# Global Conservation Education

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The challenges of preserving biodiversity are facing every country on the planet. However, with the exception of a few notable instances such as the afforestation efforts to fight desertification in Africa led by the late Nobel Laureate Wangari Maathai “Green Belt Movement,” work outside of the United States, Northern Europe, and Japan rarely receives much attention.

We need to redress this oversight because it will take a concerted global effort to address what some experts have referred to as the “age of the greatest extinction ever.” We do not have the option of being ostriches with our heads stuck in the sand. Nor can we say (NYIB) “not in my backyard” because on such a small planet, “everyone lives downstream.” Ecosystems are globally connected, due to rapid air travel, so emerging infectious diseases such as the SARS virus can jump from a bat to a ferret in a rural meat market to nearly every major city in China. A West Nile virus in a migrating stork in Israel can jump to crows in New York City and within a short time across the whole United States. Invasive species of plants terraform whole islands, coral reefs are bleaching pervasively and global warming is causing shrubification of alpine meadows.

For this Issue, Guest Editors Lily Rodriguez of Peru and Nathalie Zamora of Costa Rica worked with us to attract contributors, who as researchers and educators, have been working hard to address these conservation issues. Ten country cases (Australia, Brazil, China, Costa Rica, India, Peru, Russia, Singapore, United States, and Ukraine) and 12 projects are included. Our contributors describe their experiences in developing, implementing and evaluating their conservation initiatives, within their specific contexts, in terms of biodiversity resourcing issues, challenges, environmental impacts and ecosystems. The initiatives vary tremendously in terms of scale, timeframe, available resources, access to technology, and potential for sustainability. They vary according to target groups, participants, and beneficiaries of these projects. But, foremost these contributors' projects share the overall goal to inspire and resource participants such that they appreciate the diversity of life and can address some of the specific threats to the biodiversity and ecosystems in their regions of the world.

Read collectively, through what these educators have observed, developed, used, learned, archived, and advocated, some common strategies and processes emerge that can transcend the particulars of their contexts and projects to inform similar work by others. For example:

- Many projects treat local participants as researchers of their ecosystems and teach them how to observe, collect, archive, and analyze data. Beyond that the model "Citizen Science" expands participants' roles as researchers and scientists by honoring their prior knowledge, engaging them in establishing the criteria for worthwhile problems, choosing the sorts of data to collect, actually analyzing the data, and deciding how the work should be shared and vetted by the larger community. All projects engaged their participants, to various degrees, in processes of doing conservation science.

- Many contributors critiqued the traditions of teaching science in classrooms versus the field. They critique memorization versus active construction, individual versus
collective and collaborative work, and individual assessment versus peer review processes. Thus, the projects described in this issue engaged participants in the latter, more active and collaborative aspects of teaching and learning.

- Several projects created resources, developed databases, and established communication networks. Thus, they enabled participants to link with others in the global community so that knowledge and resources could be shared and expanded. Thereby, these educators involved local participants in the collaborative construction and expansion of the knowledge base of conservation science.

- Many projects developed ways to engage participants in critical discussions of the issues raised by their local investigations with the intent of impacting the participants’ personal choices and propensity for stewardship and activism.

- All projects respected local indigenous communities and knowledge; they recognized the value of directly learning from, involving and empowering local people. In that sense, they practiced and advocated much like phylogeneticist Jonathan Eisen, who argues that secrecy and silencing have stymied scientific progress and public interest and support for science. Eisen, like many of the contributors here, believes that greater direct participation of citizens in science ("Citizen science") will greatly benefit us all.

What can we learn from such a diverse collection of context specific initiatives?

We believe that this issue of Biology International provides a way to expand our own knowledge base and tool kit for action plans. The individual experiences and stories here are inspiring on their own. They describe how conservation educators have creatively and ingeniously used their available resources and capacities (sometimes meager, sometimes extensive) to develop appreciation, problem solving, capacity building, and activism for biodiversity conservation. But, beyond that, these reports so richly describe the particulars of their ecosystems, participants’ backgrounds, educational interventions, challenges overcome, that they render approaches, opportunities and possibilities so others can recognize what can be extrapolated, adopted, adapted, and mashed-up. Essentially DIY!

John R. Jungck, Editor
The Project *Cyberhives*: Virtual Learning Communities was developed with the objective to promote the innovative use of science and technology in the classroom, on field (wild protected areas) and in cyberspace. It aims to generate practical experiences and projects that stimulate student learning of biodiversity in primary and secondary schools. By taking advantage of tools and experiences developed through social networks in cyberspace, *Cyberhives* allows students, teachers and scientists of the National Biodiversity Institute (INBio) to form virtual communities so that students experience all stages of the work done by taxonomists using the technology of the XXI Century. *Cyberhives* is supported in a collaborative environment on the web and through the experience of the Bioliteracy Program of INBio. The minimum desirable time for its implementation is one year, and schools must have a computer lab with Internet access. The process includes (1) training of teachers and students, (2) the development of a group project on local biodiversity, (3) interaction with parataxonomists, scientists of INBio, and other students and teachers through the web site of *Cyberhives*, and (4) monthly visits to educational centers. The program finishes with the presentation of the results in a science symposium at the end of the year. This process is not limited to biological or other science topics. The constructivist orientation in the development of projects, as well as the informatics tools developed, allows for the implementation of virtual communities in practically any other subject that teachers want to develop. The significance of the results includes a direct benefit to approximately 1500 students and more than a hundred teachers around the country. It has helped improve the quantity and quality of science projects in rural communities. We hope to scale the project to a national level.

El Proyecto Cibercolmenas: Comunidades de Aprendizaje sobre Biodiversidad nace con el objetivo de incentivar el uso innovador de la ciencia y la tecnología tanto en el aula, como en el campo (áreas silvestres) y el ciberespacio, para la generación de vivencias y proyectos que estimulen el aprendizaje sobre la biodiversidad del estudiantado de primaria y secundaria. Aprovechando las herramientas y experiencias existentes en el desarrollo de redes sociales en el ciberespacio, Cibercolmenas permite a estudiantes, docentes y científicos de INBio formar comunidades virtuales para que los estudiantes experimenten todas las etapas del trabajo que desarrollan los taxónomos usando las tecnologías informáticas del Siglo XXI. Cibercolmenas es una metodología apoyada en un ambiente de trabajo colaborativo en el web y en las experiencias del Programa de Bioalfabetización del INBio. El tiempo mínimo deseable para su implementación es un año lectivo y las escuelas deben tener un laboratorio de cómputo con acceso a Internet. La metodología incluye capacitación a docentes y estudiantes, una visita-campamento a INBioparque, el desarrollo de un proyecto grupal sobre la biodiversidad de su localidad, interacción con parataxónomos, científicos de INBio y otros estudiantes y docentes por medio del portal de Cibercolmenas y con los parataxónomos de INBio a través de visitas mensuales a los centros educativos, y culmina con la presentación de los resultados de las investigaciones en un simposio científico al finalizar el ciclo lectivo. La metodología de Cibercolmenas no se limita a temas biológicos o científicos. El enfoque constructivista y orientado a proyectos, así como la herramienta informática desarrollada permiten la implementación de comunidades virtuales en prácticamente cualquier tema que los docentes quieran desarrollar. Cibercolmenas ha permitido beneficiar a más de 1500 estudiantes y 100 docentes de todo el país, así como el mejoramiento de la cantidad y calidad de los proyectos de investigación en comunidades rurales.

Key words: *Cyberhives*, INBio, biodiversity, Costa Rica, information and communication technologies, virtual communities of learning, schools, high schools, wild protected areas.
Introduction
The present article refers to the evaluation of the project Cyberhives: Virtual Communities of Learning on Biodiversity, a successful experiment in education for the conservation of biodiversity. In Costa Rica, environmental education or education for the conservation of biodiversity is considered successful if it demonstrates the fulfillment of the following criteria according to the National Commission of Environmental Education (CONEA) in the 2010:

1. Conscience Development: Information that shows the development of a constructive process throughout time.
2. Knowledge: Information that shows the growth of the knowledge throughout the project.
3. Attitudes: Information that documents favorable environmental actions on behalf of the target group.
4. Capacity of evaluation: Information that shows development of the capacity of evaluation of the vulnerability of the sites, of the responsibility of the human being and of the risk that is assumed with the individual or collective decisions.
5. Participation: Citizen participation in the resolution, minimization and/or prevention of environmental problems.

This article is divided into 11 sections: Background of the project; Problems addressed; Goals; Theoretical and methodological approaches; Implementation; Benefitting population; Results and impacts; Resources used; Learned lessons and analysis; and References.

Background of the Project: The educative system in Costa Rica
In Costa Rica, as in many countries in the world, the classroom reigns supreme as the only learning space for the students, particularly in primary and secondary school. However, diverse education theories have significantly supported the necessity to incorporate more educative spaces that complement the classroom (Rodriguez et al., 2000). Some examples are: an open classroom where the students understand better the world that surrounds them and offers the opportunity to observe and to interact directly with different components of their environment and, more recently, cyberspace. Zúñiga and Arnáez (2009) mention that current information on any subject can be easily accessed allowing users to interact in real time and achieve a better understanding about anything (Web 2.0).

Another area to improve in the Costarican education system resides in the memorization and conduct approaches that still reign in the system. Frequently, it has been observed that teachers of different disciplines reinforce the use of memorization, making it the predominant educative strategy throughout the school years. Nowadays, however, there is a growing emphasis on using constructivist strategies to generate significant learning in students (Díaz and Hernandez, 1999).

In the last years, the public education system of Costa Rica has been making an improvement by developing research projects as part of the work that must be executed by students with the guidance of its teachers, to promote the development and popularization of scientific attitudes (Durán et al., 2007). Although the execution of these projects takes up several months in the school.
calendar, it has been observed that the months turn into only a few weeks in the development of the project. By consequence, there is a decrease of the practical experience to which the student is supposedly exposed.

There is an enormous opportunity to use more of the Technologies of Information and Communication (ICT) to serve education goals. Although, the development of education in Costa Rica has not gone hand-in-hand with the development of technology, specifically in ICTs, it has been generally seen that a significant percentage of the student population with access to ICT frequently uses this technology in an informal way for recreation and entertainment purposes, which leaves the educational goals and objectives that potentially could be developed from their use last; furthermore, the number and the quality of the researches made on the uses and forms of incorporation of the ICT in formal education have not grown in an equal rate as the uses and experiences’ growth (Ramirez, 2006). One of the main reasons is that the present methodologies of teaching and learning in schools are based on conventional methods that do not include technological means or devices based on ICTs. Ironically then, the schools do not use the very technologies that the students prefer to use!

Based on a study of the Advisory Commission on High Technology (CAATEC) (Ruiz, 2009), only the 42% of the educative centers of Costa Rica have broadband Internet connection. From these educative centers, 39% of public schools and 61% of public high schools have this kind of connectivity. In addition, significant differences exist between the connectivity of the countryside (33.3%) versus the urban regions (70.7%). As far as the speed, most of schools have access to connections between 256 and 512 kbps (Ruiz, 2009). The current government plans to extend broadband connectivity to all sectors of society. At the same time, there is a technological agenda in the Ministry of Public Education directed towards greater innovation in education and learning (Méndez, 2011).

**Environmental Values of Costaricans**

The environmental situation in the country has improved in the last years with respect to the recovery of habitat, particularly secondary forests in all the country (SINAC-INBio 1999). (Figure 1)

![Figure 1](image)

Figure 1. Note the tremendous ecological change over the last 60 years which has resulted in tremendous fragmentation of ecosystems in Costa Rica.

However, there are still environmental problems that harm the conservation of environment. According to a study on environmental values, Costaricans do not consider the deterioration of the environment as a high-priority problem. At the same time, the majority thinks that the environment’s health is getting worse (UNIMER, 2002). This study also mentions that Costaricans consider the pollution of the rivers as the main environmental problem, among others.
At a world-wide level, the CBD (2010) mentions that the main threats to conservation are deforestation, climate change, introduction of exotic species, and illegal hunting, amongst other things. Costa Rica takes the Latin American first place in the Environmental Performance Index, according to the Columbia and Yale universities in the United States. Recently however, the country has been harshly criticized due to the development of its growing agricultural models (as for pineapple) and some tourist projects (developed apparently without studies of territorial ordering and environmental impact) (Avendaño, 2005). The CBD globally supports the development of programs of environmental education in formal spaces as a real strategy towards the development of better prepared people to successfully face the progress of true sustainable development.

The National Strategy for Conservation, INBio and its bioliteracy program.

The Institute of National Biodiversity (INBio) is a nongovernmental organization, based on and decreed by public interest focused on the biodiversity’s research and management. Its action fields are research and technological innovation, business management, and, education and conservation for biodiversity. Its mission is to promote a greater awareness about the value of biodiversity as a means to improve the quality of life for human beings. Costa Rica has adopted a national conservation strategy composed of three main actions: Save-Know-Use (Figure 2) and INBio has been concentrating on Knowing and Using biodiversity through developing sustainable actions.

Strategically, it is believed that the best way to conserve biodiversity is the simultaneous execution of these three actions, where each one depends on the other to obtain a successful sustainable development. For example, in order for the people to obtain goods and services from nature through time it is required they develop scientific knowledge from natural areas. At the same time, to be able to keep executing actions of use and knowledge about nature, it is indispensable to preserve wild representations of forests indefinitely. INBio has been supporting this strategy for more than 21 years through an institutional core process that consists of three stages: Capture/generation; Administration/Interpretation; and, Sharing. (Figure 3)
As part of the “Capture” component, INBio has been working, using specific standards, to make a collection of specimens focused in terrestrial biodiversity: fungi, plants and arthropods. At the same time, each specimen report is entered into a public database (processing). Finally, the process of information transference is based on the bioliteracy concept which is understood as, "a dynamic hands-on continuous learning process that empowers the individual to appreciate biodiversity, embrace an ethics of respect for life, and assume responsibility in the management and conservation of all living beings and ecosystems” (Gámez, 2008). By means of bioliteracy, people acquire a greater awareness about the value of biodiversity and hopefully become citizens who not only know very well the biodiversity of their country, but, also become aware of its value and carry out concrete actions to preserve it. In order to make the processes more attractive and accessible, INBio has introduced methodological innovations by using different ICTs.

Examples of bioliteracy activities of INBio include a training program for parataxonomists: men and women of rural areas of Costa Rica are enabled to initially collect, mount and identify specimens of plants, insects, mollusks and fungi. They provide information on the natural history of the specimen and act like educators in their communities (INBio, 2010). Another initiative of bioliteracy is the creation of INBioparque, a theme park based on biodiversity, and which has been called the “house of bioliteracy.” It offers practical and interactive learning experiences to thousands of visitors on the importance of biological resources. Another initiative is INBio’s Publishing house, which has more than 100 titles published and has twice won the National Council of Science and Technology prize. Other programs in which actions of Bioliteracy take place, are the Training Guide Programs that include the certification of Naturalistic Guides and the spreading of information on biodiversity using the radio communications, written press, television, Websites and social networks.

More recently, INBio has implemented the Cyberhives project, conducted from 2004 to the present (in three phases). Methodologically, it is oriented to improve education in the natural sciences and to take advantage of ICTs in rural education centers of Costa Rica, through the creation of virtual communities of learning about biodiversity (Mata et al., 2007).

**Problems addressed by the Cyberhives program**

**Low quality in education and in biodiversity learning.**

The report of the State of Nation 2010 reveals the urgency to incorporate pertinent information into the education system in the country. According to the report, it is crucial to harness the advantage of the ICTs to stimulate creative thought and the development of abilities to investigate, problem solving and teamwork. All of these could be catalysts for the benefit of greater educative quality levels.

**Citizens do not value their local environment and/or they do not know how to use it sustainably**

Most of the citizens of Costa Rica feel responsible in contributing to the deterioration of the environment and consider that information and education are the most useful tools for helping people contribute to the conservation of the environment (UNIMER, 2002). This shows the importance of the work that INBio has been doing to forge citizens
as naturalists. This concept has guided institutions to build interactive and practical learning experiences to allow individuals to become sensitive about the value of biodiversity and to accept responsibility in the handling and conservation of local biodiversity (Gámez, 2008).

Goals of the Cyberhives Project
The general goal of the Project is to promote the innovative use of science and ICTs in the classroom, wild protected areas and cyberspace in order to generate experiences and projects that stimulate students to learn and build knowledge about their local biodiversity.

Specific goals
1. To use techniques which promote interest in students about science and technology, and influence and motivates them to learn and be actors in educative and environmental processes.
2. To enable collaborative relations among students, teachers, INBio's specialists, technicians and employees of the region’s MEP and MINAET.
3. To establish long-lasting alliances among education centers participating in the Project by interacting, sharing accomplishments, and culminating in presentations of the Project’s results.
4. To build up communities of virtual learning that integrates people of INBio, MEP, MINAET, FOD and students, both in classroom processes and research experiences.
5. To promote the development of naturalist citizens who value their local biodiversity in the rural areas of the country.

Theoretical and methodological approaches
The environmental education approach is to benefit communities so they will be suitably informed about their environment. It is based on theories of significant learning, open classrooms, constructivism and project-based learning (PBL).

Constructivism is a theory of learning that allows for the construction of knowledge through interaction of individuals with their surroundings. Diverse sources postulate that through the constructing of concepts, students can successfully increase knowledge of their social and natural environment and stimulate motivation and personal growth. Ausubel, Diaz, and Hernandez (1999), state that significant learning can be experienced by means of constructivism, when students substantially relate new information to previous knowledge and experiences. This allows them to identify, to value, to develop and to articulate educative projects that go beyond one’s own necessities and possibilities (Torres, 2004).

A characteristic key of project-based learning is that the project does not focus on learning concepts, but in solving a certain problem (Moursund, 2003). PBL has its roots in the constructivist approach that evolved from the works of psychologists and educators like Jean Piaget, Lev Vygotsky, Jerome Bruner, and John Dewey; therefore it allows for the construction of knowledge (Diaz and Hernandez, 1999). In addition, it facilitates a process whereby students share ideas, opinions, and serve as points-of-contact to negotiate solutions. These are fundamental aspects of coexistence in society (Galeana, 2006).

Implementing the Cyberhives project
Next is a brief summary of the strategies used in implementing the project.
1. Induction and diagnosis. It consists of presenting/displaying the Cyberhives project to teachers and
students of selected schools. A questionnaire is used to diagnose the interests of the students with respect to the Sciences and assess their previous knowledge in biodiversity and informatics.

2. Teacher Training. This consists of preparing teachers in subjects of education and informatics applied to the knowledge of biodiversity; so that they can guide their students in the development of projects for research.

3. Student training in biodiversity and bioinformatics. This is starts with a visit to INBio’s facilities, where students develop learning activities with parataxonomists and scientists. In addition, the students can become qualified in the use of technological tools, like cyber-taxonomists.

4. Execution of scientific projects. This starts with the selection of scientific projects that are to be developed in the next months with the support of a virtual community of learning (other students, scientists, educators, and the use of informatics). The projects are executed under the supervision of a general coordinator of Cyberhives, a parataxonomist who periodically visits them in their schools, and the support of a virtual community. The project includes all the stages of the scientific method. Among them are the clear definition of objectives, materials, methods, as well as the field, and bibliographical research. It uses INBio’s data bases and other research centers on the Internet. (Figures 6, 7)

5. Presentation of results of the project researches. The students present/display the results of their projects in a Scientific Symposium developed in INBio.

6. Evaluation of the results of Cyberhives. Finally, another questionnaire is applied to evaluate the results of the project compared to the initial diagnostic questionnaires.

Benefiting population.
The primary beneficiaries are the primary and secondary education centers and the science and informatics teachers. As of now, more than 1200 students and 100 educational centers throughout the country have participated (Figure 4, third phase 2010-2011).

![Figure 4. Map of Costa Rica indicating the location of selected education centers participating in Cyberhives in 2011.](image)

Results and impacts
1. Students with new knowledge and greater sense of value of local biodiversity.
2. Students with more motivation to learn scientific subjects by using the information and communication technologies.
3. Educators with abilities and skills to use the methodology of Cyberhives in the improvement of education in the science subjects.
4. Education Centers present themselves as innovative institutions in the education of natural sciences, pioneering in forging naturalistic citizens of the 21st Century.
Figure 5. Percentage of participating students in scientific fairs at the beginning (green) and at the end (yellow) of the project (2008).

Figure 6. Students working on projects.
Learned lessons / Final analysis of the Cyberhives Project

Finally, more can be determined about the performance of this experience using the criteria mentioned at the beginning of the article (CONEA, 2010):

1. Conscience Building: Cyberhives is based on a constructive process that starts working with the previous knowledge of the participants and continues its development throughout the project. Through the generation of local knowledge it seeks to add values in individuals that translate into environmental actions. For example, there was the creation of butterfly gardens, native plants gardens in schools and reforestation projects. Also, the project recurs to a specific social group to be evaluated before and during the process. It also recurs to the use of participative, reflective methodologies, and of significant learning that originates and/or reinforces environmental conscience.

2. Knowledge: The project has demonstrated the development of knowledge in environmental subjects. With each phase, the students defend their projects of research and everything they learned through the school year. The symposiums organized at the end of the project are opportunities for it, since the students must demonstrate all they have learned throughout the project’s process. Many of these projects have managed to connect with their communities (environment-economy-culture). (Figure 5)

3. Attitudes: Cyberhives looks for the active involvement of the student in learning about their immediate surroundings, which can be described as the development of pro-environmental attitudes. The main criteria for this is based on demonstrating responsibility for recovering biodiversity and sustaining local initiatives with no need for direct participation of other institutions. Some limitations in meeting these criteria have been: the infrastructure at the national level, Internet connectivity and computer laboratories.

4. Capacity of evaluation: The main opportunity of improvement in these criteria is the generation of more environmental actions after the project concludes. Evaluating these criteria is not possible because there is no follow up after the project finishes. However, there is some data that Education Centers have
continued to develop local projects of investigation today. We would probably find that that many more keep doing it if we had more follow-up information, or if forums were developed to communicate on behalf of the beneficiaries of the project and to share knowledge or to take care of specific problems. In order to develop and assess these criteria further, it is necessary to develop an evaluation with longitudinal indicators.

5. Participation: Cyberhives has managed to motivate communities consisting of other students (children and young) and teachers who wish to be part of this project. It is desirable, for environmental purposes, to integrate more adults of the communities, and diverse cultural and social groups. In some cases, the research projects of the students actively engaged other local people and government agents from their own communities through interviews and contacts. The participation of private companies, government and municipal offices is recommended, in the planning, execution and evaluation of the activities and environmental projects that are being generated as in Cyberhives.

References


Natalia Zamora is the Director of Education and Communication at Costa Rica’s National Biodiversity Institute (INBio). She works at INBio since 1995 and has had several positions within the institution, from Communications Officer and Social Outreach Coordinator to INBioparque’s General Manager and Entrepreneurial Development Director. Her working experience ranges from areas such as education, public involvement, management and product development to communications and international consulting. She led the development process of INBioparque, a 20 acre biodiversity theme park, house of Bioliteracy in Costa Rica. She also has the experience in training teachers in environmental education methods. Ms. Zamora has worked as an International Project advisor and consultant for the United Nations Development Program (UNDP), United Nations Office of Programme Services (UNOPS), the Norwegian Nature Research Institute (NINA), USAID and World Bank among others. Currently Doctorate Candidate in Environmental Education at Universidad Autónoma de Madrid, Spain. She holds a MSc. in Environmental Education and Communication Sciences of the College of Forest Wildlife and Range Science, Resources, Recreation and Tourism Department at the University of Idaho, ID, USA and a Bachelor’s Degree in Collective Communication Sciences of the University of Costa Rica.

Alejandro Calvo is the Coordinator and leader of the Education Program at the National Institute of Biodiversity (INBio). He is responsible for enforcing and strengthening objectives of the Environmental Education Strategy at INBio. He coordinates projects based on the environment, science and technology aimed at primary and secondary schools, with an emphasis on rural communities. Mr. Calvo also supports the efforts of the various units of INBio to translate scientific information into a language understandable to the general public and participates in the development of educational offerings for public and private sectors. He also helps build strategic alliances with various national and international bodies to promote bio-literacy and research in environmental education. He holds a bachelor degree in Tropical Biology in the University of Costa Rica; and in Teaching of Natural Sciences in the State Distance University (UNED). At the moment he is developing its thesis to get its Masters degree in Natural Resources Management at UNED with emphasis in Environmental Education and Biodiversity.
An Innovative Approach to Biodiversity Conservation Education

Shivani Jain and Shefali Atrey
Centre for Environment Education, India
Website: www.ceeindia.org
Email: shivani.jain@ceeindia.org

Even with the rich biodiversity heritage in the Indian subcontinent, there is a strong disconnect between people and the way they perceive their ecological heritage. This article, through two Formal Education initiatives, establishes the effectiveness of multidisciplinary and real-life based teaching-learning approaches in biodiversity education in the Indian context. The article argues that while the Indian Formal Education system has created opportunities for such initiatives, there exists a large gap between the curricular goals (in biodiversity education) and actual outcomes of classroom-based teaching-learning processes.

Keywords: biodiversity education, formal education, agro-biodiversity, experiential learning, multidisciplinary teaching-learning

Introduction
India is extremely rich in biodiversity. It is one of the twelve countries, which together account for more than 60 per cent of the world’s biodiversity. A land of high species richness and endemism as well as of agro-biodiversity, India, with about 2.5 per cent of the world’s landmass, supports an astounding 8 per cent of the world’s biodiversity. India is unique, not so much for the numbers of species, but for the range of biodiversity, which is due to the diverse eco-geographic zones. It is appropriately called a sub-continent in itself!

Further, India is also one of the world’s oldest agricultural societies. India is characterised by a complex mosaic of distinct agro-ecosystems, differentiated by their climate, soil, geology, vegetation, crops grown and other features. Irrespective of a call for intensifying industrialization, India, in recent years has remained predominantly an agrarian economy. The stability and sustainability of its agriculture is therefore of paramount importance.

With the importance of agriculture in and for India, it could be a pivotal part of the curriculum of school education in the country. However, the understanding of biodiversity and agriculture varies with the context provided to the young learner through their surrounding environment. In most cases, it remains limited to mere theoretical chapters in their science and social science textbooks.

It is so, because today the Indian formal education system at large, deals with the science of biodiversity and its significance for the country’s socio-economic life, in only a few paragraphs in the textbooks of science in primary and secondary grades. The real-life connections, in the teaching and learning of biodiversity and its conservation, are rather weak in the formal education system today.

