Request for an EdEn Supplement to DEB-0217631 SGS-LTER: Long-Term Ecological Research-Shortgrass Steppe

We propose to form a consortium of four Long Term Ecological Research (LTER) programs (located in Michigan, Colorado, Baltimore, and Santa Barbara) that will engage in coordinated efforts to achieve two mutually reinforcing goals.

1. We will develop a *research-based learning progression for environmental literacy* that specifies appropriate content and reasoning goals for K-12 students of different ages and cultures, teachers, and adults in the general public. This learning progression will connect national science education standards to LTER Grand Research Challenges and environmental research frontiers identified in the AC-ERE report (Pfirman and AC-ERE 2003). It will be supported by research on learning about environmental systems and by assessment instruments that can be used to assess learners' progress.
2. We will develop *measures and instruments for program evaluation* that will provide LTER education programs with an array of formative and summative evaluation data. These measures and instruments will enable individual programs to improve their effectiveness and assess the impact of their activities. Because these measures will be used at multiple sites, they will also help us to assess the overall impact of LTER education activities, and inform us the learning progression for environmental literacy as proposed above.

These goals were developed through the strategic planning process of the LTER Network. As a part of that process, the Education, Outreach, and Training (EOT) Committee was given the charge to assess the benefits and challenges of linking research and education beyond the site level. The EOT Committee identified three overarching needs:

1. research what we need to know to effectively reach a diverse audience and evaluation of the success of our programs,
2. teaching both content and reasoning to a culturally diverse audience, that includes K-12 students, teachers, and the general public, and
3. improving the broader education system as it relates to environmental literacy

The activities supported by the EdEn supplement will focus on the first of these needs: research and evaluation. We believe that a small investment now in research and evaluation will greatly enhance the effectiveness of the larger efforts addressing needs 2 and 3 identified by the EOT. In particular, these research efforts will provide a basis for collaborative work by LTER education programs at different sites by creating a framework within which we can exchange resources, compare programs, and develop joint efforts directed at common goals.

We propose to develop and pilot-test our learning progression and program evaluation measures at four different LTER sites in Baltimore (Baltimore Ecosystem Study), Michigan (Kellogg Biological Station), Colorado (Shortgrass Steppe), and California (Santa Barbara Coastal). These sites have education programs that work with teachers and students from a diverse set of urban, suburban, and rural locations. The students and teachers participating in these programs are also racially and culturally diverse, including European American, African American, American Indian, and Hispanic populations. The development of each of our proposed products is described below.

Developing a Research-based Learning Progression

Rationale. In our discussions, the LTER EOT committee has focused on the question of how LTER research could better contribute to the improvement of our K-12 education system. We believe that with a well articulated framework and research base, LTER education would be positioned to substantially influence the broader education system. The new knowledge being developed through LTER research can and should influence standards at the national and state levels; standardized assessments; teacher training programs; and school system level programs to foster environmental citizenship and

ecological literacy. LTER education programs are well positioned to help meet our nation's need for new frameworks and research address the critical intellectual challenges and learning outcomes addressed by LTER research, which is inter-disciplinary, local/empirical linked to global/databases, and linked to practical applications.

The EOT Committee discussed these issues at length and has proposed that that an appropriate goal for LTER Education and Outreach efforts is to promote *environmental literacy* in students, teachers, and the general public. We suggest a definition based on the work of the LTER scientific and education communities. We define environmental literacy as having two dimensions: *understanding environmental content* as defined by the LTER community (Figure 1) and *scientific practices* (i.e., inquiry and application, see Figure 2). This organizational framework provides the necessary structure with which a common set of learning goals can be defined across sites.

Content understanding dimension. The LTER community identified four grand challenges, each defining a body of content knowledge:

- Alterations in biodiversity
- Altered biogeochemical cycles at multiple spatial scales
- Climate change and climatic variability
- Coupled human-natural ecosystems

In our discussions the EOT Committee identified the fourth Grand Challenge, coupled human-ecosystem interactions, as impacting the other three, as illustrated in Figure 1 below. The future work of the LTER network will focus on building an integrated understanding of coupled human-ecosystem interactions.

