1. Problem Statement.

Historically science education has been driven by content and fact memorization, reinforced by a focus on preparing students for standardized tests (Marx et al. 2004); many elements of this continue today in K-12 schools, in spite of a call by the American Association for the Advancement of Science (1993) and the National Research Council (1996) for less emphasis on memorizing scientific facts and more emphasis on inquiry-based science learning and active-learning techniques. The surprising observation is that a similar call was made almost 50 years ago to reinvent the way Biological Sciences were taught in schools (especially high schools) (Biological Science Curriculum Study 2005). The BSCS initiative begun in 1958 resulted in the production of 3 different curricula for High School Biological Science; each had a large “inquiry-based” component. The Green Version, “Biological Sciences – An Ecological Approach” (BSCS 2002) in particular employed a variety of active-learning techniques. This version first appeared in the early 1960’s and is now in the 9th edition. The question we face today is why has it been so difficult to institutionalize a new culture for the way science is taught? And what is the evidence that inquiry-based education actually does improve student understanding of science.

The case that inquiry-based or active-learning education approaches actually improve student understanding and appreciation of science is now well documented (see Patrick and Yoon 2004, Max et al. 2004, Gibson and Chase 2002, Gerber et al. 2001). Of course this also reflects how scientific research is actually done by scientists. Why then has there apparently been so little progress in uniformly establishing this approach? The reasons appear to be several.

First one can look to pre-service teacher training experiences. There have been calls for including structured inquiry into the preparation of those who will teach science, but actual research upon the effects of such efforts are rarely reported (Anderson & Mitchener, 1994). In part this reflects differences among student teachers in their personal histories and preferences, and modes of learning. Some student teachers claim that they learn better through hands-on experience while others claim to be more traditional, didactic learners. The former seem to respond better and benefit more from inquiry-based teaching methods courses (Eick and Reed 2002). Thus learning orientations, past experiences in schools, and experience in teaching and doing science on the part of teachers and student teachers all influence the degree to which individuals successfully adopt or integrate inquiry-based education in their classrooms. One way to address this problem would be to adopt inquiry-based educational curricula early in elementary school and early on in teacher training programs.

A second, related problem is how to effectively implement inquiry-based methods in the classroom setting. How does the teacher structure inquiries that could be open ended? How is student creativity best encouraged? How might the teacher and the student “partner” in a program of scientific inquiry and discovery, as opposed to the classical scheme with the teacher
anchored as the authority figure (Tabak and Baumgartner 2004, Polman and Pea 2001)? How does the teacher accommodate differences among students in motivational beliefs and thoughtfulness (Patrick and Yoon 2004)? One of the challenges in motivating students is making the topic relevant to his or her life experiences. In structuring discussions and decision-making processes in science inquiry, how do teachers maximize quantity and quality and avoid making the scientific process seem routine? These are not easy issues to address. They require development and feedback during both pre-service and in-service training.

Some of the most successful inquiry-based science teaching may come about from informal learning (Gerber et al 2001, Zervanos and McLaughlin 2003, Whitehead 1995). How does one utilize this model in a school setting? Addressing this is a fundamental objective of the proposed study here. We have received very positive feedback to our “BioBlitz” biodiversity inventory programs over the past several years from participating students and teachers (e.g. the New London schools, following the 2003 Bioblitz [http://web.uconn.edu/mnh/bioblitz/BioBlitz2003.html]). These programs, open to the general public, provide an intensive 2 day informal learning experience that is hands-on/experiential for all participants. A spectrum of professional scientists from universities, the Connecticut Department of Environmental Protection, and industry participate in the BioBlitz along with accomplished naturalists, the public at large, and kids. These events are infused with an atmosphere of excitement, adventure, wonder, and most importantly, genuine discovery. This was delightfully captured in the 2001 production by the National Geographic Society of the BioBlitz in that year. The show still airs on the National Geographic Channel. Our goal here will be to carry this event into the school classroom.

Thirdly, many science curricula are prepackaged by publishers or various organizations interested in fostering a particular topic. For example, the focus in this proposal is on developing effective methods for teaching biodiversity science in the Middle School. There are curricula elsewhere on biodiversity that are available for classroom implementation (e.g. AMNH 2004). Many of these may be generic and typically have been developed without input from classroom teachers or field trials in classrooms. For inquiry-based science education to be successful, there must be greater involvement by teachers in curriculum design and development (Keys and Bryan 2001). In the design process one must take into account variation in teachers’ beliefs, knowledge, and practices, as well as variation in student learning modes. Of course one must also take into account variation in resources that may be available or can be accessed locally by different schools.

