Enclosed are the rationale and budget ($15,000) in request for supplemental

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1. Equipment and Data Management:

We appreciate the opportunity to upgrade and expand our research instrumentation. The proposed equipment will allow us (a) to monitor the effects of livestock grazing on net primary production on a daily or even shorter basis, (b) to expand our network of precipitation measurements for better accounting of subregional variability, and (c) to replace necessary laboratory equipment used to process samples for long-term datasets. In addition, we request funding (d) to support greater involvement by Susan Stafford for development of a long-term plan for data management at SGS-LTER.

a. Net primary production is a key ecosystem variable and understanding it is a necessity for understanding all other ecosystem processes and for allow us to be successful in reaching our SGS LTER project objectives. Current radiometric technology provides us with an opportunity to monitor in real time a variable that is closely correlated with net primary production, normalized difference vegetation index (NDVI). NDVI is measured as a ratio of reflectances in the red and infrared wavelengths. The addition of radiometers that measure NDVI to existing micrometeorological stations within and outside of grazing exclosures will allow us to monitor the effects of livestock grazing on net primary production on a daily or even shorter basis. We request funding for 2 radiometers to be used for this purpose.

b. Water is the key driving force for the structure and dynamics of shortgrass ecosystems. Understanding daily, weekly, monthly, and annual amounts of precipitation received at a location in the shortgrass steppe is crucial to understanding the dynamics of ecosystem processes and to making it possible for us to achieve our SGS-LTER project objectives. Our current rain gauge network allows us to characterize precipitation amounts for a portion of our research site. We will need many more gauges to provide coverage over the entire research area. As the gauges are located at increasingly large distances from our central headquarters, the feasibility of frequent tending of the gauges goes down. Therefore dataloggers for the gauges are a necessity. This current request represents a first step in expanding our monitoring of precipitation. We request 8 combination rain gauge/compact dataloggers to begin this effort.

c. Continued sampling of long-term datasets is, of course, at the heart of our scientific mission. We have several pieces of equipment central to this effort that have been with us since the International Biological Programme in the late 1960's. One of our 32-year old muffle furnaces finally failed last year and is irreparable. Therefore, we request funds to replace this piece of equipment.

d. Data management consistent with LTER Network standards is a goal deeply important to our site. Under the direction of our previous data manager (departed in November, 1999), we maintained a position at the forefront of Network data management efforts. We feel very strongly that we once again need the vision and direction of someone interested in and deeply involved with data management. We are in the unique and enviable position of having Susan Stafford as department head, and would very much like to fund her to provide information management and input in the development of our renewal proposal as well as continuing development of our data management system. Therefore, we request 1 month of summer salary plus fringe for Dr. Stafford.

2. Research Experience for Undergraduates:

Last year, we requested and received funding for two REU students. The program was an enormous success with respect to the experience for the REU students, the science that was accomplished, and the overall influence of the REU students on the LTER program. This year we request funding for two students and, if possible, we would like funding for a third student who is a member of a racially underrepresented group. We have received applications from several interested and qualified students and expect to receive more applications before our March 15th deadline. Because of the interest already expressed, we are confident in our ability to fill three REU positions.

Results from 2000 REU Supplement

- Alissa Loeffler from Denison University, Ohio, explored the effects of grazing on invasion by exotic species. Alissa's research findings did not show a significant difference in the number of exotic species between grazed and ungrazed pastures. She found very few exotic species and hypothesized that an abnormally dry year had severely limited the number and species of exotics able to survive in this already semi-arid region or that the fields of the shortgrass steppe are resistant to exotic invasion due to factors independent of grazing conditions.

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- Heidi Gerstung from the University of Georgia, Athens, Georgia, examined whether elevated CO_2 causes a reduction in leaf chlorophyll and nitrogen in Pascopyrum smithii. Since 1997, six open-top chambers have been maintained on short-grass steppe in northeastern Colorado on the USDA Agricultural Research Service, Central Plains Experimental Range (CPER) to evaluate the effects of elevated CO_2 on this grassland. Three chambers have been continuously supplied with ambient air of approximately 360 ppm CO_2, three have been supplied with air enriched to approximately 720 ppm CO_2, and three additional unchambered plots serve as controls. Heidi estimated leaf chlorophyll and nitrogen concentrations in native Pascopyrum smithii (western wheatgrass) in June and July in each of the nine plots in order to investigate several plant metabolic responses to elevated CO_2. Concentration readings were obtained from variable locations in each chamber, including areas that were undergoing a nitrogen fertilizer treatment. Mean leaf chlorophyll concentrations were found to be 35-40% lower in the elevated CO_2 chambers. Leaf nitrogen was also lower in the enriched CO_2 environments. No significant interaction between nitrogen fertilizer treatment and leaf chlorophyll concentration was observed.