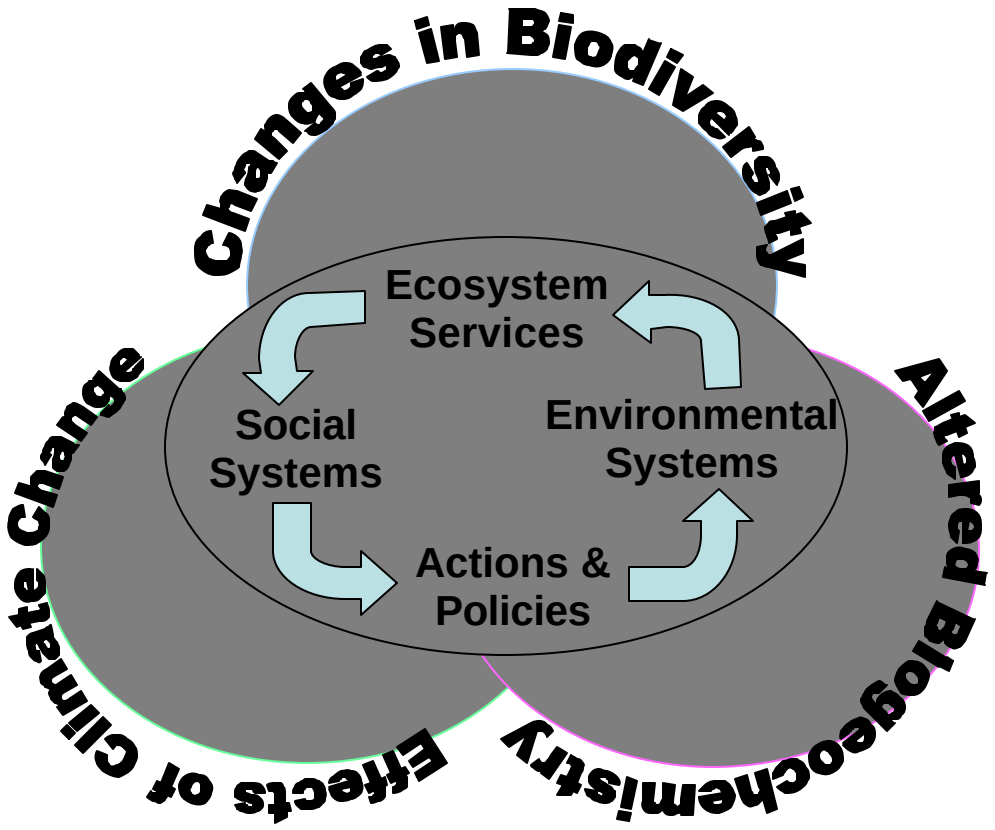


Figure 1: Understanding Coupled Human-Ecosystem Interactions

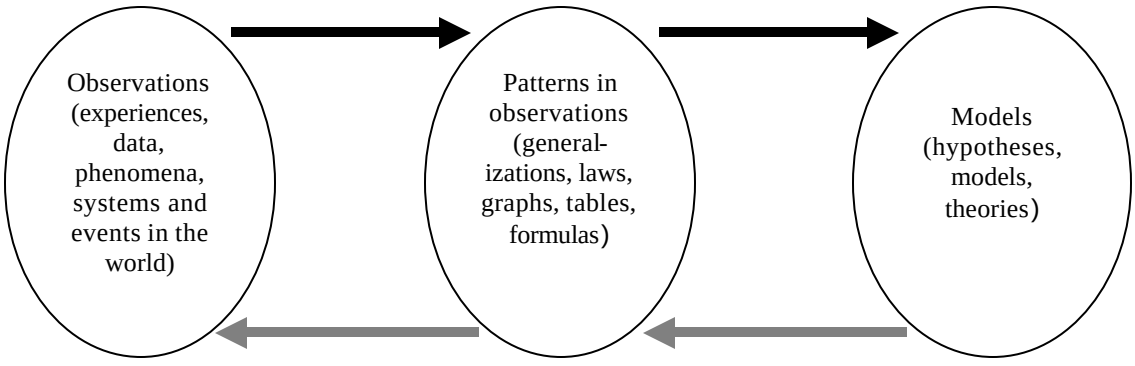
We suggest that this understanding of coupled human-ecosystem interactions is an appropriate goal both for science and for education. It is an appropriate goal for science because our scientific understanding of these interactions is far from complete, yet critical to our future. It is an appropriate goal for education because maintaining the systems that sustain us is a shared responsibility of all citizens. Citizens take individual actions that have environmental implications when they decide what kinds of food to buy, how they will get to work, where they will live, and how to spend their leisure time. Citizens can also influence collective actions with environmental implications—land use planning, tax policies, transportation policies, or participation in international dialogs. All citizens need to be environmentally literate since the actions of all citizens affect the environment.

