ARCHES NATIONAL PARK
RESEARCH SUMMARY 2010

1) Study Title: The Moab Project Site Environmental Air Monitoring Program Conducted by the U.S. Department of Energy's Grand Junction Office
Permit No.: ARCH-2010-SCI-0001
Principal Investigator: Ed Baker
Purpose of Scientific Study: DOE's environmental air monitoring program will monitor local and background air quality for various radioparticulates (Uranium, Th-230, Ra-226 and radon-222) and radon gas and direct gamma.
Findings/Accomplishments for 2010: The air monitoring station at Arches (east side of visitor's center) is one of 14 stations operated by the US Department of energy to detect levels of radiation on the DOE mill tailings site and surrounding locations. The Arches stations is ~ 1/4 mile downwind of the project activity. No elevated levels of radiation have been detected at Arches. As the tailings pile is excavated and transported to Crescent Junction, the Arches station will continue to record data. See DOE "Environmental Air Monitoring Data Quarterly Report" on the Moab UMTRA Project web site: http://www.gjem.energy.gov/moab for more information.

2) Study Title: Impacts of Climatic Change and Land Use on the Southwestern U.S.
Permit No.: ARCH-2010-SCI-0003
Principal Investigator: Jayne Belnap
Purpose of Scientific Study: The population of the southwestern United States has grown rapidly over the past two decades and is projected to increase greatly over the next several decades. As the population has grown, climatic variations that would have affected relatively few people in the past will impact the lives of millions. Rapid and wide-spread climatic changes, such as those seen thousands and hundreds of years ago in the region and those projected for the future, may profoundly change the character of the region. Arid and semi-arid regions of the southwestern U.S. are among the most sensitive regions to changes in climate and land use, but the potential interactions between climatic change and land use are largely unknown (http://climweb.cr.usgs.gov/info/sw_new/swmap.html). U.S. Geological Survey and collaborating scientists are seeking to understand how climate and how land use has influenced surface geologic processes that modify landscapes and ecosystems. Such understanding is then used to model the landscape's response to future changes in climate and land use over time scales of seasons, of a few years, and of a few decades, so that information and interpretations can be applied by federal, state, and local agencies, as well as by Native American governments, for their land-use planning and management of resources. Project scientists work with ecologists, hydrologists, geographers, cartographers, and archeologists to address questions about:
(1) the causes and timing of changes in alluvial environments (rivers, streams, hillslopes), such as flooding, the cutting and filling of arroyos, and sediment discharge;
(2) the role of eolian dust for soil fertility, invasion of exotic species, hydrology, and surface stability in deserts;
(3) the interaction of physical and biologic processes critical for ecosystem functions;
(4) how climate in the southwest has varied over decades, centuries, and millennia;
(5) how future climatic variations will affect the Southwestern land surface (in terms of erosion, sand-dune activity, dust-storm frequency, flooding, landslides,);
(6) how past climatic changes and environments affected prehistoric cultures.

General Project Goals
-- Understand how past climatic change affected land surface: soil loss, fluvial erosion and alluviation, sand-dune mobilization, ecosystems, under time frames of past decades, centuries, and millennia.
-- Understand today's interplay among climate, land use and surface processes (geologic and ecologic).
-- Understand the impacts of future climate on land surface under the following time frames: seasons; El Nino/La Nina cycles; multiyear wet/drought periods; and decades, as atmospheric CO2 increases.
A major goal is to interact with federal, state, and local government agencies as well as non-governmental organizations to provide information useful for management decisions regarding land-surface vulnerability to wind erosion. Another goal is to provide to managers and other parties ongoing remote sensing and meteorological monitoring bearing on the vulnerability of the land to natural and human disturbances.
Findings/Accomplishments for 2010: This is a long-term project, with which we hope to understand climatic variability and its effects on dust projection and soil fertility.
Multiple years will be required to capture the full range of variability so that we may better understand the role of extreme events, as well as normal regimes.

3) Study Title: Carbon and Nitrogen Cycles in Arid Lands: The Role of Biological Soil Crusts as Influenced by Soil Surface Disturbance, Climate
Change and Annual Grass Invasion
Permit No.: ARCH-2010-SCI-0012
Principal Investigator: Jayne Belnap
Purpose of Scientific Study: Models indicate the presence of a large carbon (C) sink at temperate latitudes in the northern hemisphere. Over thirty percent of lands both globally and in the United States consist of semi-arid or arid landscapes. Very little is known about carbon dynamics in these regions. Biological soil crusts, composed primarily of cyanobacteria, algae, lichens and mosses, can completely cover plant interspaces in undisturbed areas, and constitute 70 percent or more of the living ground cover. These soil crusts can be the dominant source of nitrogen (N) for vascular plants. They fix C at a high rate and are critical for soil stability and aggregate formation, which is important in C storage. They also absorb significant amounts of CH4. In areas where precipitation is low and soils have low fertility, native plants often rely on intact biological soil crusts to provide increased water and nutrient flow to the broadly scattered vegetation.
Thus, there are many ways in which biological soil crusts influence biogeochemical cycles and the structure and productivity of the vascular plant community.
Soil surface disturbance, invasive plants, and climate change have the potential to dramatically alter the structure and function of biological soil crusts. The current combination of recreational use and livestock grazing is resulting in unprecedented levels of surface disturbance on many arid lands. In regions that did not have substantial amounts of surface disturbance in the Holocene, biological soil crusts disappear readily when trampled by animals or vehicles. Exotic annual grasses are invading many of these areas. Trampling and invasion results in reduced cover and changes in the species composition of biological soil crusts. This, in turn, leads to changes in processes such as decomposition, N and C fluxes, soil moisture, and nutrient availability to vascular plants. Decreases of only 1 percent of soil organic carbon in the top 10 cm of rangeland soils is equivalent to the total C emissions from all croplands nation-wide. Changes in climate regimes, such as a shift in the summer monsoonal boundaries in the western United States, are expected to influence the composition and physiological functioning of biological soil crusts. Various crust components have different photosynthetic and respiration responses to temperature and moisture. In addition, different crusts have different methane fluxes.

