Handbook for LTER Education

First Edition

2005

Written by:
S. Bestelmeyer, S. Dailey, M. Elser, P. Hembree, C. Landis,
K. O'Connell, B. Simmons, S. Sommer, S. Steiner
Reviewed by LTER Education Representatives Nov. 2005

Goal of LTER Education:
Use the uniqueness of the LTER programs and network to promote training, teaching, and learning about long-term ecological research and the earth's ecosystems.

Table of Contents

Chapter 1: Introduction and Getting Started

Patricia Hembree, Georgia Coastal Ecosystems LTER

This handbook is presented as a brief guidebook for those interested in the education programs and activities of the Long Term Ecological Research (LTER) network. The handbook is not intended to be exhaustive, but simply to give the reader an overview of LTER education efforts and to share some frameworks, materials, and best practices that have been developed and tested at LTER sites. The six chapters and eight appendices provide strategies and resources from current programs to design and develop a new program, collaborate with other sites, and to provide ideas for program expansion. Each chapter contains key references related to program design, development, implementation, and evaluation. It is important to note that each LTER site is unique and often requires site-specific plans for maximizing outreach efforts; however, all sites share the overall goals of the Schoolyard LTER (SLTER) and have several common approaches. Sharing frameworks and best practices facilitates the collaborative development and testing of the Schoolyard LTER (SLTER) as a model for the integration of ecology research and education. We encourage you to spend time reading the collection of documents on the LTER webpages that are related to education. Much of the information in this chapter can be found in detail in those documents.

Chapter 1 gives a brief history of LTER Education initiatives and potential goals/objectives for a wide range of learners: kindergarten through high school teachers and students, undergraduates, graduates, and the public. Remaining chapters focus on K-12 education efforts that are generally referred to as the SLTER efforts. Chapter 2 provides links to a variety of standards and strategies used in education and in designing professional development programs. Chapter 3 discusses some of the successful collaborations that have been used throughout the LTER Network and provides tips on coordination of your program. Specifics to remember and consider as you plan for program delivery are presented in Chapter 4. In Chapter 5, you will find suggestions for seeking financial support, links to funding sources, and links to help in writing grants and applying for support. The final chapter discusses the 2004 Education Survey and identifies opportunities for assessing scholarly outreach. The handbook includes eight appendices: the first discusses teacher recruitment and the second discusses scientists' involvement. Appendix 3 are guidelines developed by the SLTER community that are intended to serve as a reference for LTER sites to use for informal self-assessment and planning. Appendix 4 includes examples of activities using LTER data and suggestions from the LTER Data Managers on appropriate use and citation of LTER data. Appendix 5 provides suggestions for conducting effective field trips. Appendix 6 provides a list of several examples of how sites have leveraged supplement funding to expand and improve education activities and programs. Appendix 7 is a copy of the 2004 Education Survey and finally, Appendix 8 provides a selected list of publications and resources.

History of the SLTER

The 10-year review of the LTER program in 1991 recognized that the program not only had established a record of accomplishment for excellence in research but had also provided unique education opportunities. The LTER network had succeeded in training students in ecological research in site-oriented environments with interaction and collaboration among many

disciplines. The committee that reviewed the LTER program was convinced that while the program should continue its research trajectory, there was an expanded role for integrating research in education as part of LTER activities. The review committee recommended that LTER function as a network of integrated sites and that this new Network must assume a broader role in environmental education. "Because the process of ecological science can best be understood by observing and participating in environmental science in action, sites like those in the LTER network have a strong potential to provide unique educational experiences. Thus, the new LTER network must assume a broader role in environmental education." The committee report further stated that because of the variety of ecosystems that LTER encompasses, it allows the network to serve as a test-bed for the development of curricular materials, to provide relevant learning contexts for students of all levels, and to provide opportunities for teachers to learn about science in ways they can transfer to the classroom. In addition, the LTER network was the ideal vehicle for demonstrating the necessary interplay between teaching, and research.

In 1998, the Network formally expanded its education efforts to include K-12 students and teachers—mainly through the SLTER program funded by the Division of Environmental Biology (DEB) at NSF. NSF provided funding supplements upon request to LTER sites to design their own program in relation to the ecological research conducted at the site and the particular needs and resources of the local school district and community. This provided much needed resources for LTER sites to develop and pilot a diverse array of education activities and programs.

In 2000, the LTER leadership engaged in a process of priority setting and drafted *LTER 2000-2010: A Decade of Synthesis White Paper* (http://intranet.lternet.edu/archives/documents/reports/lter_2010/lter_2010_GRS.html). This document specifically included education as one of the ways that the LTER can and should achieve its mission. In 2002, the Network Office initiated a strategic planning process for that education component. LTER Education Representatives from 20 sites including teachers, graduate students, and science educators met to provide input for the LTER 2000-2010 White Paper and to discuss issues, objectives, and recommendations to include in a Strategic Plan for Education. During this meeting an LTER Education Committee was formed to represent the LTER Education Representatives at the LTER network level. In 2003, seven education representatives met to develop a working document that has resulted in this handbook.

Each site's education program shares the same, overarching mission -

> To use the uniqueness of the LTER programs and network to promote training, teaching, and learning about long-term ecological research and Earth's ecosystems.

Unique features associated with LTER include:

- Long term research, detecting patterns and phenomena of importance that are not typically discernible through short-term study.
- Cross-site comparison and synthesis, taking advantage of parallel methodologies, data availability, and a culture of collaboration and synthesis.

- Study of large-scale systems, phenomena, and processes affecting significant portions of the globe.
- The sustained nature of our individual and collective programs, allowing long-term relationships to build between scientists and various education communities.
- The LTER culture of inclusion, cross- and inter-disciplinary thinking, and application to real problems.

With this mission guiding the LTER network, the following goals have guided program design:

1. Improve understanding of long-term ecological research and Earth's ecosystems for students of all ages and the public at large.

2. Enhance the diversity of future generations of ecologists and educators involved in and supporting long-term ecology research and education.

Conclusion

Each LTER site is unique. This requires an understanding, by the Education Representatives at each of the sites and the Network, of the flexibility needed in the design of individual programs. As you design, refine, or expand your individual program, it is important to establish specific, local goals and objectives guided by those of the LTER Network but dictated by the practicalities of your situation. For example, though it is hoped that each site is able to serve students from Kindergarten to graduate school to adult education, access to the necessary resources and proximity of the target audience may pose constraints and limitations. Each site typically prioritizes their efforts and resources according to their unique circumstances. We have the opportunity to establish within the LTER Program an ambitious and innovative linkage between research and education.

Chapter 2: Background – Standards and Strategies

Monica Elser, Central Arizona--Phoenix LTER

The objectives of a Schoolyard Ecology Program should reflect the needs of local educators (formal and non-formal) and should promote effective teaching strategies. This section provides links to national resources, suggested references and possible local connections.

Education Standards

The most commonly referenced science standards are the National Science Education Standards published by the National Research Council in 1996. Other good resources are from the American Association for the Advancement of Science Project 2061, which include *Benchmarks for Science Literacy* and the *Atlas of Science Literacy*.

National Science Education Standards from NRC:
http://www.nap.edu/readingroom/books/nses/html/
OR the book:
National Science Education Standards. Washington, D.C.: National Research Council, National Academies Press, 1996. ISBN 0-309-05326-9
Available online at http://books.nap.edu/catalog/4962.html.

Project 2061 from AAAS
http://www.project2061.org/default_flash.htm

American Association for the Advancement of Science. *Atlas of Science Literacy.* New York: AAAS Press, 2000.

American Association for the Advancement of Science. *Benchmarks for Science Literacy.* New York: Oxford University Press, 1993.

Each state also has education standards; these are typically found at each state's Department of Education website. Additionally, local school districts also have education standards. Generally the state and local district standards are consistent. They are usually based on the National Science Education Standards. Many school districts and states will list the standards that should be taught by grade level. Also many states administer state-wide tests on science, consequently it may be useful to know which grades are being tested and what science content is being assessed.

Other state education standards may also fit into a SLTER program. Many ecology lessons are interdisciplinary and have obvious connections to math, social science, or language standards. Here's a list of different standards in Arizona: The Arts; Comprehensive Health/PE; Foreign and Native Language; Languages Arts (reading and writing); Mathematics; Science; Social Studies; Technology; Workplace Skills.

Professional organizations also have developed standards for their disciplines. For example, the National Council of Teachers of Mathematics has developed the Principles and Standards for School Mathematics which can be found at: http://www.nctm.org/standards/.

Standardized Testing
Another current issue facing teachers is high stakes standardized testing. Most states have these tests for math and language arts (reading & writing) and are developing them for other content areas including science. In 2007, the No Child Left Behind legislation requires that states test students in science. This information should be at each State's Education Department.

A good resource on tests is at the National Center for Education Statistics which has the NAEP Questions Tool which provides easy access to NAEP questions, student responses, and scoring guides that are released to the public. The NAEP Questions Tool allows searches for test questions by grade level and subject. Both national and state data, where appropriate, are presented. Here's the link http://nces.ed.gov/nationsreportcard/itmrls/.

The National Assessment of Educational Progress (NAEP), also known as "the Nation's Report Card," is the only nationally representative and continuing assessment of what America's students know and can do in various subject areas. For further information on NAEP : http://nces.ed.gov/nationsreportcard/about/.

Teaching Strategies and Science Education Research
Research on teaching science encompasses so many areas that we can't really do justice to it in a few pages. One obvious resource is the other LTER network Education Representatives and the LTER network web site (http://www.lternet.edu). For resources in your area, check out local nonformal and formal education providers including: College of Education faculty, local nature centers, museum, and school district science coordinators. Below is a very brief list of resources that might be useful:

From the National Research Council:
Inquiry and the National Science Education Standards: A guide to teaching and learning ISBN 0-309-06476-7

How People Learn, ISBN 0-309-07036-8

From the Ecological Society of America:
Teaching Issues and Experiments in Ecology (*check out the glossary of terms*)
http://tiee.ecoed.net/teach/teach.html

From the North American Association for Environmental Education
http://naaee.org

National Project for Excellence in Environmental Education
http://naaee.org/npeee/materials.php

Also, located here are guidelines for learning:
http://naaee.org/npeee/learner_guidelines.php

Other Resources:

Websites

Theory into Practice Database: http://tip.psychology.org/
TIP is a tool intended to make learning and instructional theory more accessible to educators. The database contains brief summaries of 50 major theories of learning and instruction. These theories can also be accessed by learning domains and concepts.

Educational Resources Information Center:
http://www.eric.ed.gov
ERIC has a searchable database for education-related articles.

The National Science Teacher Association:
http://nsta.org
They publish three journals (high school, middle school & elementary) and various books.

National Association of Biology Teachers
http://www.nabt.org/
They publish the *American Biology Teacher*

Journals

Journal of Research in Science Teaching
Research in Science Education
Science Education
Journal of Environmental Education
The Journal of Marine Education

Books

Berkowitz, A., C. Nilon, and K. Hollweg, editors. *Understanding Urban Ecosystems: A New Frontier for Science and Education.* Springer-Verlag, 2003. ISBN 0-387-95496

Lieberman, G. and L. Hoody. *Closing the Achievement Gap: Using the Environment as an Integrating Context for Learning.* State Education and Environment Roundtable, 1998. Available online at http://www.seer.org

Chapter 3: Program Coordination and Collaboration

Susan Steiner, Coweeta LTER
Kari O'Connell, Andrews LTER

Collaborative programs are, by definition, an endeavor to cooperate with others with whom one is not immediately connected. The LTER network is based on the principles of cooperation and collaboration. Naturally, the LTER-associated educators also collaborate, reaching out for funding, for expertise in science and education, and for contacts of who best can be reached through our programs. Program coordination protocols vary among the sites, depending on the goals and mission of the program, and the amount and type of funding.

Collaboration with University, Private, and National Organizations

Examples of collaborative programs can be found in the education sections of nearly every LTER site web page. Many sites work with university programs. A few of these include:

- The SMILE (The Science Math Investigative Learning Experience) program at H.J. Andrews in cooperation with Oregon State University involves students in science-based after-school programs and provides in service development for teachers. http://www.fsl.orst.edu/lter/edu/schoolyard/smile.cfm?topnav=125
- K-12 Partnership for Science Literacy at Kellogg Biological Station with Michigan State University works with science teachers, providing them with ecological science education and exposes them to current science teaching methods. http://www.kbs.msu.edu/K12_Partnership/Index.htm
- Journey to El Yunque, (http://elyunque.net/journey.html) at Luquillo, is a website program producedby The Learning Partnership. This dynamic web program is packed full of information on rainforest ecology, and is terrific fun to use.
- North Temperate Lakes LTER staff, Center for Biology Education, and the University of Wisconsin – Madison School of Education Outreach work in partnership to provide a 4-week Winter Limnology workshop for students grade 5-8. http://limnosun.limnology.wisc.edu/K_12.html
- Palmer Station in the Antarctic partners with Teachers Experiencing the Antarctic and Arctic and with the University of California at San Diego. A great website of activities is linked to this page: http://tea.rice.edu/tea_classroommaterials.html
- Georgia Coastal Ecosystems at Sapelo Island works closely with the Dept of Science Education at the University of Georgia. Their program, Scientists and Professional Educators Learning Outdoors (S.A.P.E.L.O.), brings teachers to the Island to do science research with GCE-LTER scientists and graduate students. http://gce-lter.marsci.uga.edu/lter/education/slter_jan04.htm
- North Temperate Lakes partners with the System-wide Change for All Learners and Educators Math Science Partnership with school districts in Los Angeles, California, Denver, Colorado, and Madison, Wisconsin http://www.wcer.wisc.edu/scalemsp/

Other sites have collaborations with private groups:

- Virginia Coastal Reserve has used NSF funding as leverage to secure additional funding from a private foundation.
- The BP Exploration Alaska program sponsors a Saturday lecture series at the Arctic SLTER in Barrow, Alaska. This program also supported several students and their

teachers in traveling to the Toolik Lake Field Station to participate in tundra warming experiments. http://ecosystems.mbl.edu/ARC/