Unless these links are strengthened and connections are made, we predict that India will soon have a generation of young urban citizens who:
Would be oblivious to the critical importance of biodiversity in Indian life, economy and polity.
Will fail to appreciate the symbiotic relationship between farmers, cattle, and crops; and their own lives.
Would find ‘biodiversity and farming’ a romanticized concept in their textbooks, to be adored and expressed merely through poetry and paintings!

The fast emerging disconnect in the formal education system, between theory and practice of biodiversity and its conservation, needs to be addressed urgently. There is a felt need to review the way environment and biodiversity and related ideas and concepts are taught and learned. This paper describes two case studies aimed at making biodiversity conservation education (agro and herbal) real-life based. We have explored several creative educational approaches and efforts that we believe are required to make biodiversity education meaningful in the agrarian economy of India.

Case Study Examples
During 2009-2010, two experimental programmes, referred to as Case Studies in this paper, reached out to two different populations:

1. 160 grade 8 (13-14 year olds) students and their 4 science and social science teachers.
2. 50 undergraduate students of Computer Science, Electronics & Communication and 5 undergraduate lecturers in Computer Science, Electronics & Communication.

Case 1: Students in a city school learn about Agro-biodiversity
The science and geography of agriculture dealt with in textbooks provided an opportunity to introduce ‘Agricultural Biodiversity’ to young learners in a city school. A team of conservation educators from the Centre for Environment Education (CEE) 1 worked with about 90 students of grade VIII (13-14 year olds) in a city school in Ahmedabad, Gujarat, India. This 7-month programme, called ‘CEE ka Biscope’2 (CKB) is an ICT enabled educational module meant for students in the age group of 12-15 years old. With focus on learning for life, the activities of the module help integrate Environmental Studies, Science, and Mathematics as well as Social Sciences.

In the year 2009 and in 2010, a special CKB Module with a focus on agro-biodiversity encouraged the young learners in a city school to understand biodiversity beyond text-books, and helped them explore Agricultural Biodiversity in a way that is practiced in the farms and fields.

Agro-biodiversity: All About my Food!
Learning is a life long process. However, children and adults have very different learning processes and needs. While adults are motivated by the purpose and result/s of learning, children are motivated by the process itself! Thus, if children could decide, they would often chose to keep the process going for a long period of time.

In this case study, the learning design of the module on agro-biodiversity conservation

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1 Centre for Environment Education, India (CEE) is a pioneer institution that has been working in the field of education for sustainable development for over two decades. For more information, log on to www.ceeindia.org

2 CKB is a practice-based learning module. Interpreting the local environment and surroundings is integral to the philosophy of this module. The module involves interaction of students with maps, satellite imageries and several computer-enabled data interpretation applications, appropriately combined with several other teaching techniques including field trips, classroom sessions, games and activities.
was inspired by methods developed by John Dewey\(^3\) and William H. Kilpatrick\(^4\).

**The Methods of Learning**

John Dewey (1859-1952) wanted to develop a school in which the students could explore, create and experiment. A school which formally divided educational content into study areas, lessons, subjects and tasks was not congruent with students’ needs for comprehensive learning. William H. Kilpatrick's (1871-1965) theory of learning emphasized what he called “purposeful activity” engaged in by pupils as they worked on a variety of projects. He also introduced the need of group work as a learning tool.

The module was designed in a way that students were encouraged to explore, experiment and learn. The learning skill moved from ‘known to the unknown’ and ‘concrete to abstract’. (Figure 1)

![Figure 1. Module Processes](image)

Instead of beginning with definitions of biodiversity, the number of species and cropping patterns in India, etc., the Module began with a brief activity titled, ‘*All about my food*’. The students, in groups of two, made an inventory of dishes they usually ate for breakfast/lunch/dinner. They then tabulated these dishes, detailed the ingredients in them and mapped in which part/region/state of India they are grown. Using GIS based interactive portals, they ended by tracking the miles/kilometers that each of these ingredient items is likely to have traveled before reaching their kitchens and platter! (Figure 2)

For these young urban citizens, this was a revelation—their direct dependence on agro-biodiversity! This provided them a new outlook towards ‘biodiversity, farming, crops and farmers’. Biodiversity was no more a distant concept to them, locked somewhere in dense forests, but it was very much around them, in the vegetable markets and in their own kitchens!

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\(^3\) John Dewey has been one of the most influential thinkers on education in the 20\(^{th}\) century. Dewey's work is known for the attention he gave to the critical impacts of experience and reflection, and democracy and community, for learning (see Dewey, 2009).

\(^4\) William H Kilpatrick (1926) furthered Dewey’s philosophy and work on learning, and expanded it into the ‘Project Method’ of learning.
Green Revolution, Food Security
The stage was now set for the CEE-CKB team to discuss with them the evolution and development of agriculture in India. The science and practice of agriculture, the importance of agro-biodiversity as well as agriculture technology: seed science, irrigation, storage of grains, high yielding varieties, mixed-cropping, etc. were discussed.

‘Green Revolution: the two sides of it’ was a topic discussed in great length with the students. A number of real-life case studies from the major wheat and rice growing states of the country were provided to groups of students. They were then asked to
do more research on those cases and provide an in-depth analysis of information contained in each of the cases. Students were also asked to visualize what might the Indian agriculture scenario be like today, had there been no Green Revolution in the country. This helped students realize both the advantages and disadvantages of the Green Revolution in India.

At this point in time, statistics of population, food and nourishment for all Indians as well as concerns like food security were discussed in detail. Major crop exports and imports were discussed. Relevant issues like fuel and electricity subsidies for farmers, food pricing policies, market chains, etc. were discussed as well.

These discussions brought in the concepts of sustainable agriculture, agro-biodiversity, and their links with socio-economic aspects of the community.

**Young Biodiversity Specialists Meet Farmers**
The 13-year-olds had now begun to see the links between agriculture, biodiversity, economics, population and many more concepts that they learned in their science and social science classes. (Figure 3) It was now time for them to see agriculture in practice. To demonstrate the wide and rich agricultural biodiversity of the region, students were taken to farms in a village named Rajpur.

Prior to the field visit students were oriented to the rich agricultural biodiversity of India and its interrelationship with its agro-ecosystem. This orientation was conducted with a series of interactive sessions and simulation experiments like role plays to provide enhanced understandings of Indian agricultural scenarios, biodiversity and related issues.

The objective of taking students on the field visit to Rajpur village was to help them:
1. Understand the important role of biodiversity in agriculture.
2. See the holistic approach towards sustainable agriculture: diversity, animal husbandry, economic and market links, social status of farmers, etc.

![Figure 3: The Agro-biodiversity module of CKB focused on multi-disciplinary aspect of teaching-learning.](image-url)
**Rajpur: A rapidly Changing Village**

Rajpur is a small village of 70 households with a total population of about 300 residents. The main occupation of people in the village is agriculture and related activities like livestock farming including animal husbandry. The native vegetation of the village includes Neem (*Azadirachta indica*), Babul (*Acacia arabica*), wild berries and dry shrubs, indicative of the semi-arid climate of the region. Over the years, this small village has observed changes in its agro-ecosystem that have resulted from excessive human interference as the village is near the state capital. The village which used to cultivate staple food crops like millet, wheat and rice is now harvesting cash crops like cotton and castor, which reaps more money for the farmer. Some years ago, nitrogen fixation in the soil was attributed to fields filled with nitrogen fixing leguminous crops like moong (*Phaseolus Aureus*), pulses, and sesame (*Sesamum Indicum*) which enhanced the soil’s fertility. This has been replaced by the current trend of providing supplements to soil through chemical fertilizers and the heightened use of pesticides. The adverse effect of chemicals in the agro-ecosystem of Rajpur has been observed to decrease the number of worms and bees which led to a reduction in the number of Bee eater birds (*Merops orientalis*). With encroaching city extension, land prices are a towering inferno that tempts marginal farmers to sell their lands at high rates thereby reducing the agricultural and natural biodiversity of the village.

(As told by: Mr. Parthesh Pandya, Resident, Rajpur Village).

During the field trip, the students visited a number of farms and also interviewed the farmers as well as children (of their own age) studying in the government Primary School, Rajpur. (Figures 4, 5)

**Figure 4: Field learning for students on a farm visit.**

**Agro-ecosystems: Understanding the Web of Sustainability**

The CKB team members observed that during the field visit to the village *Rajpur*, students made observations not only about the variety of crops, cropping pattern and techniques, but also made observations pertaining to interrelationships among crops, soil, water, plants, birds, livestock and humans. The field exposure helped students analyze agricultural ecosystems in an integrated and holistic manner, which enabled them to appreciate linkages and connections between agriculture and humans, and socio-economic activities.

**Figure 5: Firsthand interaction between students and farmers.**
Sustaining Rajpur: An Exhibition by Students

After data collection and analysis, the students wanted to share their findings with their teachers and peers as well as residents of Rajpur village. Consequently, with support from the CKB team, these young learners set up an exhibition on ‘Agriculture in Rajpur—Past, Present and Future’. The focus of this exhibition was to provide a birds-eye view of agriculture and development in Rajpur. The budding conservationists provided their views on connections among biodiversity, agriculture, economy and quality of life in and around Rajpur. They discussed many ways of sustaining Rajpur with a higher quality of life for its residents!

Case 2: Appreciation of local biodiversity by College Youth

Indian Higher Education System

The Higher Education system in India has grown in a remarkable way to become one of the largest systems of its kind in the world. The Indian Universities are required to perform multiple roles—teaching, research and community outreach. This is done by creating new knowledge, acquiring new capabilities and producing an intelligent human resource pool, through challenging teaching, research and extension activities so as to balance both the need and the demand. (University Grants Commission; Higher Education in India: Issues, Concerns and New Directions; December 2003; New Delhi.)

One prerequisite to appreciate biodiversity in nature is to understand the interrelationships, importance, and variety of existing species. This not only requires the skills of an ecologist, a conservationist or a scientist, but also requires sensitivity and respect for nature and its processes. Direct and first-hand interaction with nature is said to be one of the best pedagogical techniques to inculcate this sensitivity.

Such opportunities are not readily available for the young and are often overlooked before they form an opinion regarding relevance of natural processes in our immediate environment. As a result, biodiversity seems to become merely a concept in science with no connections to our daily lives.

Such an alienated view of biodiversity is one of the reasons leading to unpleasant confrontation between humans and nature. Today, it is of utmost importance to inculcate the feeling of belongingness towards the immediate local environment among the youth. They will be the responsible citizens and decision makers of tomorrow.

We now discuss one such effort to enable and develop capacity building among youth to take positive actions towards conserving local species on their college campus. This attempt was a part of a project called ‘SamVednaa – an initiative towards developing ‘Model Green Colleges’, implemented by CEE with support from UNEP5 under APFED Showcase project6.

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5 United Nations Environment Programme (UNEP) is an international body providing leadership and encouraging partnership in caring for the environment by inspiring, informing, and enabling nations and people to improve their quality of life without compromising that of future generations (www.unep.org).

6 Asia-Pacific Forum for Environment and Development (APFED), a regional group of eminent experts supported by Ministry of the Environment, Japan, aims to address critical issues facing Asia and the Pacific and to propose new models for equitable and sustainable development of the region (www.apfed.net).
The Government Science College\textsuperscript{7}, \textit{Valod} in \textit{Tapi} district in Gujarat, India was one of the three participating colleges in the \textit{SamVednaa} project.

\section*{Tapi, Gujarat}

The district of Tapi is one of the youngest in the state of Gujarat in western India. Vyara town is the district headquarters. The area of the district is 2951.10 sq km with a population of 719,634 (2001 census). The area is a beautiful hilly region with cane, bamboo and teak wood forests. The rich forest area with its loamy undergrowth has an interesting development of flora and fauna with variations in plants having traditional properties utilized in medicinal decoctions. The fluidly resident tribal communities are deeply intertwined with the surroundings and share an abidingly nurturing relationship with their landscape. Some of them have moved on to marginal farming and rearing domesticated animals to supplement their income. Agriculturally, the district is dominated by sugarcane, paddy, groundnut, cotton and mango cultivation.

\section*{Green College Campus: Reviving local Biodiversity}

Besides research and teaching, reaching out to the larger society is one of the major functions of higher education institutes in India. The idea of involving students in the task of national service dates back to the times of Mahatma Gandhi. The National Service Scheme\textsuperscript{8} (NSS) is one such opportunity that college students in India can opt to work with. The Government Science College in Valod offers NSS to the students. The Project \textit{SamVednaa: An Initiative towards building ‘Model Green Colleges’}, worked with these student NSS volunteers.

\textit{SamVednaa: An initiative towards building ‘Model Green Colleges’}

Project \textit{SamVednaa} provided an experiential learning opportunity to the students through sustainable development related projects. The programme engaged college students on issues of immediate concern in their neighbourhood and college campus, such as water conservation and managing Green Spaces, etc.

Surrounded by acres of farms of sugarcane, the Valod College is situated near the green-belt of southern Gujarat. The area has rich natural biodiversity and traditional knowledge among the local tribal population. However, once the students enter the college premises they seem to be completely cut off from this real-world — the rich natural heritage around their college campus.

\section*{Understanding Trees and Plants as part of an intricate Web of Life!}

Through establishing an Eco-Club in the college, 40 students, guided by several faculty members, came forward to be a part of this Green initiative.

The first step was to work with the college students to help them develop a conceptual understanding of biodiversity, interrela-
tionships and the role of these interactions in maintaining a balance in nature. Based on these factors, various sessions, activities, and field exposures were conducted for the college youth. This laid the foundation for improved understanding of natural systems and their importance for the existence of life. More importantly, the visits to neighbouring areas, as well as around their own college campus, provided a new insight to the students about the local plant species and associated biodiversity.

**College Students set up a Biodiversity Park**

As part of the *SamVednaa* initiative, the College Eco-club decided to establish a Biodiversity Park in their college campus. They consciously decided to plant native and locally found species in this Park. (Figures 6, 7)

![Figure 6. Developing a Campus Biodiversity Park.](image)

The students, aptly guided by a multidisciplinary team from CEE—a plant expert, architect and designer—decided to have specific sections of plant species in their Biodiversity Park. The three major sections of the Park were decided to be: Ornamental plants, Medicinal Plants, and Tree species (Tables I, II, and III).
Designing their own Biodiversity Park, planting the species and soiling hands to nurture the plant biodiversity provided a memorable and learningful experience to the College students. The Eco-club, handed over to a new batch of students, continues to be maintained and managed as the Biodiversity Park.

Table I. Ornamental Plants

<table>
<thead>
<tr>
<th>S. No</th>
<th>Common Indian Name</th>
<th>Botanical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Parijatak</td>
<td>Nyctanthes arbor-tristis</td>
</tr>
<tr>
<td>2</td>
<td>Gultora</td>
<td>caesalpinia pulcherrima</td>
</tr>
<tr>
<td>3</td>
<td>Ticoma Gaudi Chaudi</td>
<td>Tecoma gaudichaudi</td>
</tr>
<tr>
<td>4</td>
<td>Madhu Kamini</td>
<td>Murraya exotica</td>
</tr>
<tr>
<td>5</td>
<td>Double Desi Hibiscus</td>
<td>Hibiscus rosa sinensis L.</td>
</tr>
<tr>
<td>6</td>
<td>Bougainvillea</td>
<td>Bougainvillea</td>
</tr>
<tr>
<td>7</td>
<td>Snow Bush</td>
<td>Euphorbia leucocephala</td>
</tr>
<tr>
<td>8</td>
<td>Ixora</td>
<td>Ixora coccinea</td>
</tr>
<tr>
<td>9</td>
<td>Dwarf Karan</td>
<td>Lagerstroemia indica L.</td>
</tr>
<tr>
<td>10</td>
<td>Dwarf Hibiscus</td>
<td>Hibiscus syrians</td>
</tr>
<tr>
<td>11</td>
<td>Durranta</td>
<td>Duranta erecta</td>
</tr>
<tr>
<td>12</td>
<td>Croton</td>
<td>Cordiaum variegatum</td>
</tr>
<tr>
<td>13</td>
<td>Star Tenopeta</td>
<td>Telopea speciosissima</td>
</tr>
<tr>
<td>14</td>
<td>Furcaria (White leave)</td>
<td>Furcaria giganta</td>
</tr>
<tr>
<td>15</td>
<td>Pedilanthus</td>
<td>Pedilanthus tithymaloides</td>
</tr>
<tr>
<td>16</td>
<td>Euphorbia</td>
<td>euphorbia cactus</td>
</tr>
</tbody>
</table>

Table II. Medicinal Plants

<table>
<thead>
<tr>
<th>S. No</th>
<th>Common Indian Name</th>
<th>Botanical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ardusi</td>
<td>Adhatoda vasica Nees</td>
</tr>
<tr>
<td>2</td>
<td>Tulsi</td>
<td>Ocimum sanctum L.</td>
</tr>
<tr>
<td>3</td>
<td>Asparagus</td>
<td>Asparagus racemosus</td>
</tr>
<tr>
<td>4</td>
<td>Aloe Vera</td>
<td>Aloe vera (L.) Burm.f.</td>
</tr>
<tr>
<td>5</td>
<td>Ashwagandha</td>
<td>Withania somnifera L.</td>
</tr>
<tr>
<td>6</td>
<td>Shyam Tulsi</td>
<td>Ocimum sanctum L.</td>
</tr>
<tr>
<td>7</td>
<td>Nagod</td>
<td>Vitex negundo L.</td>
</tr>
<tr>
<td>8</td>
<td>Baheda</td>
<td>Terminalia bellirica</td>
</tr>
<tr>
<td>9</td>
<td>Lemon Grass</td>
<td>Cymbopogon citratus</td>
</tr>
<tr>
<td>10</td>
<td>Ajmo</td>
<td>Trachyspermum coticum</td>
</tr>
<tr>
<td>11</td>
<td>Guggal</td>
<td>Boswellia serrata Roxb</td>
</tr>
<tr>
<td>12</td>
<td>Karaunda</td>
<td>Carissa congesta</td>
</tr>
<tr>
<td>13</td>
<td>SarpGandha</td>
<td>Rauvolfia serentina</td>
</tr>
<tr>
<td>14</td>
<td>Safed Musli</td>
<td>Chlorophytm Borivilianum</td>
</tr>
<tr>
<td>15</td>
<td>Vidya</td>
<td>Platycladus orientalis</td>
</tr>
</tbody>
</table>

Table III. Trees Species

<table>
<thead>
<tr>
<th>S. No</th>
<th>Common Indian Name</th>
<th>Botanical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fish Tail Palm</td>
<td>Caryota urens</td>
</tr>
<tr>
<td>2</td>
<td>Bottle Palm</td>
<td>Hyophorbe lagenicaulis</td>
</tr>
<tr>
<td>3</td>
<td>Coconut Palm</td>
<td>Cocos nucifera</td>
</tr>
<tr>
<td>4</td>
<td>Saptpami</td>
<td>Alstonia scholaris</td>
</tr>
</tbody>
</table>

Today, about 1900 square meters of the College Campus is flourishing as a hub of local biodiversity, supporting not only several plant species, but also a variety of associated life forms—insects, birds, a few reptiles, small mammals, and above all,
Homo sapiens! The students have appreciated not only the aesthetic value of their hard work, but also the ecological services that such Green Spaces can provide to a town or a city!

**Conclusion**

Within the formal education systems (schools and colleges), education for biodiversity conservation cannot be successful if left only to the curriculum in textbooks. During the two projects shared in this paper, the CEE team of conservation educators realized that such a treatment would further alienate the concept of biodiversity and its links to real life would seem even weaker.

For example, the CEE-CKB team noticed that the perception of agriculture by a young student is limited to only some agricultural practices, such as the types of soils, or instruments used for farming, as mentioned in his/her science and geography textbooks. There existed a gap in student’s understanding and perceptual experience of agriculture when the topic was only dealt with through textbooks, and chalk-and-talk methods in the classroom.

The school timetable does provide time and space for interactive and experiential teaching-learning approaches which can develop real-life concepts, concerns, and viewpoints related to biodiversity, and their ecological significance as well as social and cultural values. However, it is recommended that the approaches to teaching and learning be reviewed to enhance not just the conceptual understanding, but, also provide an analytical and critical overview of issues involved in the subject.

Similarly, co-curricular projects and activities in the college can ensure that concepts such as responsible citizenship and sustainable development, leading to prudent use of natural resources and their conservation, can be made an exciting and meaningful priority area for the youth of today, thereby helping them become thoughtful citizens of tomorrow.

The two-year-long project was well designed: It focused on identifying issues, problems and actions that could be implemented in colleges and enable youth to take positive actions for the environment, in order to develop their college as a ‘Model Green College’.

The action-oriented approach by students was a result of the positive attitude and appreciation they developed towards local biodiversity. The participatory involvement and decision making process followed by the students foreshadowed their success in bringing about changes in attitudes of those yet reached by this initiative.

A key challenge faced during the project’s implementation was making education for biodiversity and environmental conservation a priority in the Higher Education system. With the evaluation and assessment based system, conservation education often tends to take a backseat in technical, research-based, and social-relation institutes.

Further, to sustain the efforts made by students on their campus, it is necessary to have not only teaching, learning, and education strategies reviewed, but, also to ensure the provision of funds, expertise and time allocations within the formal education systems.

Education for biodiversity conservation will succeed only when it is taught and learned in the real-life context, exploring multidisciplinary connections and the understanding of life support systems.
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Shivani Jain graduated from the University of Delhi in 1992 with B.Sc. (Honours) in Botany, and in 1994 received her Masters in Life Science and Education from the Regional Institute of Education Bhubaneswar, Utkal University. Shivani holds a post graduate diploma in Ecology and Environment Management from the Indian Institute of Ecology and Environment, New Delhi. Shivani has been trained as a trainer under one of the programmes of the World Bank Institute. Shivani served as a Postgraduate teacher in Biology for over a year and in 1996 joined the Centre for Environment Education (CEE) in India. She has worked with CEE since 1996. At CEE, Shivani is currently engaged in training and networking in Education for Sustainable Development (ESD). She has coordinated over 20 international training programmes in ESD for a variety of in-service professionals. Shivani is also instrumental in exploring the use of ICT in enhancing in-service training as well as school education. Teachers and teacher trainers is one of the main groups with whom Shivani has experimented the use of open and distance learning for continued professional development. Shivani has authored and co-authored four publications on Environmental Education and written and presented over 20 articles and papers on Education for Sustainable Development. Shivani is also serving as the Regional Vice Chair (South and South East Asia) for IUCN’s Commission on Education and Communication.

Shefali Atrey is a Programme Officer at Centre for Environment Education, India. With a background in Geography and GIS, Shefali has a keen interest in working with young learners and in exploring the use of ICT and GIS for enhancing the quality of education in Indian Schools. Along with schools, Shefali works with youth in educational and vocational training institutes, as an environmental education facilitator. She is involved in training and capacity building of youth and faculty members towards effective environmental education and education for sustainable development with the use of technology. With an inclination towards education and pedagogy, Shefali has contributed towards academic writings and has co-authored a manual for energy conservation educators in vocational training institutes.
Using Field Research in China as a Catalyst for Effectively Promoting Global Environmental Awareness and Stewardship

Jacqueline McLaughlin¹, Xiaoying Cheng², and He Liu³

Associate Professor of Biology, CHANCE Founding Director, The Pennsylvania State University—Lehigh Valley, Center Valley, Pennsylvania, USA, jshea@psu.edu¹
Associate Professor of Environmental Engineering, Jiangnan University, Wuxi, Jiangsu, China²
Professor of Environmental Engineering, Jiangnan University, Wuxi, Jiangsu, China³

China’s biggest environmental challenge to date is stemming the tide of negative impacts of its burgeoning economy upon its natural resources—and especially its waterways. American and Chinese students recently collaborated on a study of the water quality of China’s Lake Taihu as part of a field course organized by CHANCE—(Connecting Humans And Nature through Conservation Experiences), which uses the Field Course Experience Learning Model. As members of a multidisciplinary group that included agriculture, economics, engineering, international relations, liberal arts, and science majors, students gained hands-on experience as they examined many factors that impact the lake’s health. The students visited factories, algal salvage and waste treatment plants, met with residents and local officials, and conducted their own independent research on the lake’s state of eutrophication. As with previous courses conducted using CHANCE’s Field Course Experiential Learning Model, the results demonstrated enhanced understanding of both scientific/environmental concepts and promoted environmental awareness, and the importance of related economic and industrial factors in maintaining water quality.

Key words: water quality, pollution, conservation, field-based courses, curricular coherence

摘要：当前中国最大的环境问题根源于中国迅速发展的经济对环境的负面影响，尤其是对水环境的影响。中国和美国的学生最近联合开展了对中国太湖水质的研究，此研究作为CHANCE（通过保护自然连接人类和自然）一门野外课程的一部分，采用了实地课程体验式学习模式。研究小组由多学科成员构成，包括农业、经济、工程、国际关系、文科和科学专业。学生通过参观工厂、参观蓝藻打捞和污水处理厂、与当地居民和地方官员交流、对太湖富营养状况进行独立研究等多种方式获得了第一手资料，了解并验证了影响湖泊健康的诸多环境因素。结合其他采用CHANCE实地课程体验式学习模式的课程教学内容，学生更好的理解了科学概念与环境概念，提升了学生的环保意识，更加确定了保持水环境质量时彼此联系的经济与工业因素的重要性。

Key words: water quality, pollution, conservation, field-based courses, curricular coherence
Introduction

One of the most divisive public policy debates of the last 50 years has been the conundrum of balancing economic development with conservation of natural resources—as though they were mutually exclusive. But in truth, as American paleoclimatologist and Tyler Prize for Environmental Achievement recipient Dr. Richard Alley points out, the two are inextricably intertwined:

“We have very high scientific confidence that many aspects of our current patterns of living are unsustainable,” Alley recently stated. “We must find new ways if we are going to keep a rising population fed, clothed, and otherwise supported.” As examples he cited the rapid depletion of groundwater, soil erosion, and the limited quantity of fossil fuels. On top of that is our burgeoning interconnectivity.

“The increasing interconnectivity of global trade means that a change in any of these issues affecting any notable part of the global system will actually affect everyone,” Alley explained. “A drought in China that causes the Chinese to import more food, or a drought in Russia that reduces supplies, can raise prices worldwide, triggering unrest in the Middle East or Africa. A decision about exports of rare earth elements from China can raise costs of catalysts for petroleum refining, magnets for wind-power generators, and other energy sources worldwide.”

Given such connections, achieving environmental sustainability will require reaching across traditional borders. When it comes to higher education, learning to work with researchers, economists and governmental and non-governmental officials abroad can help put students on the fast track to becoming global citizens. With that goal in mind, we set about establishing a short-term study program that blended environmental research with economic realities using a proven “Field Course Experiential Learning Model”—in China.

