EXPANDED VERSION

Paleontology, Nature, and Natural History: an Old New Approach to "Environmental Education"

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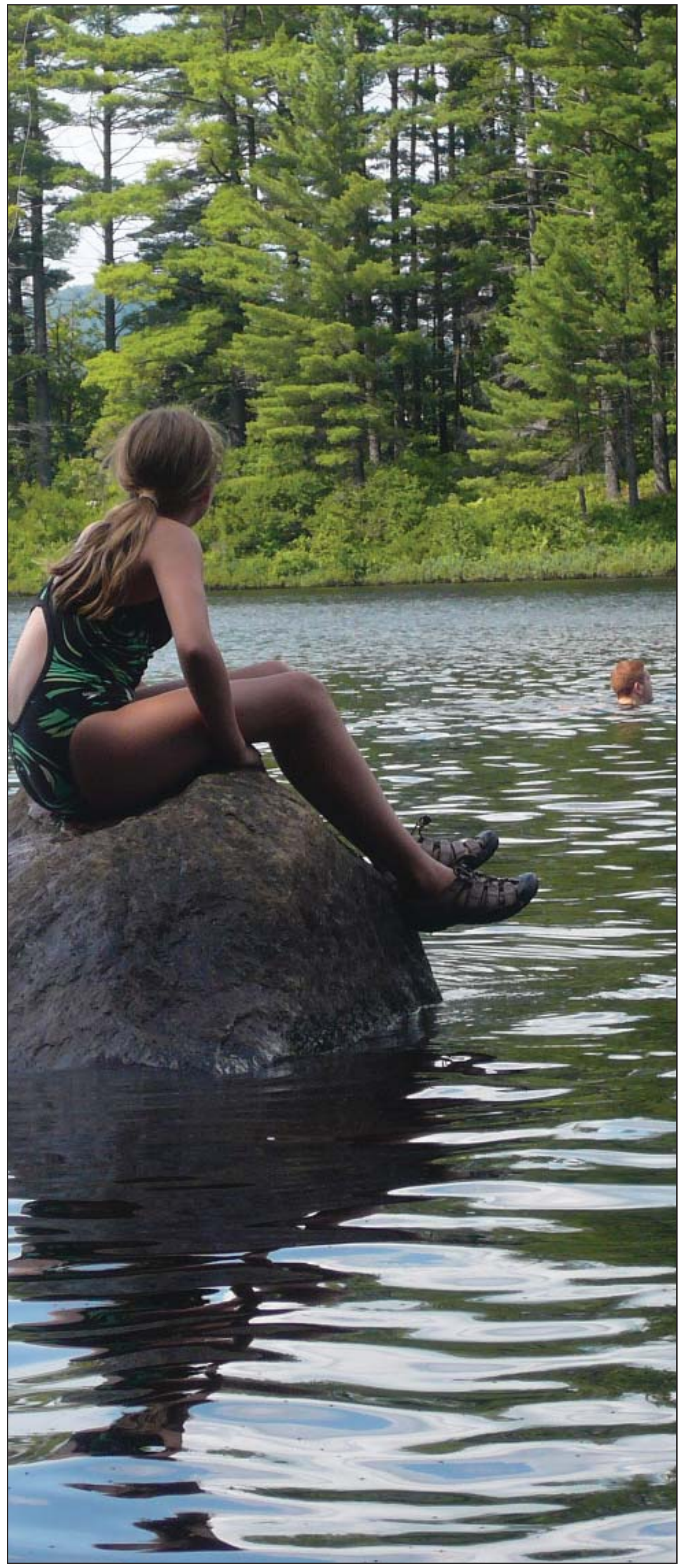
In January 2011, the Boards of the Paleontological Research Institution and the Cayuga Nature Center voted unanimously to move forward with a full merger of the two organizations. At first glance, this might seem an unlikely alliance. However, deeper reflection – on both the ways in which scientists study the Earth and its life, and the most effective ways of teaching about such study – reveals that paleontology is a crucial link in learning about how living and non-living nature came to be, and about how humans can learn to live more sustainably in the future.



Increasing specialization seems to be an inescapable property of human intellectual history. Five hundred years ago, the only highly educated people in Western society were members of the clergy, who besides ministering to people's spiritual needs also were university teachers of every subject from mathematics to rhetoric. Where once there were only "historians," now there are academic specialists in the history of virtually every nation, culture, and socioeconomic group imaginable. Where once there were only "physicians," now there are medical specialties focusing on almost every organ of the human body. In 1800, there were only "natural philosophers" (the word "scientist" hadn't yet been invented); by 1900, there were well-defined separate fields of physics, chemistry, and biology. Today, there are entire university departments devoted to narrow subdivisions of these broad subjects, from molecular biology to high-energy physics to neurobiology.

