

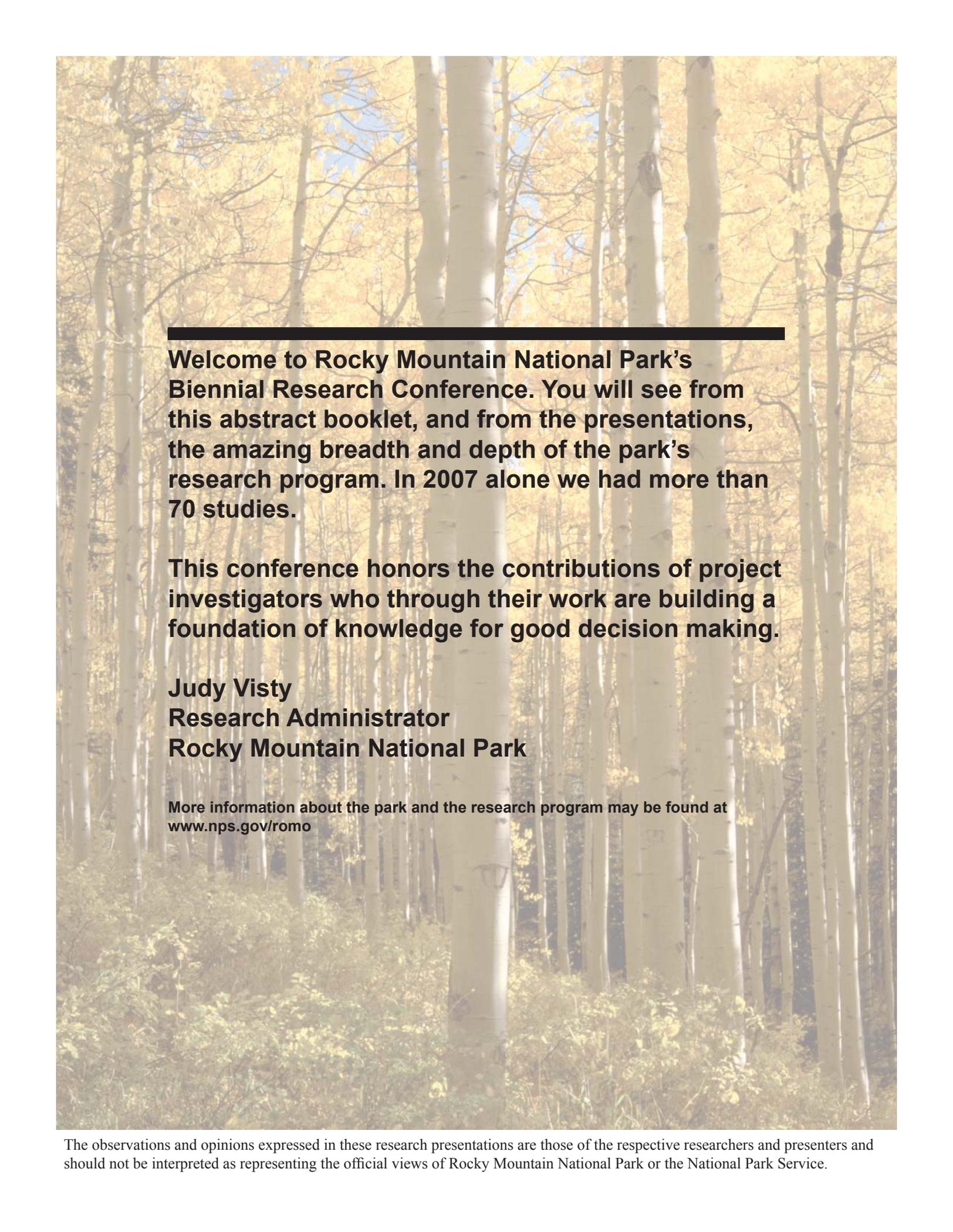
**National Park Service  
U.S. Department of the Interior**

**Continental Divide Research Learning Center**



**Rocky Mountain National Park  
Research Conference 2008**





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**Welcome to Rocky Mountain National Park's Biennial Research Conference. You will see from this abstract booklet, and from the presentations, the amazing breadth and depth of the park's research program. In 2007 alone we had more than 70 studies.**

**This conference honors the contributions of project investigators who through their work are building a foundation of knowledge for good decision making.**

**Judy Visty  
Research Administrator  
Rocky Mountain National Park**

**More information about the park and the research program may be found at [www.nps.gov/romo](http://www.nps.gov/romo)**



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## Monday, April 7 Climate Change

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1:00-1:30	Ben Bobowski	Welcome and Climate Change Initiatives in Rocky Mountain National Park
1:30-2:00	Klaus Wolter, NOAA	The Changing Climate
2:00-2:15		Break
2:15-2:45	Judy Visty	Park Ecosystem Response to Climate Change
2:45-3:15	Jill Baron	Climate-Induced Changes in Nitrogen Dynamics in Loch Vale Watershed, Rocky Mountain National Park
3:15-4:00	Juraj Švajda	Tree line Shifts in Tatra Mountains as a Result of Climate Change or Land Abandonment

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## Tuesday, April 8 Cultural Resources and History

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8:30-9:00		Coffee
9:00-9:20		Welcome: session introduction and orientation
9:20-9:40	Sally McBeth	Afterlife of the Rocky Mountain National Park Ute Ethnobotany Project
9:40-10:00	Sierra Standish	Nominating the East Longs Peak Trail to the National Register of Historic Places
10:00-10:20	Ann Komara & Amanda Jeter	Images of Rocky Mountain National Park: A Reception History
10:20-10:40		Break
10:40-11:00	Bob Brunswig & Dave Diggs	Native American Lives and Sacred Landscapes in Rocky Mountain National Park
11:00-11:20	Cheri Yost	Where Cultural Meets Natural: Dr. Beatrice Willard's Alpine Tundra Research Plots



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## Tuesday, April 8 Cultural Resources and History, cont.

11:20-11:40	James Lindberg	The Architect of Record: Tom Casey and Planning the Future of Beaver Meadows Visitor Center
11:40-12:00	Juraj Švajda & Tomas Vancura	Participatory and Sustainable Management of Tatra National Park, Slovakia
12:00-1:00		Lunch

## Tuesday, April 8 Air and Water, Plants and Animals

1:00-1:20	Mary Jane Howell	Slime Molds of Rocky Mountain National Park
1:20-1:40	Rich Wanty	Regional Variations in Surface-water Chemistry in Central Colorado: Establishing Geochemical Baselines
1:40-2:00	Philip L. Verplanck	Utilization of Lead Isotopes and Trace Elements in Alpine Lake Sediments to Determine the Nature and Timing of Atmospheric Deposition, Front Range, Colorado
2:00-2:20	John Burghardt	USEPA Eugenia and North Star Abandoned Mine Site Characterizations
2:20-2:40		Break
2:40-3:00	Colleen Flanagan	Assessing Ozone Injury on Rocky Mountain National Park Vegetation
3:00-3:20	Carl Schreck	Do Airborne Contaminants Cause Endocrine Disruption of Salmonids in Western U.S. National Parks?
3:20-3:40	Jeff Connor	Aspen Cavity Nesting Survey on the Elk Winter Range of Rocky Mountain National Park
3:40-4:00	Caroline E. Krumm	Mountain Lion Ecology in Rocky Mountain National Park: Research Challenges
4:00-4:20	Jenny Powers	Evaluation of Methods for Managing Elk Population Health and Abundance in Rocky Mountain National Park, Colorado



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## Wednesday, April 9 Plants and Animals