A nation of more than 1.3 billion people, China accounts for one-fifth of the world’s population (National Bureau of Statistics of China; CIA Factbook). Even as China continues its rush toward becoming the world’s most dominant economy, China’s leaders and citizens are only now beginning to realize the devastating impact of so much growth on its environment. The extensive use of environmental resources associated with industrialization, inadequate policy planning, and a desire for Western-style consumption have put China’s sensitive ecosystems in grave trouble, in some cases resulting in irreversible harm while threatening serious economic setbacks (Economy, 2004).

The good news is contemporary China represents an environmental field station where valuable lessons can be learned. Moreover, the dynamic correlation between China’s economic growth and its impact on the environment, if experienced firsthand by students and researchers in the context of pedagogical methods designed to help them address complex problems through field research, can be a catalyst for effectively promoting global environmental stewardship—including environmentally sound economic policies.

Perhaps the most urgent problem facing China is that of water. Several studies
published in a number of countries (including China) rank China in the bottom third of nations in terms of water quality and its effects on humans (Global Serpa, 2010; Environmental Performance Index, 2010; Yun, Zou, and Feng, 2009; The World Bank, 2006). According to the New York Times, last year China’s government admitted that pollution data it released in 2007 was wrong, and that its water pollution levels were more than twice as severe as those reported. The national pollution census had failed to include agricultural effluents such as fertilizers and pesticides, and thus found 13.8 million tons of chemical oxygen demand (which measures chemical compounds in terms of the oxygen demand) rather than the actual 30.3 million tons. The article noted that government planners previously estimated that the country’s rivers and lakes could handle only 7.4 million tons of chemical oxygen demand. The director of the Institute of Public and Environmental Affairs in Beijing put the new figures into perspective, saying, “We believed we needed to cut our emissions in half, but today’s data means a lot more work needs to be done.”

Though the stats are daunting, we must consider that this is not just China’s problem. “Each nation can influence all the others, so sustainability is becoming a truly global issue,” Alley explains. If we are to address it effectively, we citizens of the world must begin with the stark recognition that we’re all in this together—scientifically, biologically and economically. The biomes of the Earth, such as the tropical rainforest, tundra, deciduous forest, coniferous forest, desert, polar ice and grasslands—are interconnected. Also, many misguided conservation efforts and policies exacerbate the problems. Fortunately, CHANCE’s Field Course Experiential Learning Model is well-suited for tackling such complex problems head-on.

To understand just how and why CHANCE’s Model dovetails with a multidisciplinary, international field course in China, it’s important to briefly consider the CHANCE program’s origins, mission and structure.

The CHANCE Program
Initiated in 2004, the Chance program began as a partnership between The Pennsylvania State University (PSU) and the Pennsylvania Department of Education (PDE). It was developed to (a) engage Pennsylvania in-service and pre-service high school teachers and Pennsylvania State University (PSU) undergraduates in environmental science and conservation biology through the excitement of hands-on field research in selected ecosystems in Costa Rica; and (b) enhance the way Pennsylvania teachers teach and the way Pennsylvania students learn by using technology to bring real-world scientific data into the classroom.

Today, in 2011, CHANCE has twenty-four partners and numerous funding streams such as the Smithsonian Tropical Research Institute (STRI), Caribbean Conservation Organization (CCC), Hawk Mountain Sanctuary, American Institute of Biological Sciences (AIBS), sanofi pastuer, DOW Chemicals, and ATAS International, Inc.
The program also has broadened its educational outreach to include undergraduate students in China, and K-8 in-service and pre-service teachers and students from the United States, Canada and Panama.

The overarching goal of the CHANCE program, however, still remains the same: to produce levels of understanding, knowledge retention, and transfer of core environmental science and conservation biology concepts and world-wide realities that are greater than those resulting from traditional lecture-based classes by blending teaching and basic research. These goals are achieved by implementation of international field courses, development and implementation of the CHANCE “research modules,” and professional development workshops on the use of inquiry in science education for K-12 teachers (McLaughlin, 2006a; McLaughlin and Arbeider, 2008; McLaughlin, 2010a and 2010b; McLaughlin and Fadigan, 2010). The purpose of this article is to illustrate the ways in which the CHANCE Field Course Experiential Learning Model enhances scientific understanding and fosters environmental advocacy. To that end, we will now provide an overview of the Model itself, data supporting its effectiveness in Costa Rica, and an overview of how this field course model was successfully implemented in China. (Figure 1)

The Field Course — The Model

The CHANCE field course strictly employs the Field Course Experiential Learning Model (Zervanos and McLaughlin, 2003; McLaughlin, 2006b), which evolved from repeated short-term study abroad (embedded) field course experiences in selected biomes around the world over a six-year period. Assessment of student learning guided the development of an integrated course model featuring three steps:

1. Innovative online pre-trip assignments that provide essential background knowledge on topics and areas to be explored;

2. A field-based trip experience (approximately two and one-half weeks in duration) that includes hands-on conservation experience, journal keeping, inquiry-based research on a real-world environmental issue, participation in discussion groups, species assignments, formal research presentations, and independent exploration; and,

3. Post-trip online assignments that encourage the integration and application of key concepts learned (McLaughlin and Johnson, 2006).

This design facilitates increased understanding of environmental science and conservation biology through encouraging students to become active participants in their own education. Learning is further enhanced through interdisciplinary perspectives incorporating principles of biology, ecology, environmental engineering, geography, economics, sociology, political science, history, and other disciplines. Interdisciplinary perspectives promote learning through addressing principle sources of curricular incoherence including irrelevance, information under/overload, obscurity or indirectness, and inaccuracy (Johnson and Ratcliff, 2004).

The main objective is to move students beyond simple memorization of facts to higher-order domains of application and integration (Bloom, 1956; Anderson and Krathwohl, 2001). For this reason, the Field Course Experiential Learning Model has embedded performance assessments that require students to: (1) perform authentic
Using Field Research in China as a Catalyst for Effectively Promoting Global Environmental Awareness and Stewardship

Costa Rica field course showed students reporting cognitive and affective learning gains in all learning activities evaluated (McLaughlin and Johnson, 2006; Tables 1 through 3.) Additionally, data revealed that problem-centered field experiences enhanced the students’ self-assessed knowledge of biodiversity, increased their understanding of how humans impact ecosystems, and influenced how they would make behavioral decisions relative to biodiversity in the future.

**Table 1. Student-Reported Gains in Knowledge***

<table>
<thead>
<tr>
<th>Knowledge Gained</th>
<th>Rating</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic principles of biodiversity</td>
<td>4.71</td>
<td>0.45</td>
</tr>
<tr>
<td>How human activities impact biodiversity and ecosystem stability</td>
<td>5.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Culture and geography of Costa Rica</td>
<td>4.43</td>
<td>0.73</td>
</tr>
<tr>
<td>Conservation biology as it relates to Costa Rica</td>
<td>4.71</td>
<td>0.45</td>
</tr>
<tr>
<td>Conservation biology in general</td>
<td>4.43</td>
<td>0.73</td>
</tr>
<tr>
<td>Biocomplexity of ecosystems</td>
<td>4.43</td>
<td>0.73</td>
</tr>
<tr>
<td>Community ecology</td>
<td>4.29</td>
<td>1.03</td>
</tr>
</tbody>
</table>

* Uses a Likert scale of 1 = no gain through 5 = very significant gain in knowledge.

tasks, (2) to reveal knowledge and skills, and, (3) demonstrating the ability to apply their conceptual understanding. For example, students keep daily journals similar to field journals used by scientists to organize and document field observations (Appendix B). This authentic assessment replicates scientists’ journal activity while encouraging — and providing evidence of — higher-order thinking (Anderson and Krathwohl, 2000). Journal assessment is supplemented by a post-trip assignment in which students provide open-ended responses to questions (Appendix C). This assignment helps students connect required pre-trip readings and questions (Appendix A) with their field experiences and provides an opportunity to demonstrate their level of learning. Student lead discussion sessions on course-related topics researched during the pre-trip segment, and formal group-based presentations of actual data gathered and interpreted from field research are also assessed.

**Self-Assessments of Field-Based Learning**

A “Student Assessment of Learning Gains” was also developed as an indirect measure of student learning. This instrument asks undergraduate students to rate and verbally elaborate on the extent to which specific learning activities contributed to specific knowledge and skill outcomes. For example, students are asked to rate the extent to which the field experience contributed to their understanding of basic principles of biodiversity, their ability to conduct field research, and their ability to relate human and social activity to the environment. Similar questions explore how the experience contributed to gains in scientific and higher-order cognitive skills. Assessment findings from three cohorts of undergraduate students (62 participants total, from three courses held during three consecutive summers) participating in the
Table 2. Student-Reported Gains in Skills*

<table>
<thead>
<tr>
<th>Skills Gained**</th>
<th>Rating</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applying basic biological principles to field study</td>
<td>4.57</td>
<td>0.49</td>
</tr>
<tr>
<td>Communicating through writing</td>
<td>3.63</td>
<td>1.29</td>
</tr>
<tr>
<td>Conducting field research</td>
<td>4.16</td>
<td>0.46</td>
</tr>
<tr>
<td>Presenting information effectively to others</td>
<td>4.31</td>
<td>1.17</td>
</tr>
<tr>
<td>Working as a team to increase learning</td>
<td>4.44</td>
<td>0.64</td>
</tr>
</tbody>
</table>

* Uses a Likert scale of 1 = no gain through 5 = very significant gain in skills.

** Students gave slightly lower ratings on skill gains, perhaps due in part to the collaborative nature of the field work: They might not have perceived that they were doing independent work and developing specific individual skills. Their journal entries indicated some possible confusion about this.

Table 3. Student-Reported Gains in Conceptual Learning*

<table>
<thead>
<tr>
<th>Conceptual Learning Gains</th>
<th>Rating</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding the concepts of biodiversity as they relate to tropical rain forests</td>
<td>4.57</td>
<td>0.49</td>
</tr>
<tr>
<td>Understanding how human and social activity impacts biodiversity</td>
<td>4.57</td>
<td>0.49</td>
</tr>
<tr>
<td>Understanding how societal decision making alters biodiversity</td>
<td>4.43</td>
<td>0.73</td>
</tr>
<tr>
<td>Ability to make informed decisions on ecological issues</td>
<td>4.57</td>
<td>0.49</td>
</tr>
<tr>
<td>Thinking critically about complex conservation issues</td>
<td>4.43</td>
<td>0.73</td>
</tr>
<tr>
<td>Ability to think through a problem or argument as it pertains to the environment</td>
<td>4.14</td>
<td>0.83</td>
</tr>
</tbody>
</table>

* Uses a Likert scale of 1 = no gain through 5 = very significant gain in conceptual learning.

From surveys of participants in the same study, we also know that hands-on experience promotes a deep understanding of scientific concepts and increased passion for research. In addition, one unanticipated
benefit is a better awareness of, and respect for, other disciplines, opinions, and ideas. Fully 78 percent of participants felt the Costa Rica experience influenced them to behave more responsibly with respect to environmental issues.

**The CHANCE Model Goes to China**

From three years of Penn State undergraduate field courses, we learned that implementing experiences in environmental contexts through experiential learning not only advances the understanding of biological concepts, but also instills an environmental ethic. We believe the CHANCE Model should be considered for application to other branches of study and other countries.

In 2008, the CHANCE Director (Jacqueline McLaughlin) envisioned a program that translated the CHANCE Model used annually in Costa Rica (and now also Panama) to China. She went to China to tour several provinces and to visit several institutions of higher education to establish parameters for the course format, including venues, partners, commercial facilities, and academic collaborators. This program would be multidisciplinary and emphasize the link between China’s booming economy and deteriorating environment by creating a field-based research opportunity that allowed students to understand and critically think about China’s environmental reality: its polluted water.

Jiangsu Province has long been China’s most populated, affluent, and educated region, especially in the southern portion of the province. Since the establishment of the port of Shanghai, it’s also been China’s most heavily industrialized region, responsible for a disproportionate percentage of China’s industrial production. This province was selected as the main site for CHANCE’s field course in China for these reasons, and also because it is home to Lake Taihu and Jiangnan University.

Three years later, the CHANCE course was offered as part of Penn State Lehigh Valley’s summer course schedule, Biology 497C, *Global Environmental Sustainability: A Field Study in China* [http://www2.lv.psu.edu/jxm57/explore/china2011/]. The course objectives were met by an interdisciplinary group of Penn State students carrying-out the following under the supervision of Penn State and Jiangnan University faculty: “pre-trip” on-line assignments throughout the spring 2011 semester; a two and one-half week “trip” (field-based research experiences and activities described below) in Shanghai, Suzhou, Wuxi, and Beijing, China, from May 14 – 31, 2011; and, submission of a “post-trip” assignment and trip related journal entries following return to the United States and up until June 30, 2011.

The course “trip” included a 17-day international, and as such a biogeographical, cultural, economic, and historical, adventure throughout the above listed areas in China. The key research component of the course occurred in Wuxi, Jiangsu Province, wherein 13 Penn State student participants and 3 faculty performed hands-on research alongside Chinese research scientists, technical experts, governmental leaders, and more importantly, 15 Chinese student participants and 5 faculty, at established field sites along Lake Taihu, tributaries of the Yangtze River, and in the laboratories of Jiangnan University, School of Environmental and Civil Engineering [http://www.jiangnan.edu.cn/english/index.html](http://www.jiangnan.edu.cn/english/index.html).

Students were guided through a program of research activities that focused on the water
pollution and eutrophication realities of Lake Taihu – China’s third largest fresh water lake, which serves as a major source of water for the Taihu Basin Economic Region, the second most industrialized region in China. In Wuxi, heavy and rapid urbanization and industrialization (representing 11.6% of China’s GDP) have contributed to the eutrophication of Lake Taihu, a process characterized by the accumulation of nutrients and the proliferation of algal life. Students also evaluated the past, present, and future water purification technologies that have, or have, the potential to be utilized on and along Lake Taihu to assist in its remediation.

To become familiar with the many issues related to the present-day reality of China’s water pollution, the interdisciplinary group of Penn State students and faculty first visited businesses such as Dow Chemical Company’s Quingpu and Zhangjiang manufacturing facilities in Shanghai to tour their wastewater treatment plants and receive hands-on experience in industrial water purification technology. In DOW’s research laboratories, students set-up ion exchange resins and utilized them to remove copper from water that’s been polluted by effluents from electronics manufacturers. They compared the United States’ and multinational manufacturing regulations related to water quality, and met with water treatment specialists and government officials. Tours of the Boa Steal Corporation, Shanghai Urban Planning Center, and the Huangpu River delta were also included.

Figure 3. Data gathered from the survey question: My real-world research on the eutrophication of Lake Taihu has given me a better understanding of the field of environmental science.
After meeting their Chinese counterparts, both American and Chinese students attended a one and one-half day long Jiangnan University and Pennsylvania State University International Workshop entitled, The Water Environment and the Ecological Restoration of Taihu Lake, which featured numerous American and Chinese research scientists and government officials (some of whom participated via Skype) such as renown scientist and Nobel Laureate Richard Alley of Penn State’s Earth and Mineral Sciences Institute, and Zhejiang University’s top aquatic researcher, Chen Yingxu. Next, they were charged with undertaking a seven-day cooperative set of experiments on the water quality of, and land use around, Lake Taihu to improve their awareness of environmental problems and learn sampling and analysis methods used to diagnose aquatic ecosystem health and stability (Figure 3).

After analyzing the chemical, biological, and physical characteristics, students found that nutrient levels are indicative of a eutrophic state and the water is unsafe for human consumption (drinking). Since Lake Taihu remains an important ecological and therefore economic concern for nearby Wuxi City, more waste and industrial water treatment facilities are warranted, as is enhanced ecological restoration in this vast area, and environmental education to create a more knowledgeable and responsible citizenry. The good news is that restoration efforts presently in place (blue-green algae salvage ships, dredging lake bottom, factory relocation, artificial floating beds, introduction of algae eating fish, water transferring via Yangtze River tributaries, restoration of riparian buffers) are cumulatively acting to lessen the eutrophication process.

At the conclusion of their field research endeavors, faculty members, technical experts, government leaders, business leaders, and noted American and Chinese scientists fielded questions from students about the economic and environmental health of the area studied. Students also delivered group research projects on the water quality and sustainability of Lake Taihu, including experimental design, implementation, and data interpretation. An official awards ceremony ended the research program of the course wherein each student participant received a certificate of completion by the administration of Jiangnan University and all faculty involved in developing, orchestrating, and mentoring this program. Highlights of the student presentations can be viewed at: http://chance.psu.edu/china-videos2011.html

The field research at Jiangnan University ended on a high note, with the Jiangnan students throwing a goodbye party that included a talent show, karaoke, and dancing to the ChaCha Slide. Numerous sightseeing and historical/cultural outings and activities were also embedded in the trip component of this field course, including regular Mandarin lessons, sleeping accommodations on one of China’s famous bullet trains, and visits to popular attractions such as the Forbidden City and Tiananmen Square in Beijing. And, students will no doubt long remember the evening they spent sleeping in a watchtower along the Great Wall of China.

**CHANCE Impact in China**

Finally, 27 students completed a 15-question survey at course-end and provided details about their experiences in the field and its relationship to “real” life. As with previous CHANCE assessments, survey results suggest these highly motivated students returned home with much more than a stamp in their passports.
Working in the field gave 88% of respondents a better idea of how environmental scientists conduct field research. “We got to do the investigation by ourselves and to get data and suggestions from the local people,” one student commented. “It was real, not in our textbooks or lecture notes.” Another participant noted that, “I felt very involved, and I understood the lab material. I am not a science major, so this was amazing.” (Figure 4)

CHANCE’s Lake Taihu course gave 85% of students a concise, personal lens through which they came to better understand just what global interconnectedness means in terms of our natural world. They came to understand both the local and global impact of protecting this important body of water. As one student noted, “The people we surveyed for our land research all use water from Taihu Lake, so I am now fully aware just how significant Taihu is to them. We must make great efforts to improve the water quality of Taihu for their survival.” Another participant looked beyond the lake, commenting that, “Taihu Lake’s pollution has a great influence on both China’s economy and its environment. It also has an influence on the world’s economy and environment. My perspective of globalization was broadened through this international research.

Figure 4. Data gathered from the survey question: My real-world research on the eutrophication of Lake Taihu has helped me better understand the importance of global environmental sustainability.
Figure 5. Data gathered from the survey question: My real-world research on the eutrophication of Lake Taihu has motivated me to engage in global environmental stewardship activities.

One of the most notable results of CHANCE’s Model is a newfound affinity for environmentalism in general. In China, 88% of participants said the course motivated them to engage in environmental stewardship activities in their own lives—and 46% of those felt strongly motivated (Figure 5). As one student explained, “I want to break language barriers and understand other cultures so that I can do more research in other places like we did here in China.” Another student put it this way: “If we learn from the mistakes of the past, developing nations could avoid causing future environmental problems for themselves in the future. This motivates me to work towards sustainability in my country and all over the world.” Activities students said they would be likely to get involved in include scientific research, animal species conservation, public policy, community action, future CHANCE courses, changing personal consumption, and promoting environmental education.
Cultural insights among the participants were significant (Figure 6). At trip-end, 81% of the respondents felt their previous ideas about Chinese culture and people were incorrect—of these 68% felt strongly about having misconceptions. “I now view China in a completely different light,” one student said. “This culture and its people have so many prejudices against them and so many are so wrong. I hope to return to China one day and bring my family to show them the real China.” Some were shocked at what they learned: “I did not know that they have it far worse than we do, [that] even if they have a leading world economy they do not have clean tap water in many places.” Another student appreciated the chance to get outside of major cities. “My experiences have made me more open minded and tolerant of differences across cultures and countries. The field investigation of the land enabled me to gain a different perspective of China. We were able to witness more rural areas as opposed to the large urban city areas.”

**Conclusion**

When it comes to conserving our natural resources and biodiversity, it’s important to recognize that internationally we’re all in this together—the biomes of the Earth are indeed interconnected. Thus, in order for nations, regions and local communities to implement effective policies that support global conservation initiatives, educators worldwide must encourage their students, the future citizens of the world, to develop levels of understanding of core environmental science, ecological and economic concepts that allow them to comprehend the negative impact and consequences of any broken ecosystem—be it a polluted stream, river, ocean, an overharvested forest, or hillside overtaken by an invasive species. The CHANCE Field
Course Experiential Learning Model presents educators with a unique opportunity to do just that—by bringing research science and classroom together.

CHANCE has proven to be effective in each location where the model has been used to structure field-based coursework. CHANCE educates future scientists, teachers, engineers, and leaders about how biomes work and the importance of collaboration in the field. The CHANCE model has been used successfully in Costa Rica and Panama. In this article we have shown that it is uniquely powerful when adapted to address the dire environmental circumstances that currently exist in modern China.

The Model is designed to be adaptable and to foster higher-stage learning via hands-on research experience. Therefore, we have shown that it works for undergraduates in the United States, as well as it does for undergraduates in China – who major in many fields of study. In truth, we suspect the full range of the model’s potential has not yet been fully explored. We agree with Dr. Alley that it does provide a useful and necessary template for international collaboration between researchers and academics. When it comes to solving our shared environmental problems, says Alley, “the major global players must be involved for development of truly sustainable answers.”

Sustainability and the related issues of biospheric health will require solutions that work globally. Says Alley, “I don’t see how this is possible without a lot of talking across borders. No single project can do this, but it won’t happen without projects such as CHANCE China 2011.”

References


Jacqueline S. McLaughlin is Associate Professor of Biology at The Pennsylvania State University-Lehigh Valley, where she teaches basic biological concepts and biodiversity, physiology, developmental biology, molecular and cell biology and environmental science. She is the Founding Director of the award-winning, international Connecting Humans And Nature through Conservation Experiences (CHANCE) program. Based on her Field Course Experiential Learning Model, CHANCE uses field research and on-line curricular tools to provide K-12 teachers and students, undergraduate, and graduate students with inquiry-based research opportunities and conservation experiences that foster greater understanding of some of the world's most troubling environmental issues. A career advocate of innovative scientific pedagogy, McLaughlin has won numerous teaching and research awards and has held a variety of curriculum and professional development roles for organizations such as the Pennsylvania Department of Education (PDE) and the National Association of Biology Teachers (NABT).

Dr. Xiaoying Cheng is Associate Professor of Environmental Ecology at Jiangnan University, Wuxi, China where she teaches introductory environmental science, environmental quality evaluation, and ecological restoration engineering. At present, she is committed to building the international education platform at her university and to reform the models of teaching in the majors of environmental science and engineering throughout China.

Dr. He Liu received his PhD degree in Environmental Engineering at Zhejiang University of P.R. China. He is a professor at the School of Environmental and Civil Engineering, Jiangnan University. His research expertise is in environmental microbiology in the specific areas of molecular microbiological ecology and anaerobic fermentation for volatile fatty acids production by sewage sludge. Presently, he is teaching a graduate course entitled, Biotechnology for the Treatment and Disposal of Wastewater and Sewage Sludge.” He is also teaching an undergraduate course entitled, “environmental microbiology.” He is author of numerous research studies published in peer reviewed journals and conference proceedings.
Ecological Cooperation: A Russian Network Project for Environmental Education, Communications and Biodiversity Conservation

Marina E. Rykhlikova

Institute of Ecological Soil Science
Lomonosov Moscow State University, Russia
eccoop@online.ru

The Russian Network Project "Ecological Cooperation" was organized at Lomonosov Moscow State University in 1997. Combining information technology with traditional teaching methods enabled to organize a dynamic system to solve the problems of environmental education, youth participation in the biodiversity conservation, and improve teacher training. Every year over 4,500 students and 400 teachers from all over Russia and a number of institutions of Belarus, Ukraine and Kazakhstan perform joint environmental research and engage in practical activities to protect nature. Webinars, seminars and master classes for students and teachers, equipping schools with methodological literature, regular consultations and exchanges of experience in seven web forums, and the posting the information on the web site are carried out in the Project. One demonstration of the effectiveness of training can be observed at the annual All-Russian Conferences, "Children will save the Nature of Russia". Project staff, together with colleagues from German Federal Agency for Nature Conservation, took part in the creation of a pilot multilingual Internet Platform "Biodiversity Detectives", which was opened and tested at the 7th Conference of the Parties to the Convention on Biological Diversity (2004). This was attended by 31 educational institutions from five countries of Eurasia.

Ключевые слова: образовательное обучение, биоразнообразие, природа, охрана, Интернет проект, экология, информационная технология
Biological diversity education and public awareness play an important role in the strategy of sustainable development. Environmental education of young generations and youth involvement in the conservation of nature are the most relevant. Use of information technology and, above all, telecommunications, combined with traditional teaching methods helps to solve these problems on a qualitatively new level. Via telecommunications, you can arrange for joint research work with students, exchange information, exchange timely advice, provide professional development for teachers, improve communication skills, and process information using the most modern technologies (Frieberg, 2000).

The Ecological Cooperation Project is a large-scale ecological educational and research Internet-based project in Russia. This Project was organized by the Institute of Ecological Soil Science, Lomonosov Moscow State University, in 1997. The Project objectives are:

1. Popularization of modern knowledge for children and young people.
2. Formation of environmental vision, involvement of the younger generation in activities for nature/biodiversity conservation.
3. The development and implementation of innovative teaching methodologies.
4. Strengthening partnerships between educational institutions of Russia; the creation of a common information space.
5. International cooperation with environmental funds and organizations.

More than 600 educational institutions (schools, colleges, environmental and biological centers, local history clubs, educational departments of national parks and nature reserves) from 52 regions of the Russian Federation and 9 organizations from Belarus, Ukraine and Kazakhstan took part in the Ecological Cooperation Project from 1997 to 2011 (Figure 1).

![Figure 1. Geography of the Ecological Cooperation Project](image1)

Every year over 4,500 students and 400 teachers are involved in joint research and nature conservation activities. (Figure 2, 3) Children and adolescents from 6 to 17 years old participate in the Project. Most of them are students from middle and upper grades.

![Figure 2. St. Petersburg participants of the Ecological Cooperation Project: A real team of associates.](image2)

The system of distance learning for students in the Project includes environmental research in the natural and human ecosystems, consultant support, networking conferences and competitions, and environmental protection measures. Teacher training is based on the organizing of seminars and master classes, supplying teaching materials for educational institutions, placing of operative information on the project site, and the exchanging of experiences in the web forums.
There are six branches of environmental research in the Project: botanical research, zoological research, water research, soil research, monitoring of terrestrial ecosystems, and Nature Protected Areas. Qualified professionals (curators) advise participants in six web forums on all issues.

