2006 RESEARCH PERMITS

Charles Schelz / SEUG Ecologist

ARCHES NATIONAL PARK

2006 Research Permits

1) Sucec Permit Denied

2) Permit #: ARCH-2006-SCI-0002

Study Title:

PILOT STUDIES TO INFORM RIPARIAN MONITORING PROTOCOLS – REFINEMENT OF SITE SELECTION METHODS AND FIELD TRIALS OF PROPOSED MONITORING METHODS

Primary investigator contact information:

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Project Summary:
We propose a research program aimed at testing methods described in the current draft protocols for monitoring riparian resources in Southern and Northern Colorado Plateau Network Parks. The monitoring of riparian resources has been identified by both networks as a high-priority because these ecosystems contribute to high local biodiversity and are sensitive to a wide range of on-site and off-site human activities. By conducting field trials, we intend to refine two important components of the riparian monitoring protocols: (1) the site selection process based on the draft stream classification framework; and, (2) the in-field sampling procedures. Pilot studies will allow us to test the application of the classification framework, to conduct methods comparisons trials, to evaluate inter-observer error trials and to determine the number of stream transects within a reach that will be required to adequately characterize variance for selected metrics. Following the pilot studies, we will report the results in the 2006 field trial report and refine the draft riparian protocols; ultimately contributing to rigorous, repeatable and cost effective riparian monitoring protocols for the Southern and Northern Colorado Plateau Networks

Collections:
No material or specimens will be collected for this project.

3) Permit #: ARCH-2006-SCI-0003

Study Title:
THE MOAB SITE ENVIRONMENTAL AIR MONITORING PROGRAM - CONDUCTED BY THE U.S. DEPARTMENT OF ENERGY'S OFFICE OF ENVIRONMENTAL MANAGEMENT LOCATED IN GRAND JUNCTION, COLORADO.

Primary investigator contact information:

Name: Mr. Joel Berwick, U.S. Department of Energy (DOE)
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Project Summary:
DOE's environmental air monitoring program will monitor local and background air quality for various radio-particulates (U-nat, Th-230, and Ra-226), radon-222, and opacity (i.e., fugitive dust emissions). This project was initiated following concerns the Atlas tailings pile might be contributing to declining air quality.

Collections:
Only air samples will be collected at a station set up near the Arches visitor center. No other sampling allowed.

2004 Findings and Status:
Monitoring data collected during 2004 indicate that concentrations of airborne radioparticulates (i.e., Po-210, Ra-226, Th-230, and natural [total] Uranium), atmospheric radon-222, and direct gamma radiation levels observed at the Arches National Park monitoring location are indistinguishable from background (naturally occurring) concentrations and levels. None of the 2004 data collected at this location exceeded any regulatory limit, threshold, or guideline that is applicable to this study. The uranium mill tailings stockpiled at the former Atlas mill site (located approximately 0.75 miles south of the Arches National Park entrance) do not appear to have any significant impact upon air quality and public radiation dose/exposure levels, as measured at the entrance to Arches National Park. DOE is required to conduct environmental monitoring and surveillance at sites where DOE activities have the potential to release contaminants to either the public and/or the environment. DOE will continue to monitor air quality and public exposure limits at this location to document negative exposure and public impacts, and to better understand variations in seasonal air quality conditions.

2005 Findings and Status:
Monitoring data collected during 2005 indicate that concentrations of airborne radioparticulates (i.e., PO-210, Ra-226, Th-230, and natural [total] Uranium), atmospheric radon-222, and direct gamma radiation levels observed at the Arches National Park monitoring location are indistinguishable from naturally occurring concentrations and levels. None of the 2005 data collected at this location exceeded any regulatory limits, thresholds, or guidelines that are applicable to this study. According the measurements taken during this reporting period at the monitoring station near the park entrance, the uranium mill tailing stockpile at Moab UMTRA Project site (located approximately 1/2 mile south of the Arches National Park entrance) does not appear to have any significant impact on the air quality or public radiation dose and exposure levels. DOE is required to conduct environmental monitoring at sites where its activities have the potential to release contaminants to the public and/or to the environment. DOE will continue to monitor the air quality and public exposure limits at this location for the duration of the Moab UMTRA Project to document any exposure impacts and to better understand variations in seasonal air quality conditions.

4) Permit #: ARCH-2006-SCI-0004

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

Primary investigator contact information:

Name: Dr Jayne Belnap, USGS Canyonlands Field Station
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Phone: 435-719-2333 **Email:** jayne_belnap@usgs.gov

Project Summary:

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.

Collections:

Soils from the top 10 cm of the soil surface will be collected using a small (<1" diameter) soil auger. At each site, approximately 20 auger samples will be haphazardly collected from an area approximately 20x20 m. Holes are small enough that they self-fill shortly after the disturbance. These samples will be taken once each year.

All samples will be destroyed in analysis.

2005 Findings and Status:

STRUCTURE AND FUNCTION OF SOIL BACTERIAL AND FAUNAL COMMUNITIES AROUND A GRASS AND SHRUB AS INFLUENCED BY BIOLOGICAL SOIL CRUSTS . Vascular plants and soil crusts provide resources directly to soil bacteria and faunal grazers, and indirectly to other soil fauna that feed on them. Plants and soil

crusts may also shape the structure and function of soil communities by controlling inputs of carbon, nitrogen, water and light into the soil. Because soil resource availability is expected to decline with decreased plant and crust cover, and differ by plant and crust type, we examined two plant and crust types to quantify underlying soil chemistry and bacterial and faunal communities. In two separate locations, containing both early successional (Microcoleus dominant) and later successional (Nostoc/Scytonema/Collema) soil crusts, we sampled three microsites (stem, dripline, and interspace) around a dominant shrub (Coleogyne ramosissima) and grass (Stipa hymenoides). Soil chemistry analyses revealed N availability typically was greater at the plant stem, while P availability was greater in interspaces around Coleogyne. Microsites closer to the plant had greater abundance of rhizosphere-dependent bacteria and nematodes, regardless of crust type. Soil protists, however, rarely differed by microsite in either crust type, indicating that soil crusts may more strongly influence their distribution than vascular plants. Abundance of soil biota also differed by plant species, with Coleogyne supporting more bacteria and fauna than Stipa. Overall, these results support the hypothesis that plants and biological soil crusts affect the structure and function of soil bacterial and faunal communities. Global change induced shifts in plant community composition or losses of biological soil crusts in the southwestern US will likely result in reduced soil nutrient cycling via declines in plants, biological soil crusts, and their dependent organisms.

5) Permit #: ARCH-2006-SCI-0005

Study Title:

IMPACT OF INTRODUCED GRASSES ON GRASSHOPPER COMMUNITIES IN COLORADO PLATEAU GRASSLANDS: IMPLICATIONS FOR POPULATION VIABILITY OF NATIVE PERENNIAL GRASSES

Primary investigator contact information:

Name: Dr. Tim Graham, USGS
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Phone: 435 719-2339 **Email:** tim_graham@usgs.gov

Project Summary:

The change from native to non-native grasses affects quality, quantity and timing of available food for grasshoppers and other herbivores. Grasshopper community composition changes, and pressure on remaining native perennial grasses increases. Insectivores also respond negatively to dominance by non-native grasses, primarily because of a simplification of plant architecture. Predation on grasshoppers and other herbivores thus decreases, resulting in additional consumption of remaining native species. It has been suggested that increased herbivory reduces competitive ability of native grasses enough that non-native species are able to maintain dominance even after the disturbances that allowed establishment have ceased.

The proposed study will document differences in grasshopper community structure in native and cheatgrass dominated grasslands of the Colorado Plateau, and correlate these differences with characteristics of the grassland vegetation communities such as amount of bare ground, grass height, cover of perennial and annual grasses, etc. Implications for interactions between cheatgrass and native perennial grasses will be explored as well. In particular, the effect of maturing cheatgrass on grasshopper survival and fecundity, and thus population size, will be tested, and experiments on competitive abilities of cheatgrass vs. selected native grasses with and without grasshopper herbivory will be conducted. The study could be expanded to the Great Basin and Columbia River Basin, which are also being overrun by cheatgrass and other introduced plants, to see if herbivory plays a role in continued dominance by these exotic species in other arid and semi-arid grasslands.

Collections:

The collection of voucher specimens of grasshoppers only is allowed. Specimens will be stored at the Northern Arizona University-Colorado Plateau Museum of Arthropod Biodiversity.

2005 Findings and Status:
No activity was conducted in Arches NP in 2005 related to this project.

6) Permit #: ARCH-2006-SCI-0006

Study Title:
VEGETATION DATA COLLECTION IN SUPPORT OF THE U.S. GEOLOGICAL SURVEY NATIONAL PARK SERVICE VEGETATION CLASSIFICATION AND MAPPING PROGRAM AT ARCHES NATIONAL PARK

Primary investigator contact information:

Name: Mr. James Von Loh, Engineering-Environmental Management, Inc.
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Project Summary:
The National Park Service (NPS) and U.S. Geological Survey (USGS) are cooperating to produce detailed vegetation classifications and digital databases, including vegetation maps, as part of the National Biological Information Infrastructure Program (NBII). Approximately 250 national parks and monuments will benefit from this cooperative effort upon successful program completion. The National Park Vegetation Classification and Mapping Program is a strong component of the NPS Inventory and Monitoring Program, established in 1991, and is based on a repeatable set of standards and flexible protocols.Sampling will be conducted in accordance with the Vegetation Classification and Mapping Work Plan developed for Arches National Park in February 2003, which has been reviewed by USGS-NPS Vegetation Classification and Mapping Program leaders, Northern Colorado Plateau Network (NCPN), and/or Arches ecologists. This work plan will serve as the basis for all such efforts at the park, including sampling methodology, and should be considered as the study proposal. Copies of the work plan, both electronic and hard-copies, are available through the NCPN Inventory and Monitoring Program, or from the park ecologist.

The field work to be performed this spring is related to accuracy assessment of the vegetation map. Following completion of the vegetation map, a random sample of points will be determined by Gery Wakefield and Aneth Wight that will be used to test the accuracy of mapped data. At this time I do not know the exact number of points or their locations, but would expect them to be in the range of 800-1,000. Field biologists (Vegetation mapping crews from NCPN led by Liz Ballenger) will download the AA point UTM coordinates into GPS receivers and navigate to the point. They will complete an accuracy assessment form that provides location, environmental, and vegetation cover information and will also key the vegetation of the area around the point (40 m radius circle) to a plant association using an illustrated field key. Two or more photographs will be taken to adequately document the site. These data will be entered into a database and analyzed to produce a contingency table illustrating the accuracy of each plant association tested and will also provide the overall map accuracy. The national map accuracy standard is 80% accuracy for each map unit and 80% accuracy for the entire map.

Collections:
Collection of parts of plants for identification purposes only allowed. These must be destroyed in analysis. Plant species that are very uncommon or are legally protected under the Endangered Species Act will not be collected but will have digital photos taken for documentation. No curation of plants is allowed.

2005 Findings and Status:

While no field data collection was performed in ARCH in 2005, several other vegetation classification and mapping tasks were conducted. An illustrated field key of the 62 plant associations for ARCH was produced with photos and a dichotomous key. Photo interpretation created a vegetation map with a legend key that was digitized. Also, local descriptions of the 62 plant associations identified for ARCH were produced describing the environmental conditions and species present for the associations within the park.

7) Permit #: ARCH-2006-SCI-0007

Study Title:
HERBARIUM AND FIELD STUDIES OF VASCULAR PLANT FLORA OF ARCHES NP FOR NATIONAL PARK SERVICE INVENTORY AND MONITORING PROGRAM

Primary investigator contact information:

Name: Walter Fertig
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Project Summary:
The purpose of this study is to document the vascular plant flora of Arches National Park (ARCH) and develop a plant distribution database using the National Park Service's NPSpecies system.

2005 Findings and Status:
As a first step in developing an updated species list and distribution database for the park, I examined all specimens in the Arches NP herbarium to correct misidentifications, update species nomenclature (following Welsh et al. 2003, "A Utah Flora, third edition"), and add variety or subspecies names if needed. Of the 623 specimens currently deposited in the collection, 32 were misidentified (5.1%), 28 had their names updated (4.5%), 122 had variety names added (19.6%), and 441 were confirmed as correctly identified (70.8%). Another 259 specimens reported in the park's museum database (ANCS+) are presently on loan and could not be verified. The Arches herbarium currently contains 365 vascular plant taxa collected within the park (plus an additional 14 species from outside park boundaries). At least 122 additional plant species have been reported for Arches NP by Schelz and Moran (2005 SE Utah Group Plant list) and Harrison et al. (1964 "Plants of Arches National Monument, BYU Biological Series 5(1):1-23) but are not represented by collections in the Arches herbarium. Based on the Atlas of the Utah Flora (Albee et al. 1988), 229 additional species are reported from comparable habitats in the vicinity of Arches NP, but have not yet been documented within the park. These results suggest that the Arches NP herbarium is missing a significant number of plant taxa known or likely to occur in the park. In particular, fall-flowering and wetland species appear to be under-represented. Targeted inventory work to fill gaps in the Arches NP vascular plant collection is recommended so that park manager's will have an improved understanding of the composition and status of the flora of the park and a more complete reference collection for researchers and staff interested in plant identification.

8) Permit #: ARCH-2006-SCI-0008

Study Title:
A STUDY TO DETERMINE THE AGE AND SOURCE OF RECHARGE FOR THE WATERS OF THE MOAB MEMBER AND NAVAJO SANDSTONE AQUIFERS IN THE COURTHOUSE WASH AREA, GRAND COUNTY, UTAH

Primary investigator contact information:

Name: James Harte
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Project Summary:
This project consists of the sampling and analysis of water from four ground water wells and four springs near the west boundary of Arches National Park, located about ten miles north of Moab, Utah. The wells and springs are located along an approximately ten-mile section of the geologic structure known as the Courthouse Syncline. Two of the ground water wells produce water from the Navajo Sandstone aquifer and two ground water wells produce water from the Moab Member aquifer. The source of water for the springs is the Moab Member aquifer (Hurlow and Bishop, 2003). The Utah Geological Survey (UGS), 1594 West North Temple, Suite 3110, P.O. Box 146100, Salt Lake City, Utah 84114-6100 will be responsible for the collection and analysis of the water samples under the direction of Jim Harte, National Park Service, Water Resources Division. The UGS contact will be Mr. Mike Lowe, (801) 537-3389.

OBJECTIVE:
Determine the relative age and source of recharge for waters of the Moab Member and Navajo Sandstone aquifers. "Fingerprint" waters from Moab Member and Navajo Sandstone aquifers. Determine if a connection exists between the Moab Member and Navajo Sandstone aquifers near the west boundary of Arches National Park.

DESCRIPTION OF SITE LOCATIONS AND WORK TO BE PERFORMED
The National Park Service desires to test ground water and spring water in the Navajo Sandstone and Moab Member aquifers from sources adjacent to Arches National Park to determine its chemical characteristics, age, and source of recharge.

SAMPLE COLLECTION:
Samples will be collected by UGS personnel using applicable standard USGS sampling protocol. Water samples from each well and spring site will be analyzed at a certified laboratory using established EPA analysis protocol.

Water samples collected from each well and spring will be analyzed for the following constituents: General Chemistry (State of Utah Type 3), Ammonia, Dissolved Nitrate and Nitrite, Dissolved Total Phosphate, Total Phosphate, Carbon 14, Tritium, Oxygen 18 and Deuterium.