Part of this trend is undoubtedly driven simply by growth. The more people there are researching a subject, the more they are motivated to specialize in order to make a unique contribution. Most of the specialization of modern academic life, however, is surely a result of the immense increase in knowledge in every discipline over the past two centuries. Whereas it was once possible for one person to have command of all that was known about botany, chemistry, geology, meteorology, or paleontology, today it is impossible for one individual to have mastery of more than a small slice of the available knowledge in any one of these fields. Thus the common description of modern academics as "knowing more and more about less and less."

An unmitigated benefit of specialization is that science as a whole really does know much more about almost everything. Scientists now devote careers to unraveling the minute details of specific phenomena, from genetic function to galactic rotation. This would not be possible if we all were generalists, trying to do research in numerous different fields.

There is a long history of skepticism about the specialization of scientific knowledge (*e.g.*, Baekeland, 1907; Armitage, 2009; and references therein), and there is perhaps now even more reason for such criticism. With the continuing narrowing of scientific specialties, it is, for example, increasingly difficult for non-scientists to understand what cutting-edge scientists do. The average graduating major in a science subject also knows proportionately much less of all that is known in their field compared to a graduate a generation ago. There is even similar concern about advanced graduate education, that PhDs are trained in narrow specialties without adequate skills in communication or understanding their broader impacts (McCook, 2011).

More significantly, because the operation of the natural world itself is not constrained to the limits of human cognition or of academic boundaries, many of the most compelling problems in the natural sciences are inherently interdisciplinary. In fact, almost paradoxically, in parallel with growth of specialization has been growth in studies of "complex systems" – the interactions among variables from different scientific specialties – and some of the most exciting research going on today is occurring along discipline boundaries. Much current discussion within university curriculum committees is therefore devoted to the issue of how to prepare students to think across boundaries and in terms of systems, given the traditional focus on ever increasing specialized knowledge within individual disciplines.

There are at least two widely accepted solutions to these challenges. One is to try to prepare students to continue to learn long after they have left school. Indeed, an emphasis on "life-long learning" is ultimately the only answer to the increasing mismatch between a fixed number of years in school ("K-16") and the accelerating growth of knowledge. The other is to try to buck the entire trend, and encourage cross-disciplinary thinking and learning, through innovative majors like "Math and Social Sciences" (Dartmouth) and "Science of Earth Systems" (Cornell). According to data from the National Center of Educational Statistics, the number of interdisciplinary bachelors degrees awarded annually in the U.S. rose from 7,000 in 1973 to 30,000 a year by 2005. Educational leaders have increasingly advocated for the value of interdisciplinary approaches to problem solving in the 21st century, and this is reflected in the increase in academic programs with titles like "Energy and Environment" and "Sustainability Science," and even larger entities, such as the School of Interdisciplinary Studies at Miami University, the Department of Interdisciplinary Studies at Wayne State University, and the Department of Interdisciplinary Studies at Appalachian State University.

Moreover, pedagogical research suggests that students achieve deeper understandings when they focus on a small number of concepts that operate across or between fields. The overall approach of the U.S. National Research Council as they prepare new science education standards will be to increase cross-disciplinary concepts, and to focus on what are frequently termed "Big Ideas" that have broad explanatory power (*e.g.*, Ross & Duggan-Haas, 2010). Though these revised standards are still in preparation, we can expect the next phase of K-12 national science education to emphasize such cross-disciplinary thinking.

Natural History and Nature Study

Against the backdrop of this (still somewhat limited) realization that narrower and narrower specialization might not necessarily be the only or best way to learn or teach about the natural world, it is ironic that a discipline that inherently tried to look across the broadest possible swath of nature has not experienced a renaissance on campuses. In the late nineteenth century, Natural History was a prominent academic subject at virtually all colleges and universities in America. It had all of the accoutrements of an acknowledged field, from endowed professorships and journals to what we now call "infrastructure" (mainly museums and collections). Academic Natural History, in turn, spawned a subdiscipline within Education known as Nature Study, which also had its own appropriate paraphernalia of books and journals.

Nature Study was actually more than an academic field. It was a movement – a concerted effort to encourage and train educators to expose children to nature as a way of learning the basics of both the natural world and the nature of science. It was part of the progressive-era sense that experience in the outdoors was good for the mind and the body, and also a major educational theme across much of the United States (Armitage, 2009; Kohlstedt, 2010).