In addition to teacher training and professional development in the sciences, there needs to be a community support knowledge or information network. Where does the teacher go for answers to questions and for science material support? One problem is that scientists are perceived by teachers as being inaccessible or aloof. The challenge is transcending this obstacle and making scientists and science more accessible. One of the objectives in this proposal is to develop a knowledge base network for teachers interested in issues of biodiversity. This includes expert advice, necessary materials (or access to these) and mentoring. The mentoring starts with pre-service contact between student teachers in training and science faculty. These contacts need to be maintained though in-service training and mentoring.

It would be inappropriate to question the significance of science education within middle school students’ experiences because of perceived emphasis upon numeracy and literacy. Indeed, the National Science Education Standards and American Association for the Advancement of Science have championed a “scientific literacy” orientation (AAAS, 1989; NRC, 1996), a
considerable change from the science for future scientists approach from the post-Sputnik era (DeBoer, 1991). Further, the No Child Left Behind agenda will expand to include science within the annual assessment of yearly progress within the next few years. Beyond political movements and policy declarations, there is a moral imperative to provide high quality science learning experiences to all students, independent of their ethnicity, language, social class, etc. (Siegel, 2002). The most recent Science Report Card, based upon the National Assessment of Education Progress effort, reveals a continued achievement gap between White students and their Hispanic and African-American peers (NCES, 2003). Clearly there is substantial need to improve the science education for minority students, including better resources, improved curricula, and qualified science teachers.

The specific science focus of this proposal is on Biodiversity. Why biodiversity? Because it is the diversity of life across levels, from genes to species to ecosystems to biogeographic regions. Food, fiber, fuel and medicine are just a few of the many goods obtained directly or indirectly from wild and domesticated stores of biodiversity. Biologically diverse systems provide many other essential goods and services, from pollination services to forest and fisheries products, nutrient cycling, and global climate regulation. Of the many environmental problems we face today, perhaps the only irreversible one is the global loss of biodiversity. Indeed this is the prime motivation that drives global conservation initiatives, with more than $7 billion being devoted annually around the world to the conservation of biodiversity. Implicit in this investment is a recognition of the importance of biodiversity to humans, i.e., biologically diverse systems provide essential public and private goods that enhance the well-being of local and global communities. Yet the loss of biodiversity continues unabated. We see this in tropical forests, coral reefs, and many other systems around the world. This provides the motivation for Biodiversity as an important topic in biological and environmental sciences and its relevance to individuals. The human aspect allows one to potentially incorporate social sciences or humanities components along with science into the study of Biodiversity. Finally biodiversity is about numbers – numbers of species and their geographic distribution in space and time. The challenge is how and where to sample and how to summarize and analyze the data collected. Biodiversity science thus addresses directly the fundamentals of scientific numeracy.

2. Related Work: There have been several attempts to develop Biodiversity curricula for middle schools in addition to elementary and high schools (e.g. AMNH 2004: http://www.oology.amnh.org/biodiversity/index.html, Biodiversity Education Network 2004: http://www.bioednet.org/projplanning.html, Berkowitz and Hogan 2004, Feinsinger 2001.). Many other supplementary biodiversity educational materials have also been developed for a variety of different audiences – from kids to the public at large. Many of these are available on line and a selection of these is listed below under “Selected WorldWideWeb Sites.” However, there has been little effort to assess or compare these curricula. Moreover, few attempts have been made to involve teachers directly in the design and implementation of Biodiversity curricula. One exception is the SYFEST program (Berkowitz and Hogan 2004). It is noteworthy that there has been considerable success in developing curricula in biodiversity conservation in K-12 schools throughout Latin America (Feinsinger et al., Rozzi, Silander et al 2000, Rozzi and Feinsinger, personal communication).

As a precursor and motivation for this project UConn’s Center for Conservation and Biodiversity (Wagner and Silander are co-Directors) in collaboration with the Connecticut State Museum of Natural History (Harty is Director) and the Two Rivers Science Magnet Middle

A number of other organizations and businesses will either be co-sponsoring or partnering with the UConn’s Center for Conservation and Biodiversity for this event, including the Science Center of Connecticut, Capitol Region Educational Council, Hartford School System, Department of Environmental Protection, and Riverfront Recapture.

Silander has published widely on mapping and modeling biodiversity patterns in Madagascar, South Africa, Chile and Connecticut (see attached Biography for examples) Silander was also involved in the development of an invasive species curriculum unit for middle schools in association with one of his B.S. Honors students, Kate LeRose. See: [http://invasives.eeb.uconn.edu/ipane/curriculum/curriculum.htm](http://invasives.eeb.uconn.edu/ipane/curriculum/curriculum.htm).

Wagner is co-chair of the All Taxa Biological Inventory currently being conducted in Great Smoky Mountains National Park. The effort has an extraordinary record of educational and public outreach for K-12 students as well as undergraduates and graduate students. His new book on Guide to Caterpillars of Eastern North America (Princeton University Press) includes a special section on school activities and curricula. He recently revised the Golden Guide for Insects, the go-to insect guide for children across the nation (see attached CV).