Additional information about our past REU programs can be found in a new section on our website – http://sgs.cnr.colostate.edu/EdWeb/EdWebHomepage.htm.

Our highest priority for students in this project is not that they learn a large number of facts about the ecology of the shortgrass steppe, nor that they become expert in field, laboratory, or computer analyses. Rather, our primary goal is that the students learn that science is an exciting process of discovery, and that they explore their interest in the field of ecology. They will be involved in the everyday process of research, and through this, we hope to infuse them with excitement about both science and ecology. Thus, although we focus below on the technical components of their activities, we will place a great deal of our effort with the students on the overall experience.

There are a number of components to the learning experience for the REU students. We subdivide these components into 1) basic ecology; 2) environmental issues; 3) hypothesis generation in the research process; 4) methods of field and laboratory analysis; 5) data analysis and synthesis; 6) the use of computers in research.

Below, we detail chronologically our plan for how the students will develop this knowledge base.

- Pre-arrival orientation: We will send students a copy of James Michener's "Centennial" before they arrive. This book focuses on the history of European settlement of the northeastern Colorado-southeastern Wyoming region, and provides an excellent introduction to the area and its fascinating history of land use. Students will also be sent representative journal articles produced from research at SGS-LTER and instructed to review past REU projects through our web page.

- General Orientation: The first 2 days of the summer will be spent on field orientation. The students will accompany project scientists for 2 days in the Pawnee National Grasslands and surrounding area. We will discuss the ecology of the shortgrass steppe and the common land management practices. We will provide an overview of both the natural history and the human cultural context.

- Field, Lab, and Data Analysis Assistance for Research Projects: During the first 6 weeks, the students will assist project scientists in existing research projects. The purpose of this involvement is: 1) to introduce the students to the process of science, including question-generation and design phases; 2) to introduce students to field and laboratory methods in ecosystem ecology, and 3) to allow the students to work as part of a team in the field. We would like the students to get a strong sense of the interdisciplinary and cooperative nature of ecosystem ecology. Each student will be assigned a graduate student or postdoc mentor with whom the student will work most closely. The mentor will be responsible for providing continuity among the field, lab, and data-analysis activities, and for helping to assure that the student feels connected to the science being conducted.

- Independent Research Projects: During week 5, we will begin to work with the students to develop their own research projects. The student research projects will necessarily be extremely well focused and simple. During the remaining weeks of the summer, students will conduct their field and laboratory work.

- Data analysis: When the students get close to completing their lab analyses (about week 10), we will begin to involve them in data analysis for an existing project. Each student will work closely with his or her mentor in this process, and will learn how the researcher is analyzing her or his data using simple graphical and statistical analysis. Further, the students will work with their mentor to plan their own data analysis.

- Research Completion and Presentation: Students will complete their projects during the last weeks of the summer program. They will present their results to our research group in a special end-of-season symposium. We will invite members of our extended research group for the Shortgrass Steppe Long Term Ecological Research Project.

- Ecological Society of America meetings: If time and funds permit, we plan to take the students to the ESA meetings in Madison, WI. In the six-year history of REU student involvement in the SGS-LTER, this trip has often been described as a program highlight. Past REU students attended the ESA meetings and commented on how these meetings helped to characterize many of the components of the science

of ecology. This exposure to the current field of ecology is invaluable in providing the students with a sense of the discipline, as well as giving them the chance to make contacts for graduate school.

- Enrichment Activities: Our Education and Outreach Coordinator will be facilitating the REU program as well as other education programs. We believe it is beneficial to students and mentors to have support for administrative duties and enrichment activities. This year we will coordinate joint activities for REU students, RAMHSS participants, and the SGS-LTER field crew. These groups have overlapping roles with LTER and can benefit from sharing experiences. Activities will include a weekly seminar and breakfast at the field station, an end-of-summer BBQ, and optional activities such as a trip the Denver Museum of Nature and Science and to CSU's mountain campus at Pingree Park.