- At the CAP LTER, the Southwest Center for Education and the Natural Environment (SCENE) offers expertise and workshops on schoolyard native habitats and is an environmental education resource center.
- The Konza Prairie's environmental education program is supported by the Friends of Konza Prairie, a private group. Trained docents volunteer their time for presentations, workshops and public education about KPBS research. http://www.ksu.edu/konza/keep
- The Santa Barbara Coastal LTER is partnered with the Community Environmental Council and utilizes the facilities of the South Coast Watershed Resource Center for educational programs. http://sbc.lternet.edu/education/index.html
- The Jornada Basin LTER education programs result from a collaboration between the LTER, a USDA/ARS lab (the Jornada Experimental Range), and a local science education nonprofit organization (the Chihuahuan Desert Nature Park). http://www.zianet.com/cdnp2/SDD_Home.htm

Sites combine funding from the National Science Foundation Schoolyard Supplements for LTER with other types of national funding:

- The Arctic SLTER in Barrow, Alaska, receives funding from the NSF office of Polar Programs for the Barrow Arctic Science Consortium (BASC), which supports a tundra greenhouse warming experiment and a Saturday lecture series.
  http://www.sfos.uaf.edu/basc/edu/index.html and
  http://www.nsf.gov/od/opp/aboutopp.htm
- Konza Prairie receives funding from the Eisenhower Professional development program to support the Konza Environmental Education Program's Teachers' Technology Workshops. Websites:
  http://www.konza.ksu.edu/ and
  http://www.cfda.gov/public/viewprog.asp?progid=1043
- Florida Coastal Everglades has received funding from both the EdEn Venture Programs and Research Education for Teachers (RET) programs at NSF. Through these funding opportunities, Florida Coastal Everglades has worked closely with teachers and students in the Miami Dade County School system and with Everglades National Park science education rangers. Classroom programs, research information and links, and examples of teachers' RET experiences can be found on their website at: http://fcelter.fiu.edu/schoolyard/
- Kellogg Biological Station uses funding from the National Science Foundation Directorate for Education and Human Resources (EHR) to fund the KBS K-12 Partnership for Science Literacy. http://www.nsf.gov/home/ehr/
- Palmer Station receives funding from the Office of Polar Programs, as well (see the Arctic SLTER). Teachers Experiencing Antarctica and the Arctic (TEA) is a program reaching school teachers in all states of the country. http://tea.rice.edu/ and http://pal.lternet.edu/education/ and (under construction) http://pallter-dev.uscd.edu/outreach
- The Shortgrass Steppe LTER education and outreach program utilizes funding from the GK-12 Graduate Fellowship Program as part of a large collaborative education effort of

the Colorado Front Range GK-12. http://www.nsf.gov/home/crssprgm/gk12/ These education efforts are in addition to the Schoolyard LTER projects.

- Georgia Coastal Ecosystems receives funding from Georgia's Teacher Quality Higher Education Programs, which are federally funded through the US Department of Education. Information about Teacher Quality Enhancement grants can be found at: http://www.ed.gov/programs/heatqp/index.html
- Sites such as Coweeta Hydrologic Lab, the Luquillo Experimental Forest, and the Andrews Forest are facilities located on National Forest Service lands. Contributions of time by Forest Service scientists and staff, plus site and equipment use, help to extend the yearly $15,000 Schoolyard LTER funds. At Luquillo, the Schoolyard program is coordinated jointly by the Research Director from the USFS, a faculty member from University of Puerto Rico and a teacher from a local high school.

Other partnerships include those with private schools:

- The Bosque Environmental Monitoring Program (BEMP) at the Sevillita site, coupled with the Bosque Preparatory School, provides salary for one of the coordinators. http://www.bosqueschool.org/Environmental%20Science%20Programs/about_bemp.htm
- The Coweeta Hydrologic Lab collaborates with the Rabun Gap Nacoochee School, accessing their school property for research as well as leading a section of the sophomore class in research activities during their school's spring intersession. The private school is able to provide all the necessities for a week- long camping trip, while the Coweeta Lab staff leads the students in conducting research on site. http://coweeta.ecology.uga.edu/webdocs/1/schoolyardlter.htm

Collaboration with Other LTER Sites or Off-site Schools

Several cross-site proposals have been discussed and some of them submitted in 2004, unfortunately none were funded. These efforts included: A proposal led by Marion Dresner of Portland State University that continues and expands on a teacher training program based at the Andrews LTER. That proposal emphasized teacher training through a two-week field program at several LTER sites. The program would have been supported by follow-up web-based materials and included expansion of the training to regional environmental education providers. A second proposal for Instructional material was led by Dr. Steve McGee at The Learning Partnership . (see "Journey to El Yunque" project previously mentioned). The proposal was for "development of a middle-school life science curriculum based on the synthesis themes of LTER. A third proposal, led by Robert Bohanann from NTL, included the creation of virtual professional development resources, targeted not only at educators, but also informal science educators, scientists, and managers. Many of these are being resubmitted.

Online, a teacher's manual of classroom activities based on LTER themes is available at: http://www.dnr.cornell.edu/ext/LTER/lter.asp. This manual was developed by scientist / educators at Cornell University in collaboration with scientists and educators at the Hubbard Brook LTER site and a contribution from the Central Arizona-Phoenix LTER site.

The Ecosystems Center, of the Marine Biological Laboratory at Woods Hole, MA, http://ecosystems.mbl.edu/Education/education.html sponsors a summer program joining

researchers at Plum Island Sound LTER site, Toolik Lake Arctic site, and the Harvard Forest with science journalists for a hands-on environmental science course.

Another type of collaboration is found at McMurdo Dry Valleys LTER site. The Schoolyard program involves students from three high schools across the United States: from Alabama, Washington and Ohio. http://www-bprc.mps.ohio-state.edu/EnvironmentalGeochemistry/Lyons/schoolyard-LTER/index.html

The Palmer Station's participation in Teachers Experiencing Antarctica and the Arctic (TEA) reaches teachers (and consequently their students) from all across the United States. http://tea.rice.edu/index.html

Program Coordination

Much of the nuts and bolts of program coordination depend upon the type and amount of financing the program receives. Generally, the larger and more involved programs have more formal coordination. Examples range from having the PI of the site coordinating the program with a few committed individuals to implement activities, to having a team, or even a formal education committee that can include a dozen or more members.

For a small program, a loose organization of strong, committed individuals from various organizations can work together to facilitate programs. Over the long term, especially if the program is to grow, a more formal approach needs to be taken. A small group dependent on a few individuals is unsustainable, as personnel and commitments change over time. Unfortunately, the Schoolyard grant money, currently $15,000 yearly per site, is not enough to fund an education coordinator for each site. A very dependent variable, insofar as coordination of the program, comes down to money: How much money is available in order to facilitate the Schoolyard program for your site?

Other variables concerning education program coordination are the program goal and the target audience. Each education program needs clear definition, goals, and a mission. Define the audience you are working with: K-12 education, K-gray education, education for land managers, the general public, other scientists and college faculty, undergraduate, and graduate students. Most sites are addressing all of these audiences to a certain extent. A well-planned, well-coordinated education effort is essential in presenting a high quality program.

The H.J. Andrews LTER site addresses several important questions regarding program coordination on their website. They have published an Education Plan for their site at: http://www.fsl.orst.edu/lter/edu/edplan/aefedplan.cfm?topnav=12

In consideration of an Education Coordinator position, the following questions should be posed:

- What should the overall scope of duties be?
- Should the person be an educator as well as a coordinator?
- Is the job more one of facilitation or direction of a program?
- What is their role in curriculum development?
- What fraction of this position's time should involve securing funding?
- What are the primary domains/audiences?

  - Academic?
  - Professional?
  - Public?
- Where should the position be located?
- What is the appropriate academic home and physical location of an office?
- Where should the position fit in the administrative structure?
- What is the position's role in establishing policy?

These are a few of the questions to be considered in developing the leadership for your Schoolyard LTER program.

The Baltimore Ecosystems Education program is coordinated by an education committee with daily coordination by the education staff.
http://www.beslter.org/frame5-page_1.html

The role of the representative of the Bonanza Creek Outreach effort is to coordinate between the LTER researchers and district teachers. The researchers identify ideas for suitable projects and the representative approaches the school faculty and staff for participation in the projects.
http://www.lter.uaf.edu/sylter/schoolyard.htm

Kellogg Biological Station has two Project Coordinators, one from KBS and one from the schools.
http://www.kbs.msu.edu/K12_Partnership/Index.htm

Population Diversity

One objective of the education programs of the LTER network is to "improve the diversity, training, and support of future generations of ecologists." (The LTER Education Strategic Plan, as of 7/31/03
http://intranet.lternet.edu/archives/documents/reports/education/eudaction_strategic_plan.html). Our goal is to contribute to the diversity of the ecological research workforce. In order to accomplish this goal through education programs, diversity needs must be specifically addressed. Many sites are located in areas of high traditionally minority populations, such as the Arctic LTER site, the Luquillo site, and sites in the Southwest and Florida. Urban sites can attract minority students, as well.

Some sites, such as the Shortgrass Steppe, are actively pursuing the minority population. John Moore's proposal for research assistantships for minority high school students has more information: http://sgs.cnr.colostate.edu/EdWeb/EdRAMHSS/ramhss_proposal.htm

Other ideas for reaching out to more diverse students would be to work with Upward Bound. This program is for pre-college students interested in going to college who must meet federal income requirements and are likely to be first generation college students. The program is funded by the U.S. Department of Education and is free of charge to the participants. Upward Bound programs are in place at most colleges.
http://www.ed.gov/about/offices/list/ope/trio/index.html

Other resources for working with minority populations include the ESA's initiative: SEEDS. The Strategies for Ecology Education, Development, and Sustainability (SEEDS) program of the Ecological Society of America addresses ecology opportunities for minority students. SEEDS supports undergraduate research fellowships, campus ecology chapters, travel and field trips, and is also partnered with the United Negro College Fund. http://www.esa.org/seeds/

The SMILE Program at the H.J. Andrews Forest reaches educationally disadvantaged students and/or those of lower socio-economic status to encourage them in the science and mathematics fields. http://smile.oregonstate.edu/

Teaching Tolerance is a web project of the Southern Poverty Law Center. Their website has sections for teachers with many free activities and ideas for addressing cultural differences and disability issues in lesson plans. http://www.tolerance.org/teach/index.jsp

Legal Issues

The legal issues involved with liability insurance, photo permission (including online posting), field trip permissions and safety concerns all need to be kept in mind. Fortunately, the schools have already addressed these legal issues, in accordance with the Family Education Rights and Privacy Act (FERPA, 1974). You need to know and adhere to your participating schools' policies.

Address any safety concerns that are unique to your site with your teachers or administrators. Work with them to create any additional safety procedures or plans.

Conclusion

As you can see from the material in this chapter, program coordination and collaboration varies from site to site. Through collaboration, various types of funding or in-kind services can be assimilated. The overall coordination of your program depends partly on funding, and partly on the goals and mission of your program. For further online review of education programs at the LTER sites, see the website of the LTER network at http://www.lternet.edu/sites/.

Chapter 4: Program Delivery

Monica Elser, Central Arizona – Phoenix LTER
Carol Landis, McMurdo Dry Valleys LTER

SLTER programs should take advantage of the diversity of research and opportunities at their sites. Schoolyard education programs should stem from a site SLTER plan that includes goals and evaluation strategies. Evaluation strategies may be formal (surveys) and/or informal (advisory committees). The programs should relate to and articulate the science being conducted at the LTER site and illustrate the value of long-term ecological research. Each SLTER program will be different – reflecting local research, state education goals, the grade-level of teachers and other factors. Included in this chapter is some very basic information and advice on program delivery.

Building Student-Teacher-Scientist Partnerships
A major strength of the Schoolyard LTER programs is building a student-teacher-scientist partnership. In many of the LTER programs the education representative facilitates these interactions.

The following are recommendations for building a good partnership from a paper by Wormstead et al (2002) based on the experience of the GLOBE program. Below is a summary of their findings.

Components Should:

- Engage students in the full process of science from identifying questions to data analysis.
- Provide science background information, written at introductory level and placed separate from data collection instructions.
- Provide curriculum/education standards integration assistance.
- Provide categorized resource lists.
- Provide classroom management suggestions on how to engage the whole class in data collection and how to manage the class during field work.
- Provide age-appropriate material.
- Provide student assessment sections/ideas.
- Include student pages with age-appropriate reading level and formatting.

Guidelines for Layout and Organization of Material:

- Clearly organize material with easy-to-follow, graphical layout.
- Provide consistent lesson format: title, grade level, objective/purpose, time, concepts/skills/process, material needed, prerequisites, procedure, follow-up discussion, student assessment.
- Write procedures (instructions) in step-by-step format.
- Start lessons with very basic concepts/skills and build upon them sequentially.

Guidelines for Writing Concept and Skill-Building Lessons and Instructions:

- Develop hands-on lessons where possible.
- Include specific information to make science lessons relevant to students (motivating context).
- Include "outdoors" lessons where relevant.
- Develop inquiry-based lessons where possible.
- High-order cognitive strategies
- Collaboration (PI's, scientists, graduate students, teachers, school districts)

Important Issues to Consider:

- Recognize the importance of a strong collaborative relationship with teachers and provide follow-up support including information sharing and training workshops.
- Recognize the importance of the involvement and support of the entire learning community, especially school administration and other teachers, but also including the students' parents and community members.
- Consider issues related to time constraints.
- Consider that schools often have limited funding.

Working with Teachers

One of the first steps to setting up an education program is to "know your audience". Most SLTER programs work with teachers from the K-12 community. Here is some basic information:

Pre-service teachers: generally students still in college who are earning a teaching certificate.

In-service teachers: teachers who are employed in a school.

Teacher re-certification hours: most states require that teachers complete a specified number of professional development hours to maintain their certification. If your workshops/internships **are not** being offered for college credit, you should offer teacher certificates including the number of hours the teacher participated in your program as well as the dates.

School District "in-service" programs: most districts sponsor in-service training designed for professional development. If you conduct a workshop with the district, they will issue the certificates to the teachers.

District science coordinator: many districts employ a science coordinator—they can be great resources and links to the district's science teachers.

Working with Scientists (Faculty, Grad Students, Post-Docs, Undergrads, Technicians)

Many scientists associated with LTER sites enjoy working with teachers and students. By providing teachers and students with access to a number of different scientists (faculty, grad students, technicians, etc.) they can see that science is a collaborative process. Most people appreciate some guidelines for making presentations and working with students and teachers.

Making Presentations

Borrowed from a set of guidelines for scientists entering elementary classrooms, the following five general principles are useful for presentations to learners of all ages, whether in the field or indoors:

- Know your audience. (Check the National Science Education Standards for that age group, understanding that schools vary widely in their adopted goals).
- Use props (demonstrate strategies, skills, locations, etc. with student help).
- Show your sense of humor.
- Involve the teacher (Working side-by-side with a scientist sends a message to students).
- Follow-up a few days after the event. (Make yourself available for questions that may arise.)

