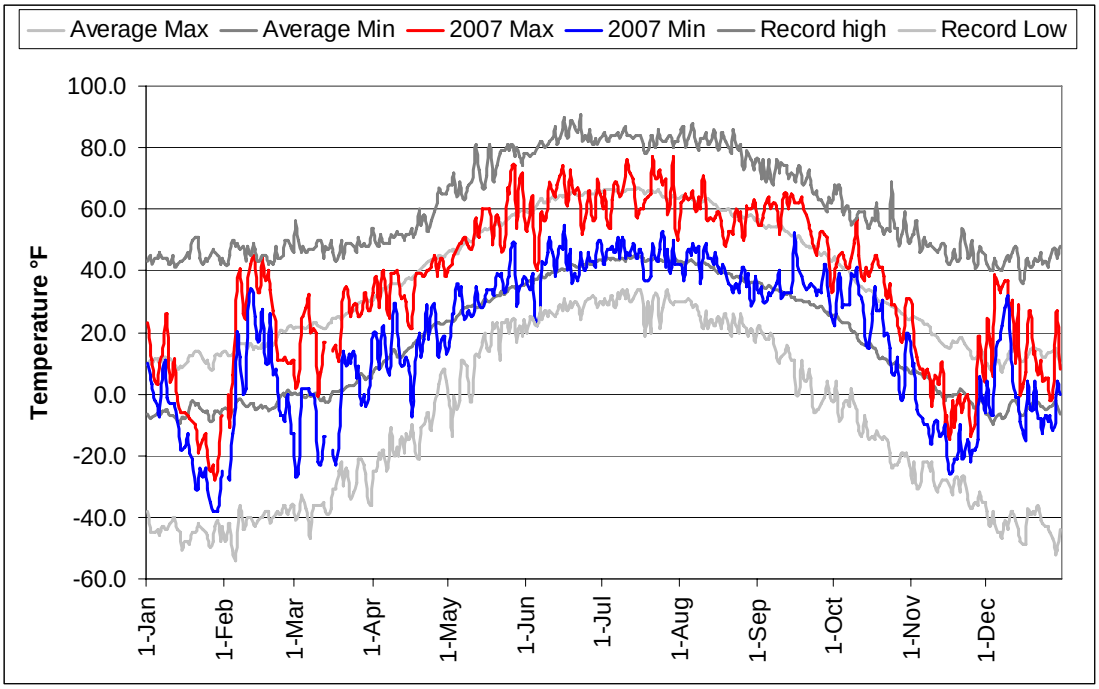
- maximum temperature 77°F on July 21 and 29
- minimum temperature -38°F on January 27, 28, and 29
- mean annual air temperature 26.8°F which is cooler than the historical average of 27.2°F

Denali Headquarters
Average Monthly Temperatures (°F)

	2006	80-Year Historic Average
January	-9.3	*2.3*
February	15.2	*6.7*
March	9.3	*13.0*
April	25.4	*27.2*
May	44.0	*41.6*
June	51.7	*52.1*
July	54.8	*54.9*
August	49.5	*50.7*
September	45.8	*41.0*
October	30.3	*24.2*
November	-4.9	*9.3*
December	9.2	*3.4*
Yearly Average	**26.8**	***27.2***

Temperature Notes for 2006

Mean annual temperature	26.8° F
Departure from normal	-0.4° F
Highest temperature	77° F on July 21 and 29
Lowest temperature	-38° F on Jan 27, 28 and 29
New record highs/lows	1/1
# Highs above 80° F	0 days
# Lows below -40° F	0 days



Precipitation

Denali Headquarters
Monthly Precipitation (in)

	2006	Historic Average
January	0.60	*0.73*
February	0.87	*0.58*
March	0.49	*0.43*
April	0.48	*0.44*
May	0.28	*0.80*
June	2.76	*2.21*
July	3.64	*3.00*
August	3.01	*2.68*
September	1.44	*1.59*
October	1.37	*0.98*
November	0.12	*0.76*
December	0.92	*0.83*
Yearly Total	**15.98**	***15.05***

Precipitation Notes for 2006

Total Precipitation	16.0 inches
Departure from Normal	+0.93 inches
Max. 24 hr precipitation	1.16 inches on June 26
Total Snowfall	57.8 inches from July 1 – June 30
Departure from normal	-22.7 inches
Maximum 24 hr snowfall	6.6 inches on January 22

2006 Records for Denali Park headquarters

June 5: 22° F minimum temperature (previous record 23° F in 1933)
June 26: 1.16 inches of rain (previous record 1.14 inches in 1937)
October 10: 0.78 inches of rain, not snow (previous record 0.41 in 1989)
October 10: 57° F maximum temperature (previous record 53° F in 1979)

Weather Notes for 2006:

- Most of January's snow fell on January 22 (6.6 inches)
- Temperatures came up above normal ~February 6 and stayed there for 2 weeks
- May was warmer than normal mostly due to the temperature spike the last week of May
- The "snow off" date for headquarters was May 11 (about normal)
- Unlike the previous two summers, 2006 was cooler and wetter, or more like normal
- The largest rainfall in 24 hours on June 26 (1.16 inches) was also a record for this date
- A large rain event occurred July 12-14 (total of 2.08 inches of rain)
- There were 18 days in August with measurable rainfall including every day Aug 17-24
- October's precipitation fell mostly as rain (snowfall was 2.9 inches; normal total is 12.7)
- On October 31st there was only 1 inch of snow on the ground
- It was the third coldest November on record (after 1932 and 1963)
- November was cold
- It finally started to snow in December for a normal monthly total
- It snowed for 10 days straight starting on December 19 (4 inches on Christmas Eve)

Snow Surveys

In the winter of 2005-2006, 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 in 2005-2006. Highlights of the data are presented below.

January: The combination of cold temperatures and ash from Mt. Augustine volcano thwarted flights to conduct the snow survey. Observations were only made at the snow course accessible by snowshoe (Rock Creek) and the SNOTEL site at Kantishna. Both sites had 12 inches of snow. Based on other stations around the Tanana Basin hydrologic region, snow depths in the northeast part of the park were 47 to 59 percent of normal.

February: The area south of the Alaska Range in Denali had snow packs that were 79 percent of normal. On the north side, the eastern snow courses had normal snow depths, Kantishna was 70 percent of normal, and the western snow courses at Lake Minchumina and Purkeypile were 105 percent of normal.

March: The region north of the Alaska Range from park headquarters west to Kantishna was 65 to 80% of normal for March. Purkeypile remained just above normal at 102% and Lake Minchumina was normal at 20 inches. The aerial markers on the south side of the Alaska Range were between 74 and 91% of normal. The Tokositna Valley site normally has 62 inches on March 1 and 57 inches was recorded.

April: On May 1 there was still a substantial snowpack at headquarters. There was 18 inches of snow at Rock Creek Ridge, 128 percent of normal for that date. Kantishna was just about normal and Minchumina and Purkeypile still had deep snowpacks at 220 percent of normal for May 1. The snowpacks on the south side were all about normal for May 1 ranging from 47 to 75 inches.

Snowpack Characterization

This project provides snow depth and density information to park managers who are faced with the decision to open or close areas of the park and preserve to snowmobile use based on the current snow conditions. This study focuses on measuring the snowpack characteristics that will allow adequate support of snowmobile travel without causing adverse impacts to vegetation and soils. Snow depth and density were monitored at several fixed survey sites throughout the winter season (December 2006 through May 2007).

The snowpack was slow to develop for the 2006-2007 season. Very little snow fell in Ocotber and November to create any kind of base to protect vegetation. The last 10 days of December brought snow, and by the second week of January there was adequate snow cover on the south side except for the area between the West Fork of Chulitna River and Windy Creek at the north end of Broad Pass. After additional snowfall between January 12 and 17, the use of snowmobiles for traditional activities in all the 1980 additions to Denali National Park and Preserve opened for snowmachine use, including the areas on the north side of the range. Generally the snowpack on the north side deteriorates first, closing the area in mid-April, while south of the range the snowpack remains deep enough until May 1. Depending on the spring conditions the south side may remain open until mid May.

Air Quality Monitoring

Long-term monitoring of air quality continues at the stations near Park Headquarters and Trapper Creek. 2007 marks the 28th year of uninterrupted air quality monitoring in the park through national monitoring networks. Parameters measured at the headquarters station include atmospheric deposition, ground-level ozone, sulfur and nitrogen oxides, fine particles and aerosols, and associated meteorological parameters. The Trapper Creek station measures fine particles and aerosols 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. During summer, naturally-occurring wildfire smoke is the primary contributor to air quality degradation.

More information about the National Park Service nationwide air quality monitoring program can be found at the following web site: www2.nature.nps.gov/air.

Toxic Airborne Contaminant Assessment

Although Denali seems an unlikely place to find Persistent Organic Pollutants (POPs) and other toxic airborne contaminants, these pollutants are a growing concern throughout the Arctic and Subarctic.

In 2004, the NPS Western Airborne Contaminants Assessment Project (WACAP) sampled fish, lake sediments, lake water, snow, lichens, willows, and spruce trees at Wonder Lake and McLeod Lake as part of a multi-park assessment of contaminants in park ecosystems. Subsistence hunters also donated samples from moose harvested near the park. Spring snow sampling occurred at the two Denali study lakes from 2003 to 2005. Chemical analyses of all samples in all parks were completed in January 2007, and the final comprehensive project report will be published in September.

Information about toxic airborne contaminants and the WACAP project can be found at www2.nature.nps.gov/air/studies/air_toxics/wacap.cfm See also page 60.

Visibility Web Camera

Park staff and air quality monitoring contractors installed a web camera at Eielson Visitor Center in July 2004 to document summer visibility conditions in the park. The Denali camera is part of a nationwide network of visibility webcams operated by the NPS Air Resources Division. During summer, the camera takes a picture once every 15 minutes, and the image is transmitted to the web via satellite. Current ozone and weather data from the air quality monitoring station near park headquarters are also displayed on the webcam home page and updated hourly. 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.

In addition to the clear and cloudy views of the Alaska Range documented by the web camera, wildfire smoke sometimes obscures the view of Mt. McKinley. While the new Eielson Visitor Center is under construction, the Denali web camera has been temporarily relocated to the Wonder Lake area. The web page and links to visibility cameras in other parks can be found at: www2.nature.nps.gov/air/webcams/parks/denacam/denacam.cfm

Monitoring Landslide at Mile Post 45

At Milepost 45 on the park road, survey stations were established in 1993 to monitor the rate of movement of the surface area of a mass movement (landslide)—a classic rotational slump with a headwall scarp, subsiding basins, pressure ridges and fractures, and flow features. The apex of the headwall scarp is within 35 horizontal feet of the park road, and park management and Federal Highways personnel are concerned about the threat that this movement poses to the road.