Student Participants:

We target highly qualified students in the recruitment process for REU students. Advertisement of positions is occurring through our web page and through contacts with CSU's Honors program, the McNair Scholars program, Upward Bound, the Center for Life Sciences, and the Center for Science, Math, and Technology Education at CSU. E-mail announcements will be sent to career center coordinators at small liberal arts schools where students would not normally have the opportunity to participate in scientific research projects. During the past six years, we have had at least one woman or minority student as an REU participant each year. This year we have been making concerted efforts to advertise the REU positions to students in underrepresented groups.

Ethics Component:

It is both important and appropriate to give the students a strong sense of the process of science as one that is dependent upon integrity at all stages of the process. We propose to introduce students to a collection of topics that relate to an "ethics component," through group discussions and through interactions with mentors. Our students, postdocs, and investigators regularly discuss issues related to our personal commitment to integrity in a competitive environment, such as quality control in research, and behavioral standards for scientists. We are also very interested in topics related to balancing a sense of professional accomplishment with a well-integrated life, particularly as members of under-represented groups in science. We have identified a number of short readings that elaborate upon these topics.

We have weekly lunchtime discussions with our research group. REU students will be required to attend these discussions. We blend informal discussions with more formal ones, sometimes with readings as the focus. The informal atmosphere is very effective for focusing on issues that are philosophical yet have great importance to our daily activities. Past REU students have contributed a great deal to these discussions by introducing discussion topics that may not have otherwise been discussed.

In summary, we are very excited about the opportunity to continue an REU program. We are extremely enthusiastic about the program and the experiences it affords the students and our research group.

3. Schoolyard LTER:

Shortgrass Steppe LTER investigator Dr. John Moore (University of Northern Colorado – UNC) will again, as in years past, take the lead on the Schoolyard LTER program. Dr. Jrene Rham (UNC), a faculty member in the Department of Educational Psychology at UNC with expertise in assessing the effectiveness of outreach programs on K-12 education, will be involved this year as well.

Program overview: We established with funding from NSF-DUE (spring 1998) Schoolyard LTER demonstration plots on the campus of UNC that mimics an experiment at the SGS LTER site. Baseline vegetation and soil samples were taken in the summer of 1998, treatments were imposed in the fall of 1998, and students have sampled the plots for vegetation and soil biota each year. The samples taken to date have been analyzed by first-generation low-income high school students that are part of the UNC Upward Bound Program (funded by the DOEd) and that are receiving fellowships from the 1998 through 2000 RAMHSS supplements, and undergraduates and graduate students taking courses at UNC (ecology, microbiology, mycology, and botany). We have also submitted lab modules based on these efforts for publication and dissemination to the schools (Moore et al. 2000).

Teacher involvement is critical to the impact of the Schoolyard LTER effort on systemic change in science education. Supplemental funds have solidified our efforts; brought teachers onboard, and provided tangible products (the plots, web pages and curricula) that can be used as instruments of change. The Schoolyard LTER effort played a prominent role in an NSF GK-12 proposal that was recently funded.

We will continue to involve 5 schools from school districts along the Northern Front Range of Colorado, the K-12 Laboratory School on the campus of UNC, and the Poudre Learning Center that operates through a collaboration of schools within the Greeley area.

The following schools are participants in the program:

School	Location
Rocky Mountain High School	Fort Collins, CO

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Trademark High School	Greeley, CO
UNC Laboratory School	Greeley, CO
Poudre Learning Center	Greeley, CO
High Plains School	Siebert, CO
Weld Central High School	Keensburg, CO

- Plot and database development: In 2001, we will continue to develop our sites and databases. To date, science teachers from the schools have met with SGS-LTER graduate students and scientists during a workshop in March 2000 and a follow-up workshop in August 2000 at the SGS LTER site and UNC demonstration plots. The group discussed potential experiment designs, data collection, database maintenance, and means by which the projects can be integrated into curricula. Teachers submitted plans to SGS scientists for review and feedback. We propose a follow-up workshop for 2001 that would include new schools and our current participants. We do not request funding for the site visit for fiscal year 2001 since we have funding from other awards. At this workshop will decide on the type of experiments to be conducted at each school, guidelines for supplies and equipment, determine the variables to be sampled, and establish a protocol for data collection and dissemination. Several schools have already made progress on this front. Trademark High School of Greeley, CO and the UNC Laboratory School decided to use the UNC demonstration plots since the school is within walking distance of the UNC campus. The remaining schools developed plots patterned after LTER experiments. Weld Central High School of Keensburg, CO secured an abandoned agricultural field adjacent to the school and is studying old-field succession.

