2009 Shortgrass Steppe LTER Request for Supplemental Funds

Part A: Education – Schoolyard LTER

1. Results from prior support 2008-2009

The 2008-2009 funds were used to strengthen our existing partnerships with a modest amount directed towards expansion.

Field trips - Field trips to local nature areas and/or the SGS-LTER field site are an integral component of the SGS-SLTER program. In 2008-2009 we supported the transportation needs for 10 schools to hold field trips to local natural areas. The field trips to the SGS field station have been limited due to the lack of potable water at the new classroom facility. Once the water has been certified as potable, we will host more trips to the site.

Teacher Professional Development (PD) Workshops – For 2008-2009 we hosted eight workshops and four additional meetings to discuss ongoing schoolyard efforts, to review proposals generated by the teacher-graduate student teams, and to present the scope and objectives of the projects at the individual schools. The PD workshops for 2008-2009 focused on the development of experiment designs, data collection, protocols on maintaining databases, Climate Change and means by which the projects can be integrated into curricula (see Appendix A). K-12 science and mathematics teachers from the schools within our partnership met with LTER scientists. The PD activities also included summer field experiences, proposal development and curriculum/module development geared toward schoolyard ecology activities**.**

Supplies - Funds were used to purchase 10 GPS units for use by the teachers for the schoolyard activities across our partnership. The GPS are available to K-12 teachers for classroom use on rotation/as needed basis. The GPS units are housed at CSU and managed by the SLTER Program Coordinator.

Outreach – In 2006-2007 the SGS-LTER presented displays of research and education at a number of public events, e.g., Colorado State University AgDay and the National Western Stock Show. Given the positive feedback regarding our Educational displays we requested funds to pay entrance fees for these events, transportation to the event as well as consumables to hand out at the event. To these ends, we attended the National Western Stock Show in January 2008 and AgDay in Sept 2008. We purchased pencils with the SGS LTER name and website on them to hand out at these events.

Graduate Student Augmentation Awards - Using our current NSF GK-12 model we proposed to continue to place graduate students in the K-12 classroom to work with teachers within our partnership. The Graduate Student Augmentation Awards will be paid as a supplemental award to graduate students with an existing GRA or GTA. The graduate students will be expected to spend an afternoon a week in a K-12 classroom assisting the teacher in either implementing or planning an activity. For 2008-2009 we supported six graduate students on Augmentation Awards funded by the SLTER supplement and a separate award from the Colorado Department of Education. On average they have been in the classroom 2.5 hours a week.

Program Coordination – For 2008-2009 funds were used to support a program coordinator. The program coordinator paired teachers and SGS LTER scientist for the research experience, organized the professional development workshops for teachers, and assembled the materials needed for the workshops. The program coordinator also worked closely with the LTER web master to update the education information on the website. This has been slowed because the University opted to update and coordinate the 'look' of all University websites. We now have full control of the site and will continue updating the information.

Research Coordination – Funds were used to support a SLTER research coordinator to assist in coordinating the LTER researchers with the K-12 teachers who participate in research activities, and to coordinate follow-up activities in the K-12 classrooms.

2. SLTER Supplement Request for 2009-2010

Enclosed are the rationale and budget in request for supplemental funding under the Schoolyard LTER development program. The 2009-2010 funds would be used to strengthen our existing partnerships. The request includes funds for supplies aimed at school-based activities and SGS Field Station needs related to education, and funds to support our regional outreach efforts to the broader community.

Supplies

***School-based Activities* –** Our SLTER partnership includes over 35 teachers in 20 schools in three school districts. School-based activities aligned with state science content standards that emulate SGS field research are the centerpiece of SGS-SLTER program. Teachers will purchase supplies for their classrooms that cannot be purchased with the annual budget supplied by the school districts (i.e., SLTER funds will not supplant district funds). We are therefore requesting funds to provide the teachers with the items they need to continue their LTER Schoolyard activities in their classrooms. Teachers will develop a proposal with the SGS graduate students with whom they do summer research and in-class work during the academic year. The proposals will include a plan to connect the SGS field research to an activity or series of activities to be implemented during the 2009-2010 school years. The proposals will also include a budget to purchase the materials needed for these activities, and will be submitted in early August. In late August-early September, the proposals will be reviewed and vetted by a panel of their peers much like a typical NSF review panel. Panel reviews and summaries will include specific recommendations on how to improve upon the plans. All teacher-graduate student teams will present a mid-year summary of their activities at the January All SGS-SLTER partnership meeting.