Therefore, changes in the timing or amount of temperature and precipitation is expected to alter soil C and N fluxes through changes in physiological response or crustal composition. This, in turn, can significantly impact vascular plant productivity.
This project will establish how alterations in species composition by surface disturbance, invasive grasses, and/or climate change may affect N and C inputs and fluxes, in different soils under different climatic regimes. Because current and expected changes in land use and climate will occur over millions of acres in western rangelands, impacts to soil crusts have the potential for dramatically affecting C cycles, N cycles, and vascular plant productivity over much of the western United States. In addition, semi-arid and arid ecosystems represent over one-third of the Earth's terrestrial surface, and most are covered by biological soil crusts. As human impacts are escalating both regionally and globally in these drier regions, the research questions posed in this proposal have significant implications for global C budgets as well.
Findings/Accomplishments for 2010: With this ongoing project, we are continuing to maintain the treatments within our experimental plots and collect data. As we are looking at long-term effects of soil surface disturbance, we will continue to annually monitor change, and analyze data in the future.

4) Study Title: Southern Utah Visitor Profile Study 2010
Permit No.: ARCH-2010-SCI-0013
Principal Investigator: Emmett Steed
Purpose of Scientific Study: The purpose of this study is to understand Southern Utah's tourists, who stay overnight and travel more than 50 miles from their homes. The research seeks to answer the following questions:
1. What are the demographic characteristics of Southern Utah visitors?
2. What relationships exist among Southern Utah visitors in regard to place of origin, Southern Utah destinations visited, transportation utilized, activities selected while in Southern Utah, and trip expenditures?
3. Are there seasonal differences in origin, destinations, activities, and expenditures?
4. What are the information sources utilized by Southern Utah visitors?
Findings/Accomplishments for 2010:
Upon completion of 2/4 seasons of data collection we have initial demographic information and an initial count of the most influential information sources utilized by Southern Utah visitors. Below are descriptive statistics from initial data analysis (n-456).
Specific to national parks:
79% of visitor surveyed are visiting national parks;
71% are influenced by the internet;
62% are influenced by past knowledge in their travel plans; 53% are influenced by friends/family.
Demographics of survey visitors:
Gender: 50% male;
Ages: 27% 45-54; 24% 55-64; 18% 35-44;
Originating area codes:
27% mountain zone;
26% foreign zones;
16% pacific zone;
Marital status: 74% married
Education level: 38% graduated college; 38% post graduate degree
Profession: 25% professional; 16% managerial/executive; 18% retired; 13% education
Travel club affiliation: 47% belong to AAA; 26% belong to AARP
Household income: 41% >$100,000; 25% $60,000-$99,999; <$59,999 16%

CANYONLANDS NATIONAL PARK
RESEARCH SUMMARY 2010

1) Study Title: Population monitoring of humpback and bonytail chub in Cataract Canyon
Permit No.: CANY-2010-SCI-0001
Principal Investigator: Paul Badame
Purpose of Scientific Study: Goals: Maintenance of long term catch rate trend data, longitudinal distributions, and population size structures for humpback and bonytail within Cataract Canyon.
Objectives: 1. Complete one ten day pass each year sampling five sites within Cataract Canyon.
2. Obtain highest possible rates of capture of humpback and bonytail within concentration habitats and maximize number of individuals marked and captured at each sampling site.
3. Determine annual catch rate trend for chubs, examine population size structure, and compare longitudinal distribution to past years.
Findings/Accomplishments for 2010: Complete one sampling trip in Cataract Canyon in October 2010. Annual sampling was conducted October 21-28 2010 at the three long-term trend monitoring sites and at rapid 12 (Figure 1). Daily mean flows ranged from 6563 â 8282 ft3/sec (Figure 3) and water temperatures ranged from 13.9 â 11.1 ÂºC. No sites were sampled below the Big Drop rapids.
Humpbacks: A total of 14 Humpback chub were captured in 2010. Of these 11 were caught in trammel nets during 566.2 hours of effort resulting in a catch rate of .019 Humpbacks/ net hr. All Humpback chub caught by trammel nets were adults (i.e. >150 mm) with a mean total length of 225.2 mm. Electrofishing yielded three juvenile (i.e. <150 mm) Humpback chub during 4.12 hours of sampling resulting in a catch rate of .73 Humpbacks/ hr. No Humpback chub tagged prior to the 2010 were caught.
Bonytails: Two adult Bonytail were captured in trammel nets in 2010 at rapid 10 (RM 207.3-208.3). Their lengths were 265 and 255 mm. The 255 mm fish was initially stocked in April 1998 at river mile 94 on the Colorado River. It was recaptured in the Green River at river mile 341.2 in October 2008. During this time this fish grew a total 149 mm gaining 21 mm over the previous two years. The other Bonytail was not previously marked.
Overall Catch: A total of 163 fish consisting of 14 species were captured by trammel nets in Cataract Canyon in 2010. Humpback chub, Razorback sucker, and Bonytail made up 12.9% of the total sample. The total catch was comprised of 20.9 % natives. Humpback chub and channel catfish were the most common native and nonnative species present (Table 2). One hundred twenty five fish were encountered during electrofishing efforts. Endangered species, native species and nonnative species made up 3.2%, 5.6%, and 94.4% of the sample, respectively. Channel catfish and gizzard shad were the most abundant species in the sample.

