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Alpine vegetation composition, structure, and soils monitoring for Great Sand Dunes National Park and Preserve

2010 Summary Report

Natural Resource Data Series NPS/ROMN/NRDS—2011/152

ON THE COVER
Looking from Mount Herard towards Mount Six. Mount Six is the highest GLORIA summit in the Great Sand Dunes National Park and Preserve. September 2010.
Photograph by: Kurt Chowanski

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Contents

Figures

Page

Tables

Page

Executive Summary

Alpine ecosystems are important monitoring targets for the Rocky Mountain Inventory and Monitoring Network (ROMN) for a number of reasons, including their value to park visitors, wildlife, and water resources in the West and because the alpine is particularly vulnerable to climate change. Here we present a summary of our efforts in 2010 to monitor vegetation composition, structure, and soils in four sentinel sites in the alpine of Great Sand Dunes National Park and Preserve (GRSA). This was not a full monitoring event; in 2010 we spent 3 days in GRSA collecting and replacing temperature dataloggers that were deployed in 16 locations in July 2009. We did not conduct vegetation surveys, because active fires made access to the sites unsafe during July. This report also includes soil chemistry analyses from 2009 that were completed in the winter of 2010. The intention of this report is to provide a timely release of basic data sets and data summaries. We expect to produce reports with more in-depth data analysis and interpretation when we do the second full sample event (5 years) or as needed for park management and interpretation. In 2010, we found the following:

- Soil texture was similar across summits in the GLORIA target region. We found soil texture to be a sandy clay loam or sandy loam. The highest summit, SIX, tended to have higher nutrient concentrations than the lower peaks.

- The alpine is characterized by a short growing season and cold temperatures with temperatures decreasing at higher elevations. All summits showed similar daily patterns in temperature suggesting they are in the same climate zone.

Continued monitoring of the vegetation and temperature at sentinel sites will allow us to determine whether climate change correlates with changes in biodiversity in select locations in GRSA's alpine. Warmer temperatures may contribute to the extinction of some plant species while simultaneously increasing the elevation and latitudinal limitations of other species.

Acknowledgments

I thank all those that assisted with field work, particularly Kurt Chowanski, Craig Magtutu, and Jennifer Magtutu. I would also like to thank the staff at GRSA for being helpful with logistics. Finally, the staff at the GLORIA office have been invaluable, particularly Barbara Friedmann and Christian Klettner, by providing databases, field sheets, and methods. I thank the Colorado State Plant and Soils Lab for analyzing soil samples. This manuscript was improved by comments from Berndette Kuhn, Phyllis Pineda Bovin, and the ROMN Staff.

Introduction

One of the objectives of the National Park Service (NPS) Inventory & Monitoring (I&M) Program is to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. The Rocky Mountain I&M Network (ROMN) identified vegetation composition, structure, and soils as a vital sign that can be used to better understand the condition of terrestrial park ecosystems (Britten et al. 2007). The alpine, defined as the vegetation communities that exist above treeline, is represented in three of the ROMN parks: Glacier National Park, Rocky Mountain National Park and Great Sand Dunes National Park and Preserve (GRSA). The area above treeline, including vegetated and non-vegetated areas, makes up 28%, 20%, and 3% land cover in each park, respectively. The ROMN selected alpine ecosystems as an important vegetation monitoring target in these parks for a number of reasons, including their value to park visitors, wildlife, and water resources in the West and because the alpine is particularly vulnerable to climate change.

The long-term objectives of our alpine monitoring effort are to:

(1) Determine the status and trend in **vegetation composition and structure** of four sentinel alpine peak communities at a range of elevations.

(2) Determine status and trend in **cover of invasive/exotic plant species** at four sentinel alpine peak communities at a range of elevations.

(3) Determine the status and trend in **soil condition** based on a suite of physical and chemical properties that include: surface stability, soil carbon (C) and nitrogen (N) content, pH, texture, evidence of erosion, extent of bare (non-vegetated) soils, and compaction at four sentinel alpine peak communities.