Cornell University was one of the major centers of Nature Study in the late nineteenth and early twentieth centuries (*e.g.*, Bailey, 1904; Palmer, 1944), and Cornell professor Liberty Hyde Bailey (1858-1954) was an early leader of the movement. According to Bailey,

> *Nature-study, as a process, is seeing the things that one looks at, and the drawing of proper conclusions from what one sees. Its purpose is to educate the child in terms of his environment, to the end that his life may be fuller and richer. Nature-study is not the study of a science, as of botany, entomology, geology, and the like. That is, it takes the things at hand and endeavors to understand them, without reference primarily to the systematic order or relationships of objects. It is informal, as are the objects which one sees. It is entirely divorced from mere definitions, or from formal explanations in books. It is therefore supremely natural. It trains the eye and the mind to see and to comprehend the common things of life; and the result is not directly the acquiring of science but the establishing of a living sympathy with everything that is.*

Treetops

In 1911, Cornell professor Anna Botsford Comstock (1854-1930) published the first edition of *Handbook of Nature Study*. Comstock was the founder and first head of the Department of Nature Study at Cornell (and the first woman to be appointed to the Cornell faculty). Written originally for elementary school teachers, the book (which went through twenty four editions and is still in print) was a gentle guide to everything that a student or parent or teacher might see in nature (at least in the northeastern U.S.), how to observe it carefully, and why such study was important. Nature study, wrote Comstock, "is for the comprehension of the Individual life of the bird, insect or plant that is nearest at hand." It "consists of simple, truthful observations that may, like beads on a string, finally be threaded upon the understanding and thus held together as a logical and harmonious whole." Nature study, she contended, aimed not only to "cultivate in the children powers of accurate observation and to build up within them understanding," but also to "cultivate the child's imagination and "love of the beautiful," aid "both in discernment and in expression of things as they are," and most importantly, "gives the child a sense of companionship with life out-of-doors and an abiding love of nature."

In 1949, Cornell professor Ephraim L. Palmer (1888-1970) published the first edition of *Fieldbook of Natural History*. Palmer was Professor of Nature and Science Education at Cornell from 1919 to his retirement in 1952 (Bellisario, 1969). He authored more than 700 publications across a huge range of subjects in natural history and education, and hosted a popular weekly radio broadcast, "This Week in Nature" for 27 years. Palmer's book had much in common with Comstock's. It was written, he said, to address what he saw as the increasing gap between the technical literature of natural science and the "average person," who does not easily see how such science serves matters in his daily life. "It is hoped," Palmer wrote in the Preface, "that this combination of philosophy, facts, and techniques may help us all enjoy doing what must be done, when it must be done wherever we may be. This should lead to a sound citizenship, a rational conservation policy, and a happy life" (Palmer, 1949: 5).

Such descriptions seem quaint to modern readers, and it has been a long time since either Natural History or Nature Study enjoyed such a seat at the "high table" of academia. Ask today's average college professor, undergraduate, or member of the general public for a definition of "natural history" and you much more likely to get a description of looking at dusty bones in a museum or an amateur dilettante doddering around in a field netting butterflies, than a description of an exciting, modern scientific field. Similarly, despite the growing emphasis on the environment, the word "nature" has taken on a connotation of a colloquial term for what scientists would be more like to call the "environment"; the scientific community might associate the term "nature" with unscientific concepts such as "harmony" and "beauty." The modern field of "Environmental Education" is growing, but

draws heavily upon fields outside science such as sociology and policy, and thus tends to be separate from the disciplines of biology and geology. Natural History and Nature Study appear to belong to a bygone era.

Environmental Education

Modern environmental education (EE) is a descendant of a number of early-twentieth century predecessors, including "nature study," "outdoor education," and "conservation education" (Marcinkowski, 2010: 34). Since it came into widespread use in the 1960s, the term "environmental education" has had many variations encompassing a range of scope, intention, and definition. One of the earliest and most widely recognized definitions was proposed in 1969: EE, it said, is "aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its problems, aware of how to help solve these problems, and motivated to work toward their solution" (Stapp *et al.*, 1969: 31; quoted by Marcinkowski, 2010: 44).

More recently, one of EE's most eloquent spokespersons, Oberlin professor David Orr, describes it simply as "instruction directed toward developing a citizenry prepared to live well in a place without destroying it" (Orr, 1994: 14). The 1977 UNESCO-UNEP Tbilisi Intergovernmental Conference boiled the objectives of environmental education down to five elements: "awareness, knowledge, attitudes, skills, and participation" (Intergovernmental Conference on Environmental Education, organized by UNESCO in cooperation with UNEP, Tblisi, Georgia, USSR, 14-26 October, 1977. Final report. Available at http://unesdoc.unesco.org/images/0003/000327/032763eo.pdf)

As a recent review article put it:

> ***Environmental awareness*** *… is that process of alerting people to the multiplicity of factors which influence their environment, the first step towards the systemic way of thinking.* ***Environmental literacy*** *is built on awareness by the acquisition of greater knowledge and understanding of the components of the system, the links between them and the dynamics of the system.* ***Environmental responsibility*** *recognizes the special role of humankind in determining and guiding change, and the capacity to evaluate between different options.* ***Environmental competence*** *implies a degree of mastery of the system, not only to understand and to evaluate it but to act effectively for its better functioning. Together they add up to* ***environmental citizenship****…*" (Smyth, 2006: 250)

These definitions encompass both the wide swath and potential tensions inherent in EE: It is based in natural science but goes beyond it, to encourage not just knowledge but particular attitudes and, ultimately, behaviors. It is about non-human nature, but also about human impacts on that nature, up to and including "viewing human beings as one part of the natural world and human cultures as an outgrowth of interactions between species and particular places" (Smith & Williams, 1999: 3).