Thus our collective future depends on the ability of children now in school to understand and evaluate evidence-based arguments about the environmental consequences of human actions and human technologies, and to make responsible decisions based on those arguments. Preparing our citizens for this future makes new demands on scientific communities: our research knowledge base remains incomplete. Preparing our citizens also makes new demands on our schools and teachers, whose own experiences in science education are likely to have focused on less-than-current knowledge taught in traditional ways.

Practice dimension: Inquiry and application. Figure 1 above suggests a *model* for understanding coupled human and natural systems. That model is meaningful, however, only if it can be connected with *observations* or data. *Patterns in data* play an essential role in linking models to observations. This is true for the general public as well as for scientists. If students and citizens cannot see examples of environmental systems and ecosystem services around them, then the model stays disconnected from their lives and actions. Both scientists and the general public thus need to be able to connect the model of coupled human-ecosystem interactions with observations of natural and human systems.

Environmental literacy involves mastery of *practices* as well as content understanding. We propose that environmental literacy involves relating one type of knowledge to another—i.e., citizens' abilities to argue from evidence and explain observations in light of patterns in nature and scientifically accepted models (see Figure 2). Practices that we associate with *inquiry* or inductive reasoning generally involve going from observations to models (black arrows); performances that we associate with *application* or deductive reasoning generally involve going from models to observations (gray arrows).

Reasoning from evidence (Inquiry): Finding patterns in observations and constructing explanations for those patterns



Reasoning from models and patterns (Application): Using scientific patterns and models to describe, explain, predict, design

Figure 2: Scientific knowledge and practices

Our formal and informal educational systems currently lack the resources to support environmental literacy in students or in the general public. Long-term ecological sites, including the LTER network could play an important role in coordinating and developing those resources. In particular, long-term ecological sites have three important assets that are essential to teaching for environmental literacy:

- Research communities with long histories of interdisciplinary work on environmental issues
- A network linking those research communities to one another and to educational systems through both personal contact and information technologies
- Place-based, long-term, spatially distributed data sets and resources for acquiring data.

With these assets the LTER network has the potential to help students and citizens develop a deep understanding of coupled human and natural systems. A learning progression shared among LTER sites will enable coordinated work that makes the unique assets of the LTER network available to schools and the general public.

Elements of a learning progression. A completed learning progression for environmental literacy will include the following:

- *Big ideas* or unifying concepts that are appropriate for learners of different ages and cultures
- Key *application and inquiry practices* that are appropriate for learners of different ages and cultures
- *Specific objectives or learning goals* that are aligned with national standards and that enact the big ideas and practices
- *Misconceptions or barriers to understanding* that learners of different ages and cultures are likely to encounter—beliefs or habits of mind that may lead them to misunderstand big ideas and practices (e.g., relying primarily on narrative reasoning)
- *Assessment questions or tasks* that could be used to reveal learners' reasoning about key concepts and practices.

Development activities. KBS will be the lead institution for development of the learning progression. We will be building on the work of the EOT Committee and on the work of the Environmental Literacy project at KBS, which has been funded in part by a 2003 EdEn supplement (see results of prior research below). The work of this proposal will expand on those previous efforts by involving a wider range of scientists, educators, and learners, and by more effectively connecting school curricula with LTER research.

Our definition of environmental literacy (see Figure 1 above) identifies three primary strands in the development of environmental literacy—changes in biodiversity, effects of climate change, and alterations in biogeochemistry—each of which must be understood in the context of coupled human and natural systems. We propose using EdEn funding to support development of a learning progression focusing on the first of these strands—changes in biodiversity. (We have also applied for funding from NOAA's environmental literacy program to support development of learning progressions for the other two strands. The activities proposed here complement, but are not dependent on, the activities proposed in the NOAA grant.)