(4) Determine the status and trend in **soil temperature** and snow cover period of four sentinel alpine peak communities at a range of elevations.

A summary of our initial effort to monitor vegetation composition, structure, and soils in the alpine of GRSA in 2009 can be found in Ashton et al. (2010a). We plan to complete a full resurvey and monitoring effort at these sites in 2013. Here, we present a summary of our efforts in 2010. In 2010, we downloaded and replaced soil temperature loggers and completed the laboratory analyses of soil samples collected in 2009. We did not monitor vegetation because access to the field sites in July was limited by the Medano Fire. This report is intended to provide a timely release of basic data sets and data summaries. We expect to produce reports with more in-depth data analysis and interpretation when we do the second full sample event (5 years) or as needed for park management and interpretation.

Methods

The ROMN adapted an alpine monitoring protocol from the Global Observation Research Initiative in Alpine Environments (GLORIA), an international monitoring network established in 2001 to assess and predict biodiversity and temperature changes in alpine communities in response to drivers such as climate (Pauli et al. 2004). The goals of the GLORIA program are to provide a global baseline for vegetation monitoring in alpine environments and to assess the risks of biodiversity loss and ecosystem instability from climate change. The methodology is extended by cooperators, such as the ROMN, to create a long-term monitoring network at the global scale. The ROMN Alpine Vegetation Composition, Structure, and Soils monitoring protocol follows those established by GLORIA but adds components for soil condition, treeline movement, and human disturbances (Ashton et al. 2010b).

Sample design

We followed the GLORIA monitoring design (Grabherr et al. 2000). One GLORIA protocol calls for the establishment of four sentinel sites on alpine peaks representing an elevation gradient within a target region (e.g. Great Sand Dunes National Park and Preserve, CO). Sites are established on the top of peaks (summits). The summits can vary from just above treeline to the highest life zones of vegetation. Within one region, all four summits share qualitatively similar geology, climate, disturbance, and land-use history, leaving vegetation differences among the summits to be driven primarily by elevation. The four alpine monitoring sentinel sites within GRSA are listed in Table 1.

Table 1. Name, location, elevation, and vegetation zone of the four alpine sentinel sites within the target region of GRSA.

GLORIA Summit code	Summit name	Latitude (decimal degrees)	Longitude (decimal degrees)	Elevation (m)	Vegetation zone
SIX	Unnamed	37.861501	-105.492034	4000	alpine/nival ecotone
PAD	Unnamed	37.87965	-105.478217	3870	upper alpine
MUD	Unnamed	37.887517	-105.47665	3700	lower alpine
HUK	Unnamed	37.89615	-105.473733	3550	lower alpine/subalpine ecotone

Plot layout and sampling

Vegetation is sampled on each summit in a series of nested plots arrayed across the north, east, south, and west aspect (Figure 1). Details of the vegetation sampling can be found in the monitoring protocol (Ashton et al. 2010b).

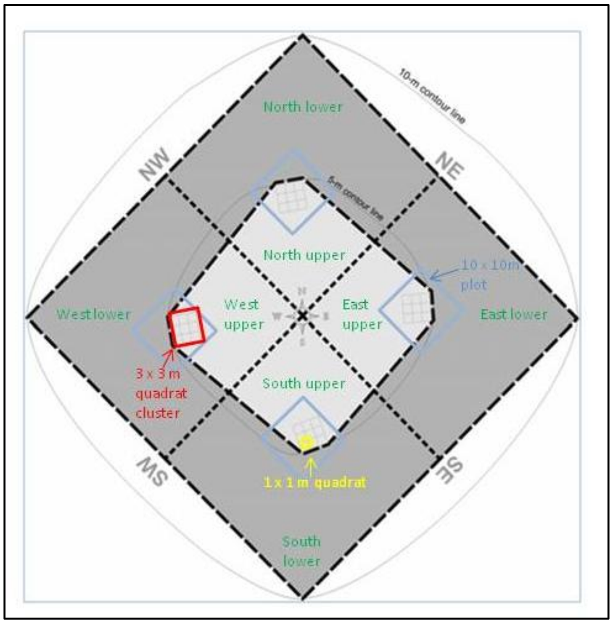

Figure 1. Field plot design for alpine monitoring in Great Sand Dunes National Park and Preserve. This design was replicated on four summits that varied in elevation. The design is centered by the highest point on the summit and extends to 10 m in elevation below the highest point. The 1 m^2 quadrats used to measure changes in plant frequency are indicated in yellow.