***SGS-LTER Field Station* -** We are requesting funds to purchase a digital SLR camera for use at the new field station. This camera will be used to document events as well as update the digital photo library of SGS LTER. These photos will be used on the website and be available to the LTER community for their presentation and publications.

Outreach

In 2008-2009 the SGS-LTER presented displays of research and education at a number of public events, e.g., Colorado State University AgDay and the National Western Stock Show. Given the positive feedback regarding our Educational displays we request a small amount of funds to pay entrance fees for these events, transportation to the event and well as consumables to hand out at the event.

Part B: Social Science

NSF-LTER Social-Ecological Systems Supplemental Funding Proposal - This narrative is common language developed by the group of collaborators, with additional information for the specific work to be completed by the SGS below (along with budget).

Maps and Locals (MALS): A Cross-Site LTER Comparative Study of Land-Cover and Land-Use Change with Spatial Analysis and Local Ecological Knowledge

Collaborators:

- Gary Kofinas – BNZ & ARC (Coordinator)
- Nathan Sayre – JRN (Coordinator)
- Gil Pontius—PIE (Map / Spatial Modeling Coordinator)
- Ted Gragson--CWT
- Jess Zimmerman--LUQ
- Rinku Chowdhury--FCE
- Laura Schneider--HBR
- Merryl Alber--GCE
- Kelli Larson--CAP
- Denise Lach—AND
- John Moore--SGS
- Colin Polsky--PIE
- Morgan Grove--BES
- Laura Ogden--FCE
- John Harrington—KNZ

Rationale - Understanding the dynamics of social–ecological interactions and organizing system-wide investigations through comparative analysis of LTER sites are key objectives of the ISSE Decadal Plan. These objectives address a grand challenge for both applied and theoretical ecology of *discerning past human effects on ecological systems and distinguishing anthropogenic from non-anthropogenic drivers of change*. Although most LTER sites have assembled historical data on land cover, climate, vegetation, and other ecological attributes, less is known about historical resource management practices and other human influences. In many cases social data are available for human communities of LTER regions, but are not well compiled. Local ecological knowledge (LEK) from long-time residents and users of landscapes provides an additional source of insight which has the potential to add to LTER studies, but *methods for documenting and integrating such data into ecological research remain poorly developed and a subject of debate*. Our objective in this collaborative research project is to develop methods and capacity for research into Social-Ecological Systems both at individual sites and at the network scale.

Objectives and Research Plan - We propose a cross-site collaborative effort with three complementary areas of activity. Participating LTER sites will 1) use spatial representation of land cover and land use to identify patterns of landscape change in regions in and around LTER sites; 2) compile and analyze social data to elaborate on these patterns and where possible draw conclusions about the drivers of change; 3) integrate LEK into theories and models of ecological change and their implications for human livelihoods. LTER sites participating in this program of research will emphasize these three activities to varying degrees. Cross-site comparisons will aid in developing methods and questions, in testing hypotheses over larger scales, and setting the stage for future cross-site comparative studies.

Our work begins with a series of virtual meetings at which participating LTER researchers will evaluate and define problems of human land use and change, identify the group's methods and strategies, and arrive at a set of common approaches. A key focus will be identifying social and ecological processes that are hypothesized to delimit the region in question, and specifying the spatial and temporal scales of those processes. Availability and utility of documentary sources (e.g., historic aerial photographs, weather station data, etc.) will also be assessed.

Local Knowledge Documentation and Social Data: For the documentation of local knowledge, individuals and classes of informants will be identified for each site, with an emphasis on people who have had continuous or regular familiarity with specific places over long time periods (10-50 years, or potentially more through ancestors). Such familiarity may involve direct management of a property or repeated regular visits for specific purposes. Considerable information about local knowledge has already been documented in many regions through past and current research projects, and to the extent possible, participating LTER sites will draw on those data to meet the needs of this comparative study. Additional, new data will be collected where opportunities and resources are present. The compiled data will serve both to generate hypotheses and as a means of corroborating and illuminating other existing data.