We know from our research review and previous work by the KBS Environmental Literacy project that biodiversity is virtually invisible to most high school and college students. For example, students' explanations of changes in populations due to selection pressures, such as explaining how cheetahs evolved the ability to run fast or the development of antibiotic resistance in bacteria, typically rely on Lamarckian mechanisms involving adaptation by individuals rather than invoking genetic diversity in populations (Anderson, Fisher, & Norman, 2002; Bishop & Anderson, 1990). Similarly at the ecosystem

level, students show little awareness of entire portions of communities, such as bacteria and detritus-based food chains. Thus development of the learning progression will focus first on analyzing the nature of, and gaps in, students' current understandings, then on developing reasonable goals for promoting (a) students' awareness of biodiversity at multiple levels and (b) students' understanding of processes that affect biodiversity, including human practices such as agriculture.

Development of the learning progression will be a three-stage process, described below.

1. Development of overall learning goals. So far we have reached agreement on a general definition of environmental literacy and a framework for understanding the relationship between content and practice (see Figures 1 and 2 and the accompanying discussion above). We still need, however, to flesh out this framework with more specific goals. Which aspects of changes in biodiversity are critical for all students to understand and accessible to K-12 students? Work at different LTER sites, including the Environmental Literacy project at KBS, gives us a good start toward answering those questions. We will continue this work through E-mail discussions and conference calls among the four collaborating projects. We will also have face-to-face conferences during the meetings of the EOT committee. At least three more meetings are scheduled.

2. Data collection on learners' understanding. The system of working groups of teachers currently being used by the KBS Environmental Literacy Project will be expanded to all four sites. Teachers in these working groups will administer pretests and posttests developed at KBS to their students, as well as meeting to discuss their results and share student work. Working at all four sites will give us samples of students that are diverse with respect to age, ethnicity, language, culture, living conditions, and socioeconomic status. We will also assess teachers' and public understanding as the opportunity arises during other educational programs. The instruments we use will be based on those developed by the current KBS Environmental Literacy project, refined as goals become clearer. These are primarily paper-and-pencil tests, but we will experiment with other types of instruments.

3. Development of grade-specific learning goals and accounts of barriers or misconceptions. The final product of this effort will suggest appropriate learning goals (both content and practice) for students of different ages and cultures, as well as discussing the resources that students bring with them to learning about biodiversity and the barriers or misconceptions that make learning difficult. This report will be based on (a) data collected by working groups, (b) a review of research on learning (mostly completed by the KBS Environmental Literacy project), and (c) current and revised national standards. Primary responsibility for writing this product will lie with Anderson and his graduate assistant, with input from other participating projects.

Program Evaluation Measures and Instruments

Rationale: We currently have very little data on the impact of sLTER programs or other education programs carried out at LTER sites. The data that we do have are generally collected at individual sites, in different forms at different sites. Furthermore, small sLTER programs lack resources to develop instruments for formative or summative program evaluation. We will work together to develop a tool kit of program evaluation measures and instruments that can be used by all sLTER programs. While our ultimate goal is to provide a comprehensive tool kit that includes recommendations for all of K-12, the focus of this project will be the high school grades (9-12).

Goal 1: Conduct a project and program wide evaluation of the effectiveness of different models used in the schoolyard ecology program in terms of participation, teacher classroom practice, and student learning.

Goal 2: Assess the role of culture in the implementation and effectiveness of the different models used in the schoolyard ecology program in terms of promoting environmental literacy and participation of groups traditionally under-represented in the study and practice of ecology and the environmental sciences.

The SGS-LTER site will take the lead in combining measures developed at different sites into a shared tool kit. Scientists, science educators, graduate students, and K-12 teachers, science coordinators and administrators from the SGS, SBC, KBS and BES LTER sites will work collaboratively to develop and and standardize the instruments. The study will be piloted within the SGS site and the other sites. Much of the work among sites will be coordinated via e-mail, conference calls, and in coordination with the meeting scheduled for the EOT committee of the LTER Planning grant. CoPI-Moore is chairman of the EOT and representatives from the other three sites are members of the committee. Funds have been requested for a workshop to be hosted at UNC on behalf of the SGS-LTER to thoroughly vet the measures and instruments, and to finalize our findings.