- Web Pages: Our goal is to have all materials developed from the projects, databases and a profile of the projects objects and participants incorporated into the web pages for the Shortgrass Steppe - LTER, the Center for Precollegiate Studies and Outreach at UNC, and those of the participating schools (if they have one). The Outreach and Education coordinator for the SGS-LTER has developed a web page (http://sgs.cnr.colostate.edu/EdWeb/EdWebHomePage.htm) and will take the lead on Schoolyard LTER data management.

- Curriculum Reform: LTER scientists and the teachers will work to incorporate Schoolyard LTER into curricula. We will use the guidelines proposed by NSF and the National Science Education Standards (National Research Council, National Academy Press, Washington, DC, 1996) to develop curricula and lab modules that are age-appropriate and inquiry-based. This is an ongoing process. Given the current discussions nationally, the mediocre performance of US high school students in the Third International Math and Science Survey, and the desire to reform math and science curricula, it is imperative that this program be used as one of several forums to initiate discussions. To this end, we have published a laboratory module based on work conducted at the plots and elsewhere (Moore et al. 2000). We proposed to Kendall/Hunt Publishers a curriculum based on the soil ecology that is being conducted at the plots and the connections between this work, research at other LTER sites, and the ease by which the work could be tied to state and national standards. Last year we received word from the publisher that they are interested and to proceed with a full proposal to formalize the agreement. We will submit the proposal to Kendall/Hunt this year.

Moore, J.C., B.B. Tripp, R. Simpson, and D.C. Coleman (2000). A springtail in the classroom: Folsomia candida as a model for inquiry-based laboratories. American Biology Teacher 62:512-519.

4. Research Assistantships for Minority High School Students:

Dr. John Moore and his colleague, Dr. Jrene Rahm, will also lead our efforts with the Research Assistant for Minority High School Students (RAMHSS) program.

Program overview: We are in a unique position with regards to the RAMHSS program. Dr. Moore has been involved with minority high school student education since 1985 through Upward Bound. Upward Bound is a program funded by the Department of Education designed to increase the enrollments of first-generation and low-income students in four year colleges. In Colorado, the majority of these students are students of color. Dr. Moore is currently the Director of a Math and Science Upward Bound Program at UNC that serves 40 high school students from schools in the North Denver to Greeley area. In 1997, our program started a student mentor program for students entering their senior year. Since 1998, this program has been supported largely by the RAMHSS supplement to the SGS-LTER. As in past years, we will select highly-motivated students from our Upward Bound program and team them up with SGS-LTER scientists, UNC graduate student(s) and a teacher from the school district. We feel that this maximizes the outreach potential of RAMHSS.

The area we currently serve with Upward Bound includes 14 high schools from the Greeley and Denver areas. These students are housed on-campus during the summer for the Upward Bound Program. Hence, by selecting students from the Upward Bound program, the RAMHSS program would include students from areas that we could not normally serve due to distance and logistics. These students have already expressed an interest in math and science careers and are eligible for college credit for RAMHSS activities. This effort is not a duplication of Upward Bound or Schoolyard LTER. The RAMHSS program affords the students greater research opportunities and larger stipends than Upward Bound alone. Schoolyard LTER focuses on building valuable partnerships with schools and teachers, but does not provide the kind of individual experience available through RAMHSS.

Students with RAMHSS will prepare methodologies to estimate microbial biomass and patterns of substrate utilization, and prepare a list of genera

of soil arthropods by comparing methodologies that are currently in place at the SGS-LTER and Arctic LTER sites. Students use soils that they collect from the SGS-LTER and the UNC Schoolyard LTER sites, and soils that were collected from the Arctic-LTER site. Following are the specific tasks carried out by RAMHSS participants.