Both horizontal and vertical movement has been monitored since 1993 by 11 (near-annual) surveys (see Table 6). Approximately 60 stations have been established over the entire period. Some have been lost due to surface fracturing or squeeze-out, and animal damage, and new ones

are added almost every year. In this most recent survey effort (September 2006), 34 stations were resurveyed or established, and 28 of those were used for calculating the horizontal (downslope) movement.

Stations in Zone 1 (above the road) are primarily drill casings in what is considered relatively stable (non-moving) ground. Surveys here began in 2002, and show little or no movement in the five years of monitoring. Zone 2 stations (below the road but above the slump scarp) show a slight increase in average movement (0.3 to 0.6 ft), demonstrating some moderate adjustment of the slope in the 14 years of monitoring. Zone 3 stations (below scarp and in upper basin) and zone 4 stations (lower basin below scarp) show punctuated, but slightly decreasing movement over the 14 year survey period.

Much of the survey movement, especially in zone 1, is not downslope, but instead represents a "wobble" within a few tenths of a foot around each survey station. In zones 3 and 4, there is moderate downslope migration, which can mostly be correlated to the average annual precipitation. The average movement for zone 3 and 4 stations increased by several magnitudes in the 2004-2005 survey year (2.5 and 3.5 ft respectively), but show a decrease in movement for the 2005-2006 survey year (1.6 and 2.1 respectively). This spike is likely a response to a slightly higher precipitation period (16.64 inches as opposed to an average of about 15 inches) during 2005, and it would be expected that future movement in these zones will slow further, unless another rise in precipitation occurs.

STATION SECTOR	93-94	94-95	95-96	96-97	97-98	98-99	99-02	02 - 03	03 - 04	04 - 05	05 - 06
ZONE 1 - STATIONS ABOVE ROAD (drill casings 1, 3, 5, 6, 7, 8 & 9)											
Number Stations Surveyed	0	0	0	0	0	0	4	4	4	5	5
Average All Stations							**0.3**	**0.3**	**0.2**	**0.3**	**0.3**
ZONE 2 - STATIONS BELOW ROAD & ABOVE SCARP (Between road and Scarp)											
Number Stations Surveyed	6	6	3	5	5	7	4	5	6	5	6
Average All Stations	**0.3**	**0.3**	**0.4**	**0.3**	**0.3**	**0.2**	**0.5**	**0.6**	**0.3**	**0.6**	**0.6**
ZONE 3 - STATIONS BELOW SCARP (on upper basin & pressure ridges)											
Number Stations Surveyed	9	8	9	9	9	12	9	8	8	8	9
Average All Stations	**6.8**	**2.3**	**2.7**	**1.2**	**3.4**	**0.9**	**1.9**	**1.5**	**0.6**	**2.5**	**1.6**
ZONE 4 - Stations Below Scarp (in Lower Basin & Pressure Ridge 3)											
Number Stations Surveyed	11	11	15	13	11	13	12	10	11	9	8
Average All Stations	**8.4**	**2.8**	**3.4**	**1.6**	**4.7**	**1.2**	**2.1**	**1.1**	**1.1**	**3.5**	**2.1**
All figures from 1993 to 2006 represent annual surveyed horizontal movement, in feet and tenths of feet.											
Annual periods (survey year) is from September to September.											

Table 6. Surveyed horizontal movement of stations on the Milepost 45 Slump, Denali Park Road

In summary, no increase in downslope movement (or other movement that is threatening to the park road) can be detected by the most recent survey, or history of surveys. Although the downslope migration of the slump continues, the rates of movement, and their spatial situation, suggests no immediate threats to the park road for the medium term (5 to possibly10 years). Of course, all bets are off if there is a period of exceptionally high precipitation.

Paleontological Survey of the Lower Cantwell Formation

It has been well known for many years that the Cantwell Formation was formed in the right age and partly under the correct terrestrial conditions for dinosaur fossil preservation. The first dinosaur fossil material (footprint) was found only two years ago in Igloo Canyon within 200 feet of the park road although some geologic mapping and other geo-investigative work had occurred in the Cantwell Formation prior to 2005. This first footprint found was that of a theropod, a carnivorous dinosaur that walked upright and probably weighed some 200 pounds. Although the footprints and skeletal remains of theropods have been found on the North Slope of Alaska, among other dinosaur types, this was the first evidence of dinosaurs in the interior of Alaska.

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

At the close of the 2006 field season, field parties had located dozens of additional dinosaur footprints including hadrosaurs (duck billed dinosaurs) and 4 sizes of theropods, bird tracks, numerous plant fossils or imprints, and other paleo-biotic features. Some of the rock strata have numerous tracks on the same horizon or surface, and researchers have come to call these sites "Cretaceous dance floors." These finds have provided insight into the paleoecology (plants, plant-eaters, animal eaters) of the Late Cretaceous (65 to 145 million years ago).

The work and the excitement will continue in the 2007 field season with plans to expand the search to the north of Sable and Polychrome Mountains. Given that the discoveries of last year were found through fairly cursory searches, intensive searches may greatly increase the number of finds. And although only footprints have been found so far, this could be the year that skeletal materials are discovered in the Cantwell Formation. (See also page 57.)

Field Class for Geologic Mapping

The University of Alaska Fairbanks under the direction of Rainer Newberry will be conducting its Field Geology class in Denali Park from June 23 to July 2, 2007. Class objectives are: (1) to teach advanced undergraduate geology students how to use field geologic information in creating a geologic map and cross section and (2) to better understand the well-exposed, but geologically complex region that sits between two major strands of the Denali fault system.

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

The group may augment their geologic observations with non-invasive geophysical techniques (including magnetics, electromagnetics, and gravity) to better define geologic structures and rock types in areas of sedimentary cover.

Mining Issues

Based on a court decision made in the fall of 2005, the owner of several hard-rock unpatented* claims, known as the Comstock claims (on Upper Eldorado Creek in Kantishna), was allowed to re-open an adit (horizontal shaft) for mineral sampling purposes (to assess the potential of the mine to produce minerals) to evaluate the value of the property. In the summer of 2006, the adit was opened, and both the NPS and the claimant accomplished the required sampling. With this information in hand, the court may now decide to allow additional sampling (by subsurface drilling) or decide that the information is adequate to render a decision on validity of the claim. Meanwhile, the NPS is in continued discussion with the claimant on the possibility of an out-of-court settlement.

*There are "patented" mining claims" (privately owned surface and mineral estates) and "unpatented" mining claims (federally held and managed surface and privately held mineral estates).

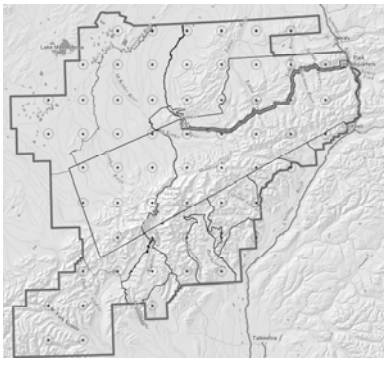
Reclamation of Disturbed Areas—Glen Creek

In 2006, resources staff and restoration ecologists visited Glen Creek to observe and monitor the progress of the 2004 earthwork and floodplain re-construction, and evaluate the need for additional transplanting or re-vegetation work.

Soundscape Inventory and Monitoring Program

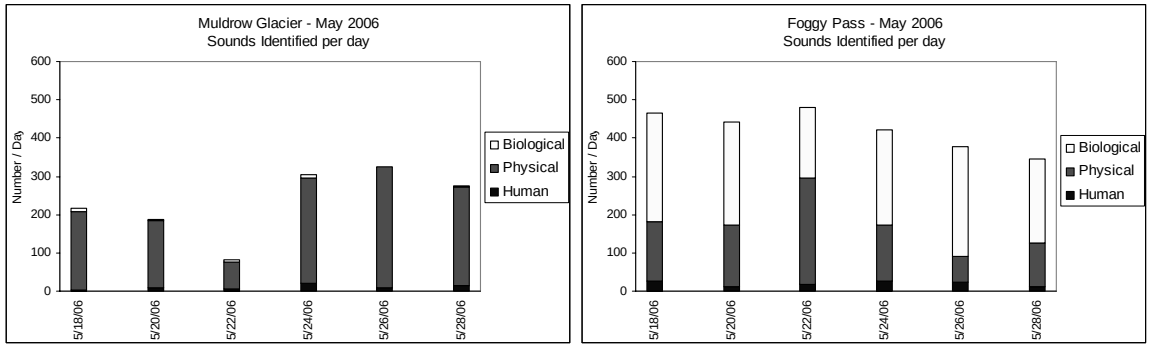
A soundscape research program has been underway at Denali National Park and Preserve since 2001. Natural and human-generated sounds have been inventoried at numerous locations around the park including along the Park Road, south of Broad Pass near Cantwell, at the Stampede Airstrip, in the Ruth Amphitheater,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

This summer's focus (2007) is to implement the second sampling season of a newly revised systematic (random) sampling plan. We will have five automated stations (see photo at left) running at any one time. Over the next ten years, stations will be placed at six new locations each year that will be randomly selected from a coarse grid of 60 points spread evenly throughout the park (see map at right). The funding for the first three years for implementing this sampling plan is being provided from an Alaska NPS regional block grant and Fee Demonstration funds. This sampling plan is part of the implementation of the new Backcountry Management Plan. This sampling plan is designed to provide statistically robust quantifiable measurements of indicators of human effects on the soundscape.



From the sound data collected thus far from 23 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 all day long. At locations with brush or trees, birds can also be heard nearly all day long during the spring breeding season. At locations near common flightseeing routes, it is common to hear 30 overflights per day. At glacier landing strips, it is common to hear more than 100 overflights per day. At locations away from common flightseeing routes, the number of overflights heard per day rarely exceeds ten. At every site sampled, there are usually around five commercial jets heard per day.

The data collected with the sound stations can be used to characterize the soundscape. For example, Figure 15 shows the relative abundances of human-made sounds, physical sounds, and biological sounds for two locations, Muldrow Glacier (Figure 15A) and Foggy Pass (Figure 15B), during the month of May, 2006. From these two figures we can see that physical sounds dominated the soundscape on the Muldrow Glacier, in contrast to Foggy Pass, where biological sounds were more abundant. Wind and rock avalanches made up most of the physical sounds on Muldrow, and bird calls were nearly continuous at Foggy Pass.