2) Study Title: Assessment of Stocked Razorback Sucker and Colorado Pikeminnow Reproduction in the Lower Green River via Larvae and Young of Year Collections.
Permit No.: CANY-2010-SCI-0002
Principal Investigator: Paul Badame
Purpose of Scientific Study: This project targeted determining and monitoring early life stages of endangered fish in the Colorado River drainage, specifically the Colorado pikeminnow (Ptychocheilus lucius) and the razorback sucker (Xyrauchen texanus). Monitoring of young-of-the-year (YOY) Colorado pikeminnow was initiated in 1986 within the upper Colorado River basin as part of the Interagency Standardized Monitoring Protocol (ISMP). The ISMP sampling in the lower Green and Colorado Rivers was proposed to monitor recruitment success of first year endangered fishes, to correlate cohort strength

and condition to abiotic and biotic parameters, and to provide data for a predictive model measuring future cohort strength. Since its inception, the ISMP protocol has been updated to refine its scope and methods to focus not only on pikeminnow but all small-bodied fishes allowing for assessment of other projects such as nonnative control actions. A comprehensive synthesis of the effect of changes in physical habitat (as a function of flow and flow variability) and other environmental conditions on the small-bodied fish community (emphasis on Colorado pikeminnow) is underway.

Another aspect of this project is designed as a pilot study to determine the presence/ absence of early life stages of endangered razorback sucker in lower Green River. By the mid 1990s most wild riverine adult razorbacks in the Green River basin were limited to one population in the middle Green River with an estimated size of about 500 adults (Modde et al. 1996). Although sampling from 1992-96 did verify the presence of larval razorback in both the middle and lower Green River it was believed that mortality rates on those larvae were very high and did not provide any significant recruitment into the wild population (Muth et al. 1998). Habitats were identified for razorback sucker larvae as ephemeral shoreline, ponded lower portions of flooded tributary streams, side canyons, washes, canals, and channels (Muth et al. 2000). Historic collections sites for larvae were Millard Canyon, the confluence of the San Rafael River, and Green River Valley area. By 2000, wild adult razorback suckers in the Green River Basin were very rare and the few remaining have likely perished (Bestgen et al. 2002). Stocking of hatchery reared razorback sucker in the Green River basin began in 1999 as a means to augment the population and continues through this current time (US Fish and Wildlife Service 2002). Thus, all current reproduction observed is likely by stocked adults. Determining the reproductive success of stocked fish in the Green River is key to understanding their ability to maintain a viable self sustaining population.

During sampling for adult Colorado pikeminnow (2001-2003 and 2006-2008; UDWR unpublished data), within the lower Green River, the occurrence of adult razorback captures had increased greatly from 9-10 individuals per year to an average of 320 captures between 2006 and 2008. In addition, during the 2007-08 adult pikeminnow sampling an increased number of ripe adult razorbacks have been captured throughout the lower Green River and in two specific locations congregations of ripe razorbacks displaying spawning behavior have been observed and captured. In 2008, three age 1+ razorbacks were captured within the lower Green as well.

This progression of events over the last three years strongly suggests that adult stocked razorback are now persisting in large enough numbers within the lower Green to facilitate successful spawning. Successful spawning among stocked razorback is an important component of a viable recovery for the species. Determining the timing, locations, and relative extent of larval recruitment will help define the success of the species. Sampling focused on year one survival of larvae will provide information about potential road blocks to recruitment of young suckers into the adult population.

Findings/Accomplishments for 2010: Razorback sucker: Light trap samples were collected in the Green River Valley between 16 May and 23 June 2010. Forty eight light trap samples were collected from the Green River Valley. Of these 27 were sent to the CSU larval fish lab. Ninety four light trap samples were collected at downstream sites between river miles 105.4 and 19.5. Fifty seven samples were sent to the CSU larval fish lab for identification.

A 1 meter kick seine was used to collect 78 larval fish samples from flooded tributaries, side channels, backwaters, and embayments between 17 May 2010 and 24 June 2010. A total of 476 m2 of suitable habitat was seined and 17 samples were sent to CSU larval fish lab to be identified.