8:30-9:30		Coffee
9:30-9:40		Welcome: session introduction and orientation
9:40-10:00	Heidi Steltzer	Elk Impacts on Alpine Willow Communities, Rocky Mountain National Park, Colorado
10:00-10:20	Dave Augeri	Carnivore Complex Dynamics in Rocky Mountain National Park
10:20-10:40		Break
10:40-11:00	Erin Muths	Occurrence of <i>Batrachochytrium dendrobatidis</i> at Breeding Sites of <i>Bufo boreas</i> in the Rocky Mountains
11:00-11:20	Jim Bromberg	Changes in the Distribution of <i>Bromus tectorum</i> in Rocky Mountain National Park Over the Past Decade: A Maximum Entropy Distribution Modeling Approach
11:20-11:40	Rich Hansen	Mites on Thistles in Rocky Mountain National Park: Utilization of Native Plants by a Eurasian Species?
11:40-12:00	Nicholas Levens	Evolution and Historical Biogeography of <i>Chrysosplenium tetrandrum</i> (Saxifragaceae)
12:00-1:00		Lunch
1:00-1:20	Katharine Driver	Distinguishing Fens and Wet Meadows in Rocky Mountain National Park: Variation in Soils, Water Table, Vegetation, and Potential Sensitivity to Climate Change
1:20-1:40	E. William (Billy) Schweiger	Long-term Bioassessment of Park-scale Wetland Ecological Integrity in the Rocky Mountain Inventory and Monitoring Network



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## Wednesday, April 9 Air and Water, Poster Session, and Fire

1:40-2:00	James H. McCutchan, Jr.	Spatial and Temporal Variation in Aquatic Chemistry and Foodweb Support in Rocky Mountain National Park
2:00-2:20	David Clow	Spatial Distribution of Nitrogen Deposition in Rocky Mountain National Park, USA
2:20-2:30		Break
2:30-3:10		Poster Session in the Lobby
	M. Alisa Mast	Historical Deposition of Mercury and Trace Metals to High-Elevation National Parks in the Western U.S. Inferred from Lake Sediment Cores
	Thomas R. Collingwood, Ph.D	YMCA Hiking Patterns at Rocky Mountain National Park: Implications for Public Health
	Fred and Tena Engelman	Rocky Mountain National Park Hummingbird Survey
	Juraj Švajda	The Institute of High Mountain Biology
	Michael J. Lavelle	Elk and Deer Use of Mineral Licks: Mineral Motivation and Implications for Disease Transmission
3:10-3:30	Jonathan D. Coop	Subalpine Post-fire Succession and Five-needle Pine Regeneration: 30 Years After the Ouzel, Badger Mountain, and Maes Creek Fires
3:30-3:50	Philip Higuera	Late Holocene Fire History in Subalpine Forests of Southern Rocky Mountain National Park

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## **Carnivore Complex Dynamics in Rocky Mountain National Park**

Carnivore guilds exert keystone influences on community processes. Our feasibility study is examining questions related to the influence of carnivore guilds on the carnivore-prey-vegetation complex in the RMNP ecosystem, and includes study of pre/post wolf re-establishment of site-occupancies, densities, abundances, and habitat use of carnivore and prey species in different habitat types and relative to human activities, habitat disturbance, and climate change. Sign surveys, camera-trapping and genetic samples of scat and hair are being used to: a) refine and advance these methods for this ecosystem, particularly relative to site occupancy, detection probability, species diversity, and spatial models and b) to improve understanding of community ecology and dynamics relative to hierarchical structure and trophic cascades within and emanating from carnivore guilds in temperate mountain ecosystems. Preliminary analyses in a ca. 64 km<sup>2</sup> study area of Cow Creek and West Creek watersheds revealed 84% of carnivore activity was between 2500 – 3500 m ASL and there was insignificant ( $P=0.2191$ ) correlation with prey species presence, including elk (Pearson's  $r=0.22$ ); there was an insignificant, but stronger correlation with game trails (Pearson's  $r=0.58$ ). Carnivores appear to be selecting 3 habitat types significantly more (77%) ( $r^2=0.327$ ;  $df=19$ ;  $F=79.76$ ;  $P<0.001$ ) with significantly more cover (74%) ( $r^2=0.372$ ;  $df=20$ ;  $F=3.16$ ;  $P<0.001$ ). At least 73% of carnivore activity was in areas with minimal/no habitat disturbance ( $r^2=0.232$ ;  $df=4$ ;  $F=11.57$ ;  $P<0.001$ ) and 61% was in areas with minimal/no human activity ( $r^2=0.211$ ;  $df=4$ ;  $F=8.07$ ;  $P<0.001$ ). Overall carnivore site occupancy in the study area based on signs was  $\Psi=0.6139$  with detection probability of  $p=0.245219$ . Site occupancy for the two largest carnivores based on camera data was  $\Psi=0.1514$  with detection probability  $p=0.317916$  for black bears and  $\Psi=0.3344$  with  $p=0.077539$  for mountain lions. Results indicate these methods are viable and are improving our understanding of carnivore-prey-vegetation dynamics in the RMNP ecosystem.

*carnivore-prey-vegetation, Canis lupus, wolf*

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## **Evaluation of Methods for Managing Elk Population Health and Abundance in Rocky Mountain National Park, Colorado**

Unregulated concentrations of elk (*Cervus elaphus*) have become a significant problem for resource managers in Rocky Mountain National Park (RMNP), Colorado. High densities of elk are severely altering native plant communities and may serve as reservoirs for transmission of infectious diseases such as chronic wasting disease (CWD).

In response to these concerns, and in coordination with RMNP manager's plan to reduce elk overabundance, we conducted investigations to evaluate: 1) antemortem methods for diagnosing CWD, and 2) a promising contraceptive agent for suppressing fertility of female elk. To accomplish these objectives, we captured, sampled, and radiocollared 120 adult female elk during January 2008. Sixty were treated with the contraceptive agent (GonaCon<sup>TM</sup>) and sixty received a saline solution (controls). Tissue and blood samples relevant to conducting live-animal test(s) for preclinical CWD were collected and are being evaluated. These results will give an estimate of CWD prevalence within the female elk population wintering in the eastern portion of the park and may reveal a useful tool for removing preclinical CWD-infected elk from the population. The duration, effectiveness, and side-effects of the contraceptive agent will be determined over the next three years in conjunction with the proposed elk reduction plan.

*elk, chronic wasting disease, contraception*

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## **Climate-Induced Changes in Nitrogen Dynamics in Loch Vale Watershed, Rocky Mountain National Park**

Mean annual nitrate concentrations have increased by 33%, and mean annual nitrogen losses have increased by 28% from Loch Vale watershed since 2000. Measured inorganic nitrogen values since 2000 are the highest observed since monitoring began in 1982. The substantial increase in nitrogen dynamics comes as a surprise, since atmospheric N deposition has not increased during this period. Coincident with the increase in stream nitrogen concentrations, there has been a period of below normal precipitation and an increase in temperatures, especially mean annual temperature, which increased from a mean of 1.3°C for the years 1985-1999, to a mean of 1.7°C for 2000-2006. The temperature increases are driven by a strong increase in July mean and minimum temperatures. We used the ecosystem model DayCent-Chem to ask whether the climate trends had altered ecosystem properties and nitrogen cycling, but rule these out as major drivers of the observed changes in stream nitrate and flux. Instead, it appears the observed N increases in Loch Vale are climatically-induced, caused by melting ice in glaciers and rock glaciers that have exposed microbially-active sediments. The phenomenon observed in Loch Vale may be indicative of nitrogen release from ice features worldwide as mountain glaciers retreat. In regions that are chronically ultra-oligotrophic additional nitrate may stimulate algal productivity and affect species assemblages, such as we have already observed. In regions that are already N-saturated, nitrate from the melting cryosphere may enhance eutrophication, and depending on the underlying parent material composition, could even promote acidification.

*climate change, nitrogen, Loch Vale Watershed, glaciers*

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## **Changes in the Distribution of *Bromus tectorum* in Rocky Mountain National Park Over the Past Decade: A Maximum Entropy Distribution Modeling Approach**

*Bromus tectorum* is an invasive weed that grows prolifically throughout the western United States. Land managers in the Rocky Mountains have expressed recent concern of its range expansion into higher elevation vegetation communities. Since land management agencies often do not have the funds to map entire ranges of species, distribution models can be a much more feasible option for making predictions. We used Maxent, a niche based species distribution model, to examine the range of *B. tectorum* from 1996 to 2007. Specifically, we wanted to know if the range of *B. tectorum* is expanding at high elevations and if the Maxent model could be used to make accurate predictions of the range of the species. Models were generated in 1996, 1999 and 2007 to look at changes in the predicted distributions over time. The number of occurrences of *B. tectorum* increased in each sampling period, while the predicted range remained similar over time. Modeling the range in earlier sampling periods correctly predicted the new occurrences that appeared in later sampling periods. While the model was able to predict the distribution of *B. tectorum* within the region of Rocky Mountain National Park that was sampled, we are not certain yet if this prediction can appropriately be extrapolated to larger scales. Sampling of these other regions of the park will likely occur in 2008 to validate whether the model can make inferences of large scale species distribution based on smaller areas of sampling. If the model has made accurate predictions of the entire park based on sampling within a smaller region, Maxent may be an extremely useful tool to land managers in making large scale species distribution predictions.