The SGS, KBS, BES and SBC LTERs each have developed their own unique interpretation of the SLTER concept. We propose to conduct both an internal evaluation of the different SLTER models developed by the SGS-LTER in conjunction and in coordination with a broader assessment of SLTER models adopted by the BES-LTER, KBS-LTER, and SBC-LTER. For example, the SGS-LTER SLTER program has developed three distinct models of educational outreach that include site-based research and activities at the SGS, school-based activities in the partner schools, and informal educational venue-based activities at remote sites (Pingree Park Fire Ecology Project) and learning centers (Poudre Learning Center). The demographics of the districts, schools and students served are diverse. The schools span remote rural (Akron, CO), suburban (Greeley, CO), to urban centers (Denver, CO). The student populations include largely low-income Hispanic (Greeley and Denver), Southeast Asian (Denver) to White European (all Districts).

A thorough evaluation of the effectiveness of the SLTER program, the different models adopted and the appropriateness of the curricula to the different cultures on the learning of ecological concepts and practices of students served has yet to be conducted. The findings of our evaluation and the assessment tools that we develop could then be used to inform and conduct a program-wide evaluation of the SLTER program involving all sites. The sites selected represent both a cross-section of models of SLTER programs and a diverse demographic of student populations. Each site has developed models that include to varying degrees LTER site-based activities, school based activities, and informal learning venues and centers. The sites encompass rural (SGS, KBS), suburban (SGS, SBC), and urban locales (SGS, KBS), school districts with low to upper income students (all sites), and a diverse spectrum of ethic groups and cultures: Hispanic (SGS, SBC), Native American (SGS), African American (BES, SGS), and White European (all sites).

Possible instruments and measures. Instruments in the tool kit will include the materials resulting from fulfilling the Objectives listed below to meet Goals 1 and 2. While our ultimate goal is to provide a comprehensive tool kit that includes recommendations for all of K-12, the focus of this project will be the high school grades (9-12). Goal 1 will be coordinated and piloted among each of the four participating SLTER partner sites. Goal 2 will be developed with the input of each partner but piloted at the SGS-LTER through its K-12 district partners and K-12 outreach activities (UNC Upward Bound Math and Science Program and UNC Frontiers of Science Program).

Goal 1: Conduct a project- and program-wide evaluation of the effectiveness of different models used in the schoolyard ecology program in terms of participation, teacher classroom practice, and student learning.

- *Objective 1.1 – Participation:* Determine the level of participation of Districts, Schools, Teachers and Students in the SLTER program. *Activities:* Develop quantitative and qualitative instruments that track the number of participants and level of their of participation. *Metrics:* Numbers of districts schools, teachers, and students; numbers of activities developed and delivered; analyses interviews of administrators, teachers and students.
- *Objective 1.2 – Classroom Practice:* Determine the effectiveness of SLTER in promoting change in classroom practice. *Activities:* Development of quantitative and qualitative assessments of teacher

pedagogical content knowledge of ecological concepts and practice. *Metrics:* Assessments of content knowledge from in-service training activities and workshops; Assessments of syllabi and assignments; Classroom observations.

- *Objective 1.3 – Student Learning:* Determine the impact of the SLTER on student learning of ecological concepts. *Activities:* Develop a suite of quantitative and qualitative learning measurements to assess student knowledge and understanding of ecological practices. *Metrics:* Performance on standardized tests; student interviews; evaluations of common essays.
- *Objective 1.4 – Assessment of Models:* Determine the relative effectiveness of the different models SLTER models–site-based, school-based, and informal educational venue-based – on participation, classroom practice and student learning. *Activities:* Conduct quantitative statistical analyses and qualitative analyses using the data and artifacts collected in Objectives 1.1, 1.2, and 1.3 to determine the impact of the three models. *Metrics:* p-values; effect sizes; contextual assessments.

Goal 2: Assess the role of culture in the implementation and effectiveness of the different models used in the schoolyard ecology program in terms of promoting environmental literacy and participation of groups traditionally under-represented in the study and practice of ecology and the environmental sciences.