The website of the Ecological Cooperation Project (http://www.ecocoop.ru) is located in the Science Park of Moscow State University. Educational materials such as, "How to explore the water ecosystems", "Album of insects and others invertebrates", "Soil is the foundation of life", etc., On-line determinant of lichen, System for input of water quality data and their graphic interpretation, have all been developed on the site to help young researchers (Figure 4). Web pages are decorated with children's drawings. The Project was awarded a Diploma of II degree "For the best ecological site" at the Competition "Ecology of Russia – 2000".

Research work in the Project is closely linked to practical nature conservation activities. For this purpose, six long-term conservation programs have been organized: "A drink of life", "We’ll save our soil", "Galactic experts", "They need to live", "Our feathered friends", and "Nature Reserve asks for help".

Figure 3. Kabardino-Balkaria Participants of the Ecological Cooperation Project.

Figure 4. Fragments of the Project's web site and a graphical interpretation of water quality measurements.
Distance learning is combined with practical training in field and laboratory conditions (Figure 5). 32 master classes for teachers from Moscow, Samara, and the Rostov and Moscow regions have been organized. Seventeen lessons in environmental camps were conducted for children in 2007-2010 with financial support from the Alcoa Foundation and the Government of Moscow. 255 pupils and 186 teachers have participated in this training (Martynenko, et al, 2010).

Two on-line seminars or webinars, connecting educators from St. Petersburg and Moscow with schools from the Samara and Rostov regions, were successfully carried out via the Program of Alcoa Foundation and the Fund for Sustainable Development. They were entitled, "We are in Charge of the Future." (Figures 5, 6, 7)

The All-Russian Conference, "Children will save the Nature of Russia" are showcases to demonstrate the effectiveness of training. The Conferences are carried out on the web forums in November-December every year. Via Internet, students have the opportunity to present the results of their research projects and receive expert advice. In March 2008, the best papers were published in a special Collection dedicated to the 10th anniversary of the Project (Rykhlikova, 2008). 140 environmental studies were presented at the 12th Conference at the end 2010. 255 pupils of 1-11 classes and 74 teachers from 58 schools and ecological educational centers, located in 14 regions of Russia, participated in this Conference (Rykhlikova, 2011).

The Project collaborates with environmental organizations such as the Fund for Sustainable Development, the Environmental Educational Center "Reserves", the Ecological Centre MSU, the Russian Bird Conservation Union, the Biodiversity Conservation Centre, etc.
Much focus is on partnerships and volunteer support for Nature Protected Areas.

The Ecological Cooperation Project was presented at the International Workshop, "Internet-based Nature Observation Projects", Germany, in 2000 (Rykhlikova, 2000). The creation of a, "Global Network Platform of Internet-based Biodiversity Observation Projects" as a contribution to the CBD-UNESCO global strategy for public awareness, was the result of this meeting (Frieberg, 2000). Development and testing of a multilingual interactive Internet-based Platform "Biological Detectives" in the form of a Russian-German Agreement on the Nature Conservation continued this collaboration in 2002-2005. The Platform was opened at the 7th Conference of the Parties to the Convention on Biological Diversity, Malaysia, 2004. Twenty one Russian educational institutions, the Belarusian Republican Ecological Center, the UNESCO Associated School from Kazakhstan, six German schools and two Finnish ecological organizations took part in the "Biological Detectives" pilot project (Rykhlikova, 2006).

The Ecological Cooperation Project is a dynamic, actively-functioning system for solving the problems of environmental education for children and youth, improving teacher training, implementing measures for nature protection.

References


Marina Rykhlikova is a biologist, senior researcher of Lomonosov Moscow State University, Russia. She is the organizer and leader of the Russian Internet-based Project "Ecological Cooperation", which brought together over 600 collective participants from whole territory of the Russia from 1997 to 2011. She is the author of 50 scientific and methodical publications. She participated in the development and implementation of Russian and international projects and programs aimed at promoting environmental education and biodiversity conservation. She was awarded the Honorary Diploma of the Supreme Environmental Council of the State Duma and Federal Assembly of Russian Federation "For the development of environmental education in the Russian Federation".
Introduction

My name is Ken Walker and I have 30 years experience as the curator of entomology at Museum Victoria, in Melbourne Australia. Being the curator of “bugs” means that I have spoken with tens of thousands of people about their bug problems, bug phobias, bug curiosities and just plain weird bug experiences.

My formal entomological training and years of experience as a taxonomist, usually allows me to quickly provide a scientific and common name for the bug in question. However, a scientific name or even common name (Ground beetle) is often not the “full answer” most enquirers have come to me to find out about – they either want to know something about the biology and natural science of their bug or they seek advice about their bug problem and if needed, how to resolve it.

Answering questions about bug biology is often difficult for me because I work in an insect “morgue”. All of the specimens in our museum collection are dead; some of them have been dead for decades and a few of them have been dead for more than 2 centuries! Any live insects are considered to be pests and are soon dispatched with and add to the collection.
I am much better talking about the problems bugs can cause. I generally divide bug enquiries into 3 categories. Is it a: (1) medical problem – Do something about it!; (2) economic problem – Do something about it!; or (3) nuisance problem – You decide whether you want to spend time and money but you really don’t need to.

When I am discussing the natural history or pest status of bugs, I try to construct a story that allows the person to better understand the nature of their bug or the source of their bug problem and why they can or cannot treat the problem themselves.

Pre-Internet
The picture I have painted for you above was the classical way that we did good science in the 20th pre-computer century. It relied on someone at a museum to answer your questions.

Our practices were predicated on four basic tenets of doing good science:

- Make observations.
- Look for patterns.
- No new discovery can become science until it is made public.
- Learn before you discover.

“Learn before you discover” was a 20th century pre-requisite for good science. You began the journey with a good school-leaving grade and then moved into a university to learn the basics of science. Following graduation with a Bachelor degree, you then embarked on postgraduate studies and finished up with an alphabet of degrees after your name. I often describe this process as akin to obtaining a union ticket that allows you to work on a construction site. Like a union ticket – you either have it or you don’t. Few people ask me what my postgraduate studies were about – they primarily want to know what degrees I have and from which universities.

However, as I have found to my own misfortune, the enormity of the natural world is such that no amount of degrees can adequately prepare you for dealing with public enquiries.

I well remember my first day of employment as the curator of entomology when a member of the public gave me an insect larva and asked me name it and tell her something about it. I easily recognized it as a beetle larva – but that was of little use as one in every five known animals in the world is a beetle. All of my university training had been about adult insects – no one had taught me about the immatures, the grubs, the larvae and the nymphs. To my eternal thanks, I turned for help to the collection assistant who had no university degrees, but, more than 30 years of on-the-job training. Elizabeth identified the larva as the Carpet beetle (*Anthrenus verbasci*), which is a strong indicator of an economic problem in the enquirer’s house eating organic fibres from carpets or blankets or clothes. And so, Elizabeth began my “in the real world of entomology” training and I have never forgotten what she taught me.

With Internet
The advent of the Internet and its availability for public use in the late 1990s had a profound effect on the ways we communicate. Primarily it allowed anyone to have a voice in almost any conversation – often a good thing and sometimes not so good. The Internet has now changed the 20th century basic tenets of doing good Science. The tenets now read:

- Make observations.
- Look for patterns.
No new discovery can become science until it is made public.
Discover to learn.

For decades, there have been thriving groups of non-scientific field naturalists who through their observations have made many valuable contributions to the knowledge of science. An example, our knowledge of the life histories and distributions for most butterflies has come from field naturalists. These field naturalists are usually well-experienced biologists, associated with natural history clubs and societies that have strong links to scientific organisations. These are the “Elizabeths” of the natural history world – walking encyclopedias.

The most significant contribution the Internet has made to our society is allowing anyone to have a voice and make a contribution. The Internet has flattened the hierarchical process of how we used to make a contribution. From the age of 13, my son and his friends have been making video clips of their soccer tricks and putting them onto the social media site YouTube. They have no formal photographic training but still they are able to submit their contributions and viewers become their peer review critics.

Natural History Observers and Citizen Science
The Internet has led to the development of a new group of natural history observers. Unlike the traditional field naturalists, these people have little training or experience with field naturalists clubs but simply have a love of or intrigue of nature and want to make contributions about something they have “Discovered” and then to “Learn” more about what they have found.

Welcome to 21st century world of Citizen Science – a whole new army of people who are happy to document nature (usually photographically) and then share their discoveries through the Internet in the hope that someone finds their contribution of use and tells them more about what they have found.

The attraction of Citizen Science is its immediacy and its reach. Unlike formal naturalists clubs and societies that meet once every month or two and have a 10-15 minutes “notes and exhibits” section during their meetings devoted to what members have discovered, Citizen Science is a 24/7 forum with an audience ranging from local to national to international.

The Internet has also broken the rigid barrier of “No new discovery can become science until it is made public”. Prior to the Internet, making a discovery public meant a publication in a recognized journal or newsletter. Formal peer-reviewed publishing can take months if not years and often the author has to pay page charges to get the discovery into print. Quite often, the journal then assumes copyright of anything published so that the author has to request permission from the journal to re-use their own work in another publication. Fortunately, many of the rules and charges are now beginning to disappear; however, the need to publish still exists.

Online publication is becoming more and more acceptable as a means of making a discovery public and thereby making it available to science.

What a massive change has occurred in the past decade to the way we can do good science and who can now be involved in science.
The BugBlitz Program
About 10 years ago, I was approached by a group of retired businessmen who had an idea. These businessmen were the trustees of the Hugh Williamson Foundation - a Foundation dedicated to improving youth leadership within the community. Unlike many philanthropic groups that solicit grant applications and run a peer-review process to award funding, the Hugh Williamson trustees decide themselves what projects to fund and then approach people to make it happen. The Williamson trustees had been inspired by the work of Wilson and his BioBlitzes. However, they wanted to do something different here in Australia.

In America, the famous naturalist and Harvard scholar Edward O. Wilson had recently begun two major new Biodiversity public awareness projects. The first was an online project called “Encyclopedia of Life” (EoL) which has as its long-term goal to document every life form on earth. EoL is a wonderful project, which will gradually become the knowledge-bank for the natural world. The second Biodiversity project proposed by Wilson was designed to highlight local biodiversity. He called it BioBlitz. Wilson chose high profile locations, such as Central Park in New York, to run 24-hour BioBlitzes. Teams of scientists and helpers “blitzed” Central Park and made an inventory or species checklist of what they found during a 24 period. BioBlitzes began to occur in other parts of America and also in Europe. The Wilson BioBlitzes gathered together a range of skilled scientists and they and their helpers collected or observed every living animal and plant they could find in a 24-hour period. The Williamson trustees wanted to expand on the collecting time but narrow down on the audience and the target collection group.

BioBlitzes are a very successful way of making Biodiversity real and within the comprehension of most people. I often think that scientists do a disservice to Biodiversity when they speak in terms that are well beyond the powers of non-scientific comprehension. Estimates of the number of species on earth range from 10 to 30 million species and yet presently we have documented less than 2 million species. It is difficult to sell the idea that every species is important when we do not even know how many species there are! The fight/debate/discussion about finding the correct balance between commercial land use and protecting biodiversity is very difficult when we cannot quantify the biodiversity side of the equation.

The very nature of Science is sometime used against it. Science is rarely about absolutes – we call them axioms; it is more about theories and good science tests, questions, and theories. When someone wants to dismiss or delay making a decision that is based on science, you will sometimes hear this comment: “The scientific jury is still out.” But, that’s what good science is about!

BioBlitz is all about making biodiversity real and personal. BioBlitzes are run locally; they have a defined goal; and, they make discoveries that can be shared immediately. They engage people from scientific and non-scientific backgrounds as well as people just curious about what’s in their own backyard fauna and flora. It’s something a family group can do in their own backyard or a local park.

From BioBlitz to BugBlitz
The Australian form of BioBlitz is called BugBlitz and its audience is school children, primary and secondary and they just collect Bugs.
I had agreed to take part in the Australian BugBlitzes but lots of questions remained. Where and when should they be held? Who should run them? What were the markers of success?

The Williamson trustees spoke to the management of Sovereign Hill, a tourist attraction site in central Victoria. They had recently been donated a sheep property called Narmbool which contained land that varied from degraded pastures to grasslands to pristine old growth forests. The property had natural wetlands, a year round flowing creek and a number of dams dotted across the sheep running areas.

I remember standing with the trustees overlooking the Narmbool property and being told that a conference/accommodation centre and a science centre would be built and within two years they were.

Taking stock:
- We had a place (Narmbool) with its multi-varied habitats.
- Narmbool was a managed working sheep property which needed to make a profit to survive so a balance between conservation and commercial interests had to be found.
- The 60-person conference/accommodation and science resource centres were ready
- We knew how to survey its Bug fauna.

What we didn’t know were:
- How to make it work?
- How to fund it?
- What were the prime take away ideas we wanted to impart?
- How to give it longevity?

The Williamson trustees covered the funding question, so the rest looked easy!

During the construction of the conference/accommodation and science centres, we ran a one-day BugBlitz. While everyone enjoyed the day, we realized there was nothing special for the children to take away from the experience. This first group was from the country so a day in the countryside was nothing new to them.

Almost by luck, we found the BugBlitz “magic”! The Williamson trustees had been supporting a number of local artists and we approached one who seemed to be having success interacting with children – Ian the puppeteer. After much discussion and hesitation, we adapted the BugBlitz to revolve around the making and performing with puppets to tell a Biodiversity story – learning by stealth and having fun. Who would think that a couple of days in the country on a nature outing would involve making your own puppets, videos and music and finally putting them all together in a staged performance to be voted on by the audience! And, you took home the puppets and video to show everyone.

The “magic” of the puppets is that they enable students to express in their own ways the experiences and lessons they have learnt from their interactions with Biodiversity.

We expanded the student participation to between 40 – 60 students with no single school providing more than 10 students. We took them to Narmbool for 3 full days staying on the property. The last thing the children expected to do when they first arrived at a BugBlitz was to sit down to a full-on Punch and Judy puppet show – with singing and dancing participation from the audience.
This was the icebreaker for most students and our way to spot any of the “difficult” sections of the audience. The BugBlitz Punch and Judy show had been adapted to a conservation theme. The show finished up with a raucous rendition of “A Crocodile has got my baby.” It generated lots of fun and laughter and began to break down the interschool barriers.

Preparing for BugBlitz
The week prior to the commencement of a Narmbool BugBlitz, my colleagues and I head up to the property to establish the insect collecting traps. These include a range of simple and not so simple traps but nonetheless, traps that will work for us 24 hours a day and will guarantee us a catch.

The traps we use include:

Pitfall traps. These are simply foam coffee cups dug into the ground about a metre apart and 10 in a line. We place glycol into each cup as a preservative to store the week’s catch. We also place an ice-cream container lid just above each cup to prevent dingos and other animals from drinking the contents of the cup. We run 3 lines of 10 cups at each of 3 sites, i.e. 30 cups per site.

Malaise traps. These are like small tents designed to catch insects flying between ground level and 1 metre above. Malaise traps can be purchased commercially or home made. We make our own trap from white and black bra-liner material. The black material is used for the tent’s central baffle that runs from the ground to the top of the tent. The white material is used for the roof-side flaps of the tent and extends outwards at a 45-degree angle about one-third the height of the tent. Looking at the tent sideways, one end of the tent is higher than the other tent. The theory behind how a Malaise trap (named after the man who invented the trap) works is simple. An insect flying along hits the central black baffle and either hangs on or falls to the ground. The normal escape response for an insect is to head to the brightest light source. This is why the roof and side flaps are made from the white material. The insect either flies up or walks up the black baffle until it hits the top of the tent, and then continues to walk to the higher end of the tent, which has a clear collecting bottle into which the insect walks and cannot escape. We place small pest strip into the collecting bottle to kill the insect.

We choose 3 different habitat locations:
- Grassland
- Lightly wooded area but with an open tree canopy
- Heavily wooded area with a closed tree canopy.

The theme for the Biodiversity part of the BugBlitz is simple – Learn to read the Landscape. Do you think there may be a difference in the Biodiversity between the 3 chosen sites? If so, why? If not, why? Let’s make a theory and go out to test it – that’s what science is about.

Day One: Implementing BugBlitz
The first day is spent visiting each of the sites and becoming familiar with their habitat composition. We explain the different trapping techniques and how they work. The contents of the traps are emptied and carefully labeled to identify trap and habitat type before being returned to the science centre. While out at the sites, we usually pull back bark from some of the large eucalypt. All sorts of spiders and insects as well as geckos and sometimes frogs jump out at us or scurry around on the exposed bark. A favourite is Delena cancerides, the colonial huntsman spider that grows to the size of your outstretched hand. While large and very hairy, these
spiders will happily sit on your hand or slowly walk up to arm and over your shoulder to sit on your back. Just don’t wear a short-sleeved jumper or the spiders will crawl under the jumper mistaking it for a piece of protective bark.

The Delena cancrivora is also a favourite as it allows us to explore adaptive evolution right before their eyes. We ask the students why they think huntsman spiders are often found on tree trunks and under bark. Usually silence is the response. So we ask what kind of body type would best suits living under bark – big and round or big and flat? Flat becomes the obvious answer. Then we ask them to look at the lengths of the different legs on the huntsman spider. Once asked to look, they soon realize that not all of the legs are the same length. The first two pairs on each side are noticeably longer than the hind two pair. Okay, but why? What shape is a tree trunk? Round? So imagine you were trying to sneak up on an insect around the trunk of a tree. Would it be more effective to walk forwards or sideways? When you think about it, sideways is the answer. The more effective you can walk that way the more chance you will have to catch prey.

The best way to walk sideway easily is to have the first two pairs of legs long and the hind two pair of legs much shorter. Only huntsman spiders have this type of leg arrangement. It makes it easy for us to identify huntsman spiders, but it’s useful to know why they have different length legs.

**Day Two: Field Work and Puppetry**

The second day is spent in the Science Centre sorting out the catch from the pitfall and malaise traps. The contents from each trap type and each habitat are placed into large, white containers and the specimens are sorted. The students then use the tried and tested method of sorting: Place like with like. We use plastic egg-cartons as sorting containers that provide an easy way to separate the catch.

During this sorting phase of the day, we pull out examples of different insects and put them under a microscope which has a video camera attachment connected to a large TV screen. Everyone gathers around and we point different features of the different insects and what characters we use to divide them into different groups (i.e. Spider, Fly, Beetle, Centipede, Moth, Wasp etc).

Sorting is only to the level of Class or Order and when the sorting has been finished we tally up the number of each Class or Orders collected at each habitat and what each trap type had collected at each habitat.

The results are always instantaneously recognizable - the less diverse the habitat, the lower the Biodiversity. We then begin to explore the relationships between biodiversity and habitat. Why would a butterfly want to expose itself, with no protective cover, to being eaten by a bird when flying across a grassland compared flying inside a sheltered woodland where it can dart for cover and protection? Why are ants and beetles, that spend all of their time at ground level, the dominant species in a grassland? Why are there more species of hunting spiders in wooded forest than in a grassland? Why are there more species of orb weaving spiders in a wooded forest compared to a grassland? Why is the difference between the open canopy and closed canopy forest much less than between these habitats and the grassland?

The students begin to understand how to read the landscape and to understand the differences. They begin to understand how to devise a theory and then out and test it.
Just below the science centre there are 3 small, round ponds. During the day, small birds can often be seen skimming the surface of these ponds and we ask the students what are they doing. Most answer: “Getting a drink of water.” In the afternoon of the second day and using aquatic nets, we sample the sides of these ponds and return to the science centre to put the collected samples under the TV video camera. The explosion of life and movement of the aquatic insects is always a crowd pleaser. It is easy to show the detritus feeders such as the caddisfly larvae moving slowly about inside their silken cases, compared to the large predators such as the dragonfly and damselfly nymphs. The students always get a laugh when you point out their delicate, flap-like anal appendages that are indeed their noses. Extending their toothed lower mandible not only shows why they are predators but also how they catch their prey. There are usually some vicious looking Dytiscid beetle larvae with their enlarged, sabre-like, pointed mandibles ready to impale any poor passerby. The backswimmers beetles scoot past the viewing area in a great twirling hurry. While the blood red, wriggling, non-biting midge larvae are always a mystery and why are they red. The students soon realize that the birds are after insects rather than trying to get a drink of water.

The video camera is also marvelous to look at and examine insect eyes. Insect and spider eyes come in all sorts of sizes, shapes and numbers and it is fun to try to connect the habitat type and the insect eyes. A good example is to compare the eyes of a spider collected from a web and a spider collected in a pitfall trap. We call the web spider a web-hunting spider compared to a vagrant-hunting spider that stalks and runs down its prey. Apart from the leg type differences between the two spiders, the eyes show it best. A spider that sits in the middle of a web all day and waits for its prey to enter its web does not need a good set of eyes. And so, the web-hunting spider’s eyes are small and fairly ineffectual. Indeed, scientists suggest that web-hunting spider eyes are really only used to differentiate day from night. Some web-hunting spiders hide during the day and build a new web each night. Now compare these weak eyes to the large, orb-like eyes characteristic of a vagrant-hunting spider. It is not difficult to display and explain evolutionary patterns are linked with life style which is linked to habitat.

Speaking of spiders, a much-enjoyed nighttime activity for the students is to looking for Wolf spiders. These spiders have two enormous orb-like eyes at the front of their head. Wolf spiders come out at night and hunt for prey. If you go out at night and hold a torch next to your ear and scan the surrounding area you will often see two sparkles of light suddenly appear on the ground inside the beam of the torch. These sparkles are the light of your torch being reflected off the back retina of the Wolf Spider eyes. This technique will only work if you hold the torch next to your ear at about the same level as your eyes. Once you spot a Wolf Spider’s eyes, you can generally walk up slowly to it and have a better look at the spider. If you walk up quickly the spider will turn and dart away. Once it turns, it is lost in night from your torch.

During the afternoons of both the first and second days, the puppeteer begins to teach the students the art of puppetry. There is nothing sophisticated about his tools of trade – an empty drink bottle, the jaw bone of a sheep picked up in the paddock, a feather, a piece of cloth and of course rolls and rolls of masking tape. The students soon learn how easy it is to make the puppet the centre of
attention and they also learn that their voice can add so much character to even the roughest made puppet.

It is usually about the end of the second day that the “magic” begins to kick in – or perhaps it’s a case of “Necessity is the mother of invention”. The students break into groups and these groups must be mixed across the schools. They then must choose a theme or story related to their Narmbool Biodiversity activities and everyone must be involved in the 5-10 minute show. They make their own puppets, music or videos all with the help of the teaching staff from Narmbool.

It’s fun to stand back and watch the creativity kick in. We used to lock up the science lab about 8PM but we have found the students want to go back to the lab or work on their specimens or continue building their puppets so we now leave it open until lights out time.

**Day Three: Performing what they have learned**
The third day is spent finalizing the performances. In the afternoon we sit back, enjoy the show, and gain insights into what our students have learned.

The variety of ideas and techniques, as well as the quality of the performances, never ceases to amaze us. A bit of lighthearted competition between the groups is also a good incentive. It would be impossible to recount all of the different shows we have seen, but here are a few highlights:

- Along the sides of the creek is a large willow tree and in the base of this tree is where a platypus has made its home. Now the willow tree is an exotic plant in Australia so should it be removed from the creek bank? Apart from providing a home for the platypus, it also protects the edges of the creek bank from the sheep coming down to drink when there are nearby man-made ponds nearby for them to use. Two girls made a platypus puppet and while one of them played the role of the platypus, the other interviewed the platypus as to whether or not the willow tree such be removed. The interview was video-taped, a sound track added and played to us as the show. It was brilliant. They covered all of the pros and cons for keeping or removing the tree, the biodiversity impact of removing the tree compared to leaving it there and lots of humour was added as well. Magic stuff.

- Over the years, many of the shows have revolved around the eagles that circle Narmbool looking for prey such as snakes and other vertebrates. It is always amazing to see the effort and ingenuity put into making and flapping giant eagle wings and watching the eagle circle down onto a helpless snake puppet. The snake then tries to persuade the eagle to become a vegetarian rather than being top of the food chain on the Narmbool property.

- One group of boys who came along wanted to show us that ‘BugBlitz’ was not for them. They all wore beanies or hoods over the heads and were clearly not helpful. On the last afternoon, and much to our surprise, they had joined a group and made a wonderful piece of art comprised of two twisted sticks joined as a cross. In the middle of the cross was a sheep skull and on the ends of the
sticks they had attached feathers they had collected. As other group members performed, they sang a song and hit the art piece to make a rhythm. It all worked so well.

- One boy we “feared for” was a gifted child who was in Grade 9 but should have been doing his PhD at a University. His knowledge of nature was extensive and he liked to help by telling everyone what he knew. He eventually found his way into a group but only on the fringes. However, on performance day, he was the centre of that group. There are insects called ant-lions which dig a cone shaped hole in the ground and sit at the bottom of the cone with their enormous, sickle shaped jaws waiting for an insect to fall in. They are amazing to watch. When an ant ventures into the upper circles of the cone, the ant-lion will throw sand above the ant in an attempt to cause an avalanche on the sides of the cone which would bring the prey down the bottom and into jaws of the ant-lion. Our gifted student knew of this behavior and had collected several ant-lion larvae in the field and put them into our discarded pitfall foam coffee cups and added sand he collected with the ant-lions. Within a few hours, the ant-lions had built their perfect cone inside the sand filled foam coffee cups. He then encouraged several ants into the ant-lion cone and filmed the behavioural sequence of the ant-lion throwing sand to catch the ants. The other members of the groups developed this footage into a David Attenborough style Natural History documentary with dramatic sound effects, voice-overs and a commentary. The video went for about 5 minutes and it was a great success for all – and each student took away a copy of their video.

Our milestones for BugBlitz success were to simply watch the change in the students over the three days compared to when they first arrived. Had they understood what we meant by “Reading the landscape”? One surprising and unexpected milestone has been the number of students who have volunteered to return the following year to help with the annual Narmbool BugBlitz.