### 3. Methods

This project will consider changes in the understandings and perceptions of three different kinds of Bioblitz participants: middle school pupils, EEB students, and Neag interns. For purposes of comparison, we will administer the questionnaires and interviews to a comparable collection of individuals who did not participate in the Bioblitz. The research questions are:

1) How does participation in the Bioblitz influence participating pupils understandings of biodiversity, sense of environmental stewardship, and perceptions of the scientific enterprise?

2) How does being involved with a Bioblitz in urban settings influence EEB and Neag students’ views of multicultural education, regard for experienced-based learning, and views about culturally resonant science teaching?

Data sources take three different forms. First, members of the project team will create and administer pre-/post-questionnaires addressing particular aspects of Bioblitz for which there is no existing instrumentation. We will draw upon science misconceptions research as well as environmental education inventories created by other researchers that can be tailored to the specific features of the Bioblitz program. Second, we will administer a Nature of Science questionnaire to uncover participant epistemologies and views of the scientific enterprise (e.g., the tentativeness of scientific knowledge). There is an electronic version of a candidate instrument available at stilt.genetics.utah.edu as well as more traditional paper/pencil versions we can use. Finally, we feel it will be necessary to supplement these quantitative measures with individual interviews of a purposeful selection of participants. In particular, because the context of this project is decidedly urban, we are interested to uncover the adult participants’ views of the potential of science education within those settings. One reason we have chosen to do this project in this setting is because of desire to better apprehend the student achievement gaps and we see this as an opportunity to examine the trajectory of scientists’ and educators’ views about urban and multicultural education as a consequence of being immersed in circumstance placing them in collaborative contact with such students.
Quantitative data will be analyzed for changes over time using ANOVA and possible categories of participant conceptions will be subjected to an exploratory factor analysis. Qualitative data will involve coding of transcripts by Settlage and a doctoral student with an eye toward establishing high inter-rater reliability. Potential explanatory themes will be tested against possible disconfirming evidence and ultimately subjected to member checking to insure the credibility of the interpretations. We anticipate sharing the results at a subsequent meeting of the Association of Science Teacher Educators. Because of the necessarily small sample size, our goal is not generalizability. Instead, our ambition is to create working hypotheses for later and greater implementation of Bioblitz’s in the future, perhaps with the support of NSF through a grant we are in the process of submitting.

We are focusing this proposed project on middle schools with substantial numbers of minority or underserved students. The initial focus of the study will be on Two Rivers Science Magnet Middle School. In addition we are exploring partnering with Windham schools, specifically Windham Middle School, and we are in contact with the administration about this possibility. We have also initiated a dialog with the Hartford School System administration about partnering with their middle schools (e.g. Breakthrough Magnet Middle School, Fox Middle School, Hartford Magnet Middle School). Another goal of this project is to develop and customize biodiversity curricula for the needs of particular schools and then to evaluate these products. We will ensure that this curriculum meets National Science Education Standards for "science as inquiry" and "life science" contents (NRC 1996) as well as meeting State of Connecticut standards (http://www.state.ct.us/sde/dtl/curriculum/currsci.htm).

We anticipate submitted a proposal to the CT State Office of Education to support a curriculum development / professional enhancement project which targets teachers in high need school districts. In the 2004-05 fiscal cycle, RFPs specifically focusing upon middle grades and urban districts led to the funding of a dozen professional development projects to commence in summer 2005. Without such funding, the scope of our professional development combined with curriculum development and refinement efforts would target a smaller number of teachers; however, a successful proposal to the Math/Science Partnership competition at the state level would allow us to accommodate at least two dozen middle school science teachers.

Settlage will conduct statistical analyses of the survey data and will advise a science education doctoral student in the coding, analysis and interpretation of qualitative data (i.e., student and participant interviews).

Time frame: The project will commence with the June 2005 BioBlitz. Curriculum development will proceed over the 2005 summer. Curriculum implementation, data collection and analysis will proceed over the 2005-06 academic year. This longer period is required since the outdoor components of biodiversity science are typically constricted to the May to October growing season. However we will examine other outdoor activities related to biodiversity during the non-growing season. Final reports will be filed by the summer of 2006.

4. Expected End Products:
   TNE report and presentation.
   Presentation of results at targeted conferences (Ecological Society of America, Society for Conservation Biology, Association of Science Teacher Educators (Northeast Region and National)).
   Articles in peer reviewed journals (e.g. Conservation Biology, The American Biology Teacher, Journal of Science Teacher Education)
The above scholarly outlets will provide specific recommendations for the practice of experiential based science teaching, based on evidence gathered in this project, that are generalizable to other Middle School settings. We anticipate that element of this project may be adapted for other K-12 educational settings.