- Objective 2.1 – Promoting Environmental Literacy: Determine the world-views and level of environmental literacy (based in part of the learning progression work developed at KBS) of students from different cultural backgrounds. Activities: Develop instruments to assess student beliefs and world-views of the environment and ecology, in relation to their understanding of environmental and ecological concepts (see Objective 1.3). Metrics: Performance on standardized tests; student interviews; evaluations of common essays.
- Objective 2.2 – Promoting the Study: Determine the impact of the SLTER program on increasing student interest in coursework and activities in related to ecology. Activities: Collect information and development instruments to assess the number of courses in ecology or environmental studies offered, taken and developed in partner schools and districts. Metrics: Numbers of courses offered, developed, and taken; numbers of AP/IB courses offered, developed, and taken.
- Objective 2.3 – Promoting Practice: Determine the impact of the SLTER program on increasing student interest in pursing careers in ecology or environmentally related fields (e.g., planning and management, environmental law, etc…). Activities: Develop instruments and collect information to track student career development. Metrics: High school graduation rates; choices of majors; college graduation rates; student interviews; evaluations of common essays.
- Objective 2.4 – Assessment and Culture: Determine the relative impacts of the SLTER program models on districts, schools, and teachers serving students from different cultural backgrounds. Activities: Conduct quantitative statistical analyses and qualitative analyses using the data and artifacts that have been disaggregated using cultural identity collected in Objectives 1.1, 1.2, 1.3, 2.1, 2.2, and 2.3 to determine the impact of the three models. Metrics: p-values; effect sizes; contextual assessments.

Development activities. The four sites will work collaboratively, developing and sharing instruments, as well as piloting instruments developed at other sites. The SGS site will take the lead in combining measures developed in meting Goals 1 and 2 at different sites into a shared tool kit. Development activities will include the following:

- Collecting examples and results from current evaluation activities, including instruments and measures used by outside evaluators.
- Consulting LTER education leaders about priorities. We will do this both through E-mail and telephone contact and through face-to-face consultation at meetings of the LTER education leaders and planning group.

- Development and pilot testing of measures. Different sites will have responsibility for initial development of different measures. Instruments will be piloted at all four sites, followed by revision based on the results of pilot testing.
- Developing framework for sharing results. We will work together to develop a shared framework for program evaluation comparable to the environmental literacy framework for our learning goals. The framework will help us to compare and synthesize results from individual instruments and individual sites.

Project Timeline:

Time	***Biodiversity Learning Progression***	***Program Evaluation***
June, 2005	PI's meet in Santa Fe during the LTER Planning grant meeting to discuss measures and instruments.	
June-August, 200	Review currently available research and assessments Develop initial learning goals Revise and pilot assessments Form teacher working groups	Collect measure and instruments used and SGS-LTER and our collaborating sites. Meet with representatives of CLT-W to discuss development of instruments and interview questions to assess the cultural relevancy of SLTER programs.
November, 2005	PI's and key staff members meet in conjunction with LTER EOT fall meeting	
Fall, 2005	Meetings of teacher working groups Administering pretests in classrooms and to other populations (e.g., teachers, general public) Teachers begin teaching about biodiversity	Develop quantitative and qualitative instruments listed in Objectives 1.1, 1.2, 1.3, 2.1, and 2.3
Winter/spring, 2006	Continue meetings of teacher working groups, teaching about biodiversity Administer posttests Data analysis of pretests and posttests	Conduct quantitative statistical analyses and qualitative analyses per Objectives 1.4 and 2.4 using the data and artifacts collected in Objectives 1.1, 1.2, 1.3, 2.2, and 2.3 to determine the impact of the three models.
March, 2006	PI's meet in conjunction with LTER Planning Grant meeting	
Summer, 2006	Develop and disseminate final products: Goals, assessments, discussions of resources and misconceptions	Develop and disseminate final products

Key Personnel and Institutional Resources

Charles W. Anderson is Professor in the Department of Teacher Education, Michigan State University; he works with the Kellogg Biological Station (KBS) LTER project. He served as lead consultant to the State of Michigan for the development of Michigan's state science objectives. He also led the development of the life science component of the Michigan Educational Assessment Program. He is past president of the National Association for Research in Science Teaching. He has been co-editor of the *Journal of Research in Science Teaching* and associate editor of *Cognition and Instruction*. He recently served as design team member for the NRC's Committee on Test Design for K-12 Science Achievement, and he is currently a member of NRC's Committee on Science Learning, K-8 and the NAEP Science Framework Planning Committee.

Dr. Anderson will lead data collection and data analysis for the learning progression. The Teacher Working Groups associated with the KBS LTER will include teachers from two sources: Teachers

associated with the KBS K-12 Partnership for Science Literacy, who come from 15 rural school districts in Southwestern Michigan, and teachers from the Lansing area who work with Dr. Anderson on the MSU teacher preparation program. Thus the KBS LTER will collect data from urban, suburban, and rural Michigan students .