Because of its frequent focus on local natural environments, EE frequently grades into what has come to be called "place-based education" (*e.g.,* Gruenewald, 2005; Duffin *et al.*, 2008), which holds that people should be prepared "to live and work to sustain cultural and ecological integrity of the places they inhabit," and that to do so, they "must have knowledge of ecological patterns, systems of causation, and the long-term effects of human actions on those patterns" (Orr, 1994; as cited by Woodhouse & Knapp, 2000).

Most EE assumes (or hopes) that through such a focus on local nature, "it may be possible to reestablish the link between people and the natural world that has become so tenuous in industrial growth societies" (Smith, 1999: 214). EE might thereby begin to repair what naturalist Gregory Bateson called the disrupted "feedback loops between events in the natural world and human behavior" with the result that "human decisions have become decreasingly intelligent and more dangerous." Reacquainting with nature, in other words, can lead to "reacquainting ourselves with the impact of our actions and decisions" (Bateson; quoted by Smith, 1999: 215). (This is strongly reminiscent of the Nature Study goal of encouraging "sympathy" for living things; see Armitage, 2009.)

Paleontology and Natural History

To most people, paleontology is an unpronounceable, narrow, esoteric-sounding branch of human endeavor. Even many other scientists view it as off the main path of science and certainly not a "core" subject. The most familiar point of contact that most people have with the field – dinosaurs – doesn't really help this situation, since they are widely viewed as something that kids eventually grow out of rather than a serious scientific pursuit.

Physics and chemistry have long held the thrones as the king and queen of the sciences. One of our personal college chemistry texts, for example, was entitled *Chemistry. The Central Science* (Brown & LeMay, 1977). Why, these authors ask in the preface, "is it that so many diverse areas of study should all relate in an essential way to chemistry?" Their answer: "chemistry is, by its nature, the *central* science" (emphasis in the original) because "[i]n any area of human activity that deals with some aspect of the material world, there must inevitably be a concern for the fundamental character of the materials involved."

In such a view, a field like paleontology is bound to seem very "non-central." Yet a truly "interdisciplinary" approach to the sciences would argue that such a simple hierarchy of the sciences is inadequate for addressing the challenges and opportunities that society now expects science to address. This more adequate view of how science works recognizes that all areas of science depend, to a greater or lesser degree, on all others, and a complete view of one discipline is impossible without reference to (and knowledge of) at least one other.

In this view, paleontology stands astride numerous fields of human understanding. Paleontology is among the broadest of all human pursuits, literally essential for an adequate understanding of the history (and future) of the Earth's climate, as well as its biodiversity, ocean circulation, and geochemical cycles. It is not just because fossils are key tools for the dating of rocks and the location of hydrocarbons, and for reconstructing past positions of continents and oceans (and thus for an understanding of the tectonic and seismic history of the Earth). It is now widely recognized by Earth scientists that life is one of the most important geological forces on this planet. From erosion to carbon and oxygen in the atmosphere, organisms have been profoundly affecting geological processes for several billion years. We know this in large part because of paleontology. In sum, paleontology is, at its best, inherently a systems-level pursuit that crosses academic boundaries to solve some of the most compelling scientific questions about why Earth's environments look the way they do.

Moreover, fossils are also the only direct evidence for the evolutionary history of life (including humans), and so are crucial for any understanding of evolution, which is the central idea of all biology, from ecology to medicine. Just to take one prominent current example, the billions of dollars now being spent on decoding the genomes of humans and other organisms would be wasted without the understanding that evolutionary biology – including paleontology – provides.

Finally, as human beings have become increasingly (albeit belatedly) aware of the enormous – and mostly negative – effects they have had on the Earth, paleontologists can make uniquely valuable contributions to both the teaching and researching of problems of "global change" (*e.g.,* Dietl & Flessa, 2011). Humans are organisms, and their effects on the Earth and its systems can be most clearly seen as examples of the effects all organisms have and have had on the planet for billions of years. Paleontologists can therefore serve as the links between geology and biology departments in both teaching and research in areas at the very forefront of public attention.

Thus, in many ways, paleontology *is* natural history, *and* environmental education, *and* nature study (*e.g.*, Lane, 1978; Allmon, 2008). This was explicitly the view we took a decade

ago when we were designing the Museum of the Earth at PRI. Despite the fact that the permanent exhibits focus on fossils, it is about far more than fossils – it is about the entire Earth system through all time, and humans' relationship to it (Allmon, 2004).

What is a "Nature Center"?