Workshop Resources

The Environmental Education Toolbox Series includes a booklet called "Designing Effective Workshops". You can buy it from NAAEE and you can buy just this book in the series. http://www.naaee.org/publications/pubdescriptions.php

Bringing Students to the LTER Site

Many publications offer advice to educators about conducting a field trip and/or setting up an outdoor field study site. While similar elements are involved when engaging young scientists, volunteers, and other learners with scientific research, some very basic checkpoints might be helpful to those who are beginning a collaborative program. Long Term Ecological Research is problem-based and often requires outdoor participation. A summary of tips and suggestions from the literature is offered below. A checklist is offered as an organizer at the end of this chapter.

Beiersdorfer and Davis (1994) state that "a mixture of guided tour instruction and individual or group problem solving activities provide the optimal learning experience" (p. 308). Additionally, they suggest the following:

- Prepare the students/helpers for the trip (where, when, what, why, how, etc.)
- "Walk through" your planned field experience to gauge the time needed. (Some unplanned time for additional exploration is better than an unfinished protocol.)
- If travel time to the study site is lengthy, audio tapes can be used to provide information (rather than reading and the resulting car-sickness).
- Walking from site to site also provides some time for interpretation and discussion of results, but some "down time" is also important for group interaction.
- Limit groups to not more than 15 people per adult leader.
- The "experts" should systematically move through the groups to be available for comments and questions.
- Offer parallel activities (observation journals or other related activities in addition to the primary research tasks) for slack time.
- Discuss the schedule and responsibility for chores prior to the experience.
- Provide a list of required and suggested equipment prior to the experience and offer to discuss it with first-timers.
- Reassure participants that safety is the highest priority and first aid kits will be available.
- "Field sites should be left in the same or better condition" (p. 310).
- General behavior of all participants "should reflect concern for others" (p. 310).
- Get medical information about participants and keep a copy of their emergency medical treatment form with you in the field.

- Familiarize students with disposal procedures for human waste.
- Request ideas to accommodate participants with disabilities. (They usually can describe strategies that enable them to participate in some parts of the field experience, if not all.)

Nancy Klepper (1990) provided additional tips for a successful field trip:

- State the objectives and expectations in measurable terms.
- Explain about collecting permits and laws about endangered species (p. 245).
- Identify poisonous or otherwise dangerous organisms and situations (p. 245).
- Illustrate the type of field notes that will be used and guide participants as they record data (p. 246).
- Accommodate allergies and food preferences or limitations.
- If a field lecture is necessary, make it short, interesting, and relevant (p. 247).
- Encourage photography (document, document, document).
- Use lab analysis of samples, a notebook, or report as a follow-up activity.

The following tips were generated in a course for teacher-interns at The Ohio State University (Landis). They supplement the set of considerations listed above.

- Provide field guides or other illustrations for visual comparisons.
- Indicate the range of acceptable measurements on data sheets.
- Trouble-shoot potential glitches in the process with the volunteers before beginning to sample.
- Routinely ask for feedback ("How's everyone doing?" "How can I help you?")
- Instruct in proper waste disposal and spill kit locations and use.
- Minimize human impact (trampling or other disturbances).
- Strongly discourage (do not allow) removal of "souvenir" items from the natural environment.
- Encourage participants to use their other talents (artistic, musical, poetic, etc.) to enrich the group's experience.
- Take waste bags along so you can "leave it cleaner than you found it."

Other practical considerations recalled from many years of outdoor teaching experiences (Landis):

- Clearly label all containers.
- Carry Material Safety Data Sheets for each substance (or save the information in a PDA).
- Have portable and reliable 2-way radios or cell-phone communication devices on hand.
- Check batteries before departing for the field.
- Establish a distress signal and a different signal to re-group.
- File an itinerary and/or travel plan with a departmental office or field manager.
- Ask participants to share any limitations they have (fear of heights, inability to swim, etc.) with any of the group leaders—and share that info among the leaders as appropriate.
- Encourage and monitor proper hydration, bring plenty of fresh water.
- Encourage use of sunscreen by providing it.
- Require a buddy-system for "out-of-line-of-sight" travel.
- Review first aid strategies and establish a "chain-of-command" after first response.
- Reduce use of disposable cups and other materials (label and wash cups and silverware).

- Monitor use of fuel resources.
- Rotate participants through chore-groups.
- Verify that participants know how to tie knots (to secure items and/or lift objects).
- Exchange cameras (or picture "doubles") for a different angle and/or a picture of yourself.
- Always have Plan B.

Other Useful Sources

As noted elsewhere in this Handbook, several organizations offer workshops and other instructional sessions for environmental/outdoor educators (G.L.O.B.E., NAAEE, Project WET, etc.) at which time their curricula are distributed to those who successfully complete the course. Those curricula usually present background information, teaching strategies, and lessons or units that include hands-on, minds-on activities for students of all ages. They are usually cross-referenced to the National Science Education Standards.

Journals

The following journals are rich sources of discipline specific tips about conducting science with inexperienced learners:

American Biology Teacher
The Journal of Marine Education
International Journal of Environmental Education and Information
Journal of Environmental Education
Journal of Geoscience Education,
Journal of Science College Teaching
Journal of Research in Science Teaching
Journal of Science Teacher Education

On-line References Supporting Environmental Studies

Acorn Naturalists is an organization that provides support to those who wish to teach in the context of environmental education. They make resources accessible on many levels for informal/nonformal educators, science and environmental educators, and parents. The resources include curricula, strategies, games, rationales, etc.
http://www.acorn-group.com/search.htm

Carol Adkins and Bora Simmons compare and contrast Outdoor Education, Environmental Education, and Experiential Education, placing them in a theoretical context.
http://www.ericdigests.org/2003-2/outdoor.html

David Haury states compelling arguments for conducting field studies, and links field work to the National Science Education Standards and the guidelines that relate directly to the study of ecosystems.
http://www.ericfacility.net/databases/ERIC_Digests/ed478712.html

Carol Landis identified publications on many aspects of field work, including use of urban environments, overcoming gender bias, subject integration, a variety of examples of experiences, and tips for success. This ERIC Digest lists source material for further consultation.

http://www.ericfacility.net/databases/ERIC_Digests/ed402154.html

Scott Willis presents a rationale for engaging in field studies with students (field trips K-12). He also includes a list of challenges and addresses concerns about group size, safety, etc.
http://www.ascd.org/publications/curr_update/1997winter/willis.html

Selected References

Beiersdorfer, R.E. and Davis, W. E. 1994. Suggestions for planning a class field trip. *Journal of College Science Teaching 23*(5): 307-311.

Klepper, N. H. 1990. How-to-do-it. Lifetime legacy: the successful field trip. *The American Biology Teacher, 52*(4): 245-248.

Wormstead, S. M Becker, and R. Congalton. 2002. Tools for successful student-teacher-scientist partnerships. *J. of Science Education and Technology, 11*(3): 277-287.

Chapter 5: Financial Support

Stephanie Bestelmeyer, Jornada Basin LTER

Almost all sites have discovered that the demand for LTER education opportunities rapidly outstrips available resources. While the $15,000 supplements can be leveraged effectively to provide a considerable amount of education and outreach, most sites find it necessary to obtain additional funding for their education initiatives. Table 1 shows some of the external financial support gathered by each site. This chapter will focus on tapping into these and other sources for additional funding for LTER education programs.

Federal Funding Opportunities

Numerous funding opportunities exist for LTER education programs through the federal government. You can do an exhaustive search of federal funding opportunities online through Grants.gov (www.grants.gov) or the Catalog of Federal Domestic Assistance (www.cfda.gov). Below are a few opportunities that may fit your LTER education program.

National Science Foundation (NSF) – http://www.nsf.gov

- Environmental Education Supplement Program (EdEn) – Co-funded by LTER, this supplement program provides grants up to $75,000 for education programs.
- Instructional Materials Development (IMD) – supports the development, dissemination, and implementation of instructional materials and assessments for science, technology, engineering, and math education.
- Informal Science Education – targets projects that take place outside the formal classroom environment and that focus on public audiences or professionals whose work directly affects science, technology, engineering, and math learning. A special component of this program is the "Communicating Research to Public Audiences" program that provides up to $75,000 to communicate to public audiences the process and results of current research that is being supported by any NSF directorate.
- Teacher Professional Continuum (TPC) – supports projects targeting recruitment, preparation, enhancement, and retention of science, technology, and math teachers at the K-12 level.
- Graduate Teaching Fellows in K-12 Education (GK12) – supports graduate students in science, engineering, and math to serve as resources in the K-12 classroom.
- Research Experiences for Undergraduates (REU) – funds undergraduate students to work in research programs at host institutions.
- Research Experiences for Teachers (RET) – a supplement to awards made in the Directorate of Biological Science. This program supports teachers in an effort to facilitate professional development of K-12 teachers through research experience at the cutting edge of science.
- Integrative Graduate Education and Research Traineeship Program (IGERT) – supports programs that work toward a change in graduate education, encouraging collaborative, interdisciplinary training and research.
- Undergraduate Mentoring in Environmental Biology (UMEB) – encourages undergraduates, especially those from under-represented groups, to pursue careers in environmental biology.

Environmental Protection Agency (EPA) – http://www.epa.gov

- Environmental Education Grants Program – supports programs that enhance the public's awareness, knowledge, and skills to make informed decisions that affect environmental quality. Grants of less than $25,000 are awarded by the 10 EPA regional offices; grants for more than $25,000 are awarded by the EPA headquarters.

Department of Education – http://www.ed.gov

- Minority Science and Engineering Improvement Program (MSEIP) – assists predominantly minority institutions in effecting long-range improvements in science and engineering education and increasing the flow of underrepresented ethnic minorities into science and engineering careers.
- Teacher Quality Enhancement Grants – consists of three separate programs: Partnership Grants for Improving Teacher Preparation, State Grants, and Teacher Recruitment Grants.

NASA – http://www.earth.nasa

- Check under "Research Opportunities"

State Government Funding Opportunities

Since each state is different, talk to your state legislators about LTER education programs and get their input on possible funding sources. There may be opportunities for funding and/or partnerships through the state department of education (if your state has one) or through general state appropriations.

School District Funding Opportunities

Talk to school board members and administrators at the school districts you serve. Focus especially on how your LTER education programs help teachers accomplish their existing responsibilities and meet state and national standards. Many sites have found great cooperation from school districts that see the LTER education program as a resource for teachers rather than an additional responsibility. A few potential opportunities for funding from school districts include:

- Title 1 funds (Improving the Academic Achievement of the Disadvantaged) – These funds are given to school districts by the US Department of Education based on census counts of children from low income families and other need categories. Funds are used to improve the quality of education in high poverty schools and/or give extra help to struggling students. Some of this money must be used to increase parent involvement and provide professional development for teachers.
- School districts often have large budgets for teacher professional development. Some LTER sites have worked with district administrators to provide funding for LTER teacher workshops through this source. It may be possible to pay teacher stipends and/or fund the entire workshop through the cooperating school district.
- Most districts offer money for field trips to each school. This enables schools to pay for the buses to bring students to LTER education programs. Some sites have also been able to cover the cost of field trip supplies by charging a small fee for each field trip; these funds generally come from field trip funds at the school.

Foundation Funding Opportunities

There are more than 70,000 private foundations in the United States. It is a good bet that at least a few of these foundations are interested in funding innovative science education programs in your area. The Foundation Center is an excellent place to start searching for foundations that may be interested in your programs (www.fdncenter.org). The Foundation Center publishes *The Foundation Directory*, which can be found in many public and university libraries as well as at Foundation Center libraries and cooperating collections (see a list of these on the Foundation Center web site). You can also purchase a subscription to the *Foundation Directory Online*.

Another online source of information about foundations is GrantSmart (www.grantsmart.org). On this site, you can search by city, foundation name, or other criteria to find registered foundations.

After you find a name of a foundation that has shown an interest in funding programs like yours, make sure you do your homework about the foundation. A great place to start is with the foundation's Form 990-PF (Return of Private Foundation) that is filed annually with the Internal Revenue Service. This form contains a wealth of information about the foundation, including its annual total contributions in gifts and grants, the people associated with the foundation, information on how to apply for grants, and a list of organizations supported during that year. You can find copies of Form 990-PF for most foundations on the following web sites: GrantSmart (www.grantsmart.org) or GuideStar (National Database of Nonprofit Organizations; www.guidestar.org).

Corporations

Of the $240 billion donated to nonprofits by the private sector in 2002, only about 5% came from corporations (84% came from individuals and 11% came from foundations). Nonetheless, don't forget about local businesses and corporations when finding funding or supplies for your education programs. LTER science education programs appeal to many corporations that focus their giving on projects that will increase public goodwill toward their company and/or will train the future high-tech workforce.

The National Directory of Corporate Giving (published by The Foundation Center) contains detailed information about corporate giving programs for approximately 2,800 corporations. You should also compile a list of corporations with headquarters or facilities in your area and check their web sites directly for funding programs. Many corporations have foundations specifically designed for giving grants. Other corporations have funding programs organized through their public relations departments.

Once you have information on the corporation's giving policies, call the corporate or local office and ask to give a presentation about your program. Don't forget to also ask for in-kind donations, supplies, volunteers, etc. These will be great contributions to your programs and may also lead to financial support in the future.

Individual Donations

Several LTER sites (including Jornada Basin and Konza) have partnered with a nonprofit organization for their education and outreach programs. This opens up considerable opportunities

for getting financial support through individual donations (which are tax deductible to the donor). Individuals can also contribute research equipment and supplies for your program. If your LTER site publishes a newsletter, ask to include a "wish list." You will likely be surprised by how many people are happy to donate the items you need.

Collaborations

Collaborations can be a fantastic source of support for your LTER education programs. LTER sites have collaborated with nonprofit organizations, science museums and centers, zoos, education departments at universities, MESA programs (Mathematics Engineering Science Achievement), the United States Department of Agriculture, the Bureau of Land Management, Fish and Wildlife Service, National Parks Service, and other federal and state agencies.

Learn as much as you can about other science programs in your area. Check with local school districts, the National Science Teachers Association (www.nsta.org), and the North American Association of Environmental Educators (www.naaee.org) for a good start. Be sure to think outside the box when coming up with potential collaborations; any group with an interest in science education is a possible partner.