A. B.

Figure 15. In May, physical sounds dominated the Muldrow Glacier site (A), while biological were more abundant at the Foggy Pass (B). Bar height indicates the number of 5-second recording intervals in which sounds of each category were heard during one week in May. Sounds were identified as human (black portion of bar), physical (dark gray bar), and biological (light bar).

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

Water Resource Management Plan Development

The park's existing Resource Management Plan (1998) calls for the development of a Water Resources Management Plan to protect and preserve the high quality of surface and ground water resources and to correct current water quality degradation problems. Planning and development efforts within and adjacent to Denali National Park and Preserve have been occurring at an accelerated pace for the past five years. The potential for large projects to impact resources continues to exist (e.g., North Access and South Side development). As a result of development pressures, a comprehensive Water Resources Management Plan planning process was initiated in 2004 and completed in 2006.

A comprehensive review of Denali's water resources was completed in 2005, entitled *Water Resources Information and Overview Report*. This report outlines the foundation documents pertaining to water resources, historical and current events affecting water resources, summarizes completed studies and water resource investigations, and outlines water resource management issues that will be addressed during 2006 in the *Water Resources Stewardship Report,* which will act as the park's guidance for water resources management. The planning report will identify Denali's significant unprotected water resources and protection measures for them. The *Water Resources Stewardship Report* was developed with professional analysis and public involvement. It provides an adequate conceptual framework to address the identified issues in a realistic manner for the next 10 years. The stewardship report defines the parks fundamental water resources, identifies our water resource goals, and provides strategies for achieving the water resource goals. There are three water resource goals which address water quality, functional morphology, and navigability of park streams and rivers.

Permafrost Monitoring

The Central Alaska Inventory and Monitoring Network staff are developing a comprehensive permafrost monitoring program. Two permafrost monitoring pilot projects have already gathered information to understand the relation of permafrost trends to climate trends. One project uses air and satellite photo interpretation to identify the general rates and nature of landscape change due to permafrost changes in the park. A second quantitative study initiated in 1991 has made annual measurements of borehole temperatures in developing thermokarst near the park.

In 2006, a third aspect of permafrost monitoring was initiated through a partnership with Ted Schuur of the University of Florida. His project, *Development of Monitoring Techniques to Detect Change in Carbon Cycling in Relation to Thermokarst in National Parks and Preserve*, will provide critical elements to the design of a comprehensive permafrost monitoring program. Recommendations from this work will be combined with those from complementary remote sensing interpretation and borehole monitoring pilot studies to design the formal monitoring protocol.

Shuur's project centers on the same borehole site outside the park in Healy where permafrost thawing and thermokarst have been observed to occur over the past several decades. This natural experiment will be used to develop monitoring techniques for changes in vegetation and ecosystem C cycling that are a result of thermokarst. The research outcomes of this project will be to: (1) quantitatively determine current plant species composition, growth, and biomass patterns, (2) provide an historical reconstruction of disturbance as a result of thermokarst, and (3) detect the contribution of old carbon to ecosystem carbon cycling. These three measurement approaches can be applied on a widespread scale to analyze change in northern ecosystems. The study will guide monitoring of Carbon cycle processes that can be affected by permafrost thawing and thermokarst. The draft monitoring protocols will be developed in coordination with Dr. Schuur during 2007.

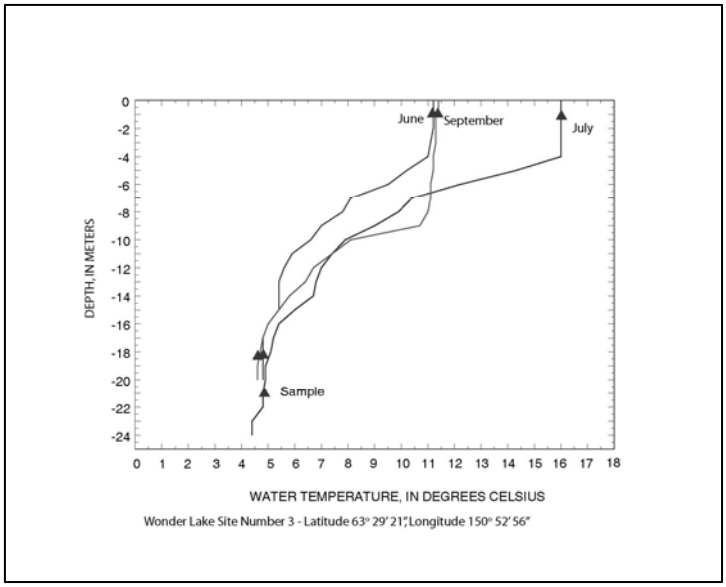
Wonder Lake Water Quality and Limnology Study

In 2006, the U.S.Geological Survey (USGS) began a three-year comprehensive water quality and limnology study of Wonder Lake and other selected lakes in the northwest portion of Denali.

The objectives of this intensive water-quality study are to (1) determine the present limnology and water quality characteristics of Wonder Lake, (2) determine whether or not there have been human impacts to the water quality of Wonder Lake, (3) utilize hydrodynamic and water quality models to determine 'threshold' levels of nutrients of other water quality constituents that would severely impact the water quality of Wonder Lake, (4) choose a number of other 'index' or 'benchmark' lakes in Denali for water quality sampling to provide a better overview of the park's lacustrine systems, and (5) as an outreach effort, partner with the Murie Science and Learning Center to involve students and the general public with the science of this project.

Field sampling trips to Wonder Lake were conducted on April 23, June 20, July 25, and September 7. During the April trip, researchers collected water and snow from one site. During the other trips they conducted full limnological analyses (depth stratified water sampling and measurements and plankton tows).

All water chemistry analyses have been completed; results for the snow and plankton samples are pending. Wonder Lake was stratified (see figure) and relatively similar in temperature, dissolved oxygen, pH, conductivity, and chlorophyll during all open-water field trips, so these data provided little information about seasonal lake mixing regimes, but do provide a solid baseline of water quality for comparison to future work with other lakes. Water chemical composition of Wonder Lake also varied little among dates and by depth, indicating seasonally consistent source-water contributions and relatively low biological productivity.



A comparison of Wonder Lake water chemistry to many small lakes sampled by Amy Larsen (CAKN) in 2006 suggests that Wonder Lake has very different water characteristics (high alkalinity, sulfate, and dissolved solids (particularly Ca^{2+} and Si), and low dissolved organic carbon). These results are likely unsurprising given that Wonder Lake is very large and deep and positioned at a mountain toe-slope in glacial outwash material. Most of the lakes sampled by CAKN are kettle, thermokarst, and floodplain lakes located in organic soils of the northwest portion of the park. (See also page 56.)

Historic Photos of Glaciers

In 2007, there may be the opportunity to re-visit additional historic photo sites, including many taken by Bradford Washburn in the 1950's. During 2004, over 200 historical photos of park glaciers were obtained. These are ground-based images made in the early 1900's by survey and research expeditions to the Denali area, including Cathcart, Capps, Washburn, Post, and others. Many of these sites were "reoccupied" to repeat the images using modern digital cameras. New photo stations were established at locations lacking historical coverage. The photo-comparisons

of the glaciers are often dramatic, showing significant changes in the ice extents – including over 700 vertical feet of ice loss on a glacier in the Teklanika valley.

The GIS data and photographic media will be available to researchers, park management, park natural resource and interpretive staff, park visitors, educators, and the general public through the accompanying website.

Muldrow Glacier Monitoring

Denali staff members have monitored ice elevations and flow rates of the Muldrow Glacier since 1992. The Muldrow last surged in 1956-57 extending its terminus some 2.5 miles (four kilometers). Surges may occur at 50-year intervals; thus, another surge is anticipated within a few years of 2007. Monitoring efforts in the last few years have described the quiescent glacier between surges so that the data can be compared to information collected during and after the next surge. To detect flow rate changes that might signal the start of a surge, ice surface flow rate is measured from movement of survey markers on various points of the Muldrow Glacier and its two largest tributary glaciers (Traleika and Brooks). A survey in April 2006 indicated no glaciers in Denali are currently surging. High resolution elevation data was acquired late in 2006 (LIDAR) which will be compared with a detailed topographic map made by Bradford Washburn in the 1970's. The difference in glacial volume and ice distribution will help us understand the glacier fluctuations and dynamics.

Long-term Glacier Monitoring

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

Monitoring on the Southeast Fork of the Kahiltna Glacier began in 2004 and will continue in 2007 and beyond. Movement rates, winter accumulation, and summer ablation rates will be determined. Magnets are also placed in outhouse holes for determination of their movement rates. Preliminary measurements indicate that the ice under the main "Base Camp" is 300-400 meters thick and is moving approximately 0.60 meters/day. The thickest measured ice in the park is in the Ruth Gorge. Near the center of the glacier the thickness based on seismic measurements is 3805 feet (1150 meters). From the summit of Mt. Dickey (9545 feet) to the bottom of the ice-filled valley is almost 9000 feet. The ice moves 3.1 feet per day (0.95 meters per day) in the center of the glacier, with much less movement near the glacier margins.

Shallow Lakes Monitoring

In 2006, the Central Alaska Inventory and Monitoring Network (CAKN) began a shallow lake monitoring program in Denali. In the three CAKN parks, there are more than 25,000 shallow lakes and ponds distributed across the landscape. Not only are shallow lake systems abundant, they are an excellent choice for monitoring changing conditions because they are more easily tracked, they are easy to sample, they have distinct boundaries (as compared to other wetland ecosystems), and they provide relatively easy opportunities for field experiments. Shallow lakes are a major wetland feature in northwestern Denali and many of them are relatively free of direct human modification. Vital signs to be monitored in shallow lake ecosystems include water quality, water quantity (e.g., are lake levels falling?), vegetation, and macroinvertebrates. These vital signs were chosen because they represent important physical, chemical and biological elements of healthy wetland ecosystems. (See also page 61.)

Seismic Monitoring

Researchers at the Geophysical Institute at the University of Alaska Fairbanks have maintained seismic monitoring stations within Denali at Wickersham Dome, Thorofare Mountain, and Mt. Healy for over thirty years. An upgrade of sites to allow for digital multi-signal transmission and the installation of a new site on Double Mountain occurred in 2003. Real-time earthquake data and maps showing recent seismic activity are available through the Alaska Earthquake Information Center. The new equipment allows for much more precise location of earthquakes, recording ground movement in all three directions.

In September 2006, a new seismometer was installed at Castle Rocks (after an Environmental Assessment identified some mitigation measures) in order to better characterize activity on the western portion of the Denali Fault and the "Kantishna Swarm" of earthquakes (a cluster near Kantishna). The Kantishna Swarm is of interest to researchers working on the geologic evolution of the Alaska Range and the apparent seismic gap that occurs between the eastern and western portion of the Alaska Range (all of Denali). (See also page 58).