*cheatgrass, Maxent, species range expansion, niche based model, species environmental matching*

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## **Native American Lives and Sacred Landscapes in Rocky Mountain National Park**

The University of Northern Colorado, since 2001, has pursued research in Rocky Mountain National Park to better understand religious practices in the lifeways of its past prehistoric and historic Native American inhabitants. That research, referred to as the Sacred Landscape Project, began with archeological and Native American consultant investigations of a large stone feature site on Trail Ridge (2001-2003), followed by recent field surveys and Geographic Information

System (GIS) predictive site modeling studies (2004-2007). Project results suggest past Native American park inhabitants, particularly ancestors of the modern Ute tribe, once viewed the park's natural landscape as an integrated natural-spiritual-mythological realm where ritual and prayer were conducted in special places and summer subsistence activities often accompanied by ceremony and ritual in a seamless fusion of everyday life and the spiritual world. Evidence for belief and practice related to this realm is based in the archeological study of rock features believed to have been used in spirit-seeking, vision-questing and prayer rituals, late 19th-early 20th century historic and ethnographic records, on-site consultations with Native American elders, and the application of modern GIS technology to extract site location patterns consistent with Native American cultural beliefs and religious practices. GIS analysis of currently known or inferred religious site variables using correlation, view shed and weights-of-evidence techniques resulted in a predictive model of likely locations where other such sites might be located within the park boundaries.

*Native American, Ute, Arapaho, sacred landscape, geographic information systems*

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## **USEPA Eugenia and North Star Abandoned Mine Site Characterizations**

The National Park Service and the U.S. Environmental Protection Agency entered into a partnership in 1999 to develop and implement a sampling procedure to evaluate the environmental risk of abandoned mine waste rock. EPA contributed funding and expertise to develop a sampling design to evaluate these risks. This partnership has led to mine site characterization work in Canyonlands, Capitol Reef, and most recently, Rocky Mountain National Park. The NPS Abandoned Mine Land (AML) Program and individual parks have closed many hazardous mine openings throughout the national park system, but mine waste rock piles at remote sites have usually not been reclaimed for reasons such as limited funding, minimizing new impacts, and preserving historic mining fabric. The human health and environmental risks of leaving these piles unmitigated is currently being assessed. The Eugenia Mine and North Star (a.k.a. "Shipler") Mine are two such sites at Rocky Mountain National Park. Park staff joined staff from the NPS Natural Resource Program Center / Geologic Resources Division, NPS Intermountain Region Environmental Management Division, and EPA Region 8 Office of Pollution and Federal Facilities Program to conduct sampling events at Eugenia Mine in August 2006 and June 2007, and at North Star Mine in September 2007. The analysis at both sites compares on-site and downgradient heavy metal concentrations in soils, water, and vegetation to background levels and existing soil and water standards. The analysis indicates that these abandoned mine sites pose little significant threat to human health and the environment. Remedial actions at these remote sites would create unacceptable impacts to the surrounding environment and would likely mobilize more metals than are currently available to the system, increasing current contamination levels. It is therefore the EPA/NPS research team's opinion that "no action" would be the preferred alternative for management of these sites.

*mine, AML, waste rock, sample, contaminant, heavy metal, background, concentration*

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## **Spatial Distribution of Nitrogen Deposition in Rocky Mountain National Park, USA**

High-elevation streams and lakes in Rocky Mountain National Park are being adversely impacted by atmospheric deposition of nitrogen (N). Previous studies have documented high concentrations of nitrate in surface waters, particularly on the east side of park, and resultant changes in species composition of aquatic biota. Prevailing winds are from the west, but transport of pollutants from urban and agricultural sources to the east probably occurs during upslope meteorological conditions that are common during spring and summer. Higher N deposition rates on the east side of the park have been suggested as an explanation for the higher surface-water nitrate concentrations there, but there is little quantitative information about spatial patterns in N deposition in the park, largely due to the difficulty of access.

In this study, a relatively new method using ion-exchange resin (IER) collectors is being tested as an inexpensive means of collecting spatially-extensive deposition data in the park. IER collectors

use a 7 inch-diameter plastic funnel to capture rain, which flows downward through a column containing ion-exchange resin. Columns are swapped twice per year, and N compounds are eluted from the resins in the lab and analyzed. IER collectors were deployed in pairs from late July, 2006 to early October, 2006 along several east-west transects in the park. Valid samples were obtained from 11 sites on the eastern slope and 5 sites on the western slope. The median difference between pairs of co-located samplers was 13% for total N deposition, indicating good reproducibility. Nitrate deposition measured by IER collectors co-located with the Loch Vale NADP site matched that of the NADP collector (0.48 kg/ha as N); ammonium deposition was slightly higher from the IER collectors (0.60 kg/ha as N) than from the NADP collector (0.50 kg/ha as N). On average, ammonium accounted for  $60 \pm 7\%$  of total N in the bulk deposition captured by the IER collectors, compared to 45% in wet deposition at the two NADP sites in the park. CASTNET data indicates that dry deposition of N occurs primarily as nitrate compounds, so the difference in ammonium deposition probably is not due to dry deposition. The IER collectors may be less prone to loss of ammonium via nitrification than NADP collectors.

Average N deposition for the 85-day exposure period at the eastern slope sites was  $0.85 \pm 0.21$  kg/ha, and at west-slope sites was  $0.69 \pm 0.12$  kg/ha. An ANOVA analysis indicated that differences in the means of east- and west-side sites were not statistically different at  $p < 0.05$ , however, these results should be interpreted with caution due to the small sample size. Sampling is continuing and additional sites have been added on the west side of the park to provide improved statistical power.

*nitrogen, atmospheric deposition*

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**YMCA Hiking Patterns at Rocky Mountain National Park: Implications for Public Health**

Joint initiatives by the YMCA, Centers for Disease Control (CDC) and the National Park Service encourage the use of public lands to promote physical activity. However, little is known about physical activity patterns in national parks.

Data from the YMCA of the Rockies hiking program that provides leader led hikes into Rocky Mountain National Park (RMNP) were analyzed to assess hiking patterns for one summer season (June-August). The YMCA of the Rockies is a family residence camp that had an estimated 14,565 potential hikers (excluding very old and very young) during that summer season.

Data were analyzed from the Hike Report forms used to record number of hikers, distance, elevation gain, hiking time and difficulty level for leader led hikes. To measure the relative activity benefit of hikes, an energy cost estimate was calculated for different hike categories.

Of 343 hikes, 64.54% were categorized as easy, 27.1% moderate and 8.5% difficult. 1937 individuals participated in hikes which represented 13.3% of the estimated potential hiker sample. Of that sample, 72.7% participated in only one hike with 23.3% participating in two or more hikes. 69.3% of hikers only took easy hikes. Using the mean distance, time and percent grade dimensions for a given hike category it was possible to calculate the metabolic energy cost per minute for type of hike. The mean oxygen consumption levels ranged between 11.01 mlO<sub>2</sub>/kg/min and 19.92 mlO<sub>2</sub>/kg/min.

While the actual percentage of visitors who hike and the number of individual hikers who did not use the YMCA hiking program is unknown, anecdotal data from RMNP Rangers suggest that the 13.3% may be within the range of actual hikers. The hiking patterns at RMNP may be reflective of general population inactivity suggesting the need to design strategies to promote hiking while at RMNP.