Volunteers

Volunteers are the most important resources for many LTER education programs. Principal investigators and other researchers associated with each site are often more than happy to assist with providing background information for education programs and/or directly assisting students and teachers. There also may be retired teachers, scientists, and others in your community willing to share their time and expertise to assist with education programs.

Volunteer hours should be carefully documented; the value of this time can often be used as matching funds for grants. A common and widely accepted method to put a price tag on these donated hours is to use the Independent Sector's annual wage estimation for volunteer help (www.independentsector.org/programs/research/volunteer_time.html). The 2004 value is $17.16 per hour.

Writing Grant Proposals

There are many good books and resources that will give you guidelines on writing an excellent grant proposal to federal agencies, corporations, and foundations. This section is meant to be only a brief outline of some ideas to get started.

Most government agencies and some corporations and foundations have very specific application forms and guidelines. Follow these instructions! The following guidelines are for those corporations and foundations without specific instructions and/or those that ask only for a proposal or a letter explaining your program. For these proposals, the following general structure works well (adapted from The Grantsmanship Center's *Program Planning and Proposal Writing*; for more information on their training programs, check www.tgci.com). Omit the section headings in letters.

- Proposal Summary – This briefly introduces the group asking for support, the need for the project, the objectives and general methods of the project, and the total cost of the project, including how much is being asked for in this proposal. Keep the summary brief.

It is often easiest to write the summary last, even though it should appear at the beginning of the proposal.

- Introduction / Organization Information – This section introduces the group proposing the project and gives documentation on the credibility of the group. Explain who makes up the group, why and when the group was started, and the mission of the group. Include statistics on what you have already accomplished, quotes from participants, and/or other indications of why your group is uniquely prepared to take on this project.
- Needs Assessment / Opportunity Statement – This section focuses on why your program is necessary. For LTER education programs, this is an appropriate place to include information on the state of science education, the needs of students and teachers in your area, and any other problems/issues you are trying to change with your programs. Two good sources for some statistics for the needs assessment include the Annie E. Casey Foundation's *2004 Data Book Online* (www.aecf.org/kidscount/databook/) and Data on the Net (http://odwin.ucsd.edu/idata/).
- Objectives – These are the actual measurable outcomes of your program. Be specific! It is a good idea to include in each objective a statement of what you will accomplish, by when, and how will you measure it. For example, "At the end of the five-day workshop, at least 15 of the 18 participating teachers will demonstrate at least a 50% gain in their knowledge of ecological science concepts as measured through pre- and post-workshop tests."
- Methods – This section describes exactly how your program will work. Include who will run the program, the steps to be taken, and the sequence or timeline of events. Make sure your methods coincide and follow directly from your needs assessment and objectives.
- Evaluation – This section describes how you will measure the results of your program. It should follow directly from the objectives.
- Future Funding – If your program will continue after the grant period, this section describes how it will be funded.
- Budget – Be as specific as possible with each line item in your budget. In most instances, it is best to include the entire project budget and show which funds are being sought through this proposal and which are being provided by other sources. Be sure to include the $15,000 LTER supplements, volunteer hours, and donated supplies or in-kind services.

Conclusions

There are many ways to fund an expansion of your LTER education programs beyond what is possible with the $15,000 supplements alone. Be creative, be persistent, and always keep the many beneficiaries (students, teachers, etc.) of your programs at the forefront of your mind during your hard work to raise funds. Best of luck!

Chapter 6: Program Survey and Assessment

Beth Simmons, Palmer Station LTER and California Current Ecosystem LTER

Introduction

In this chapter is a brief discussion of the results of a 2004 Education Survey. The survey was designed to gather information and opinions from each Schoolyard LTER (SLTER) site regarding their past and present involvement in the SLTER Education and Outreach program. The responses gathered from this online survey revealed that although connected via a homogeneous set of five core LTER research areas, each site's efforts vary in their ability to generate, exchange, apply, and preserve knowledge and scholarship. While the dedication to the nature of outreach scholarship by the SLTER education coordinators commonly cuts across teaching, research, and community service lines, the types of infrastructure the SLTER 15K supplement stabilizes vary across the sites. This structure encourages the identification of opportunities for scholarly outreach and the development of long-term elements that contribute to curriculum development and program enhancement, which add reciprocal value to outreach. Whether maintaining an already existing schoolyard program or experiencing the excitement of seeding a new SLTER program, the survey results may offer you suggestions but may also inspire others concerning the future of the Schoolyard LTER Education and Outreach.

The Schoolyard LTER 2004 Education Survey

In this decade of synthesis, the survey was conducted in order to assess the nature of outreach at each SLTER site. While no single instrument can adequately gauge the success of a program, the 2004 Education Survey aimed to take a snapshot of the existing SLTER federation of individual site programs. The survey assessment avoids presenting an inventory of all that each site accomplishes over time. Instead, it intended to delineate the current functions and structure of SLTER Education Outreach by providing a frame of reference that permits interpretation and allows a maturing definition of service and outreach to emerge from our discussions.

The survey is included in the Appendix and results are posted online at the network website http://www.lternet.edu/. Respondents to the survey represent 79% of the education coordinators from the twenty-four LTER sites. The structure of the survey was designed with a mix of questions such as quantitative, frequency counts, and fill-ins as well as simple multiple-choice questions. Furthermore, the results of the SLTER survey were reviewed much in the same way they were organized--with one general program category of SLTER, including general contact information, and four site categories. These categories were: site involvement in SLTER, collaboration (broader impacts), education efforts, and assessment methods used for site program and outreach. We will look in more detail at the results for each of these four categories.

Site Involvement in SLTER: One of the first questions of the survey asked each participant what title they used to describe their role. Titles varied including: education coordinator (6) SLTER coordinator (3), education and outreach coordinator (2), liaison (3), director/manager (3), environmental educator (1) education community chair (1), education representative (1), unsure (2). While some 38% of sites have five other paid personnel directly involved, an additional 81% of the responses indicated reliance upon more than four other personnel to effectively coordinate and implement their LTER site program.

Collaboration and Broader Impacts: While outreach involves diverse areas which transcend and inform the mission of the LTER, what is presently being accomplished seems to be a function of the physical and intellectual resources at each site within the constraints imposed by existing infrastructures.

- 81% of the SLTER community collaborations rely upon university connections and links with K-12 schools.
- 74% of the K-12 education outreach encompasses teacher workshops, teacher training, and other classroom collaborations.
- More than 50% have associations with Environmental Organizations and Federal/State agency personnel.
- About 50% of the respondents indicated they were involved in developing cross-site collaborations through proposals for materials development, the Agrarian Landscapes in Transition (Ag-Trans) project, and this handbook.

Education Efforts: The LTER Program includes a wide variety of educational aspects including undergraduate and graduate education, informal education (such as museums and environmental groups) as well as K-12 education. This survey provided a backdrop, so to speak, for examining outreach productivity.

- 62% of the survey participants reported that the 15K LTER supplement funds fewer than 50 teachers at their site, so they sought additional funding to support about the same number of teachers.
- 52% of respondents work less than 40% time with elementary level students; but allocate time rather evenly between middle and high school level students.
- More than 50% of participants indicated they work less than 40% time with informal education facilities (libraries, museums) as well as on professional development (Note: the manner in which the question was worded made it difficult to determine if the professional development was for the teachers or for the education coordinators).
- 52% responding to the survey indicated that between 1 and 10 graduate- and undergraduate-level students are involved with their SLTER programs equaling less than 40%.

To broaden the impact of their education efforts, many sites utilize the web to disseminate educational materials and concepts. However, it seems that this directly depends on site affiliations, teaching, research area(s), instructional technologies and depth of outreach scholarship. Within SLTER:

- 71% of the Education Coordinators predominantly use their SLTER website and teacher workshops to disseminate educational materials and enhance teachers' professional development.
- 43% indicated that their websites include lessons, some of which embed the site data into inquiry lessons; while the remaining 57% provide data sets ready to use.
- 62% include site background on their websites.
- 52% include other resource links, including schoolyard protocols, pictures, check lists of ecosystem plant/animals, maps, and additional scientific/educational resources.

SLTER Assessment: When asked what types of assessment strategies each site uses as developmental markers for their SLTER program, 47% indicated they use teacher pre/post workshop attitude surveys to receive feedback. It is difficult to gauge from our survey whether those workshop surveys provide feedback for each site's overall program, SLTER outreach, or

information on the inquiry lessons provided within the workshop itself. Some sites indicated that interviewing teachers, other workshop participants, and students was also a part of their current form of assessment.

The entire survey is posted on the network LTER site. Despite its limitations the survey does answer some of the more basic questions regarding outreach and educational scholarship and pulls together some subtle concepts that prove to be promising avenues of thought for further discussion, such as: "What is the function of the Schoolyard LTER Supplement?" and "What is the potential role of assessment and outreach scholarship?"

That 15K Supplement – Springboard or Safety Net!

During the last five years this unconditional support from LTER has served as a seed fund which provides for the latitude to innovate, build, or refresh education programs by recognizing the diversity of local infrastructures. This 15K supplement matches the intermittent resource availability and leverages the particulars of existing site infrastructures and alliances. The strength of the funding may very well reside in the combination of continuity and small size by promoting not only maintenance of the traditional efforts of education and outreach but also increased levels of collaboration and synthesis. The small size fosters 'bottom-up' ingenuity to synergize within an existing infrastructure knowing that large new programs cannot be built with such limited funds. Depending on the existing ties at each site, some education coordinators may strive to identify existing educational efforts and interests, explore local opportunities or invest in small site-sponsored events. On the other hand, education coordinators at sites with existing education ties may augment their education programs by introducing long-term research perspectives or facilitate local education-research bridges. Either way, the supplement provides a stabilization (safety net) or the resilience (springboard) to seek additional funding sources and/or foster innovation within the existing organizational structure. This expanded view of scholarly outreach has been a hallmark of the LTER network. It encourages education coordinators to identify opportunities for scholarly outreach and develop long-term measurements that contribute to curriculum development while adding reciprocal value to outreach.

Hand in Hand – Assessment and Scholarship on Outreach

As education outreach professionals strive to be effective and productive, they will consider the definition of outreach, how to improve their programs through assessment, and what other education researchers have discovered as they asked these same questions. A definition of outreach cannot simply be prescribed but will, gradually, emerge through the interaction of multiple components of an educational system over time (Rahm et al. , 2003). The SLTER survey provides valuable guideposts from which you may seek direction as you continually assess and develop your SLTER program. Because of the dynamic manner in which the SLTER components at each site interact, features of outreach scholarship have emerged and may give us a context for emphasizing the interactions between education coordinators, scientists, educators and the learning environments we create.

SLTER outreach is grounded in ecological science and is defined through collaborations and ongoing negotiations among its participants. While constructing a definition for successful outreach may vary from site to site within the Schoolyard LTER program, we are at the forefront of articulating a new paradigm for scholarship and outreach. This relationship is one in which

basic research bridges to a larger context of learning, initiating interdisciplinary conversations that recognize the communal nature of scholarship and the application of knowledge (Boyer, 1990).

Putting this new paradigm into action not only depends on the quality of the tasks and projects that are undertaken by the education coordinator(s), research scientists and associated community at the sites, but also on the quality of feedback obtained from assessing the work. By developing specific standards, developing a working definition of outreach and adhering to guidelines for education and outreach, we can monitor and evaluate our work as education coordinators, measure our efforts, and improve our function. Assessments can help to marshal the energy and resources needed to honor the vision of education and outreach for the LTER network.

How Does Outreach Scholarship Discuss Assessment?

Assessment, as data-gathering strategies, analyses, and reporting processes, can provide information to be used in determining whether or not intended outcomes are being achieved. Such assessments provide an opportunity to gather information that will facilitate program planning. Formative assessment, providing feedback during learning, is distinct from the concept of evaluation which provides a summative ranking of performance of what has taken place. (See Resources listed below.). A broad view of what assessments should include, whether at the classroom level or in the context of large-scale programs like the Schoolyard LTER, is outlined clearly by the George Lucas Educational Foundation interview of Grant Wiggins, author of Educative Assessment. (www.glef.org). Generally, he suggests, assessments should:

- Provide diagnostic feedback.
- Help educators set standards.
- Evaluate progress.
- Relate to a student's/program's progress
- Motivate performance (for students, teachers and others)

Information garnered from assessment can support decisions on maintaining, changing, or discarding instructional or programmatic practices. These strategies can inform:

- The nature and extent of learning,
- Facilitate curricular decision making,
- Correspondence between learning and the aims and objectives of teaching, and
- The relationship between learning and the environments in which learning takes place (Foundation Coalition, 2001).

The rationale behind assessment is primarily to educate and improve performance, not merely to audit it (Wiggins, 1998). Typically the design of assessments encompasses three broad purposes: assist learning, measure achievement, and evaluate programs (National Research Council, 2001). Most researchers agrees that success in education and outreach relies on the alignment of the curriculum, instruction and assessment (Ruiz-Primo & Furtak, 2004). By developing a routine mechanism for documenting and assessing outreach, feedback will be available on an education program, and may provide a valuable opportunity for change and improvement in instruction and program design.

Applying Assessment to Schoolyard LTER

The nature of outreach continually changes. However, core concepts emerge from current research clearly applicable to education efforts within SLTER. Successful outreach has the following general characteristics:
(Schmitz, 1999)

- Emphasis on rooting the work in a disciplinary base.
- Self-reflection and critique on the part of the faculty/staff member conducting outreach.
- A concept of outreach as a two-way flow of information and benefits, i.e., knowledge comes from the "outside in" as well as goes from the "inside out."
- Maintaining some standards of quality in their work (see Table 1).

These commonly re-occurring characteristics collectively lay the groundwork for beginning assessment and reviewing the challenges involved in promoting excellence in outreach. The work of excellent outreach is typically guided and assessed by qualitative standards (Glassick et al., 1997). These standards of quality have been adapted for use within SLTER and are included for your reference in Table 1.

