Conservation Biology

Conservation Practice and Policy

Taking the Conservation Biology Perspective to Secondary School Classrooms

YAEL WYNER* AND ROB DESALLE†

*Secondary Education, City College of New York, 160 Convent Avenue, New York, NY 10031, email ywyner@ccny.cuny.edu
†Division of Invertebrate Zoology, American Museum of Natural History, Central Park West and 79th Street, New York, NY 10024-5192

Abstract: *The influence of conservation biology can be enhanced greatly if it reaches beyond undergraduate biology to students at the middle and high school levels. If a conservation perspective were taught in secondary schools, students who are not interested in biology could be influenced to pursue careers or live lifestyles that would reduce the negative impact of humans on the world. We use what we call the ecology-disrupted approach to transform the topics of conservation biology research into environmental-issue and ecology topics, the major themes of secondary school courses in environmental science. In this model, students learn about the importance and complexity of normal ecological processes by studying what goes wrong when people disrupt them (environmental issues). Many studies published in* Conservation Biology *are related in some way to the ecological principles being taught in secondary schools. Describing research in conservation biology in the language of ecology curricula in secondary schools can help bring these science stories to the classroom and give them a context in which they can be understood by students. Without this context in the curriculum, a science story can devolve into just another environmental issue that has no immediate effect on the daily lives of students. Nevertheless, if the research is placed in the context of larger ecological processes that are being taught, students can gain a better understanding of ecology and a better understanding of their effect on the world.*

Keywords: conservation biology, ecology education, education, environmental education, high school, secondary school

Introducción de la Perspectiva de la Biología de la Conservación a las Aulas de Escuelas Secundarias

Resumen: *La influencia de la biología de la conservación puede ser mejorada significativamente si alcanza más allá de estudiantes universitarios de biología y llega a los niveles de escuela secundaria y preparatoria. Si se enseñara una perspectiva de conservación en las escuelas secundarias, los estudiantes que no están interesados en la biología podrían ser influenciados a estudiar carreras o adoptar formas de vida que pudieran reducir el impacto negativo de los humanos en el mundo. Utilizamos lo que denominamos el método de ecología-perturbación para transformar los temas de investigación en biología de la conservación en tópicos ambientales y ecológicos, los temas principales en los cursos de ciencia ambiental en las escuelas secundarias. En este modelo, los estudiantes aprenden la importancia y complejidad de los procesos ecológicos normales estudiando lo que pasa cuando la gente los perturba (temas ambientales). Muchos estudios publicados en* Conservation Biology *están relacionados de alguna manera con los principios ecológicos que se enseñan en las escuelas secundarias. La descripción de la investigación en biología de la conservación en el lenguaje de los programas de ecología de las escuelas secundarias puede ayudar a trasladar estas historias científicas al aula y darles un contexto en el que pueden ser entendidas por los estudiantes. Sin este contexto en el plan de estudios, una historia científica puede recaer en solo otro tema ambiental que no tiene efecto inmediato sobre la vida diaria de los estudiantes. Sin embargo, si la investigación es colocada en el contexto de procesos ecológicos mayores que son enseñados, los estudiantes pueden obtener un mejor entendimiento de la ecología y una mejor comprensión de su efecto en el mundo.*

Paper submitted February 18, 2009; revised manuscript accepted November 9, 2009.

Conservation Biology, Volume 24, No. 3, 649–654

DOI: 10.1111/j.1523-1739.2010.01478.x

Palabras Clave: biología de la conservación, educación, educación ambiental, educación ecológica, escuela secundaria, escuela preparatoria

Introduction

Introductory conservation biology courses are usually confined to university programs affiliated with biology departments, a logical placement because a biological appreciation and understanding of biodiversity is the common language of conservation biologists. Nevertheless, the influence of the discipline and recruitment of new students could be enhanced if the subject was not confined to undergraduate biology departments and was taught in secondary schools. By reaching a more-general audience, conservation biology can influence students who are not interested in biology to pursue careers or live lifestyles that reduce the negative impact of humans on the world.

An analysis of courses offered by five magnet public high schools in New York City showed an absence of conservation biology courses even in schools that are known for their depth of science course offerings. Additionally, a web search for high school conservation biology courses revealed only one public high school in the United States that offers a course in conservation biology.

Bringing Conservation Biology to Secondary Schools

The lack of engagement of conservation biologists with education and outreach is a recurring theme of papers published in *Conservation Biology* (Rivas & Owens 1999; Brewer 2001; Brewer 2006; Bride 2006). Another problem identified is that when conservation instruction makes its way into classrooms, it tends to focus on exotic locations, rather than local or even national conservation issues (Brewer 2002*a*). Additional barriers to bringing conservation biology to a wider audience are the scientific underpinnings of the discipline. Like all science, the inferences made in conservation biology are hypothesis driven. Hence, such inferences are revisable and retestable, making the forceful use of data in teaching generalizations on this subject difficult (Bride 2006).