*physical activity, public lands, hiking, YMCA*

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## **Aspen Cavity Nesting Survey on the Elk Winter Range of Rocky Mountain National Park**

This presentation presents aspen cavity nesting survey results started in 1997, restarted in 2002 and completed every year through 2006. I will also discuss expected songbird response in aspen from the implementation of the Elk and Vegetation Management Plan and the current bark beetle epidemic. In 1997, the Rocky Mountain Bird Observatory (RMBO), in conjunction with Resource staff at Rocky Mountain National Park, initiated efforts to inventory cavities in Quaking Aspen (*Populus tremuloides*) suitable for nesting birds within the elk (*Cervus elaphus*) wintering range of the park. This project provided valuable data for assessing the potential impact that elk may have on cavity-nesting birds through their browsing of a focal plant community – aspen. Zaninelli and Leukering (1998) reported on 556 aspens hosting 1381 cavities in 21 stands within the study area. In 2002, RMBO restarted this project. The 2002 work re-found many of the trees documented in 1997, documented new cavity trees, total number of cavities found, and bird occupancy of cavities (Leukering and Gobris 2003). In the report for the 2003 and 2004 field seasons (Leukering and Gobris 2005), RMBO included additional and more detailed results of stand surveys, as well as an analysis of cavity orientation and a brief summary of efforts to color-band cavity nesters. The 2005 field season report (Gobris and Leukering 2006) included results of surveys in stands not visited since 1997, an examination of cavity-occupancy rates by stand, and a summary table of all birds banded since 2003. The 2006 report also includes a thorough stand survey and occupancy rates of the Lower Beaver Meadows stand.

*aspen, elk winter range, cavities, songbirds*

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## **Subalpine Post-fire Succession and Five-needle Pine Regeneration: 30 Years After the Ouzel, Badger Mountain, and Maes Creek Fires**

Fire has long been a keystone process in subalpine forests of the southern Rockies. However, recent trends of increasing fire severity and extent suggest that post-fire plant communities are likely to make up a greater proportion of future forest landscapes. The objectives of our research were to characterize post-fire plant communities in four ca. 30-year old, high-elevation burns east of the Continental Divide in Colorado, and to assess how landscape context affected patterns of post-fire regeneration. We examined patterns of understory composition and tree regeneration along transects running from unburned stands into burn interiors. We focused particularly on five-needle pines to gain insight into the role of fire on populations of these species and to assess how disturbance might be incorporated into proactive management of stands to mitigate expected declines from white pine blister rust. Overall, plant communities were differentiated more by geographic affinity (i.e., northern vs. southern Colorado) and topography (elevation, slope, and aspect) than by recent burn history. However, understory plant species richness was approximately doubled in burns at both the plot- and landscape-scale. Exotic species were not problematic in these high-elevation burns. Tree regeneration was highly variable, and decreased with elevation and increasing distance into burns. Five-needle pine regeneration was generally dwarfed by that of other tree species. Limber pine regeneration was high in burn interiors at Ouzel in the northern Front Range, but did not show this pattern farther south; Rocky Mountain bristlecone pine regeneration was concentrated beneath surviving seed sources. In summary, high-severity fires in subalpine forests may generate positive effects in the form of landscape diversity, but can, in some locations, result in protracted population losses for 5-needle pines already highly vulnerable to declines from white pine blister rust and mountain pine beetle.

*Ouzel, wildfire, succession, Pinus flexilis, Pinus aristata, fire suppression, white pine blister rust, plant richness*

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## **Distinguishing Fens and Wet Meadows in Rocky Mountain National Park: Variation in Soils, Water Table, Vegetation, and Potential Sensitivity to Climate Change**

Fens and wet meadows are two of the most abundant montane and subalpine wetlands in the Rocky Mountains. Fens are ground water fed peat accumulating ecosystems. They are characterized as having organic soils and perennially saturated soils. Due to limited nutrient availability and perennial saturation, fen vegetation consists of highly specialized wetland species. In contrast, wet meadows have mineral soils and only seasonally have water tables near the soil surface. Lack of continuous saturation limits organic material accumulation although these soils typically have redoximorphic features characteristic of seasonally anoxic soils. Higher nutrient availability and less saturated soils support a broader range of plant species in wet meadows. However, there is little information to characterize the hydrologic regimes and vegetation that distinguish these wetland types and that could be used as indicators of climate change impacts. Preliminary water table data suggests that climate change may affect fens and wet meadows differently. Fens depend upon perennial soil saturation and yet reduced ground water flow due to lower snowpack, earlier melt dates, or reduced summer precipitation could result in lower water tables in fens, altered peat accumulation rates and threatened vegetation. Wet meadows would be affected more by changes in the timing, duration, or amount of summer monsoonal precipitation, which historically has come from mid July through August, at the height of the growing season. If mid-summer aquifer recharge is inadequate, wet meadows will experience extreme drying, vegetation change and could become dry or upland meadows. Establishing “thresholds” that distinguish fens from wet meadows and uplands is important for long term monitoring of wetland condition.

*fen, wet meadow, wetland hydrology, vegetation, climate change*

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## **Rocky Mountain National Park Hummingbird Survey**

The survey's main objectives are to collect demographic information for breeding and transient hummingbird species, monitor nesting and migration, document rare species, monitor movement and dispersal, and assess survivorship and philopatry. During the five year field data collection, we captured, banded, measured, and released 4,558 hummingbirds of four species. *Selasphorus platycercus* (broad-tailed hummingbirds), the breeding species, comprised between 75-90% annually of all hummingbirds banded while *Stellula calliope* (calliope hummingbirds) were 0.7-2.4%, and *S. rufus* (rufous hummingbirds) were 9-24%. We documented a single *Archilochus colubris* (ruby-throated hummingbird) in 2004. First year return rates for broad-tailed averaged 22% on the east side of the Continental Divide and 29% on the west side.

We observed gravid broad-tailed females from the second week of May through the third week of July (east side) and from the first week in June through the third week of July (west side). The peak east side nesting activity usually occurred 1-2 weeks earlier than on the west side due to altitude and climate differences. Overall broad-tailed fledging success was good on the east side in all but 2004 when cold, wet conditions reduced nesting success. We could not reliably measure fledging success on the west side due to less frequent (weekly) monitoring.

Rufous hummingbird numbers fluctuated considerably for unknown reasons. Rufous per active trap hour ranged from 1.9 in 2003 to 0.7 in 2004. Numbers increased since 2004 to 1.7 per trap hour in 2007. The adult to hatch year ratio also fluctuated widely from 3:1 in 2003 to 24:1 in 2004 and 23:1 in 2005. The ratio in 2007 was 4.5:1. These data indicate poor fledging success in 2004-5 for the population(s) transiting the park. The small numbers of calliope hummingbirds observed in the park make determination of population status difficult to assess.

*hummingbirds, migration, survivorship, philopatry, bird banding*

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## Assessing Ozone Injury on Rocky Mountain National Park Vegetation

Ozone, produced by photochemical reactions in the atmosphere involving emissions from combustion of fuels and other sources, can travel long distances, and occurs in high concentrations even in remote areas. High levels of ozone present health concerns both for healthy adults and for sensitive people, particularly the elderly, young children and those with asthma or other respiratory ailments. In addition to harming human health, ozone harms plants. Ozone bioindicators, plant species that display distinctive visible leaf injury resulting from ozone exposure, act as sensitive warning systems of potential impacts of ozone on plant communities. Following recently-developed National Park Service guidelines, Rocky Mountain National Park conducted foliar ozone injury assessments during the 2006 and 2007 summer seasons. Symptoms indicative of ozone injury—"black fleck"—were present on the bioindicator cut-leaf coneflower (*Rudbeckia laciniata* v. *ampla*) during both years. Controlled ozone exposure experiments are being conducted to verify the response. A record of plant bioindicator status at RMNP is important because ozone levels are high on the east side of Rocky Mountain National Park, and the State of Colorado is in the midst of an effort to reduce ozone air pollution across Denver and the north Front Range.

*ozone, bioindicators*

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## Mites on Thistles in Rocky Mountain National Park: Utilization of Native Plants by a Eurasian Species?