Soil temperature is measured hourly at 15cm depth in four locations on all summits using HOBO Onset® Dataloggers. The dataloggers are placed in the center of a 3 x 3 m quadrat cluster (Figure 1) on the north, east, south, and west aspect. The dataloggers were originally installed in the summer of 2009. In September 2010, we replaced all loggers. The loggers have the memory and battery power to be deployed for longer than one year, but replacing them is quick and ensures that we can report on soil temperature data in a timely manner. Our strategy has been to replace the loggers each year, rather than download the data in the field and continue to use the same logger. This is done because it eliminates the need for a computer in the field. Also, we verify that all dataloggers are working and properly programmed prior to deploying them. We can reuse dataloggers the following year and replace batteries as needed.

In 2009, crews collected a soil sample from each of the quadrat clusters for laboratory analyses of each peak's soil chemistry. Soils were sampled to a depth of 20cm at three locations using a 2cm diameter soil probe. The three samples per quadrat were combined in a plastic bag and brought back to the office. The soil samples were air dried and sent to a cooperating laboratory at Colorado State University for analysis. Data were not available at the time of publication for the 2009 report. However, it is included here. The soil samples taken in 2009 will provide a baseline for the GLORIA sites and we plan to repeat collections every 5 or 10 years. Our expectation is that soils will respond more slowly than vegetation to change.

Field work for 2010 totaled 3 days. The first day was spent traveling from Fort Collins to the Medano Lake Trailhead via the 4WD road over Medano Pass. We camped at one of the designated camp sites near the trailhead. The second day involved hiking to SIX and collecting the dataloggers. We returned in the evening and camped at the same site. On the 3rd day, we broke camp, proceeded to Hudson Ditch, and hiked up the drainage to replace loggers on PAD, MUD, and HUK. We returned to Denver that evening, arriving close to midnight. The WRD vehicle was returned the following day.

All loggers were downloaded in the office and raw data were complied into one file with each logger in a separate column. The starting and ending date of all loggers were checked in this file and data from before or after the loggers were deployed were deleted. Statistical software (JMP) was used to calculate daily averages from the hourly raw data. The datalogger from the west plot on HUK had failed to log any data. The error returned suggested that it was an electrical error which could possibly be due to nearby lightning activity.

Photographs taken in 2010 were added to the 2009 GSD photograph tracking database and included a large number of species identification pictures. We estimate the data entry process took eight hours. Much of that time was spent on proper documentation of photographs and species. The QA/QC process, which is mainly automated, is completed and both the 2009-2010 photograph database and 2009 GLORIA database are available to the park upon request. The GRSA database is on the shared ROMN drive in the alpine monitoring database folder. The GLORIA office in Vienna also has a copy (http://www.gloria.ac.at/). The ROMN plan is to create a master database in 2011 that includes soil chemistry and temperature logger data. Currently, logger and soil chemistry data are available in *.txt format.

The main purpose of this report is to provide an annual update of the data and metadata collected in the alpine at GRSA in 2010. As a result, we conducted very few statistical analyses and instead present simple descriptive statistics. Soil data were analyzed in R 2.9.2 (2009) using a multivariate model (MANOVA) to test for differences among summits.

Results & Discussion

Soil chemistry

Soils from the GLORIA peaks were typically described as sandy clay loam or sandy loam in texture with a mean pH of 5.4 ± 0.1 (Table 2). Based on a multivariate ANOVA, we found a marginally significant difference in soil chemistry among summits (Pillai's Trace=2.73, P=0.06) but no difference across aspects. The difference was driven by higher concentrations of nitrate, sulfate, phosphorus, and total nitrogen on SIX than the other summits (Figure 2).