Colorado pikeminnow: Annual monitoring for YOY Colorado pikeminnow in Reach 3 began on September 12 and was completed on September 14, 2010. Seining was conducted on the Green River from river-mile 120 (Green River State Park) to river-mile 0 (confluence

with the Colorado River). Samples were collected at two backwater habitats within every 5-mile sub-reach, as available. A total of 29 of 48 possible backwaters were sampled in 20 of 24 sub-reaches in the lower Green River. Lower Green River flows (measured at USGS Gage #9315000 in Green River) fell from 2300 cfs to 2280 cfs over the three days of sampling. The lower Green River, measured at USGS Gage #9315000 in Green River, peaked this year on June 10 at 23,900 cfs (Figure 1). This is slightly higher and later than the 46-year (since dam operation began in 1964) median peak of 17,400 cfs on May 28, but consistent with long-term trends. Basin-wide flash flooding in August caused significant changes to the fluvial geology of side canyons, outwashes, backwaters, sandbars, and the main channel of the Green River. At the time of sampling, some backwaters had been scoured out and were still flowing; some areas had been flushed out and dropped suddenly leaving isolated pools where backwaters once were; other backwater habitats were clogged with sediment and debris from nearby flash floods. These events and resulting changes to backwater habitats may be correlated to lower numbers and shorter lengths of Colorado pikeminnow found during sampling as fish may have been washed out of habitats they had moved into before flooding. Because the locations of these stochastic climatic events were downstream from the Green River gage, we cannot track them using the current flow data.

In the lower Green River, 131 YOY Colorado pikeminnow were captured and measured. All fish were sorted, identified and enumerated in the field. The number of YOY Colorado pikeminnow captured was less than in 2009 (423 fish). This is also lower than the 10-year average (193.70 fish/year), 15-year average (248.47 fish/year), and 25-year average (501.08 fish/year) (Table 4). The CPUE this year was 4.57 fish/100m2, lower than the 10-year and 15-year averages (6.27 fish/100m2 and 7.22 fish/100m2, respectively), and considerably lower than the 25-year average of 14.88 fish/100m2 (Table 4). The average length of YOY Colorado pikeminnow was 29.86 mm, shorter than the 10, 15, and 25-year averages (43.36 mm, 39.46 mm, and 39.24 mm, respectively) (Table 4).

Other native species captured in the lower Green River were 3 juvenile Colorado pikeminnow, 7 flannelmouth suckers, 3 bluehead suckers, and 12 speckled dace (Table 5). Nonnative captures were enumerated during the first seine haul in each primary habitat. Total catches in reach 3 was once again dominated by nonnative cyprinids. Five nonnative species were present compared to six in 2009 (Table 6). These included red shiners (n = 1028), sand shiners (n = 1025), fathead minnows (n = 150), green sunfish (n=5), and gizzard shad (n = 4).

3) Study Title: Ground Cover on Aeolian Dunes in the Colorado River Corridor Through Cataract Canyon, Canyonlands National Park

Permit No.: CANY-2010-SCI-0003

Principal Investigator: Amy Draut

Purpose of Scientific Study: The purpose of the proposed study is to evaluate landscape ground cover in aeolian (wind-formed) dune fields within the Colorado River corridor through Cataract Canyon, Canyonlands National Park. Ground-cover properties serve as a proxy for evaluating sediment supply to, and sediment mobility within, aeolian landscapes. This study would constitute part of an ongoing, long-term research program investigating the effects of Glen Canyon Dam on the Colorado River ecosystem; complementary data have already been collected from aeolian dune fields downstream of the dam, in Grand Canyon National Park. The source of sediment supplied to aeolian dune fields in the Colorado River corridor is primarily from fluvial (river-deposited) sandbars. Because Glen Canyon Dam has eliminated the mainstem sediment supply in the Colorado River below the dam, with consequent loss of fluvial sandbars in Grand Canyon, it is likely that aeolian dune fields too have therefore evolved differently in Cataract and Grand Canyons since the dam was closed in 1963. Studying aeolian landscapes in Cataract Canyon, a river reach with near-natural sediment supply and annual floods, will provide data that are not only valuable

for ecosystem monitoring in Canyonlands National Park, but that provide a critical comparison with landscapes affected by Glen Canyon Dam in Grand Canyon National Park. I propose to measure ground cover on aeolian dunes above the recent spring high-water line through Cataract Canyon. Measurements would include quantifying the amount and species of vegetation, amount of biologic crust, and amount of open sand space within dune fields, focusing on areas that are near (within 100 m) and downwind of fluvial sandbars that form by annual Colorado River floods. This work can be accomplished with minimal impact to resources, and is anticipated to generate results of great value to understanding the effects of dams on the Colorado River ecosystem with widespread applications to other arid riparian zones.