9) Permit #: ARCH-2006-SCI-0009

Study Title:

SOIL SURVEY OF ARCHES NATIONAL PARK, UTAH

Primary investigator contact information:

Name: Mr Victor Parslow, USDA Natural Resources Conservation Service
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Phone: 435.896.6441 ext. 134 **Email:** Vic.Parslow@ut.usda.gov

Project Summary:
To provide an updated soil and ecological site inventory for Arches National Park (ARCH), that meets National Cooperative Soil Survey (NCSS) standards and park management and planning needs.

The existing soil survey was conducted in the 1970s's and the early 1980's as part of the Henry Mountains, Utah soil survey and the Arches Soil Survey. These inventories was primarily designed as a tool for use in managing grazing lands and has been found to be too general to be useful in managing the park. Information is insufficient to model salt movement, mitigate visitor impacts, identify and protect habitat of Threatened and Endangered species, and other park responsibilities.

In 2003, reprensentatives of the National Park Service approached the Natural Resources Conservation Service to update the existing soil surveys within Arches and Canyonlands National Parks and Natural Bridges and Hovenweep National Monuments and the Orange Cliffs section of the Glen Canyon Recreation Area. The Plan of Work and contract were approved in 2004. This application is seeking permission to carry out the field work necessary to complete the contract.

Collections:
Soil sampling allowed: 200 to 300 gram soil samples only. Archeologist must be present when digging any holes in ground. Some clipping of vegetation is allowed but must be kept to a minimum. Majority of soil samples will be destroyed in analysis. No collection of plants is allowed. Photos of plants for identification purposes is allowed.

10) Permit #: ARCH-2006-SCI-0010

Study Title:

CO2 GEOLOGICAL STORAGE :
LONG TIME GEOCHEMICAL REACTIVITY OF ARGILLACEOUS CAP-ROCKS MATRICES

Primary investigator contact information:

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Project Summary:
The aim of this PhD study is to investigate the long term behaviour of cap-rocks for CO2 geological storage, where argillaceous minerals are abundant. In this context, we will focus on polycrystalline diagenetic clay-rich rocks, avoiding any consideration on fractures. In particular, we want to determine what could be the role of mineral reactivity and fluid-rock interactions for assessing risks involved in the choice of a geological storage site.

Three approaches are possible to validate a potential geological storage site. The first approach consists in using and studying some field analogues, where CO2 paleo fluids bearing sediments crop out. This approach is limited by the number of good and accessible sites, which makes some compromises more difficult to make and thus introduces unquantitative uncertainties. We can also underline that pressure-temperature-time constrains on natural samples are complex to obtain and in many case, not precise enough to give any information on the time-duration of CO2 accumulation and residence. A second possibility is to undertake numerical simulations of large scale fluid-rock chemical reactions and transport. In this case, models are limited by the knowledge of physical and chemical constants (thermodynamics and kinetics for example) and by their capabilities to fit natural analogues or experiments on natural samples. Lastly, in terms of durability and predictability, using experimental simulations on natural samples is drastically limited to time durations of experimental runs.

We propose to elaborate an experimental protocol, to quantify some constants used in the numerical simulations (based on experimental synthetic materials), and on the other hand, to validate numerical simulations based on a geological time scale from different experimental tests on natural samples. The experimental methodology will be validated by comparing the different approaches on natural CO2 bearing samples from different geological environments (Colorado, Italy, …).
By these combined approaches using numerical modelling, experimental simulations, and natural samples characterisation, the study will attempt to predict reactive behaviour of argillaceous matrices that compose aquifer/reservoir cap-rocks and which are progressively invaded by CO2 gas or dissolved CO2.

The first task is to quantify mineralogical changes as a function of geological times, and later, to calibrate some of the parameters (thermodynamics and kinetics) in order to validate some of the numerical models (textural model for example) of fluid-rock transport aimed at predicting storages behaviours.

This PhD should then make a critical review of the present numerical models possibilities in use at I.F.P., and allow better long term geological phenomena to be estimated. From this study, an experimental protocol to validate an hypothetical storage site will be given to avoid systematic research of natural analogues.

Collections:
Small loose rock samples only are allowed for collection. No chipping from larger rocks allowed. The only rock samples approved for collection are those that are loose on the ground. Limited to a total of 10 samples for the entire project, each sample no larger than 10cm by 10cm by 10cm. All Specimens shall be destroyed in analysis.

11) Permit #: ARCH-2006-SCI-0011

Study Title:

RIPARIAN AND AQUATIC INVERTEBRATE MONITORING PROTOCOL AND DEVELOPMENT (NPS I&M PROGRAM)

Primary investigator contact information:

Name: Dr Anne Brasher, USGS, Water Science Center
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Project Summary:
The objective of the study is to develop a rigorous, well-integrated set of protocols for long-term riparian and macroinvertebrate monitoring across the Colorado Plateau. Another objective is to evaluate the utility of aquatic macroinvertebrates and riparian ecosystems as reliable indicators of aquatic ecosystem conditions in dryland systems characteristic of the Colorado Plateau.

Collections:
In general, macroinvertebrate samples are destroyed during analysis. Upon arrangement with the Park curator, a voucher collection from the sampling effort can be maintained at an established (museum) location following NPS repository standards.

Only the collection of aquatic invertebrates allowed. Most will be destroyed in analysis. Those curated will be stored according to NPS regulations at the Utah State University Bug Lab.

2005 Findings:
No activity was conducted during this report year.

12 Permit #: ARCH-2006-SCI-0012

Study Title:

IMPACTS OF CLIMATIC CHANGE AND LAND USE ON THE SOUTHWESTERN U.S.

Primary investigator contact information:

Name: Dr. Jayne Belnap, USGS, Canyonlands Field Station
Address: 2290 SW Resource Blvd., Moab, UT 84532
Phone: 435-719-2333 **Email:** jayne_belnap@usgs.gov

Project Summary:

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 have influenced surficial 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

1 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.
2 Understand today's interplay among climate, land use and surface processes (geologic and ecologic).
3 Understand the impacts of future climate on land surface under the following time frames: seasons; El NiTo/La NiTa cycles; multi-year 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

1 Understand geologic origins of soil nutrients and the interactions of soil compounds and plants.
2 Understand geomorphic controls on plant distribution

3 Understand the recent (past several decades, centuries, millennia) geologic/geomorphic evolution of the ecosystem to reveal patterns of surface stability and instability.
4 Recognize areas vulnerable to wind erosion and soil loss.
5 Understand conditions of cheatgrass (and other exotic plants) invasion to predict areas most vulnerable to expansion and to help devise mitigation strategies.

2005 Findings and Status:
Report from USGS Project Effects of climatic variability and land use on American Drylands.

The project conducts research on linkages among geologic substrates and their origins; biogeochemical nutrient cycling; weathering of substrate; soil moisture and water infiltration; weather events and climate; surface dynamics, including erosion; as well as past and current land uses. A large component of research is devoted to understanding how geologic substrates influence plant community distributions, including the distribution of cheatgrass and other invasive plants. Another focus is on the effects of historical grazing on soil nutrients. Substantial progress has been made in both topics as summarized in publications listed below that are available at the project website. Progress has also been made in developing remote sensing techniques to track invasion of Park lands by invasive plants. Another major effort last year resulted in publication of a document that describes conceptual models for dryland ecosystems to inform the vital signs selection process. Much project work is designed to address land-management priorities.

Activities of work done in and near Arches National Park are summarized in the project website http://climchange.cr.usgs.gov/info/sw/index.html

Project members completed several studies that resulted in publications.

Multi-decadal impacts of grazing on soil physical and biogeochemical properties in southeast Utah
J.C. Neff, R.L. Reynolds, J. Belnap, and P. Lamothe, 2005, Multi-decadal impacts of grazing on soil physical and biogeochemical properties in southeast Utah: Ecological Applications, 15(1), 2005, pp. 87-95.

Atmospheric dust in modern soil on aeolian sandstone, Colorado Plateau (USA): Variation with landscape position and contribution to potential plant nutrients
R.L. Reynolds, J.C. Neff, M. Reheis, P. Lamothe, 2006, Atmospheric dust in modern soil on aeolian sandstone, Colorado Plateau (USA): Variation with landscape position and contribution to potential plant nutrients: Geoderma, v. 130, p. 108-123.

Late Quaternary eolian response to paleoclimate, Canyonlands, southeastern Utah
M.C. Reheis, R.L. Reynolds, H. Goldstein, H.M. Roberts, J.C. Yount, Y. Axford, L. Cummings, and N. Shearin, 2005, Late Quaternary eolian and alluvial response to paleoclimate, Canyonlands, southeastern Utah: GSA Bulletin, v.117, no. 7/8, p. 1051-1069.

13) Permit #: ARCH-2006-SCI-0013

Study Title:

DEVELOPMENT OF A RESTORATION RAPID ASSESSMENT TOOL (RRAT) FOR THE NATIONAL PARK SERVICE TO PRIORITIZE SITES FOR WEED CONTROL AND RESTORATION

Primary investigator contact information:

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Phone: 928-523-0324, 928-779-6008 **Email:** std5@nau.edu

Project Summary:

The purpose of this study is to develop a protocol with which to rapidly assess disturbed sites within the National Park Service, so the resource managers may easily prioritize sites for restoration. The RRAT uses ecological attribute indicators of soil, hydrology and vegetation to assess the health and condition of a site. We will be field testing the RRAT on actual disturbed sites within the Colorado Plateau and Midwest Parks so that we may detect inefficiencies among indicators. Ideally, this field study will help guide us in making future modifications that will allow for an RRAT that is more usable and helpful to resource staff.

Objectives:

The RRAT project has been in the making since 2003 over a series of "phases". Phase 1 involved the draft of the RRAT and an email survey sent out by former Northern Arizona University (NAU) graduate student Rebecca Harms (Harms, 2003). The survey asked NPS resource managers and staff what weeds threatened their ecosystems most and what protocols they currently used to prioritize sites for restoration. In phase II, NAU graduate student Amy Richey set out to test the validation of three of the six attributes upon which the RRAT indicators are based: hydrology/landform, soils/water quality, and vegetation. The other attributes include animal stressors, site value, and land use history. In her research, Richey found that while the vegetation indicators provided valid assessments of site condition, hydrology/landform and soil/water quality did not. Phase III's objectives seek to take the RRAT to the field once again to test whether NPS resource staff with varying levels of knowledge and experience achieve the same results with RRAT. Also, because RRAT has only been tested in riparian areas, we seek to test whether the RRAT may transcend its utility beyond riparian areas, by taking it to upland and other non-riparian areas. Other objectives for summer 2006 research include testing economy/efficiency of RRAT, and testing each attribute's efficacy (of hydrology/landform and soil/water quality and vegetation) at discriminating between sites.

Hypotheses to be Tested:

1. Do resource managers with different levels of experience, education, and knowledge respond similarly to the RRAT? (sampling error)
2. How do RRAT prioritization scores compare with current resource manager prioritization strategies?
3. How does each attribute alone (vegetation, soil, hydrology) discriminate between sites vs. the RRAT?
4. Does the RRAT help resource managers conceptualize a restoration strategy?
5. Is the RRAT adaptable to non-riparian sites?
6. Does the RRAT detect sites where a little restorative action would lead to a large benefit or where lot's of restorative action would earn few benefits?

Methods:

The field testing will involve visiting National Parks within the Colorado Plateau. Ideally, the RRAT will be conducted on 3-5 field sites per park. NPS resource managers will be asked to choose the sites in advance so that they compose an array of degrees of disturbance. Multiple

resource manager presence at each site will allow us to determine sampling error between RRAT users.

Collections:
The collection of specimens is not allowed.

Logistics:
The park will be notified and park ecologist will accompany the researcher in the field.

CANYONLANDS NATIONAL PARK
2006 Research Permits

1) Permit #: CANY-2006-SCI-0001

Study Title:
GEOMETRIES OF SEDIMENTARY BODIES WITHIN THE PERMIAN CEDAR MESA SANDSTONE, SE UTAH.

Primary investigator contact information:

Name: Dr. Richard Langford, University of Texas at El Paso
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Project Summary:
This project will describe the three dimensional geometries of the depositional environments of sediments in the Cedar Mesa Sandstone, including exposures in the Needles district of Canyonlands National Park. There two major purposes to this. First, we have recently learned, in recent studies that many of the white sandstones on the Colorado Plateau are exhumed hydrocarbon reservoirs. This has raised an important question; why were some sandstones bleached white and filled with oil while others were never invaded with oil and remained red? Previous studies in both outcrop and subsurface have shown that cement that formed during deposition seems to be the primary control.

We propose to use global positioning surveying to define the geometries of different dune types, stream channels, flood deposits, interdune ponds and soils in the Permian Cedar Mesa Sandstone in several localities, including the needles district of Canyonlands National Park. We will also describe how the different colors observed in the monument relate to the different dunes and soils.

The Second major objective is that our results should provide detailed snapshots of the desert environments that formed the sandstones in the needles as well as to help explain the distribution of red and white coloration.

Collections:
Small loose rock samples only will be allowed for collection. No chipping from larger rocks allowed. The only rock samples approved for collection are those that are loose on the ground. Limited to a total of 20 samples, each sample no larger than 15cm by 10cm by 3cm. All Specimens shall be destroyed in analysis.

2005 Findings and Status:
Activities
These largely involved mapping of strata within the needles district. We mapped two units within the park as well as 22 interdune ponds. A 20-25 m thick unconformity-bound eolian sandstone was mapped in three dimensions over a 5 km2 area in the Needles District of the Canyonlands using GPS. After correcting for a regional tectonic dip of 1° to the northeast, 3-D maps of surfaces within the sandstone were evaluated to deduce paleotopography of the dune field. 234 GPS points delineate bounding surfaces which envelop packages of eolian dunes, interdunes and fluvio-lacustrine units. We also collected approximately 20 hand specimens from loose rubble for petrographic thin section analysis.

Results
The results were revolutionary for the science of sedimentology. Most dune strata, such as those making up the Cedar Mesa, have long been thought to form relatively continuous layers by migrating steadily through an area. We have been able to document that at least in some layers in the Canyonlands, dunes formed large complex sand mounds termed draas that grew to over 25 meter tall, 500 m across and over 1 km long. The mounds were elongate perpendicular to the sand-transporting winds and migrated to the SE. These large

sand mounds ceased to migrate and then were buried under sand sheets and other dunes. At least some of the continuous layers observed at Canyonlands formed through a two stage process. First the sand mounds were formed and then the low interdunes between them were later filled. This process is similar to the processes observed in modern deserts and explains much of the complexity observed in ancient strata.

During the coming year, we will complete our study of the interdunes ponds and the second sand layer, which is about half mapped. We have constructed a probe air permeameter that allows us to determine the ability of the sandstone to transport fluids and we will attempt to determine which eolian sands would make the best reservoir in the subsurface.

2) Permit #: CANY-2006-SCI-0002

Study Title:

ABUNDANCE ESTIMATES FOR COLORADO PIKEMINNOW IN THE GREEN RIVER BASIN, UTAH AND COLORADO

Primary investigator contact information:

Name: Dr. Patrick Goddard, Utah Division of Wildlife Resources
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Phone: 435-259-3781 **Email:** patrickgoddard@utah.gov

Project Summary:

Goals:
Obtain an accurate (unbiased) and reliable (precise) estimate of the adult population abundance and survival of Colorado pikeminnow that occupy the Green River study area.