John Moore is a Professor of Biology and Director of the Mathematics and Science Teaching (MAST) Institute at the University of Northern Colorado. His research in the area of food web ecology with an emphasis on the interplay between food structure, nutrient dynamics and mathematical notions of stability. He is a Co-PI and education coordinator on the Short-grass steppe (SGS) LTER, a senior scientist on the Arctic (ARC) LTER, and PI on several funded projects. As Director of MAST, Dr. Moore coordinates several K-12 outreach efforts (e.g., NSF GK-12 and DOE Upward Bound Math and Science), teacher professional development projects (e.g., CDE MSP and NSF CLT), and research on the roles and relationships of culture in teaching, learning, and mentoring on educational achievement of under-served populations.

Dr. Moore will lead and coordinate the development of program evaluation measures and instruments proposed in Goals 1 and 2. Additionally, Dr. Moore will coordinate the collection of data on the Learning Progression of K-12 students participating in the summer resident programs at UNC (Upward Bound and Frontiers of Science), the summer research internships for minority high school students at the SGS-LTER and students within local districts served by the NSF GK-12 project. Dr. Moore will coordinate his efforts with Dr. Anderson, providing input into the development of instruments, implement the data collection in Colorado, and assist in the data analysis.

Dr. Richard Jurin is the Director of the UNC Environmental Studies. His expertise is in the area of world-views and environmental awareness of students and the general public. He has expertise in curriculum development and assessment. Dr. Jurin has served as the science and academic coordinator for the UNC Upward Bound Math and Science program for the past 4 years working with students from underrepresented groups. Dr. Jurin will take the lead in developing and coordinating the qualitative instruments and analyses proposed under Goals 1 and 2. Additionally, Dr Jurin will assist Dr. Moore the analysis of the quantitative measures proposed under Goals 1 and 2 and collection of data for the Learning progression of K-12 students participating in the UNC summer resident programs (Upward Bound and Frontiers of Science).

Alan Berkowitz has been Head of Education at the Institute of Ecosystem Studies (IES) in Millbrook, New York since 1985. He is the Education Team Leader for the Baltimore Ecosystem Study LTER project, and has conducted ecological research in plant ecology in agroecosystems, powerline rights-of-way and urban areas. He has extensive experience in K-12 curriculum and professional development, was involved in developing environmental education standards with the North American Association for Environmental Education (NAAEE), is a past Vice President for Education and Human Resources for the Ecological Society of America (ESA), and does research into ecology teaching and learning. Dr. Berkowitz will work with education colleagues, staff, teachers and students associated with the Baltimore Ecosystem Study's Investigating Urban Ecosystems program to carry out research into student understanding of identified dimensions of the framework.

Allison Whitmer is a Research Biologist at the Marine Science Institute (MSI), University of California, Santa Barbara, where she serves as Director of Education. Her research is on the ecology and evolution of marine organisms. As Director of Education at MSI, she develops and coordinates education programs for K-12 and undergraduate education. Her role covers activities such as developing education materials for MSI research, providing professional development opportunities for K-12 teachers, and engaging undergraduate students in education and outreach programs. Dr. Whitmer is a co-PI on the LTER Planning Grant and facilitates the work of the LTER Education, Outreach and Training Committee.

Dr. Whitmer will work with teachers (and their students) involved in student outreach and teacher professional development programs associated with the Long-term Ecological Research projects (SBC

LTER, MCR LTER), PISCO, and other research programs. Dr. Whitmer will coordinate her efforts with Drs. Anderson, Moore, and Berkowitz providing input into the development of instruments, implement the data collection in California, and assist in the data analysis.

Results from Prior EdEn Venture Funding:

The Kellogg Biological Station (KBS) LTER was awarded an EdEn Venture grant in 2003 (DEB 0331787), entitled "Synthesis and Assessment of the Research Base for a K-12 Environmental Literacy Curriculum." The work funded by this research included a review of the research literature on student learning related to environmental literacy. This review served as the basis for a draft framework for K-12 Environmental Literacy. We used the framework to develop pretests and posttests designed to reveal the thinking of K-12 students about five topics related to environmental literacy: physical and chemical change, carbon cycling, water cycling, biodiversity and evolution, and connecting human actions with environmental systems. These assessments were used by teacher working groups to assess how their students understood these aspects of environmental literacy. The results of the assessments are now being used to revise the framework and the assessments themselves. First drafts of the framework and assessments are available on our website: http://scires.educ.msu.edu/EnvironmentalLiteracy/index.html. Revised versions will be available by the end of the summer.