Mapping: Concurrently, each site will assemble a time series ($n \geq 2$) set of maps that represent known biophysical, infrastructural, and land-use changes in their region. At each site, maps will be used both as corroborating data and as research tools for use in collecting local ecological knowledge. At the network scale, the maps will be gathered at PIE for development and application of methods for spatial/GIS analysis (see supplemental proposal from PIE).

Initiative Meetings and Products: We will initiate this project with a working group at the upcoming Annual LTER Meeting in Estes Park and conclude our work with a final workshop in Fairbanks, AK or Berkeley, CA of all participating researchers to share findings, synthesize results, and produce a set of publishable papers that address our objectives.

Coordination: We seek a Linux-like, open-source organizational approach to our collaboration and have intentionally left many of our specific activities and research questions defined in general terms for specification in individual site supplemental proposals and for further refinement over the course of the projects. Coordination of the initiative is by Gary Kofinas (UAF/BNZ and ARC), Nathan Sayre (UC-Berkeley /JRN), and Gil Pontius (Clark U/PIE).

Activities for the Short Grass Steppe (SGS) LTER

The SGS LTER site will integrate spatial data bases, historic agricultural census data, and case study survey data from farmers and ranchers in order to determine how land use changes during the last 100 years have impacted the social-ecological systems near the SGS LTER site. In turn, we will investigate how these changes affect key components of SGS structure and function. The major activities include: 1) linking an historical analysis of US Agricultural Census data for Weld County (Parton et al. 2007-Figure 1) with the analysis of historic photographs from the site which start in the 1930's and 2) combining the observed land use change data with case study local farmer survey data (Bohren et al. 1996). We will combine photographic land use change analysis and US Agricultural Census data for the last 100 years with farmer survey data in order to determine the combined social-economic-ecological factors which control historic patterns in land use change.

SGS Mapping Data - Our current analyses of historic photographs from sites within the SGS show how land use patterns have changed since the 1930's. This analysis of the historic photographs is being done as part of a funded NIH land use change project. The photographic land use data will be combined with spatial data on the climate and soils within the SGS research site. Soil texture, climate and the access to irrigation water are the main factors that seem to control the patterns in land use. The three major traditional land uses in the region include dryland agriculture, irrigated cropping and grazing of native pastures (Figure 1). In the past 20 years, acreage has been placed into the Conservation Reserve Program (CRP). With the economic expansions that occurred during the 1980-present, the population in Colorado has more than doubled with increasing ex-urban expansion into the SGS in the form of 35-acre ranchettes. The net result has been a trend in the land use pattern that is more diverse and fragmented (discussed below). The new analysis will attempt to combine the spatial photographic historic land use change data with the non-spatial observed Weld county level US Agricultural Census data to better document these trends and to develop a framework to assess the impacts of the changes in land use to structural and functional attributes of the SGS.

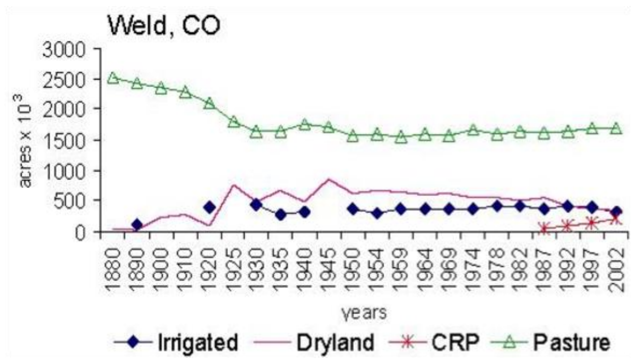

Figure 1. Historical trends in acreage by land use within Weld County Colorado, host to the SGS-LTER Site.