Objectives:
1. Complete a minimum of three sampling passes through five Green River Basin reaches to capture sub-adult and adult Colorado pikeminnow:
a) Green River between the confluence of the White River upstream to the lower end of Whirlpool Canyon (i.e., upper Rainbow Park).
b) White River between the confluence of the Green River upstream to Taylor Draw Dam,
c) Yampa River between Deerlodge Park and Craig, excluding Cross Mountain Canyon,
d) Green River from the White River confluence downstream to near Green River, Utah, and,
e) Green River from downstream of Green River, Utah, to the confluence with the Colorado River.

2. Obtain highest possible rates of capture of Colorado pikeminnow within concentration habitats and maximize number of individuals marked and captured on each sampling occasion.

3. Obtain estimates of probability of capture and abundance for Colorado pikeminnow in each of the five reach and for the entire study area.

End Product: The end products are abundance and survival estimates for sub-adult and adult Colorado pikeminnow for each of the White, Yampa, and Green River populations. An overall estimate will also be calculated.

Collections:
Collection of specimens is allowed only for data collection. Catch and release only. Trammel netting and electrofishing allowed. Some fish may be taken for transported to Wahweap State Fish Hatchery according to RIP protocol. PIT tagging allowed.

3) Permit #: CANY-2006-SCI-0003

Study Title:

MAPPING AND EVOLUTION OF THE JOINTS AND FAULT SYSTEM IN THE CEDAR MESA SANDSTONE IN THE GRABENS AREA, CANYONLANDS NATIONAL PARK

Primary investigator contact information:

Name: Jasmin Mertens, University of Aachen, Germany
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Project Summary:
The aim of this research project is to understand the fundamental processes of early salt tectonics in sedimentary basins.
A high resolution geologic map will be prepared based on Quickbird satellite images. It will be focused on the fracture and joint pattern in the Cedar Mesa Sandstone in the Cutler Formation. During the research conducted in the Canyonlands National Park the researcher is doing ground verification as non- intrusive field mapping.
The map will be investigated in explaining the role of the pre-existing joint set in the Cedar Mesa sandstone of the Cutler formation in the development of recent normal faulting in a young graben system.

In addition to the joint mapping, ten rock samples will be carried out from the field site. The samples will have a size of about 10 cubic centimeters and will be investigated using optical microscopy and helium poropermeametry.
The location of sampling will be chosen checking with Park authorities as to be as non-intrusive as possible.

Collections:
Small loose rock samples only are allowed for collection. No chipping from larger rocks allowed. The only rock samples approved for collection are those that are loose on the ground. Limited to a total of 10 samples for the entire project, each sample no larger than 10cm by 10cm by 10cm. All Specimens shall be destroyed in analysis.

4) Sucec Application Denied

5) Permit #: CANY-2006-SCI-0005

Study Title:

Sound Levels in Canyonlands National Park

Primary investigator contact information:

Name: Skip Ambrose,
Address: HC 64 Box 2205 Castle Valley, UT 84532

Phone: 435-259-0401 or 970.227.8154 **Email:** skipambrose@frontiernet.net

Project Summary:

To determine natural ambient sound levels in the primary vegetation types in Canyonlands National Park (CANY), and the relative influence of human-caused sounds on natural sound levels.

The only collections will be the collection of recorded sound data.

The National Park Service (NPS) is concerned with degradation of natural soundscapes in units of the National Park system. NPS Management Policies (4:9; 2001) states: "The National Park Service will preserve, to the greatest extent possible, the natural soundscapes of parks. Natural soundscapes exist in the absence of human-caused sound. The natural soundscape is the aggregate of all natural sounds that occur in parks, together with the physical capacity for transmitting natural sounds. Natural sounds occur within and beyond the range of sounds that humans can perceive, and can be transmitted through air, water, or solid materials."

"Using appropriate management planning, superintendents will identify what levels of human-caused sound can be accepted within the management purposes of the parks. The frequencies, magnitudes, and durations of human-caused sound considered acceptable will vary throughout the park, being generally greater in developed areas and generally lesser in undeveloped areas. In and adjacent to parks, the Service will monitor human activities that generate noise that adversely affects park soundscapes, including noise caused by mechanical or electronic devices. The Service will take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values, or that exceeds levels that have been identified as being acceptable to, or appropriate for, visitor uses at the sites being monitored" (NPS 2001).

OBJECTIVES

1. Determine natural ambient sound levels in the primary habitats/acoustic zones in Canyonlands National Park, during the summer and winter seasons; and

2. Assess the influence of man-made noise on natural ambient sound levels.

   The primary objective of this project is to provide basic acoustic data necessary for preparation of a Soundscape Management Plan for Canyonlands National Park. A secondary objective is to collect acoustic data which will be useful in assessing the influence of man-made noise on natural sounds.

6) Permit #: CANY-2006-SCI-0006

Study Title:

ASSESSMENT OF UPLAND ECOSYSTEM CONDITIONS IN THE SALT CREEK WATERSHED, CANYONLANDS NATIONAL PARK

Primary investigator contact information:

Name: Dr. Mark Miller, U. S. Geological Survey
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Project Summary:

This project involves the assessment of upland ecosystem conditions (soil stability, hydrologic function, and vegetation composition/structure) in the Salt Creek watershed and surrounding portions of Canyonlands National Park (CNP). Salt Creek is the only perennial stream in CNP other than the Colorado River itself. Riparian and aquatic resources associated with the Salt Creek drainage are key to the ecological integrity of this dryland park, and the condition of these riverine resources is linked to overall watershed condition. CNP has virtually no information concerning impacts of past livestock activities, recurring trespass livestock, on-going visitor-use activities, high mule-deer numbers, and recent drought on upland watershed conditions. This assessment project – which is equivalent to an inventory of ecosystem function – will fill an important need in that regard, and it will provide information required for determining the necessity for restoration, monitoring, and/or other management activities.

Understanding and mitigating past and current impacts of visitors and livestock on soils, vegetation, and watersheds are high-priority resource-management issues identified in CNP's 1993 Statement for Management and in the 1994 Resource Management Plan. This project supports NPS servicewide goals for vital-signs monitoring by assessing the condition of park ecosystems to allow managers to make better-informed decisions and to develop effective mitigation measures (http://science.nature.nps.gov/im/monitor/). It also supports the number one resource-protection goal identified in the U.S. Department of Interior's Draft Revised Strategic Plan for FY 2003-2008 (February 2003 draft) – "...improve the health of watersheds, landscapes, and marine resources that are DOI managed or influenced...."

Objectives:

1. To assess the functional condition of upland ecosystems in the Salt Creek watershed and surrounding portions of CNP;
2. To analyze / synthesize results of this assessment and describe park-specific management implications pertaining to restoration, long-term monitoring, and other management activities;
3. To analyze / synthesize results of this assessment and describe implications pertaining to the use of this technique in the design of long-term monitoring in 35 NPS units of the Northern Colorado Plateau and Southern Colorado Plateau Inventory & Monitoring Networks (NCPN and SCPN);
4. To train NPS resource-management staff in the performance and interpretation of the assessment technique;
5. To establish reference areas applicable as benchmarks for assessment and monitoring elsewhere in the Colorado Plateau region (e.g., on lands managed by BLM);
6. To acquire / provide data in support of the development of ecological models describing dynamics of rangeland ecosystems on the Colorado Plateau, in cooperation with NPS, BLM, TNC, and the U.S.D.A. Natural Resources Conservation Service (NRCS).

Collections:

10 g of green leaf tissues from common, dominant vascular plant species at each of 210 sample sites in Park. Probable species include Coleogyne ramosissima, Stipa hymenoides, Stipa comata, Hilaria jamesii, Bromus tectorum, Atriplex canescens, Ceratoides lanata, Sporobolus cryptandrus, and Sporobolus contractus.

All material collected will be destroyed in analysis.

2005 Findings and Status:

No activity was conducted this report year. Field work for this study was postponed by one year and will be conducted during the 2006 and 2007 field seasons.

7) Permit #: CANY-2006-SCI-0007

Study Title:

PILOT STUDIES TO INFORM RIPARIAN MONITORING PROTOCOLS – REFINEMENT OF SITE SELECTION METHODS AND FIELD TRIALS OF PROPOSED MONITORING METHODS

Primary investigator contact information:

Name: Dr. Michael Scott, U. S. Geological Survey
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Phone: 970-226-9475 **Email:** Mike_L_Scott@usgs.gov

Project Summary:
We propose a research program aimed at testing methods described in the current draft protocols for monitoring riparian resources in Southern and Northern Colorado Plateau Network Parks. The monitoring of riparian resources has been identified by both networks as a high-priority because these ecosystems contribute to high local biodiversity and are sensitive to a wide range of on-site and off-site human activities. By conducting field trials, we intend to refine two important components of the riparian monitoring protocols: (1) the site selection process based on the draft stream classification framework; and, (2) the in-field sampling procedures. Pilot studies will allow us to test the application of the classification framework, to conduct methods comparisons trials, to evaluate inter-observer error trials and to determine the number of stream transects within a reach that will be required to adequately characterize variance for selected metrics. Following the pilot studies, we will report the results in the 2006 field trial report and refine the draft riparian protocols; ultimately contributing to rigorous, repeatable and cost effective riparian monitoring protocols for the Southern and Northern Colorado Plateau Networks

Collections:
No material or specimens will be collected for this project.

8) Permit #: CANY-2006-SCI-0008

Study Title:

THE ROLE OF BIOLOGICAL SOIL CRUSTS IN SOIL NUTRIENT CYCLES AS INFLUENCED BY SOIL SURFACE DISTURBANCE, CLIMATE CHANGE AND ANNUAL GRASS INVASION

Primary investigator contact information:

Name: Dr. Jayne Belnap, USGS, Canyonlands Field Station
Address: 2290 SW Resource Blvd., Moab, UT 84532
Phone: 435-719-2333 **Email:** jayne_belnap@usgs.gov

Project Summary:
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.

Collections:
The collection of soil samples is allowed and has been cleared by the SEUG Archeologist. The collection of leaf samples will also be allowed.

2005 Findings and Status:
In July 2004, our group installed a solar-powered system including 6 in-situ sensors at two depths in the soil (5 and 15 cm) to monitor carbon dioxide amounts in the soil gas profile. These were inserted from the surface and did not require digging.

Also in July 2004, Belnap’s group installed a solar-powered system including two automatically-closing aboveground chambers which allowed direct measurement of the flux of CO2 leaving the surface of the soil.

We found strong seasonal patterns in CO2 amounts belowground, and in the CO2 flux, that were driven primarily by soil moisture and soil temperature. The period of maximum belowground activity was in June following an unusual rain event, somewhat later than we expected based on aboveground plant productivity which peaks in April-May.

Both systems were removed in December 2005 and we do not expect to reinstall them during 2006. Some soil sampling at the site will be required to establish physical parameters for soil diffusion modeling and we anticipate this sampling will occur in spring or summer 2006. We are currently analyzing the data and expect to submit it for publication sometime in 2006.

9) Permit #: CANY-2006-SCI-0009

Study Title:

IMPACTS OF CLIMATIC CHANGE AND LAND USE ON THE SOUTHWESTERN U.S.

Primary investigator contact information:

Name: Dr. Jayne Belnap, USGS, Canyonlands Field Station
Address: 2290 SW Resource Blvd., Moab, UT 84532
Phone: 435-719-2333 **Email:** jayne_belnap@usgs.gov

Project Summary:
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 have influenced surficial 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 (bold titles indicate activity at Canyonlands National Park):
(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
1 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.
2 Understand today's interplay among climate, land use and surface processes (geologic and ecologic).
3 Understand the impacts of future climate on land surface under the following time frames: seasons; El NiTo/La NiTa cycles; multi-year 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

1 Understand geologic origins of soil nutrients and the interactions of soil compounds and plants.
2 Understand geomorphic controls on plant distribution
3 Understand the recent (past several decades, centuries, millennia) geologic/geomorphic evolution of the ecosystem to reveal patterns of surface stability and instability.
4 Recognize areas vulnerable to wind erosion and soil loss.
5 Understand conditions of cheatgrass (and other exotic plants) invasion to predict areas most vulnerable to expansion and to help devise mitigation strategies.

2005 Findings and Status:

Report from USGS Project Effects of climatic variability and land use on American Drylands.

The project conducts research on linkages among geologic substrates and their origins; biogeochemical nutrient cycling; weathering of substrate; soil moisture and water infiltration; weather events and climate; surface dynamics, including erosion; as well as past and current land uses. A large component of research is devoted to understanding how geologic substrates influence plant community distributions, including the distribution of cheatgrass and other invasive plants. Another focus is on the effects of historical grazing on soil nutrients. Substantial progress has been made in both topics as summarized in publications listed below that are available at the project website. Progress has also been made in developing remote sensing techniques to track invasion of Park lands by invasive plants. Another major effort last year resulted in publication of a document that describes conceptual models for dryland ecosystems to inform the vital signs selection process. Much project work is designed to address land-management priorities.

Activities of work done in and near Canyonlands National Park are summarized in the project website http://climchange.cr.usgs.gov/info/sw/index.html

Project members completed several studies that resulted in publications.

Multi-decadal impacts of grazing on soil physical and biogeochemical properties in southeast Utah
J.C. Neff, R.L. Reynolds, J. Belnap, and P. Lamothe, 2005, Multi-decadal impacts of grazing on soil physical and biogeochemical properties in southeast Utah: Ecological Applications, 15(1), 2005, pp. 87-95.

Atmospheric dust in modern soil on aeolian sandstone, Colorado Plateau (USA): Variation with landscape position and contribution to potential plant nutrients
R.L. Reynolds, J.C. Neff, M. Reheis, P. Lamothe, 2006, Atmospheric dust in modern soil on aeolian sandstone, Colorado Plateau (USA): Variation with landscape position and contribution to potential plant nutrients: Geoderma, v. 130, p. 108-123.

Late Quaternary eolian response to paleoclimate, Canyonlands, southeastern Utah
M.C. Reheis, R.L. Reynolds, H. Goldstein, H.M. Roberts, J.C. Yount, Y. Axford, L. Cummings, and N. Shearin, 2005, Late Quaternary eolian and alluvial response to paleoclimate, Canyonlands, southeastern Utah: GSA Bulletin, v.117, no. 7/8, p. 1051-1069.

10) Permit #: CANY-2006-SCI-0010

Study Title:

INTERACTIONS OF CLIMATE CHANGE AND OTHER ENVIRONMENTAL FACTORS ON INVASIVE PLANT INFESTATION IN THE ARID WEST

Primary investigator contact information:

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Project Summary:
Invasive, non-native plants dominate terrestrial and riparian landscapes in the arid western United States and are an increasingly important challenge for land and water managers. Abundance of invasive species and their native competitors is influenced both by coarse-scale factors like climate and fine-scale factors like soil chemistry, grazing, and flood timing. Understanding the interplay of these factors is essential for predicting the effects of land use and global change on invasive plant distributions. We propose to address three groups of invasive species: annual grasses, forbs, and riparian trees. We will use existing, recently collected databases documenting the distribution of these species to develop models predicting the likelihood of invasion at any site as a function of both climatic and non-climatic factors. For annual grasses and tamarisk (Tamarix spp.) we will carry out physiological experiments to identify critical biological mechanisms controlling susceptibility to invasion. Finally, we will use General Circulation Model Predictions to assess potential changes in susceptibility under various potential future global climate change scenarios. This proposal integrates all of the ongoing BRD Global Change research on invasive plants in the arid and semi-arid west. Our results will provide land and water managers with general and site-specific information on site susceptibility to invasion and factors controlling abundance of invasive species. This information is essential for developing and prioritizing realistic cost-effective strategies for dealing with invasive species in a changing climate.