≺ Social Sciences ≻

Visitor-related Projects

Two ongoing projects monitor visitation to Denali National Park and Preserve. One of these projects also focuses on park use by park staff.

- ✧ **Monthly public use report:** This project documents visits to the park including Talkeetna Ranger Station, mountaineering, aircraft landings, railroad passengers, Park Road traffic, bus passengers, and backcountry users, for both recreational and non-recreational purposes. According to this report, recreational visitors to the park were 415,935 in 2006, compared to 403,520 in 2005 and 404,234 in 2004. However, there have been some glitches in the program that formulates the

representative numbers for Denali and reexamination of the formulas and input method is forecast for some time in 2007.

- ✧ **Road traffic monitoring:** Because the road corridor is a human feature within a pristine natural area, monitoring the direct and indirect effects of park road use on the natural resources is critical. Vehicle use of the park road by both visitors and park staff is being documented. The only traffic counter maintained in 2006 to assist with the Monthly Public Use Report is the one in the entrance area across from the road to the post office. In 2006, approximately 111,425 vehicles entered the park on July 4 compared to 17 on December 25. Vehicle trips are also counted at the Savage Check Station during summer months.

◃ Subsistence ▹

Changes in Staff

Amy Craver, formerly of U.S. Fish and Wildlife Service (FWS) / Office of Subsistence Management in Anchorage, began her Subsistence Manager position at Denali on February 5, 2007. Amy grew up in Talkeetna, where her family has long been engaged in homesteading and a subsistence lifestyle. She holds degrees in anthropology (BA from Evergreen State College, MA from Indiana University) and is currently completing her Ph.D. dissertation. Amy worked as a social scientist at FWS and as a liaison regarding subsistence harvest with other federal and state bureaus and native organizations. As Denali's Subsistence Manager, Amy's communication skills, knowledge of subsistence in Alaska and background in social science research will be a significant enhancement to Denali's subsistence program. In addition, her work throughout the state will aid her contributions to the regional subsistence team.

Traditional Subsistence Access Review for the Cantwell Area

At the request of eight Cantwell subsistence users and the Denali Subsistence Resource Commisssion (SRC), and in compliance with ANILCA, NPS regulations and policies, the NPS undertook a project to compile and review traditional access information for the Cantwell area. A report was completed in July 2005 entitled *A compilation and review of information pertaining to use of ORVs as access for subsistence purposes in the Cantwell area by federally qualified subsistence users.* Based on the information gathered, on July 22, 2005, the park published a final "Cantwell Subsistence Traditionally Employeed ORV Determination" in which the park determined that the community of Cantwell had used ORV's for successive generations for subsistence purposes in portions of the Denali Park additions before the establishment of the Denali National Monument in 1978. On August 1, 2005, the park implemented a temporary 120-day closure to protect park resource in the area where Cantwell residents traditionally employed ORV's for subsistence purposes. Three existing trails were exempted from this closure. The closure allowed reasonable access to subsistence resources for the residents of Cantwell. It protected park resources, while allowing the park time to complete environmental documentation

evaluating ORV effects on park resources and values. A CD was produced in January 2007 (*Cantwell TUA ORV Information*) that included a summary of the 2005 data and maps. An Environmental Assessment, which presents alternatives for managing subsistence ORV use in the Cantwell area to minimize adverse impacts to park resources values while providing reasonable access for subsistence purposes, is in its second round of reviews. The EA will be printed in early May and the public comment period will be mid May to mid June. (See also page 14.)

Kantishna River Fall Chum Salmon Stock Assessment

In 2006, mark-recapture studies on fall chum salmon *Oncorhynchus keta*, were conducted for the eleventh consecutive year on the Tanana River and for the seventh year on the Kantishna River. In the Kantishna River, chum salmon were captured in a fish wheel on the left bank of the river, approximately 9-km upstream of its terminus on the Tanana River, and recaptured through the use of fish wheels located approximately 113 km upstream in the Toklat River (one on each bank) and fish wheels located 139 km (90 miles) upstream on the Kantishna River. Denali National Park and Preserve has funded the operation of the tag recovery wheels on the Kantishna River. The NPS component of the study has enabled Alaska Department of Fish and Game (ADF&G) to estimate the annual abundance of fall run chum salmon migrating past the Turner homestead into headwater spawning streams in the Preserve. (Coho salmon are thought to be more abundant than fall chums in the upper Kantishna but are not tagged and abundance estimates are not produced.)

Project data are used by ADF&G primarily for in-season management of the Tanana River commercial, subsistence, and personal-use fisheries and as a post-season report card on the efficacy of regulations and management strategies. Commercial fishing does not occur on the Kantishna River and because subsistence salmon harvests in the Kantishna are minimal and sporadic, in-season regulation changes are rarely applied.

Prior to the initiation of this project, little was known about numbers or distribution of fall chum salmon in the upper portion of the Kantishna watershed. During the 7 years of tagging (see Table 7), the upper Kantishna drainage is thought to have experienced both the largest (108,000 in 2005) and the weakest (21,000 in 2000) fall chum salmon runs in the past thirty or more years.

*Table 7. Estimates (with standard error) of fall chum salmon abundance, upper Kantishna River drainage, 1999-2006**

Year	Estimate	S.E.	Lower Bound	Upper Bound
1999[1]	27,199	3,562	20,218	34,180
2000	21,450	3,031	15,510	27,390
2001	22,992	2,172	18,734	27,250
2002	56,665	4,122	48,587	64,743
2003	87,359	8,041	71,600	103,118
2004	72,196	3,716	64,912	79,480
2005	107,719	7,649	92,727	122,711
2006[2]	61,476	3,305	54,998	67,954
Average	57,068	4,710	40,368	56,908

* upstream of Turner homestead @ mile 87

[1]Toklat River only [2]preliminary

Aerial Fisheries Salmon Surveys

Flights will be made over Denali streams in 2007 (pending adequate funding) to determine the presence and abundance of chinook salmon (mid-summer flights) and chum and coho salmon (late fall flights). Similar surveys may be conducted in selected rivers within Gates of the Arctic and Yukon Charlie National Preserve.

◅ Cultural Resources ▻

Denali's Historic Resources and National Register

Denali staff continue to research what sites are eligible for listing on the National Register of Historic Places but have shifted their evaluations from mining sites to the numerous trapping cabins in the park.

To date, only two historic resources are listed on the National Register: the Headquarters Historic District and the Patrol Cabins of Mt. McKinley. Historical sources of information (correspondence, archival material, oral history, photography, and architectural information) are collected and evaluated to develop Determinations of Eligibility to the National Register. Draft nominations include the Kantishna Mining District, Caribou Creek (part of Kantishna District), McKinley Park Station, CCC Camp, and the Stampede Mine Historic District. Work continues in 2007 on these drafts that are now in the stage of gathering documentation to support the nominations (generating maps and diagrams and reproducing photographs). As an outgrowth of this National Register work, information is being compiled about mining in the Kantishna Hills for the park website.

A Determination of Eligibility was prepared for the historic Savage Camp and concluded that the site of the camp is significant and is eligible to be listed on the National Register of Historic Places. The State Historic Preservation Officer concurred with the park's determination. Next step is to prepare a nomination to list the site on the National Register.

A Determination of Eligibility is currently underway for 4 houses in the Headquarters housing area that were designed by well known NPS Mission 66 architect Cecil Doty.

Eielson Visitor Center and the National Register of Historic Places

Protecting cultural and historic resources is a key element of the National Park Service (NPS) mission. The NPS was the driving force in writing and passing the National Historic Preservation Act of 1966 (NHPA), and the NPS is the agency everyone turns to for information and guidance for historic preservation.

Any governmental agency including NPS must comply with Section 106 of the NHPA for any project undertaken by the agency. Under Section 106, the agency is required to examine the project and determine its affects on cultural resources, e.g., historic buildings, sites. If there will be an effect, the agency must decide if the cultural resource is historically significant and has

integrity for listing on the National Register of Historic Places (NRHP) using specific criteria developed for the NRHP.

Eielson Visitor Center was built in 1958-1960 during a program called Mission 66, a system-wide program funded to improve park infrastructure by 1966. In the 1990s, numerous NPS visitor centers that were part of Mission 66 were evaluated for NRHP eligibility. In 1999 Sarah Allaback wrote *Mission 66 Visitor Centers: the History of a Building Type* in which she developed registration requirements for registering Mission 66 visitor centers on the NRPH.

For Eielson, Denali cultural resource staff had in-depth discussions with the State Historic Preservation Officer (SHPO). SHPO determined that EVC is not eligible for the NRHP. Specifically:

> "Eielson Visitor Center does not meet National Register of Historic Places (NHRP) Criteria A or C registration requirements as defined in *Mission 66 Visitor Centers: the History of a Building Type*. Although associated with Mission 66, Eielson Visitor Center does not exemplify the programmatic goals of Mission 66 nor did the Mission 66 program have a lasting effect on the development of Denali National Park and Preserve. In addition, Eielson Visitor Center lacks any notable association with other events that have made a significant contribution to the broad patterns of our history as required under Criteria A of the NRHP. Since Eielson Visitor Center is not the work of a master architect, does not possess high artistic values, and was radically altered in 1976; it is not eligible under Criteria C. In addition, in accordance to NRHP Criteria Consideration G, Eielson lacks the higher standard of integrity required for a building less than fifty years old to be eligible for the NRHP."

While the building itself is not significant, the site is significant under Criteria A of the NRHP for its long history of providing enhanced visitor experience and visitor services. The spectacular view of Mount McKinley and the surrounding landscape from this location has made the site a focal point for the visitor experience at the park. Beginning in 1934, a tent camp established at the site offered the visitor a wilderness experience with a few of the comforts of home. Mount McKinley National Park began seeing a significant tourist impact with the opening of the Denali Highway in 1957, and with the spectacular views at the site, Eielson would remain a destination within the park.

The Eielson Visitor Center was built to accommodate visitor needs at that time. Over the past decades, visitor numbers have increased to such a point that Eielson was inadequate to meet current needs. Replacing Eielson with a new visitor center will allow the park to continue to use the site as it has for over 60 years, enhancing the visitor experience and serving visitor needs.

Historical Research and Oral History

Cultural resource staff will continue to participate in planning for interpretive exhibits and interpretive trails (new Eielson Visitor Center and the entrance area). Staff will continue to produce educational programs interpreting park history for staff and visitors, acquire and accession historic photos, and conduct oral history interviews with park "elders", i.e., park staff, former employees, local residents, and others to document conditions and experiences in the park.