It is unclear why SIX has much higher nutrient concentrations than the other peaks. There was a great deal of marmot activity on the summit at the time the soil was collected and animal feces could be contaminating results. It is more likely, however, that this is a true effect and that on SIX low temperatures and high winds are limiting plant production more than nutrient availability. Future studies of deposition rates at these summits may help us better understand these patterns. Snow chemistry data from Music Pass suggests that sulfate, ammonium, and nitrate deposition has declined since 2006 ((Ingersoll 2010), but we have limited understanding of whether these patterns are consistent across the park. We recommend more intensive sampling of soils at the next site visit to better understand these patterns (e.g. add replicates on each aspect or add additional sampling along this ridgeline).

Temperature

The soil temperatures at 15 cm below the surface were generally very cold on the GLORIA peaks from July 2009- September 2010 (Figure 3). Freezing temperatures began in October 2009 and were common through May 2010. Temperatures on the highest summit were generally cooler than the lower summits (Figure 3). The fairly consistent temperatures on the east side of MUD peak (compared to the west) during the winter months suggest that an insulating snow cover (~0.5 m) was present for this period. The west side of the peaks is often subject to greater winds than the other aspects, limiting snow accumulation on the surface of the soil. As a result, the west side of most peaks shows the coolest temperatures.

The alpine at GRSA is characterized by extremely cold temperatures and a short growing season (Table 4). When the sites were established, we assumed they were all in the same climate region (a prerequisite of a GLORIA target region). The broad scale patterns in the temperature data suggest that this is the case. For instance, all summits experienced peaks in the summer and low temperatures in the winter at roughly the same time (Figure 3). Over time, the temperature data collected at these sites will greatly add to our understanding and documentation of climate change in the alpine at GRSA.

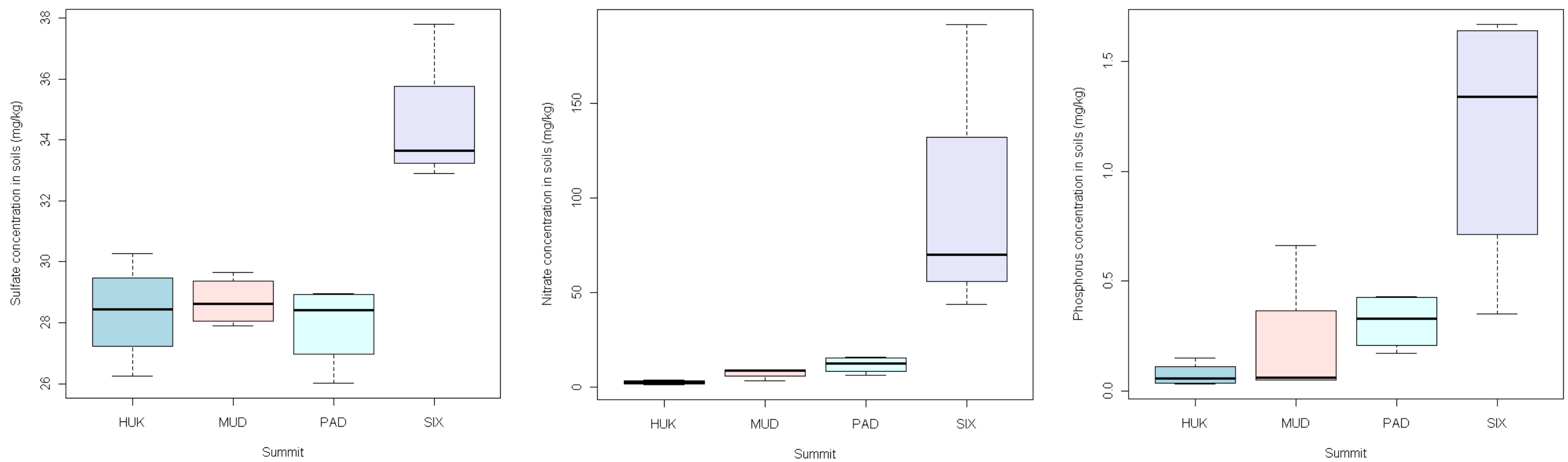

Figure 2. Boxplots of soil sulfate, nitrate, and phosphorous concentrations on the four alpine summits in GRSA. The three lower summits are similar to one another and SIX has higher nutrient concentrations in the soil.