The term "nature center" has a variety of definitions. According to Wikipedia, for example, a nature center is:

> *"… an organization with a visitor center designed to educate people about nature and the environment. Usually located within a protected open space, nature centers often have trails through their property. Some are located within a state or city park, and some have special gardens or an arboretum. Their properties can be characterized as nature preserves and wildlife sanctuaries. Nature centers generally display small live animals, such as reptiles, rodents, insects, or fish. There are often museum exhibits and displays about natural history, or preserved mounted animals or nature dioramas. Nature centers are staffed by paid or volunteer naturalists and most offer educational programs to the general public, as well as summer camp, after-school and school group programs."* (http://en.wikipedia.org/wiki/Nature_center)

This and most other definitions share a number of common themes. A nature center is a place to experience and "appreciate" nature – aesthetically, emotionally, etc.; a place to learn about nature, via a combination of hands-on activities indoors and out; a place for enrichment and support of local school curricula; a place for family enjoyment and recreation; a tourist attraction; and a place to cultivate and inspire a sense of environmental stewardship.

A 1990 directory (apparently the most recent comprehensive attempt) counted at least 1,261 nature centers in the United States and Canada (Directory of Natural Science Centers, 6th edition, 1990, Natural Science for Youth Foundation; summarized by Evans & Evans, 2004; there are currently at least 113 in New York State alone). About 60% of these were run by a government agency, while approximately 40% were run by private, non-profit organizations. Nature centers vary in size from relatively tiny entities run completely by volunteers to very large organizations with multi-million-dollar budgets. Most are located on 100-200 acres, have fewer than 10 full-time paid staff, and serve 10,000-50,000 people annually. In these and other aspects, Cayuga Nature Center (CNC) is a fairly typical nature center.

Nature centers frequently have their greatest value in offering children and their families access to the natural world, albeit in a limited form. It has long been argued that experiences with non-human nature are essential for our psychological as well as material well-being (see, *e.g.*, Louv, 2008). For many people, especially in urban areas, nature centers might be their only such access. Less frequently noted, however, is the (perhaps ironic) need to expose rural audiences to nature. Although they might live in "the country," people in rural areas do not necessarily have a deeper understanding of non-human nature than do city dwellers. Although they might appear to be surrounded by nature and, for example, farm, hunt, or fish, this does not necessarily translate directly to environmental understanding,, especially if the primary activities in the community are focused on human control of nature such as agriculture, or use of resources from the earth such as mining. And they might spend just as much time indoors and in vehicles as less rural citizens, and thus learn just as little about how natural populations or ecosystems actually function. Science education that might build deeper environmental understanding is generally relatively poor in rural communities, in part because overall education resources are poor relative to those in many suburban and urban contexts. Factors include geographic isolation, small size of schools, and limited economic resources (see, *e.g.*, Berns *et al.*, 2003).

Rural residents might, furthermore, be more likely than urban or suburban residents to view nature as existing only or mainly for human use. A number of studies have examined the difference in environmental concern among urban and rural residents (*e.g.*, Huddart-Kennedy *et al.*, 2009, and references therein). Literature in the 1980s and 90s suggested that rural communities have less concern, because of lower education levels, lower income, and/or pragmatic perspective focused on the economic value of resource extraction from the land. Some studies indicate that the gap has been narrowing in recent years and depends on opportunities for environmentally supportive behavior such as recycling, which have been in the past been more readily available in urban areas. Thus, for nature centers in mainly rural areas, such as CNC, this presents both a special challenge and a special opportunity.

The Cayuga Nature Center

The Cayuga Nature Center (CNC) is a 501(c)3 non-profit organization located on 120 acres of land overlooking Cayuga Lake on Route 89, about 7 miles north of downtown Ithaca (and 4.3 miles by road from PRI). On this property are located the main historic lodge building, a TEAM Challenge ropes course, a gorge and miles of trails, a four-story tree house ("Treetops"), seasonal butterfly house, and maple sugarbush. CNC also owns a 30 acre parcel of "old growth" forest known as Smith Woods located nearby.

CNC's mission is to serve as a community resource that cultivates awareness, appreciation and responsibility for the natural world through outdoor and environmental education. Most of its programs focus around environmental and nature education. Its two largest programs – summer camp and the TEAM Challenge course – are the source of most of its revenue.

Smith Woods was established as a private park open to the public in 1909, and was administered for the next century by a small group of local trustees. It is commonly referred to as "old growth," meaning that it has not been extensively logged or managed (except for removal of blown-down trees in 1954 and 1989), and as one of the few such forest stands in central New York; its oldest living trees date to the early 1700s (Strauss, 1977; List, 1990; Marks *et al.*, 1999).