The main lessons we have learned include:

- Let the students go on a pathway of self discovery.
- Add an element that you would not usually associate with a form of learning.
- Make a deliverable not something they would associate with a form of learning.
- Provide enough structure to achieve your goals but guide rather than direct what you want them to discover.
- Make it fun and don’t rush it.
- Push their comfort zones but allow them to be comfortable.
Ken Walker is the curator of entomology at Museum Victoria in Melbourne Australia. Museum folk tend to stay in their jobs for long periods – it takes more than 10 years just understand the nature and history of the collection and then to find ways to use it in your daily task. My job entails a combination of 3 major tasks: (1) Conducting original research (in my case the taxonomy of native Australian bees); (2) Curating a collection of over 3 million specimens; and (3) Providing access to and interpretation of the State’s Insect and Spider collections through public programs. The creative part of the job is in the public programs and I have tackled this task through on-floor exhibitions, online websites and programs such as BugBlitz experiences. All three venues for expression have their own challenges and rewards but none can beat the one to one interaction with students – some of who are eager to learn and some who do not think it is “cool” to enjoy science but in the end just join in and have fun. The digital revolution continually reinvents my avenues for communication and expression of science and this is where the creativity of my job is most engaged.
The Encyclopedia of Life: An International, Open Educational Resource for Biodiversity Learning

Tracy Barbaro, Jeffrey Holmes, and Marie Studer
Encyclopedia of Life Learning and Education Group
Harvard University, Cambridge, MA, USA

Email: mstuder@eol.org
Please contact us at education@eol.org

The Encyclopedia of Life (EOL; www.eol.org) was established to make comprehensive, authenticated information about the world’s biodiversity freely available over the Internet in a single, trusted digital resource. Encyclopedia of Life currently includes more than 700,000 authenticated species pages with text or image content and links to over 34 million pages of digitized biodiversity literature through the Biodiversity Heritage Library http://www.biodiversitylibrary.org/. In addition, EOL is a partnership of 12 international institutions and over one hundred content providers from around the world. The EOL international partners serve species pages for the flora and fauna from a specific geographic area, in languages used in the region, making this valuable information much more accessible. EOL is an Open Educational Resource (OER) that provides an engaging and informative learning platform where students and others can work together to help build this global resource and learn about biological diversity worldwide. Examples of tools and activities available for biodiversity learning through EOL are described, including students writing species pages using the EOL Education LifeDesk tool and other partner’s tools.

Keywords: Encyclopedia of Life (EOL), Biodiversity Heritage Library (BHL), Open Educational Resource (OER), Education LifeDesk, species pages, student authoring, biodiversity

The Encyclopedia of Life has been called a “Biological Moonshot” for its vision to create a centralized Web portal with a page for every living organism on Earth. “Like flying to the moon, making one encyclopedia of all life is an old idea that technology might finally make possible” (Milius, 2008).

The Encyclopedia of Life (EOL; www.eol.org) is an endeavor to provide detailed information for all 1.9 million known species on the planet in an easy-to-navigate, freely available online format. The project brings together students, educators, citizens and scientists from around the world to create a dynamic and interactive place to explore, learn and share information and resources about biodiversity. EOL provides access to the most current content of what is known about the diversity of life on our planet. Information is aggregated from content partners all around the world into a common template called a “species page.” Educators have the opportunity to use the rich resources of the EOL site to further students’ appreciation for, and understanding of, the amazing variation of life and to foster students’ own crucial role as biodiversity stewards.
In addition, EOL provides access to digitized, primary literature through our partnership with the Biodiversity Heritage Library (BHL; http://biodiversitylibrary.org). Twelve major natural history museum libraries, botanical libraries, and research institutions joined to form the BHL. The participating libraries have over two million volumes of biodiversity literature collected over 200 years to support the work of scientists, researchers, and students in their home institutions and throughout the world.

Since 2009, the BHL has expanded globally http://biodivlib.wikispaces.com/About#BHL%20Consortium%20Membership. The European Commission’s eContentPlus program has recently funded the BHL-Europe project, with 28 institutions, to assemble the European language literature. Additionally, the Chinese Academy of Sciences, the Atlas of Living Australia, Brazil (through SciELO and BIREME), and The New Library of Alexandria have created regional BHL nodes. These projects will work together to share content, protocols, services, and digital preservation practices.

Table 1. EOL Global Partners

<table>
<thead>
<tr>
<th>Region</th>
<th>Lead Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arab region</td>
<td>New Library of Alexandria, Egypt</td>
</tr>
<tr>
<td>Australia</td>
<td>Atlas of Living Australia</td>
</tr>
<tr>
<td>Brazil</td>
<td>Scientific Electronic Library Online</td>
</tr>
<tr>
<td></td>
<td>BIREME (Regional Library of Medicine)</td>
</tr>
<tr>
<td>China</td>
<td>Chinese Academy of Sciences</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>INBio (Instituto Nacional de Biodiversidad)</td>
</tr>
<tr>
<td>Mexico</td>
<td>CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad)</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>NCB Naturalis (Nederlands Centrum voor Biodiversiteit)</td>
</tr>
<tr>
<td>South Africa</td>
<td>South African National Biodiversity Institute</td>
</tr>
</tbody>
</table>

EOL also continues to cultivate global partnerships and collaborations to develop regional versions of EOL. It typically serves species pages for the flora and fauna from a specific geographic area in languages used in the region. EOL’s current global partners are listed in Table 1.

As EOL’s international contributor and user base grows, people everywhere can be engaged with a greater number of enhanced species pages and an expanding set of knowledge tools to navigate, access and contribute to EOL. It is committed to open source software development and continuous improvement of content and tools. This allows new applications of EOL to be developed by and for different end-users that range from educators and students to conservation scientists and the general public, while also potentially increasing the interaction among these groups. Through its text, image, and media resources, as well as the tools and activities offered, EOL provides a chance for students of all ages, in all learning settings, to contribute to the enterprise of citizen science and to become contributors to a global “biodiversity commons” (Moritz, 2002). This paper will present a variety of learning tools available through EOL, with particular emphasis on the activity of students authoring or contributing to species pages (see Table 2).

**Learning While Building a Global Resource**

EOL can be incorporated into learning activities across ages and skill sets. It can be used as a reliable reference for a wide range of information about species, including but not limited to life history, ecology, molecular biology, genetics and current conservation status and threats.
Through the participatory capabilities, such as uploading images and videos, building customizable field guides and creating communities around a particular interest, EOL can serve as an interactive platform to better engage audiences to learn about biodiversity and to hone 21st century skills. Several of these resources and activities are listed in Table 2 and on the EOL website.

Table 2. EOL Tools, Services and Activities for Biodiversity Learning

<table>
<thead>
<tr>
<th>Resources and Tools</th>
<th>Description</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>One Species at a Time podcasts</strong></td>
<td>These 5-minute audio pieces are highly engaging and link to species content on the Encyclopedia of Life. The podcasts are accompanied by a “Meet the Scientist” feature page, multimedia extras, interesting facts, relevant educational materials and calls for listener participation. We have heard back from many educators about how they use the podcasts in their classrooms.</td>
<td><a href="http://education.eol.org/podcast">http://education.eol.org/podcast</a></td>
</tr>
<tr>
<td><strong>Field Guide Tool</strong></td>
<td>The Field Guide tool provides a way to organize species information for a particular project or purpose. Field Guides enable the creation of customized content to include just the information from EOL specific to your educational needs.</td>
<td><a href="http://education.eol.org/ideas/tools/fieldguide">http://education.eol.org/ideas/tools/fieldguide</a></td>
</tr>
<tr>
<td><strong>Education LifeDesk</strong></td>
<td>An online collaborative tool called an Education LifeDesk to facilitate the writing of species accounts by undergraduate biology students.</td>
<td><a href="http://www.edulifedesks.org/">http://www.edulifedesks.org/</a></td>
</tr>
<tr>
<td><strong>BioBlitz Resources</strong></td>
<td>A BioBlitz is a snapshot -- a limited-time, limited-space species inventory of the organisms that live in an area. EOL is interested in BioBlitzes because our mission is to document information about all species of life on Earth. EOL provides the following BioBlitz and species inventory resources: a BioBlitz Worldwide map where new events can be posted by the general public or institutions hosting events, information on how to contribute species and BioBlitz event images and downloadable Backyard BioBlitz activities.</td>
<td><a href="http://education.eol.org/bioblitz">http://education.eol.org/bioblitz</a></td>
</tr>
</tbody>
</table>
Contribute Images
Share images and video of your local flora and fauna by uploading them to the EOL Flickr Photo Pool. Once tagged, images and video are harvested and pulled into the Encyclopedia of Life. [http://education.eol.org/ideas/contribute](http://education.eol.org/ideas/contribute)

EOL Public API
The EOL Public API (Application Programming Interface) is now available. The API allows third party applications or websites to access content from EOL. For more information and to see examples of current usages of the EOL API please visit: [http://www.eol.org/content/page/api_examples](http://www.eol.org/content/page/api_examples)

Biodiversity Heritage Library
The Biodiversity Heritage Library (BHL) is a consortium of natural history and botanical libraries that digitizes and makes accessible the legacy literature of biodiversity held in their collections. [http://www.biodiversitylibrary.org/](http://www.biodiversitylibrary.org/)

NameLink
NameLink is a service offered by EOL that allows you to submit a webpage address and have the taxon names within the page automatically identified and linked up to projects which have information about those names. Developers can easily embed this functionality within their own webpages by using the NameTag API. [http://www.eol.org/content/page/namelink](http://www.eol.org/content/page/namelink)

Students Contribute to the Encyclopedia of Life
Around the world, undergraduate students from colleges and universities have contributed to more than 5,000 EOL species pages. Working under the direction of their professors and class instructors, students use the EOL Education LifeDesk [http://www.edulifedesks.org/](http://www.edulifedesks.org/) or other online work environments that provide a collaborative space for creating, editing and publishing web pages of species information.

Students learn scientific content, gain experience in scientific writing, develop technology skills while contributing to an important global endeavor, and achieve what for most of them is their first scientific publication. Students become highly motivated when they realize their course work has a scientific and public application through the contribution to EOL.

Who can be involved and how do students benefit?
To date, graduate, tertiary, and secondary school students have contributed to EOL. Students might create pages as part of a class project, special assignment, or individual research effort. Student authors are from all backgrounds, from large and small schools, colleges, and universities, and at many different stages in their studies.
Students who contribute to EOL report that they feel the satisfaction of contributing to the global knowledge base on biodiversity by helping to bring together in one place all of the most important information about a species. They appreciate the opportunity to get very familiar with an organism that, in many cases, may not be known to them or to anyone except an expert. Students learn throughout the process how to weigh content from many sources, in exactly the same way an expert does, and become familiar with the processes of identifying, cataloging, and describing species from their selected taxonomic groups. Pages created by students go through a series of reviews, and once vetted, student pages are made available to the EOL community on the same footing as pages created by all other contributors.

**How do professors and other instructors benefit?**

Faculty report that students take the assignment to contribute to EOL very seriously. They report that such projects contribute to group collaboration, motivate students to learn more, and empower students to take more responsibility for their learning, in some cases, encouraging them to continue their studies further in the field. These EOL projects advance teaching and learning by giving learners an opportunity to work through the type of real-life challenges that scientists face in their professional careers. Creating EOL pages can take the place of a traditional research paper or other end-of-term assignment (see Figure 1).

**First Steps for Teachers and Professors**

Helping students contribute to EOL is straightforward. The first step is to identify the group of organisms that your students will work on and the level of detail you wish them to contribute. Instructors have discretion over the selection of topics for students to complete for their course. It is not required that students research and provide content for all EOL Table of Contents sections. Depending on the goals of the course, students may focus on particular sections, such as the Overview, Ecology and Habitat sections, for example.

The next step is to select which on-line tool to use for the project, depending on the taxa being studied and the level of support required. EOL currently works with three partners who have systems and tools in place to facilitate student authoring of species pages for animals, amphibians and fungi. Partners may provide expert review, and serve as a single contact point for uploading species pages. These three partners are listed in Table 3 and each of them publishes detailed guidelines and instructions about how to enter new pages into their respective databases. In many cases, they can provide advice and additional support.

The EOL Education LifeDesk environment is another option for student authoring of species pages. It is an online collaborative workspace that can be used to create species or other taxon pages for publishing into the Encyclopedia. It can be used for any taxonomic group and is tightly aligned with EOL. It offers systems to create groups, assignments and a workflow for editing, reviewing and publishing student’s work.

*We need to encourage children everywhere to exercise their curiosity with nature and to do this we need simplified tools that they can use – not just Field Guides, but on-line resources such as the Encyclopedia of Life and national and global programs that encourage children to explore the wonders of nature. It is through these programs in the early years of life that encourage children to grow up appreciating nature and to become active, life-long citizen scientists.* — Arthur D. Chapman, Dec. 2009

**Figure 1.** Common Green Tree-Frog (*Litoria caerulea*) near Toowoomba, Queensland, Australia. Photographed on 18 June 2005 by Arthur D. Chapman.
<table>
<thead>
<tr>
<th>Table 3. Tools and platforms for students to author species pages</th>
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<tbody>
<tr>
<td><strong>Education LifeDesks</strong></td>
</tr>
<tr>
<td>LifeDesks provide a collaborative space for creating, editing, and publishing web pages of species information. The LifeDesk environment provides content management tools that enable instructors to setup groups (for example, a herpetology class) and manage content evaluation, assignments, and group members. A list of resources for using Education LifeDesks can be found on our web page.</td>
</tr>
<tr>
<td><strong>Mushroom Observer</strong></td>
</tr>
<tr>
<td><a href="http://mushroomobserver.org/?_js=on&amp;_new=true">http://mushroomobserver.org/?_js=on&amp;_new=true</a></td>
</tr>
<tr>
<td>Mushroom Observer is a citizen-science group that records observations about mushrooms and other fungi, helps users identify mushrooms and related species that they are not familiar with, and expands the community around mycology. While their emphasis is on large fleshy fungi, like mushrooms, other fungi such as lichens, rust, and molds, as well as fungus-like organisms such as slime-molds, are all welcome.</td>
</tr>
<tr>
<td><strong>Amphibiaweb</strong></td>
</tr>
<tr>
<td><a href="http://amphibiaweb.org/">http://amphibiaweb.org/</a></td>
</tr>
<tr>
<td>&quot;We have the ambitious goal of establishing a home page for every species of amphibian in the world.&quot; Currently over 2,500 amphibians are included and the number is expanding monthly.</td>
</tr>
<tr>
<td><strong>Animal Diversity Web</strong></td>
</tr>
<tr>
<td><a href="http://animaldiversity.ummz.umich.edu/site/index.html">http://animaldiversity.ummz.umich.edu/site/index.html</a></td>
</tr>
<tr>
<td>Located at the University of Michigan, the Animal Diversity Web is a widely-used educational resource, visited by more than 15,000 people every day. ADW offers a sophisticated template structure that incorporates the work of all of its contributors into a single natural history database, adding a powerful structured search engine for students to explore these data, investigate patterns and address questions in evolution and ecology.</td>
</tr>
</tbody>
</table>
Once a content partner has been chosen, the next step is to contact them to receive the latest, most complete information and guidelines. Instructors and classes are assigned an account so the information created by students can be entered on-line. Usually, the instructor(s) receives additional user privileges so that you can review and edit student work, and then release it for publication at the end of the semester. Once the content partner has been selected, instructors can begin to involve students in the assignment.

Case Study: Harvard course "Biology of the Fungi"

Since 2008 Professors Anne Pringle and Donald H. Pfister have partnered to teach a course for Harvard College undergraduates called "Biology of the Fungi." The course explores all aspects of fungal ecology, evolution, and morphology, as well as the diversity of fungi, including mushrooms, smuts, rust, and molds. As a final class project, students create a page for a fungus that they chose to learn more about. They weighed existing sources, chose the most accurate information, and wrote descriptions that resulted in new pages on EOL.
How did creating EOL content fit into the course and how do students benefit?
The students in the class created EOL content as a way of tying together the knowledge and skills gained in course lectures, labs, and readings. Several students claimed that they enjoyed this project more than the alternative of writing a research paper.

Students benefited by doing a practical review of the scientific literature and trying to balance differing points of view about their species. Because EOL requires certain detailed information, the students had to use creativity and insight to merge information from a variety of sources. Often, they turned to the original species descriptions. All this is excellent practice for what scientists do.

What challenges did contributing to the species pages present?
While some students had to look hard for information about their species, others, who had a more common or economically-important species, had the time-consuming task of sifting through and weighing large amounts of information. (Figure 2)

In an evaluative focus group at the end of the semester, one student expressed concern that because she was not a fungal expert, her page would not be as accurate or publishable as pages written by experts. The instructors in the course disagreed, saying that the challenge of seeking out and synthesizing information from sources that may not all agree is an essential part of what scientists do on a daily basis. It is great practice for students, whatever career path they choose.

Finally, the instructors were concerned about the amount of editing that the student pages required them to do in making all pages consistent in tone and style. While instructors should carefully review their students' work for accuracy, some of the partners listed in Table 3 can provide some editing assistance, thereby alleviating this part of the instructor's responsibility.

The goals of the Mushroom Observer are to record observations about mushrooms, help people identify mushrooms they aren't familiar with, and expand the community around the scientific exploration of mushrooms (mycology). Involving as many people as possible works directly to achieve those goals. Helping people learn about Fungi is critical to connecting people to the natural world around them. Having people participate in creating the site pushes people to really explore and get invested in a way that passive reading simply can't. The direct feedback and encouragement from the rest of the community helps new contributors to improve their photographs and notes, which in turn help with the identifications. It's been great to watch some of the participants go from relatively little knowledge to excellent field mycologists in a matter of a few months.

Naively it might seem like the sites (Mushroom Observer and EOL) are in competition. However, in reality they are strongly symbiotic. Mushroom Observer is a specialist community that can provide photographs, descriptions and expertise to EOL. EOL, on the other hand, is a generalist that provides a wider audience and greater recognition for the contributions that come through the Mushroom Observer and new users. Last fall I saw a gradual drop off in the participation in the site. This fall I have seen a steady increase that I believe is a direct result of the pilot project and the visibility Mushroom Observer has gained by being associated with the EOL.

- Nathan Wilson, Mushroom Observer

How was student work in "Biology of the Fungi" evaluated?
After students submitted their work in draft form, the instructors reviewed the pages for accuracy on-line and edited student language for consistency. At this time, instructors graded the pages based on the amount of information presented, the consistency and completeness of the presentation, accuracy of information, quality of references, etc. Grades took into
account the relative obscurity or prominence of the chosen species. For example, a few references for an obscure species would have been awarded the same credit as several more references for a common species.

In the final student grade, EOL pages were given the same weight as had been given in previous years to a 20-page research paper. Most students felt happy with their work on their EOL pages and one expressed that it was a better use of his time than writing a research paper "that no one but me and my professor would ever read."


Conclusion
EOL provides rich content, multi-media resources and tools, all of which are either in the public domain or served under a Creative Commons License http://creativecommons.org/ or other Open Access licenses. These freely available resources can help increase learners’ awareness, knowledge and understanding of life on Earth, provide exposure to various scientific methodologies and the process of scientific discovery. Through its participatory features, EOL allows students to become more involved in their learning and to be contributors to this international, life-long learning website. Thus, EOL is not a passive resource. http://education.eol.org/collaborations/under_init1

So far, thousands of species pages created by students have been incorporated into the Encyclopedia of Life. We urge other classes to get involved with this endeavor. With 1.9 million species identified by scientists so far, and millions more yet to be discovered, there are plenty of species pages to work on. Join the citizens and scientists from around the world are making EOL a dynamic and interactive place to learn and share. Students can also have this unique opportunity. EOL can help them learn how to think like an expert and make a real contribution to global biodiversity information.

References
Biodiversity Heritage Library http://www.biodiversitylibrary.org/
Creative Commons License http://creativecommons.org/
Encyclopedia of Life (EOL) http://www.eol.org
EOL Education LifeDesk http://www.edulifedesks.org/
Giant Bluetongue Skink http://www.eol.org/pages/790463
Glistening Ink-cap http://www.eol.org/pages/243564

The Encyclopedia of Life: An International, Open Educational Resource for Biodiversity Learning
Tracy Barbaro is the Project Coordinator for the Encyclopedia of Life (EOL) Learning and Education (L+E) Group. She comes to EOL from Boston Public Schools (MA, USA), where she taught middle school technology. Prior to this, she worked for the U.S. National Park Service, the Student Conservation Association and the AmeriCorps National Service Program. Tracy focuses on outreach, the development of resources to help educators and learners utilize the species content from the Encyclopedia of Life and facilitating the development of educational partnerships. Tracy brings to EOL her extensive background in instructional technology, environmental education, and service learning. Tracy has an M.S. in Education from the University of New Haven, CT, USA and a B.A. in Political Science from Bates College, Lewiston, ME, USA.

Jeffrey Holmes is the Digital Learning Editor in the Encyclopedia of Life (EOL) Learning and Education (L+E) Group. With a background in veterinary medicine, Jeff has spent the last 17 years developing technology-based education programs and conducting a wide range of research in teacher education, cross-cultural learning, and technologies aimed at the K-12 level. Jeff came to EOL from Discovery Education (a division of Discovery Communications), where he was Director of Instructional Design, focusing on the design and development of media-based learning and assessment programs. Jeff draws on his experience in science, technology, and education to explore new ways of learning about biodiversity, especially through the use of tools and applications that encourage participation and collaboration. Jeff earned his DVM from the University of Guelph, Guelph, CA and a Ph.D. in Educational Technology from Vanderbilt University, Nashville, TN, USA.

Marie Studer is the director of the Learning and Education (L+E) Group for the Encyclopedia of Life (EOL). She coordinates and manages the outreach and partnerships to introduce EOL to educators and learners in all kinds of formal and informal education settings. Meeting with stakeholders across the country and around the world, she promotes awareness of EOL, engages various audiences in dialogues about the use of EOL in education and develops partnerships. In the ten years before she joined EOL, Marie was the Chief Scientist for Earthwatch Institute, responsible for overseeing the research, education and conservation programs for this international citizen science organization. She received a Ph.D. in Environmental Science from the University of Massachusetts Boston and a B.A. in Chemistry from Wheaton College, Norton, MA, USA.
Arid Lichens from the Red Data Book of Ukraine:
Perspectives on Assessing, Conserving, and Educating

O.V. Nadyeina¹, L.V. Dymytrova¹, O. Ye. Khodosovtsvev², Yu.S. Nazarchyk ³

¹M.G. Kholodny Institute of Botany/ Department of Lichenology & Bryology, Kyiv, Ukraine
²Kherson State University/ Botany Department, Kherson, Ukraine
³I.I. Mechnykov State University/ Botany Department, Odessa, Ukraine

The project supported by Rufford Small Grant Foundation was carried out in Ukraine during 2009-2011 and combined lichen floristics, community ecology and public education. Our working team includes specialists from different parts of Ukraine – Kyiv (Dr. O. Nadyeina, Dr. L. Dymytrova), Kherson (Prof. O. Khodosovtsev) and Odessa (Yu. Nazarchuk). Our focus was on arid terricolous lichens in steppes because these ecosystems occupy an important part of the Ukrainian territory. However, steppe ecosystems are amongst the most disturbed areas, affected by built-up areas, mines, industries, crop farming and overgrazing. The main aim of this study was to disseminate knowledge about steppe lichens and their conservation to the local population, governmental and regional administrations, and staff of protected areas. Our activity included monitoring the terricolous lichen communities and species distribution in Ukrainian steppes. We have prepared and distributed an informative brochure for school associations of young biologists and ecologists, biological faculties of universities from the main regions, administrators of protected areas, and the Ministry of Environment and Natural Resources of Ukraine. Eight months after distribution we received lichen specimens from schools and social organizations. Also, some local children’s and historic-cultural journals expressed interest in our project. From a scientific point of view, we have collected data about historic and modern localities of terricolous lichens with relations to the steppe zone of Ukraine, including 10 species from the present edition of Red Data Book of Ukraine (2009): Agrestia hispida, Aspicilia fruticulosa, A. vagans, Cetraria steppae, Fulgensia desertorum, Leptogium schraderi, Seirophora lacunosa, Squamarina lentigera, Xanthoparmelia camtschadalis, X. ryssolea. We documented localities for 10 redlisted species, some as new, others to confirm or disappeared records from the 19th century. In this project, we described associations of terricolous lichens and clarified some taxonomically difficult species, as Cetraria steppae and Xanthoparmelia ryssolea. Our field trips and collaborations with other organizations and colleagues stimulated the establishment of new protected areas in the south of Ukraine, notably in Kherson, Donetsk, Luhansk, Odessa regions and Crimea. We assume that popularizing the lichen conservation issue will also influence the acceptance of local and regional administrations for lichen conservation.
**Objectives and origin of our idea**

The Ukrainian Steppes are the western part of the Eurasian Steppe Area. Therefore, some arid species have their western boundary in eastern Ukraine or occasionally occur here after disjunction. (Figure 1) Additionally, steppe landscapes in Ukraine are influenced by anthropogenic pressures (as plugging-up, network of settlements, mines etc.). Lichens are intricate symbiotic associations of fungus and algae, which make them different from other fungi and allow them to survive in extreme environments for a long time. At the same time, lichens express a very high level of habitat selectivity and sensitivity to long-term environmental changes. Lichens are an important component of steppe ecosystems and are usually used as bioindicators. Overall, we can consider many species as vulnerable because their occurrence is endangered. A scientifically based algorithm for evaluating the species to be included in the Red Data Books was developed by IUCN (2001) and adapting it for work with lichens was proposed (Scheidegger & Goward, 2002; Zavarzin & Muchnik, 2005). There are 52 lichens included in the Red Data Book of Ukraine (2009) and 11 of them are from the ecologically arid zone (*Agrestia hispida* (Mereschk.) Hale & W.L. Culb., *Aspicilia fruticulosa* (Eversm.) Flagey, *A. vagans* Oxner, *Cetraria steppae* (Savicz) Kärnefelt, *Fulgensia desertorum* (Tomin) Poelt, *Leptogium schraderi* (Bernh.) Nyl., *Seirophora lacunosa* (Rupr.) Froden, *Squamarina cartilaginea* (With.) P. James, *S. lentigera* (Weber) Poelt, *Xanthoparmelia camtschadalis*, *X. ryssolea* (Ach.) O. Blanco, A. Crespo, Elix, D. Hawksw. & Lumbsch). Some of them are pictured in Figure 1. The criteria for including those lichens were based mainly on the number of scattered reports and the impression from a few experienced lichenologists. However, a comprehensive documentation of changes in the lichen flora of Ukraine does not exist. The situation with lichens described in the Red Data Book in Ukraine has inspired us to check all their known localities and discover new ones. We decided to concentrate attention only on arid lichens because steppe ecotops in Ukraine are changing and we risk losing knowledge about present lichen diversity and threats. Our aim was also concentrated on adopting the idea of nature conservation and social monitoring of the distribution of rare terricolous lichens in Steppe and also in Forest-Steppe zones of Ukraine. We planned our work so that school organizations of young naturalists from main regions of Ukraine could also contribute.