Eriophyid mites (*Acari: Eriophyidae*) are minute, plant-feeding arachnids that may be free-living or live within plant galls. The Canada thistle rust mite, *Aceria anthocoptes*, is a Eurasian mite that feeds on leaves of Canada thistle, *Cirsium arvense* (Asteraceae). *A. anthocoptes* was introduced into North America and now appears to be widely established in the northern U.S., where Canada thistle is a widespread exotic weed. *A. anthocoptes* is one of two *Aceria* mites recorded from *C. arvense* in Europe; no eriophyid mites had previously been collected from Canada thistle in the U.S. There are more than 100 native *Cirsium* thistles in the U.S., from which no native or introduced mites have been reported. I am attempting to document (1) the occurrence of *A. anthocoptes* on Canada thistle in Colorado and adjacent states, and (2) possible utilization of native thistles by this mite. In 2006 and 2007, we collected leaf samples from populations of three exotic thistles – Canada thistle, bull thistle (*Cirsium vulgare*), and musk thistle (*Carduus nutans*) – and four native thistles – *Cirsium canescens*, *C. scariosum*, *C. scopulorum*, and *C. undulatum* – in RMNP. In both years, mites were found on Canada thistle but not the other exotic species, and on all four native thistles. Mite numbers extracted from native *Cirsium* spp. were comparable to, or exceeded, numbers from Canada thistle. Mites were collected from native thistles at RMNP sites that were a considerable distance from known Canada thistle populations (> 2 km). No visible symptoms of mite feeding were observed at any Canada thistle or native thistle sites. We believe that mites found on Canada thistle in RMNP are *Aceria anthocoptes*, but the identity of mites collected from native thistles remains uncertain. Results will have implications for the possible use of this mite as a Canada thistle biological control agent.

*thistles, Cirsium spp., mites, Aceria spp., biological control*

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## Late Holocene Fire History in Subalpine Forests of Southern Rocky Mountain National Park

Landscape heterogeneity in subalpine forests is strongly influenced by temporal and spatial patterns of fire. Tree-ring records provide detailed fire history information covering the past 500 years and, in conjunction with paleoclimate records, they illustrate strong climatic controls on fire occurrence at inter-annual to decadal time scales. Little is known, however, about the characteristics of subalpine forest fire regimes at longer time scales or the sensitivity of these regimes to multi-centennial climatic change. We are utilizing pollen and macroscopic charcoal from a network of seven lake-sediment records to describe subalpine forest fire regimes across a 250-km<sup>2</sup> region in Rocky Mountain National Park since 4000 yr BP (calibrated years before 1950 AD).

We report results from three records on the east side of the continental divide in Rocky Mountain National Park. Comparisons to previously published tree-ring reconstructions of fire history in the study area indicate the faithfulness of the charcoal records over the past several hundred years. At individual sites, fire return intervals (FRIs) inferred from peaks in charcoal accumulation rates are highly variable, ranging from 50 to > 400 years and reflecting the stochastic nature of local fire occurrence in subalpine forests. Mean FRIs varied little between sites, with values since 2000 yr BP ranging from 160 to 190 years. Prior to 2000 yr BP, mean FRIs were longer, ranging from 210 to 270 years, but not significantly different from the 2000-0 yr BP period at any one site. Ongoing charcoal and pollen analysis on these and additional cores, as well as comparisons to regions paleoclimate records, will help facilitate inferences into the mechanisms controlling historic fire regimes in subalpine forests of Rocky Mountain National Park.

*subalpine forests, fire history, fire regimes, lake sediments, late Holocene*

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## **Slime Molds of Rocky Mountain National Park**

Slime molds (myxomycetes) are common but rarely appreciated denizens of Rocky Mountain National Park. In 2005 we began surveying the slime molds across the range of habitats in the park. A similar survey began in Great Sand Dunes National Park the following year.

Slime molds can be inventoried in two ways. One is to grow (culture) slime molds in the lab from field-collected bark and plant debris. The other is to find live or fruited specimens in the field. Hundreds of specimens have been gathered, and are in the process of being identified. Photographs and representative specimens will be preserved in the park's records and museum.

This baseline inventory can be used by future studies to look for environmental changes. This presentation gives an introduction to the life cycle of the slime molds with close-up photos of the often intricate and beautiful internal structure of the fruiting bodies, as well as an illustrated discussion of the species most likely to be seen in the field.

*slime mold, myxomycetes*

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## **Images of Rocky Mountain National Park: A Reception History**

Over the last one hundred and fifty years a vast number of images have been created around the landscape we now call Rocky Mountain National Park. This reception history of Rocky Mountain is an interpretation of place that seeks to discern the discourse of meaning embedded in place and created through its legacy of images. The images carry messages about wilderness and conservation, ideals of environmental experience, tourism, adventure and leisure through three dominant thematic subject areas -- scenic beauty, natural history in flora and fauna, and recreational activities. The images present these different aspects of the park through a variety of media and formats which also exemplify diverse modes of image production and distribution. Singly, each image reveals specific authorial intentions and bears witness to the aesthetic and cultural milieu that informed its production. Collectively, the images frame particular ideas about place and offer insights into the life of the park over time. Through their cumulative legacy they constitute and locate our reception of this landscape straddling the Continental Divide between Estes Park and Grand Lake, the "wilderness playground of the Colorado Rockies."

*reception history, place meanings, scenic beauty, natural history, flora and fauna, recreation*

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## **Mountain Lion Ecology in Rocky Mountain National Park: Research Challenges**

Mountain lion research can be challenging at many levels. As large predators they can be dangerous and unpredictable. They are highly adapted for secrecy, long-lived, and require large home ranges within an complex patchwork of land ownerships. Like other areas in the west, Colorado's Front Range is faced with a rapidly growing human population, ever reducing the historic range of mountain lions. Alcoves of protection such as Rocky Mountain National Park are becoming increasingly more important to free ranging predators such as the mountain lion. Live animal studies inside national parks, however, face additional challenges over studies in other wildland settings.

In 2004, we began a study to examine the ecology of the mountain lion population in and around Rocky Mountain National Park's east side, approximately 400 sq. km. In 2007, less than four years into the planned 7-10 year study, agency priorities shifted and funding for the study came to an end. Aside from some early technical difficulties with telemetry gear, capturing lions in varying terrain and over a multitude of land ownership proved to be the most challenging aspect of the study. Although we had a selection of capture methods at our disposal (hounds, cages, snares), not every capture technique was suitable for every location. Under the conditions of our research permit, we would not be granted the use of hounds until we had exhausted all other options. After two years of poor success, we were granted provisional use of hounds. The original cage traps used were designed by the Colorado Division of Wildlife (CDOW) for catching "problem" lions, and were not considered safe for research captures. Leg-hold snares proved a challenge—all good snare sites were also used by a variety of other wildlife and park visitors.

To overcome some of these challenges, we designed a safer cage trap, eventually used hounds, and discovered through trial and error a novel luring technique to pull lions to snare sites off well-used trails. And to counter the lack of agency funding and long-term commitment, a new non-profit organization, The Rocky Mountain Cat Conservancy, was formed to help raise the funds needed to continue this much needed research.

*mountain lion, puma, ecology, cage trap, Rocky Mountain Cat Conservancy*

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## **Elk and Deer Use of Mineral Licks: Mineral Motivation and Implications for Disease Transmission**

North American cervids require and actively seek out mineral supplements to satisfy physiological requirements. The minerals free-ranging cervids require exist as exploitable natural and artificial mineral licks found on the landscape. Mineral licks serve as focal sites with potential for both spatial and temporal crowding. Soil ingestion by cervids susceptible to chronic wasting disease (CWD) at these focal sites may create an environment with considerable risk of CWD transmission. We evaluated mineral concentrations and visitation rates at mineral licks ( $n = 18$ ) by Rocky Mountain elk (*Cervus elaphus nelsoni*) and mule deer (*Odocoileus hemionus*) between 1 June and 14 October 2006 in Rocky Mountain National Park, north-central Colorado. We collected > 400,000 time-lapse images with digital cameras during the study, of which 991 included elk and 293 included deer. Additionally, we analyzed soil samples to evaluate correlations between visitation rates and site-specific characteristics of mineral licks. We also documented behaviors of elk and deer at mineral licks to evaluate risk of disease transmission. Elk frequented many of the licks monitored, with deer and moose visiting licks occasionally. We found that for elk and deer, high-Na concentrations were correlated with site use and appeared to be the primary factor in driving visitation. Mineral licks may potentially play a role in disease transmission by acting as sites of increased interaction as well as reservoirs for deposition and ingestion of contaminants.