The main lodge building of CNC was built by the Cayuga Preventorium, an organization founded to provide a retreat for children who might otherwise be exposed to tuberculosis. The Preventorium's first home (in 1914) was located on the east side of Cayuga Lake, at Esty's Point, housing youngsters during the summer months. By the 1930's, TB was no longer as big a threat, and the Preventorium was used to sponsor a series of cardiac clinics. Mr. and Mrs. Ernest T. Paine gave 75 acres of land on the west side of the lake to be used to serve children recuperating from cardiac and other diseases, and the Works Progress Administration (WPA) helped complete construction of the main lodge building in 1939. With the onset of World War II, however, the center was forced to close, and remained unused until 1950, when Cornell University leased the building for student housing. In later years, the building was used as a camp for children of working mothers, but remained closed for most of the year.

In the 1960s, the Preventorium's Board of Directors

Cayuga Nature Center

decided to offer the facility as a conference center available year round. Conferences and small day camps covered the day-to-day expenses, but the building was not used to its full potential. A new direction was introduced at a workshop in Brewster, NY sponsored by the State Education Department to discuss outdoor education programs to be run by NY State's Board of Cooperative Extension Services (BOCES). As a result of this conference, a program was established for providing outdoor education with BOCES using the Preventorium as a base for promoting outdoor and environmental studies.

In 1975, BOCES, the Ithaca schools, and Onondaga Nature Centers, Inc., collaborated to open the Preventorium as a nature center. In 1981, the Cayuga Nature Center was incorporated as an independent, private, non-profit educational organization.

A major setback occurred in the early 1990s, when as a result of State budget cuts the Ithaca City School District canceled its contract with CNC. The organization never really recovered from this event, and never developed a new business model or reliable source of revenue. A series of Executive Directors over the next 15 years was unable to move the organization in a sustainable direction. In 2007, with the support of the Triad Foundation, Tom Trencansky was hired as interim Executive Director, and a consultant was hired to recommend what to do about the organization's future. It was as a result of that consultant's report that the partnership with PRI was initiated.

PRI and CNC

In late 2007, at the request and with the support of Ithaca's Triad Foundation, PRI began collaborating with CNC, which is located just four miles north of PRI on the west shore of Cayuga Lake. The collaboration focused on improving and expanding CNC's long-established summer camp, and was by all measures very successful. The collaboration also produced a *Field Guide to the Cayuga Lake Region* (Dake, 2009), published by PRI, which has been very well received and is now in its second printing. Again with the support and encouragement of Triad Foundation, the two organizations then began serious discussions about an even closer relationship, with the result in January 2011 being unanimous votes by the Boards of both organizations to move toward total merger. The response of the Ithaca community to this plan has been almost uniformly positive and supportive. CNC is widely viewed as a local treasure that the community does not want to lose. PRI is widely respected for having successfully built and operated the Museum of the Earth for almost a decade. Yet along with these positive reactions has frequently come an expression of puzzlement usually along the lines of "Why would a dinosaur museum want to take over a nature center?"

The answer is as we have described above: paleontology is an integral part of what nature centers do, and environmental sciences are integral to paleontology.

PRI's mission is to "serve society by increasing and disseminating knowledge about the history of the Earth and its life." Although founded almost 80 years ago as an organization with a relatively narrow focus (research and publication in invertebrate paleontology), since 1992 PRI has dramatically expanded its role to include collections and research on a wider range of paleontology and related topics, and a major commitment to educational outreach, for audiences from K-12 to college students and the general public.

Significantly, during the almost 20 years that this expansion of PRI's mission was taking place, paleontology as a discipline was also undergoing a major transformation, from a scientific field dominated by applications in geology and the petroleum industry to one focused more on problems of evolution and environmental change, including climate, biodiversity, and conservation – that is, what has come to be called "Earth system change." PRI's changing mission, in other words, has in many respects mirrored the changes within paleontology itself. Indeed, because its outreach programs are so young, PRI has emerged as a national leader in communicating this changing conception of paleontology, as a field representing Earth system science, to the general public.

Yet, like paleontology in general, PRI struggles with this broadened mission. The public still does not usually think of paleontology as particularly relevant to environmental education or climate change or conservation. PRI lacks some of the basic assets and features of organizations that the public does generally associate with these subjects – such as extensive open, natural space and an explicit and easily-recognized programmatic connection to "nature." Moreover, PRI programming has not grown in some areas of environmental science where it has long seen connections – for example, making linkages between the ancient (bedrock, topography) to the immediate (weather, water, flora and fauna) through historical phenomena such as climates, watersheds, soils, and forests.

PRI outreach will always include the paleontological "basics," such as fossils, dinosaurs, local geology, as well as innovative efforts on evolution. Yet a significant proportion of PRI's future outreach effort will unavoidably lie in what can broadly be called "environmental education," and the Institution therefore needs to have access to the resources necessary to move further in this direction. In other words, if PRI had not moved to merge with CNC now, it would eventually have had to create much of what CNC currently has in order to retain and improve its position as a nationally significant player in Earth system science education.

More specifically, a merger between PRI and CNC promises to bring substantial short-term opportunities that (at least in the view of staff and Board) far outweigh the risks and costs.