Current and recent work includes these projects:

- ❖ Plans for interpretive information and panels about prehistoric use of the Teklanika area will be developed.

- ❖ Historic photographs from Denali's Museum Collection will be identified and updated descriptions will be entered in the Rediscovery database. To enhance Denali's collection of historic photographs, cultural staff will continue to seek out historic park-related photographs and to help accession any donated private historic photograph collections.

- ❖ Historian Frank Norris (Alaska Regional Support Office) completed writing the first volume of the park's administrative history. *Crown Jewel of the North: An Administrative History of Denali National Park and Preserve, Volume I* covers the time period 1917 to 1980 and was published in November 2006. Jane Bryant selected and prepared the illustrative photographs. Frank Norris will finish Volume 2 (1981 to present and selected thematic chapters) in 2007.

- ❖ Jane Bryant conducted oral history interviews with two informants in 2006
    - William A. (Bill) Weber (his 1954 lichen studies in Mt. McKinley National Park)
    - Earl Plumb of Anchorage (his experiences working at the Savage Tourist Camp, his parents' cabin on Mt. Healy)

Archeology

Brian Wygal, hired in a 4-year term position as park archeologist starting in 2006, has been and will be working on archaeological survey work in the park. In 2006, Brian and a survey crew did some helicopter reconnaissance to help focus the planning for on-the-ground fieldwork in 2007 and beyond. The survey for areas identified as having a high potential of having archeology sites will continue this year.

Museum Collection

In 2006, the park hired Jane Lakeman as the park's Museum Curator. The primary tasks of the Museum Curator are caring for the park's museum collection, updating the museum database, and providing customer service (appointment access to the collections) to park staff and the public. Many additional tasks have been identified for the Curator including moving the park library and combining its maintenance with the museum function. The Museum Collection is housed in the basement of the resources building and the park library will be housed there in the near future. Compressed shelving was purchased for the Museum Collection Room and the (relocated) park library. This shelving reorganizes the space and will allow for more storage, work areas, and the use of the park library.

◅ 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. The Denali National Park and Preserve GIS is used by all functions in the park for preparing maps for planning purposes, public displays, and analysis of park resources. Engineering drawings for construction, mining site rehabilitation, and design work are also produced by the GIS. Denali's GIS includes several hundred layers or themes of information (hydrology, elevations, buildings, roads, etc.) that can be overlain by the computer to form composite maps. In addition to producing maps and other visual products, the associated databases can be queried in an unlimited variety of ways to analyze the features appearing in the maps. The system is managed on a central workstation and used by park staff on their desktop computers. Efforts are on-going to make the technology and/or products more useful and available. Applications such as Google Earth have brought GIS technology to anyone with an internet connection.

One notable addition to the park's GIS dataset involves and on-going project to collect high-resolution (1 meter) satellite imagery of the park. The project was started in 2005 and to date the portion encompassing the road corridor and south to the Alaska Range has been collected. In 2005 several areas of the existing imagery were re-collected due to smoke in the earlier images. It is anticipated that the entire park will be collected as clear images become available resulting in a base map far more accurate than the existing USGS Topo Quads.

The park maintains a copy of the entire NPS GIS dataset for the state of Alaska locally (over 400gb 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.

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 accurate 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 Administration

As of April 1, 2007, 754 study numbers have been assigned to scientific and scholarly studies. Some studies are in progress, some in review for 2006, and some have taken place in the park over the years. Each year there are approximately 50-75 studies that are ongoing or recently completed. These projects are either conducted by Denali staff (described at length in this

document) and park cooperators (e.g., U.S. Geological Survey, Biological Resources Division, and the Alaska State Department of Fish and Game), or by other investigators (e.g., from 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). 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.

Fact Sheets about Denali Research and Resources

Several color fact sheets about Denali resources and research are available now in hard copy or on the web. Fact sheets on additional topics will be developed in 2007 and beyond.

- Central Alaska Network: Inventory & Monitoring Program
- Climate Change
- Dinosaur Track Found in Denali
- An Integrated Study of Park Road Capacity
- Large Mammals…How many are there?
- Permafrost Landscapes
- Resource Stewardship Strategy
- Rivers and Streams (4-pages)
- Soil Survey and Ecological Classification
- Soundscapes

◃ Brief Synopsis of Research Findings in 2006 ▹

The following researchers (non-park staff) held research permits in 2006. This table provides brief information about their findings. (Some research is reported in more detail elsewhere in Current Resource Projects.)

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

Researcher	Affiliation	Project
Adams	USGS-Alaska Science Center	Population dynamics of wolves and their prey in a subarctic ecosystem (caribou only)
Information reported on page 24-26.		
Akasofu	International Arctic Research Center, UAF	Weather conditions on Mt. McKinley
Information reported on page 35-36.		
Brabets	USGS-Alaska Science Center	Limnology and water quality of Wonder Lake and other selected lakes, Denali National Park and Preserve, Alaska
Snow samples were collected at Wonder Lake in April 2006 and analyzed for semi-volatile organic compounds. In June, July, and September, depth profiles of water temperature, specific conductance, pH, dissolved oxygen, turbidity, and chlorophyll were collected at 3 locations in Wonder Lake - the south and north ends and the middle of the lake. Depths ranged from 13 meters to 65 meters. The most interesting profiles were of water temperature. The maximum water temperature recorded was 16 degrees C in July (near the surface) but even on that date it was 12 degrees cooler at a depth of 15 meters. Water samples were collected 1 meter below the water surface and 1 meter above the bottom at all three sites. Water samples were analyzed for nutrients, major ions, dissolved organic carbon, and chlorophyll, and e-coli bacteria. No counts of bacteria were found.		
Chestnut	Washington Department of Transportation	Detecting a deadly amphibian disease: are park visitors inadvertent vectors?
The chytrid fungus Batrachochytrium dendrobatidis (Bd) is associated with mass amphibian mortalities and local extinctions in both disturbed and pristine landscapes. Bd causes the disease chytridiomycosis, an epidermal infection fatal to susceptible frogs. Disease transmission may occur when exposed to Bd zoospores for less than one minute. The wood frog (Rana sylvatica) is the most widespread amphibian in Alaska and thus became the focal species of the investigation in the state. In 2002, Bd was detected in a wood frog at the Kenai National Wildlife Refuge. At Denali in 2006, 33 ponds were surveyed for frogs (4 ponds near the park entrance, 2 ponds in the Teklanika vicinity, 12 ponds along the road in the Wonder Lake vicinity, and 15 backcountry ponds (more than a mile from the park road) in the Wonder Lake vicinity. Thirty wood frogs were detected and sampled for Bd (12 in roadside ponds and 18 in backcountry ponds). Eight animals encountered in the backcountry were recently deceased or dying. These animals were collected for further analysis in the lab. All samples tested negative for chytridiomycosis. Follow-up testing for other pathogens is currently being conducted.		

Researcher	Affiliation	Project
Densmore	USGS-Alaska Science Center	Long-term monitoring of restoration of placer-mined watersheds in Denali
We resurveyed the existing cross-sections of the reconstructed floodplains and stream channel. We also measured natural and planted revegetation on the reconstructed floodplains. We are currently analyzing the data to assess the ecological effectiveness of the restoration.		
Densmore	USGS-Alaska Science Center	Factors controlling establishment and growth of *Taraxacum officinale* in Alaskan national parks
Different revegetation treatments in the park are being compared for the establishment and growth of nonnative species, particularly dandelion (*Taraxacum officinale*). During the first three years of the study, very few non-native plants have invaded any revegetation treatments. Dandelions are invading four years after disturbance and revegetation, and data collection will be continued to determine any treatment effects. A manuscript entitled "Potassium and estimated soil temperature influence distribution of dandelion (*Taraxacum officinale*) in Denali National Park and Preserve" has been submitted to a journal for review.		
Dortch	University of Cincinnati	Timing and extent of glaciation on the northern slopes of Alaska Range
This project is reconstructing past climates by mapping landforms and defining the timing of glaciation (by analyzing how long the surface boulders have been exposed after glacial retreat). Eight boulders were successfully identified and sampled in 2005 for cosmogenic radionuclide dating. Results are pending.		
Fiorillo	Dallas Museum of Natural History	Paleontological survey of the lower Cantwell Formation, Denali National Park and Preserve
The paleontological survey of the Cantwell Formation (Late Cretaceous to Early Tertiary) in Denali has discovered over 20 localities of dinosaur and fossil bird footprints in the Igloo Creek/Tattler Creek area and on the north side of Double Mountain. Some sites contain individual tracks while other localities contain hundreds of tracks. The most frequent footprint type found among all sites is the tracks of a medium-sized theropod. The tracks attributable to this animal measure approximately 20-25 cm in length. This length provides an estimated hip height of approximately 90 cm and a body length of approximately 3 m. Additional theropod tracks range from small tracks (10-14 cm in length) to very large tracks (over 50 cm in length). In addition to the more common theropod tracks, there are two sites that contain tracks attributable to hadrosaurs. An exceptional site contains several hundred tracks attributable to a medium-sized wading bird. The morphology of the tracks indicates the substrate was still very wet when these birds walked on the surface. Further nearly circular depressions attributable to probe-style feeding by these ancient shorebirds are also preserved at this site. These initial results demonstrate that Denali National Park is an exciting, rich, new area for dinosaur studies (the first record of dinosaurs in the Alaska Range). This record consists of tracks of small, medium, large, and very large-sized theropods, as well as hadrosaurs. In addition, the Cantwell Formation contains the first record of fossil Aves. Further, this occurrence of fossil birds records feeding behavior in these presumed ancient shorebirds. In combination this new suite of Mesozoic fossil vertebrate sites adds to the understanding of biodiversity in Alaska during the Cretaceous at the beginning of the land bridge referred to as Beringia. The Cantwell Formation correlates with other rock units in Alaska that produce dinosaur remains such as the Prince Creek Formation of northern Alaska and the Chignik Formation in Aniakchak National Monument in southwestern Alaska. Thus, further work will provide the opportunity for a more detailed regional paleoecological and paleoenvironmental understanding of an ancient high latitude terrestrial ecosystem on a greenhouse Earth.		