The Shortgrass Steppe (SGS) LTER was awarded an EdEn Venture grant in FY2004 entitled "Environmental Education and Outreach Program for Educators of Native American Students." The objectives of the program were to establish partnerships with tribal schools in Arizona, Montana, and North Dakota to develop Schoolyard LTER programs and teacher professional development opportunities to increase environmental literacy and increase interest in careers in ecology and related fields among Native American students. Native American communities in the reservations face concerns shared by many rural and urban communities: disproportionately high rates of poverty, a lack of innovative science instruction, curricula aligned with science standards, and low test scores in the sciences. Additionally, many of the communities face many of the same pressures in terms of natural resources that are currently under investigation at the SGS-LTER, e.g., grazing, agriculture, soil erosion and land development.

To date, our project is on target with its proposed timeline. Project PI's met with counterparts from Montana and North Dakota at regional meetings in Montana (October 2004) and a national meeting in Washington, DC (February 2005) for the NSF funded Center for Learning and Teaching in the West, our partner in the project. Representatives from the tribal schools attended the SGS-LTER annual symposium held in January 2005. The SGS-LTER PI (Gene Kelly), Co-PI and EdEn project leader (John Moore) and the project senior personnel (Lori Riensvold and Robert Wang) traveled to the Rough Rock Community School on the Navajo Reservation to meeting with teachers, school administrators and tribal elders to discuss planned activities. The group met in Montana (April 2005) with the remaining partners.

The SBC-LTER was awarded an EdEn Venture grant in FY2004 to engage K-12 teachers and educators in research and curriculum development focused on watershed-scale ecology. Efforts have focused on the development of a middle school environmental education curriculum and lesson plans and an after-school program for high school students that focuses on environmental monitoring. The middle school curriculum has been developed, piloted and evaluated in a local school. Revisions are currently underway. The SBC-LTER has partnered with the Marine Technology Institute at the Cabrillo High School (CHS) to develop a series of lesson plans and afterschool club activities that use the theme of marine technology in their life and physical science courses to better understand nearshore coastal research. The physical science curriculum has CHS students build and test remotely-operated vehicles (ROVs), which are used in coastal monitoring programs. An after-school club extends this learning to include design of specialized vehicles for competition. The regional competition included a scenario in which ROVs were used to assist in a toxic spill clean up in a marine sanctuary. (The CHS team is traveling to Houston, TX for the national competition later this month!) Teachers are working with the SBC-LTER to develop a similarly themed curriculum for life science.

Significance and Impact

Our collective work developing a learning progression and evaluation measures will meet several EdEn priorities, as detailed below.

- *Addressing AC-ERE environmental research frontiers.* The AC-ERE report identifies three research frontiers to be addressed by EdEn projects: Coupled human and natural systems, coupled biological and physical systems, and people and technology. Since this project is organized around the LTER Grand Challenges, all three of the AC-ERE research frontiers are addressed.
- *Impact on underrepresented groups and inner-city students.* Teachers and students from two urban systems (Baltimore and Lansing) will participate in this study. The SGS program works extensively with American Indian teachers and students. The SBC program works with Hispanic students.
- *Interdisciplinary content.* The environmental literacy framework and learning progression will reflect the interdisciplinary nature of LTER research.
- *Evaluation plans.* The program evaluation measures developed through this project will be useful for future EdEn and sLTER programs.
- *Involvement of multiple institutions.* This will be a cooperative venture of four programs.

We also believe that the work on the learning progression has great potential for impact on programs and policies beyond the LTER network. Some elements from the KBS Environmental Literacy framework are being incorporated into the Framework for the 2009, 2013, and 2017 NAEP science assessments (Anderson is on the Planning Committee). This work will also generate assessment items that can be incorporated into the NAEP and other assessments, and the learning progression will help us influence likely upcoming revisions of the National Science Education Standards.

References

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