Table 1: Standards of Quality: **(adapted from Glassick et. al. 1997)**

1. **Clear goals**—Are the purposes of SLTER outreach clearly stated for your site? Are objectives realistic and achievable? Does the outreach identify and teach about important questions in your field of research ?
2. **Adequate preparation**—Does the outreach show an understanding of existing scholarship in the specific field of ecological research? Does the outreach representative bring the necessary skills to his or her work? Does the outreach bring together the resources necessary to move the projects and /or research forward?
3. **Appropriate methods**—Are the methods and goals aligned? How effectively are the methods for outreach selected? Are the methods for outreach modified in response to changing circumstances and synthesis?
4. **Significant results**—Are your goals achieved through your outreach efforts? Does your outreach effort add consequentially to the field of LTER research? Could your outreach work open additional areas for further exploration?
5. **Effective presentation**—Does your program use a suitable style and effective organization to present your education and outreach efforts? Do you use appropriate forums for communicating work to its intended audiences? Do you present your site's message with clarity and integrity?
6. **Reflective critique**—Does your SLTER program critically assess work? Do you bring an appropriate breadth of evidence to the critique of your outreach program? How do you use assessment to improve or evaluate the quality of future work?

While assessment can be defined as a data-gathering strategy, analyses, and reporting processes, it provides information to be used in determining whether or not intended outcomes are being achieved. Assessments provide an opportunity to gather information that allow us to modify our actions.

Summary

The 2004 Education Survey presented an opportunity to compile a portrait of SLTER outreach in 2004 and, as a result, give ourselves a chance to understand our own diversity of infrastructure and program elements, as well as to take inspiration from each other's accomplishments and

innovations. Analyzing the responses to the survey leads us to consider the assessment, effectiveness, and impact of what we do as Education Coordinators. As new sites are added to LTER and established education programs grow in new ways, the SLTER education efforts will unfold with diverse elements and in a manner consistent with local infrastructures.

Acknowledgements: Recognition is given to the Schoolyard/LTER community in general and to the specific contributions of Karen Baker (Information Manager, Palmer Station and California Current Ecosystem LTER), Dawn Rawls (Science Editor, Palmer Station LTER), Stephanie Bestlemeyer (Coordinator, Jornada Basin LTER), Monica Elsner (Education Liaison, Central Arizona LTER), Elena Sparrow (SLTER Coordinator, Bonanza Creek LTER), in addition to Marshall White (LTER Network Office) for web delivery and support with the SLTER 2004 Education Survey.

References:

Boyer, E. L. 1990. *Scholarship Reconsidered: Priorities for the Professoriate*. San Francisco: Jossey-Bass Publishers. (not used but leader in this stuff)

Glassick, C.E., Huber, M.T., and Maeroff, G.I. 1997. *Scholarship Assessed: Evaluation of the Professoriate*. The Carnegie Foundation of Teaching and Learning; San Francisco, CA: Jossey-Bass Publishers. ISBN: 0787910910

National Research Council, 2001. *Knowing What Students Know: The Science and Design of Educational Assessment,* Washington D.C., National Academy Press. 382 pgs. ISBN. 0309072727 http://www.nap.edu/books/0309072727/html/

Ruiz-Primo, M.A., and Furtak, E.M. 2004. *Informal Formative Assessment of Student's Understanding of Scientific Inquiry* (CSE Report 639) Center for the Study of Evaluation (CSE), Los Angeles, CA. 39pgs.

Rahm, J., Miller, H.C., Hartley, L., and Moore, J.C. 2003. The value of emergent notion of authenticity: Examples from two student/teacher-scientist partnership programs. *Journal of Research in Science Teaching* 41(9): 905-935.

Schmitz, Dr. Connie C. (1999) *Methods of Assessing the Quality of Public Service and outreach in Institutions of Higher Education* http://www.wkkf.org/pubs/YouthED/Pub577.pdf

Wiggins, Grant (1998) *Educative Assessment: Designing Assessments to Inform and Improve Student Performance*, San Francisco, CA. Jossey-Bass.

Resources for Assessment/Evaluation:

1. http://www.flaguide.org/index.php The FLAG offers broadly applicable, self-contained modular classroom assessment techniques (CATs) and discipline-specific tools for instructors interested in new approaches to evaluating student learning, attitudes and performance.
2. http://nces.ed.gov/nationsreportcard/science/ The Nation's Report card on assessment in science
3. http://www.glef.org/php/keyword.php?id=005 Edutopia: The World of Learning (Assessment)
4. W.K. Kellogg Evaluation Handbook/Toolkit http://www.wkkf.org/Pubs/Tools/Evaluation/Pub770.pdf An example of an evaluation approach to determine the worth of a program and to guide program implementation and management, as well relevant and useful to program practitioners.
5. http://schoe.coe.uga.edu/index.html The Clearinghouse and National Review Board for the Scholarship of Engagement has established criteria for assessing and evaluating the scholarship of engagement.
6. 6 .http://www.foundationcoalition.org/homekeycomponents/assessment_evaluation.html
7. Moorcroft, T.A., Desmarais, K.H., Hogan, K. and Berkowitz, A.R. (2000) Authentic assessment in the informal setting: how it can work for you. Journal of Environmental Education 31(3): 20 – 24.

Appendix 1: LTER Site Schoolyard Education Program Guidelines

Contributed and Reviewed by SLTER Education Representatives Fall'04/Winter'05
Approved by LTER Coordinating Committee April 6, 2005

Introduction

The mission of LTER Education programs is to use the uniqueness of the LTER Network to promote learning about long-term ecological processes and the earth's ecosystems. Beginning in 1998, the LTER network formally expanded its education efforts to include K-12 students and teachers—mainly through the Schoolyard (SLTER) program funded by the Division of Environmental Biology at the NSF. They provided supplements upon request to LTER sites to specifically design their own program in relation to the ecological research conducted at the site and the particular needs and resources of the local school district and community.

This document, developed by the LTER education representatives, is intended to serve as a reference for LTER sites to use for informal self-assessment and planning. These guidelines are for SLTER only, although most, if not all sites are also involved in additional education activities, including but not limited to, education for the general public, undergraduates, etc. Because of the nature of the funding, each site is not expected to achieve all program features in one year, but over several years. Keep in mind that each SLTER program is unique and reflects the strengths and interests of that particular site.

Administration

- Site has a designated education representative/coordinator to serve as a liaison between the site research program participants and the broader community.

- Education representative maintains ongoing dialogue with the PIs, co-PIs, information managers, graduate students, and others working at the site as well as an understanding of the site and LTER Network infrastructures.

- Education representative keeps all site personnel informed about the site's education program and coordinated Network activities.

- Site scientists and other site participants show a commitment to the education program. This might include one or more of the following: assisting with program planning and/or curriculum development, participating in teacher workshops and field trips, securing additional funding, encouraging the participation of LTER-funded graduate students, post-doctoral associates and technicians in education activities.

Program Features

- Programs directly relate to and articulate science being conducted at the LTER site, or complement the LTER science furthering LTER goals.

- Programs stem from a site SLTER plan with goals as well as assessment and evaluation strategies. These assessments might range from teacher surveys to advisory committees.

- Programs foster teacher and/or student awareness of the full process of science, including hypotheses development, data collection, data analysis and forming conclusions based on data. When possible, teachers and/or students take part in the entire scientific process.

- Programs illustrate the value of long-term and ecological research.

- Programs relate to teachers' needs (e.g., programs correlate with national, state, and/or local education standards, further developing ecological/environmental science content and science process knowledge).

- Site education materials, including web pages are developed and maintained with useful information available for teachers, students, administrators, and site participants interested in the program.

Community

- Diversity of participating teachers and/or students accurately reflects the general population diversity of the region being served. Efforts are made to involve underrepresented students and/or teachers serving underrepresented students.

- Programs serve an appropriate number of schools, students, and teachers given their location and budget.

- Site education representatives are aware of the diverse groups in their community (e.g., universities, nonprofit organizations, government agencies, other NSF-funded education programs, school districts) and take advantage of collaborations when possible.

Network-Level Collaboration

- Education representative participates in the LTER Education Committee, including representing the site at Annual and All Scientist Meetings, responding to LTER Education Committee inquiries, and, when possible, contributing to the design of network-level activities.

- Education representative communicates information about site programs to the LTER Network through electronic messages, listserv responses, web posts and/or newsletter submissions.

- Development of or participation in cross-site activities is undertaken as a synergistic opportunity when possible

Appendix 2: Teacher Recruitment

Susan Dailey, Florida Coastal Everglades LTER

These are some of the ways that teachers have been attracted to participate in workshops and educational activities from LTER sites.

- **Communication with school administrators, superintendents, principals and curriculum coordinators is essential in the recruitment of teachers.**
  Principals or assistant principals must be contacted prior to entry to any school. This is an excellent way to advertise to target schools from the district that are interested in receiving your LTER educational programs.

- **Word of mouth: teachers already involved will recruit other teachers**
  Your best "seller" for the participants of workshops is through advertisement from individuals who have already participated in one of your programs. One way to encourage teachers to share their experiences is to suggest a sharing activity with other teachers in their department for their teacher work day. You may want to post teacher evaluation and feedback on your web site to encourage the participation of other teachers.

- **Pay for substitute for a day so teacher can come to workshop.**
  This can be done through your education program and may be welcomed especially in some of the low funding school districts. You may want to schedule workshops and teachers training activities for teacher workdays. The teacher will not need a substitute but still receives pay for their workday. Teachers will need to gain permission from their principal to attend your teacher workshop.

- **Offer university credits or continuing education credits for workshops.**
  Another attractant for some teacher recruits is to provide curriculum that might be part of the action plan for their school district or department. Young teachers without any biology or research background may find this particularly helpful as classes for ecology education are probably difficult to find in your area.

- **Send recruitment fliers to science coordinators throughout the districts.**
  There are often web pages to use for your school district to find out what useful sources of information, activities and programs may be available in your district. Contact the webmaster at your district approved biology or environmental education site to determine whether your site can be added as an information link. You may also want to attend meetings with local educators and at least contact the other coordinators of research programs in your region. Once these connections are established, it may become useful to construct a web list where information can be disseminated in a timely fashion.

- **Provide monetary incentives for teacher participation.**
  One way to attract teachers is to provide traditional compensation for their time and effort in the form of a stipend for a workday. Other incentives that have proven successful and especially useful in the classroom might include a classroom set of books on the curriculum that you have covered. There may be books available that your researchers may want to suggest or that they have participated in as an contributing author. These

classroom book sets are then available for students to use for the entire career of that teacher.

- **Attendance at "Science Coordinator" meetings.**
  This is a good way to share your programs with regional educators and the people who are devising the standards to ecology curriculum in your district. Networking with these individuals is an excellent way to spread the word about your programs and teacher training activities. Teachers are more likely to welcome you and your LTER site education programs when they have met you in person. You also have a chance to interact with other coordinators to develop partnerships and lead proposal writing.

- **Recruit in rural areas where science scores are low, funding is low and resources are limited.**
  These teachers may be the most likely to respond to any extracurricular material that may be available to their locality. Often the teachers from poorly funded regions of your district are looking for any way to help them address standards in the classroom and schoolyard.

- **Direct contact with teachers already involved to help establish networks with their colleagues.**
  The teachers whom have already participated in your programs in some capacity are often the ones who you will continue to contact with about new programs and curriculum that you have developed.

- **Determine the network that is use in the district or school with whom you are interacting.**
  You may want to add an announcement to the after school announcements at your regional schools. Other successful means of networking might be through advertisement in the community education section of your local paper. These sections usually do not charge for an educational advertisement.

- **Invite and/or offer workshops for school administrators.**
  The teachers are the ones attending your ecological workshops and activities and you may have very little interaction with the school administrators. One way to engage your local administrators might be to invite those individuals to workshops to observe and participate in training activities.

- **Advertise how workshop contributes to the fulfillment of testing and state standards requirements.**
  You may want to advertise through your both your research websites and education websites to increase your audience loads. It may also be important for you to include key words that will increase the likelihood of web browser hits for your topic of study.

- **Attend meetings of teacher organizations (e.g. NSTA).**

Appendix 3: Scientists' Involvement in LTER Education

Susan Dailey, Florida Coastal Everglades LTER

Consultation for education programs
Ask for feedback from researchers in your organization before your release web materials or curriculum materials. You may want to target excerpts of advice from the experts for each program that you develop. Try not to rely too heavily on the consultation of any one researcher and take advantage of the many information resources within your program.

Content support
Stay current with research developments for each of your workgroups and be sure to include the information in any curriculum that is being developed. As education representative for your site, you may want to attend workgroup meetings, workshops, and graduate student meetings (or hold your own) to encourage free flow of information from all investigators.

Classroom visits
Recruit researchers from all levels of your LTER site to visit a classroom with you to give part or all of a presentation. If there are any researchers who have children in your organization, you may want to ask them to give a presentation with you at their child's science classroom.

Teachers workshops
Invite researchers at your LTER site to make a presentation with a piece of sampling equipment, or to share a story from their field or research experience with students or teachers.

Fieldtrips and tours of research facilities
Plan student trips that also encompass a tour of the research facilities and staff. Ask your researchers for feedback and evaluation of the activities that you plan to do with the students. You may want to recruit an expert to demonstrate the use of the equipment or to share some of their findings with the teacher or students. Do measurements with actual field equipment and ask the researchers which parameters might be best for students to measure in their schoolyard plots.

Assisting with experimental setups
You may want to attend the class or laboratory exercises or training that is available from each of the working groups at your LTER site. To adapt material and sampling activities, you may want to draw on the expertise of your scientists and their research network.

Presentations
When the classroom or teacher is focusing effort on a topic that relates directly to current research in your organization, recruit those researchers to make a visit to the classroom. You may also want to see if there is any information that researchers at your site might want to add to an activity or presentation.

Providing staff time
Take advantage of the resources within your research group. You may want to coordinate educational sampling trips around research field trips so that students may also observe the

researchers at the LTER site. Sit down with your site manager and see what resources are available to you through your site and facility.

Student recruitment
Learn the interests of your graduate students and in particular those graduate students that are planning on having a teaching career. Remind those individuals to keep a portfolio of the teaching activities, or teacher leadership activities in which they have become involved.

Interactive video conferencing
This may be an attractive alternative to taking the researcher out of their natural environment. It takes less time investment from the researcher and the audience gets to see the researchers' study habitat or workplace.

Mentoring
There are many programs that involve the training or mentoring (RET) of teachers, undergraduate students (UMEB and REU). These programs can be developed formally or informally in the laboratory or assisting in the field. These experiences require one on one training between the researcher and pupil.

Role models
Ask your researchers to make an appearance for career days at your participating schools. This may be particularly easy to facilitate with parents who are also researchers at your LTER site. Visits to the classroom by any of your researchers encourages the participation of the students and may be formative in their career choices.