Researcher	Affiliation	Project
Freymueller	University of Alaska Fairbanks	Repeated Global Positioning System (GPS) and absolute gravity measurements to measure active crustal deformation in southern Alaska
This project began with two goals: (1) carry out absolute gravity measurements at the Wonder Lake to learn about subsurface mass movements caused by viscoelastic relaxation following the 1964 Alaska earthquake and (2) carry out Global Positioning System (GPS) measurements (also relate to the first goal) to understanding the Denali fault system, which cuts through the Alaska Range and Denali Park, and the effects of the Nov 3, 2002 magnitude 7.9 earthquake. Previous GPS data from a profile along the Parks Highway shows ~8 mm/year of steady slip on the Denali fault at depth, but another parallel fault may be active north of the main fault (probably the Hines Creek fault that runs through the park entrance). From the Parks Highway data alone, we could not precisely tell how much slip was on each of the two faults (most likely the majority on the main Denali fault). The data from Wonder Lake show that it moved differently from the Parks Highway sites, and appeared to be affected substantially by post-seismic deformation. In 2002, we carried out a high precision GPS survey of four survey marks along the Denali Park road within the Park (Wonder Lake, Eielson Visitor Center, East Fork Toklat River, and Savage River. Additional surveys in 2003 were compared to the pre-earthquake data to measure the surface displacements from the 2002 earthquake, and determine the distribution of fault slip on the Denali fault. In 2003, we made absolute gravity measurements at Wonder Lake – these measurements will be repeated in a future year. Since 2002, we have carried out annual surveys of the GPS sites within the park to better characterize the hazards posed by the western part of the Denali fault, which did not rupture in 2002. In 2006, we repeated surveys of all four survey marks along the Denali Park road. Although we did not survey most of these sites before 2002, we can compare the post-earthquake motions to the pre-earthquake motions for Wonder Lake and Parks Highway. One of the key questions we face is how to separate the long-term trend from the post-2002 reactions. The 2005 and 2006 measurements may be consistent with the pre-earthquake trend. If correct, this means that in a few years we can use the time series to evaluate the current tectonic deformation of this part of the Denali fault system.		
Haber		Dynamics of wolf-prey systems and wolf societies in the Denali Region, Alaska
This research, which began in 1966, focuses on groups rather than populations. Fourteen groups of wolves were studied throughout the park/preserve in biological year 2006 (May 2006-April 2007), including the well-known road corridor groups. Results are summarized in detail in the NPS Investigator's Annual Report for this project that is available at NPS headquarters.		
Haeussler	USGS Alaska Science Center	Behavior of the Denali Fault, Central Alaska Range
The goal is to model how the Denali fault works in time and space, how often large earthquakes occur, whether recurrence intervals vary, and how long ago an earthquake occurred on the sections of the fault that did not rupture in 2002. Field work in 2005 included finding features offset by the Denali Fault (east fork of Cantwell Creek, north side of the west fork of the Bull River). Alluvial fan channels that had been offset approximately 4, 8, and 12 meters in the last three earthquakes were selected for study. No field activity was conducted in 2006. Analysis of samples continued in the lab and research findings were presented.		
Hansen	University of Alaska Fairbanks	Denali Seismic Monitoring Sites (including repeater on Double Mountain)
The seismic network in Denali consists of 3 seismic stations (Wickersham, Thorofare, and park entrance), two telemetry "repeater" sites (Double Mountain and Mount Healy), and a receiver site (MSLC). All existing sites worked in 2006 so no maintenance was required. The installation of a new station at Castle Rocks was planned for June, but nesting peregrine falcon found during pre-installation site inspection delayed the installation until August 30-31. Future plans: (1) removal of older analog seismic stations now that the new digital stations are stable, (2) modernize the display maintained at the Eielson Visitor Center (after construction is complete). Plans being considered are the addition of another station west of Wonder Lake, and adding a seismometer at Double Mt. These would be necessary to obtain a better resolution on the source of that very active zone of seismicity located roughly between Mount McKinley and Wonder Lake at a shallow depth. This would also provide valuable insight to the rupture process should the western portion of the Denali Fault rupture.		

Researcher	Affiliation	Project
Hansen	University of Alaska Fairbanks	Expanded earthquake monitoring near Kantishna with portable seismometers
On June 21, 2006, Natalia Ruppert, Alaska Earthquake Information Center (AEIC) seismologist, along with two Denali representatives (including the park cultural specialist) visited 6 benchmark sites in Denali. The trip served as site reconnaissance for the installation of 6 temporary (duration of 2-3 months) seismic sites. At each site, the cultural specialist made a broad visual scan for archeological evidence and dug a shallow test hole to make sure no archaeological artifacts would be disturbed if the site were used for an installation. No archeological evidence was found. The actual installations did not proceed in the summer of 2006 due to scheduling conflicts, but may happen in the 2007 field season.		
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
Two 2 potential sites for locating instrumentation were identified in Denali NP. They are located at Wickersham Dome and Tokosha COMM facility. An application has been submitted to the park for construction of these sites.		
Jeffries	University of Alaska Fairbanks	Lake ice and snow studies at Horseshoe Lake, Denali National Park and Preserve: scientific research contributing to science education
One objective of this study is to learn about the variability (within a year, and among years) of lake ice thickness, snow depth and density on the ice, and the conductive heat flow through the ice and snow to the atmosphere throughout Alaska. A second objective is to contribute to science education by involving K-12 teachers and students in a scientific inquiry that involves hands-on participation in the Alaska Lake Ice and Snow Observatory (ALISON). The ALISON study site on Horseshoe Lake was set up on November 28, 2006. This year teachers Dorothy DeBlauw and Kirsten Alburg and their respective Tri-Valley School 4-5 grade students made measurements during the winter. These included the depth, density, and top-and-bottom temperatures of the snow accumulated on the ice. The conductive heat flow through the snow was derived from these snow data. Kristen Friesen (NPS employee) has been helping with the measurements again this winter. The Tri-Valley School group continues to contribute to acquisition of knowledge about winter processes at Horseshoe Lake. They have laid the foundation for a long-term data set that is important at this time of environmental change in Alaska. Their participation in the ALISON project during the 2006-07 ice growth and decay season represents a contribution to the International Polar Year (IPY) effort that began 1 March 2007. Measured ice thicknesses are greater this season (2006-2007) than those obtained in the winters 2003-04 and 2004-05 (no ice thickness data were acquired in winter 2005-2006 due to equipment failure). The snow depth was lower than in previous winters (2004-05, 2005-06) but not as high as the snow depth during the 2003-2004 season. The snow density and conductive heat flow values were similar to previous seasons. The current Horseshoe Lake data are posted at http://www.gi.alaska.edu/alison/HLY_CURRENT_Graph.html. Previous years' data are posted at http://www.gi.alaska.edu/alison/HLY_PAST_Graph.html and see Alaska Park Science 5(2): 18-23.		

Researcher	Affiliation	Project
Jorgenson	ABR, Inc., Environmental Research and Services	Collaborative study on permafrost characteristics of Wrangell-St. Elias and Denali parklands

The purpose of this study is to evaluate geomorphic processes related to permafrost and ground ice. In 2005, vegetation, soil, and permafrost characteristics were described from 11 locations of degradation of buried glacial ice at the Muldrow moraine, and along two transects at Gosling Lake. At both locations, small temporary temperature dataloggers were installed below the soil surface to monitor temperatures. At the Muldrow site, the data indicate rapid thawing of buried glacial ice, kettle formation, and dramatic exposure of glacial ice that had been buried in the Little Ice Age moraine. At Gosling Lake, the permafrost was very ice-rich and the development of thermokarst (slumping due to thawing of permafrost) was evident along both transects.

No new information for 2006 was reported as of 4/5/07.

Landers	U. S. Environmental Protection Agency	Western Airborne Contaminants Assessment Project (WACAP)

Accomplishments for the Western Airborne Contaminants Assessment Project (WACAP) in 2006 include the collection of snow or bulk precipitation from four national parks, the collection of passive air sampling devices (PASDs) from 11 national parks and one national forest, and the continued analysis of samples from 2003 through 2005. In addition, investigators have been working on interpretation of 2003-2006 data for the WACAP Final Report and other publications. A draft of the final report has been prepared and is currently being reviewed.

Two passive air samplers were installed in Denali NP in September 2005, one near Wonder Lake and another at Friday Creek. These samplers were retrieved on September 18, 2006 after over a year at each site, and mailed to the Simonich Environmental Chemistry Laboratory at Oregon State University in Corvallis, OR. The resin tubes in the samplers have a consistent uptake rate for air toxics, and this resin was extracted and analyzed for semi-volatile organic compounds. Data analysis is continuing on these samples and the samples from all the participating parks.

WACAP has been sampling a variety of ecosystem indicators (snow, fish, water, lake sediment, lichens, conifer needles, and moose meat) at eight "primary" national parks to provide information about contaminant accumulation.

Larsen	Central Alaska Network	Central Alaska Network shallow lake monitoring project

Thirty lakes were sampled in the northwestern corner of Denali National Park and Preserve in summer 2006. Sampling followed procedures outlined in draft monitoring protocols for Central Alaska Network shallow lake monitoring. Samples were collected for analysis of water and macroinvertebrates. Surveys on lake morphology were also conducted to estimate lake level and bathymetry to estimate lake volume. Vegetation surveys were not conducted in 2006, but will be completed in 2007. RADARSAT images were collected throughout the ice-free season in both index sites in Denali and Wrangell-St.Elias National Park and Preserve. These images will be used to estimate lake surface area.

We observed significant decreases in lake surface area in three of the lakes we sampled, as a result of infilling with vegetation (likely due to a decline in water level). Twelve of the lakes had evidence of recently created thermokarst from melting of permafrost and 90 percent of the lakes had evidence of older karst activity. Four of the lakes had evidence of fire. Two lakes are located within the area burned in 2005 by the Highpower Fire, one in 2002 and another in 1986.