![Figure 1. Position of Ukraine within Eurasian Steppe Area (marked yellow) – reproduced from the logo of V International Symposium “Steppes of the Northern Eurasia” (Orenburg, 2009).](image-url)
Arid Lichens from the Red Data Book of Ukraine: Perspectives on Assessing, Conserving, and Educating

Figure 2. Some vulnerable terricolous vagrant lichens from Red Data Book of Ukraine: Agrestia hispida, Xanthoparmelia ryxsolea, X. camtschadalis, Cetraria steppae. Photos by C. Scheidegger, L. Dymytrova, O. Nadyeina.

Figure 3. Top physical map of Ukraine reflects zonal landscapes which were common here more than 200 years ago. The natural habitats are very fragmented. Bottom map shows how the modern territory of Ukraine is networked by settlements, transport and industrial systems.

Figure 4. Our collaboration with colleagues: Dr. I. Moysyenko and Prof. O. Khodosovtsev (Kherson State University) during the Conference in honour of J. Pachosky. Explanation of cryptogame role in sand weathering intensity, Oleshkivsky Pisky National Park, Oct 2009. Photo by N. Parshikova.
Studying and assessing

Based on data obtained from the literature, records, or public Herbaria (KW, KHER, MSUD, CWU)\(^1\), we designed and constructed a database for terricolous arid lichens. We mapped old localities of those lichens and planned our field trips according to these localities. Then six expeditions were carried out to preserved steppe localities during 2009-2011 years namely in Odessa, Kherson, Mykolaiv, Zaporizhzhya, Donetsk, Luhansk Regions and Crimea Autonomic Republic. (Figures 3, 5) During our field trips, we checked if there were still terricolous arid lichens (including those from the Red Data Book) growing, and described terricolous lichen associations according to Braun-Blanque protocol. (Figure 6) Areas without a protection status, as well as protected areas, were investigated: “Askania-Nova”, “Chornomorskyi” and “Dunajskyi” Biosphere Reserves; “Oleskhivsky Pisky”, “Azovo-Svashskyi”, “Kalararskyi Step”, “Byloberezha Sviatoslava”, “Nyzhnioudnystrovskyi”, “Tuzla’s Lyman” National Nature Parks; “Chudova Gavan”, “Kinburnska Kosa”, “Tarutynskyi Step” Regional Landscape Parks; and “Karantype” Nature Reserve, “Kamjani Mohyly” unit of the Ukraininan Steppe Nature Reserve; “Provalskyi Step”, “Triohizbensk Step” and “Stanychno-Luhanske” units of Luhansk Nature Steppe Reserve. (Figures 7, 8, 9, 10) We completed lichen species lists for “Annals of Nature” for the mentioned protected areas.

\(^1\) KW – Herbaria of M.H. Kholodny Institute of Botany; KHER – Kherson State University; MSUD – I.I. Mechnikov National University of Odessa; CWU – V.N. Karazin National University of Kharkiv.
Our team also had prepared a scientific justification for the creation of new protected areas. They are: “Naddniprianski Areny” National National Park (Kyiv Region); “Bili Gory”, “Zhemchuzhyna Perevalshyny”, “Mykhailivskyi Kanion” (Luhansk Region) Botanical Reserves and “Nagolnianski Vysoty” (Luhansk Region), “Ushkalski Visoty” (Kherson Region), “Kuialnytsky” and “Tiligul Balki” (Odessa Region) Landscape Reserves. Those objections have been sent to the Ministry of Ecology and Nature Protection of Ukraine (to the Protection Area Business Department) and now in a stage of consideration.

During project exploration several scientific papers and abstracts for conferences were prepared, dealing with such topics as clarifying of taxonomy of terricolous arid lichens with problematic delimitation, terricolous lichen associations selected according to Braun-Blanquet protocol. We are planning to publish a final monograph reflecting the results of our project “Terricolous lichens in the Ukrainian Steppes: assessment, conversation, perspectives”.

**Conservation and education**

Nature conservation is impossible without changing the minds of citizens who have no special eco-, geo- or biological education. However, not much is known about lichens and especially their role in nature, history with humanity, general aesthetic and pharmacologic qualities. The value of lichens is more clear in tundra landscapes where, for example, “Deer’s Moss” (lichens from genus Cladonia, usually Cladonia rangiferina, Cl. alpestris, Cl. mitis) is the main food for deer. Locals in boreal or alpine areas know “Iceland Moss” (Cetraria islandica) because of its classical pharmacological value or “British soldier lichen” (Cladonia cristatella) because of its aesthetic beauty. On the contrary, local people know nothing about...
steppe lichens and understand Steppes, like places with *Stipa, Arthemisia, Thymus*, at best as habitats for bid birds or marmots. Nevertheless, many fungi, alga and lichens inhabit steppes and play a significant role in the functionality of a Steppe ecosystem. To enrich the local’s perception of the Steppes we published and distributed a local population brochure, “What do you know about steppe lichens? Minute world under your feet”. Our 20-page brochure, in Ukrainian, has colored pictures, photographs and clarifying text, and a circulation of 700 issues (Fig. 11). It is available as a pdf on [http://pryroda.in.ua/step/biblio/lichens/](http://pryroda.in.ua/step/biblio/lichens/) or as hard copy on request.

Figure 11. Brochure “What do you know about steppe lichens? Minute world under your feet”, Cover page and pp. 16-17.
The brochure introduces readers to lichens, and describes peculiarities of their micro-habitats and distribution patterns, how to recognize them locally, some interesting facts from human history which are connected with lichens, how to recognize common and rare terricolous lichens, understanding them as a part of a steppe ecotope, the role of different species in the stage of steppe succession, and advice, on what everyone can do for lichens and nature conservation. In particular, lichens are compared with other organisms (plants, animals mainly) emphasizing the impossibility of their introduction and protection in the Botanical Gardens. Lichens can only be saved in their native localities. Otherwise, they appear in the Herbaria on the pages of scientific papers. Also, from practical point of view, it is shown that lichens are significant due to their relation with other soil inhabitants for soil stability, decreasing weathering intensity, and oxygen and water circulation in soil.

We believe ecological education and the mind can be enhanced effectively if dealt with at different levels of society: from school- or student-citizens to resources from protection areas, the Ministry of Environment and Natural Resources of Ukraine, or, similar governmental organizations. Therefore, we distributed our informative brochure to more than 150 organizations in the Ukrainian Steppes districts (protected areas, schools specialized in ecology and biology, universities, administrations and people with active life positions, specifically:

1) School organizations with bio-, eco- or nature conservation profile (total 101 organizations), namely city or district Ecological-Naturalistic Centers, district Center of Environmental and Naturalistic Art pupils, City Station of Young Naturalists and so on.

2) Administrations of protected areas (total – 16 organizations) as Nature Reserves and Regional Landscape Parks.

3) Peoples with active position, colleagues (including abroad, total – 62 persons), from different parts of Ukraine and Russia: mycologists, botanists, ecologists, biologists, lichenologists, zoologists, algologists, bryologists, ornithologist, geobotanists, entomologist, herpetologist, school teachers, and foresters.

4) Administrative governmental resources (total – 16 organizations), as Ministry of Ecology and Nature Recourses of Ukraine, Governmental Service of Nature Protection, several Regional Councils (Nature Resources Department), State Department of Environmental Protection in different regions of Steppe zone.

A bit more than 8 months after distribution of the brochure, we received comments, additional questions to be clarified, additional requests for Brochure issues, photos and specimens to complete our current project and even small scientific reports about lichens around. Also, local children’s and historic-cultural journals (“Parostok”, “Biology for inquisitives”, “Saint business”) expressed their interest to publish in their journals some issues about lichens and steppe conservation. (Figure 12) Our brochures are useful for University and School biology courses and teachers, because they are very illustrative and provide available information about conservation problems and lichens. Presentation of Brochure was carried out in the Kherson and Odessa branches of the Small Academy of Sciences of Ukraine, in the National Ecological-Naturalistic Center (Kyiv), the Odessa Region Center of out-of-school Education “Yunnatsky”, and the Crimean Republican out-of-school Educational Organization “Center for Ecological-Naturalistic Arts of School Youth” (Sympheropol).
We received feedback from the following organizations: Severodonetsk City Station of Young Naturalists (Luhansk Reg.), Svitlovodsk City Station of Young Naturalists (Kyrovograd Reg.), Mykolaiv Region Ecological-Naturalistic Center of School Youth (Mykolaiv Reg.), Crimean Republican Center for Ecological-naturalistic art for pupils (AR Crimea), Kherson Region Ecological-Naturalistic Center of School Youth (Kherson Reg.), Dnypro-Oril Nature Reserve (Dnipropetrovsk reg.), Dnipropetrovsk National University. It should be mentioned, however, that for the moment people still do not distinguish with 100% certainty, lichens from other groups of organisms. In the parcels from school organizations, there were still some specimens of aphylophoroid fungi and mosses between lichens. Also, people sent everything they were interested in and could collect, including mosses, fungi and epiphytic lichens. Nevertheless, we consider this as a positive trend and suppose that it is necessary to accept lichens in minds at all, accumulate ideas of conservation, and after a time people will better know these objects.

Figure 12. Publication in children’s journal “Parostok”: “Lichens are more wise and tricky then others”.

To make publicity on conversation easier, we created the open group, “Lichens all around us” in “the-former-soviet” social network Vkontakte http://vkontakte.ru/club29217268. Here, everybody can share pictures, ask questions, and find collaboration with others. Recently (from Aug 2011), from this public forum we have received questions about understanding the relationships among components of lichens. (Figure 12)
Arid Lichens from the Red Data Book of Ukraine: Perspectives on Assessing, Conserving, and Educating

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RSGF is acknowledged for financial support of current project and giving us great possibility to explore our idea; social group “Save Ukrainian Steppes” for permanent help with publicity and providing us with important contacts; O. Vasylyuk, O. Godlevska, V. Ivanets (Shmalgauzen Institute of Zoology, Kyiv) – for material collecting used in current project; T. Lutsak (Shevchenko National University of Kyiv) – for her help in the Lab; Dr. A. Gromakova (Karazin National University of Kharkiv), N. Rusina (Luhansk Steppe Reserve), Dr. P. Boyko, Dr. Yu. Khodosovtseva and A. Boyko (Kherson Argicultural Univeristy), Prof. M. Boyko and G. Naumovych (Kherson State University), Prof. A. Yena (Sympheropol State University), I. Syrenko (Kamjany Mohyly Reserve) – for their help and support during field trips and discussing of the materials; Prof. C. Scheidegger (Swiss Federal Institute for Forest, Snow and Landscape Researches) for discussing of the current project on its different stages of explorations; V. Nazarchuk (Odessa) for helping us to complete the original-market of the brochure and its quick publishing.
Literature

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An International Union of Biological Sciences outreach education programme on Elcho Island, northeast of Darwin, Australia, ran in August 2011. It had two important outcomes: A poster showing indigenous children involved in and enjoying biology, and a Course Manual in which a systematic response to the environment was pursued. Importantly, the manual encouraged participants to see the significance of their own culture in natural resource management. We include the Course Manual here so readers can see details and adopt and adapt as appropriate.


Hopefully, it will inspire some to make a choice to actively contribute to the biological sciences in their future vocations. The Course took place over three days, included a full day on Elcho Island and included back-up discussion at Kormilda College (the host secondary school in Darwin). It is proposed that this project be seen as a model for other developing regions, where participation of indigenous people in the sciences is low. The poster produced is to be circulated to all schools in the Northern Territory, Australia.

Keywords: indigenous education, biological science, Australia.

Introduction

There are few Indigenous Australians undertaking senior secondary school study in science and subsequently entering science and technology as a vocation. This is reflected in the very low numbers of Aboriginal & Torres Strait Islanders employed as scientists and engineers in universities such as Royal Melbourne Institute of Technology. A low level of engagement with science and technology is seen here as an impediment to any 21st Century society.

Recent outreach from the Royal Melbourne Institute of Technology and IUBS is based on the premise that an interest in science is best developed in the young. A course, Introduction to Science and the Environment, was designed to develop the interest of young Aboriginal and Torres Strait Islanders in science whilst at the same time enhancing the status of their own language(s) was undertaken in August 2011. The coursework manual is now available online from the Biology International site as a supplement in pdf format.

A poster was also produced. It includes photographs of each of the animals and plants studied (generally taken by the school pupils), plus their own sketch of the organism (made in the field). It also includes the name of the organism in English and their local tongue, alongside the biological nomenclature. (see Figure 1)
Elcho Island is a tropical island on the north central periphery of Australia. (Figure 2) It is a magical place and I felt privileged to be there. However, there are problems. These range from discarded drift nets to introductions of exotic species such as cane toads… a threat primarily from human activity. It was alarming to document the first record on the island of the cane toad *Bufo marinus* – a highly successful, but environmentally catastrophic, species that was originally introduced to Queensland sugar cane crops to control insect pests. The introduction was a disaster… the toads simply moved off to other parts of Australia, where they have decimated local fauna.

Figure 2.

The success of the programme was due to a number of factors, one of the most important being involvement of Kormilda College. Kormilda College is a large secondary school in Darwin that has a significant proportion of Aboriginal students, many of whom come from Elcho Island (Figure 3). The College was pivotal in selecting pupils who showed an interest in nature, and who would be likely to benefit personally, and contribute to the College through their participation. The College made classroom space available before and after the trip to the island, and co-ordinated the layout and printing of the poster. The Parks and Wildlife Service of the North Territory Government also provided a ranger, who joined the group for the trip to Elcho Island. Finally, but of course, not least, was the buy-in from native Elcho Islanders. The Gumurr-Marthakal Rangers, a group established to manage the natural resources on Elcho Island, actively participated in the field excursions, and provided the pupils with an indigenous perspective of their environment (Figure 4).

Figure 3. Elcho Islanders getting up close to nature in the RMIT led “Introduction to Science and the Environment” course run on the island in August 2011. The IUBS sponsored the project through the IUBS Ethics Commission.

**Evaluation of the Outreach Programme**

One of the key features that I wanted to develop, and demonstrate, was that Western science is not the sole way in which natural resources can or should be managed. Conservation of biota can only
be achieved through a synergy of ideas – an approach where the best aspects of science are combined with traditional knowledge. No part has ascendancy, and nor should it, if we want to have our natural environment maintained for the benefit of future generations.

The programme was indeed successful, and hopefully will be a model for the future – both in other parts of Australia and overseas.

John Buckeridge is the Head of the School of Civil, Environmental, and Chemical Engineering at RMIT University. He is also Immediate Past President of the International Union of Biological Sciences (IUBS), Chairman of the IUBS Bioethics Committee, Past President of the International Society of Zoological Sciences, and he has acted as a consultant on environmental ethics to UNESCO’s COMEST (World Commission on the Ethics of Scientific Knowledge and Technology). Professor Buckeridge is an Honorary professor at Wismar University, Germany, in recognition of his work in engineering ethics. He has published more than 250 books, journal articles, and reports, in subject areas that include geology, geological engineering, paleobiology, engineering systems, ethics, marine biology, forensics, and natural resources management.
A Proposal for Expanding Capacity for Conservation Science Education in the Tropical Asia-Pacific Region

Charles H. Cannon1,2,3, Rhett Harrison1,2, Lan Qie1,2, J.W. Ferry Slik1 and Jin Chen1

1Key Lab in Tropical Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Mengla, Yunnan 666303, China
2Program for Field Studies in Tropical Asia, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Mengla, Yunnan 666303, China
3Department of Biological Sciences, Texas Tech University, Lubbock 79410 USA

Conservation science in the tropical Asia-Pacific region confronts a wide range of challenges that go far beyond the basic issues of conservation or science. These challenges have many dimensions: biogeographic, cultural, linguistic, political, and religious. The region has no unifying language or culture. While the general high level of endemism and complex biogeography is well known, particularly in the archipelago, the anthropogenic differences among neighboring countries can also be quite profound. Because the region hosts such a phenomenal diversity of biology and humanity, conservation biologists working there need a unique set of skills to navigate these many challenges. The Program for Field Studies at the Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences has initiated a set of courses aimed at graduate students in the region to foster the development of a regional network of young scientists. Direct interaction and collaboration during international field courses among students from the many countries of the region is an effective way to create such a network. We hope that the PFS office can serve as an impetus for the growth of a consortium of international courses that can bring together the many experts and institutions to inspire and educate the enthusiastic spirit of the young conservation biologists in the region.

保护生物学在热带亚太地区所面临的广泛挑战已超越了保护工作和科学本身的范畴。这些挑战表现在包括地域、文化、语言、政治及信仰的多个维度上。热带亚太地区的生物地理特点和特有种的丰富度众所周知，尤其是在群岛区域，同时这个地区众多国家之间的人文差异也具有相当的复杂性。正是由于生物和人文领域的高度多样性，在这里工作的保护生物学家需要具备一套全面的技能来应对各种挑战。中国科学院西双版纳热带植物园热带亚洲考察研究项目为培养本地区保护生态学科的研究生，在本地区形成一个训练有素的青年科学家网络，已建立起一套培训课程。学员们在参与国际化的野外培训班过程中进行交流与合作，结果证实这是建立一个国际网络的有效手段。我们希望热带亚洲考察研究项目作为促成一个国际性培训合作团体的原动力，能将更多本领域的顶尖专家和院校联合起来，为热带亚太地区培育一代充满热情的青年保护生物学家。
Tropical rain forests comprise over 50% of Earth's terrestrial biodiversity and are a major focus of global conservation efforts. The rainforests of tropical Asia, in particular, harbor a large fraction of the Earth’s terrestrial biodiversity in a relatively small area (Wright, 2005). Extending to the island of Papua and the northern margin of Australia in the east, to the Western Ghats and the island of Sri Lanka in the west, these forests cross a remarkable landscape with a deep and varied biogeographic history. Here, two ancient biota are slowly merging at Wallace’s Line (Hall and Holloway 1998; Morley 2000). The Asian rainforests also represent the only tropical region where a large area of forest has connected equatorial regions with the subtropical and temperate biomes, allowing for mixture over long periods of geological time across these strong environmental gradients (Heaney, 1991; Voris, 2000; Cannon et al. 2009).

Unfortunately, the region is also infamous for its continued high rates of forest conversion and degradation (Sodhi, Koh, Brook et al., 2004, Laurance & Useche 2009, Harrison, in press). Extrapolating current rates into the future indicates that we will be the last generation of scientists to study these rainforests in their 'natural' condition, where community species composition and physical structure are a result of long historical processes and not the direct and indirect effects of human management. Already less than 1% of tropical Asia harbors an intact faunal community (Morrison 2005). We are witnessing the extinction of wilderness across the region.

For conservation efforts to be effective, the globalization of biological research is required, in parallel with the globalization of human economies and cultures. Adequate infrastructural investment, particularly in terms of local human capability, by the international conservation community is required. We need to train graduate students for the coming challenges, pool our resources, maximize synergies, and share our accumulated knowledge and expertise more effectively. The creation of a regional network of young scientists in the Asia-Pacific region would reflect the biological connectivity among the many countries. Improved coordination among organizations would more efficiently employ limited resources and enable us to provide more and better educational opportunities for graduate students in tropical ecology, conservation, and natural resource management from the tropical Asian region.

Figure 1. Activities during the Advanced Fieldcourse in Ecology and Conservation - XTBG 2010. Course Opening. Participants came from ten countries: Argentina, Benin, Cambodia, Cameroon, China, India, Indonesia, North Korea, Sri Lanka and Thailand.

Ultimately, we need more young professional scientists who have the necessary skills to integrate environmental and economic issues within the context of their national policies and global trends. These young scientists should come from both academic and managerial positions, with backgrounds in basic or applied research. These students should be enthusiastic enough to tackle daunting environmental issues by combining research with policy development. Unfortunately,
opportunities for education and training in the conservation, research, and management of tropical natural resources, has not fulfilled the demand for training, especially at the graduate level. The few available courses usually have five-fold more applicants than places. Organizations have run regular graduate-level courses for tropical biology and conservation in the Neotropical (e.g. Organization for Tropical Studies, or OTS) and African regions (e.g. Tropical Biology Association, or TBA). Both of these programs have made substantial contributions, over the decades, to increase local capacity for conservation and natural resource management. They have also spawned a generation of natural history researchers and have been successful in stimulating international collaborative research.

The need for a network of young conservation scientists in the Asia-Pacific region

A major challenge in creating such a regional network in tropical Asia is the substantial diversity, particularly in terms of culture, language, political systems, and religion. While the Indonesian and Malaysian languages share similar roots and are largely intelligible to one another, the other countries share only English as a common language, which is spoken by a relatively small fraction of people. However, the religious differences are probably more profound than the linguistic differences, as the countries of the Asian tropics include major populations of Muslims, Buddhists, Christians, and Confucianists. Moreover, these more widespread belief systems are often layered over a wide variety of local animistic belief systems. While English can function as an international language, identifying and accepting 'universal' religious principles is considerably more difficult, particularly towards environmental ethics and natural resource management. Clearly, religion has a major impact on the relationship between humans and nature, how policies are developed, and the utilization of wilderness.

Many of these differences are best overcome through personal contact and direct interaction, particularly among young professionals who were born into a global world where communication easily crosses international borders and distance has lost some of its meaning. A regional training course would play a critical role, allowing the students to get past preconceptions and prejudices, to develop trust and understanding across languages and religions, and to share experiences and discover similarities. After they return home, these young professionals will work in a variety of settings, from local non-governmental organizations to tenured civil servants in governmental ministries. A growing network of young professionals could create an information-sharing system about the main issues and threats. Morale is also important to conservation and simple discussion with peers who have similar experiences and ambitions can be a great support.

Figure 2. Activities during the Advanced Fieldcourse in Ecology and Conservation - XTBG 2010. Plant identification workshop.
Such a network would also address many of the biological and environmental realities of tropical Asia. Many countries share the same natural resources, like the Mekong River among many Indochinese countries and the island of Borneo among Indonesia, Malaysia, and Brunei. Natural resource policies in these countries have various upstream and downstream effects. Several groups have recognized the need for coordination among countries in their environmental policies. For example, the Asian Development Bank and its Greater Mekong Subregion project aims to create a common policy environment across the subregion and to establish a network of nature reserves and biodiversity corridors. Students who attend the types of courses and workshops described here will become scientists and environmental policy makers who can fit into these regional efforts.

In terms of basic research, alumni from these courses will also facilitate cross-border coordination of research efforts and the creation of databases containing compatible informatic resources with more effective data- and sampling-sharing mechanisms. The world is experiencing a fundamental change in the way in which data and information is managed, stored, and distributed. Environmental scientists and conservation biologists ought to learn to exploit these technological changes to improve the effectiveness of their message and the implementation of reasonable management.

**Overview of field course experiences in tropical Asia**

One of the largest problems in tropical Asia is the shortage of well trained local conservation managers and researchers and the funds to support their activities. The conservation tasks are real, substantial, and constantly evolving. Colleagues working in tropical Asia have often expressed the need for more and better graduate-level training opportunities, and several institutes have run independent courses for limited periods of time, including the Diversities in Western Pacific and Asia (DIWPA) courses in Sarawak (1995), Thailand (1996) and Australia (1997), and the Center for Tropical Forest Science – Arnold Arboretum (CTFS-AA) courses in Peninsular Malaysia (2001, 2003, 2008), Sarawak (2004), Thailand (2005), Sri Lanka (2006) and Yunnan, China (2007). While these courses have been quite successful, a stable program with sufficient funding to support their activities would allow students to plan sufficiently ahead, so they may obtain funding to attend these training activities. It would also bring together the experience and expertise gained from currently separate efforts. Previous courses run by individual universities and networks have typically provided considerable scholarship support so that students from poor countries can attend, but these scholarships increase the price of the courses considerably. To improve the likelihood that a program can remain stable and well-funded, we would expect students from more wealthy countries to subsidize students from less wealthy countries. Moreover, to meet the demand for field-based courses, a considerable expansion in the course offerings each year is required.

**The Program for Field Studies in Tropical Asia**

In 2010, the directors of XTBG agreed to support an office for The Program for Field Studies in Tropical Asia (PFS-TropAsia - www.pfs-tropasia.org). This office was established to form an international consortium of institutions and universities and to provide high quality and affordable training courses for young conservation
scientists from across the Asia-Pacific region, similar to OTS and TBA. Several meetings have also been held at the Asia-Pacific chapter meetings of the Association for Tropical Biology and Conservation (ATBC-AP), where the program has received broad support. Indeed most of our resource staff has been recruited from the ATBC-AP.

The program office has already supported several training courses. We hosted the third Advanced Fieldcourse in Ecology and Conservation – XTBG (AFEC-X), initiated by the Xishuangbanna Tropical Botanical Garden (XTBG) and the Ecological Evolution group (Figure 1). In 2010, a grant from the Asia-Pacific Network for Global Change Research (APN) supported a six-week field course in Indonesia (July-Sept.), organized by the PFS office, in collaboration with the University of Indonesia and the ATBC-AP. In association with the annual ATBC-AP meetings, the program has also run shorter training courses on Experimental Design & Data Analysis and Scientific Paper Writing (2010 and 2011). These courses were expanded in 2010 to include both Basic and Advanced levels.

The training courses run by PFS-TropAsia target graduate entry-level students (MSc or 1st year PhD) and equivalent level participants from government research organizations, universities, and NGOs, focusing on students from the tropical Asian-Pacific region. Currently, a major element of the program is the advanced fieldcourse (AFEC-X), which is an intensive course in field research methods, research design, sampling and analysis 

http://www.pfs-tropasia.org/fieldcourse-modules/advanced-fieldcourse-on-ecology-conservation/ held at XTBG. (Figures 3, 4) Participants receive lectures from leading experts, participate in group discussions on both the theory and practice of ecological and conservation research. (Figure 2) Participants also gain practical research experience by designing and conducting independent projects at several long-term field stations situated in tropical Yunnan, China and supported by XTBG-CAS. Students present the results of their research at a symposium on the final day of the course and publish their written reports in the form of Course Proceedings. (Figure 5) Students are also encouraged to go on and publish their results wherever possible (e.g. Zhang et al. 2010, Sreekar et al. 2010, Beaudrot et al. 2011). PFS-TropAsia is currently developing other field courses in Thailand and Indonesia with the ultimate aim of holding three courses annually. However, these efforts will depend on receiving stable funding, either through consortium members or significant financial backer.

The Experimental Design and Data Analysis course on the other hand, is a six-day workshop to teach concepts in experimental design and sampling and how to analyze data using R – a free open source statistical computing program. In conjunction with the statistics workshop, the Scientific Paper Writing workshop covers the process of how to prepare a good poster, ethical questions

Figure 3. Activities during the Advanced Fieldcourse in Ecology and Conservation - XTBG 2010. Participants walking to the field site.
surrounding the publication “game”, and the review process. It is targeted at people with limited or no publishing experience. PFS-TropAsia is also considering other types of short courses, such as courses in tropical plant identification, integrating social and natural science research for ecosystem services, and wildlife monitoring techniques.