Teaching science activities
Get involved with each of the working groups from your LTER site. Be aware of upcoming workshops of any laboratory training exercises or field exercises that they may be conducting. Ask the working groups if you can include some of your advanced teachers or students in the workshop or training activity.

Advisory committees
Establish a list of individuals within your LTER group that are able to interact with you and provide feedback to your programs. You may want to schedule regular (annual or semi-annual) meetings with your Lead Principal Investigator or Principal Investigators for assessment and feedback on your education program.

Data interpretation
You may want to meet with the working groups within your research group to determine the best way to analyze data that you may want to collect from your schoolyard sites. Be sure to meet with your researchers before you collect your data because it may guide your sampling design for field activities.

Provide research experience for teachers
Ask all levels of the organization to participate in the teacher training exercises you are providing. Scientists in your organization may be willing to review, comment and provide

references for curriculum development for educational activities and workshops for teachers. Be aware of the expertise and research that each of your scientists is conducting. You may want to invite the researchers to demonstrate the equipment use or background material for a teacher training workshop.

Corresponding with teachers via email

Regular emails to the teachers who participate in your research program are important to maintain contact. You may want to develop a list serve for your email to keep all of your teachers aware of upcoming events, opportunities and updates to your web pages.

Appendix 4: Tips for Conducting Field Work

Carol Landis, McMurdo Dry Valleys LTER

✓	**Planning Phase:**
	Define the basics (who, what, where, when, why, and how)
	Assemble background information (preceding effort, legal issues, field guides, publications, etc.)
	Define roles and responsibilities
	Recruit team members to address roles
	Run pre-trip exploration of site and determine needs: permits, special equipment, backups, etc.
	Brainstorm, describe, and control safety issues
	Determine appropriate protocols and necessary equipment and supplies
	Construct preliminary budget
	Develop lists for specific equipment and supplies (by provider, with Item numbers, costs, etc.)
	Develop rough schedule and identify deadlines
	Provide for adequate documentation (pictures, video, audio, datasets, etc.)
	Weeks/Months Prior to Launch:
	Develop schedule and responsibilities for components of it
	Order supplies (including first aid and repair kits) and refine lists
	Obtain and demo spill kits, safety precautions, and procedures for hazardous situations
	Obtain permits and communicate with political entities in charge of field site/s
	File itinerary with department or field office
	Identify and address potential hazards; include training/responsibility for each
	Develop field notebook as you train participants
	State objectives and expectations in measurable terms
	Save MSDS info into palm-pilot/PDA (or take copies of sheets)
	Illustrate field notes and data records (show acceptable range of values as examples)
	Select field guides and other reference materials as resources
	Outline conditions, operation, and rules of field site/camp
	Obtain personal information from participants (medical info., parental permissions, preferences, interests, and abilities)
	Arrange for 2-way communication, as needed
	Establish documentation plans: photography, video, audio, data backups, etc.
	Use a suggestion box
	Pre-Launch:
	Confirm and update Emergency Medical and Contact Info for entire field team
	Double-check itinerary details and provide procedure/s for a cancellation or interruption of it
	Discuss equipment use: potential difficulties, manipulation issues, storage, etc.
	Inventory all equipment and supplies (prepare shipping/packing invoices)
	Clearly label all containers (store with those needed at the same time)
	Reduce reliance on disposables (unless water supply is an issue)
	Check batteries; have extras
	Obtain and check waste management supplies
	Double-check food, fuel resource, first aid, and water needs
	Use a suggestion box
	In the field:
	Establish and maintain contact with field office and support organizations/groups
	Demonstrate waste management procedures

	Demonstrate and verify strategies for securing materials and supplies (tying knots, use of locks, switches, valves)
	Confirm data storage, backups, and transmission
	Rotate participants through chores and safety procedures so everyone is familiar with them
	Have clipboards for illustration during field-based discussions (use rubber bands to secure loose ends of paper in the wind)
	Reinforce safety and wellbeing: sunscreen, hydration, travel on foot or in vehicles etc.
	Stress importance of minor first aid treatments
	Establish distress and re-group signals
	Minimize human impact; discourage souvenirs
	Ask participants early and often about unforeseen concerns
	Request feedback often ("How are you doing? How can I help?")
	Use a suggestion box
	Closure:
	Confirm data storage, backups, and transmission
	Clean the facility and power-down for off-season
	Inventory materials and supplies while packing for storage and/or shipment
	Report to field office or department
	Summarize data collection effort and involvement of participants (initial draft)
	Organize and categorize pictures
	Thank colleagues and participants
	Brainstorm potential funding sources for the future
	Reinforce networking tips
	Jot notes now about possible changes
	Post-trip:
	Follow up with participants a few days after return
	Be available for questions
	Know your audience—address specifics of their request for a presentation
	Present lab analysis, summarize findings and observations
	Exchange pictures and share and document reflections about the experience
	Work with teacher/group organizer for any presentations to their group
	Select props and/or develop visuals that are informative and appropriate for the audience
	Ask under-represented students to assist with demonstrations and props
	Arrange for publicity and communicate with news agencies/writers; request ability to proofread the article/report before publication

Appendix 5: Using LTER Data and Databases

Monica Elser, CAP LTER

The LTER network encourages the re-use of scientific data and has put a great deal of effort into making more LTER data sets available to a variety of users. Developing lessons from these data sets is encouraged. These three lessons are all based on data from LTER sites.and can be found at http://tiee.ecoed.net/vol/v3/toc.html. :

Changes in Lake Ice: Ecosystem Response to Global Change
Robert E. Bohanan (University of Wisconsin – Madison), Marianne Krasny (Cornell University), and Adam Welman (Cornell University)

Comparing the Influence of Precipitation, Fire, and Topography on Plant Productivity in the Tallgrass Prairie
Jesse Nippert (Colorado State University) and John Blair (Kansas State University)

Long-term Response of an Arctic River Community to Phosphorus Fertilization
Linda Deegan (The Ecosystems Center)

At CAP LTER, the k-12 education team has worked with the data managers to create data entry, retrieval and analysis features on their website (http://caplter.asu.edu/explorers , link to the data center). These features encourage teachers and their students to contribute their data to the CAP LTER database and also lets them compare their data with those of other students.

Another source of lessons using data sets from a variety of resources can be found at The Digital Library for Earth System Education (DLESE). DLESE is a distributed community effort involving educators, students, and scientists working together to improve the quality, quantity, and efficiency of teaching and learning about the Earth system at all levels (http://www.dlese.org/dds/index.jsp) SLTER education representatives including Ali Whitmer and Beth Simmons have contributed to this site.

Data Use Agreements:

The LTER Data Managers have developed this set of recommendations for using LTER data.

Conditions of Use
The re-use of scientific data has the potential to greatly increase communication, collaboration and synthesis within and among disciplines, and thus is fostered, supported and encouraged.
Permission to use this dataset is granted to the Data User free of charge subject to the following terms:

1) *Acceptable use*. Use of the dataset will be restricted to academic, research, educational, government, recreational, or other not-for-profit professional purposes. The Data User is permitted to produce and distribute derived works from this dataset provided that they are released under the same license terms as those accompanying this Data Set. Any other uses for the Data Set or its derived products will require explicit permission from the dataset owner.

2) *Redistribution*. The data are provided for use by the Data User. The metadata and this license must accompany all copies made and be available to all users of this Data Set. The Data User will not redistribute the original Data Set beyond this collaboration sphere

.

3) Citation. It is considered a matter of professional ethics to acknowledge the work of other scientists. Thus, the Data User will properly cite the Data Set in any publications or in the metadata of any derived data products that were produced using the Data Set. Citation should take the following general form: *Creator, Year of Data Publication, Title of Dataset, Publisher, Dataset identifier. For example:*

> McKee, W. 2001. Vascular plant list on the Andrews Experimental Forest and nearby Research Natural Areas: Long-Term Ecological Research. Corvallis, OR: Forest Science Data Bank: SA002. [Database]. http://www.fsl.orst.edu/lter/data/abstract.cfm?dbcode=SA002. (21 October 2004)

4) *Acknowledgement*. The Data User should acknowledge any institutional support or specific funding awards referenced in the metadata accompanying this dataset in any publications where the Data Set contributed significantly to its content. Acknowledgements should identify the supporting party, the party that received the support, and any identifying information such as grant numbers. For example:

> Data sets were provided by the Forest Science Data Bank, a partnership between the Department of Forest Science, Oregon State University, and the U.S. Forest Service Pacific Northwest Research Station, Corvallis, Oregon. Significant funding for collection of these data was provided by the National Science Foundation Long-Term Ecological Research program (NSF Grant numbers BSR-90-11663 and DEB-96-32921).

5) *Notification.* The Data User will notify the Data Set Contact when any derivative work or publication based on or derived from the Data Set is distributed. The Data User will provide the data contact with two reprints of any publications resulting from use of the Data Set and will provide copies, or on-line access to, any derived digital products. Notification will include an explanation of how the Data Set was used to produce the derived work.

6) *Collaboration.* The Data Set has been released in the spirit of open scientific collaboration. Data Users are thus strongly encouraged to consider consultation, collaboration and/or co-authorship with the Data Set Creator.

By accepting this Data Set, the Data User agrees to abide by the terms of this agreement. The Data Owner shall have the right to terminate this agreement immediately by written notice upon the Data User's breach of, or non-compliance with, any of its terms. The Data User may be held responsible for any misuse that is caused or encouraged by the Data User's failure to abide by the terms of this agreement.

Definitions

"Data Set" – Digital data and its metadata derived from any research activity such as field observations, collections, laboratory analysis, experiments, or the post-processing of existing data and identified by a unique identifier issued by a recognized cataloging authority such as a site, university, agency, or other organization.

"Data User" - individual to whom access has been granted to this Data Set, including his or her immediate collaboration sphere, defined here as the institutions, partners, students and staff with whom the Data User collaborates, and with whom access must be granted, in order to fulfill the Data User's intended use of the Data Set

"Data Set Creator" - individual or institution that produced the Data Set

"Data Set Owner" – individual or institution that holds intellectual property rights to the dataset. Note that this may or may not be defined as a legal copyright. If no other party is

designated in the metadata as Data Set Owner, it may be presumed that these rights are held by the Data Set Creator.

“Data Set Distributor” - individual or institution providing access to the Data Sets.

“Data Set Contact” - party designated in the accompanying metadata of the Data Set as the primary contact for the Data Set.

OTHER LTER-Related WEB REFERENCES

Searchable Network Databases: http://www.lternet.edu/

Personnel Directory
All-Site Bibliography
Links to all individual LTER sites

Network Intersite Products and Modules: http://intranet.lternet.edu/

Or, http://www.lternet.edu/data/:

LTER Site characteristics (SiteDB):
http://savanna.lternet.edu/site/

Climate and Hydrology Data Access (ClimDB/HydroDB) –
Daily, monthly, annual data from most LTER sites
Direct URL: http://www.fsl.orst.edu/climhy/

LTER Site Climate Summaries:
Direct URL:
http://intranet.lternet.edu/archives/documents/Publications/climdes/siteclim.toc.html

New Network Data Catalog (under construction with few participating sites – expect a better interface and greater participation of sites in the coming months):
Direct URL: http://knb.lternet.edu:8088/knb/index.jsp

Original Network Data Table of Contents of LTER Data Sets:
Direct URL: http://lternet.lternet.edu/DTOC/

Annual net primary production (ANPP) database of 11 LTER sites:
Direct URL: http://intranet.lternet.edu/cgi-bin/anpp.pl

Satellite Image Data:
Direct: http://intranet.lternet.edu/data/

2005 LTER INFORMATION MANAGERS

Site	Site Name	Info. Manager	E-mail, Phone
AND	Andrews LTER	Don Henshaw	don.henshaw@oregonstate.edu, (541) 750-7335
ARC	Arctic LTER	James Laundre	jimL@mbl.edu, (508) 548-3705 X7476
BES	Baltimore Ecosystem Study	Jonathan Walsh	WalshJ@EcoStudies.org, (845) 677-7600 X103
BNZ	Bonanza Creek LTER	Brian Riordan	ftbar1@uaf.edu, (907) 474-6364
CAP	Central Arizona Phoenix Urban LTER	Corinna Gries	corinna@asu.edu, (480) 727-7860
CCE	California Current Ecosystem LTER	Karen Baker	kbaker@ucsd.edu, (858) 534-2350
CDR	Cedar Creek Natural History Area	Steve Bauer	bauer051@umn.edu, (763) 434-5131
CWT	Coweeta LTER	Barrie Collins	barriec@arches.uga.edu, (706) 542-5691
FCE	Florida Coastal Everglades LTER	Linda Powell	powell@fiu.edu, (305) 348-6054
GCE	Georgia Coastal Ecosystems LTER	Wade Sheldon	sheldon@uga.edu, (706) 542-5955
HBR	Hubbard Brook LTER	John Campbell	jlcampbell@fs.fed.us, (603) 868-7643
HFR	Harvard Forest LTER	Emery Boose	boose@fas.harvard.edu, (978) 724-3302
JRN	Jornada Basin LTER	Ken Ramsey	kramsey@jornada.nmsu.edu, (505) 646-7918
KBS	Kellogg Biological Station LTER	Sven Bohm	bohms@msu.edu, (517) 355-0223
KNZ	Konza Prairie LTER	Jincheng Gao	jcgao@ksu.edu
LNO	LTER Network Office	James Brunt	jbrunt@LTERnet.edu, (505) 277-2535
LUQ	Luquillo LTER	Eda Melendez-Colom	emelend@www.ites.upr.edu, (787) 764-0000 X4943
MCM	McMurdo Dry Valleys LTER	Christopher Gardner	Gardner.177@osu.edu, (614) 688-3365
MCR	Moorea Coral Reef LTER	Andrew Brooks	brooks@lifesci.ucsb.edu, (805) 893-7670
NTL	North Temperate Lakes LTER	Barbara Benson	bjbenson@wisc.edu, (608) 262-2573
NWT	Niwot Ridge LTER	Todd Ackerman	todda@Colorado.EDU, (303) 492-4771
PAL	Palmer Station LTER	Karen Baker	kbaker@ucsd.edu, (858) 534-2350
PIE	Plum Island Ecosystem LTER	Hap Garritt	hgarritt@mbl.edu, 508-289-7485
SBC	Santa Barbara Coastal LTER	Margaret O'Brien	mob@icess.ucsb.edu, (805) 893-2071

