Real Science: Real Connection to Parks

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National parks are known for providing educational experiences for learners of all ages and for creating special park programs for school-age children. In addition, a number of national park Research Learning Centers (RLCs) have created programs that provide professional development for science teachers. Outreach to science teachers grows out of the RLC mission, which recognizes the importance of promoting science literacy as a key element of informed stewardship.

Working with teachers is an efficient way of multiplying the resources of park staff and partners. Once a science teacher understands some of the scientific research and science-related issues in the parks, that teacher can, year after year, bring successive classes of students into contact with this research and these concerns. Moreover, teachers provide parks with a way to take their scientific message out to students who are geographically distant from a park and who could not easily participate in on-site learning.

This paper focuses on the experiences of three Research Learning Centers, based in three different parks, with different approaches to teacher professional development.

Schoodic Education and Research Center at Acadia National Park

Acadia's Schoodic Education and Research Center (SERC) is managed by Acadia Partners for Science and Learning, a non-profit organization. Acadia Partners also develops educational programs and oversees educational research at SERC.

In 2007, working with support from the Maine Department of Education, and in partnership with the University of Maine's Senator George J. Mitchell Center for Environmental and Watershed Research, Acadia Partners initiated a professional development program intended to (1) introduce teachers and students to scientific research and issues at Acadia, (2) assist teachers in engaging students in field-based science in forests and watersheds around their schools, (3) provide teachers and students with the opportunity to participate with working scientists in authentic research, and (4) improve science literacy.

The work with teachers builds on Acadia National Park's mercury research; the park has been engaged in research into the sources, movement, and concentration of mercury in the park ecosystem for more than two decades (Kahl et al. 2007). Recent advances in mercury measurement technology have dramatically reduced the cost of analyzing mercury content in soil and tissue samples (EPA 2007). Acadia Partners recognized that the decrease in cost created an opportunity to engage students in a citizen science project that could meas-

ure mercury content in soils, macroinvertebrates, and fish from different sites around schools across Maine. Citizen science projects combine useful observation or data collection with an opportunity for non-scientists to learn more about scientific principles, problems, and processes. Citizen science is typically conducted as informal science education. Acadia Partners decided to explore using it in a formal education setting.

The project gives teachers the content knowledge and skills to use mercury research as an integral part of science education in the areas of ecosystems, food webs, evolution, human health, earth science, and statistics. The program currently supports more than 20 teachers working with more than 300 high school students in a dozen schools.

Assessment of teacher and student activity over the first two years of the project has included structured classroom observation (Piburn et al. 2000), use of concept maps to capture teacher understanding of the watershed system and its relation to course objectives (Novak and Gowin 1984), surveys of teacher and student understanding of the nature of science (Liang et al. 2006; Odgers 2003), interactions with teachers during summer and in-service training workshops, and a review of student understanding of science as evidenced in student poster presentations.

Research findings and project evaluation to date suggest that combining citizen science and formal science education opens new learning possibilities while also presenting a few new problems. Positive outcomes include greater awareness of Acadia National Park, of mercury as an environmental problem, and of where mercury comes from. Response from teachers has been that this project satisfies an important, difficult-to-fill need to engage students in meaningful scientific work.

Cautionary observations include the following:

1. This kind of professional development takes time. Most teachers need more than one year to get comfortable with undertaking field research as part of their course structure.
2. Many teachers need help and training in working with data, including help with basic research design and statistics.
3. It is easy for teachers and students to get wrapped up in the mechanics of data collection and to not spend time on higher level learning associated with creating hypotheses, designing studies, or thinking about the systems underlying observed results.

One of the more striking findings emerging from the project is that most of the students in the program hold naïve and even misleading views of what science is all about. In surveying the beliefs about science held by more than 250 students in 8 different schools we learned that the overwhelming majority believe that "Scientific theories exist in the natural world and are uncovered through scientific investigations." In other words, scientific understanding is a pile of facts, rather than something constructed on the basis of evidence. Consistent with this, most students believe that "Scientists follow the same step-by-step scientific method" and that "When scientists use the scientific method correctly, their results are true and accurate." Further, students believe that "Scientists do not use their imagination and creativity because these conflict with their logical reasoning."

These survey results suggest that students are at risk of leaving high school poorly prepared to make judgments as citizens about matters where scientific understanding is undergoing rapid change and reconstruction, such as global climate change. A key research question that Acadia Partners will continue to pursue is whether hands-on engagement with professional scientists and meaningful problems has the effect of leading students to a richer, more realistic view of what science is and does.