Social Survey Data - The US Agricultural Census data contains information about the changes in population, cropping yields, mixture of crops, and animal production on a five to 10 year basis since 1890's for Weld County. Local case study surveys from farmers (dryland and irrigation), and ranchers in the SGS region document the local knowledge about land use changes shown in Agricultural Census data and suggest social-economic factors contributing to these land use changes. The sale of the grazing land to local developers for 35-acre ranchettes is a recent land use pattern which is removing a substantial amount of land from traditional ranching systems which will evaluated in this project. This work will complement a recent case study interview project which will evaluate how farmers and ranchers feel about the potential to include carbon sequestration and greenhouse gas reduction as part of there decision making process.

Budget Justification for SGS Contribution to MALS project

Funds are requested to support Maps and Locals (MALS): A Cross-Site LTER Comparative Study of Land-Cover and Land-Use Change with Spatial Analysis and Local Ecological Knowledge. This is being coordinated at the SGS by John Moore and Bill Parton (Natural Resource Ecology Laboratory), with the help of a post-doctoral researcher to be announced. Funds provide for two months of post-doctoral salary while working on the project, for supplies associated with the project, and travel both to local field sites and to attend coordinating meetings in Estes Park, CO, Fairbanks, AK, and Berkeley CA.

Literature Cited

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Part C: International Collaboration

No requests at this time.

Part D: Other Scientific Support

Pulsed land-atmosphere exchange of H_2O, CO_2 and coupled N-dynamics

It has long been known that rainfall pulses in water-limited systems excite ecosystem dynamics (e.g. microbial decomposition, photosynthesis, recruitment and growth of plants), and that pulses of activity are separated by extended periods of relative inactivity. The importance of such intermittent events in dryland systems has led ecologists to propose various conceptual and mathematical models to describe ecosystem functional responses to pulses of rainfall or soil water. For example, the pulse-reserve paradigm of Noy-Meir (1973, modified by Reynolds et al., 2004), and the threshold-delay model of Ogle and Reynolds (2004; elaborated by Collins et al., 2008), span early and more recent conceptual models representing the functional responses of ecosystems to the pulse-decay temporal structure that typifies resource inputs in arid and semi-arid ecosystems. The question becomes more pressing, however, with predictions from general circulation models (GCM) that pulses of precipitation will be less frequent but more extreme in the future (Knapp et al. 2008).

The short grass steppe ecosystem is defined by a regime of low average annual precipitation, seasonal temperature fluctuations, and grazing by large herbivores. *Inter*-annual variability in both temperature and precipitation, resulting in years-long droughts, is a feature of the local climate (Peilke and Doesken 2008), but GCM predictions suggest that *intra*-annual variability will likely become more pronounced. The result will be not only more intense precipitation events, but also more severe heat waves during intervening periods and a greater importance for pulse-response dynamics on the SGS. The pulse-response literature has focused primarily on ecosystem-level responses to rainfall, such as growth, carbon and water exchange, and the thresholds and lags that emerge in these responses (e.g. Schwinning et al., 2004). At the SGS, past research has demonstrated the importance of rainfall events (timing and magnitude) on vegetation growth and primary productivity (Lauenroth et al. 2008; Heisler-White et al. 2008), but less emphasis has been placed on the cascading impacts of rainfall pulses on the full range of ecosystem-level functions (e.g. nitrogen and other biogeochemical cycles, but see Burke et al. 2008), or on the responses of diverse microbial, plant and faunal taxa. In particular, SGS research, and the pulse-response literature in general, lacks comprehensive studies of the interactions and feedbacks that certainly exist between ecosystem-level responses to pulses and the microbial, plant and faunal groups that drive, and respond to, emergent ecosystem-level behavior.

The SGS-LTER is implementing a pulse-response framework to integrate research that scales from soil microbial processes to responses by the dominant short grasses, to larger-scale biogeochemical fluxes. We will examine temporal dynamics of carbon, water and nitrogen, in response to rainfall pulses in areas that have experienced different long-term grazing effects either by livestock or Black-tailed prairie dogs (*Cynomys ludovicianus*), the relatively small colonial burrowing rodents endemic to the Great Plains. Evapotranspiration, net carbon dioxide exchange, N_2O fluxes and N-mineralization rates, are all stimulated by rainfall pulses, but the degree, duration and timing of stimulation may be highly variable. Further, little is known about the interactions between carbon, water and nitrogen, or how microbial respiration, N-mineralization, and plant photosynthesis interact during the pulse-decay sequence. Nonlinear behaviors may relate to lags in soil microbial and faunal activity, contingencies in N-availability and N-mineralization rates, and related variability in plant N-uptake, photosynthetic recovery and growth. Plant population dynamics (recruitment, death) and responses to pulse events add an additional layer of complexity.