SEV	Sevilleta LTER	Kristin Vanderbilt	vanderbi@sevilleta.unm.edu, (505) 277-2109
SGS	Shortgrass Steppe LTER	Nicole Kaplan	nicole.kaplan@colostate.edu, (970) 491-1147
VCR	Virginia Coast Reserve LTER	John Porter	jhp7e@virginia.edu, (434) 924-8999

Appendix 6:

Stephanie Bestelmeyer, Jornada Basin LTER

Site	Supplemental Funding Sources	In-kind Support
Andrews	NSF: TE NSF: ATE NSF: RET NSF: REU NASA: New Investigator Program US Dept of Ed: University/School Partnerships Foundations School districts	US Forest Service; Willamette National Forest Oregon State University Portland State University Chemeketa Community College
Arctic	NSF: Office of Polar Programs	
Baltimore Ecosystem Study	NSF: REU NSF: UMEB EPA: Environmental Education NASA US Forest Service Chesapeake Bay Trust Foundations	Forest Service Parks and People Foundation
Bonanza Creek	NSF: TE NSF: GEO NASA	
Central Arizona-Phoenix	NSF: EdEn NSF: GK12 NSF: REU Foundations	
Cedar Creek		
Coweeta		Forest Service
Florida Coastal Everglades	NSF: Informal Science Education NSF:EdEn NSF: RET	Everglades National Park Miami-Dade County Schools — student community service hours
Georgia Coastal Ecosystems	Dept. of Education – Teacher Quality Enhancement	
Harvard Forest		
Hubbard Brook	NSF: EdEn NSF: GK12	
Jornada Basin	NSF: GK12 NSF: REU EPA: Environmental Education Foundations Corporations School districts	Agricultural Research Service Nonprofit organization
Kellogg Biological Station	NSF: Teacher Enhancement NSF: EdEn	
Konza Prairie	NSF: EdEn NSF: REU State Einsenhower Foundations Local businesses Nonprofit organizations	Nonprofit organizations Private gifts Volunteer time Boy Scout Eagle projects

Luquillo	NSF: IMD Foundations	Forest Service
McMurdo Dry Valleys	None	None
Niwot Ridge		
North Temperate Lakes	NSF: GK12 Eisenhower State	
Palmer Station	NSF: Teachers Experiencing the Arctic and Antarctica NSF: Office of Polar Programs	Scripps Institution of Oceanography
Plum Island Ecosystem	NSF: EdEn Dept. of Education: Professional Development State and Federal Community Service Learning Grants School Districts Foundations Local Businesses Gulf of Maine Council Gulf of Maine Institute	
Santa Barbara Coastal		
Sevilleta		
Shortgrass Steppe	NSF: GK12 NSF: CLT NSF: REU NSF: RAMHSS Dept. of Education: Math & Science Upward Bound Foundations	University of Northern Colorado MAST Institute
Virginia Costal Reserve	Foundations	

Appendix 7: 2004 Education Survey

Beth Simmons, Palmer Station LTER and California Current Ecosystem LTER

US Long Term Ecological Research Network -: Schoolyard04

The US Long Term Ecological Research Network

Schoolyard04

master.com

The following survey is designed to gather information and opinions about past and present involvement in the Schoolyard LTER program. Information from this survey will be included in the Education Handbook Chapter 6: Program Maintenance & Outreach. The LTER Network Office will make information and results from this survey available to the SLTER education community online. Thank you in advance for completing the survey.

Please contact Beth Simmons for updates or claification to questions on this survey.

1) Contact Information

Note: Portions of this form have been filled in automatically based on your previous registration.

Email: besimmons@ucsd.edu

First Name:

Last Name:

Title:

Company:

Street address:

City:

State (US):

Zipcode (US):

Country: United States

Time zone: --Select Time Zone--

Phone:

Fax:

2) LTER Site Affiliation

3) Who is the person designated as SLTER education program coordinator?

4) How is the position described or titled, i.e. Coordinator, liaison, director?

US Long Term Ecological Research Network -: Schoolyard04

5) How many LTER Principal Investigators have been involved with the SLTER project for the 2003 - 2004 calendar year (enter zero if none)?

6) How are Principal Investigators involved with your SLTER program?

7) How many other personnel (associated, community, education liaisons etc.) have been involved with your LTER site program from 2003 - 2004?
○ 0 ○ 1 ○ 2 ○ 3 ○ 4 or more

8) How many other paid personnel (associated, community, liaisons) have been involved with to your LTER site program?
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

9) List the main elements of your SLTER Education Program (Ex: Teacher workshops etc..).

10) How many undergraduate and graduate students have been involved with the SLTER program from 03-04?
○ 0 ○ 1-10 ○ 10 - 25 ○ 25 - 50 ○ greater than 50

11)How many K-12 students have been involved with the SLTER program from 03-04?
○ less than 60 ○ 60 - 100 ○ 100 - 500 ○ 500 - 1000
○ greater than 1000

12)How many K-12 teachers have been supported through the 15K supplements from the SLTER program?
○ 0 ○ less than 50 ○ 50 - 150 ○ 150 - 300
○ greater than 300

13)How many K-12 teachers have been supported using additional funds outside of the 15K supplement?
○ 0 ○ less than 50 ○ 50 - 150 ○ 150 - 300
○ greater than 300

14)What is the percentage of effort you work with grades K - 3?
○ Less than 40% ○ 40% to 60 %
○ Greater than 60% ○ Don't work with these grades

15)What is the percentage of effort you work with grades 4 - 9?
○ Less than 40% ○ 40% to 60 %
○ Greater than 60% ○ Don't work with these grades

16)What is the percentage of effort you work with grades 10 - 12?
○ Less than 40% ○ 40% to 60 %
○ Greater than 60% ○ Don't work with these students

17)What is the percentage of effort you work with undergraduates?

○ Less than 40% ○ 40% to 60 %
○ Greater than 60% ○ Don't work with these students

18) What is the percentage of effort you work with graduates?
○ Less than 40% ○ 40% to 60%
○ Greater than 60% ○ Don't work with these students

19) What is the percentage of effort you work on professional development?
○ Less than 40% ○ 40% to 60 %
○ Greater than 60% ○ Don't work on professional development

20) What is the percentage of effort you work with informal education programs (libraries, museums)?
○ Less than 40%
○ 40% to 60 %
○ Greater than 60%
○ Don't work with informal education programs

21) What community collaborations exist for your SLTER program? (Check all that apply)
☐ Open houses ☐ University Connections
☐ Environmental Organizations ☐ Native Elders
☐ Host of School Field Trips ☐ Parents
☐ Teacher Workshops ☐ Federal/State agency personnel

22) Add any other community collaborators not listed above.

23) How do your education materials get disseminated?
☐ Teacher Seminars ☐ Teacher Workshops
☐ Schools ☐ Professional Development
☐ University/Affiliated Open Houses ☐ Site Educational Website
☐ Publications ☐ Community Website
☐ courses/classes

24)Add any other ways you disseminate materials not listed above.

25)Please give your SLTER website address.

26)Please list any other local web site addresses associated with your SLTER. (i.e.Schoolyard address / LTER web page)

27)What types of materials are posted at your SLTER web site?
☐ Lessons ☐ Site Background ☐ Site biome description
☐ Other links ☐ Field journals ☐ Datasets ascii
☐ Datasets database ☐ Site tour ☐ Webcam

28)Please add any other materials posted on your website.

US Long Term Ecological Research Network -: Schoolyard04

29) What other forms of outreach/partnerships exist that disseminate SLTER information?

30) What approaches do you use to disseminate the authentic scientific research/data from your site?

- ☐ Site data is embedded within inquiry lessons,
- ☐ Raw data given to schools to create lessons etc.
- ☐ Site website
- ☐ Site databse
- ☐ ESA/TIEE program
- ☐ GLOBE program

31) Other approaches not listed above.

32) Which group(s) listed below are represented in your SLTER program? Check the boxes if you work with students from each of these categories.

☐ Female students ☐ Under represented groups ☐ Minority groups
☐ Special Needs

33)What percentage of the students you work with are from underrepresented groups?
○ Less than 40% ○ 40% to 60% ○ Greater than 60%

34)Other groups not listed above.

35)What kind of cross-site education/LTER are you involved in from 03-04? Leave blank if none.

36)What current assessment strategies does your SLTER site use as developmental markers?

☐ Pre/Post teacher attitude surveys ☐ Pre/Post student attitude surveys
☐ Pre/post workshop surveys ☐ Inquiry lesson evaluation
☐ Online Surveys ☐ None

37)Other strategies not listed above.

38)List achievement honors or forms of recognition for participants by your SLTER program. (i.e. Awards to Teachers, Awards to Students etc.)

39)General Comments about this survey.

Appendix 8: Bibliography

Shelly Sommer, Niwot Ridge LTER

Background and inspirational reading

Berkowitz, Alan R., Charles H. Nilon, and Karen S. Hollweg, editors. *Understanding Urban Ecosystems: A New Frontier for Science and Education*. New York: Springer-Verlag, 2003.
Nowhere is the challenge for ecological understanding greater than in cities, where human activity is most intense. Educators, education researchers, and leaders in the biological, physical and social dimensions of urban ecosystem research show the vital links between human actions and urban environmental quality.

Beveridge, William. *The Art of Scientific Investigation.* New York: Vintage Books, 1950.
Excellent discussion of science as a creative art. It emphasizes the imagination and intuition at the heart of science. Several chapters make excellent reading for teachers during professional development workshops. Many of the examples are from biology.

Chang, Raymond. *Chemistry with Online ChemSkill Builder*, 8th edition. New York: McGraw Hill, 2004.
Traditional, well-regarded text for straight-up chemistry answers.

Sobel, D. *Place-Based Education: Connecting Classrooms and Communities*. Great Barrington, Mass.: Orion Society, 2004.
Brief, but thoughtful and comprehensive, review of place-based education—from philosophy, to strategy, to good examples. Use it to argue persuasively for place-based education in your schools.

Van Matre, Steve. *The Earth Speaks.* Institute for Earth Education, 1983.
Thoughtful, peaceful, discussion-provoking readings on the natural world. This book is not hard science for today's young ecologists, but lovely perspectives from some of the great naturalists in our history.

Resources for educators—program evaluation and development

American Association for the Advancement of Science. *Atlas of Science Literacy.* New York: AAAS Press, 2000.
This innovative graphical tool depicts connections among the learning goals established in *Benchmarks for Science Literacy* and *Science for all Americans.* Fifty linked maps show how K-12 students can expand their science literacy understanding and skills. The maps show connections across different areas of mathematics, technology, and science.

American Association for the Advancement of Science. *Benchmarks for Science Literacy.* New York: Oxford University Press, 1993.
This companion to *Science for All Americans* is a tool for K-12 educators designing curriculum that fits local needs, inspires students' imaginations, and meets grade-level standards.

How People Learn: Brain, Mind, Experience, and School: Expanded Edition. Washington, D.C.: National Research Council, National Academies Press, 2000.
This book offers exciting new research about the mind, exploring how existing knowledge affects what people notice and learn, what the thought processes of experts tell us about how to teach, learning needs and opportunities for teachers, and a realistic look at the role of technology in education. What can we do to help children learn most effectively? The book examines the implications for what and how we teach and assessing what our children learn.

Loucks-Horsley, Susan, et al. *Designing Professional Development for Teachers of Science and Mathematics*, 2nd edition. Thousand Oaks, Calif.: Corwin Press, 1998.
Almost required as a citation when applying for education grants and for presenting your design to school administrators—and not a bad read either. Guides developers, administrators, and teacher leaders through designing learning experiences for teachers that are directly linked to improving student learning.

Loucks-Horsley, Susan, and Steve Olson, editors. *Inquiry and the National Science Education Standards.* Washington, D.C.: National Research Council, National Academies Press, 2000.
A practical guide to teaching inquiry and teaching through inquiry, as recommended by the *National Science Education Standards.* This book explains and illustrates how inquiry helps students learn science content, master how to do science, and understand the nature of science. Detailed examples help clarify when teachers should use the inquiry-based approach and how much structure, guidance, and coaching they should provide.

National Commission on Mathematics and Science Teaching for the 21st Century. *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century.* U.S. Department of Education, 2000.
Available online at http://www.ed.gov/americacounts/glenn. This concise report on the status of STEM teaching in the United States makes a strong case for the importance of math and science education and sets three broad goals for improving K-12 education in STEM.

National Science Education Standards. Washington, D.C.: National Research Council, National Academies Press, 1996.
Available online at http://books.nap.edu/catalog/4962.html. The standards offer a coherent vision of what it means to be scientifically literate, describing what all students, regardless of background or circumstance, should understand and be able to do at different grade levels. They address teaching, criteria for assessment, design of science programs, and needed resources and support. The standards reflect the principles that learning science is an inquiry-based process, that science in schools should reflect the intellectual traditions of contemporary science, and that all Americans have a role in improving science education.

Owen, John M. and Patricia Rogers. *Program Evaluation: Forms and Approaches.* London: Sage Publications, 1999.
A solid, practical introduction to localized evaluation of your program, designed to give beginners and practitioners a handle on processes and ideas. Good evaluation can support program planning, improve delivery, and determine impact.

Rutherford, F. James and Andrew Ahlgren. *Science for All Americans.* New York: Oxford University Press, 1990.
Based on Project 2061, a scientific literacy initiative sponsored by the American Association for the Advancement of Science, this wide-ranging study explores what constitutes scientific literacy in a modern society; the knowledge, skills, and attitudes all students should acquire from kindergarten through high school; and what steps this country must take to begin reforming its system of education in science, mathematics, and technology.

Resources for educators—activity guides

Colburn, Betsy and Nancy Childs. *Vernal Pool Lessons and Activities: A Curriculum Companion to* CERTIFIED: A Citizen's Guide to Protecting Vernal Pools. Massachusetts Audubon Society.
The cross-curricular activities range from identification games to mock public hearings on the protection of vernal pools. Includes lists of important vernal pool species and a glossary.

Comstock, Anna Botsford. *The Handbook of Nature Study.* Norwood, Mass.: Comstock Publishing Company, 1986 (reissue of 1939 revised edition).
Originally published in 1911, this massive work is the ultimate guidebook (and teacher's handbook) for North American temperate animals, plants, rocks, soils, and weather. Originally written for elementary school teachers, but often used for more advanced grades. Many Internet sites provide supplemental information and activities.