Findings/Accomplishments for 2010: Field work took place in July 2010 at 13 sites, listed in Table 1 of the report referenced here. The study successfully collected data on vegetation abundance and substrate composition in aeolian sand landscapes of Cataract Canyon, and we published the results in a USGS open-file report in December 2010: Draut, A.E., and Gillette, E.R., 2010, Vegetation and substrate on aeolian landscapes in the Colorado River corridor, Cataract Canyon, Utah: U.S. Geological Survey Open-File Report 2010-1273, 61 p., 14 tables, http://pubs.usgs.gov/of/2010/1273/. I also have a journal manuscript in review that compares those properties of Cataract Canyon aeolian landscapes with those downstream of Glen Canyon Dam, in Grand Canyon National Park. When that gets published, I will send it to Canyonlands NP; the data in the journal paper are the same as those raw data presented in the open-file report listed above. The study was entirely successful; I don't know whether we will need to do additional work in Canyonlands next year so I checked "completed", but if at some time in the future we would benefit from collecting additional data, I will contact the Park to ask about resuming permission to work there.

4) Study Title: Impacts of Climatic Change and Land Use on the Southwestern U.S.
Permit No.: CANY-2010-SCI-0004
Principal Investigator: Jayne Belnap
Purpose of Scientific Study: The population of the southwestern United States has grown rapidly over the past two decades and is projected to increase greatly over the next several decades. As the population has grown, climatic variations that would have affected relatively few people in the past will impact the lives of millions. Rapid and wide-spread climatic changes, such as those seen thousands and hundreds of years ago in the region and those projected for the future, may profoundly change the character of the region. Arid and semi-arid regions of the southwestern U.S. are among the most sensitive regions to changes in climate and land use, but the potential interactions between climatic change and land use are largely unknown (http://climweb.cr.usgs.gov/info/sw_new/swmap.html). U.S. Geological Survey and collaborating scientists are seeking to understand how climate and how land use has influenced surface geologic processes that modify landscapes and ecosystems. Such understanding is then used to model the landscapeâ s response to future changes in climate and land use over time scales of seasons, of a few years, and of a few decades, so that information and interpretations can be applied by federal, state, and local agencies, as well as by Native American governments, for their land-use planning and management of resources.

Project scientists work with ecologists, hydrologists, geographers, cartographers, and archeologists to address questions about:

(1) the causes and timing of changes in alluvial environments (rivers, streams, hillslopes), such as flooding, the cutting and filling of arroyos, and sediment discharge;

(2) the role of eolian dust for soil fertility, invasion of exotic species, hydrology, and surface stability in deserts;

(3) the interaction of physical and biologic processes critical for ecosystem functions;

(4) how climate in the southwest has varied over decades, centuries, and millennia;

(5) how future climatic variations will affect the Southwestern land surface (in terms of erosion, sand-dune activity, dust-storm frequency, flooding, landslides,);
(6) how past climatic changes and environments affected prehistoric cultures.
General Project Goals
-- Understand how past climatic change affected land surface: soil loss, fluvial erosion and alluviation, sand-dune mobilization, ecosystems, under time frames of past decades, centuries, and millennia.
-- Understand today's interplay among climate, land use and surface processes (geologic and ecologic).
-- Understand the impacts of future climate on land surface under the following time frames: seasons; El Nino/La Nina cycles; multiyear wet/drought periods; and decades, as atmospheric CO2 increases.
A major goal is to interact with federal, state, and local government agencies as well as non-governmental organizations to provide information useful for management decisions regarding land-surface vulnerability to wind erosion. Another goal is to provide to managers and other parties ongoing remote sensing and meteorological monitoring bearing on the vulnerability of the land to natural and human disturbances.
Specific goals for Canyonlands work
-- Understand geologic origins of soil nutrients and the interactions of soil compounds and plants.
-- Understand geomorphic controls on plant distribution
-- Understand the recent (past several decades, centuries, millennia) geologic/geomorphic evolution of the ecosystem to reveal patterns of surface stability and instability.
-- Recognize areas vulnerable to wind erosion and soil loss.
-- Understand conditions of cheatgrass (and other exotic plants) invasion to predict areas most vulnerable to expansion and to help devise mitigation strategies.
Findings/Accomplishments for 2010: This is a long-term project, with which we hope to understand climatic variability and its effects on dust projection and soil fertility.
Multiple years will be required to capture the full range of variability so that we may better understand the role of extreme events, as well as normal regimes.

5) Study Title: Atmospheric Dust Deposition to Canyonlands National Park
Permit No.: CANY-2010-SCI-0005
Principal Investigator: Jayne Belnap
Purpose of Scientific Study: The purpose of installing a total suspended particulate (TSP) sampler at Island in the Sky, Canyonlands National Park is to quantify the transport of windblown dust and to characterize the temporal variations in the chemical composition of this dust. Dust is a major atmospheric contaminant and a primary cause of reduced visibility in National Parks and other Class 1 airsheds. Despite the importance of dust to air quality and visibility, the sources, variability and composition of dust is not well understood. Accordingly, we are proposing the installation of a dust collector at Island in the Sky in CNP in order to develop a long-term dataset on dust deposition to the park. There are many factors that control the emission of dust from arid ecosystems including both land-use and climate. However, in order to better assess the quantity of material that is moved as well as its geochemical composition, we need the ability to regularly collect samples of suspended dust. The proposed sampler will provide a tool for the collection and chemical analysis of dust on a regular timescale and will greatly improve our estimates of dust fluxes to and from Canyonlands NP. The TSP sampler is a simple instrument that allows for the high volume filtration of suspended particulates. It consists of a 7.0 amp pump motor that is housed in an aluminum enclosure, resembling a large birdhouse. The pump pulls air over the lip of the aluminum enclosure through an 8â x10â filter paper. The physical barrier provided by the lip prevents large objects such as leaves or insects from being collected on the filter but does allow the collection of a large range of particle sizes. In comparison with