Collections:
The collection of soil samples and leaf tissue is allowed. All samples must be taken only from areas previously cleared by the SEUG archeologist. No new sites may be sampled. All samples shall be destroyed in analysis.

2005 Findings and Status:
1.SOIL BIOTA CAN CHANGE AFTER EXOTIC PLANT INVASION: DOES THIS AFFECT ECOSYSTEM PROCESSES? Invasion of the exotic annual grass Bromus tectorum into stands of the native perennial grass Hilaria jamesii significantly reduced the abundance of soil biota, especially microarthropods and nematodes. Effects of invasion on active and total bacterial and fungal biomass were variable, although populations generally increased after 50+ years of invasion. The invasion of Bromus also resulted in a decrease in richness and a species shift in plants, microarthropods, fungi, and nematodes. However, despite the depauperate soil fauna at the invaded sites, no effects were seen on cellulose decomposition rates, nitrogen mineralization rates, or vascular plant growth. When Hilaria was planted into soils from not-invaded, recently-invaded, and historically-invaded sites (all currently or once dominated by Hilaria), germination and survivorship were not affected. In contrast, aboveground Hilaria biomass was significantly greater in recently-invaded soils than in the other two soils. We attributed the Hilaria response to differences in soil nutrients present before the invasion, especially soil nitrogen, phosphorus, and potassium, as these nutrients were elevated in the soils that produced the greatest Hilaria biomass. Our data suggests that it is not soil biotic richness per se that determines soil process rates or plant productivity, but instead that either 1) the presence of a few critical soil food web taxa can keep ecosystem function high, 2) nutrient loss is very slow in this ecosystem, and/or 3) these processes are microbially-driven. However, the presence of Bromus may reduce key soil nutrients over time and thus may eventually suppress native plant success.
2. Soil lichen and moss cover and species richness can be highly dynamic: the effects of invasion by the annual exotic grass Bromus tectorum, precipitation, and temperature on biological soil crusts in SE Utah. Biological soil crusts are an

essential part of desert ecosystems throughout the world, as they are important in soil stabilization and soil fertility. Despite their importance, there have been few efforts to examine the population dynamics of the dominant species comprising these crusts or the effect of exotic plant invasions on these dynamics. In this study, we followed changes in lichen and moss cover for eight years in plots dominated by native grasses or invaded by the exotic annual grass Bromus tectorum and across sites representing a range of land use histories. Our data showed that cover of both lichens and mosses can increase dramatically over short time periods, often going from just above 0% cover to as high as 9% cover in only six months. Cover of the nitrogen-fixing lichen Collema declined throughout the study, going from 19% in 1996 to as low as 2% in 2003, likely in response to an increase in monthly maximum temperatures during the study period. Changes in chlorolichen cover (lichens with green algal phycobionts), on the other hand, appeared related to precipitation patterns. Past grazing may be responsible for declines in species richness for both mosses and lichens and decline in cover for lichens. A recent Bromus invasion did not affect species richness in never-grazed plots, but a 50-year invasion appeared to be related to lower species richness in the previously intermittently-grazed plots. Bromus invasion was related to lower cover of Aspicilia, Collema, Placidium, yellow lichens combined (Caloplaca tominii, Candelariella terigena, Fulgensia bracteata, and Fulgensia desertorum), total lichens, and total mosses in some plots in some years. Extended drought was likely responsible for a large decline of all species in 2003. Loss of lichen and moss cover is expected to affect many aspects of this ecosystem. Of special concern is the loss of Collema, as it is the dominant source of nitrogen for this region.

11) Permit #: CANY-2006-SCI-0011

Study Title:

Enhancing the Spatial Delineation of Ecological Sites in NPS Units of the Northern and Southern Colorado Plateau Networks

Primary investigator contact information:

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Project Summary:
The NPS Inventory and Monitoring Program intends to use maps of soils and associated ecological sites to stratify park landscapes into units for long-term monitoring. However, existing soil map units commonly are "complexes" that include more than one type of soil and ecological site. The purpose of this joint USGS-NPS project is to develop an approach for enhancing existing soil maps by using field and image-analysis techniques to delineate individual soils and ecological sites found in complex map units, thereby reducing the internal variability of map units. Reducing within-unit variability will improve efficiency and reduce costs of the sampling design and subsequent long-term monitoring efforts.

The field effort associated with this project will consist of 1-2 technicians using a hand-held GPS unit to delineate soil components and ecological sites that can be differentiated on the basis of observable soil, geomorphic, and vegetation attributes. Emphasis will be placed on complex map units associated with those ecological sites which have been identified by Park managers as high-priority targets for long-term monitoring.

Collections:
No plant or soil materials will be collected in conjunction with this work, and no holes will be dug. A collection permit will not be issued.

12) Permit #: CANY-2006-SCI-0012

Study Title:
HERBARIUM AND FIELD STUDIES OF VASCULAR PLANT FLORA OF CANY FOR NATIONAL PARK SERVICE INVENTORY AND MONITORING PROGRAM

Primary investigator contact information:

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Project Summary:
The purpose of this study is to document the vascular plant flora of Canyonlands National Park (CANY) and develop a plant distribution database using the National Park Service's NPSpecies system. Research in 2006 will focus on filling in gaps in the documented flora of the park, based on a review of specimens already vouchered in the CANY Herbarium.

Collections:
The collection of plant specimens will be allowed, all specimens will be stored in the Canyonlands Museum Herbarium:
Collection of only one specimen per plant species allowed, or 1-3 specimens of the same species can be collected to represent the species on a single herbarium sheet. Researcher can only collect plants not represented in the Canyonlands National Park Herbarium.Plant species that are too uncommon or are legally protected under the Endangered Species Act will not be collected but will have digital photos taken for documentation.

2005 Findings and Status:
As a preliminary step in developing an updated species list and distribution database for the park, I examined all specimens in the Canyonlands NP herbarium to correct misidentifications, update species nomenclature (following Welsh et al. 2003, "A Utah Flora, third edition"), and add variety or subspecies names if needed. Of the 1199 specimens currently deposited in the collection (not including 363 specimens out on loan) 65 were misidentified (5.4%), 62 had their names updated (5.2%), 115 had variety names added (9.6%), and 957 were confirmed as correctly identified (79.8%). The Canyonlands NP herbarium currently contains 451 vascular plant taxa collected within the park. Three additional species have been documented for Canyonlands NP based on collections at other herbaria and another 134 taxa are reported for the park (without vouchers) by Schelz and Moran (2005 SE Utah Group Plant list) and Welsh (1970 "Canyonlands Flora", Great Basin Naturalist 21(1):26-37). Based on the Atlas of the Utah Flora (Albee et al. 1988), 368 additional species are reported from comparable habitats in the vicinity of Canyonlands, but have not yet been documented within the park. These results suggest that the Canyonlands NP herbarium is missing between 23-44% of the plant taxa known or likely to occur in the park. In particular, fall-flowering, non-native, and wetland species appear to be under-represented. Targeted inventory work to fill gaps in the Canyonlands NP vascular plant collection is recommended so that park manager's will have an improved understanding of the composition and status of the flora of the park and a more complete reference collection for researchers and staff interested in plant identification.

13) Permit #: CANY-2006-SCI-0013

Study Title:
PALEONTOLOGICAL RESOURCE MANAGEMENT FIELD INVESTIGATIONS

Primary investigator contact information:

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Project Summary:

This project was initiated by Resource Management staff at Canyonlands National Park and is funded by the CANY Fee Demo Program. The primary goal of this project is to establish baseline paleontological resource data for Canyonlands National Park. This inventory/survey will include numerous components which will be provided to the park in the form of written reports, maps, and photographs. The survey components are directly linked to specific goals/objectives.

Collections:
Only the collection of fossils is allowed. These may be taken for for verification and identification. All kinds of fossils are anticipated: vertebrate, invertebrate, paleobotanical, and perhaps samples for microfossils. All fossils shall be collected as surface disturbance only, with little or no disturbance to soils or bedrock. Sample sizes shall be hand-samples that can be easily carried out. Special permission is needed for larger fossil sizes.

2005 Findings and Status:
Field work conducted in 2005 was concentrated in the Green River and Colorado River corridors, in canyons and exposures in the Island in the Sky, and in the Needles District. Field work consisted of on-the-ground pedestrian surveys, especially along trails and on exposures that are accessible on foot. Field crews of two to four paleontologists searched for fossil resources. The most significant results were the recognition of many sites in Paleozoic formations that have important marine invertebrates. A few sites in Triassic formations (Moenkopi and Chinle Formations) have vertebrate fossils or likelihood of vertebrate fossils and tracks. None of the fossils we located were imperiled by erosion or human impacts to the extent they should be collected. Many camping sites along the river corridors are close to sites with invertebrate fossils, and sites in side canyons accessible by trails used for day hikes and recreation. The survey has been a sample of all of the formations in the park in Island in the Sky and the Needles District to the extent they are accessible on foot. The survey will be expanded in 2006 to include the Maze District. To date no critical fossils have been discovered that require immediate attention, or that warrant additional research.

14) Permit #: CANY-2006-SCI-0014

Study Title:

SOIL SURVEY OF CANYONLANDS NATIONAL PARK, UTAH

Primary investigator contact information:

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Project Summary:
To provide an updated soil and ecological site inventory for Canyonlands National Park (CANY), that meets National Cooperative Soil Survey (NCSS) standards and park management and planning needs.

The existing soil survey was conducted in the 1970s's and the early 1980's as part of the Henry Mountains, Utah soil survey and the Canyonlands soil Survey. These inventories was primarily designed as a tool for use in managing grazing lands and has been found to be too general to be useful in managing the park. Information is insufficient to model salt movement, mitigate visitor impacts, identify and protect habitat of Threatened and Endangered species, and other park responsibilities.

In 2003, reprensentatives of the National Park Service approached the Natural Resources Conservation Service to update the existing soil surveys within Arches and Canyonlands National Parks and Natural Bridges and Hovenweep National Monuments and the Orange Cliffs

section of the Glen Canyon Recreation Area. The Plan of Work and contract were approved in 2004. This application is seeking permission to carry out the field work necessary to complete the contract.

Collections:
Soil sampling allowed: 200 to 300 gram soil samples only. Archeologist must be present when digging any holes in ground. Some clipping of vegetation is allowed but must be kept to a minimum. Majority of soil samples will be destroyed in analysis. No collection of plants is allowed. Photos of plants for identification purposes is allowed.

15) Permit #: CANY-2006-SCI-0015

Study Title:

RECONSTRUCTING THE GEOMETRY AND PALAEOCLIMATE OF THE CEDAR MESA AND WHITE RIM SANDSTONE (PERMIAN)

Primary investigator contact information:

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Project Summary:
Although desert margin sedimentary systems are known to be highly sensitive to climate change, the response of these systems to such changes is currently only poorly understood. This project seeks to investigate the sedimentological and stratigraphic response of an ancient desert margin system to climate change. This will be achieved through an outcrop based study of mixed aeolian, fluvial, lacustrine and marine successions exceptionally well exposed in the Permian Cutler Group of southern Utah and will involve extensive phases of field-based data collection. The Cutler Group comprises a series of mixed aeolian, fluvial, lacustrine and shoreline successions that accumulated under a regime of oscillating arid to semi-arid climatic cycles, somewhat analogous to those of the late Quaternary period of parts of the Sahara Desert. This project will provide information on the preserved sedimentary expression of cyclical climate changes within various desert margin sub-environments (e.g. aeolian dune, interdune, fluvial and lacustrine). Importantly it will document how transitions between these various sub-environments respond to the external modifying influence of climate change. Additionally, this project will devise generic models that explain the dynamics of sediment accumulation and long term preservation at erg margins. It will document how aeolian sand seas form, are accumulated as strata, and are preserved in the rock record for a marginal sand sea area subject to high magnitude climate change. Work for 2004 will focus on the Lower Cutler Beds that immediately underlie the Cedar Mesa Sandstone within the Canyonlands National Park region (Jagger, 2003, Mountney and Jagger, 2004).

Aims and Objectives:
1. Quantitatively determine the spatial arrangement of genetically related sets of aeolian, fluvial and lacustrine strata and establish 3D geometric relationships between genetically related stratal packages in adjoining erg margin sub-environments.
2. Identify cyclic episodes of sedimentation across a variety of sub-environments that are indicative of progressive drying- or wetting-upward climatic trends.
3. Distinguish key stratal surfaces related to autocyclic bedform migration from those related to allocyclic (externally forced) episodes of erg shutdown.
4. Develop a generic model to explain how the dynamics of sediment accumulation and preservation are modified by the influence of a periodically changing climatic regime across a range of desert margin aeolian, fluvial and lacustrine sub-environments.
5. Establish techniques for the correlation of marine and non-marine strata in desert systems and test current models that equate non-glacial global sea level high-stands with restricted erg activity and stabilization.

Methods:
Research in 2006 field excursions to Southeast Utah at localities within the Shafer Basin near Moab and within Canyonlands National Park. The orientation of the present-day canyon walls within these regions provides near-continuous exposure of the succession. This will enable the architecture of genetically related rock units to be established in 3D. A leveling instrument will be used to trace-out key bounding surfaces across the area. The position of these surfaces will be recorded in x,y,z space and viewed using dedicated visualization software, thus revealing the three dimensional geometry of the depositional system. The spatial arrangement of minor bounding surfaces and cross-stratification planes will be used to reconstruct the morphology of the original aeolian bedforms using the procedure of Rubin and Hunter (1983). The spatial arrangement of major aeolian bounding surfaces and their relationship to adjacent fluvial deposits will be used to distinguish surfaces related to autocyclic bedform migration from those related to allocyclic episodes of erg termination, thus testing the models proposed by Kocurek and Havholm (1993). Vertical sedimentary logs will be established at key localities. These will act as 'marker posts' to which the architectural data can be tied. Both the vertical logs and the architectural data will be used to investigate the detailed sedimentology of the succession. Sedimentary evidence to support a deflationary mechanism for the periodic termination of aeolian dune preservation would include the presence of laterally persistent horizons of coarse-grained lags or wavy laminae. Aeolian bypass would be signified by evidence of dune migration (but not climb) coincident with fluvial encroachment into surrounding interdune areas. The preservation of degraded (relict) dune topography and the presence of rooted horizons on dune flanks would signify stabilisation of the sedimentary system. Careful sedimentary observation allied to quantitative surveying of the set architecture will enable theoretical models for erg margin development and termination to be devised, tested and refined.

Collections:
This work will not require and destructive sampling such as trenching or hammering. Neither will this work require the removal of any rock samples.

Expected outcomes
Outcomes of this work will include the development of generic sedimentary behavior and response models that can then be applied to further our understanding of climate change in ancient, Quaternary and modern desert systems. Furthermore, this work will document how climatically-forced sedimentary signatures expressed in the ancient rock record can potentially be used for chronostratigraphic correlation purposes. This has potential for application in subsurface correlation of analogous units, which are notoriously difficult to correlate with either radiometric or biostratigraphic techniques.

16) Permit #: CANY-2006-SCI-0016

Study Title:
AMPHIBIAN POPULATION DYNAMICS AND INVERTEBRATE DIVERSITY OF SALT CREEK CANYON, CANYONLANDS NATIONAL PARK: DIFFERENCES CORRELATED WITH PRESENCE/ABSENCE OF 4WD VEHICLE USE.