During the first two years of the AFEC-X course and the APN-funded course in Indonesia, a total of 68 participants from 15 countries have attended, with most of them from Southeast Asia. Our courses also have a regular pool of instructors from international institutions with a broad range of expertise. These instructors volunteer their time to teach in the field courses, receiving only travel and living expenses. While the students benefit from both the classroom and field work, these courses also greatly enhance international collaboration and cultural exchange, reflecting the national and ethnic diversity of the region. The program maintains and grows its network of course instructors and alumni through an alumni website (http://www.pfs-tropasia.org/alumni/). Building on these successes, the AFEC-X course recently received accreditation from the Graduate University of the Chinese Academy of Sciences.

Developing a field course program consortium in Tropical Asia

PFS-TropAsia was initiated with the vision of forming a consortium of universities, research institutes, governmental and non-governmental organizations from across the tropical Asia-Pacific region to run the above mentioned courses. Through financial contributions from all consortium members, the program hopes to achieve a sustainable level of funding and expand the number and topics of shorter workshop type courses. Essentially, each consortium member would be represented on the program board, which would develop the basic policy of the program. Although the PFS-TropAsia secretariat is currently at XTBG-CAS, as the founding member of the consortium, the program must be a truly collaborative effort with ownership belonging equally to all consortium members. The program is currently in discussion with several potential partners, including the World Agroforestry Centre (ICRAF), Center for International Tropical Forestry (CIFOR), King Mongkut’s University of Technology in Thonburi, Thailand, and the University of Gajah Mada, Indonesia.
Optimally, the regional consortium would offer two to three long (six weeks) field courses annually that would be based consistently at the same locations and utilize a small number of long-term field sites. These field courses require a great deal of logistic support and coordination and returning to the same few sites creates efficiencies that are not possible when the field course site is moved from country to country and field site to field site. Additionally, the students could participate in long-term research projects, like forest restoration efforts or climate change monitoring, to build a temporal depth of data and knowledge so that subsequent students, over a decade, can directly measure the changes in the ecosystem.

The program would also continue to offer shorter specialty courses according to demand, resources and instructor availability. Associating these courses with various regional meetings, like the annual meetings of the ATBC-AP, is an effective way to minimize travel expenses and to broaden contact with students and instructors in the host countries.

Challenges and next steps
A major challenge in developing a regional course is meeting the educational needs of students from a wide range of backgrounds and experiences. For example, some students arrive very well versed in advanced statistical analysis and phylogenetic interpretation of results while other students have already specialized on some particular organism and have considerable taxonomic skills. Most students do not have comprehensive training and have substantial gaps in their knowledge of scientific research methods. Student experience and ability often varies widely in terms of knowledge of the basic scientific literature and using large public databases. Cultural differences in the students' approach to the educational process and their response to peer review can make discussion difficult. Fortunately, most young people today are quite knowledgeable about internet resources and social media, quickly picking up new ideas and techniques. Finally, because English is the dominant language of science today, the students must have adequate English fluency to fully participate and take advantage of the courses. The applicant pool needs to be carefully screened to balance representation of students from different countries and backgrounds with appropriate levels of previous training and expertise to contribute to and benefit from the course.

Ultimately, the fundamental challenge will be to create a self-sustaining, self-funded organization that can coordinate the type of graduate education program in ecology and conservation that we have described here. While XTBG has taken a first step in this direction with the creation of the PFS-Tropical Asia office and the AFEC-X course, many questions remain. While the Chinese economy and development will dominate the region over the coming decades, its current monetary policies make these types of international educational activities somewhat difficult. For example, because currency conversion and money transfers are tightly regulated, visa regulations are strict and can change suddenly, and access to natural areas is tightly controlled. Unfortunately, one faces similar problems in most countries in the region, as learned from our experiences in Indonesia and elsewhere. Basing the field courses regularly in the same locations should ease these problems over time as trust and understanding increases among the various players in the situation.
Finally, the consortium must attract partners who are willing to commit sufficient funds and resources to create a stable curriculum. Additional courses can be made available as extra funds and instructors become available. The funding level for any one institution will not be substantial, probably in the range of 20,000 USD per year, with guaranteed participation of 3-4 students and the possible contribution from their educational staff. Ultimately, mechanisms need to be established so that a reserve fund can be accumulated and built up into a financial cushion for the program. The administration of this fund and its long-term use would have been detailed by the founding members of the consortium.

References


A Proposal for Expanding Capacity for Conservation Science Education in the Tropical Asia-Pacific Region


Charles Cannon has been studying tropical biology since 1987, when he spent a year at a remote research site in the Gunung Palung National Park, Kalimantan, Indonesia, studying primate behavior and tropical ecology. This opportunity was supported by the Research Experience for Undergraduates program at the U.S. National Science Foundation. After completing his PhD at Duke University on the phylogeography and evolution of tropical Asian oaks, he has continued to publish on a wide range of topics concerning tropical Asian forests in general. His experience clearly illustrates the importance of education and research opportunities early in a student's career in shaping their ideas, priorities, and focus.

Rhett D. Harrison is an Associate Professor at Xishuangbanna Tropical Botanical Garden, Chinese Academy of Science. His research interests include co-evolutionary biology, in particular the fig - fig wasp interaction, and conservation biology. He has taught graduate-level courses in the Asia-Pacific region since 2001.
Lan Qie originally came from a background of electronic and biological engineering. It was the passion to work as a field biologist that made her decide to start a career in Ecology. As challenging as it was, her background in engineering also gave her a number of advantages. She was fortunate enough to attend the six-week field course at XTBG in 2007, which helped her to build the knowledge foundation in Ecology as well as basic skills in statistics. She recently concluded my PhD at National University of Singapore. Her research focuses on forest fragmentation and community disassembly, island biogeography, ecological roles and conservation of arthropods in the tropics.

Ferry Slik’s research is focused on trying to understand spatial and temporal patterns in plant distributions. This is done with the help of remote sensing (GIS), molecular techniques and spatial and temporal modeling. One of his main research themes is how global change will affect plant communities and vegetation patterns. Based on research results he tries to suggest optimum conservation strategies that integrate economic and social development with environmental sustainability.

Jin Chen is director of Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, and principle investigator of the Ecology & Evolution of Plant-animal Interaction Group. His group's current interests focus specifically on the following questions: 1) How do plant-animal interaction complexes contribute to the creation and maintenance of biodiversity in above and below ground ecosystems? 2) To what extent are interacting plants and animals co-evolutionarily adapted to and shaped by each other? 3) How do plant-animal interactions respond to changing environments? Their study systems include animals such as frugivorous birds, rodents, ants and spiders, and plants such as figs, pines and Tacca spp.
The global availability of web-based computing coupled with the need to address pressing problems in the environment and in society have led to the articulation of new information management, problem solving and communication skills for 21st century learners (UNESCO, 2011). This paper describes how opportunities to practice these skills may be implemented in the classroom using investigative case-based pedagogy with online data and tools for making evidence-based decisions about contemporary issues such as energy utilization. In Singapore in August 2011, a group of lower secondary teachers were introduced to investigative case-based pedagogy, newly published 21st century competencies for the classroom, and an online carbon calculator developed for public use. The following paper presents a review of the project planning, methods and materials used, example products, and conclusions.

Introduction
New educational standards are being developed by various agencies, governments and educational groups to address escalating challenges in education due to the availability of web-based computing and the accessibility of information, data, and tools both inside and outside of the classroom (NSF, 2008). Today’s students need to be able to manage and communicate information, develop inquiry skills, and use technology for life-long learning (NRC 2000, 2009). These requirements are recognized as “21st Century Skills” (UNESCO, 2011) or “21st Century Competencies” (Ministry of Education, Singapore, 2010 b).
Table I.

|---|---|
| Creativity and Innovation  
Critical Thinking and Problem Solving  
• creative, reflective, collaborative and problem-solving | Critical and Inventive Thinking  
• Includes: Thinking outside the box,  
• Taking on challenges  
• Desire to learn  
• Make sound decisions |
| Communication and Collaboration  
• foster cross-cultural understanding and the peaceful resolution of conflict | Civic Literacy, Global Awareness and Cross-cultural skills  
• Includes being informed, aware and active citizen  
• Broader worldview  
• Able to work with people with different perspectives |
| Social and Cross-Cultural Skills  
• productive and able to participate fully in society and influence the decisions which affect their lives | Information and Communication Skills  
• Includes identifying information  
• Being discerning  
• Being safe |
| Information literacy  
• able to use ICT tools to handle information and generate knowledge |  |

The UNESCO ICT Competency Framework for Teachers (2011) directly addresses 21st century skills for teachers and learners. One stated goal is to deepen knowledge in order “to increase the ability of students, citizens, and the workforce to add value to society and to the economy by applying the knowledge gained in school subjects to solve complex, high priority problems encountered in real world situations” (p.11). The Framework emphasizes the ways information and communication technology (ICT) can help develop the needed skills.

The Ministry of Education for Singapore has developed an extended vision of what 21st Century learners should be able to do, as outlined in the pamphlet “Nurturing Our Young for the Future” (Singapore Ministry of Education, 2010b). In addition to ICT skills similar to those detailed in the UNESCO documents, the Singaporean vision includes developing global awareness and cross cultural skills, civic literacy, and, critical and inventive thinking. In Singapore, this vision is presently being developed into expectations and learning outcomes that will be articulated across the entire future curriculum in 2012-2014 (Singapore Ministry of Education, 2010a). We used Investigative Case Based Learning (ICBL) (Waterman and Stanley, 2000, 2010; Stanley and Waterman, 2003) pedagogies as well as online data and tools to address 21st century skills while promoting global awareness and informed energy choices in Singapore and the US.

ICBL, like other case-based methods (Herreid, 2007, Duch et al., 2001), helps learners connect the content learned in school to its uses outside the classroom. The settings for investigative cases describe realistic, everyday situations (contexts) that learners might encounter and relate to in a meaningful way. The recent Vision and Change Report (AAAS, p. 19, 2010) indicated that students prefer to learn science in the context of applications.
The ICBL approach was uniquely designed to engage learners in a three phase process (Stanley and Waterman, 2003):

**Phase I: Analyzing the case and generating questions (posing problems),**

**Phase II: Investigating the case (problem solving), and**

**Phase III: Sharing findings (peer review).**

These steps are based in steps scientists take: Problem Posing, Problem Solving and Peer Persuasion (Peterson and Jungck, 1988). Later, we will show how these three phases applied to the case *Choices* used by different groups of learners and illustrate some of the learning outcomes observed.

In July of 2011 we offered a 2-day workshop on “ICBL: Teaching Science While Developing 21st Century Competencies” for 40 lower secondary teachers (grades 6-10) in Singapore through the National Institute for Education at Nanyang Technological University. Within that workshop we engaged the participants in a case module built around an online carbon calculator for Singapore. The goals of the workshop relevant to this module were to:

- Demonstrate how using cases and investigations develops 21st century competencies as students ask questions, conduct explorations, and produce final products for peer review.
- Illustrate the use of the online carbon calculator to gather evidence for making informed decisions about home and business energy consumption.

This module was also used with 110 science instructors in the United States during a presentation at the National Center for Case Study Teaching in Science conference in Buffalo, NY, in September 2011.

**Investigative Case Module Development**

The module was developed to address objectives in the current Singapore Science Syllabus for Lower Secondary (Singapore Ministry of Education, 2008) focusing on their Science & Technology and Energy themes. Specific objectives included:

- Discuss the importance of reducing electrical energy wastage
- Appreciate the need for Singapore to conserve energy
- Use scientific inquiry skills such as posing questions, designing investigations, evaluating results and communicating learning
- Present evidence-based conclusions about the impact of energy choices

To address these objectives we planned to create a module including a case, investigations and assessments to go with an online ecological footprint calculator with which we were familiar, but whose data base did not include Singapore. Further searching, however, uncovered a better option: a Singapore-specific carbon calculator developed by the NGO Singapore Environment Council (SEC). This online tool supported meaningful case-based learning specific to experiences of Singaporean learners. (Interestingly, the SEC carbon calculator was later used to challenge American teachers to extend exploration of energy choices outside their borders.)

To understand what this calculator is measuring, we examined the concept of a carbon footprint. Weidmann and Minx (2008) surveyed relevant literature from 1960-2007 and found the term “carbon footprint” began to be used in 2005 and was derived from the broader concept of
ecological footprint. They also found that while enjoying wide use, the term is poorly and variously defined. A common definition is the amount of greenhouse gases emitted as a result of our daily activities, usually measured as mass of CO2 emitted. Unfortunately, this common definition is ambiguous and they recommend a more specific definition.

The definition provided by the company Carbon Footprint Ltd. (2011), a firm specializing in assessing carbon footprints, is more specific. A carbon footprint includes primary (or “direct”) emissions (resulting from direct burning of fossil fuels) and secondary (or “indirect”) emissions. These secondary emissions usually involve a Life Cycle Assessment, that is, an evaluation of the amount of CO2 resulting from all facets of the production and delivery of goods or services over the course of their lifetime.

The SEC Carbon Calculator “provides a lifestyle carbon assessment tool which is targeted at households in Singapore. It also includes a transport carbon calculator specific to Singapore” (Singapore Environment Council, 2010). We believe that this calculator focuses on direct emissions arising from activities that burn fossil fuels (such as driving a car) and indirect emissions that arise from electricity usage. We did not see evidence that it includes Life Cycle Assessment level data for goods and services. This Carbon Calculator meshes well with the Singapore National Climate Change Strategy which aims to mitigate greenhouse gas emission by improving energy efficiency; it includes an individual’s choices about energy (Singapore Ministry of Environment and Water Resources, 2008).

We saw the potential of the Carbon Calculator as a tool to test hypotheses about how carbon emissions could be reduced by making different choices. With this in mind, we wrote a case scenario - “Choices”, instructions for using the Carbon Calculator, instructions for designing tests of hypotheses, guidelines for a poster to present findings, and an assessment form for peer review of a poster.

Implementing the Module
Phase I. Analyzing the Case and Generating Questions (Posing Problems).

Open and read the case.
Participants received the case, Choices, at the start of the session - not before. We gave each learner a copy of the case and also projected it on a screen. We asked a volunteer to read the case out loud while everyone else followed along silently. Then we asked participants to spend 2-3 minutes silently reading the case again and noting words or phrases that seemed to be important to understanding what the case is about. The case scenario is shown below.

**Choices**
Jiaming sat across from one of his favorite clients, Mrs. Seng. His partner, Siti, joined them by computer conferencing. Today’s discussion was focused on web advertising for the client’s new line of instantaneous gas water heaters. As usual, Mrs. Seng provided useful background materials. Her project fit easily into their work schedules and the meeting ended well. (cont. next page)
While Jiaming returned to his office, Siti decided to Google an unfamiliar term used during the meeting. “Just what is a carbon footprint,” she thought, “and what does it have to do with water heaters?”

Although Jiaming and Siti lived in the same neighborhood and worked for eSolutions, only Jiaming rode the train to work. Siti preferred to work from home. She couldn’t imagine riding ten stations down the line every day. The pair made an excellent team, but they had very different lifestyles.

“I wonder,” Siti said to herself, “if working from home makes much of a difference between Jiaming’s and my carbon footprints?”

Case Analysis
Next we distributed a blank “Case Analysis Sheet” This sheet contains a “Know/Need to Know” chart where students can keep track of their thoughts about what they already know related to the case as well as questions they have about aspects of the case (what they need to know).

We asked participants to consider:
- What is this case about?
- What do you already know about these topics?
- What do you need or want to know about to understand this situation?

Individual participants were asked to write down one thing they knew and one question they had. A minute or two later we asked them to form groups of 4-7 people to share their ideas and further develop their questions. After about 10 minutes, we debriefed the groups asking each to contribute one thing they knew and the most important question they had agreed upon. Finally we asked them to consider what kinds of resources might be useful to answering their “Need to know” questions.

**Choices CASE ANALYSIS SHEET with responses from Singaporean participants in italics.**

1. **Recognize potential issues and major topics in the case.**
   What is this case about? Underline and list terms or phrases that seem to be important.
   Then, list 3-4 biology-related topics or issues in the case.
   - Working at home versus commuting
   - Carbon footprints
   - Environment
   - Technology versus preserving green
   - Choices: work at home/children
   - Consumer choices

2. **What specific questions do you have about these topics?** By yourself, or better yet in a group, list what you already know about this case in the “What Do I Know?” column. List questions you would like to learn more about in the “What Do I Need to Know?” column.
<table>
<thead>
<tr>
<th>What Do I Know?</th>
<th>What Do I Need to Know?</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Singapore government encourages people to take public transport to make country go Green</td>
<td>● How much loss of man hours occur while traveling to work on public vs private transport?</td>
</tr>
<tr>
<td>● There is instantaneous information available at the press of a button</td>
<td>● How to calculate carbon footprint?</td>
</tr>
<tr>
<td>● Most families have water heaters (electric)</td>
<td>● Does working at home mean we are more environmentally friendly than working at the office?</td>
</tr>
<tr>
<td>● The concept of carbon footprint is getting more popular and in common knowledge</td>
<td>● How can we reduce our carbon footprints effectively?</td>
</tr>
<tr>
<td>● Understand computer conferencing and working from home</td>
<td>● How does the individual lifestyle impact the carbon footprint?</td>
</tr>
<tr>
<td>● A person’s life style can affect the size of the carbon footprint</td>
<td>● What is the difference between a conventional water heater and an instantaneous gas heater (green)?</td>
</tr>
<tr>
<td>● Our carbon footprints are a measure of our contribution to global warming</td>
<td>● What exactly is a carbon footprint?</td>
</tr>
<tr>
<td>● On average if you use a gas heater on a daily basis, the carbon footprint will be 21 Kg C/year (just looked this up)</td>
<td>● How can we save the Earth by the pedagogies we use in our classroom?</td>
</tr>
<tr>
<td></td>
<td>● How much fuel does it take for the train versus the personal vehicle?</td>
</tr>
<tr>
<td></td>
<td>● Does working at home have any adverse effects on one’s health?</td>
</tr>
<tr>
<td></td>
<td>● Does Siti get as much pay as Jiaming?</td>
</tr>
<tr>
<td></td>
<td>● How does Siti create a relationship with coworkers and clients when she communicates by computer?</td>
</tr>
<tr>
<td></td>
<td>● How much energy generated in festivals, laser shows?</td>
</tr>
<tr>
<td></td>
<td>● What other forms of measure can we use instead of carbon footprint?</td>
</tr>
</tbody>
</table>

3. Put a check mark by 1-3 questions or issues in the “What do I need to know?” list that you think are most important to explore.

The most often checked question was *Does working at home mean we are more environmentally friendly than working at the office?*
4. What kinds of references or resources will help you answer or explore these questions? Identify two different resources and explain what information each resource is likely to give that will help you answer the question(s). Choose specific resources or types of resources.

- Ministry of Health website (to look at data on benefits of working at home)
- National Environment Agency website
- Public Utilities Board website (http://www.pub.gov.sg)
- Online carbon footprint calculator (Figure 4)
- Survey different groups of people about lifestyle
- World Wildlife Fund website (info on carbon footprints and impacts)
- Log sheet of what you do every day and how it impacts
- Check utility bills in office versus at home
- Case studies from both the general public (newspapers) and scientific articles
- Earth hour in Singapore, when people shut off lights/power
- Singapore power services (SPS)
- Google carbon footprint and look for journal publications
- Interview staff at MRT (rapid transit system)
- Sharing of knowledge among ourselves
- Textbooks

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**Phase II: Investigating the Case (Problem Solving)**

With investigative cases, students can engage in investigations at many levels. They can be entirely teacher-designed or entirely student-designed. They can be open-ended, as with experiments, simulations, and/or models. Or they can be close-ended, such as interpreting data, reading a map, making a graph, or critiquing an experimental design (see Waterman and Stanley, 2010 for examples).

Choosing appropriate resources can be the responsibility of either the instructor or the learners or both. Since we were working with an audience new to case-based learning, we chose the major resource, an interactive carbon calculator simulation (Figure 4) designed for Singaporean citizens to learn more about their energy choices.
There are two entry points for the carbon calculator simulation, Household and Small Business. You can interactively assess energy use in terms of carbon emissions by describing the duration and frequency each specific type of appliance turned on within a room inside the home or small business. You can add the distance and frequency of travel for each type of transport outside the home or small business as well. The carbon footprint for each use is displayed and added to an overall summary for an individual. Further, recommendations for reducing that carbon footprint are suggested at the end of the simulation.

Investigations
We chose to begin with a specific question for learners to answer using the Carbon Calculator. Then we asked them to use this simulation to test a hypothesis in an experiment of their own design. The tasks included:

1. Compare the carbon cost of transportation to work for Jiaming and Siti.
2. Design and run an experiment using this simulation to answer other questions stemming from the case analysis.
   - State hypothesis
   - Experimental design (identify and operationalize variables)
   - Collect data in data table
   - Make inferences from evidence

Phase III: Sharing Findings (peer review)
Another way to think of this phase is that students will produce materials that explain their methodologies, provide data, and support their conclusions. These materials are easily assessed. Scientists present evidence to support their conclusions and they publicly present their evidence as talks, posters, online sessions and publications. Their peers review their work and make recommendations about the publication readiness of the work.

Rubrics (scoring guides) are useful to provide to students before they begin to make their products. For this particular setting, working with teachers, we chose to illustrate a formative type of assessment, one that will help students learn what to look for and to reflect on their experience in viewing the work of others and talking with others about their work. In a subsequent poster session, we might ask peers to also score the poster based on a given set of criteria.

Mini Poster Instructions
Use a single sheet of newsprint. You may use it in portrait or in landscape mode. These posters are not meant to be final products, so they will be somewhat unpolished. You are encouraged to illustrate your poster to enhance the reader’s understanding and to better communicate your findings.

Your poster needs to include the following:

1. The title of your investigation
2. The investigators’ names
3. The hypothesis being tested
4. A description of how the hypothesis was tested
5. Data
6. Inferences drawn from the data

You will have about 30 minutes to prepare the poster.

We will be doing a poster session for 20 minutes. During that time, each person needs to visit the other posters. One person needs to be at your poster to answer questions. Work this out so that everyone gets 15 minutes to view the other posters.
Mini Poster Rubric
You will need to be at your poster to answer questions for 5 minutes. We will announce the end of each period of 5 minutes, so you can expect to have 15 minutes to view the other posters. Be prepared to ask questions and consider the presenter’s answers.

1. List one of the questions you asked about another group’s poster.
2. Describe in your own words the answer the presenter gave.
3. Did your question and/or the presenter’s response help you understand more about their experiment?

Examples of Group Products: Posters with notes
Group 1. Hypothesis tested:
If a person works from home, their energy expenditure will be less than a person who works from an office.

The cartoon graphic (Figure 5) provides a visual summary of the problem and is followed by a hand drawn graph comparing the total kg C/yr for the categories of Laptop, Air Conditioning, Lights, Printer, and Transport. Shaded columns represent working at home.

In the poster session, presenters from this group indicated surprise at the expenditure of energy in working from home.

Members of the group wanted to do more simulations with this carbon calculator as well as try other carbon footprint calculators.

Group 2. Hypothesis tested:
If I take a shorter time to shower, I will contribute less to my carbon footprint.
A cartoon graphic (Figure 6) accompanies their hand drawn graph comparing the total kg C/yr for showering duration categories of less than 5 minutes, 5-10 minutes, 10-20 minutes, and over 20 minutes.

The independent variable was shower time, dependent variable was carbon footprint, and the constants in this investigation were average temperature setting and type of water heater.

The poster provides a strong message in their conclusion. Members of the group also expressed an interest in further exploration.

The Choices case was also presented at the Fall 2011 Conference sponsored by the National Center for Case Study Teaching in Science in Buffalo, New York. As part of a plenary address entitled “Cases, Social Networking, and Workspaces” to about 110 participants from K-12 and undergraduate institutions, Choices provided an example of investigating science with open source simulations designed for use by individuals facing real decisions in their everyday life.

When a question arose about providing a different carbon calculator for U.S. students, an interesting discussion arose about the merits of asking American students to use the SEC carbon calculator from the point of view of a Singaporean. Providing an opportunity for students to develop greater global awareness of how energy choices are made in other parts of the world seemed a logical extension of the case objectives.

Conclusions:
Teaching with cases is a useful strategy for environmental science education. Investigative cases provide opportunities for learners to explore scientific concepts in the context of making decisions in their everyday lives. Not only can we address critical issues such as energy choices, but also the emerging needs of our 21st century learners.

In addition:
- the SEC Carbon Calculator simulation facilitated exploration and data collection required by learners to make evidence-based energy choices;
- the investigative case pedagogical approach provided an opportunity for inquiry as learners worked in groups, sharing their prior knowledge and building new knowledge through posing questions, solving problems and presenting their solutions for peer review (Figure 7);
- the Choices case provided an opportunity for learners to use multiple 21st century competencies/skills; and,
- the Choices case may be used to encourage learners to develop global awareness of energy choices beyond their own borders.

Figure 7. Working on investigative cases requires collaborative problem posing, problem solving, and peer review (Waterman and Stanley, 2000).
References:


Ethel D. Stanley is the Director of the BioQUEST Curriculum Consortium which actively supports educators interested in the reform of undergraduate biology education through collaborative development of curricula. Dr. Stanley leads or collaborates on multiple BioQUEST projects, which feature teaching strategies that support inclusivity, open-ended inquiry and numeracy while using simulations, tools, data, cases and other resources for problem posing, problem solving, and peer review. Dr. Stanley earned her MS in botany at Wayne State University and her Ed.D. in science education at Illinois State University. To her leadership of reform in biology education, Dr. Stanley brings over two decades of teaching experience at Millikin University and Oakland Community College where she taught innovative courses for preservice teachers, biology majors and majors outside of the sciences. She has served as President of the Association of College and University Biology Educators, Chair of the Teaching Section of the Botanical Society of America, and Editor of Bioscene: The Journal of College Biology Teaching. She presents on reform in biology education nationally and internationally, as well as works with teachers and college faculty in professional development workshops. She has co-authored three books and over 30 articles on biology education, visual learning and investigative case based learning.