other common aerosol sampling equipment, such as those used by the IMPROVE network, the TSP is able to collect a more representative sample of suspended dust. Additionally, because the TSP rapidly samples high volumes of air, more concentrated samples can be collected. The flux of dust from Canyonlands ecosystems has important ecological implications. Dust is generated from the wind erosion of surface soils and this process is most extreme in arid and semi-arid ecosystems. Both the removal and subsequent deposition of dust can influence the ecosystem nutrient cycling and productivity. For example, the removal and/or redistribution of surface soils in arid ecosystems have been shown to alter the nutrient composition of surface soils and to influence the heterogeneity in vegetation composition. Additionally, dust exported from the arid southwest can be represent and significant input of materials to downwind ecosystems as far away as the Rocky Mountains.
Findings/Accomplishments for 2010: Dust collector is maintained, and samples are regularly collected by NPS personnel in the ISKY district of Canyonlands.

11) Study Title: Climate change in dryland regions: response of ecosystem components, including biological soil crusts, vascular plants and soil nutrients, to decreased soil moisture. (Rainout Shelters)
Permit No.: CANY-2010-SCI-0011
Principal Investigator: Jayne Belnap
Purpose of Scientific Study: Long-term climate models predict that the southwestern area of North America will experience a significant decrease in annual precipitation over the coming decades. This research study is part of a larger project that has sites located throughout Southeastern Utah investigating the effects of decreased precipitation on biological soil crusts and the surrounding vegetation of multiple different plant and soil communities. The big project plans to look into the sensitivity and thresholds in biocrusts, native and invasive plants, dust production, and snowmelt in the western United States. The Park's land provides us with areas which have been fenced off from cattle, which would be a fantastic addition to the other sites available to us for this research. At each of the four research sites in Canyonlands (two in the Needles district and two in ISKY) there are two experimental plots, a control plot and a plot that has a rainout shelter. This shelter is designed to prevent approximately 25% of all precipitation events from reaching the soil surface by a series of gutters that divert the precipitation off of the plot. Each of the sites also has an automated datalogger that records air temperature and relative humidity, precipitation, and soil temperature within each plot. Throughout the study we will monitor the biological soil crust and plants within each plot to determine the effects on species composition and survivability with respect to the different precipitation regimes.
This project addresses USGS Science Strategy (1. Ecosystems, 2. Climate Variability), the US Climate Change Program Strategic plan (8.1, Feedbacks; 8.2., Potential ecosystem consequences, 8.3., Options) and Goals 1, 2, 3 and 4 of the BRD Global Change meeting notes.
Findings/Accomplishments for 2010: During this first year of the study, the experimental plots were established at the four locations in the park. We also collected the first set of measurements looking at the soil and plant characteristics within the control and shelter plots. We are currently processing and analyzing this data.

13) Study Title: Repeat Photography of Cataract Canyon and Vicinity, Southern Utah
Permit No.: CANY-2010-SCI-0013
Principal Investigator: Robert Webb
Purpose of Scientific Study: From 1991 through about 1995, our research group matched approximately 270 photographs of the Colorado River in Canyonlands National Park, particularly in Cataract Canyon. Of these, 60 were originally taken during the Brown-Stanton expedition of 1889 and 25 by the 2nd Powell Expedition in 1871. We propose to

rematch these photographs and to assess mortality and recruitment information for common species of desert and riparian vegetation along the river corridors.
Findings/Accomplishments for 2010: We matched 35 photographs taken by Franklin A. Nims in May-June 1889 and first matched between 1991-1996. These photographs generally document changes in desert vegetation but also changes in riparian vegetation along the Colorado River.