Table 2. Soil properties at the four alpine summits in Great Sand Dunes National Park and Preserve. Values represent means and standard errors are in parentheses, n=4.

Summit	pH	NH_4 (mg/kg)	NO_3 (mg/kg)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	SO (mg/kg)	CEC (meq/ 100g)	Total N (%)	Total C (%)	Organic Matter (%)
HUK	5.5 (0.32)	5.9 (1.70)	2.5 (0.60)	0.07 (0.03)	247 (20.4)	1142 (147.8)	146 (15.8)	28.3 (0.83)	8.0 (0.85)	0.22 (0.05)	3.2 (0.40)	8.9 (2.00)
MUD	5.1 (0.18)	7.2 (0.72)	7.5 (1.45)	0.21 (0.15)	286 (32.0)	726 (58.8)	141 (20.1)	28.7 (0.40)	6.0 (0.33)	0.62 (0.08)	6.0 (0.76)	15.4 (7.21)
PAD	5.8 (0.25)	7.2 (0.82)	11.7 (2.19)	0.32 (0.07)	336 (28.0)	1665 (340.0)	206 (18.2)	27.9 (0.69)	11.4 (1.84)	0.41 (0.08)	4.7 (0.74)	9.4 (3.73)
SIX	5.0 (0.25)	44.2 (20.51)	94.0 (33.27)	1.18 (0.31)	283 (11.8)	1626 (430.6)	156 (31.8)	34.5 (1.12)	10.7 (2.43)	0.49 (0.13)	5.7 (1.67)	11.5 (4.82)