Primary investigator contact information:

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Project Summary:
The objectives of this study are to: 1) establish riparian and aquatic invertebrate and amphibian monitoring locations in the vicinity of vegetation monitoring stations; 2) evaluate a variety of sampling methods for invertebrates and amphibians to determine which provides the best estimates of community structure (relative abundance and species composition); 3) identify which taxa, guilds, functional groups of invertebrates and/or amphibians will make optimum

indicators of riparian and aquatic ecosystem recovery in Salt Creek; 4) recommend the best monitoring techniques for target indicator groups based on results of this research; 5) work with CANY staff to develop, test and refine a monitoring plan that will guide sampling, analysis, and interpretation of the data collected over time, and that can be extended to other areas.

Collections:
Specimens include terrestrial arthropods captured in pitfall, pan, or flight-interception traps, exact number can't be estimated. Sampling will be done at 4 sites in the Salt Creek annual flood zone, one in the open road, 2 in the closed road, and one in the no road segments of the canyon. Approximately 640 samples will be collected during 2006 in June. The number of specimens cannot be predicted--numbers depend on how many organisms fall into traps. Most specimens will be identified to order, family, and perhaps genus, and held pending identification of selected specimens to genus and species. Duplicate specimens will be evaluated for quality, and either destroyed or incorporated into the voucher collection. Voucher specimens will be curated at the Colorado Plateau Museum of Arthropod Biodiversity.

2005 Findings and Status:
Fieldwork was conducted in May and June of 2005, planned for September, but massive flash floods prevented access, much less work. A significant number of samples have been sorted to order, and some progress has been made at finer taxonomic levels for some groups. All ants collected from 3 sites (one each in open-, closed-, and no-road segments, from 2000-2004, have been identified to genus. All beetles from these sites have been identified to family, and some to genus and species. Flies from June 2005 RO3 and CL1 were identified to morphospecies. Orthoptera from June and September 2000 from RO3, CL1 and NR2 were identified to family (subfamilies for Acrididae).

Results of some of these analyses were presented at conferences: George Wright Society, March 2005, Ecological Society of America, August, International Orthopterists' Society, August, 8th Biennial Conference of Research on the Colorado Plateau, November.

17) Permit #: CANY-2006-SCI-0017

Study Title:

GEOLOGIC EVOLUTION OF CATARACT CANYON, CANYONLANDS NATIONAL PARK

Primary investigator contact information:

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Project Summary:
The age of Cataract Canyon is broadly known from other canyon reaches on the Colorado Plateau. This age is important for interpretation of the geologic history of Canyonlands National Park as well as for understanding processes that control the formation and maintenance of rapids along the Colorado River. Past work has suggested from evidence elsewhere that Cataract Canyon's age may range from 15 million years to 500,000 years or less.

Several important clues exist as to the nature of Cataract Canyon and its overall age. First, in 1914, the U.S. Reclamation Service drilled four holes into the bed of the river just downstream from the Confluence. Those holes were a maximum of 125 feet deep and ended with boulders that were talus from the cliffs above. Second, river gravels are preserved in strath terraces up to the rim of the canyon on both approaches; some of these terraces approach a half million years in age, suggesting that the canyon's approaches may be less than a million years old. As one approaches Cataract Canyon, these river gravels appear to go beneath water level, suggesting that the river has been dammed downstream, and tributary mouths just upstream from the Confluence are backfilled with sediment. Third, the USGS in 1921 surveyed a longitudinal profile through Cataract Canyon and reported that Rapid 47, west of Dark Canyon and now inundated by Lake Powell reservoir, was bedrock controlled. During that trip, geologist Hugh Miser prepared a longitudinal profile of the river that suggested a wedge of sediment in Cataract Canyon that made it unsuitable for construction of dams.

The purpose of this project is to examine geologic evidence within Cataract Canyon, typically in the form of surficial deposits; to collect samples that date coarse debris fans within Cataract Canyon; to perform geophysical evaluations of the depth to bedrock at various locations along the river corridor; to make fathometer measurements of depth of the channel through Cataract Canyon; and to recreate the longitudinal profile originally surveyed by USGS to look at long-term change and age of Cataract Canyon. In addition, we propose to update research done by Salzer et al. (1995) on the use of tree-ring analysis of netleaf hackberry to determine the flood history of Cataract Canyon over the last 200-300 years.

Objectives:

The objectives of this project are (1) to use several dating techniques to determine the ages of debris-fan aprons that line the river corridor from Rapid 1 to Imperial Canyon; (2) to use seismic refraction techniques to determine the depth to bedrock at various points in Cataract Canyon and along its approaches; (3) to replicate the 1921 longitudinal profile survey through Cataract Canyon to determine if any changes are detectable that are related to a combination of tributary debris flows and reworking of deposits by the Colorado River; (4) to determine the water depth of the thalweg (deepest channel thread) through Cataract Canyon; (5) and to recollect cores from living netleaf hackberry trees and slabs from dead ones that can be used to assess riparian tree health as well as reconstruct the long-term flood history through Cataract Canyon.

Methodology:

(1) Age Dating

We propose to use a combination of radiocarbon and cosmogenic dating to determine the ages of preserved geological deposits in Cataract Canyon. Prehistoric debris flows along tributaries in the canyon can be dated using radiocarbon analysis of preserved organic matter. Previous work suggests that fine twigs can be preserved among boulder piles for as long as 1,000 years in this environment. Little organic material has been observed in stratigraphic profiles, suggesting that no stratigraphic work will be attempted on this project.

Cosmogenic age dating will be used to directly date particles lying on the surface of debris fans and talus aprons and to estimate long-term sediment yields. This technique essentially measures the “sun tan” of the particles and how long they have been exposed to cosmic-ray bombardment. Three cosmogenic techniques will be used: (1) 3He dating is possible on rocks bearing mafic minerals such as olivine, pyroxenes, and hornblende. This restricts usage to igneous rocks, either intrusive or extrusive, and both types are relatively rare within Cataract Canyon but are common in river gravels preserved in the approaches. Cosmogenic 3He dating has an effective range of several thousand to about 2 million years old and is relatively inexpensive to perform. (2) Cosmogenic 14C dating is possible for sedimentary rocks bearing quartz crystals. This technique, which is still experimental, offers the best opportunity for dating of debris fans and talus aprons with in Cataract Canyon. The age range covered by this technique is 0 to about 15,000 years old. (3) 10Be analysis, combined with 26Al, offers age dating in the range of approximate 10,000 to 2 million years. This technique also uses quartz crystals and therefore can be more commonly applied than 3He. However, sample preparation for both 14C and Be-Al analyses is expensive and 3He is the preferred dating technique where it can be applied. All three cosmogenic techniques require collection of rock samples weighing on the order of 100 g to 10 kg, depending upon how abundant the target minerals are within the sample. A total of 10 samples will be collected as replicates from each surface. In addition, we need about 10 samples of river sand from Cataract Canyon to estimate long-term sediment yields for the Colorado River.

(2) Geophysical techniques

We propose to use seismic refraction to determine the depth to bedrock at several points, both on the approach to Cataract Canyon and through the rapids section. According to the reconstructed bedrock profile beneath the river through Cataract Canyon (see figure), the deepest point in the alluvial fill should be at or near Spanish Bottom; two years ago, we in fact measured a depth of 80 m at that point. University of Utah scientists, in 2005, measured depth to bedrock using the same techniques at The Portal downstream from Moab (Peyton Gardner, University of Utah, written commun., 2005). To fill out the depth-to-bedrock profile, we need to add several other points. We propose to use our seismic technique at Sangria Island, in the middle of the river upstream from The Loop in Meander Canyon, and at the large debris fans at Range and Imperial Canyons within Cataract Canyon.

Two factors are expected to complicate subsurface geophysical examination: the alluvial fill is expected to be saturated below river level, creating problems for some techniques (radar, possibly electrical resistivity) that could be construed as less intrusive. Also, the presence of the anhydrite dome at the mouth of Lower Red Lake Canyon and at other points may affect those measurements and make seismic refraction difficult to interpret without multiple shots. Finally, the vertical walls around Spanish Bottom are expected to extend into the subsurface, raising the possibility of reflection of seismic waves from the sides interfering with those coming from directly beneath the bottomland. Our research plan

from 2004 reflected those potential complications, and we determined that seismic refraction was the only viable technique for measuring depth to bedrock in Cataract Canyon.

Seismic refraction consists of a line of geophones stretched from a control system and some source of acoustic energy. The setup is light enough to be hand carried and placed with minimal disturbance, and we propose to work on islands or debris fans that annually are inundated. Refraction as described here is essentially one-dimensional, yielding information in the vertical direction for each setup. Therefore, multiple setups may be required to obtain information on the variability of depth to bedrock. Several possible sources of acoustic energy are possible, ranging in magnitude from "sledgehammer hitting a steel plate" to large explosives. The choice of energy source is extremely important and is tailored to the geophysical problem being addressed; we need to use sufficient energy to penetrate the anticipated depth of alluvium while minimizing hazards and disruption of park visitors and resources. For this trip, we propose to use a combination of a sledgehammer hit on a steel plate and a blank acoustic charge (Betsy charge) input into the ground. Both of these techniques are safe and are minimally invasive to the park's mission and integrity. The geophysical data consists of arrival times at the various geophones. Post-processing can be done on site using laptop computers, allowing repositioning of equipment to handle any anomalies that might be viewed in the data. We anticipate that multiple applications of acoustic energy may be required to adequately and reproducibly estimate the depth of alluvium above and through Cataract Canyon.

(3) Releveling of the longitudinal profile through Cataract Canyon and fathometer profile
In 1921, the U.S. Geological Survey, led by William Chenoweth, surveyed a longitudinal profile along the Colorado River through Cataract Canyon. Their purpose was to determine baseline topography for estimation of reservoir size for potential damsites, including one at Dark Canyon. The published data for Cataract Canyon rounded the longitudinal profile to increments of 5-ft drops, but the original data was collected to 0.1 ft accuracy and was obtained from field notebooks. They normalized their data to a discharge of 10,000 ft3/s.

The survey began from what is known as the Kendrick benchmark at the Confluence. This benchmark was reoccupied by the U.S. Reclamation Service and the U.S. Geological Survey for subsequent surveying through Cataract Canyon. We propose to begin at this site by leveling this benchmark with other marks in the vicinity, including those attributed to Stanton upstream from Spanish Bottom on river left and near the head of Rapid 6. Use of these benchmarks will enable close comparison of our survey with the Chenoweth survey. We propose to do simple leveling with a total station consisting of upstream and downstream shots from each instrument setup. In some cases, such as Big Drop 2, long reaches of the channel may be visible from a single instrument station, making it possible to survey as much of a mile in river corridor before moving the station to a new location.

The purpose of the releveling will be to determine if any of the drops through rapids have changed in 82 years. In addition, this resurveying will determine the answer to a couple of historical questions concerning the presence and naming of rapids in Cataract Canyon, particularly centered in the reach near Rapid 12 (where Rapid 11 had a larger drop in 1921 than Rapid 12) and Rapids 13 and 14. Because these rapids represent alluvial fill of the channel through debris-flow additions of boulders, the releveling will yield information on how quickly such changes occur and whether they are relevant to the overall geologic history of the formation of Cataract Canyon.

We will use a standard fathometer ("fish finder") attached to a laptop computer to measure the depth of water in the thalweg (deepest channel thread) through Cataract Canyon. This depth finder will measure water depth to an accuracy of several centimeters, which is appropriate to the shifting channel conditions within the canyon. We will use low-level aerial photographs obtained from the park (1976 date) as well as the Belknap river guide, to record the locations of the fathometer profile.

Collections:
Samples of rocks and sand used in cosmogenic dating analysis. Samples of wood or organic material entrained in debris-flow deposits (boulder trains) for radiocarbon analysis.

Only samples of the following are allowed to be collected: 1) No mare than 10 loose rock samples, no chipping of boulders allowed. 2) Small fragments of organic material from debris flow levees. 3) No mare than 10 samples of river sand or sediment.

All samples will be destroyed through analysis or discarded after analysis

Logistics:
We believe we can carry out our objectives during the course of two 5-7 day river trips in early April 2006 (seismic work) and mid-October 2006 (tree rings and releveling). This trip would require motorized boats for two reasons: first,

the seismic equipment, while light enough to carry by hand to the study sites, is voluminous owing to reels of wire, and the appropriate transportation platform would be a motorized boat. Rock samples are anticipated to be relatively heavy, again indicating motorboat use would be the safest approach. Finally, the releveling work will require constant repositioning of surveying instruments and rodmen, and the work would progress much more quickly if motorboats were used. We therefore are requesting the use of two motorboats for this work in Cataract Canyon.

18) Permit #: CANY-2006-SCI-0018

Study Title:

ANNUAL FOREST LAND INVENTORY OF UTAH.

Primary investigator contact information:

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Project Summary:
Gather long-term information on the quantity and quality of forest resources, growth, mortality, removals, and forest health. We will visit only two sites in Canyonlands National Park, located at : T 30-1/2SR18E Sec32, T 31S R 17E Sec18.

Collections:
Photographing plants for identification only. No specimens shall be collected. No coring of trees allowed.

2005 Findings and Status:
The Annual Forest Land Inventory of Utah project is an ongoing natural resource inventory. Results of the inventory are periodically updated and made available at www.fs.fed.us/rm/ogden.

19) Permit #: CANY-2006-SCI-0019

Study Title:

Quantifying the impact of geologic heterogeneity on hydrocarbon recovery in marginal eolian reservoirs

Primary investigator contact information:

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Project Summary:
The proposed study forms part of a 3-year PhD research project to understand and quantify the impact of geologic heterogeneity on hydrocarbon recovery in marginal eolian reservoirs High-quality outcrop exposures of the Permian Cedar Mesa Sandstone in Canyonlands National Park and surrounding areas provide the potential to quantify geologic heterogeneity within eolian erg-margin deposits. We propose to collect datasets from suitable outcrops within Canyonlands National Park and surrounding areas using conventional, non-obtrusive and non-destructive fieldwork

techniques. These datasets will be used to develop qualitative understanding and quantitative description of the types, length-scales and hierarchical spatial organisation of geologic heterogeneity in such rocks. These data will be used to constrain three-dimensional computer models of geologic heterogeneity in subsurface hydrocarbon reservoirs deposited in analogous environments (eolian erg-margin), in order to simulate fluid flow in such reservoirs and thus aid their efficient management. The outcrop work is thus an essential complement to our current subsurface studies of selected gas fields within the Permian Rotliegend "feather edge" play of the southern North Sea, offshore UK. Model results will be made available to ConocoPhillips, who are part-funding the research. Upon completion of the PhD project, the models will be made available to the broader scientific community.

Objectives:

The aim of the 3-year PhD project is to understand and quantify the impact of geologic heterogeneity on hydrocarbon recovery in marginal eolian reservoirs.

Specific objectives are:
- To develop detailed, three-dimensional simulation models of marginal eolian reservoirs directly from suitable analogue outcrops.
- To quantify and rank the impact of different types and scales of heterogeneity on hydrocarbon recovery from marginal eolian reservoirs, with a focus on gas fields within the Rotliegend Feather Edge play of the UK Southern North Sea.
- To obtain quantitative data to constrain subsurface reservoir models.
- To identify optimal strategies for capturing key heterogeneities in subsurface reservoir models.

The proposed fieldwork addresses the first of these objectives.