Even though PRI already has numerous programs in this area (*e.g.*, climate change, biodiversity, etc.), the Institution is

not widely thought of by either the general public or funders as an organization engaged in environmental education in a significant way. This has meant that PRI has not been able to attract financial or other support from individuals and agencies primarily interested in this area – *e.g.*, many people in the Ithaca community, many national foundations, etc.

CNC has enormous and unique (but underused) assets. It owns a large, varied, and beautiful set of properties overlooking Cayuga Lake; a large and historic building with great architectural and programmatic potential; and a long and, for many, beloved tradition of nature-related programming on this site. Connecting these assets to PRI's greater institutional stability and expertise in science, administration, fundraising, and education will dramatically improve the level of environmental education in Tompkins County and central New York as a whole. If managed well, CNC has real potential to become a regional center – and national model – for environmental education for all ages, with programming that both maintains its tradition of youth- and family-focused activities and also serves schools, colleges, and community groups with state-of-the-art content in environmental science and natural history – from climate to wildlife, from water to forestry, from conservation to carbon footprints.

CNC offers major potential for improving programs that PRI already offers. Our numerous programs in Central New York paleontology and geology, for example, could be offered in CNC's on-site gorge. Our climate and biodiversity programs could be significantly improved with access to the "outdoor classroom" available at CNC. Our evolution programs could be significantly improved with access to CNC's live animals, collections of taxidermy and osteology specimens, and "outdoor classroom." CNC's live animals are already frequent – and very popular – additions to various public programs in the Museum of the Earth. Merger will allow for significant expansion. Our existing programs of teacher professional development, such as the Teacher-Friendly Guide program, can be expanded with the addition of environmental science. The Teacher-Friendly Guide project focuses on real-world application of science to regional and local contexts. The project helps teachers to use real-world settings in their community around which to focus their curricula, emphasizing field work, and helping to students to understand why any given place looks the way it does. CNC is an ideal location for this sort of place-based approach.

The potential for new programs is also great. For example, the CNC site will be ideal for encouraging exploration of local impacts of climate change, such as potential regional decline (and even extinction) of sugar maple trees, monitoring invasive species, and measuring weather and weather-related conditions (*e.g.*, temperature, precipitation, and runoff). New programs on evolution, emphasizing examples from the local environment ("your own back yard") could demonstrate the ubiquitous application of evolutionary biology to familiar natural phenomena. The availability of the 32-acre "old growth" Smith Woods (one of the few remaining such stands in central New York) offers an excellent opportunity for programming around the history of forests in the northeast, starting with the last retreat of the glaciers and continuing through the arrival of Native Americans and then Europeans. The grounds provide outstanding opportunities for modeling creation of virtual field experiences and for citizen science projects that help us to document seasonal and interannual change on the grounds.

A New Vision of Environmental Education

The potential merger of CNC and PRI offers a unique opportunity to expand the long-standing definitions of nature centers and environmental education, and to develop an innovative, potentially nationally-significant synthesis of Earth science education and environmental education and outreach.

Environmental education at nature centers almost always includes basic familiarization with local natural history, and some exposure to (usually modest) steps that individuals can take to mitigate human impact on the environment. Yet this structure is almost always missing two elements that are necessary for people to genuinely comprehend the current state of the environment and become motivated and capable to do something significant about it.

The first of these two missing elements is *Earth science*. In spite of its breadth, EE is seldom linked, especially in the public consciousness, with the established areas of Earth science education and Earth system science education. This is unfortunate because Earth science and Earth science education are essential and fundamental parts of environmental science and environmental education. Without an Earth science perspective, EE is disconnected from much of the basis for understanding how the environment works as a system. The Earth sciences address the dynamic processes below and on the Earth's surface, as well as those within the atmosphere. They examine present processes as well as those that have occurred throughout ecological and geologic time and provide information on frequency, rates, and magnitudes of Earth system changes. This allows the Earth sciences to provide a unique historical perspective against which anthropogenic environmental impacts can be evaluated. It is difficult, for example, to understand the causes and potential consequences of anthropogenic climate change without understanding how climate actually or the history of climate change in Earth history. It is similarly difficult to grasp the full significance of the current biodiversity crisis without understanding the significance of mass extinction in the history of life.

There is currently some linkage between Earth science and environmental science in K-12 education, but even these cases are often superficial or problematic. A notable example is the nationally implemented "Advanced Placement" (AP) high school course Environmental Science. There is no AP Earth Science class; instead, a modest amount of Earth science is integrated in the Environmental Science class. A committee was formed to increase the amount of Earth science content in the course, but because of entrenched differences in the way Earth and environmental science educators saw the topic, a better integration was not achieved (For an account of this debacle, see http://www.geotimes.org/may08/article.html?id=feature_rocks.html.) PRI thus has an opportunity to achieve a nationally significant synthesis where others have failed.