16) Study Title: Slack water deposits along the Green River
Permit No.: CANY-2010-SCI-0016
Principal Investigator: John Weisheit
Purpose of Scientific Study: To locate and investigate slack water deposits, which are perched river sediment deposits from extreme flooding events along the margins of the high water zone. Long-term (older than the instrument record) flood volumes and frequency can be determined by these deposits. The data are useful to agencies, such as the Bureau of Reclamation.
Findings/Accomplishments for 2010: Assessment of Future Paleoflood Analysis Sites, Lower Green River. In early July, 2010, we did a reconnaissance survey of the lower Green River, near its junction with the Colorado. Our preliminary analysis of data from this survey indicates that the lower Green River canyons contain an excellent record of extreme paleofloods, probably occurring within the last few thousand years. Using our field survey of paleostages reached at 14 sites along the Stillwater Canyon reach of the lower Green River, we estimated cross-sectional areas for the hydraulic geometries at the respective flood stages. Multiplying these cross-sectional areas by mean flow velocities determined for analogous hydraulic geometries (similar slope, similar cross- sectional areas and dimensions) by HEC-RAS analyses of the Moab Study Site on the mainstem Colorado River (Greenbaum et al., 2010), we estimate paleodischarges achieved at the 14 Stillwater Canyon sites along the Green. As shown in the table below, the peak flows achieved on the Green River seem to have reached at least 6000 cubic meters per second (cms) and perhaps as high as 8000 cms. Although we did not have the resources to do the geochronology, the flood deposits are clearly late Holocene and probably comparable in age to the deposits at the Moab Study Site (i.e., the last few thousand years).
The importance of these values can be appreciated by the fact that the largest historically documented flood of the Green River is that of 1884, with a peak flow estimated at approximately 2830 cms (6370 cms on the Colorado below its confluence with the Green, minus the 3540 cms contributed by the main-stem Colorado above the confluence).
These results show that a future in-depth survey, similar to what we did for the Moab Study Site (Greenbaum et al., 2010), would significantly transform our understanding of the magnitude and frequency of extreme flood phenomena on the entire upper Colorado system (including the Green River), showing that the modern stream gage records are totally inadequate for understanding extreme flood phenomena in this system. This conclusion points to the need for a much more extensive paleoflood study of the upper Colorado system than was possible in this limited reconnaissance study.
Reference Cited
Greenbaum, N., Weisheit, J.S., Harden, T., Dohrenwend, J.C., 2005. Paleofloods of the upper Colorado River near Moab, Utah, May,
2006. In: Weisheit, J.S., and Fields, S.M. (Eds.), The Moab Mill Project: A Technical Report Towards Reclaiming Uranium Mill
Tailings along the Colorado River in Grand County, Utah. Living Rivers, Moab, Utah, pp. 13-28.

17) Study Title: The Role of Biological Soil Crusts in soil nutrient cycles as Influenced by Soil Surface Disturbance, Climate Change and Annual Grass Invasion
Permit No.: CANY-2010-SCI-0017

Principal Investigator: Jayne Belnap
Purpose of Scientific Study: This project will establish how alterations in species composition by surface disturbance, invasive grasses, and/or climate change may affect N and C inputs and fluxes, in different soils under different climatic regimes.
Findings/Accomplishments for 2010: With this ongoing project, we are continuing to maintain our experimental plots and collect data. As we are looking at long-term effects of soil surface disturbance, we will continue to annually monitor change, and analyze data in the future.

21) Study Title: Southern Utah Visitor Profile Study 2010
Permit No.: CANY-2010-SCI-0021
Principal Investigator: Emmett Steed
Purpose of Scientific Study: The purpose of this study is to understand Southern Utah's tourists, who stay overnight and travel more than 50 miles from their homes. The research seeks to answer the following questions:
1. What are the demographic characteristics of Southern Utah visitors?
2. What relationships exist among Southern Utah visitors in regard to place of origin, Southern Utah destinations visited, transportation utilized, activities selected while in Southern Utah, and trip expenditures?
3. Are there seasonal differences in origin, destinations, activities, and expenditures?
4. What are the information sources utilized by Southern Utah visitors?
Findings/Accomplishments for 2010: Upon completion of 2/4 seasons of data collection we have initial demographic information and an initial count of the most influential information sources utilized by Southern Utah visitors. Below are descriptive statistics from initial data analysis (n-456).
Specific to national parks:
79% of visitor surveyed are visiting national parks;
71% are influenced by the internet;
62% are influenced by past knowledge in their travel plans; 53% are influenced by friends/family.
Demographics of survey visitors:
Gender: 50% male;
Ages: 27% 45-54; 24% 55-64; 18% 35-44;
Originating area codes:
27% mountain zone;
26% foreign zones;
16% pacific zone;
Marital status: 74% married
Education level: 38% graduated college; 38% post graduate degree
Profession: 25% professional; 16% managerial/executive; 18% retired; 13% education
Travel club affiliation: 47% belong to AAA; 26% belong to AARP
Household income: 41% >$100,000; 25% $60,000-$99,999; <$59,999 16%

HOVENWEEP AND NATURAL BRIDGES NATIONAL MONUMENTS RESEARCH SUMMARY 2010

1) Study Title: Soil Survey of Hovenweep National Monument, Utah
Permit No.: HOVE-2010-SCI-0001
Principal Investigator: Victor Parslow
Purpose of Scientific Study: To provide an updated soil and ecological site inventory for Hovenweep NM that meets National Cooperative Soil Survey (NCSS) standards and park management and planning needs.
Findings/Accomplishments for 2010: No field activity was conducted this report year. A draft manuscript and shapefiles were produced this year, and the soils database completed.

2) Study Title: Soil Survey of Natural Bridges National Monument, Utah
Permit No.: NABR-2010-SCI-0001
Principal Investigator: Victor Parslow
Purpose of Scientific Study: To provide an updated soil and ecological site inventory for Natural Bridges National Monument (NABR) that meets National Cooperative Soil Survey (NCSS) standards and park management and planning needs.
Findings/Accomplishments for 2010: A channel type study and riparian vegetation assessment was conducted in 2010. Data collected will be used to complete the Ecological Site Descriptions for the Monument.