Methods:

A. Description of study area
Six proposed study sites are identified in the Needles District of Canyonlands National Park, based on previously published work: (1) Needles, (2) Elephant Hill, (3) Squaw Flat, (4) Squaw Butte, (5) Salt Creek Butte, and (6) Mosquito Butte (Fig. 1). Additional sites outside of the park boundary will also be studied. Sites inside the park comprise eolian-dominated erg-margin deposits, whereas those outside comprise fluvial-dominated erg-margin deposits.

We plan to spend 2-5 days at each of the proposed study sites collecting data. Data will be collected using conventional geologic fieldwork techniques: sedimentary logging and line drawing, collection of digital photographs, spatial referencing using GPS and laser rangefinder. No rock samples will be collected, and all field techniques are non-obstrusive and non-destructive.

Collections:

No rock samples will be collected.

Analysis:

Qualitative and quantitative data collected in the field will be used to construct three-dimensional computer models of geologic heterogeneity in 'type' examples of eolian erg-margin deposits. These models will then be used to simulate fluid flow through the rock volume, in order to determine the impact of different geologic heterogeneities. Fluid flow simulations will be based on typical scenarios considered in the draining of hydrocarbon reservoirs, and our analysis will aim to identify the most efficient scenario.

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20) Permit #: CANY-2006-SCI-0020

Study Title:

Aquatic macroinvertebrate survey of Cataract Canyon

Primary investigator contact information:

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Project Summary:
The purpose of the study is to compile an aquatic macroinvertebrate species list of Cataract Canyon. We would like to catalog the current biodiversity of aquatic insects, especially potential rare species of Mayflies (Ephemeroptera) and other uncommon Southwest taxa. This qualitative survey of aquatic macroinvertebrate diversity in Cataract Canyon will increase our understanding of the distribution and relative abundance of invertebrates in Canyonlands National Park. Additionally, it will assist in determining the role of aquatic macroinvertebrates in the entire river foodweb/ecosystem. Lastly, the survey will assist in understanding the regional distribution of invertebrates over the entire Southwest, by contributing to the regional database of the National Aquatic Monitoring Center.

This work will be accomplished by using standard macroinvertebrate sampling protocols, such as kick and sweep nets. This will limit habitat disturbance while maximizing the amount of data collected. Additionally, the samples will be sorted in the field, with only a subset of taxa preserved in Ethanol. The excess invertebrates not retained will be returned to the river, minimizing the number of individuals killed. The retained specimens will be identified to the lowest taxonomic level possible by the staff of the National Aquatic Monitoring Center. Standard collection data will also be taken (e.g. GPS coordinates, date, locality name, collector, etc.).

Collections:
Specimens collected will be aquatic macroinvertebrates in the insect orders of: Ephemeroptera, Diptera, Plecoptera, Trichoptera, Heteroptera, and Coleoptera. Samples will be taken from the Colorado River in Cataract Canyon. A total of 6 to 8 samples will be taken depending on accessibility to the different habitats (i.e. riffles, eddies, and pools). The invertebrates will be stored at the National Aquatic Monitoring Center at Utah State University and cataloged with Canyonlands National Park.

21) Permit #: CANY-2006-SCI-0021

Study Title:

CO2 GEOLOGICAL STORAGE :
LONG TIME GEOCHEMICAL REACTIVITY OF ARGILLACEOUS CAP-ROCKS MATRICES

Primary investigator contact information:

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Project Summary:
The aim of this PhD study is to investigate the long term behavior of cap-rocks for CO2 geological storage, where argillaceous minerals are abundant. In this context, we will focus on polycrystalline diagenetic clay-rich rocks, avoiding any consideration on fractures. In particular, we want to determine what could be the role of mineral reactivity and fluid-rock interactions for assessing risks involved in the choice of a geological storage site.

Three approaches are possible to validate a potential geological storage site. The first approach consists in using and studying some field analogues, where CO2 paleo fluids bearing sediments crop out. This approach is limited by the number of good and accessible sites, which makes some compromises more difficult to make and thus introduces unquantitative uncertainties. We can also underline that pressure-temperature-time constrains on natural samples are complex to obtain and in many case, not precise enough to give any information on the time-duration of CO2 accumulation and residence. A second possibility is to undertake numerical simulations of large scale fluid-rock chemical reactions and transport. In this case, models are limited by the knowledge of physical and chemical constants

(thermodynamics and kinetics for example) and by their capabilities to fit natural analogues or experiments on natural samples. Lastly, in terms of durability and predictability, using experimental simulations on natural samples is drastically limited to time durations of experimental runs.

We propose to elaborate an experimental protocol, to quantify some constants used in the numerical simulations (based on experimental synthetic materials), and on the other hand, to validate numerical simulations based on a geological time scale from different experimental tests on natural samples. The experimental methodology will be validated by comparing the different approaches on natural CO2 bearing samples from different geological environments (Colorado, Italy, …).
By these combined approaches using numerical modelling, experimental simulations, and natural samples characterisation, the study will attempt to predict reactive behaviour of argillaceous matrices that compose aquifer/reservoir cap-rocks and which are progressively invaded by CO2 gas or dissolved CO2.

The first task is to quantify mineralogical changes as a function of geological times, and later, to calibrate some of the parameters (thermodynamics and kinetics) in order to validate some of the numerical models (textural model for example) of fluid-rock transport aimed at predicting storages behaviours.

This PhD should then make a critical review of the present numerical models possibilities in use at I.F.P., and allow better long term geological phenomena to be estimated. From this study, an experimental protocol to validate an hypothetical storage site will be given to avoid systematic research of natural analogues.

Collections:
Small loose rock samples only are allowed for collection. No chipping from larger rocks allowed. The only rock samples approved for collection are those that are loose on the ground. Limited to a total of 30 samples for the entire project, each sample no larger than 25cm by 25cm by 25cm. All Specimens shall be destroyed in analysis.

22) Permit #: CANY-2006-SCI-0022

Study Title:

RIPARIAN AND AQUATIC INVERTEBRATE MONITORING PROTOCOL AND DEVELOPMENT (NPS I&M PROGRAM)

Primary investigator contact information:

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Project Summary:
The objective of the study is to develop a rigorous, well-integrated set of protocols for long-term riparian and macroinvertebrate monitoring across the Colorado Plateau. Another objective is to evaluate the utility of aquatic macroinvertebrates and riparian ecosystems as reliable indicators of aquatic ecosystem conditions in dryland systems characteristic of the Colorado Plateau.

Collections:
In general, macroinvertebrate samples are destroyed during analysis. Upon arrangement with the Park curator, a voucher collection from the sampling effort can be maintained at an established (museum) location following NPS repository standards.

Only the collection of aquatic invertebrates allowed. Most will be destroyed in analysis. Those curated will be stored according to NPS regulations at the Utah State University Bug Lab.

2005 Findings:
No activity was conducted during this report year.

23) Permit #: CANY-2006-SCI-0023

Study Title:

LANDSCAPE MONITORING PROTOCOLS USING SATELLITE, AIRBORNE, AND GROUND-BASED INSTRUMENTATION

Primary investigator contact information:

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Project Summary:
The objective of this project is to research, design, and develop procedures that use very high-resolution multi-temporal satellite and airborne imaging, along with low cost ground-based soil moisture sensors and stand-alone digital camera stations to help monitor federal lands. The study sites are on the Colorado Plateau and include both NPS and BLM managed lands. Besides satellite and airborne remotely sensed images the project will also use historical aerial photos, DOQs, and DEMs, as well as field-based automatic digital camera and soil moisture stations.

Within DOI agencies responsible for the management of federal lands that range in size from large tracks of BLM land to large and small national parks a common critical need is a way to help monitor the landscape at temporal resolutions ranging from days to decades and from very-local to regional scales (USGS Information Fact Sheet, 2003). The capability to map physical and biological resources within federal lands is very important to federal land managers as highlighted in the BLM/FS National Resource Management and Geo-Spatial Tools Conference held in Phoenix, Arizona during April 2005. An important theme throughout this conference was the need by federal land managers to have the tools and data sets to monitor and detect change within and around federal lands.

It is impossible with the resources available to federal land managers to have field crews visit each square mile at a temporal resolution that allows adequate monitoring to be done. Satellite and airborne remote sensing can be used to image relatively large land areas at various temporal and spatial resolutions, and combined with digital image change detection techniques, can be used to detect change with direct application to landscape monitoring. However, the operational use by land managers of remotely sensed data has often not occurred for several reasons, including problems associated with the spatial resolution being too low and not having straight forward and easy to use procedures and data analyses tools to use on multi-temporal image sets. The improvement in satellite image spatial resolution in recent years and new readily available airborne imaging systems with very-high spatial resolution capabilities dramatically impact the low-resolution problems encountered to monitor landscapes at local scales. The emphasis of the research and development being done in this project is to help solve these limitations by taking advantage of the new improvements on spatial resolution and developing remote sensing/image processing algorithms and procedures designed for more operational landscape monitoring.

A component of our work during the first year (fy05) has been to build partnerships and have other disciplines and bureau scientists join us as collaborators. Discussions and meetings have included Mark Miller (he was with the NPS and is now with BRD in SE Utah), Rich Reynolds (he is with GD's Earth Surface Dynamics program and is Co-PI in our Mojave Desert work and has

been working on the Colorado Plateau with Mark Miller and Jane Belnap), Lisa Thomas (NPS coordinator for the Southern Colorado Plateau/I&M Network) and Chris Lauver (NPS ecologist); both Lisa and Chris are stationed at Northern Arizona University in Flagstaff. Contacts have also been made (or will be made) with the BLM biologist and NPS ecologist stationed at the federal lands that contain our two study sites (Tammy Wallace/BLM and Charlie Schelz/NPS).

Collections:
No collection of specimens is allowed

Logistics:
This permit request is to fly a Bureau of Reclamation helicopter (the pilot, Mark Santee gives OAS training classes) with our airborne digital imaging system mounted on an FAA approved tyler mount to collect very-high resolution images. The resolution of the images will vary from 2 to 6 inches, with the flying height above the ground (AGL) being above 2000 feet AGL. The passengers/imaging specialists in the heliocopter will be David Tucker and Barry Middleton, both from the USGS in Flagstaff, AZ.

The helicopter is available for our use on May 1st to May 5th, so these would be the projected dates that we'll fly several transects within the park boundary. We have interacted with Mark Miller and Rich Reynolds, and with the NPS ecologist in selecting flight lines. We will also be flying over BLM land next to the park and have selected those flight lines as well, with input from Tammy Wallace.

Flights will take place primarily in the Needles District of CANY. Flight lines have been mapped and approved by CANY management.

Conditions:
Helicopter must stay above 2000 feet of altitude. Helicopter cannot land within the boundaries of Canyonlands NP. Helicopter must stay at least ¾ mile from campground and all buildings including Visitor Center, Maintenance and Residences. Helicopter is only authorized to fly on designated flight line.

24) Permit #: CANY-2006-SCI-0024

Study Title:
AMPHIBIAN RESEARCH AND MONITORING INITIATIVE (ARMI):
PACIFIC NORTHWEST AND ADJACENT ARIDLANDS
CANYONLANDS NATIONAL PARK INDEX SITE

Primary investigator contact information:

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Project Summary:
To develop effective monitoring protocols that will provide the proportion of habitat units that host breeding populations of amphibians within selected survey areas, in a design that allows broad inference to all of Canyonlands National Park. Integrate findings in Canyonlands National Park with a national amphibian monitoring program.

Surveys will occur over most of Canyonlands NP, more intensive studies in Salt Creek and Horseshoe Canyon in the Needles District.

Objectives:

1.. To develop effective monitoring protocols that will provide the proportion of habitat units that host breeding populations of amphibians within selected survey areas, in a design that allows broad inference to all of Canyonlands National Park.
2. To develop methods to effectively estimate population density and abundance in sentinel sites that will be worked intensively over each season.
3. Work with Southeast Utah Group NPS staff to enhance and expand existing water monitoring program to ensure amphibian habitats are being monitored, and to add any parameters of importance to amphibians that may not be included in current park monitoring program (e.g., dissolved organic matter, and community attributes such as plankton composition).
4. Monitor the incidence of disease in Canyonlands amphibians.
5. Integrate findings in Canyonlands National Park with a national amphibian monitoring program.
6. Make latest monitoring data available to the NPS via web accessible database within 3 months of data collection.
7. Compile and interpret trend information on amphibians that we collect at regular intervals and place findings into local, regional, and national contexts.

Collections:
One to three specimens of each species of amphibian documented to be in Canyonlands NP (up to nine species possibly occur) will be collected from one to three locations in the park for a National amphibian disease survey. These specimens will be destroyed in analysis.

2005 Findings and Status:
A new set of segments were randomly selected in 2005 to augment the 27 segments surveyed in 2004 that were determined to have amphibian habitat during the spring season. A total of 83 sites were visited, including the 27 segments identified in 2004 as containing amphibian habitat. Of these, 40 contained amphibian habitat, and there were amphibians detected in 22 of these segments. The 2004 sites identified as containing habitat were among those surveyed in 2005, and provided 16 of the 21 segments with amphibians. However, about a third of the segments with habitat (= water or moist sediment at the time of survey) in 2004 did not meet these conditions in 2005. The sites identified in 2003-2005 will be used as the set of monitoring sites for future monitoring. Some of these may not represent amphibian habitat (will be dry) when visited each year, but we should have enough sites each year with habitat to evaluate PAO each year.

25) Permit #: CANY-2006-SCI-0025

Study Title:

Title POPULATION FRAGMENTATION, HABITAT, AND CONSERVATION GENETICS OF AMPHIBIANS IN THE GLEN CANYON / CANYONLANDS REGION

Primary investigator contact information:

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Project Summary:
Loss of connectivity among habitat patches and resulting fragmentation of natural populations are important concerns for long-term preservation of natural populations. Metapopulation studies of some anuran amphibians have demonstrated loss of connectivity among formerly extensive populations and have noted the potential contributing role of such fragmentation to amphibian declines (Sjögren 1991, Mann et al. 1991, Lehtinen et al. 1999). A variety of causes

have been implicated in fragmentation of amphibian habitat, including clearing of forest lands (Gibbs 1998), road-building (Vos and Chardon 1998), and introduction of non-native species, particularly predatory fishes (Bradford et al. 1993). Isolation of subpopulations within habitat fragments, and gradual loss of these subpopulations over time, may be an important reason for regional declines (e.g. in Rana muscosa, studied by Bradford et al.).

In the southwestern United States, there is considerable natural fragmentation of amphibian populations by broad stretches of hot, dry, inhospitable habitat separating seasonal and permanent wetlands. For this reason, the riparian areas along rivers and streams are vital habitat for many amphibians in this arid country, and provide extensive corridors linking populations. Over the last 150 years, however, there has been considerable degradation and loss of such habitats (Dahl 1990, Bogan et al. 1998), with consequent declines of species that depend on them. Some studies have examined direct effects of such habitat loss and degradation (e.g. Krueper 1993), but few have considered secondary effects such as isolation of tributary streams, side canyons, and headwater springs, and the resulting population fragmentation this may cause. Because of limited dispersal abilities and susceptibility to desiccation in arid habitats away from water, amphibians appear to be particularly vulnerable to this kind of population fragmentation.