*Cervus elaphus, chronic wasting disease, CWD, elk, geophagy, mineral lick*

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## **Evolution and Historical Biogeography of *Chrysosplenium tetrandrum* (Saxifragaceae)**

*Chrysosplenium tetrandrum* (Saxifragaceae) is a native species of the Colorado alpine flora and despite some attempts, we know little of the patterns of variation within the species or its evolutionary history. *Chrysosplenium tetrandrum* is an arctic herb, which maintains a circumpolar distribution with disjunct populations occurring sparsely in the Colorado and Wyoming Rocky Mountains. While much of the main distribution of this species has been shaped by relatively recent Pleistocene-age glacial dynamics, the establishment and isolation of the Colorado populations may date back to the Tertiary Period (~ 1.8 mya). Despite representing a unique geographic element, we know little about the chromosomal, morphological, or genetic variation these populations contribute to the species. To elucidate these patterns of variation within the species, and in the Colorado populations specifically, we used a DNA fingerprinting technique (i.e., inter-simple sequence repeat, ISSR) as well as morphometric and cytological surveys. Analyses of these data provide a framework to test historical biogeographic hypotheses of glacial survival and aid in the identification of important variation in need of conservation.

*alpine, Chrysosplenium tetrandrum, glacial refugium, historical biogeography, ISSR, morphometric, Saxifragaceae*

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## **The Architect of Record: Tom Casey and Planning the Future of Beaver Meadows Visitor Center**

The Beaver Meadows Visitor Center, or Administration Building, is the most visible and visited building in Rocky Mountain National Park. During the summer of 2002 more than 522,000 people visited the building, far exceeding the designed carrying capacity. Visitors with physical impairments have a difficult time navigating the subtle grade changes to the exterior, the narrow passageways in the interior, and the multi-level auditorium. In 2001, the Secretary of the Interior designated the building a National Historic Landmark and the park hired E. Thomas Casey, the original architect from Taliesin Architects, to complete a historic structure assessment. Mr. Casey and his colleagues found that although the building was in overall good condition, several systems were failing or on the verge of failing. Noted problems included the heating-air conditioning system, the roof, accessibility, and life safety.

Based on the assessment, the park identified a need to rehabilitate the visitors center, which was designated a National Historic Landmark in 2001. It is considered one of the four most significant visitor centers constructed as a part of the National Park Service's Mission 66 program. It represents the principles of Organic Architecture espoused by Frank Lloyd Wright. The rehabilitation needed to carefully balance occupant needs, systems improvements, and historic preservation.

In order to better understand the original design intent, the park partnered with the National Trust for Historic Preservation and interviewed Tom Casey. This oral history and several meetings that followed laid the foundation for both the rehabilitation and the long-term preservation of this important park resource.

*historic preservation, national historic landmark, Mission 66, Taliesin*

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## **Historical Deposition of Mercury and Trace Metals to High-Elevation National Parks in the Western U.S. Inferred from Lake Sediment Cores**

Atmospheric deposition of Hg and selected trace metals were reconstructed over the past 150 years using 9 sediment cores collected from remote lakes in Rocky Mountain National Park in Colorado and Glacier National Park in Montana. Cores were age dated by <sup>210</sup>Pb and sedimentation rates were determined using the constant rate of supply model. Hg concentrations in most of the cores began to increase around 1900 reaching a peak sometime after 1980. Other trace metals, particularly Pb and Cd, showed similar post-industrial increases in lake sediments confirming that anthropogenic pollutants are reaching remote areas of the Rocky Mountains via

atmospheric deposition. Some of the cores showed declines in Hg in recent sediments perhaps reflecting reductions in mercury emissions related to the Clean Air Act. Baseline (pre-1875) Hg fluxes in the sediment ranged from 5.7 to 42  $\mu\text{g m}^{-2} \text{yr}^{-1}$  and modern (post-1985) fluxes ranged from 17.7 to 141  $\mu\text{g m}^{-2} \text{yr}^{-1}$ . The average flux ratio of modern to baseline was 3.1, which is similar to remote lakes elsewhere in North America suggesting Hg is derived primarily from regional sources. Estimates of net atmospheric deposition based on the cores were 3.2 to 4.3  $\mu\text{g m}^{-2} \text{yr}^{-1}$  for preindustrial and 12.0 to 14.9  $\mu\text{g m}^{-2} \text{yr}^{-1}$  for modern times. The sediment-based modern deposition rates are in reasonable agreement with current deposition rates measured in Rocky Mountain National Park.

*mercury, atmospheric deposition, trace metals, lake sediments, paleolimnology*

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### **Afterlife of the Rocky Mountain National Park Ute Ethnobotany Project**

In 2004, a group of Northern Utes were invited into Rocky Mountain National Park as a part of the Oral History and Cultural Interpretation Project begun in 2002. While the Utes' knowledge of high altitude plants was fragmentary, the trip was powerful for its emotional energy and for its potential to renew Ute interest in learning more about traditional plant use.

Whenever a tribal community is dispossessed of their territory and removed to a distant location, much traditional knowledge is lost. In 1881 the Northern Ute bands were removed from their Colorado homelands to a reservation in Utah; subsequently assimilationist institutions such as boarding schools and missions, and simply accommodation to the twentieth century, generated tremendous cultural erasure.

Beginning in 2003, the Northern Ute tribe, the Forest Service, and the Bureau of Land Management initiated similar ethnobotany projects to assist the Ute in reclaiming not only lost knowledge about plants and their use, but also a re-connection to ancestral homelands.

This visual (DVD) presentation entitled *A Trail Home* represents how collaboration between tribal peoples and government agencies can provide the beginnings for successful documentation and transmission of plant identification skills between living Ute generations; it also addresses the power of connection to ancestral landscapes.

*Ute ethnobotany; Ute ancestral landscape; Ute cultural loss*

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### **Spatial and Temporal Variation in Aquatic Chemistry and Foodweb Support in Rocky Mountain National Park**

Variation in solute concentrations in streams and lakes regulates ecological processes in headwater ecosystems and the delivery of solutes to downstream waters. Solute concentrations in aquatic ecosystems of the Rocky Mountains vary in response to processes operating at multiple spatial and temporal scales. Thus, information on spatial and temporal variation in water chemistry will be required 1) to understand the controls on chemistry of headwater lakes and streams in the Colorado Rockies and 2) to predict the effects of environmental change on headwater ecosystems. Sources of nutritional support for aquatic food webs also vary spatially and temporally, but little is known about the effects of forest disturbance or changes in climate on the nutritional support for consumers in Rocky Mountain streams. We propose to sample water from lakes and streams in Rocky Mountain National Park; a "snapshot" approach, in which samples are collected across the park on one or two dates, will be used to characterize spatial heterogeneity in water chemistry. In addition, two watersheds (St. Vrain Creek and the East Inlet) will be studied in more detail in order to collect additional information on spatial and temporal patterns and also information on foodweb support. The results of the proposed research will provide valuable information on heterogeneity in pristine streams of the Rocky Mountains and also will provide points of reference for comparison with other streams.

*stream chemistry, watershed, nutrients, aquatic macroinvertebrates*

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## **Occurrence of *Batrachochytrium dendrobatidis* at Breeding Sites of *Bufo boreas* in the Rocky Mountains**

The amphibian chytrid fungus (*Batrachochytrium dendrobatidis*, Bd) is extirpating amphibian populations in several world regions. We analyzed the distribution of Bd across an 11 degree latitudinal gradient in the Rocky Mountains, sampling 202 historic and extant boreal toad (*Bufo boreas*) breeding sites in 97 geographical clusters. We sampled boreal toads or amphibian surrogates. Bd was detected at 64% of the clusters tested in this region. The Southern Rocky Mountains has experienced the greatest declines in *Bufo boreas* in the region but had the lowest percentage of sites with this fungus. This pattern may indicate differences in susceptibility to chytridiomycosis; or effects of sublethal stressors, including environmental and anthropogenic variables. We evaluated potential relationships between landscape attributes (latitude and elevation) and the prevalence of Bd at infected sites.