3) Study Title: Southern Utah Visitor Profile Study 2010
Permit No.: HOVE-2010-SCI-0003
Principal Investigator: Emmett Steed
Purpose of Scientific Study: The purpose of this study is to understand Southern Utah's tourists, who stay overnight and travel more than 50 miles from their homes. The research seeks to answer the following questions:
1. What are the demographic characteristics of Southern Utah visitors?
2. What relationships exist among Southern Utah visitors in regard to place of origin, Southern Utah destinations visited, transportation utilized, activities selected while in Southern Utah, and trip expenditures?
3. Are there seasonal differences in origin, destinations, activities, and expenditures?
4. What are the information sources utilized by Southern Utah visitors?
Findings/Accomplishments for 2010:
Upon completion of 2/4 seasons of data collection we have initial demographic information and an initial count of the most influential information sources utilized by Southern Utah visitors. Below are descriptive statistics from initial data analysis (n-456).
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Education level: 38% graduated college; 38% post graduate degree
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Household income: 41% >$100,000; 25% $60,000-$99,999; <$59,999 16%

4) Study Title: Wood Documentation and Research, Natural Bridges NM
Permit No.: NABR-2010-SCI-0005
Principal Investigator: Tom Windes
Purpose of Scientific Study: This study is to continue the wood documentation and tree-ring studies started in 2000 while I was an archaeologist in the Anthropology Programs, Santa Fe Support Office, during an inventory survey of sites at NABR. The goal is to map and inventory all structural wood resources in the park at sites exhibiting structural integrity. These are perishable resources which have never been systematically recorded nor mapped, are suffering from deterioration from weathering, wet soils, vandalism, natural displacement and other causes, and are part of the NPS mandate to protect and preserve the natural and cultural resources. Wood not only provides one of the most informative pieces of cultural information in archaeology but also detailed environmental records of the past regarding climate, fire histories, etc. My team of researchers are experienced, having worked in parks and other gov't lands throughout the Southwest, including Chaco Culture, Aztec Ruins, Mesa Verde, Pecos, and others, and form a unique team that records each piece of structural wood and the site within which it is associated. We also provide detailed maps of intact and semi-intact structures that provide the most-up-to date records of the cultural resources. Finally, dendrochronology is applied at each site to provide tree-ring dates, species use, and samples curated and protected from further deterioration.
Findings/Accomplishments for 2010: In 2010, our goals were to provide large detailed maps of all the complex sites with numerous structural wood resources, to number and document every piece of structural wood (and occasionally large pieces of charcoal) on the maps as well as a 54-attribute-list for each piece of wood, and to sample by coring or cutting all samples with dating potential. These would augment the earlier studies at sites, which started in 1998 (see McVickar 2001). Many pieces have suffered extreme exposure to the elements, been moved from their prehistoric contexts by historic visitors or animals or gravity, or have been destroyed by natural (e.g., fires or lightning) and historic effects (collected for firewood, as souvenirs, or just tossed). Thus, it is very important to capture their present locations on maps to enable management and researchers to discern future negative effects to the site resources and to freeze-frame the site as we found and mapped it for conditional assessments and potential future research. In addition to the structural wood, large or rare artifacts, when encountered, were also mapped (e.g., hatch covers, manos, metates, projectile points, rare minerals, textiles, etc) as well as the general locations of bulk materials such as sherds from broken pottery, chipped stones, and corn cobs (e.g., specific areas of refuse). No artifacts were collected. We retrieved 49 tree-ring samples this year, which will augment the AD 1200s dates obtained in the past. The amount of tree-ring samples retrieved since the study began make this one of the best dated and documented Park Service units in the United States, as well as providing a priceless collection of samples useful for environmental and climatic studies. Between 31 July and 12 August 2010, four volunteers conducted archaeological work at five sites in Natural Bridges: 42SA6645, 42SA6788, 42SA6803, 42SA6804, and 42SA6837. Sixteen new detailed site plans and feature maps were produced in 2010, along with site tallies of artifacts, and several dozen more pieces of structural wood were documented. Copies of this material are housed in curation at the National Park Service office in Moab, Utah.
Despite the poor weather and small field crew, we accomplished much in a week and a half in 2010. We visited five sites in the canyons and completed or revised notes for them. Four

had been documented and sampled by the Wood Project Crew previously, thus few new tree-ring samples were collected. But we expanded our field identifications of artifacts and rock art at the sites, and remapped or expanded our mapping for those sites previously documented. These sites now have a wealth of detailed information about them, which can be used for both future research and management. In addition, the new tree-ring samples should provide more dates from these sites on which to determine their initial construction and, perhaps, remodeling and newer additions, but also they help provide priceless environmental and botanical information of past conditions and tree presence.

Reference

McVickar, Janet L. (editor)
2001 An Archaeological Survey of Natural Bridges National Monument, Southeastern Utah. Intermountain Cultural Resources
Management Professional Paper No. 64. Anthropology Projects, Cultural Resources Management, Intermountain Region, National
Park Service, Santa Fe, NM.

5) Study Title: Southern Utah Visitor Profile Study 2010
Permit No.: NABR-2010-SCI-0006
Principal Investigator: Emmett Steed
Purpose of Scientific Study: The purpose of this study is to understand Southern Utah's tourists, who stay overnight and travel more than 50 miles from their homes. The research seeks to answer the following questions:
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2. What relationships exist among Southern Utah visitors in regard to place of origin, Southern Utah destinations visited, transportation utilized, activities selected while in Southern Utah, and trip expenditures?
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Findings/Accomplishments for 2010:
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