Mammoth Cave International Center for Science and Learning

In 2006, the Mammoth Cave International Center for Science and Learning partnered with Mammoth Cave National Park and the National Association of Geoscience Teachers to pilot a GeoScience-Teacher-in-the-Park internship. The summer internship paired local teachers with researchers at Mammoth Cave National Park. Each intern worked 200 hours, gave two public presentations about their experiences, and produced an educational product for use in their classrooms and to share with other teachers. The 2006 pilot internship has become a successful annual summer internship program.

Throughout the summer, the teachers work on a variety of geoscience-related research and monitoring projects. Past projects include obtaining coordinates for the park's remote cave entrances and permanently marking them, assisting with a long-term cave cricket monitoring project, and collecting water samples for an *E. coli* monitoring project. All the interns have been amazed by the variety of research occurring at the park. One intern stated, "I did not know the extent of research happening at Mammoth Cave National Park. The Geoscience-Teacher-in-the-Park program gave me first-hand experience with many different projects. The most valuable part is that I will be able to take my experiences and share the real-life examples with my students."

By design, the internship program focuses on local teachers. Since the karst ecosystem extends beyond the park's boundaries, many interns and their students have sinkholes, springs, and caves in their backyards. What the teachers learn during their internships is therefore directly applicable to their lives and their students' lives. The internships also provide strong community outreach opportunities. The teachers not only share their experiences with their students, but also with friends, families, and other community members.

In addition, the local focus facilitates the formation of a teacher support network that benefits both the interns and their coworkers. In Kentucky, elementary education students are not required to take a college geology course which leaves many new teachers feeling unprepared to teach the subject. The interns' hands-on experiences give them the knowledge and confidence they seek. The educational products they develop as part of the internship help spark ideas for additional karst-related opportunities for their students. The former interns also become sources of information and guidance for their coworkers. Often the former interns will even volunteer to return the following summer to work with new interns.

As with any project there are challenges. One challenge is finding sustainable funding to continue the program. Other challenges include matching research projects with interns. Not every project is suitable for teacher participation, and not every teacher is interested in or able to participate in every "suitable" project. Scheduling can also be a challenge, since the teachers' schedules need to be coordinated with the researchers' schedules. However, for

some projects the teachers work together to collect data without constant researcher supervision. In these cases, the interns' schedules must also be coordinated. Having even numbers of interns minimizes this challenge.

Each year the internship grows in popularity. Through the internships, the teachers gain hands-on research and management experience that provides them with the knowledge and confidence to incorporate more karst geology into their classes. The former interns are all strong advocates for the program and actively work with their coworkers to increase karst-related activities in their schools. Mammoth Cave National Park's Environmental Education Division continues to work with the former interns, and this has resulted in new partnerships with several area schools. For the park, the internships build valuable community relationships and help disseminate research information to the public. For these reasons, the Geoscience-Teacher-in-the-Park internships are viewed as a great success by everyone involved with the program.

Appalachian Highlands Science Learning Center

Working in partnership with Great Smoky Mountains National Park, the Great Smoky Mountains Institute at Tremont and Discover Life in America, the Appalachian Highlands Science Learning Center (the "Center") has been creating in-depth summer science institutes for middle and high school teachers since 2002. The goals of the "Smoky Mountains Science Teacher Institute" and the "Advanced Science Teacher Institute" are the following:

1. Give teachers opportunities to work alongside research scientists, creating mentoring relationships.
2. Provide teachers with classroom materials and curriculum that allow them to do inquiry-based teaching in their classrooms.
3. Provide teachers with the skills they need to engage students in a complete scientific investigation, with a special focus on how to analyze data they collect.
4. Create opportunities for increased park stewardship as teachers use resources from Great Smoky Mountains National Park in their classroom.

Each year the topics of the one-week Science Teacher Institute vary depending on the research occurring in the park. Each spring the Center reviews research permits, seeking out scientists working on questions relating to critical park issues. Additionally, the Center uses the workshops to increase exposure to curriculum-based citizen science fieldtrips focused on monitoring impacts of ground level ozone on plants, terrestrial insects, aquatic macroinvertebrates, lichens and salamander populations. Each of these projects has an on-line database that allows teachers to track data collected in the park by students. Since it is not necessary to visit the park to participate in these studies, teachers are taught how they can replicate the studies and use the database to compare their findings to those in the park. This gives teachers the tools they need to allow students to conduct complete scientific investigations.