*amphibian, disease, Batrachochytrium dendrobatidis, Rocky Mountains, amphibian decline*

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## **Do Airborne Contaminants Cause Endocrine Disruption of Salmonids in Western U.S. National Parks?**

Airborne contaminants have been detected in snow, lake sediment, water, and fish in alpine aquatic ecosystems. Therefore a multidisciplinary study was initiated to assess the levels and potential effects of contaminants in alpine aquatic ecosystems of western U.S. National Parks.

**Adam Schwandt**  
U.S. Geological Survey

Fish, primarily salmonids, were collected from “pristine” lakes of 8 National Parks ranging from north of the Arctic Circle to southern California and from the Pacific Coast in the West to the Rocky Mountains in the East. Other sampling matrices included, snow, lake water and sediment, vegetation, moose, and fish, all of which are analyzed for organic and metal contaminants. We assessed endocrine disruption by quantifying circulating vitellogenin (Vg) and sex steroids and examined gonads histologically. Other physiological factors were assessed to indicate the general health of the fish.

**Dixon Landers**  
U.S.EPA

Some male trout collected from parks in the Rocky Mountains exhibited significantly elevated Vg. Some trout appeared to be intersex males and others appeared to have abnormal gonadal tissue, perhaps undeveloped testes, containing some oogonia or oocytes. All fish from other parks appeared normal. The frequency of gonadal anomalies in populations where this condition was extant appears significantly higher than in old (some over 100 years) museum specimens examined for comparison. Affected specimens contained various contaminants known to be endocrine disrupting. We also found the presence of splenic and nephric pigmented macrophages in fish from several regions. Macrophage abundance correlated with whole body mercury content.

**Luke Ackerman**  
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**Staci Simonich**  
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It is possible that airborne contaminants are having adverse, endocrine disrupting effects in fishes in waters at remote locations held to be pristine. Analysis of historic collections of salmonids reveal that the frequency of intersex salmonids is on the rise in these areas. However, it is unknown if there are ecological consequences to this or not; the data could suggest that monitoring the situation through time might be appropriate.

**Tamara Blett**  
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*airborne contaminants, endocrine disruptors, salmonids, alpine aquatic ecosystems*

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## **Long-term Bioassessment of Park-scale Wetland Ecological Integrity in the Rocky Mountain Inventory and Monitoring Network**

The Rocky Mountain Inventory and Monitoring Network (ROMN) and Colorado State University are implementing a long-term wetland monitoring program in four of the six ROMN parks (GLAC, ROMO, GRSA, and FLFO). Pilot work is focused on ROMO where wetland is potentially threatened by hydrologic and floristic modification due to elk and (lack of) beaver, invasive flora and climate change. We are beginning our second year of pilot work. Accomplishments of our first year included developing a robust three-stage probability survey design (via GRTS), targeted selection of sentinel and gradient sites in the park, authoring a draft field protocol detailing site-level methods and collecting over 50 sample events. Data collected

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at each site include quantitative vegetation assemblage composition and cover, ground water hydrology, vegetation herbivory and additional semi-qualitative measure of several environmental attributes. 2007 data are currently being analyzed. Analyses include assessment of variance components and signal:noise ratios to allow more informed sample size via mixed effects models of power for trend and standard error around status estimates. We are also developing integrative assessment models of vegetation data including a multimetric Index of Biotic Integrity and a multivariate observed:expected model that predicts assemblage composition based on a suite of geophysical attributes that structure wetland condition. These models will allow informed and management relevant assessment of wetland integrity. The survey design assures that episodic status estimates are valid at the scale of the park while trend assessment will focus on sentinel sites where more frequent vegetation and more detailed hydrology data are collected. Plans for 2008 include further work on the protocol to be published in 2009 (including a detailed QA/QC plan), completing an additional 70 – 100 additional sample events, formalizing the sample design for sentinel and gradient sites and completion/calibration of the IBI and O:E models. We will also be focusing on development of quantitative reference condition distributions for select key responses. These will allow numerical assessment of changes in Rocky's wetland condition across space and through time as our long-term monitoring unfolds.

*long-term bioassessment, wetland, ecological integrity*

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## **Nominating the East Longs Peak Trail to the National Register of Historic Places**

“Longs Peak is the King of Rocky Mountain National Park,” declared Roger Toll, one of the park's most ambitious and passionate superintendents. At 14,259 feet, the mountain stands apart from any other summit in the region—the figurative and literal centerpiece of the park. Hundreds of personal accounts from three centuries express exhilaration over the scenery and exhaustion from the high-altitude effort. The public interest ensured that the tourist industry and, later, the national park would dedicate resources towards maintaining a good travel route to the top.

In 1884, one visitor to the mountain—a sickly teenager from Kansas—was particularly awestruck. As a grown man, Enos Mills externalized his deep relationship with the outdoors by working as a trail guide. It was upon the East Longs Peak Trail, which he used hundreds of times, that he sharpened his philosophy toward his work. In his 1920 book *Adventures of a Nature Guide and Essays in Interpretation*, he notes “While a guide on Longs Peak I developed what may be called the poetic interpretation of the facts of nature.” He trained two sisters, Esther and Elizabeth Burnell, in nature lore and they later became the National Park Service's first licensed guides.

Eventually, Mills left full-time guiding; for him, the obvious extension of “the poetic interpretation of the facts of nature” was a national lecture tour. Then, Mills—now a publicly-renowned wilderness expert—allied himself with F.O. Stanley and other tourism interests to lobby for the creation of Rocky Mountain National Park. Although no one person can be credited for this feat, the park's founding was widely deemed Enos Mills' success.

This talk will cover the historical significance of the East Longs Peak Trail, the efforts to nominate it to the National Register of Historic Places, and future implications for its cultural resources.

*Longs Peak, Enos Mills, National Register of Historic Places, East Longs Peak Trail, Rocky Mountain National Park, mountaineering*

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## **Elk Impacts on Alpine Willow Communities, Rocky Mountain National Park, Colorado**

In herbivore-regulated ecosystems, plant species evolve strategies to defend tissues, tolerate tissue loss, and even benefit from herbivory. However, human activities that increase herbivore abundance by altering land use and the risk of predation can lead to greater rates of consumption than a plant species can sustain. Human activities in and around Rocky Mountain National Park have led to an abundance of elk within the park. This, at least in part, has led to decreases in the height and productivity of willow communities within the elk's primary winter range. A decrease in the number of ptarmigan, a species that depends on willow, and in the height and cover of willow at sites near Trail Ridge Road (TRR) has led to concern that elk are also having a negative impact on willow in their summer range.

The purpose of our research was to assess whether elk are responsible for the decline in alpine willows near TRR and whether alpine willow communities throughout the park are declining. We set up ten exclosures of alpine willows (*Salix planifolia* and *S. brachycarpa*) across a gradient in soil water availability. Within the exclosures, we simulated browsing and measured plant production. Outside the exclosures, we measured elk consumption of willow. We also surveyed alpine willow communities in two other regions of the park. Production was not affected by browsing in drier plots, but decreased linearly with increased browsing in more mesic plots. Compensatory growth (i.e. greater growth as a result of browsing) was not observed. Consumption was five times greater (~27%) near TRR than near Ptarmigan Peak or Mummy Creek. Willow communities near Mummy Creek showed no evidence of decline and willow structure appeared to protect the most productive stems at the center of a patch. The data suggest that elk are contributing to the decline of alpine willow communities near TRR and Ptarmigan Peak through consumption and potentially through trampling. It is unclear how long it would take following a reduction in elk for the most impacted communities to recover, because some mortality of old clonal plants has occurred. We recommend that new research evaluate the importance of alpine willow as a food resource to elk in winter and summer and elk impact on willow at several more sites in the park. Understanding restoration approaches that can aid alpine willow recovery also requires further research.