The second element usually missing from EE is *an adequate understanding of just how extensive and profound human influence on the natural world has become*. Almost all nature centers, for example, expose people to the kinds, behaviors, habitats, and interactions of wild plants and animals that live in the local area. Only occasionally, however, do nature center programs emphasize how much the nature being observed is already altered from a pre-human, "pristine" condition. Yet scientists are now increasingly pointing out that there is no place, no environment, no living community of organisms anywhere in the modern world that is *not* impacted by human activity (see, *e.g.*, Vitousek *et al.*, 1997; Jackson, 2001; Wilkinson, 2005; Ehrlich & Ehrlich, 2008; Zalasiewicz *et al.*, 2008).

Our pollutants reach every continent and every part of the oceans; more than a third of global primary productivity and fresh water pass through humanity annually; our impact on landforms and biogeochemical cycling has reached geological proportions. We live in a world that is already dominated by humans, and it is becoming more so every year. What we usually think of as "nature," thus must include humans, not because we *should* be masters of nature, but because we in many ways already *are*. And the more we understand about the history of human influence, the better we understand how the rest of the system operates.

These two "missing elements" of EE are closely connected: *One of the most effective ways to realize and demonstrate the magnitude of human influence on the natural world is through the dimension of Earth science.* Although a "geological perspective" on environmental issues is sometimes used to argue that human impacts are no different from past natural changes and therefore not a cause for concern, there is increasing realization among Earth and life scientists that it shows the reverse: that all major environmental changes – natural or anthropogenic – have major effects on living things, and that many human impacts on the environment are actually more abrupt than many previous "natural" changes (e.g., see Ruddiman, 2005).

Just as current PRI programs try to encourage people to understand the Earth by experiencing their local geology, nature centers like CNC could play a major role in bridging the gap in common popular understanding of large-scale natural phenomena. Global environmental change, for example, can seem like something remote and irrelevant to the lives of individual. Nature center programming, however, could focus on how aspects of local nature have changed under human influence, and exploration of how significant are these changes compared to "natural" variation prior to human impact. Examples include relatively narrow issues such as effects of growing deer populations in the absence of large predators, to broader topics such as diversity and abundance of local fauna, to the largest questions such as the possible impact of human-caused climate change on local biota.

We "now find the causes and effects of climate change hooked to virtually every other environmental problem that has received attention in EE over the past 40 or more years…" (Marcinkowski, 2010: 46).

Putting both nature and human impact in a broad scientific context can thus make it easier for members of the public to understand the scientific basis for suggested changes in human behavior, of the sort that more "activist" elements of environmental education commonly advocate – from recycling to land use decisions to energy production to reductions in greenhouse gasses. It might also lay an objective basis for something that many environmental educators and activists alike have long advocated: development of a different set of *environmental values*. Environmental sustainability, writes John Smyth, "hinges on what people value. Values education … resolving differences between what people need, what they want, and what their resource base can provide without jeopardising the future… is a key factor for success" in such an undertaking (Smyth, 2006: 255-256).

Using nature centers as a means to encourage particular values might strike some educators as more like indoctrination or advocacy than education. Indeed, the distinction is not a bright line; what is viewed by some as "objective information" might be seen by others as "partisan." Yet environmental knowledge should be seen "less as prescriptive lists of topics and more as the necessary means for understanding, wise choices and effective action" (Smyth, 2006: 262).

The real goal of EE is not to direct or even encourage particular activities or behavioral changes; it is to help provide the explicit emotional, aesthetic, and intellectual basis for making real-world decisions about such activities or behaviors. This is critical given the current state of the environment at both local and global scales, and research suggests that information and logic alone do not generally effect significant action.

This simultaneously more direct and more nuanced approach can provide a context for considering not just environmental issues that have mostly been "resolved," such as the need to conserve energy or limit urban sprawl, but also currently active environmental controversies. An obvious example in central New York is drilling for natural gas in the Marcellus Shale: the "environment" is enormously complex; there are no "easy" answers to environmental problems; all environmental options involve some human impact; environmental issues must be examined not just in one time and place but at a variety of temporal and spatial scales; environmental decisions always involve significant and sometimes complex and nonintuitive trade-offs.

In summary: The value and importance of "traditional" nature center programs – direct experience with non-human nature – have never been greater, and the experiences that nature centers have traditionally provided are thus more needed than ever. But in order for nature centers to accomplish their mission of fostering appreciation of nature not just for its own sake but for some greater good, they are going to be compelled in the not-too-distant future to confront some new realities:

- We live in a human-dominated world. Not only do we not live in pristine nature; we do not even visit it when we go to a nature center.
- Familiarity and experience with local nature is still the best place to start, but it is not enough. Local nature in the present must be tied to global nature through geological time and a "systems perspective" of the interconnections among biosphere, atmosphere, hydrosphere, and lithosphere.
- Earth science is not separate from environmental science; and Earth science education must not be separate from environmental education.

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