Researcher	Affiliation	Project
Larsen (cont'd)	Central Alaska Network	Central Alaska Network shallow lake monitoring project
There were no obvious differences between the chemical or physical characteristics of burnt and non-burnt lakes. Water quality varied significantly among lakes. All of the lakes sampled were extremely nutrient poor based on estimates of TN and TP. According to Vollenweider's (1979) trophic classification they are classified as ultraoligotrophic to oligotrophic. These data are supported by the extremely low concentrations of Chlorophyll a we found. We also observed large populations of *Drosera* (sundew) growing adjacent to the open water zones of many of the lakes. *Drosera* are small carnivorous plants that trap small insects in a sticky substance on the modified leaf, secrete enzymes into the insects, and extract nutrients used for growth and reproduction. Carnivorous plants are frequently found in nutrient poor ecosystems. In 2007 we will resample the 30 lakes sampled in Denali in 2006. This will allow us to estimate inter-annual variation and increase our ability to detect change over time. In 2008 we plan to conduct water quality sampling on 90 additional lakes in Denali. This information will be used to develop a lake classification system that will hopefully be applicable to the other two network parks.		
Levsen	University of Kansas	A study of arctic plant evolution and phytogeography in the Alternifolium Group of *Chrysosplenium*
The purpose of this project is to determine how population history (particularly that associated with Pleistocene glacial cycles) has shaped the evolution of the North American arctic flora by examining the biogeography and molecular genetics of the Alternifolium group of the flowering plant genus Chrysosplenium (Saxifragaceae). In 2006, I was able to collect two populations of Chrysosplenium tetrandrum in Denali NP—one near the Savage River and one near Wonder Lake. The individuals of these populations have been processed for DNA extraction. Genotyping will be completed by June 2007.		
MacCluskie	Central Alaska Network (NPS)	Small mammal monitoring at the landscape scale and synthesis of monitoring data in Denali NPP
Information reported on page 26-27.		
McDonald	Jet Propulsion Laboratory under contract to NASA	Monitoring freeze/thaw transition on a regional scale in boreal forests using the ADEOS Satellite
This study assesses how well space-borne microwave remote sensors can monitor the seasonal freeze/thaw dynamics within boreal forest ecosystems. Two of the eight ground validation stations, arranged along a latitudinal gradient, are in Denali. One station is at tree-line (near Savage) and one in closed spruce-hardwood forest (Rock Creek). These stations monitor land surface state (freeze, thaw) and vegetation biophysical function (sap flow). Using data from the ground stations, there is a correspondence between start up of vegetation ecophysiological process in the spring, associated growing season length, and annual productivity with estimates of spring thaw derived from remote sensing data sets. As part of our 2006 field work, the low elevation site was relocated with the help of park personnel from an area close to C Camp to a hillside site closer to Rock Creek, near the pump station. Eventually connecting the equipment to line power available at the pump station will allow improved reliability of our data collections near Rock Creek. In the coming years, we will be evaluating any effect this relocation may have on our long-term data record.		

Researcher	Affiliation	Project
Manning	University of Vermont	A predictive study of use impacts on the Denali park Road: a study ;lan to support analysis and management of carrying capacity

One-hundred twenty-six qualitative interviews and two focus group sessions were conducted with Denali Park Road vehicle users during the 2006 use season. Interviews were conducted with users from three road use groups: (1) VTS bus users (including both general and camper buses), (2) commercial bus users (including tour and lodge buses), and (3) Recreational Vehicle (RV) users at Teklanika Campground. These interviews and focus group sessions collected data to help formulate indicators to measure and manage the quality of the visitor experience on the road. Respondents were asked questions about their experience on the road, impacts to their experience, the number of vehicles on the road, and the management of vehicle use.

Results from these interviews suggest a variety of potential indicators for the visitor experience on the Denali Park Road. These indicators include wildlife viewing, crowding, bus driver quality, bus maintenance, comfort of the bus ride, dust, and visitor compliance with rules for wildlife observation while on the bus. The interviews also suggested more specific way that these indicators might be measured and managed. For example, crowding on the road might be addressed by measuring and managing the number of encounters with other vehicles, number of vehicles within visitors' view, number of vehicles at rest stops, and/or number of vehicles at wildlife stops. Similarly, wildlife viewing might be addressed by measuring and managing the number and type of specific factors that interfere with observing wildlife. Results from the 2006 interviews and focus groups sessions will be used to inform the development of a quantitative survey. The survey will gather data to help set standards for selected indicators. This survey will be administered to Denali Park Road users in the summer of 2007. See also information on page 4-9.

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

In September 2006, macroinvertebrate sampling of the 14 long-term study streams was undertaken as part of understanding the natural variability in Denali streams and trying to link it to large climate "drivers".

A paper was presented at the Alaska Park Science Symposium at Denali on our findings from this long term study (1993 to 2004). For some unstable streams like N4 and Highway Pass Creek, the persistence in the macroinvertebrate community was significantly related to the Pacific Decadal Oscillation. We need to continue sampling these streams to add to this long-term dataset so we can see if the trends (the relationship to PDO) continue.

In September 2006 we also undertook a preliminary examination of the upwelling areas in the main fork of the Tolkat River valley as a pilot for a longer term study. Where the waters converge from different sources, there is a distinct suite of physical and chemical interactions (different from the surrounding areas) that influence productivity and hence create hotspots of biodiversity. This proposed project will start in July of 2007 and a research proposal has been submitted to NPS to involve park personnel.

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

Information reported on page 42.

Researcher	Affiliation	Project
Roeske/Altekruse	University of California-Davis	Structural constraint on the Late Cretaceous to Early Eocene development of the Alaska Range Suture Zone

The goal of this project is to use the composition of Denali's sedimentary rock to document when certain movements along the Denali Fault occurred. A comparison of heavy metal provenance analysis from rocks to the north and the south of the suture zone help narrow down when activity along the suture zones occurred. In 2005, structural data and samples for analysis were collected from the Big Creek area northwest of Igloo Mountain. These are being compared to rocks south of the Denali Fault. In July 2006, we visited two sections along the West Fork of the Chulitna River. Near the headwaters of Colorado Creek, Oligocene and younger nonmarine rocks unconformably overlie Late Cretaceous to Tertiary nonmarine rocks. A number of faults cut the area so the nature of the transition from the upper Cretaceous nonmarine rocks to the underlying marine rocks of the Kahiltna assemblage is unclear. Further structural mapping in this area is necessary to fully constrain the relationships between these units.

The second site we visited is the structurally complex northwest Chulitna district. Here, numerous faults cut Triassic to Cretaceous calcareous sandstones, argillites, and chert. Late Jurassic to Cretaceous calcareous sandstones in this section have been interpreted as a shallower marine equivalent to the Kahiltna assemblage exposed in the Northwest Talkeetna Mountains and elsewhere in the Alaska Range suture zone. We also collected samples of fossiliferous beds from two locations west of Lookout Mountain. The first is in a brown sandstone and argillite unit containing occasional fossiliferous horizons. One sample contains the snail Naticopsis (Upper Triassic), and a second sample, from float directly below the same outcrop, is primarily fossil hash. This sample contains Entolium (or Amussium), Cassianella, Monotis, Chulitnacula, and Septocardia, representing an assemblage from the upper Triassic to Late Jurassic. The second fossil location is from a rare coquinoid limestone within a calcareous sandstone and argillite unit. This sample is primarily composed of Buchia fragments (Late Jurassic to earliest Cretaceous). Thanks to Robert Blodgett, U. S. Geological Survey, for these preliminary fossil identifications. We collected samples of fine to medium grained sandstone in the Late Jurassic to early Tertiary sections in both areas for heavy mineral provenance analysis. Sample preparation is ongoing and the heavy mineral assemblages of these rocks will be compared to rocks exposed northwest of Igloo Mountain and in the Northwest Talkeetna Mountains.

Shaw	Alaska Bird Observatory	Avian influenza sampling in Arctic Warblers

Results reported on page 30-31.

Sivils		Neurological deficits during ascent of Denali

We were able to recruit over 100 people into the study in Talkeetna, but unfortunately due to storms, a heavy year for snow (we were stuck at 11,000' for a week), and other events, we were able to follow-up with only 50 climbers at 14,000'. Data analysis is still pending. I expect that the combination of good information from the NPS and from publications, good guiding practices, and perhaps because of the weather, most folks acclimatize very well to 14,000'. We did not notice neurological deficits in the data as we were recording it, except perhaps in the case of short-term memory recall. However noticing changes in our own group during our own short time at 17,000' and from discussions with other climbers, a grossly measurable deficit is more likely at 14K than at 11K. Perhaps something for future investigation.

Researcher	Affiliation	Project
Spalinger	USGS	Proteins and tannins in summer browse may limit productivity of moose
No new field work was conducted in 2006. Summaries are available via the NPS website.		
Trainor	UAF-Dept of Chemistry and Biochemistry	Chemical fate and transport of antimony in aqueous geochemical systems of Interior Alaska and the Yukon
Antimony lode deposits are found along Slate Creek and at the Stampede Mine located in the Kantishna Hills Region of Denali National Park. This project documents what happens during the transport of antimony (Sb) in the environment for both mined and undisturbed mineral deposits. In 2005, water and stream sediment samples were taken along Slate Creek to be analyzed for pH, Sb and arsenic (As) concentrations. The pH ranged from 2.8 to 8.3. Antimony concentrations ranged from 3 to 665 parts per billion (the maximum contaminant level for drinking water by EPA standards is 6 ppb). Arsenic concentrations ranged from <1 to 239 ppb (the maximum contaminant level for drinking water is 10 ppb). Elevated antimony concentrations are found up to several kilometers from the source materials (the mine tailings at the head of Slate Creek), suggesting that Sb remains highly mobile in this drainage, as it does in other sites in the Tintina Gold Province of Interior Alaska and the Yukon. The co-associated arsenic is being transported away from the source site too, but because source concentrations are lower than antimony, they are lower downstream as well. In 2006, samples were taken along Stampede Creek. No information for 2006 was reported as of 4/5/07.		
Trost	Alaska Dept of Environmental Conservation	Alaska regional haze monitoring pilot study
No field work was conducted in 2006.		
Van Ballenberghe		Ecology of Moose in Denali National Park and Preserve
2006 was the 27th year of the study. Data on production and survival of calves was gathered in Spring (5/26-6/9). For the sixth 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 2006, a radioed cow again had twin calves near Riley Creek Campground and occupied the area for several weeks. The moose was closely monitored for her interactions with people and dogs. During autumn (8/18 – 10/4), 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. Data on mating success and mate choice were gathered on radioed females. Calves were again relatively abundant in roadside areas during autumn compared to the 1980s and 1990s. Calf survival from May to September was estimated at ~25 percent in 2006, higher than in recent years. Less stable rutting groups were observed in 2006 compared to recent years. Several radio-collared females joined a rutting group at mile 10 briefly, but left prior to mating. The large rutting group at mile 9-10 was reduced in size as a result. The moose population in the eastern part of Denali National Park appears stable following a sharp decline 1970-1990.		

◃ Murie Science and Learning Center ▹

Background

The Murie Science and Learning Center (MSLC) is a collaborative effort between Denali National Park and Preserve, seven other Alaska national parks, and several park partners to promote scientific research to aid park managers and provide science-based education programs and information to students, educational institutions, and the visiting public.
This is the fourth season of operation for the center. Visit the MSLC website at http://www.murieslc.org

Partners

Although based in the park, Denali is only one of the eight national parks with sub-arctic or arctic ecosystems that the MSLC represents. 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 is more than 50 percent of the lands administered by the National Park Service nationwide.