Program evaluations revealed that teachers wanted more support in conducting scientific investigations. Some were uncomfortable with developing questions and hypotheses

and some felt they needed to improve data analysis skills. In response, the Center developed the Advanced Science Teacher Institute, which focuses less on collecting data and more on what you do with it. In this workshop teachers follow one study through the entire process of formulating questions, developing hypotheses, and collecting and analyzing data with the researcher. Past workshops have looked at ground-level ozone impacts on plants, acid deposition effects on snail populations, and millipede and salamander populations in the presence of an exotic earthworm that depletes leaf litter. Data analysis includes not only working with numbers in Excel spreadsheets but also learning how to use free GIS software to map data points.

Evaluations of both workshops have shown that they successfully provide teachers with real-world research they can bring back to their classrooms to strengthen their students' skills and understanding of the scientific process. While some of the teachers come back to the park with their students, those who can't still have opportunities to connect with Great Smoky Mountains National Park through the on-line databases.

The main challenge with these workshops is sustainable funding. For six years, the Center has been able to obtain funding for the $400 per teacher cost from various grants. The fundraising is time consuming, and funding shortfalls have occasionally forced cancellation of the Advanced Science Teacher Institute. Another challenge is finding the right researchers to interact with the teachers. They must be able to talk about their area of study in an engaging way and should have field collecting activities that are easy and inexpensive to replicate. A positive outcome of working more closely with researchers is that they can sometimes make suggestions about how to develop engaging educational materials for research grants. This has resulted in funding for the workshops from the Environmental Protection Agency and the National Science Foundation.

To view the online databases, visit www.handsontheland.org/monitoring/checkup.cfm.

Conclusions

These three programs show that there are a number of fruitful ways in which national parks and other organizations can support teacher professional development and thereby engage teachers more closely with the scientific work underway in national parks. Despite differences in approach, the three programs reviewed in this paper share important common characteristics.

Each of these programs is a significant undertaking. The teachers require support over time to be successful in bringing park science into their classrooms; although summer institutes are an important part of any professional development offering, it is the support over the course of the school year that enables teachers to succeed in applying the ideas and techniques encountered in a summer institute. The ongoing need to pursue financial support is another reason that these programs are significant undertakings.

In each of these programs teacher success depends on including a focus on pedagogical practice as well as on scientific knowledge and methods. In particular, teachers need help in working with data, in integrating the park-based science into the curriculum in their schools, and in moving beyond mere "doing" to higher level science learning.

Success for each of these programs depends on partnerships that make it possible to

develop financial support and to bring researchers in colleges and universities together with park scientists and educators.

Perhaps the most important shared feature of these programs is that teachers express great interest in them: Teachers see the scientific work in national parks as an opportunity to meet the too often unfulfilled need for meaningful scientific learning. By addressing this need, the National Park Service, working through its Research Learning Centers, connects students to the parks. Acquiring resource knowledge and developing connections to parks are the first steps toward stewardship.

References

EPA. 2007. Method 7473: *Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry.* Revision 0, February. On-line at www.epa.gov/sw-846/pdfs/7473.pdf.

Kahl, J.S., S.J. Nelson, I. Fernandez, T. Haines, S. Norton, G.B Wiersma, G. Jacobson, A. Amirbahman, K. Johnson, M. Schauffler, L. Rustad, K. Tonnessen, R. Lent, M. Bank, J. Elvir, J. Eckhoff, H. Caron, P. Ruck, J. Parker, J. Campbell, D. Manski, R. Breen, K. Sheehan, A. Grygo. 2007. Watershed nitrogen and mercury geochemical fluxes integrate landscape factors in longterm research watersheds at Acadia National Park, Maine, USA. *Environmental Monitoring and Assessment* 126:1–3, 9–25.

Liang, L.L., S. Chen, X. Chen, O.N. Kaya, A.D. Adams, M. Macklin, J. Ebenezer. 2006. Student understanding of science and scientific inquiry (SUSSI): Revision and further validation of an assessment instrument. Paper presented at the annual meeting of the National Association for Research in Science Teaching (NARST), San Francisco.

Novak, J. D., and D.B. Gowin. 1984. *Learning How to Learn*. Cambridge: Cambridge University Press.

Odgers, B. 2003. Teachers' beliefs about the nature of science and science education in relation to recently introduced constructivist syllabuses in secondary schools in Queensland, Australia. In *Proceedings of the First Annual Hawaii International Conference on Education.* On-line at www.hiceducation.org/proceedings_edu.htm.

Piburn, M., D. Sawada, K. Falconer, J. Turley, R. Benford, R., I. Bloom. 2000. *Reformed Teaching Observation Protocol.* ACEPT Report IN-003. Tempe: Arizona State University. On-line at http://PhysicsEd.BuffaloState.Edu/AZTEC/rtop/RTOP_full/ PDF/. Accessed 24 January 2008.