Margaret Waterman is a science teacher educator and professor of biology at Southeast Missouri State University. Before coming to Southeast, she taught biology at Kenyon College and Emory University and did faculty development work at the University of Pittsburgh and Harvard Medical School. Her M.S. in plant pathology and Ph.D. in science education were completed at Cornell University. Dr. Waterman is recognized for her work on problem based and investigative case based learning (ICBL) in the sciences. She works with science faculty and high school teachers on developing materials and approaches for using ICBL to integrate new content, approaches and skills in biology curriculum. In addition to numerous presentations at scientific and education organizations in the U.S., Dr. Waterman has presented internationally on investigative case based learning and sustainability education, and has worked with school teachers in India, Peru, South Africa and Singapore. She was President of the Association of College and University Biology Educators and has written over 30 papers and book chapters on undergraduate science education. With Collaborator Dr. Ethel Stanley of the BioQUEST Curriculum Consortium, she has developed ICBL approaches and materials and conducted grant-funded research and development. Their book Biological Inquiry: A workbook of investigative cases, 3rd ed. (2010) is used by undergraduates around the world. Their website at <http://bioquest.org/icbl> has a catalog of more than 50 cases ready for use.
Darren Wong is currently a teaching fellow at the Singapore National Institute of Education where he is involved in physics and science teacher education. Prior to this, he was a junior college physics lecturer, before being posted to the Singapore Ministry of Education to serve in the area of curriculum development. His interest lies in the development of educative curricula materials that promote the learning and teaching of science and physics as inquiry.

Hong Kim Tan is currently a teaching fellow at Natural Sciences & Science Education, National Institute of Education, Nanyang Technological University, helping to train primary and secondary science teachers at this teachers’ training institute. Before his secondment to NIE, he was a curriculum specialist for Biology at the Singapore Ministry of Education Headquarters where he was involved in facilitating the implementation of science curriculum as well as the development and evaluation of biology syllabuses, assessment modes and teaching materials. Prior to his posting to MOE HQ, he was a Head of Department for Science at a secondary school where, besides carrying out administrative duties, his primary role was to teach Biology, Chemistry and Lower Secondary Science. His current research interest is in the area of assessing and creating better learning environments in the Biology laboratories.
Introduction: Filling in gaps
There is a striking imbalance between the availability of academic training in biodiversity conservation in Brazil and the extent of the country’s natural riches. Although a great deal of funding has been for the training of professionals (Castro, G. and I. Locker, 2000).

Brazil has an outstanding role in the planet’s well-being. It is continental in size, the country is home to 20% of the world’s freshwater and 30% of the world’s remaining tropical rainforests, and its natural heritage places it among the highest on the list of the world’s most bio-diverse countries. In the absence of an educational system capable of generating awareness about the importance of its natural diversity and the need to protect it, however, the value of all that this represents will not be appropriately recognized among Brazilians themselves, and neither will they have the understanding and knowledge on how to implement the appropriate measures for its conservation and sustainable use.

There is, besides, an unfavorable imbalance between pressures for the exploitation of natural resources and the various fields of knowledge that are necessary if the country is to face the ever-growing challenges that result. A critical mass of native experts and thinkers is needed. The enormous challenges facing Brazil require professionals who can
meet them and respond to the complex realities while implementing truly sustainable programs for development and human well-being. There are technological and research demands for innovation and alternatives that will provide for the protection rather than the gutting of the country’s natural resources and for the appropriate respect for indigenous peoples and traditional knowledge, while promoting economic growth without destruction.

The developed world is increasingly aware of the benefits of reforestation and of protecting natural ecosystems, but Brazil persists in extracting and depleting its natural resources; converting vast areas of forest and “cerrado” to cattle ranches and agriculture, now involving unprecedented large-scale mechanized agribusiness. The profits are large and short-term. The costs are immediate and long-term, and, unfortunately, given very short shrift. The causes are not linked to immediate consequences; floods and landslides now occur more frequently, but little is said about the deforestation preceding these natural disasters. Less still is said about the unsustainable development models linked to disastrous long-term consequences—bankruptcy in natural resources and the inevitable changes in climate and the costs in addressing major economic and social upheaval.

A robust education program can not only raise people’s awareness to the importance of seeking more sustainable practices, but also prepare professionals to act according to new paradigms. And the need is vast in both urban and rural settings. Towns and cities, for example, cause enormous impacts on their surroundings, particularly because of the strain they impose on natural resources. This is a reason why environmental education programs should be adopted in urban centers, now home to more than 70% of the Brazilian population. Policy and decisions regarding rural Brazil typically come from people who live in cities, so it is not infrequent to have measures imposed on rural areas that are entirely inappropriate if not destructive. Many people are unable to grasp what their lifestyles demand. The dominant trend is one based on the entirely industrialized production of goods and a mass consumption that is utterly divorced from the realities of the massive wastefulness and extraction of natural resources and its end products—solid waste, pollutants, plastics and sewage; unsolved problems worldwide. Without due awareness of the complexity and the risks that this model represents, or the understanding of the impossibility of replacing natural resources that are exploited unsustainably, the current trend of loss is likely to continue.

Deforestation, destruction and contamination of rural areas result from the expansion of agriculture, from soil impoverishment, erosion, the wreckage of so are occurring in increasing rates, especially due to the expansion of agricultural, mining and other activities that are commonly not conducted sustainably. In a country of continental proportions such as Brazil, the damages can be irredeemable. That is why conservation education must be a priority if conservation and sustainable development are to be enhanced.

The education that is needed now is one with broad perspective and multiple task skills because the challenges are of diverse natures. So changes in the education are also needed, and often this is not easily achieved because it is a continuous and somewhat slower process than the pressures that are occurring. That is why some non-governmental organizations have been
assuming the responsibility of promoting education for conservation and sustainability, which is the case of IPE – Institute for Ecological Research that will be now be explained.

A case study of a Brazilian NGO dedicated to education in conservation and sustainability

The IPE (Instituto de Pesquisas Ecológicas/Institute for Ecological Research), is a Brazilian non-profit organization that has the following mission: to develop and disseminate innovative models of biodiversity conservation and socio-economic development through science, education and sustainable businesses. The Institute’s education pillar has always been strong, as the quality of its staff reflects how professionals were encouraged to pursue higher education levels. From its initial stages, IPE attracted interns or students who work in field projects under more senior guidance. Many of these young professionals have remained with their original group after graduating, and subsequently developed projects that incorporated and benefited from the knowledge that they generate to strengthen local conservation.

The Institute was founded on this basis in 1992 by a small number of professionals in the areas of biology, forestry, ecology and environmental education. The model attracted more and more youngsters, who followed the pattern of studying and applying what was previously only theory. IPE now has about 80 professionals working in five regions of Brazil. Ten of them have PhDs and more than 20 have completed Master’s programs. This allowed IPE to develop and offer a Master’s degree in Ecology with the accreditation of the Brazilian Ministry of Education; an achievement that is uncommon for an NGO in Brazil.

IPE’s team understands the need to stimulate learning, dare new paths and assess results. Because all have a grassroots background and experience in fieldwork, they know about the complexities of conservation and the need to adopt interdisciplinary approaches. This has led to the development of what is known as the IPE Conservation Model, which is based on broadening the scope and incorporating new fields of knowledge and action to a primary initiative, usually beginning with a study on a particular species.

The IPE Conservation Model is based on the experience of more than 20 years of fieldwork, which began in the western region of São Paulo, known as the Pontal do Paranapenema. The initial aim was to save one of the most endangered species of primates in the world, the black-lion tamarin (Leontopithecus chrysopygus), primarily through a broad scientific study. It soon became evident that other fields had to be incorporated in order to achieve effective conservation for the species and its habitat (Valladares-Pádua et al., 2002, and Padua et al., 2006).

The entire model is based on public participation, having transparency and open dialogue as key elements to raising people’s awareness of the importance of conservation and the need to reduce the current pressures on what remains of the country’s natural environments. The scientific information that is generated through continuous on-the-ground research guides all of IPE’s actions. By using participatory approaches and science, therefore, IPE has been able to integrate field studies on endangered species and their habitats with the implementation of environmental education programs, develop
sustainable alternatives that add value to the regional natural richness, plan for broader landscape management, and, whenever possible, influence policies pertinent to conservation and sustainability.

This model has been adapted to four other regions of Brazil where IPE carries out fieldwork. Jaguars, tapirs, manatees and other species have provided the initial focus. In each context, the needs are assessed so that IPE’s team can design a program pertinent to the local reality. The IPE Conservation Model has also inspired many courses offered at the Institute’s education center and is now part of its Master’s program.

Education at IPE
Training and education have always been essential for IPE. This is mostly because the institution’s professionals themselves underwent the challenge of finding adequate training, and the majority became teachers of the different courses IPE offers. But it was the lack of appropriate learning opportunities that led IPE to take upon itself the responsibility of offering education in a variety of ways (Padua & Valladeres-Padua, 2006).

In the mid 90s, IPE founded an education center for short courses, the Centro Brasileiro de Biologia da Conservação - CBBC (Brazilian Centre for Conservation Biology). Here the courses mix theory and practice, and cover fields that are not commonly found in other teaching centers, but which have been identified by IPE’s team to be critical to improve the quality of the course and increase the chances of favoring conservation.

Students who attend these courses are equally diverse in nature, as the demands for, and scope of, social-environmental themes seem to be increasing. The CBBC receives university students, educators, government employees, and people from the private sector and from NGOs. Since its inauguration, the CBBC has taught around 4,000 students through courses on the following topics: Latin American Conservation Biology and Wildlife Management (which began in partnership with the Smithsonian Institution, USA); Quantitative Ecology; Remote Sensing; Environmental Education; Community-based Ecotourism; and Geographic Information Systems, among others. Themes can also include handicrafts for communities with the focus on local species, cooking with local fruits and vegetables, and other topics that are pertinent to the context. The idea is to increase the value attributed to the local biodiversity and to bring economic advantages to having nature in one’s surroundings.

The Latin American Conservation Biology and Wildlife Management Course, for example, has become IPE’s benchmark. It attracts students from several countries in addition to Brazilians from all regions. The course complements academic education, as can be confirmed in the words of one of the students themselves:

“The university enriched my theoretical knowledge... but I feel there was a lack of a more specific and practical learning to back it up [...] I feel the need of an education that can enable me to link this theoretical knowledge with practice in the field of conservation and IPE’s course has given me this opportunity.”

The CBBC teachers come from various places with diverse areas of expertise, including professionals from IPE, all of whom share their knowledge and practical experience with the students. This has been
one of the courses’ attractions as the
students know they will have the chance to
experience theoretical content that is put into
practice.

The CBBC also hosts an annual course for
students from Columbia University and
more recently from the University of
Colorado, USA. The aim is for students
from abroad to understand how conservation
is handled in Brazil, providing them with a
broader perspective of the social-
environmental complexities related to
conservation.

IPE is increasingly recognized as an
educational institution. External
organizations often request specific courses
that are taught in various regions of the
country. For example, together with WWF-
Brazil, IPE has been offering courses in the
Brazilian Amazonian states, mainly for
managers of protected areas. Formal
evaluation processes have made it possible
to improve these courses, and IPE has thus
been able to offer similar training to other
regions that lack such opportunities.

In 2008, IPE received the required
accreditation by the Brazilian Ministry of
Education to offer a Master’s degree. IPE is
being supported in this initiative by a
Brazilian cosmetics company, Natura, and a
foundation called Instituto Arapyau.
Following the same formula as the CBBC,
students integrate theory and practice, and
have a chance to understand that the social
and the environmental aspects of
biodiversity conservation and sustainability
are inseparable.

Because the Master’s program is under the
‘Ecology’ umbrella, disciplines follow what
is pertinent to this field. A group of
specialists were invited to design the overall
course content. They developed a number of
themes under disciplines. These “Seminar”
courses are offered during the first semester.
Students are then invited to solve a real
problem in the second semester, when they
put into practice what they learn in the
classroom. Their final paper must have as its
core a theoretical background that guides a
product that can be used to help solve a
specific issue. To date, 20 students have
completed their Master’s degrees, and IPE’s
intention is to apply for a PhD level
curriculum when the current programs are
appropriately established.

Final considerations

Education institutions in Brazil offer fewer
programs on biodiversity conservation and
sustainability than the country needs. Public
universities, the most appropriate venue,
change and expand their curricula with great
difficulty. This is so for a number of reasons
that often include sluggish procedures for
hiring faculty and changing and renewing
academic curricula. Even programs that do
teach themes related to conservation tend to
prioritize theory, which makes it difficult for
the students to link ideas to practice. With
the predominance of theoretical content, it is
not always easy to adjust to the fast-
changing world scenario or to the needs that
arise over time.

Public departments that deal with education
too frequently discontinue programs when a
political mandate term ends—education is a
long-term process and as such demands
continuity not serendipity. This has been a
reality in Brazil and is perceptible in many
fields, whether related to education,
conservation or other areas. In order to face
the modern world scenario, non-profit
organizations have been channeling more
and more effort into filling the gaps in the
educational fields related to conservation
and sustainability. In setting their long-term
goals, some have been planning and
designing strategies that can increase the effectiveness of their actions. Because most of these organizations develop field projects, they can clearly identify the areas that are most in need of suitably qualified professionals, and thus try to fill in the gaps that may enhance their lines of action. The IPE and its CBBC is a major contribution to this effort.

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References


Suzana M. Padua has a Ph.D. in environmental education from the University of Brasilia, Brazil, and a Master’s from the University of Florida, USA. She is co-founder and current president of IPÊ - Instituto de Pesquisas Ecológicas (Institute for Ecological Research), a Brazilian NGO dedicated to the conservation of biodiversity, sustainable development and education in these fields. She helped create IPE’s education centers for short-term courses and a Master’s program in conservation and sustainability. Suzana is an Ashoka fellow, an AVINA leader, and is the Vice-Chair for IUCN’s Commission on Education and Communication (CEC) for South America. She is on the Board of two nonprofits besides IPE: Ashoka Brazil and the Instituto Internacional de Educação do Brasil – IEB. Suzana has received a number of awards: the 2009 Social Entrepreneur of the Folha de São Paulo and the Schwab Foundation; the Bahá’í X World Citizenship Award of 2007; 2006 Ford Motor Company of Brazil Conservation Award, Woman of the Year in 2002 from Claudia Magazine, in the environmental category she was among the Most Influential Women of Brazil (Forbes, Gazeta Mercantil and Jornal do Brasil) in 2005, and in the USA, she received the Conde Nast Traveler Environmental Award in 2003. She was featured in Time Magazine in 2002, together with her husband Claudio, as green heroes of the world.
Claudio Valladares Padua has bachelors’ degrees in Business Administration and Biology, a Master’s and a PhD from the University of Florida. Claudio is a co-founder and Vice-President of a Brazilian non-profit organization, IPÊ – Instituto de Pesquisas Ecológicas (Institute for Ecological Research). He is a retired Professor from the University of Brasilia, and Rector of the University for Conservation and Sustainability, ESCAS, which is part of IPE. Claudio is in the board member of WWF Brazil, Funbio (The National Fund for the Environment) Instituto Arapyaú and IDESA. In the US, he is an Associate Researcher at Columbia University, New York. In 2002, he was portrayed by Time Magazine together with his wife Suzana as conservation heroes of the planet and in 2009 the couple was selected Social Entrepreneurs of the year by Folha de São Paulo and Schwab Foundation (World Economic Forum). Between 1998 and 2008 he received many important national and international awards for his work in the protection of endangered species and their habitats, and for training young conservationists: the Henry Ford Award for Conservation, the Whitley Continuation Award at the Royal Geographic Society, UK, the Society for Conservation Biology Achievement Award, US and Distinguished Alumnus Award of the University of Florida. He edited four books and has more than 30 articles published in national and international journals or book chapters.

Cristiana Martins is a Veterinarian with a PhD in Ecology from the University of Campinas, Brazil. She worked in the Amazon Forest, with small mammals and fragmentation, and with Dr. Claudio Padua on the conservation of black lion tamarins, a very endangered primate species and endemic to the Brazilian Atlantic Forest. She worked in ecological tourism in the Pantanal region, and in the captivity breeding of peccaries, capybaras, and caimans at the University of São Paulo. She is a co-founder of IPÊ – Institute for Ecological, and has coordinated several projects on endangered primate species, working with a team of young researchers on integrated conservation programs. In 2008, Cristiana assumed the position of coordinator of a Master program on Biodiversity Conservation and Sustainable Development, ESCAS, which is part of IPÊ. She is currently the education coordinator, with the aim of promoting capacity building for young leaders on new models of conservation and sustainability.
Building Local Capacities for Conservation:  
A Tool Box for Managing Protected Areas in Peru

Lily O. Rodríguez, Biodiversity and climate change Project, GIZ-Peru.  
Ingrid Prem, GIZ-Brasil.

We produced a tool box on the design and management of protected areas in Peru, identified as a necessity to improve local and regional capacities. The tool box, in Spanish, was constructed with the participation of potential users: local people, managers of protected areas and the people working on conservation and protected areas in country. To disseminate the tool box, it has been incorporated as learning material by courses at universities, as an introduction in immersing classes for new park-guards, and as workshops for local people involved in participatory management. Some challenges for the production and use of the tool box are also presented.

Producimos una caja de herramientas, para el diseño y manejo de áreas protegidas en Perú, identificada como una necesidad para mejorar las capacidades para mejorar las capacidades regionales y locales. La caja de herramientas está en español y fue construida con la participación de los usuarios potenciales: la gente local, el personal encargado de la gestión y los técnicos trabajando en conservación y áreas protegidas en el país. Para diseminar la caja, ha sido incorporada como un material de aprendizaje en cursos en universidades, como una introducción en cursos de inmersión de nuevos guardaparques, y como talleres de capacitación para pobladores locales involucrados en modelos de gestión participativa de áreas protegidas. También se presentan algunos retos de la producción y uso de la caja.

Key words: protected areas, management, capacity building, Peruvian system, biodiversity conservation, Convention on Biological Diversity.

Introduction
Protected areas (PA) are among the most effective strategies to conserve biodiversity. Training decision-makers and parks staff, at all levels, is a key process to enhance their effectiveness in the field. Only by knowing the conservation principles behind the regulations one can understand, adapt and put into practice, that framework to protect your local conditions. Outside a reduced number of people, working over the years in conservation, more particularly with international cooperation programs or NGO projects, there is very little knowledge about concepts and tools of conservation biology to manage PA. Up to now, it has been the realm of “specialists”. Decision-makers are not familiar with conservation issues or concepts.

After over three decades of experience managing protected areas in Peru, we developed a tool box, in the form of 8 booklets (fascicules), to synthesize some principles and concepts, and, translate the legal and technical framework to create regional and local governmental
capacities. We promoted the involvement of interested civilians in adopting protected areas as a strategy within their land use and development plans. Incorporating local people has also shown to be the best strategy to integrate their experience and knowledge into PA management. (Figure 1).

Building the tool box was a process of over two and a half years. Herein we describe the process, challenges and first applications.

**The idea**

From the Pacific coast to the high Andes crossing the whole country from South to North, and a vast tropical rainforest expanding to the East, Peru is home of a tremendous diversity of ecosystems, species, wild and domesticated diversity of plants and animals, as well as traditional cultures. Conserving most of this biodiversity is a challenging task, enhanced by the Peruvian system of protected areas (SINANPE) and more recently supported also by global commitments such as the convention on biological diversity (CBD). More specifically, by a program on protected areas (adopted in 2004, [http://www.cbd.int/protected/pow/learnmore/intro/](http://www.cbd.int/protected/pow/learnmore/intro/)) and several conservation strategies developing in country.

![Figure 1. Cover of fascicules of the tool box.](image)
The enforcement of a new Law on protected areas, in 2001, provided the framework for local and regional (department) authorities to bring into reality the establishment of protected areas on its own initiative. Working for the technical cooperation in the field, brought the ideal situation to see the need and the opportunity to build some material to cope with the task they wanted to undertake. Having participated in the development of the law, enabled us to
know the “spirit of the law” – which means that we knew the cases and the theory behind them. This was a most auspicious setting in which to develop specific materials on PA for the general public.

We identified first the most urgent themes. The tool box is composed of 8 Booklets or “fascicules” on different topics that you would need to establish and manage a new protected area. It brings information, concepts and practical recommendations on how to proceed to involve local populations in protection, and the diversity of goals and opportunities across the whole range of categories and types of protected areas: national, private, regional or local. Producing such a tool, written entirely in Spanish, took us two and a half years and the involvement of many people.

We started by writing the outline of each book. Then, we validated and tested the tools in the field. Then we double-checked it with other specialists and the national authorities (SERNANP, National Service of Protected Areas) to ensure its quality and coherence with current applications in Peru, and, new insights and approaches.

To call attention to specific concepts, clarify concepts or provide tools and practical tips, we introduced three icons throughout the text as follows: (Figure 2)

The contents
Contents were developed taking into account basic conservation concepts such as source-sink systems, island biogeography and population dynamics.

The First booklet is dedicated to explain the categories and uses of protected areas, as well as some of the principles for which they are selected: number of ecosystems, species richness and uniqueness, size, among other things. It also provides a tool to discern between types of protection (i.e.: national, or highest national priority, regional interest, local interest). It then presents a summary of major threats to PA, to emphasize common problems with other PAs around the world. The tool box refers in several places to the CBD documents in order to popularize and link local actions to its broader contribution worldwide (SCBD, 2004, Bennet and Mulongoy, 2006, SCBD, 2008).

The Second booklet presents several of the most current and important principles for the design of protected areas. Adapting the gap analysis methodology (Margules and Pressey, 2000, Dudley and Parish, 2006, Pressey et al, 2007) to match the land-use planning process already in the law was a fascinating process. Discussions were closely followed by regional authorities who became very much involved in the selection of criteria for prioritization.

Putting together the tools to fill a file to establish a protected area, at any level, brought attention to us about the growing number of initiatives around the world (Figure 4) to cope with these types of tasks. It resulted in a large Third booklet with many references to the web that should be periodically updated as new initiatives arise and databases become available.

The Fourth booklet is on a proven participatory methodology for the socio-economic assessment of land and natural resources and assets used in communities. The novelty here is that the local people are in charge of gathering their own information. (Figures 3 and 4)
Managing the resources and working towards sustainability is the central challenge of protected areas. Offering some tracks for alternatives, raising funds, working with ecosystem services and payments, and going into the essence of what sustainability really means is developed in the Sixth booklet. This is being one of the more useful tools to local and regional stakeholders.

Finally, the Seventh booklet is also very useful at explaining current laws and procedures for reinforcing the law and to stop forbidden activities in each protected area, such as opening forests for agriculture and timber extraction.
The numbers
160 people from local communities of Alto Mayo (in San Martin), participated in discussions on contents, concepts and clarifications of the booklets. A total of 85 people, from 2 different regions (Piura and Cajamarca) participated in the construction of the methodology of fascicule 2. A group of 64 conservationists from government and NGOs reviewed different parts of the contents and made contributions.
Over 100 park guards have participated in formal courses at the university in Lima, and another 42 have been introduced to park managements in immersion courses. Additionally nearly 2000 printed tool boxes have been disseminated across the country. (Figures 5, 6, & 7)

The methods
Aside from developing regular courses in collaboration with the national service of protected areas and universities, for professionals of all disciplines (lawyers, attorneys, foresters, and consultants), we faced the challenge of working in rural areas.

Rural people have little practice reading and writing. Therefore, we had to introduce practical and outside-class room methods to train them. The first method was role playing. We used it to practice enforcement of the law, to organize local participation in communal monitoring of illegal activities. We also had to consider that in many cases rural areas have little access to internet or even worse, they don’t have electricity.

As an additional tool, we produced charts to take to the field, summarizing examples of most common cases so that people knew how to proceed and how to apply to reinforce the law. (Figure 8)
Challenges and next steps

For local people, living immersed and surrounded by tropical forests with as yet small fragmentation, it is hard for them to understand the concept of empty forests.

In places with heavy or long-term hunting practices, that are now turning from subsistence to trade in order to increase household incomes, the common saying is that animals go further into the forest
instead of acknowledging local extinctions. Discussions on home range, territories and density-dependence of species such as tapirs, monkeys and tortoises, resulted in a “scene” where the course participants played the game based on the source-sink model. (Figure 9)

![Image of source and sink model]

Figure 9. A key model applied to manage wildlife populations in and around protected areas is based on the “source and sink” theory. (Fasc. 6).

Getting technical biological information on distribution of species, for non-biologists, is a challenging task. There is always need of some expertise on this topic, when referring to the web and to data banks.

The management plan, specific to each area, continues to be a challenge. Although we developed several meetings to discuss how to convert it into a simpler process and more applicable product, we feel that we still did not fill the gap between theory and practice. We propose that managers, although not necessarily experts, should develop their own plans, with some external support.

Explaining biological reasons to establish large protected areas was not as effective as explaining the cost of management. Myths about amount of money going into the sink were also discussed. (Figure 10)

![Image of simplified explanation on best practices to design protected areas]

Figure 10. A simplified explanation on best practices to design protected areas, from Diamond (1975). This diagram of the island dilemma opened up a debate on the value of several small or single large protected areas, very actual now that natural habitats fragmentation is inexorable increasing. We use this diagram to discuss in class how to design a system of protected areas.

There is a high turnover in the public administration. Training the staff in technical aspects is a never-ending task. However, we believe that by facilitating information and organizing courses, we will contribute to create a critical mass of trained people that will implement the fundamentals of conservation from different roles in society.

A recent training course took place in Pucallpa at the local university. Several professors participated and are now trying to implement the course as part of the syllabus in the forestry faculty. The training material is being improved and will be soon on the web. This will be one of the very few accessible sets in Spanish. Note, the tool box may be downloaded at: http://www.pdrs.org.pe/node/1333
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Bibliography


Dr. Lily O. Rodríguez, biologist, works as a senior expert on biodiversity and protected areas of the German cooperation for development (GIZ) in Peru, collaborating with national authorities of protected areas (SERNANP). She earned a doctoral degree in Ecology from the University of Paris (1991). Since 1996 she has been developing books, tools and manuals to disseminate biological information and conservation issues in her home country; she also conducts field courses and classes for park guards, other stakeholders and professionals working on conservation and development. Her work on protected areas ranges from research to conducting the planning of the national system, establishment and management of large protected areas. She is also known as a herpetologist and has published several scientific papers on taxonomy, ecology and conservation.

Ingrid Prem, geographer, graduated from the University of Regensburg, in Germany, in 1999. Is coordinating projects on biodiversity conservation and climate change, on behalf of the German Federal Ministry of Environment, Nature protection and nuclear security (BMU), for the German international cooperation for development (GIZ) in Brazil. Ingrid has been working for over ten years, as an expert on managing programs of the international cooperation for development, in southern Africa, Latin America and at the international level, with special reference to rural development, land management, drylands, biodiversity conservation and sustainable management of natural resources.
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