- Determining Arthropod Diversity on the Schoolyard LTER Demonstration Plots: We established a cluster of 18 25- m^2 demonstration plots on the UNC campus. The plots are meant to serve as educational tools for K-16 students. To this end, participants in the 1998 RAMHSS program helped prepare the plots and collected preliminary pre-treatment data on soil organisms. During the fall of 1998, students from our Ecology, Mycology, and Microbiology classes collected additional samples and implemented the treatments. Data collection continued with the 1999 and 2000 RAMHSS funding. The experiment mimics an ongoing study at the SGS-LTER site in Colorado and the Arctic-LTER site at Toolik Lake. Our aim is to study the effects of nitrogen availability on the succession of a disturbed grassland. We established a nitrogen gradient on denuded plots by adding nitrogen fertilizer, maintaining an un-amended control, and by adding a labile carbon source (sucrose). Plots were seeded with native seed from native vegetation. This summer will be the fifth growing season following the treatments. Students will collect and identify soil arthropods from each plot and compare.

- Assessing Techniques to Estimate Microbial Biomass and Diversity: Several SGS-LTER projects are estimating microbial biomass. To date, we have used different conversion formulae to standardize our methods. I would like to standardize our procedures. Students will compare two means of estimating microbial biomass -- plate counts and direct counts using fluorescent stains (DTAF and Calcofluor). The objectives of their work will be to assess the different techniques for efficacy, reliability, cost, and feasibility in different settings (schools verses research labs).

- Assessing Microbial Diversity and Patterns of Substrate Utilization via Ecolog®: We have used the Ecolog® plates provided by the Biolog Corporation to assess patterns of substrate utilization. The sampling, plate preparation and incubation procedures have been worked through (see Van Lew et al. 1999). We would like to work to make the interpretation more user-friendly for high school students. Hence, our objective is to tie this procedure to state and national standards in an age-appropriate manner.

Selection Criteria: Students from under-represented minority groups and/or women will be selected from our pool of Math and Science Upward Bound students. These students are from high schools in the Denver and Greeley areas. In addition to being from under-represented minority groups, these students are either first generation (no one in their immediate family has earned a 4-year degree) or low income (family incomes below 150% of the poverty level, as determined by the Federal Government). To be eligible for the program, all students were required to undergo a formal application process. To remain in the program, students had to maintain satisfactory academic progress based on an individualized plan and behave in a mature manner (no problems with behavior, drugs, etc.).

Students are evaluated based on their academic performance at their high schools, their previous year's participation in our summer program, and their math and science ACT scores. I have provided a list of potential participants for this summer. The following students have formally requested that they be considered for participation in some form of summer research:

Potential Summer 2001 RAMHSS Scholars

Student	Gender	Ethnicity	High School
Vanessa Vargas	F	Hispanic	Denver West
Jacob Felix	M	Hispanic	Greeley Central
Tayna Rivas	F	Hispanic	Denver North
Ernest Sandoval	M	Hispanic	Denver North
Trisha Consonero	F	Caucasian	Windsor
John Ruiz	M	Hispanic	Valley
Daniel Chaparro	M	Hispanic	Greeley Central
Sylvia Garza	F	Hispanic	Eaton
Leah Gonzales	F	Hispanic	Kennedy
Anh Le	F	Asian	Lincoln
Joshua Lopez	M	Hispanic	Roosevelt
Katie Lovell	F	Caucasian	Fort Lupton
Bryon Martinez	M	Hispanic	Northridge
Sen Nguyen	F	Asian	Lincoln
Toan Nguyen	M	Asian	Kennedy
Quang Nguyen	F	Asian	Lincoln
Uyen Nguyen	F	Asian	Lincoln
Jacqueline Nunez	F	Hispanic	Kennedy
Jennifer Perea	F	Hispanic	North
Ruby Redd	F	Caucasian	North
David Saiz	M	Hispanic	Adams City

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Bernadette Torrez	F	Hispanic	Denver North
Filiberto Trejo	M	Hispanic	Greeley West

All the students listed above have at least a 3.3 from their respective high schools and 3.8 grade point average from our summer program.

We feel that this is an excellent opportunity to engage some highly motivated young people in the process and rewards of doing science.