This research will answer questions concerning ecosystem responses to pulses and, in particular, how pulse responses in carbon and water dynamics relate to pulse responses in N-mineralization rates and nutrient dynamics, including the effects on soil biology, soil microbial populations, plant and faunal dynamics. The work is guided by the following overall hypotheses:

Hypotheses:

H1: Inter- and intra-seasonal variation in fluxes of energy, water and CO_2, and the cycling of N at ecosystem-scales in the SGS are driven by pulse-decay dynamics controlled by the seasonal distribution and intensity of precipitation events.

H2: In so far as disturbance by livestock grazing and prairie dogs alter plant population dynamics, rates of change of N-mineralization, N availability, CO_2 responses, and water and energy fluxes to rainfall resource-pulses will vary accordingly.

Methods - We are implementing an integrated set of measurements at our site on the Central Plains Experimental Range, in collaboration with the USDA Agricultural Research Service (ARS). USDA-ARS has maintained long-term differences in grazing regimes at the site since 1939. The goal is to set baselines for carbon, water and nitrogen dynamics in this pulse-limited grassland, scaled from atmospheric exchanges to below-ground moisture profiles, by deploying three eddy covariance (EC) towers with associated soil moisture probes. This research builds on our previous research using Bowen ratio (BR) energy balance methodology to evaluate grazing effects on fluxes of H_2O, energy and CO_2, and allied work on crop reserve program (CRP) lands near Briggsdale, CO using the eddy covariance (EC) technique. Because of biases between BR and EC techniques (Alfieri et al. in press), we focus on EC measurements for further quantifying atmospheric exchanges. Along each EC tower will also deploy an array of time domain reflectometer (TDR) soil moisture probes (Campbell Scientific, see below) to monitor penetration of precipitation pulses into soil. The depths of probes will be 5, 15, 45 and ~70-90 cm (the lowest depth will be determined at each site by the level where carbonates form in the soils). The EC towers and the TDR soil moisture probes are designed to continuously collect and stream data, so that both the immediate and lagged effects of precipitation pulses can be measured.

Two EC towers will be placed in half-section pastures (each 130 ha) with different grazing histories: one moderately grazed (annual removal of 40% of aboveground net primary productivity (ANPP)) and one heavily grazed (60% ANPP removed). Plant cover and community composition differs between medium and heavily grazed pastures, with heavy grazing reducing abundance of the dominant warm season grass blue grama (*Bouteloua gracilis*), ANPP, and livestock weight gain (Milchunas et al. 2008). A third tower will be placed in a section that until 2007 was occupied by a prairie dog town (131 ha in size, approximately 3,700 animals). The population of that town was reduced >90% by an outbreak of plague, the deadly disease caused by the bacterium *Yersinia pestis.* The introduction and spread of plague into the western United States 110 years ago (and into the range of the black-tailed prairie dog in the 1940s) altered black-tailed prairie dynamics to a metapopulation, with regular local extinctions and recolonization of towns (Antolin et al. 2006). The effect is variability in plant community composition, as prairie dogs preferably forage on grasses like blue grama, again increasing bare ground and favoring regrowth of forb species (Whicker and Detling 1988, Derner et al. 2006). This tower will measure how H_2O, energy and CO_2 change during succession before the prairie dog town recovers, and then after prairie dog grazing resumes after recolonization of the town.

In choosing these sites, we matched them by soil types, plant community types, and topography, but also in proximity to proposed flux towers to be deployed by the National Ecological Observatory Network (NEON) within the next three years on upland and shrub habitats at the same site. This linkage provides for even larger scalability of the effects of precipitation pulses.