The Colorado River and its major tributaries once provided more or less continuous habitat for northern leopard frogs (Rana pipiens) and other amphibians. Over the last 40 years, leopard frogs have experienced marked declines throughout the Southwest (Clarkson and Rorabaugh 1989, Corn and Fogleman 1984, Sredl 1998). Northern leopard frogs are currently listed as species of conservation concern by a variety of state and Federal agencies, including the U.S, Forest Service ("Sensitive," Regions 2 and 3 (Colorado, New Mexico, and Arizona), the Arizona Game and Fish Department ("Species of Special Concern"), the State of Colorado ("Special Concern Species"), and the Navajo Nation ("Threatened").

We have conducted field surveys over the last three years in Grand Canyon and Glen Canyon that underscore the decline of this species in the Upper Colorado River region. Historical surveys found leopard frogs to be widespread both along the main course of the Colorado River, and in perennial side canyons of Glen Canyon (Eaton 1935, Woodbury 1958, Drost and Sogge 1995). With the completion of major reservoir projects such as Glen Canyon Dam / Lake Powell, however, leopard frog populations along the river have nearly all disappeared (Tomko 1975, Miller et al. 1982, Drost and Sogge 1995, Drost 2005). Northern leopard frog may now be extirpated from the Grand Canyon reach of the river. In Glen Canyon, populations of the species have become much reduced and restricted to a few scattered side canyon sites. Recent studies (Drost 2005, J. Spence, Glen Canyon National Recreation Area, pers. comm.) indicate that some of these side canyon populations are now disappearing as well.

Objectives:
1) determine current distribution of leopard frogs in Glen Canyon and Canyonlands;
2) evaluate relative population sizes in different reaches of the river, and specifically to compare population distribution and numbers between Glen Canyon (impounded) and Canyonlands (unimpounded);
3) analyze degree and pattern of geographic separation and genetic divergence among populations;
4) locate isolated, relict populations that may require direct management intervention for their persistence;
5) examine habitats used by leopard frogs in the region, for use in developing management actions; and
6) develop specific management strategies & conservation priorities for leopard frog populations in the region.

Through field surveys in Glen Canyon and Canyonlands, we will gather extensive data on current distribution and abundance of northern leopard frogs. We will use genetic analyses to evaluate genetic diversity in leopard frog subpopulations where they are found in the two

areas. We will also use genetic techniques to look for evidence of recent population bottlenecks and to characterize genetic structuring at local and regional (western US) scales.

Recent surveys for leopard frogs in Glen Canyon and Grand Canyon have been supported by the National Park Service and the U.S. Bureau of Reclamation, which are both concerned with the status of amphibians in this region. That work provides a strong foundation for the study proposed here, in terms of baseline data, equipment and methods, and experienced personnel. This follow-up study, in turn, will provide land management and conservation agencies with insight into population status throughout the region, habitat requirements of the species, demographic histories, and regional gene flow patterns, and will help prioritize future management activities to conserve these species. This study will also broadly extend and provide a regional context for existing amphibian monitoring efforts in the Canyonlands National Park region.

Collections:
No collection of specimens is allowed. Blood and/or mouth swabs of the following species, for genetic analysis only is allowed: Northern Leopard Frog (*Rana pipiens*), Canyon Treefrog (*Hyla arenicolor*), Red-spotted Toad (*Bufo punctatus*), Woodhouse's Toad (*Bufo woodhousei*). Maximum number of samples for any taxon will be 300 (calculated as 20 sampling sites * 15 samples per site). Frequency will be once for any individual, but samples may be collected over the entire course of the study period. Since a major objective of the study is to analyze patterns of genetic relatedness and population isolation, samples may be collected wherever populations are found in Canyonlands NP.

Logistics:
Crews will use USGS boats for work on the rivers. Assistance from the NPS may be requested occasionally but is not expected. Crews will be collecting data from June until September, 2006.

26) Permit #: CANY-2006-SCI-0026

Study Title:

Landsat-Based Detection and Mapping of Cheatgrass (*Bromus tectorum*) Invasion Patterns in Drylands of Southeastern Utah

Primary investigator contact information:

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Project Summary:
In an era of decreasing financial resources and increasingly rapid environmental change, land managers require cost-effective methods for detecting and mapping the distribution and dynamics of invasive exotic plants across vast landscapes. This project involves development of a repeatable protocol for detecting and mapping cheatgrass (*Bromus tectorum*) invasion patterns in drylands of Southeastern Utah by analyzing multitemporal (spring and summer) satellite imagery.

Methods:
This project consists of a lab component and a field component. In the lab, late April and early July Landsat images covering the Needles District of Canyonlands National Park and surrounding BLM lands will be used to develop a predictive map showing the distribution of cheatgrass. The image-analysis and mapping technique takes advantage of the species' rapid change from peak green biomass in late April to full senescence in early-to-mid summer by

differencing vegetation indices developed from the two separate images. The predictive map developed from this differencing technique will be ground-truthed during the field component of the study. With support from NPS staff, a spatially balanced random sample of locations predicted to be dominated by cheatgrass and locations predicted to have relatively little cheatgrass cover will be selected using a GIS procedure. Approximately 50-75 cheatgrass points and 50-75 non-cheatgrass points will be visited in the field. At each sample point, cover of vegetation, biological crusts, and bare ground will be estimated in a circular macroplot of 60-m radius (to nearest 5 percent by lifeform, except for cheatgrass) and in 5 square 1-m2 subplots located within the macroplot (by species, to nearest 1 percent cover). In addition, soil-geomorphic characteristics will be described for each macroplot location and digital photographs will be taken.

Results:
The field effort will assess the accuracy of the Landsat-based cheatgrass mapping technique, and will provide data that will inform on-going studies of soil-geomorphic relations of cheatgrass in Colorado Plateau drylands.

Collections:
No collection of any specimens or soil is allowed.

Logistics:
Researchers will not need any NPS assistance. They will be in the field between June and September, 2006, and will be using the USGS quarters in the Needles as a central office.

27) Permit #: ARCH-2006-SCI-0027

Study Title:

PHOTO-INTERPRETATION TRAINING SITE ESTABLISHMENT IN SUPPORT OF THE U.S. GEOLOGICAL SURVEY - NATIONAL PARK SERVICE VEGETATION CLASSIFICATION AND MAPPING PROGRAM AT CANYONLANDS NATIONAL PARK

Primary investigator contact information:

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Project Summary:
The National Park Service (NPS) and U.S. Geological Survey (USGS) are cooperating to produce detailed vegetation classifications and digital databases, including vegetation maps, as part of the National Biological Information Infrastructure Program (NBII). Approximately 250 national parks and monuments will benefit from this cooperative effort upon successful program completion. The National Park Vegetation Classification and Mapping Program is a strong component of the NPS Inventory and Monitoring Program, established in 1991, and is based on a repeatable set of standards and flexible protocols.Sampling will be conducted in accordance with the Vegetation Classification and Mapping Work Plan developed for Arches National Park in February 2003, which has been reviewed by USGS-NPS Vegetation Classification and Mapping Program leaders, Northern Colorado Plateau Network (NCPN), and/or Arches ecologists. This work plan will serve as the basis for all such efforts at the park, including sampling methodology, and should be considered as the study proposal. Copies of the work plan, both

electronic and hard-copies, are available through the NCPN Inventory and Monitoring Program, or from the park ecologist.

Methods:
Methodology consists of visiting specific areas of the park to confirm and fine-tune photo-interpretation analysis. Observation of plant communities in the field is the only activity.

Collections:
The collection of any specimens is not allowed.

Logistics:
Field personnel will be checking areas within easy access of CANY roads. No overnight trips are currently planned.

2005 Findings and Status
Local descriptions for 151 plant associations identified for Canyonlands National park were completed and included the environmental conditions and species present for those associations.

28) Permit #: CANY-2006-SCI-0028

Study Title:

DEVELOPMENT OF A RESTORATION RAPID ASSESSMENT TOOL (RRAT) FOR THE NATIONAL PARK SERVICE TO PRIORITIZE SITES FOR WEED CONTROL AND RESTORATION

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Project Summary:
The purpose of this study is to develop a protocol with which to rapidly assess disturbed sites within the National Park Service, so the resource managers may easily prioritize sites for restoration. The RRAT uses ecological attribute indicators of soil, hydrology and vegetation to assess the health and condition of a site. We will be field testing the RRAT on actual disturbed sites within the Colorado Plateau and Midwest Parks so that we may detect inefficiencies among indicators. Ideally, this field study will help guide us in making future modifications that will allow for an RRAT that is more usable and helpful to resource staff.

Objectives:
The RRAT project has been in the making since 2003 over a series of "phases". Phase 1 involved the draft of the RRAT and an email survey sent out by former Northern Arizona University (NAU) graduate student Rebecca Harms (Harms, 2003). The survey asked NPS resource managers and staff what weeds threatened their ecosystems most and what protocols they currently used to prioritize sites for restoration. In phase II, NAU graduate student Amy Richey set out to test the validation of three of the six attributes upon which the RRAT indicators are based: hydrology/landform, soils/water quality, and vegetation. The other attributes include animal stressors, site value, and land use history. In her research, Richey found that while the vegetation indicators provided valid assessments of site condition, hydrology/landform and soil/water quality did not. Phase III's objectives seek to take the RRAT to the field once again to test whether NPS resource staff with varying levels of knowledge and experience achieve the same results with RRAT. Also, because RRAT has only been tested in

riparian areas, we seek to test whether the RRAT may transcend its utility beyond riparian areas, by taking it to upland and other non-riparian areas. Other objectives for summer 2006 research include testing economy/efficiency of RRAT, and testing each attribute's efficacy (of hydrology/landform and soil/water quality and vegetation) at discriminating between sites.

Hypotheses to be Tested:

1. Do resource managers with different levels of experience, education, and knowledge respond similarly to the RRAT? (sampling error)
2. How do RRAT prioritization scores compare with current resource manager prioritization strategies?
3. How does each attribute alone (vegetation, soil, hydrology) discriminate between sites vs. the RRAT?
4. Does the RRAT help resource managers conceptualize a restoration strategy?
5. Is the RRAT adaptable to non-riparian sites?
6. Does the RRAT detect sites where a little restorative action would lead to a large benefit or where lot's of restorative action would earn few benefits?

Methods:

The field testing will involve visiting National Parks within the Colorado Plateau. Ideally, the RRAT will be conducted on 3-5 field sites per park. NPS resource managers will be asked to choose the sites in advance so that they compose an array of degrees of disturbance. Multiple resource manager presence at each site will allow us to determine sampling error between RRAT users.

Collections:
The collection of specimens is not allowed.

Logistics:
The park will be notified and park ecologist will accompany the researcher in the field.

29) Permit #: CANY-2006-SCI-0029

Study Title:

NCPN INTEGRATED UPLAND MONITORING IN CANYONLANDS NATIONAL PARK

Primary investigator contact information:

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Project Summary:
This study is the initial implementation of the NCPN Integrated Upland Monitoring effort.

Objectives:
Specific objectives of the NCPN Integrated Upland Monitoring Protocol are:

1) Determine annual status and trends in ground cover (live and standing dead vegetation, litter, rock, biological soil crust [BSC], and bare ground); soil aggregate stability and compactions as indicators of soil/site stability, hydrologic function, and nutrient cycling.

2) Determine annual status and trends in cover of biological soil crusts by species or morphological group.

3) Determine annual status and trends in cover of exotic plants in upland areas.

Collections:
Only very small soil samples allowed. Samples must be no larger than 3mm by 8mm, and may not exceed past a depth of 2.8cm. The collection of parts of plants also allowed for identification purposes only, but must be destroyed in analysis. The collection of anything else is not permitted.

Logistics:
Field work will start on August 14 and continue through September 30. Researchers are required to contact the park district when entering for field work. No special camping arrangements are anticipated.

30) Permit #: CANY-2006-SCI-0030

Study Title:

CHARACTERIZATION OF PERMIAN WHITE RIM SANDSTONE CONCRETIONS, SOUTHEASTERN UTAH

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Project Summary:
My research (previous and in progress) has established a valuable model for understanding the occurrence of dramatic Jurassic Navajo Sandstone coloration and the striking “Moki marbles” in southern Utah. White sandstone is proposed to be “bleached” from hydrocarbons that mobilized originally disseminated iron, and thus contribute to the source of iron for the diagenetic concretions. Concretions are often nodules, largely comprised of a minor mineral component (e.g., iron oxides of hematite and goethite) that builds up a localized mass through diagenetic differentiation and precipitates as a pore-fill cement.

In 2004, the extraordinary images of the NASA MER (Mars Exploration Rovers) revealed strikingly similar small spherical concretions (“blueberries”) in Meridiani Planum. With the Utah examples as an analog, we now want to increase our understanding of what causes some of the variability in the concretion forms that will have applications to understanding martian hematite.

Although our terrestrial model based on the Navajo Sandstone has gained considerable acceptance, people often ask how we know that hydrocarbons were the responsible mobilizing fluid in the Navajo Sandstone since there isn’t much present. One way to help answer this question is to examine a locality where we do have the hydrocarbons related to the iron concretions still nearby. The Permian White Rim Sandstone is a unit that is clearly bleached from hydrocarbons and the hydrocarbons are still present. Hence, the purpose of this proposal is to sample and evaluate white host rock as well as iron-oxide concretions from the White Rim Sandstone to establish their relationship, as an analog to understanding how Jurassic Navajo Sandstone concretions might have been influenced by hydrocarbons, even though the

hydrocarbons that bleached the Navajo Sandstone are no longer present. The White Rim Sandstone can be an important baseline for comparison because of the hydrocarbon context.

The results of this research have the potential to increase both scientific and public interest in these lesser known areas of Canyonlands National Park, as well as contributing to the evaluation of the park resources and geologically important sites.

Collections:
Small loose rock samples only are allowed for collection. No chipping from larger rocks allowed. The only rock samples approved for collection are those that are loose on the ground. Limited to a total of 12 samples for the entire project, each sample no larger than 15cm by 15cm by 15cm. No tools are allowed for dislodging rocks. All specimens shall be destroyed in analysis.

The impact and environmental assessment will be negligible, as the researcher can conduct observational field studies and would collect only hand specimens. Proposed studies will NOT require any excavations or disturbance of the landscape. Approximately a dozen or less small hand samples (~ 4x4" or smaller) will be collected. In the majority of cases, these samples can be taken from loose float that is already sitting on the surface. In all instances, the researcher will sample discreetly (and away from public view) where it will be unnoticeable and/or indistinguishable from a rock fall or natural weathering.

Logistics:
Researcher will meet with Maze District ranger Gary Cox, and he will accompany her out in the field. Field work will take only a day or two.

31) Permit #: CANY-2006-SCI-Not issued yet

Study Title:

INVESTIGATION OF THE OCCURRENCE AND DISTRIBUTION OF NATURALLY-PRODUCED PERCHLORATE IN AREAS OF MINIMAL ANTHROPOGENIC IMPACT

Primary investigator contact information:

Name: Greta Orris, United States Geological Survey
Address: 520 N. Park Ave., Ste. 355, Tucson, AZ 85719
Phone: (520) 670-5583 **Email:** greta@usgs.gov

Project Summary:
The purpose of this project is to determine the distribution and concentration of probable naturally-produced perchlorate (ClO4-) in areas with little or no anthropogenic or agricultural impact. Perchlorate has become a "contaminant" of increasing environmental concern during the last 8-10 years; in amounts as little as 1 ppb perchlorate is believed to cause a variety of growth and other problems in plants and animals, including humans. For this reason, state and federal agencies are looking to establish regulations on perchlorate in the environment. Perchlorate is a common component of rocket fuels, some munitions, fireworks, air bags and other industrial products. Initially all perchlorate contamination in the US was believed to be of anthropogenic origin. However, our USGS-Texas Tech-USAF team has determined that not all perchlorate is of anthropogenic origin; some perchlorate is created in the atmosphere and deposited in soils and surface water through precipitation. Natural perchlorate has been reported in Chilean nitrates for over 100 years; however, it was believed to be a unique occurrence. The advent of sensitive analytical tools in the mid-1990's has led to the recognition that perchlorate is present in amounts ranging from a few ppb to several ppm at numerous locations, many of which cannot be linked to anthropogenic sources of perchlorate. Particular

physical and climatic conditions can contribute to the concentration of perchlorate, including an arid climate, plants that accumulate perchlorate, impermeable soil components, and a variety of other factors. This study attempts to determine the scope of the natural perchlorate problem and the conditions in the natural environment under which it is most likely to be preserved and concentrated.