*elk, herbivory, compensatory growth, alpine willow, community structure, water availability*

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## **Tree Line Shifts in Tatra Mountains as a Result of Climate Change or Land Abandonment**

The main scientific goal of this paper is to consider the potential response in distribution of *Pinus mugo* (vertical zone and area) following expected climatic and land use scenarios for high mountain areas in Slovakia through the distributive models derived and based on environmental limits, which control abundance. The main questions are if the forest area in the mountains increases and if the forest expansion near tree line represents an invasion into abandoned grasslands (ingrowth) or a true upward shift of the local tree line. Also what are the possible drivers of forest regeneration in the tree line ecotone, climate and/or land use change? For analysis of tree line change we used a data set generated as an overlay of aerial photographs in GIS. The same rasters from two different spaces of time were reclassified and then compared. A digital elevation model served as the main input for the representation of abiotic habitat conditions. Topography and climatic conditions were calculated as variables. The historical aerial-photograph-based maps were compared with actual aerial-photograph maps. Additionally historical records were analyzed for the purpose of deriving historical data in periods of land use changes. To test possible climate change influence, the resulting upward shifts were compared to a potential tree line. Upward density of trees were considered to be influenced primarily by climate change. Two anthropogenic disturbances – rapid climate and land use changes – appear to be closely related to changes in the tree line ecotone. Climate warming, dispersal capacity and competitive interactions with established alpine vegetation determine the range expansion of *Pinus mugo*.

*tree line, climate and land use change, shift, ingrowth, Pinus mugo*

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**Participatory and Sustainable Management of Tatra National Park, Slovakia:  
Experiences from the Project**

The project “Participatory and Sustainable Management of Tatra National Park” was funded by the Danish Cooperation for Environment in Eastern Europe (DANCEE) and implemented from March 2002 to September 2004 by Holsteinborg Consult (Denmark) in close cooperation with the Tatra National Park staff and greatly supported by NGO A-Projekt. The main purpose of the project was to support the development of a common vision among stakeholders and Slovak park authorities and to provide assistance to TANAP Administration for their preparation of a new Park Plan using public participation in the planning process. The Park Management Plan was developed using participatory methods to bring the many and sometimes conflicting interests together to provide a better balance for long-term sustainable management. The involvement of main stakeholders in the development and approval of the Park Management Plan was expected to ensure sustainability of project achievements. A popular version of the Park Management Plan was also produced, intended for and available to the public. A small grant facility was provided for local individuals and groups in order to mobilize them towards project objectives and to identify new ideas and ways for solving National Park and local issues within wildlife management, tourism and recreation and forestry. The project had also co-operation with staff from other national parks and experiences from the project was utilized for reviewing national legislation aiming for a national impact.

*participatory and sustainable management, Tatra National Park, Park Management Plan*

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**Utilization of Lead Isotopes and Trace Elements in Alpine Lake Sediments  
to Determine the Nature and Timing of Atmospheric Deposition, Front  
Range, Colorado**

The trace element and Pb isotopic variations in lake sediments can be used to infer sources, whether from erosion of local rocks or from atmospheric deposition, and to monitor changes in those sources over time. To minimize influences of non-atmospheric anthropogenic sources, two alpine lakes in remote locations were chosen. Black Lake (BL), elevation 3230 m, is located within Rocky Mountain National Park, 5 km from the nearest park road, and is underlain by 1420 Ma Silver Plume Granite. Green Lake 5 (GL5), elevation 3605 m, is located within the restricted City of Boulder watershed, 25 km south of BL, and receives sediments from Precambrian schists and gneisses and the Tertiary-age Audubon-Albion stock. Twenty-seven cm of BL core was recovered, and using <sup>210</sup>Pb dating method, the base was dated at ~ the year 1250. Twenty-three cm of GL5 core was recovered, and the base was dated at ~ the year 1740. Samples were taken every 0.5 to 1 cm, dried, and digested. Trace element chemistry was determined by ICPMS and Pb isotopic compositions by multicollector-ICPMS.

From the base to the late 1800s, samples from both cores display fairly uniform chemistry; Pb in lower BL core 29-33 ppm and GL5 core 28-32 ppm. Between the late 1800s and the 1920s, concentrations of some metals (including Bi, Cd, Pb, and Sb) increase by a factor of 2 to 3, Pb concentrations in BL increase to 91 ppm and in GL5 to 95 ppm. In the younger layers, concentrations of these metals remain elevated but to varying degrees. At the chemical transition, preliminary Pb isotopic results display a sharp change from relatively constant isotopic ratios consistent with geologic background sources to ratios with a substantial component of potentially anthropogenic Pb. Possible sources of anthropogenic Pb within or adjacent to the Front Range include smelter emissions from processing of hardrock mining ore, emissions from coal-burning power plants, and leaded gas usage.

*atmospheric deposition, anthropogenic sources, lead isotopes, alpine lakes*

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## **Regional Variations in Surface-water Chemistry in Central Colorado: Establishing Geochemical Baselines**

The U.S. Geological Survey is studying surface-water quality in the Rocky Mountains of central Colorado. Within the 55,000 km<sup>2</sup> area, 358 samples were collected from 243 unique sites; the remaining samples were site duplicates or field blanks. The samples were collected between 2004 and 2007 to determine geologic and spatial controls on water quality. The dominant feature affecting water quality over the entire study area is the Colorado Mineral Belt (CMB), a northeast-trending zone through the state of Colorado that hosts large numbers of historic mines. Mining of these deposits from the late-1800s to the present has left numerous streams with a chemical signature typical of acid rock drainage. Some of the stream reaches have no mines within their catchment areas but have low pH (<5) and high natural background concentrations of metals and sulfate.

Thirty samples were collected from within Rocky Mountain National Park (RMNP), which represent watersheds unaffected by acid rock drainage. In these samples, water chemistry can be explained by variations in the watershed lithology. Rocks on the east side of RMNP are predominantly Silver Plume Granite, whereas rocks on the west side are mostly metavolcanic rocks, which have lower silica and contain greater amounts of magnesium and iron. Weathering of the granites produces stream water that has generally lower pH ( $6 < \text{pH} < 7$ ), alkalinity, and lower concentrations of magnesium and calcium compared to stream water draining the metavolcanic rocks ( $6.5 < \text{pH} < 8$ ). The water samples collected within RMNP are chemically pure compared to the entire Colorado study area- almost all of the RMNP samples rank within the top 10% of samples with the lowest total dissolved solids content.

In addition, we conducted three synoptic samplings of Glacier Creek to evaluate seasonal variations in water quality – in April, June, and August of 2006. These sample sites represent pre-runoff, runoff, and base-flow conditions. Seasonal variations in water quality of Glacier Creek help to evaluate the range of concentrations of dissolved chemical elements with changing hydrologic conditions.

*landscape geochemistry, water quality, lithology, surface water*

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## **Where Cultural Meets Natural: Dr. Beatrice Willard's Alpine Tundra Research Plots**

Dr. Beatrice Willard (1925-2003) was a beloved and respected tundra ecologist. In 1959, she established research exclosures along Trail Ridge Road at Rock Cut and Forest Canyon Overlook. Both areas showed signs of human impact: vegetation was destroyed, lichen removed from rocks, and paths worn into sensitive tundra soils. Willard's dissertation and subsequent scientific journal articles about alpine tundra recovery after human trampling have been cited extensively by scientists. In 1972, she co-authored the seminal book on alpine tundra: *The Land Above the Trees*. At Rocky Mountain National Park, Willard influenced how the park manages its alpine tundra by implementing recommendations from her 40 years of research. Dr. Willard's versatility as a scientist, park interpreter, and popular writer enabled her to take leadership in the areas of natural resource protection and national environmental policy. She was an important Colorado environmental leader, directing the Thorne Institute near Aspen, counseling Colorado governors, establishing the Colorado School of Mines environmental sciences program, protecting Florissant Fossil Beds National Monument, and convincing Bill Coors to create a recyclable aluminum can. She influenced federal environmental policy as well by developing the National Environmental Policy Act process before the law was codified. She advised Presidents Nixon and Ford as the first woman to serve on the President's Council for Environmental Quality (CEQ). During her tenure at the White House, she consulted on the design and installation of the Alaska Pipeline. The research plots are now listed in the National Register of Historic Places, the first ecological research plots in the country so recognized. They are among the earliest National Park Service research plots associated with the alpine tundra ecosystem and continue to yield important data about what is considered one of the planet's most fragile environments.

*alpine tundra, Beatrice Willard, National Register of Historic Places, Trail Ridge Road*

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