For linking of mechanistic studies on smaller plots to field-scale measurements, the eddy flux measurements will be coupled with measurements of soil moisture dynamics, N-availability/ mineralization rates, plant productivity, leaf and ecosystem-level chamber measurements of CO_2 fluxes, all organized with respect to the pulses-decay dynamic (i.e. more frequent intervals immediately following the pulse, slowing to less frequent intervals as rates of change decline). The suite of measurements provided by the EC towers and TDR soil moisture probes will provide core data required to link carbon, water, and nitrogen at field-scales in exploring and expanding the pulse-response paradigm for the SGS over the long term.

The EC work is being spearheaded by Niall Hanan. Linked measurements to be made at the same sites include (alphabetically) work by David Augustine, Paul Stapp and Mike Antolin (responses by small mammals), Justin Derner (livestock weight gains), Gene Kelly and Alan Knapp (ecohydrology and rainfall manipulation experiments), Bill Lauenroth and Daniel Milchunas (plant phenology and community responses), Jack Morgan and Dan Blumenthal (small-chamber photosynthesis and soil respiration), John Moore (soil invertebrate food webs), Bill Parton (modeling of large-scale processes), Heidi Steltzer (NDVI measurements), Joe von Fischer (small-chamber trace gas measurements and bacterial methanotroph communities), and Matt Wallenstein (soil microbial communities). In the future, this set of monitoring data will be coordinated with planned pulse-response experiments, with application of water to plots within the same pastures.

Budget: Resources requested for this supplement

Three EC towers have already been procured for previous research projects by Niall Hanan, but require upgrades of data loggers and memory cards to facilitate continuous data collection streams. Further, we request funds to purchase three arrays of TDR soil moisture probes to be deployed alongside the EC towers to measure the effects of pulses on the belowground environment. By continuously monitoring these sites over the long term, we will be able to measure ecosystem-level responses of precipitation pulses from the time they occur until the time that potential lags from below-ground processes follow.

Sites have been chosen to represent heavily grazed grasslands, moderately grazed grasslands, and grasslands recovering from severe disturbance after prairie dog towns were decimated by outbreaks of plague (the deadly disease caused by exotic bacterial pathogen after it spread into Colorado in the 1940s). Resources for measurement of linked ecosystem responses are available from existing funds of the SGS-LTER project.

Quotes for supplies are from the Campbell Scientific company.

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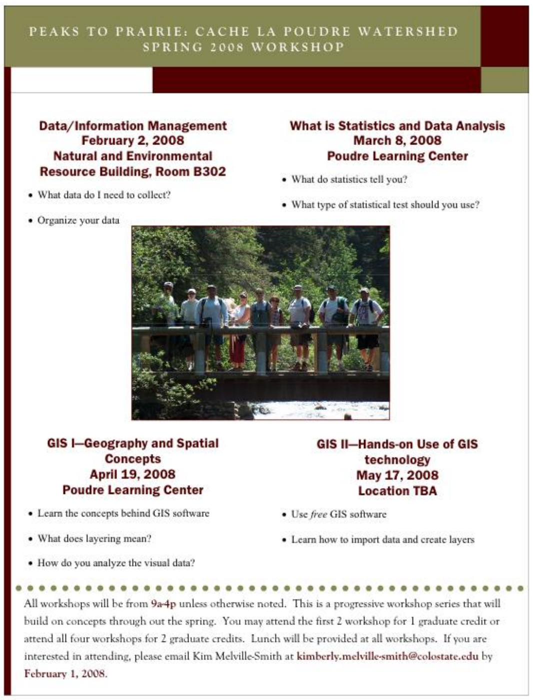
Appendix A

SGS-LTER sponsored Teacher Professional Development (PD) activities for 2008-2009



PEAKS TO PRAIRIE: CACHE LA POUDRE WATERSHED
SPRING 2008 WORKSHOP

Data/Information Management
February 2, 2008
Natural and Environmental Resource Building, Room B302

- What data do I need to collect?
- Organize your data

What is Statistics and Data Analysis
March 8, 2008
Poudre Learning Center

- What do statistics tell you?
- What type of statistical test should you use?

GIS I—Geography and Spatial Concepts
April 19, 2008
Poudre Learning Center

- Learn the concepts behind GIS software
- What does layering mean?
- How do you analyze the visual data?