Methods:
This is a perchlorate background investigation on common species to determine whether further study is necessary. For selected sites, plant, soil, sediment, and (or) rock samples will be collected and a GPS location will be recorded. This project will collect the following sample types: Soils- Up to 100 g collected from small shallow holes, pits, or hand auger holes. Rock- Up to 150 g of rocks of various ages that represent arid or lacustrine depositional environments. Plants- Up to 50 g of plant material from species present in the selected sampling areas. This might include leaves from common bushes and trees or representative grasses. We do not plan to collect any threatened species. Water- Up to 0.5 L of water will be collected when water is present. We do not plan to collect more sample than will be analyzed; therefore, do not expect to have samples requiring archive or return to the National Park Service.

Collections:
Soils – Up to 100 g collected from small shallow holes or pits. In some areas, the soils might be field tested for the presence of nitrate.
Rock - Up to 150 g of rocks of various ages that represent arid or lacustrine depositional environments.
Plants – Up to 50 g of plant material from species present in the selected sampling areas. This might include leaves from common bushes and trees or representative grasses. We do not plan to collect any threatened species.
Water – up to 0.5 L of water will be collected when water is present.

All samples will be destroyed through analysis or discarded after analysis.

Logistics:
Field work will start on August 14 and continue through September 30. Researchers are required to contact the park district when entering for field work. No special camping arrangements are anticipated.

NATURAL BRIDGES NATIONAL MONUMENT
2006 Research Permits

1) Permit #: NABR-2005-SCI-0001

Study Title:

Sound Levels in Natural Bridges National Monument

Primary investigator contact information:

Name: Skip Ambrose,
Address: HC 64 Box 2205 Castle Valley, UT 84532
Phone: 435-259-0401 or 970.227.8154 **Email:** skipambrose@frontiernet.net

Project Summary:

To determine natural ambient sound levels in the primary vegetation types in NABR, and the relative influence of human-caused sounds on natural sound levels.

The only collections will be the collection of recorded sound data.

The National Park Service (NPS) is concerned with degradation of natural soundscapes in units of the National Park system. NPS Management Policies (4:9; 2001) states: "The National Park Service will preserve, to the greatest extent possible, the natural soundscapes of parks. Natural soundscapes exist in the absence of human-caused sound. The natural soundscape is the aggregate of all natural sounds that occur in parks, together with the physical capacity for transmitting natural sounds. Natural sounds occur within and beyond the range of sounds that humans can perceive, and can be transmitted through air, water, or solid materials."

"Using appropriate management planning, superintendents will identify what levels of human-caused sound can be accepted within the management purposes of the parks. The frequencies, magnitudes, and durations of human-caused sound considered acceptable will vary throughout the park, being generally greater in developed areas and generally lesser in undeveloped areas. In and adjacent to parks, the Service will monitor human activities that generate noise that adversely affects park soundscapes, including noise caused by mechanical or electronic devices. The Service will take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values, or that exceeds levels that have been identified as being acceptable to, or appropriate for, visitor uses at the sites being monitored" (NPS 2001).

OBJECTIVES

1. Determine natural ambient sound levels in the primary habitats/acoustic zones in Natural Bridges National Monument, during the summer and winter seasons; and

2. Assess the influence of man-made noise on natural ambient sound levels.

The primary objective of this project is to provide basic acoustic data necessary for preparation of a Soundscape Management Plan for Natural Bridges National Monument. A secondary objective is to collect acoustic data which will be useful in assessing the influence of man-made noise on natural sounds.

2) Permit #: NABR-2006-SCI-0002

Study Title:
HERBARIUM AND FIELD STUDIES OF VASCULAR PLANT FLORA OF NABR FOR NATIONAL PARK SERVICE INVENTORY AND MONITORING PROGRAM

Primary investigator contact information:

Name: Walter Fertig
Address: 1117 West Grand Canyon Dr., Kanab, UT 84741
Phone: 435-644-8129 **Email:** walt@kanab.net

Project Summary:
The purpose of this study is to document the vascular plant flora of Natural Bridges National Monument (NABR) and develop a plant distribution database using the National Park Service's NPSpecies system.

Collections:
Collection of only one specimen per plant species allowed, or 1-3 specimens of the same species can be collected to represent the species on a single herbarium sheet.
Researcher can only collect plants not represented in the Natural Bridges National Monument Herbarium. Plant species that are too uncommon or are legally protected under the Endangered Species Act will not be collected but will have digital photos taken for documentation.

2005 Findings and Status:
As a preliminary step in developing an updated species list and distribution database for the park, I examined all specimens in the Natural Bridges NM herbarium to correct misidentifications, update species nomenclature (following Welsh et al. 2003, "A Utah Flora, third edition"), and add variety or subspecies names if needed. Of the 449 specimens currently deposited in the collection (not including 396 specimens out on loan) 10 were misidentified (2.2%), 38 had their names updated (8.5%), 34 had variety names added (7.6%), and 367 were confirmed as correctly identified (81.7%). The Natural Bridges NM herbarium currently contains 208 vascular plant taxa collected within the monument. Sixteen additional species have been documented for Natural Bridges based on collections at other herbaria and another 181 taxa are reported for the park (without vouchers) by Schelz and Moran (2005 SE Utah Group Plant list) and Welsh and Moore(1968 "Plants of Natural Bridges National Monument", Proceedings Utah Academy Sciences 45:220-248). Based on the Atlas of the Utah Flora (Albee et al. 1988), 309 additional species are reported from comparable habitats in the vicinity of Natural Bridges, but have not yet been documented within the monument. These results suggest that the Natural Bridges NM herbarium is missing between 49-60% of the plant taxa known or likely to occur in the park. In particular, fall-flowering, non-native, and wetland taxa appear to be under-represented. Targeted inventory work to fill gaps in the Natural Bridges NM vascular plant collection is recommended so that park manager's will have an improved understanding of the composition and status of the flora of the park and a more complete reference collection for researchers and staff interested in plant identification.

3) Permit #: NABR-2006-SCI-0003

Study Title:

SOIL SURVEY OF NATURAL BRIDGES NATIONAL MONUMENT, UTAH

Primary investigator contact information:

Name: Mr Victor Parslow, USDA Natural Resources Conservation Service
Address: 340 North 600 East, Richfield, UT 84701.
Phone: 435.896.6441 ext. 134 **Email:** Vic.Parslow@ut.usda.gov

Project Summary:

To provide an updated soil and ecological site inventory for Natural Bridges National Monument (NABR), that meets National Cooperative Soil Survey (NCSS) standards and monument management and planning needs.

The existing soil survey was conducted in the late 1970s's and the early 1980's as part of the San Juan County, Utah, Central Part soil survey. This inventory was primarily designed as a tool for use in managing grazing lands and has been found to be too general to be useful in managing the park. Information is insufficient to model salt movement, mitigate visitor impacts, identify and protect habitat of Threatened and Endangered species, and other park responsibilities.

In 2003, reprensentatives of the National Park Service approached the Natural Resources Conservation Service to update the existing soil surveys within Arches and Canyonlands National Parks and Natural Bridges and Hovenweep National Monuments. The Plan of Work and contracted were approved in 2004. This application is seeking permission to carry out the field work necessary to complete the contract.

Collections:

Soil sampling allowed: 200 to 300 gram soil samples only. Archeologist must be present when digging any holes in ground. Some clipping of vegetation is allowed but must be kept to a minimum. Majority of soil samples will be destroyed in analysis. No collection of plants is allowed. Photos of plants for identification purposes is allowed.

4) Permit #: NABR-2006-SCI-0004

Study Title:

PILOT STUDIES TO INFORM RIPARIAN MONITORING PROTOCOLS – REFINEMENT OF SITE SELECTION METHODS AND FIELD TRIALS OF PROPOSED MONITORING METHODS

Primary investigator contact information:

Name: Dr. Michael Scott, U. S. Geological Survey
Address: 2150 Centre Ave, Bldg. C, Fort Collins, CO 80526
Phone: 970-226-9475 **Email:** Mike_L_Scott@usgs.gov

Project Summary:

We propose a research program aimed at testing methods described in the current draft protocols for monitoring riparian resources in Southern and Northern Colorado Plateau Network Parks. The monitoring of riparian resources has been identified by both networks as a high-

priority because these ecosystems contribute to high local biodiversity and are sensitive to a wide range of on-site and off-site human activities. By conducting field trials, we intend to refine two important components of the riparian monitoring protocols: (1) the site selection process based on the draft stream classification framework; and, (2) the in-field sampling procedures. Pilot studies will allow us to test the application of the classification framework, to conduct methods comparisons trials, to evaluate inter-observer error trials and to determine the number of stream transects within a reach that will be required to adequately characterize variance for selected metrics. Following the pilot studies, we will report the results in the 2006 field trial report and refine the draft riparian protocols; ultimately contributing to rigorous, repeatable and cost effective riparian monitoring protocols for the Southern and Northern Colorado Plateau Networks

Collections:
No material or specimens will be collected for this project.

5) Permit #: NABR-2006-SCI-0005

Study Title:

RIPARIAN AND AQUATIC INVERTEBRATE MONITORING PROTOCOL AND DEVELOPMENT (NPS I&M PROGRAM)

Primary investigator contact information:

Name: Dr Anne Brasher, USGS, Water Science Center
Address: 121 West 200 South, Moab, UT 84532, USA
Phone: (435) 259-3866 **Email:** abrasher@usgs.gov

Project Summary:
The objective of the study is to develop a rigorous, well-integrated set of protocols for long-term riparian and macroinvertebrate monitoring across the Colorado Plateau. Another objective is to evaluate the utility of aquatic macroinvertebrates and riparian ecosystems as reliable indicators of aquatic ecosystem conditions in dryland systems characteristic of the Colorado Plateau.

Collections:
In general, macroinvertebrate samples are destroyed during analysis. Upon arrangement with the Park curator, a voucher collection from the sampling effort can be maintained at an established (museum) location following NPS repository standards.

Only the collection of aquatic invertebrates allowed. Most will be destroyed in analysis. Those curated will be stored according to NPS regulations at the Utah State University Bug Lab.

HOVENWEEP NATIONAL MONUMENT

1) Permit #: HOVE-2006-SCI-0001

Study Title:

Sound Levels in Hovenweep National Monument

Primary investigator contact information:

Name: Skip Ambrose,
Address: HC 64 Box 2205 Castle Valley, UT 84532
Phone: 435-259-0401 or 970.227.8154 **Email:** skipambrose@frontiernet.net

Project Summary:

To determine natural ambient sound levels in the primary vegetation types in HOVE, and the relative influence of human-caused sounds on natural sound levels.

The only collections will be the collection of recorded sound data.

The National Park Service (NPS) is concerned with degradation of natural soundscapes in units of the National Park system. NPS Management Policies (4:9; 2001) states: "The National Park Service will preserve, to the greatest extent possible, the natural soundscapes of parks. Natural soundscapes exist in the absence of human-caused sound. The natural soundscape is the aggregate of all natural sounds that occur in parks, together with the physical capacity for transmitting natural sounds. Natural sounds occur within and beyond the range of sounds that humans can perceive, and can be transmitted through air, water, or solid materials."

"Using appropriate management planning, superintendents will identify what levels of human-caused sound can be accepted within the management purposes of the parks. The frequencies, magnitudes, and durations of human-caused sound considered acceptable will vary throughout the park, being generally greater in developed areas and generally lesser in undeveloped areas. In and adjacent to parks, the Service will monitor human activities that generate noise that adversely affects park soundscapes, including noise caused by mechanical or electronic devices. The Service will take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values, or that exceeds levels that have been identified as being acceptable to, or appropriate for, visitor uses at the sites being monitored" (NPS 2001).

OBJECTIVES

1. Determine natural ambient sound levels in the primary habitats/acoustic zones in Hovenweep National Monument, during the summer and winter seasons; and

2. Assess the influence of man-made noise on natural ambient sound levels.

The primary objective of this project is to provide basic acoustic data necessary for preparation of a Soundscape Management Plan for Hovenweep National Monument. A secondary objective is to collect acoustic data which will be useful in assessing the influence of man-made noise on natural sounds.

2) Permit #: HOVE-2006-SCI-0002

Study Title:
HERBARIUM AND FIELD STUDIES OF VASCULAR PLANT FLORA OF HOVE FOR NATIONAL PARK SERVICE INVENTORY AND MONITORING PROGRAM

Primary investigator contact information:

Name: Walter Fertig
Address: 1117 West Grand Canyon Dr., Kanab, UT 84741
Phone: 435-644-8129 **Email:** walt@kanab.net

Project Summary:
The purpose of this study is to document the vascular plant flora of Hovenweep National Monument (HOVE) and develop a plant distribution database using the National Park Service's NPSpecies system.

Collections:
Collection of only one specimen per plant species allowed, or 1-3 specimens of the same species can be collected to represent the species on a single herbarium sheet. Researcher can only collect plants not represented in the Hovenweep National Monument Herbarium. Plant species that are too uncommon or are legally protected under the Endangered Species Act will not be collected but will have digital photos taken for documentation.

3) Permit #: HOVE-2006-SCI-0003

Study Title:
SOIL SURVEY OF HOVENWEEP NATIONAL MONUMENT, UTAH

Primary investigator contact information:

Name: Mr Victor Parslow, USDA Natural Resources Conservation Service
Address: 340 North 600 East, Richfield, UT 84701.
Phone: 435.896.6441 ext. 134 **Email:** Vic.Parslow@ut.usda.gov

Project Summary:
To provide an updated soil and ecological site inventory for Hovenweep National Monument (NABR), that meets National Cooperative Soil Survey (NCSS) standards and monument management and planning needs.

The existing soil survey was conducted in the late 1970s's and the early 1980's as part of the San Juan County, Utah, Central Part soil survey. This inventory was primarily designed as a tool for use in managing grazing lands and has been found to be too general to be useful in managing the park. Information is insufficient to model salt movement, mitigate visitor impacts, identify and protect habitat of Threatened and Endangered species, and other park responsibilities.

In 2003, reprensentatives of the National Park Service approached the Natural Resources Conservation Service to update the existing soil surveys within Arches and Canyonlands National Parks and Natural Bridges and Hovenweep National Monuments. The Plan of Work and contracted were approved in 2004. This application is seeking permission to carry out the field work necessary to complete the contract.

Collections:

Soil sampling allowed: 200 to 300 gram soil samples only. Archeologist must be present when digging any holes in ground. Some clipping of vegetation is allowed but must be kept to a minimum. Majority of soil samples will be destroyed in analysis. No collection of plants is allowed. Photos of plants for identification purposes is allowed.