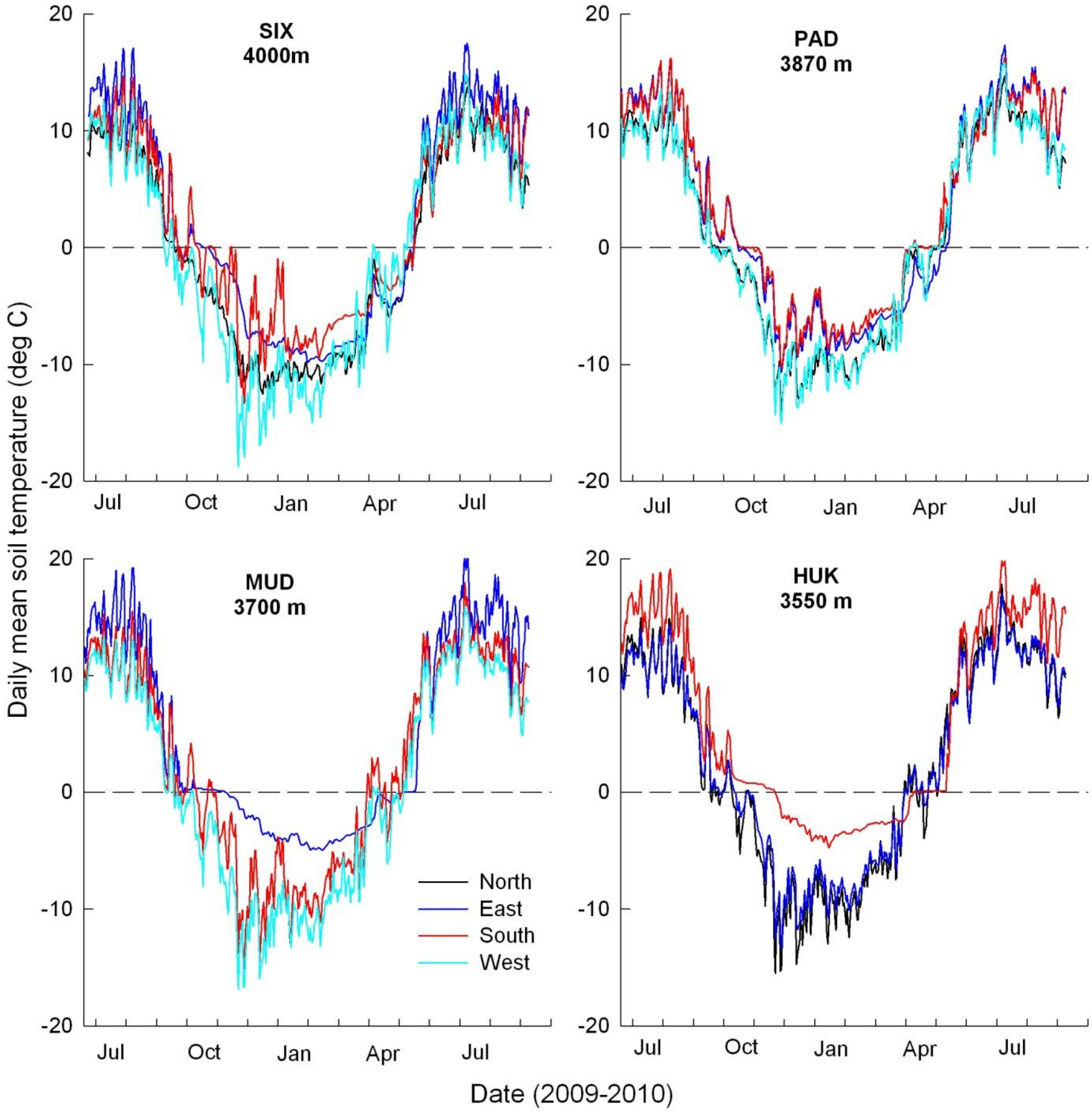

Figure 3. Daily soil temperatures from July 2009- September 2010 on the north, east, south, and west sides of SIX, PAD, MUD, and HUK summits in Great Sand Dunes National Park and Preserve. The dataloggers on the west side of HUK failed early in the season, so there are no data for this time period

Table 3. First day of Fall and Spring on GLORIA summits as defined by the first day when average minimum temperatures are below or above 0°C. Note that estimates for HUK do not include the record from the west side of the peak, which in most cases is cooler than other aspects.

	HUK	MUD	PAD	SIX
2009 fall	Oct- 1	Oct-1	Oct-6	Sep-24
2010 spring	May-16	May-20	May-19	May-26

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Appendix 1: US-GSD 2010 Field Log

Date	Peak	Persons	Activities	Notes
9/17/2010		Isabel Ashton, James Chowanski, Kurt Chowanski, Craig Magtutu, Jennifer Magtutu	Picked up WRD vehicle in Fort Collins and drove down to Medano Lake Trailhead	Camped at trailhead. Arrived ~5pm and campsites were filling up. Road was passable with the 4WD extended cab pickup truck but a SUV would have been difficult
9/18/2010	SIX	Isabel Ashton, James Chowanski, Kurt Chowanski, Craig Magtutu, Jennifer Magtutu	Hiked to Medano Lake and then to SIX to replace loggers and placed a new logger at the HSP	Accessed the peak via the ridge between Mount Herard and Mount Six. This was a fairly quick hike up and took ~1 hour at the summit. Placed a new datalogger the HSP on the summit. Slept at trailhead.
9/19/2010	PAD, HUK, MUD	Isabel Ashton, James Chowanski, Kurt Chowanski, Craig Magtutu, Jennifer Magtutu	Replaced loggers at PAD, HUK, and MUD. Placed a logger at the HSP of HUK	A very long day. Returned to vehicle at trailhead at ~5pm. Slept in Denver at the Magtutus.
9/20/2010		Isabel Ashton	Returned the WRD vehicle to Fort Collins	