GIS II—Hands-on Use of GIS technology
May 17, 2008
Location TBA

- Use *free* GIS software
- Learn how to import data and create layers

All workshops will be from **9a-4p** unless otherwise noted. This is a progressive workshop series that will build on concepts through out the spring. You may attend the first 2 workshop for 1 graduate credit or attend all four workshops for 2 graduate credits. Lunch will be provided at all workshops. If you are interested in attending, please email Kim Melville-Smith at **kimberly.melville-smith@colostate.edu** by **February 1, 2008**.

2008-2009 Teacher Workshops

Climate Change in the Classroom

PHENOLOGICAL OBSERVATIONS—Part 1
September 27, 2008, Colorado State University, 8:30a—4p

Teacher participants will be trained on how to implement a small set of specific data collection protocols and research activities though a series of workshops and follow-up meetings. All activities will be kept simple and easy to implement, using low-cost equipment as much as possible. The objective of the workhop is to learn about phenology, the seasonal changes in living organisms, and why it is important from a local and global climate perspective. We will explore how to make observations and measurements of phenologic characteristics on local plant species and learn how to develop a Project Phenology Study Site.

INVASIVE SPECIES MONITORING USING GPS AND GIS
October 18, 2008, Colorado State University, 8:30a—4p

Our goal in providing you with this training session is to equip you with the knowledge, skills, and abilities to map locations of common Colorado invasive plants using a GPS, record data about these plants in a PDA, and then finally upload these data into our national database and mapping system for invasive species locations. Our specific objectives are to (1) teach you the use of GPS units for field data collection and fun field exercises, (2) teach you the importance of standardized field data collection monitoring protocols to detect species distribution changes in relation to climate change, and (3) provide you with possible field exercises that you can incorporate into your classroom.

GIS AND COMPLEXITY SCIENCE: COMPARING WATERSHEDS IN PUERTO RICO AND COLORADO
November 15, 2008, Colorado State University, 8:30a—4p

You will examine cutting edge tools for addressing the interdisciplinary nature of the study of physical systems within a social context – watersheds. Using Google Earth, GIS, and NetLogo, you will be introduced to the latest tools that are easily accessible on the Internet. You will work through examples of comparing watersheds in Puerto Rico and Colorado. You will venture into the realm of agent-based modeling using NetLogo on a case study in Puerto Rico and discuss how such an example would be applied in Colorado.

WINTER ECOLOGY
January 24, 2009, TBA, 8:30a—4p

The Winter Ecology workshop will explore the stresses of cold temperatures on animals, plants, and humans in a snowy field setting. We will look at the biochemical changes of plants in a winter environment along with adaptations of specific species. We will also discuss the effects of winter on wildlife and how specific behavioral responses may increase survival probability. And finally, we will look at our own biophysical responses to cold temperatures and how humans that live in northern latitudes have adapted over time. This class will provide fun ideas and experiments to take back to the classroom and get students motivated to go outside on those long January days.

EARTH MATERIALS AND HEALTH
February 28 and March 7, 2009, University of Northern Colorado, 8:00a—5p

This course seeks to engage the student with Earth materials on a personal basis by discussing the general occurrences and properties of Earth materials and how they are used in medical settings, including remedies used in the home and everyday life. COURSE COST $219, TUITION AND FEES $250. To register, contact UNC Extended Studies 800-232-1749 and sign up for ESCI 575-604.

PHENOLOGICAL OBSERVATIONS—Part 2
April 18, 2009, Colorado State University, 8:30a—4p

Teacher participants will be trained on how to implement a small set of specific data collection protocols and research activities though a series of workshops and follow-up meetings. All activities will be kept simple and easy to implement, using low-cost equipment as much as possible. The objective of the workhop is to learn about phenology, the seasonal changes in living organisms, and why it is important from a local and global climate perspective. We will explore how to make observations and measurements of phenologic characteristics on local plant species and learn how to develop a Project Phenology Study Site.

To sign-up for a workshop, please email Kim Melville-Smith (**kimberly.melville-smith@colostate.edu**) and state which workshops you are interested in. You must attend 2 workshops a semester to be eligible for 1 graduate credit per semester (UNC workshop excluded since credit is available from UNC).