Professional Development seminars for Connecticut teachers on the topic of Biodiversity Science.

Development of a resource network partnering among middle schools and teachers with the Department of Ecology and Evolutionary Biology along with two other UConn institutions - the Connecticut State Museum of Natural History and the Center for Conservation and Biodiversity. Moreover this project will forge a close partnering between these entities and the Neag School of Education, which is a primary objective of the Teachers for a New Era Program.

This proposed project is partnered with an NSF-IGERT (Integrated Graduate Education and Research Training Program) proposal entitled “IGERT Biodiversity – Science, Valuation and Policy” that is being submitted simultaneously. This NSF project will augment the project proposed here. It will provide for the development of a novel trans-disciplinary curriculum in Biodiversity Science. We have submitted one other NSF proposal that includes funds to forge connections between UConn and Hartford area schools in Biodiversity science and will soon submit another proposal to the new NSF program - Partnerships for International Research and Education. These will foster international connections among schools studying Biodiversity in South Africa and Latin America.

Regardless of whether this proposal is funded, CCB and CSMNH will sponsor and run a biodiversity inventory “BioBlitz” on June 3-4, 2005 in collaboration with Two Rivers Magnet School. This event is supported with outside funds and is co-sponsored by several organizations and businesses (listed above). For more information about our BioBlitz initiative see http://web.uconn.edu/mnh/bioblitz/ and the announcement for BioBlitz 2005 attached below.

Curriculum enhancement and development in Biodiversity: We will provide and test a middle school curriculum for Biodiversity that will be implemented at Two Rivers Science Magnet Middle School in East Hartford. We will also develop, modify and evaluate this curriculum in at least one other underserved middle school.

Biodiversity “Boxes” donated to participating schools. These are modeled on the “Biodiversity Box” idea developed by ATBI educators in cooperation with Discover Life in America http://www.discoverlife.org/ These “boxes” will contain materials and supplies to get biodiversity studies off the ground – collecting devices for plants and animals, storage devices for specimens, identification manuals, and curriculum material mentioned above. One “Biodiversity Box” will be supplied to the Two Rivers Science Magnet Middle School as part of the scheduled 2005 BioBlitz.

CD Copies of the film produced in 2001 by National Geographic Television entitled “BioBlitz.” This film was developed by NGS in partnership with CSMNS and the department of Ecology and Evolutionary Biology UConn, and filmed at Tarrywile Park, Danbury, CT June 8-9, 2001. In addition to this we have the following supplementary materials available:

PictureShow series. Explores the characteristics of living things and shows how familiar and unusual organisms meet their basic needs. CD contains two shows, user’s guide, scripts, student information, and classroom activities. ISBN 0-7922-6004-X

5. Personnel (Curricula Vitae for each attached):

Principal Investigator:
John Silander, Professor of Ecology and Evolutionary Biology, University of Connecticut

Team Members:

Leanne Harty, Director, State Museum of Natural History, University of Connecticut

John Settlage, Associate Professor of Curriculum and Instruction, Neag School of Education, University of Connecticut

Edmund Smith, Science Teacher, Two Rivers Magnet Middle School, East Hartford

David Wagner, Associate Professor of Ecology and Evolutionary Biology, University of Connecticut
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2004. Inquiry-based science in middle grades: assessment of learning in urban systemic


Selected WorldWideWeb sites relevant to Biodiversity Science Education:

American Museum of Natural History – Biodiversity: http://www.ology.amnh.org/biodiversity/index.html
Biodiversity Education Network: http://www.bioednet.org/
Biodiversity Education UNH: http://www.sustainableunh.unh.edu/biodiv_ed/
Biodiversity resources, Colorado State University: http://www.nrel.colostate.edu/IBOY/links.html
Connecticut Department of Education, Division of teaching and Learning - Science: http://www.state.ct.us/sde/dtl/curriculum/currsci.htm
GloBio Organization: http://www.globio.org/
National Science Teachers Association, Building a Presence for Science: http://ecommerce.nsta.org/bap/

Selected International Biodiversity Web links:
Botanic Gardens Conservation International - Biodiversity Education for All: 
http://www.bgci.org.uk/education/biodiversity_education_for_all.html

British Museum of Natural History - FATHOM consortium on Biodiversity: 
http://www.fathom.com/special/biodiversity/

Canadian Biodiversity Education and Public Awareness: 

Costa Rican Instituto Nacional de Biodiversidad: 

Museums of Cape Town South Africa, Biodiversity Explorer: 
http://www.museums.org.za/bio/

WWF-South Africa: Biodiversity Conservation projects: 
http://www.panda.org.za/cep_projects.htm