Cornell, Joseph. *Sharing Nature with Children.* 20th anniversary edition, revised and expanded. Nevada City, Calif.: Dawn Publications, 1998.
Scores of thoughtful adventures and activities to connect children with nature are enhanced by suggestions for teachers on how to be a good nature guide. Each activity is coded by appropriate age, number of students it works best with, environment needed (field trip or classroom?), length of time required, and the experience it evokes. A wonderful index classifies the activities by attitudes and qualities, concepts, environment, and mood.

Coulombe, Deborah A. *The Seaside Naturalist: A Guide to Study at the Seashore.* New York: Prentice Hall, 1990.
This guide covers various aspects of marine life from the perspective of the Atlantic coast. Excellent for teachers and students alike.

Kenney, Leo. *Diving into Wicked Big Puddles.* Reading, Mass.: Reading Memorial High School-Vernal Pool Association (RMHS-VPA).
This resource kit for educators contains interdisciplinary activities about vernal pools. Also includes 80 slides with notes and scripts for instruction.

Kenney, Leo. *Wicked Big Puddles.* Reading, Mass.: Reading Memorial High School-Vernal Pool Association (RMHS-VPA), 1995.
This guide to the study of vernal pools includes instructions for certification, vernal pool natural history, organism identification, and color photos of organisms and vernal pools.

Kesselheim, Alan, Britt Slattery, Susan Higgins, and Mark Schilling. *Wow! The Wonders of Wetlands: An Educator's Guide.* St. Michaels, Maryland: Environmental Concern, Inc. and Bozeman, Mont.: The Watercourse, 1995.
A comprehensive selection of hands-on activities covering a wide array of water-related issues. Ideal for educators who want to broaden water study units beyond wetlands.

Mera, Cristina, Steve J. Miller, and Beverly Shadley. *The Salt Marsh: A Complete Guide to Conducting Successful Field Trips for Grades K-12.* Rye, New Hampshire: Seacoast Science Center/Audubon Society of New Hampshire, 1994.
The salt marsh provides a fascinating outdoor ecology classroom. This guide includes integrated activities for students to learn about salt marsh environmental roles and uses through time.

Mitchell, John and Gordon Morrison. *The Curious Naturalist.* Amherst, Mass.: University of Massachusetts Press, 1996.
Collected from the Massachusetts Audubon Society journal of the same name, *The Curious Naturalist* describes a variety of activities, crafts, games, and ideas for teaching children about nature—animals, plants, ecosystems, and weather.

Project Learning Tree (web site). American Forest Foundation <http://www.plt.org> (accessed November 29, 2004).
An environmental education program designed for educators working with preK-12 students, collected in modules like Energy and Society, Forest Issues, Municipal Solid Waste, Risk, and Places We Live. PLT uses the forest as a window on the world and an introduction to environmental issues.

Project WET Curriculum and Activity Guide. Water Education for Teachers (Project WET), 1995.
The book is only available after participation in a six-hour educators' workshop. It contains 90 tested, interdisciplinary activities on surface water, groundwater, water quality, water management, and water conservation. The activities are in a variety of formats such as small- and large-group learning, whole-body activities, lab investigations, and community service projects in formal and informal settings.

Salt Marsh Science Project (web site). Massachusetts Audubon Society <http://massaudubon.org/saltmarsh/index.php> (accessed November 29, 2004).

Since 1996, students in grades 5-12 on the North Shore of Massachusetts have been learning about salt marshes and collecting data on invasive plants, the effect of salinity on vegetation, tidal restrictions, and fish.

Sobel, David. *Beyond Ecophobia: Reclaiming the Heart in Nature Education.* Great Barrington, MA: Orion Society, 1996.
Speaks to those interested in nurturing in children the ability to understand and care for nature. It describes several developmentally appropriate environmental education activities and lists related children's books.

Sobel, David. *Mapmaking with Children: Sense of Place Education for the Elementary Years.* Portsmouth, NH: Heinemann, 1998.
This book describes the theoretical groundwork for how children at various developmental stages understand maps and sets out several age-appropriate map projects and techniques. Emphasizes experimental learning and offers insights into how we think about and explain the world and use information.

Resources for K-12 students

Burnie, David. *Tree.* Eyewitness Books (Dorling Kindersley), 1999.
Designed for the 6th-8th grade set, this visually oriented, oversized book shows trees as organisms in the environment. Each two-page spread focuses on a topic such as bark, leaves, cones, pollination, and pollution.

Caduto, Michael, *et al. Keepers of the Earth: Native American Stories and Environmental Activities for Children.* Fulcrum Publishing, 1999.
A blend of social studies and science, this book includes several Native American stories, each followed by discussion ideas and questions and related indoor and outdoor activities. Each story is taken as a starting point for studying an aspect of the environment. Comes with a guide for teachers.

Fourment, Tiffany. *My Water Comes from the Mountains.* Boulder, Colo.: Roberts Rinehart Publishers, 2004.
A product of the Schoolyard LTER program, this beautifully illustrated book for 4th through 6th graders explores the ecology of the hydrological cycle supplying water from the Colorado mountains to the City of Boulder and beyond, to the environment of the prairie.

Fox, William T. *At the Sea's Edge: An Introduction to Coastal Oceanography for the Amateur Naturalist.* New York: Prentice Hall, 1983.
For more advanced grades.

Gonick, Larry and Alice Outwater. *The Cartoon Guide to the Environment.* New York: HarperCollins, 1996.
Perhaps politically incorrect for some people, this book handles the concepts of dwindling resources and poor stewardship in a thoughtful way. Topics include forests,

water, cycles, evolving systems and struggling individuals, a variety of communities, limiting factors, biomes, energy webs, pollution, urbanization, and Earth as an island.

Krasny, Marianne, Nancy Trautmann, William Carlsen, and Christine Cunningham. *Invasion Ecology*. National Science Teachers Association, 2002.
This book teaches students to investigate the behaviors of nonnative and native species by studying real-life invaders such as purple loosestrife and Phragmites. Available in packets that include several student editions and a teacher's guide.

Niesen, Thomas M. *The Marine Biology Coloring Book,* second edition. New York: HarperCollins, 2000.
Coloring focuses children's attention, while the text introduces major marine environments, the lifestyles and interactions of undersea creatures, and ocean currents and global weather (including El Nino).

Odum, Eugene P. *Ecology: A Bridge between Science and Society*. Sunderland, Mass.: Sinauer Associates, 1997.
A text for beginning students, emphasizing the relevance of ecology to human affairs. Unlike most other texts, Odum starts with a view of the entire living planet and works down to the level of organisms, rather than vice versa; and he integrates humans into his account at all levels.

Parker, Steven and Philip Dowell. *Pond & River*. Eyewitness Books (Dorling Kindersley), 2000.
Designed for the 6^{th}-8^{th} graders, each two-page spread of this visually oriented book shows a different topic, such as animals and plants in different seasons and life along the various parts of a river.

Project WILD Activity Guide and *Project WILD Aquatic Education Activity Guide.* Olympia, Wash.: Ecosystems Education, Washington Department of Fish and Wildlife.
Educators' guides designed in Washington State focus respectively on wildlife and habitat, and on aquatic wildlife and ecosystems.

Parker, Steven and Philip Dowell. *Pond & River*. Eyewitness Books (Dorling Kindersley), 2000.
Designed for the 6^{th}-8^{th} graders, each two-page spread of this visually oriented book shows a different topic, such as animals and plants in different seasons and life along the various parts of a river.

Purinton, Timothy and David Mountain. *Tidal Crossing Handbook: A Volunteer Guide to Assessing Tidal Restrictions* (online book). Byfield, Mass.: Parker River Clean Water Association, 1997. < http://www.parker-river.org/tides/Handbook> (accessed November 29, 2004).
Available in full on the Internet, this handbook explains the value of tidal wetlands and steps the reader through the process of assessing tidal restrictions.

Restoring Our Wetlands: Healing Our Watersheds (videotape). Boston, Mass.: Executive Office of Environmental Affairs, Wetlands Restoration and Banking Program, 1997.
This 13-minute video, appropriate for grades 9-12 and community groups, examines methods being used to protect and restore several Massachusetts wetlands through the GROWetlands project.

Seuss, Dr. *The Lorax.* New York: Random House, 1971.
A great story for grades K-5 that teaches about human impact on the environment and the importance of conservation. Teach them to speak for the trees.

Voices of the Great Marsh: An Educational Video. Mass.: Eight Towns & the Bay Committee, 2001.
Short (14-minute) documentary about the Great Marsh of Massachusetts, important to species like migratory birds and anadromous fish, situated in its natural and cultural heritage.

Field guides

Reid, George K., Sally D. Kaicher, and Tom Dolan. *Pond Life.* New York: Golden Guides from St. Martin's Press, 2001.
Describes plants and animals commonly found in North America's ponds, lakes, streams, and wetlands, including where and when to look to find various species.

Zim, Herbert, Hobart Smith, and James Gordon Irving. *Reptiles and Amphibians.* New York: Golden Guides from St. Martin's Press, 2001.
This handy guide identifies 212 species of North America's snakes, frogs, salamanders, and turtles. It focuses on what students are really likely to see, and color illustrations and maps accompany the entries.

Zim, Herbert, Alexander Martin, and Dorothea Barlow. *Trees.* New York: Golden Guides from St. Martin's Press, 2001.
Describes and illustrates 140 of North America's most common trees, including where each tree grows and how to recognize tree shapes, flowers, leaves, and fruit.

Northwest

Benyus, Jeanine. *The Field Guide to Wildlife Habitats of the Western United States.* New York: Fireside (Simon & Schuster), 1989.
Quick and easy info shows the various ecosystems of the western United States, including how the particular habitat was formed and characteristic plants and animals. Great illustrations are good to use as visuals for kids.

Southwest

Benyus, Jeanine. *The Field Guide to Wildlife Habitats of the Western United States.* New York: Fireside (Simon & Schuster), 1989.

Quick and easy info shows the various ecosystems of the western United States, including how the particular habitat was formed and characteristic plants and animals. Great illustrations are good to use as visuals for kids.

Northeast

Alden, Peter. *National Audubon Society Field Guide to New England.* New York: Knopf, 1998.
This pocket-sized layman's guide identifies 1,000 of the region's mammals, birds, insects, reptiles, amphibians, fish, trees, wildflowers, mushrooms, and mosses. It also provides information on the region's geology, various habitats, weather, the night sky, and nature reserves.

Benyus, Jeanine. *The Field Guide to Wildlife Habitats of the Eastern United States.* New York: Fireside (Simon & Schuster), 1989.
Quick and easy info shows the various ecosystems of the eastern United States, including how the particular habitat was formed and characteristic plants and animals. Great illustrations are good to use as visuals for kids.

Gosner, Kenneth L. *A Field Guide to the Atlantic Seashore: From the Bay of Fundy to Cape Hatteras.* Peterson Field Guide Series. Boston, Mass..: Houghton Mifflin, 1999.
More than 1,000 illustrations of plants and animals are arranged taxonomically, then by visual similarities.

Hartel, Karsten, David B. Halliwell, and Alan E. Launer. *Inland Fishes of Massachusetts.* Lincoln, Mass.: Massachusetts Audubon Society, 2002.
Identify freshwater fish using illustrated keys, family and species accounts, distribution maps, and color photos and line drawings.

Magee, Dennis W. *Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast.* Amherst, Mass.: University of Massachusetts Press, 1981.
A non-technical guide to identifying 182 vascular plant species from freshwater wetland environments. Keys make finding plants easy, while clear line drawings and information on range, habitat, and physical characteristics flesh out the entries.

Pond Watchers Guide to Ponds and Vernal Pools of Eastern North America. Massachusetts Audubon Society.
This laminated, fold-out sheet, ideal for taking into the field, portrays 60 species of reptiles, amphibians, invertebrates, and plants found in ponds.

Redington, Charles B. *Plants in Wetlands* (Redington Field Guides to Biological Interactions). Kendall/Hunt Publishing Company, 1994.
An identification guide for wetland plants that also explores broader topics, such as how insects, animals, and people interact with plants. Covers the U.S. east of the Mississippi to the Atlantic. While not a complete flora, the coverage is good. A glossary, lists of interacting organisms, and forms to record field observations are also included.

Tiner, Ralph W. *A Field Guide to Coastal Wetland Plants of the Northeastern United States.* Amherst, Mass.: University of Massachusetts Press, 1987.
This non-technical guide to saltwater wetland plants follows its format of Magee (1981) described above, including line drawings by the same illustrator and step-by-step identification keys.

Watts, May Theilgaard. *Tree Finder: A Manual for Identification of Trees by Their Leaves.* Nature Study Guild Publishers, 1991.
This small-format guide to 161 species of native (and some widely introduced) trees of U.S. and Canada east of the Rocky Mountains is illustrated with line drawings. It is organized as a dichotomous key, leading the reader through a series of questions about the shape or appearance of different parts of a tree. Illustrated with line drawings.

Weiss, Howard M. *Marine Animals of Southern New England and New York: Identification Keys to Common Nearshore and Shallow Water Macrofauna.* State Geological and Natural History Survey of Connecticut, 1995.
Naturalists and college-level students will get the most out of these up-to-date keys to 1,500 species of invertebrates and vertebrates, with black and white illustrations and color photos.

Southeast

Benyus, Jeanine. *The Field Guide to Wildlife Habitats of the Eastern United States.* New York: Fireside (Simon & Schuster), 1989.
Quick and easy info shows the various ecosystems of the eastern United States, including how the particular habitat was formed and characteristic plants and animals. Great illustrations are good to use as visuals for kids.

Pond Watchers Guide to Ponds and Vernal Pools of Eastern North America. Massachusetts Audubon Society.
This laminated, fold-out sheet, ideal for taking into the field, portrays 60 species of reptiles, amphibians, invertebrates, and plants found in ponds.

Redington, Charles B. *Plants in Wetlands* (Redington Field Guides to Biological Interactions). Kendall/Hunt Publishing Company, 1994.
An identification guide for wetland plants that also explores broader topics, such as how insects, reptiles, mammals, and people interact with plants. The text covers the United States east of the Mississippi to the Atlantic coast. While not a complete flora, the coverage is good. A glossary, species list of interacting organisms, and field forms to record observations are also included.

Watts, May Theilgaard. *Tree Finder: A Manual for Identification of Trees by Their Leaves.* Nature Study Guild Publishers, 1991.
This small-format guide to 161 species of native (and some widely introduced) trees of U.S. and Canada east of the Rocky Mountains is illustrated with line drawings. It is organized as a dichotomous key, leading the reader through a series of questions about the shape or appearance of different parts of a tree. Illustrated with line drawings.