Other partners include:

- Alaska Natural History Institutes (manages and promotes the Murie Science and Learning Center programs and facility with the National Park Service—provides management assistance for the MSLC facility; experiential education programs; arts programs; services for visiting education and researcher groups; and funding for field camp housing facilities, exhibits, research grants, NPS education programs, and arts programs)
- Denali Education Center (provides educational programs and housing for researchers, as available, and assists with the Discover Denali Research Fellowship Program)
- Doyon-Aramark Joint Venture (park concessioner who operates the MSLC Dining Hall jointly with their employee dining room)
- Denali Borough School District (provides technical support and equipment to the center and partners on several education programs and in the development of the Wireless Cloud Network)

Facilities, Services, and Programming

The MSLC main facility provides a classroom, exhibit area and office space for staff and visiting researchers. The MSLC Dining Hall (next door) is shared with the park concessioner. The MSLC field camp is now located within the park by the Teklanika River (Mile 29) and consists of four tent cabins and a yurt. Services provided by the MSLC and partners are the following: providing space for both educational programs and events, and office space and resources for visiting researchers; internet access and data transmission capabilities; wireless network capabilities along the first 35 miles of the park road; video-conferencing; and food service. In 2006, the MSLC programming included citizen science programs; curriculum-based education programs for K-12 grades; school-to-work experiential learning programs; multi-day accredited field seminars and teacher trainings; youth camps; and research fellowship grants.

Programs

Citizen Science

ALISON Project. Through out the 2005-06 winter, students from Denali Borough School District hiked to Horseshoe Lake twice monthly to measure and record lake ice and snow data. The Horseshoe Lake site is one of 16 sites across the state that make up the Alaska Lake Ice and Snow Observatory Network (ALISON), a project under the direction of Dr. Martin Jeffries at the Geophysical Institute, University of Alaska Fairbanks. Tri-Valley teacher Dorothy DeBlauw and students working with NPS Education Specialist Kristen Friesen were only turned back on occasion by temperatures colder than -10ºF and extremely icy trail conditions. Through this citizen science program students provide data that may help detect changes in the ice and snow levels throughout the state over time.

Youth Camps

Denali Backcountry Adventures. This week-long learning camp for high school students was developed in partnership with the Denali Education Center, with the support of the Denali Borough School District. The program develops participants' outdoor and leadership skills while they conduct impact monitoring activities in the Denali backcountry. Information collected is entered by participants into the current park database. Indicators selected for monitoring in the park's new Backcountry Management Plan are: soundscape qualities, visitor observations and contacts, wildlife observations, and backcountry impacts. Backcountry Adventure group size is limited to six participants and two instructors. Areas for exploration and monitoring are identified by park managers. The group spends three nights in Denali's backcountry. In 2006, the MSLC will offer two sessions: July 17 – 21 for students in grades 9 and 10 and August 13 – 18 for students in grades 11 and 12.

Denali Discovery Camp. This will be the sixth season for this five-day camp that 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, 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 spend one to three nights in the park. June 19 – 23.

Denali-Susitna Exploration Camp. This camp combines an outdoor-based science curriculum with cutting edge technology for the benefit of local students. Offered in partnership with Kigluait Educational Adventures and the Upper-Susitna Soil and Water Conservation district, the goal of the camp is to share the unique natural environment and ongoing research of Denali National Park and Preserve with the middle-school- age youth who live in communities south of Denali, including Trapper Creek, Sunshine, Talkeetna, and Willow. This year's activities (July 31 to August 4) will be based out of the Sunshine Creek area and participants will help to develop interpretive information about the area's natural history. Campers will use GPS units, compasses, video-teleconference technology, and mapping software to explore their environs and create publications.

Alaska Summer Research Academy. July 9 through 20, the Alaska Summer Research Academy (ASRA) will offer two programs in Denali for students grades 8-12 who are interested in working with university faculty and industry professionals. "All Shook Up in Denali: Earthquakes Module" will explore seismic activity. The "Photography Module**"** will include photo documentation of dinosaur tracks in the park. ASRA is sponsored by the University of Alaska Fairbanks in partnership with the National Park Service, the MSLC and other partners. For more information visit: www.uaf.edu/asra.

Field Seminars and Teacher Training

Field Seminars. The MSLC will be offering 15 field seminars in the 2007 season. The seminars are active learning experiences that cover a range of topics including geology, wildflowers, birds, large mammals, Dall sheep, edible & medicinal plants, wolves, bears, 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 leads and content experts for the seminars. All field seminars are available for optional university credit through the University of Alaska - Anchorage.

Teacher Training. The MSLC will offer four teacher trainings in June and July. These three- to four-day programs will investigate using i-movie, science writing, paleontology, and wolf ecology. All teacher trainings include one to three credits through the University of Alaska - Anchorage or the University of Alaska - Southeast.

Special Programming

Discover Denali. Developed to provide a meaningful park experience for Royal-Celebrity Tours passengers, this program is offered twice weekly May – September in partnership with the Denali Education Center. The program consists of a lecture in the MSLC classroom, a skins-and-skulls hands-on session, interpretive walk through an area significant in early park history, and a ranger-introduced viewing of the new park film. Participants receive photo postcards of the historic photographs that Denali Education Center instructors use as teaching tools. A portion of the proceeds support the Discover Denali Research Fellowship Program.

Experience Denali Excursion. This MSLC program, offered 5 days a week, helps 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 out the park road by bus to the Savage River area, where they take a short walk and participate in hands-on activities.

Education Internship
2007 will be the third year of the Murie Science and Learning Center offering the summer education internship. These 14-week internships expose students to all facets of education programming and provide field experience in areas of experiential education as well as research and park management.

Research Grants

Discover Denali Research Fellowship Program
Discover Denali Research Fellowships for 2007 (made possibly by the Denali Education Center through the Murie Science and Learning Center) have been awarded to the following researchers (listed alphabetically), conditional on their applying for a research and collecting permit as with any research project:

- Roseann Densmore, USGS Alaska Science Center
  Monitoring the success of the Caribou Creek restoration project
- Michael Loso, Alaska Pacific University
  Trajectory and fate of human waste on the Kahiltna Glacier
- Robert Newman, University of North Dakota
  Population biology of the wood frog in Denali National Park
- David Sunderlin, Lafayette College, Easton, Pennsylvania
  The floral ecosystem in the lower Cantwell Formation of Denali National Park and Preserve: evolutionary, paleoecological, and paleoclimatic implications
- Martin Wilmking, Greifswald University, Germany
  A shrubby future for Denali? – Investigation on the effect of recent warming on alpine shrubs in Denali National Park and Preserve

This is the second year of the Discover Denali Research Fellowship Program, made possible through proceeds of the Discover Denali program offered in partnership with the Denali Education Center. Recipients are awarded grants up to $5,000 for research that will assist park managers make decisions about critical resource issues.

In 2006, the following research fellowships were awarded:

- Tara Chestnut, Washington State Department of Transportation, Biology Program
  Detecting a deadly amphibian disease: are park visitors inadvertent vectors?
- Vanessa Ritchie, Department of Chemistry and Biochemistry, University of Alaska Fairbanks
  Water quality and the fate of antimony and arsenic in the historic Kantishna Hills Mining District
- Blaine Spellman, School of Natural Resources Management, University of Alaska Fairbanks
  Effects of invasive white sweetclover on floodplain plant communities in Alaska

Murie Science and Learning Center – Research Awards
Financial support for research projects, which is provided by the Murie Science and Learning Center through Alaska Natural History Institute funding, is awarded in 2007 to the following researchers, conditional on their applying for a research and collecting permit:

- Chris Arp, USGS, Alaska Science Center
  Using beaver colonies as a model for ecosystem disturbance and recovery in Denali
- Jason Dortch, University of Cincinnati
  Terrestrial cosmodating of the Wonder Lake moraines, McKinley River Basin: in pursuit of understanding the nature of glaciation and climate change in the Denali National Park
- Alexander Milner, Institute of Arctic Biology, UAF
  Hydroecology of upwelling zones in a glacierized catchment

Selected Resource Highlights from 2006

❖ **Wildly successful searches for dinosaur tracks**

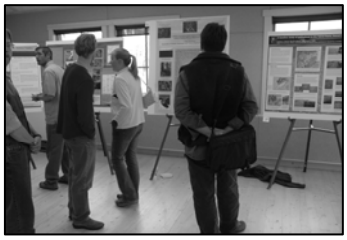
Additional searches in 2006 for Denali dinosaur tracks were wildly successful, with the tally of tracks at 26 theropods of various sizes, as well as hadrosaur and bird tracks. School groups, teachers, and scientists scoured outcrops of the lower Canwell Formation for paleontological evidence. Special finds near Tattler Creek were enough to prompt use of favorite monikers such as "Dinosaur Ridge" and the "dinosaur dance floor" (see photo). See pages 42, 57.

❖ **Road study – what happened in 2006, what's planned for 2007?**

At what time of day do bears more commonly cross the park road? What makes for a great visitor experience on the park road? These answers and more are being revealed in an integrated study of traffic, wildlife, and visitor experience that continues in 2007. Researchers from the University of Vermont and the University of Minnesota are collaborating with Denali staff to conduct the research. See pages 4-9.

❖ **Researchers present findings at Alaska Park Science Symposium**

"Park Science in Central Alaska: Crossing Boundaries in a Changing Environment" was the theme of the Alaska Park Science Symposium, held at Denali in September 2006. One hundred fifty scientists, community members, and managers gathered for oral presentations, panel discussions, and a poster session (see photo). See page 10.



Looking Ahead – 2007 and Beyond

□ **Denali's Resource Stewardship Strategy**

In 2007 Denali will complete a Resource Stewardship Strategy (RSS) to guide its research and resource program for the next 15 to 20 years. The RSS document will describe the desired conditions for park resources and values based on what the General Management Plan specifies, selects indicators to evaluate resource condition, and plans research to maintain Denali's resource values. See page 3.

□ **International Polar Year March 2007 – March 2009**

Activities at Denali will coordinate with this international effort to study polar regions to learn how climate change is affecting high latitude ecosystems. See page 9.

□ **National Park Service Centennial 1916 – 2016**

The National Park Service (NPS) will celebrate its 100th anniversary in 2016. To strengthen and prepare parks for another century of conservation, preservation, and public enjoyment, the NPS is funding many parks to address park issues prior to the centennial year. The goal is to initiate projects now so the NPS can celebrate its accomplishments 10 years from now. Denali hopes to receive funding to address deficiencies in museum standards and restore all park areas affected by Kantishna mining.

Our national parks are an inheritance we will hand down to our children and grandchildren. We invite all Americans who cherish this inheritance to rise to the challenge so the 100th anniversary of our national park system will be a great celebration of our country and our heritage. –Dick Kempthorne, Secretary of the Interior.