Perhaps the biggest impediment to bringing conservation biology to secondary schools is the issue of where to incorporate it into the curriculum and how to make it fit into national and state educational standards (NRC 1996). A national emphasis on testing leaves little room to add new topics to already overpacked curricular mandates (Charlesworth et al. 1994; Barksdale-Ladd & Thomas 2000). Therefore, bringing an introductory conservation biology course to middle and high school students may not be possible. Nevertheless, applying a conservation biology perspective to ecological topics covered in science classrooms is possible, useful, and within the mandates for secondary school education (NRC 1996).

The major themes of conservation biology center on the importance, complexity, threats, and efforts to protect the world's biodiversity and ecological integrity (Trombulak et al. 2004). These themes occur in simplified forms in national and state educational standards, specifically biodiversity, basic ecological principles (e.g., populations and ecosystems, interdependence of organisms), and environmental issues (e.g., populations resources and environments, environmental quality, and human-induced hazards; NRC 1996). Nevertheless, the interconnectedness and inherent complexity of these topics is not being taught in ecology courses at the secondary level, largely because of the way environmental issues and ecological principles are studied in the context of formal classroom settings.

Currently, environmental issues are studied and categorized as separate units from units on ecological principles in science textbooks and in district and state scope and sequence guidelines and frameworks (Schachter 2005; WESTN 2008; SBCUSD 2008). Some districts do not even teach environmental issues and ecological principles sequentially; rather, they separate the topics into different semesters or years of study (NYCDE 2008; TMS 2008). We believe the segregation of these topics into different units or semesters means an opportunity to use environmental issues to teach ecological principles is lost.

We propose the use of what we call the *ecology-disrupted* framework in which the major themes of conservation biology (biodiversity and ecological integrity) are transformed into environmental-issue and ecology topics, the themes of secondary school courses in environmental science. In this model, students learn about the importance and complexity of normal ecological processes (including biodiversity and ecological integrity) by studying what goes wrong when people *disrupt* these processes (environmental issues). Just as geneticists study mutated genes to discover gene function, secondary school ecology students would learn the complexity of fully functioning ecosystems from studying human-caused disruptions in ecological processes (i.e., ecology disrupted).

Connecting Daily Life to Ecological Principles

Another important component of the ecology-disrupted framework is the use of environmental issues to

connect ecological principles to daily life. In an effort to connect children to local environmental issues, conservation biologists have developed educational initiatives for children and teachers who live near at-risk species or ecosystems (Chesapeake Bay, Zint et al. 2002; sea turtles, Brewer 2002*b*; Florida marshes and wetlands, Main 2004). This use of local environmental issues can engage a diverse range of students about the increasing human impact on nearly all of Earth's environmental systems (Pfirman & AC-ERE 2003; NSF AC-ERE 2005), nurture the development of civically engaged citizens (Hungerford et al. 2003; NAAEE 2007; SENCER 2008), and add a new and vibrant dimension to environmental science curricula (Johnson 2004). In addition, an understanding of familiar environmental issues can help students discover the hidden interconnectedness of basic ecological principles (Elder et al. 1998; Thomashow 2002; Johnson 2004; NAAEE 2007).

The ecology-disrupted approach seeks to bring some of the excitement and engagement of local environmental issues to the formal classroom setting by using daily life to connect ecological principles to environmental issues. Linking everyday behaviors to environmental issues increases student understanding of specific environmental issues such as climate change (Cordero et al. 2008). Taking the additional step of linking daily life to ecological processes can help students discover the hidden interconnectedness of basic ecological principles (Elder et al. 1998; Thomashow 2002; Johnson 2004; NAAEE 2007). For example, teenagers in the northeastern United States are well versed in the perils of Lyme disease, but most are ignorant of its connection to fragmented habitats and disrupted food webs. By placing Lyme disease in its ecological context, students can deepen their understanding of the causes of Lyme disease and related ecological principles (e.g., habitats and food webs) (Elder et al. 1998; Bransford et al. 2000; Thomashow 2002). This ecology-disrupted approach will help students learn that no matter where they live, they are part of a system in which ecological processes and disruptions to these processes affect their daily lives.

Use of Published Data and Media in Ecology-Disrupted Units

Conservation biologists have accumulated much information that illuminates the effects of humans on ecological processes. These data can be reformatted into the ecology-disrupted framework so that they can be learned in the context of ecological processes, the foci of secondary school classrooms.

Additionally, many educational videos have been developed that explain a myriad of environmental issues, from dead zones to invasive species (Olson & Jackson 2009; *Science Bulletins* 2009). Unfortunately, bringing the resources into the classroom is hindered by contextual barriers. Most environmental curricular resources describe environmental issues on their own terms. To integrate the environmental issues into classroom discussion and to give issues context, the issues must be transformed into the language of the topics being studied in the classroom.

We describe two examples in which we transformed published studies and videos about environmental issues into case studies focused on ecology, a topic specifically addressed in classrooms. These case studies use real scientific data and a media product produced by the American Museum of Natural History (AMNH) (*Biobulletins Snapshots*; http://www.amnh.org/sciencebulletins/biobulletin/index.html) to link daily life to environmental issues and basic ecological principles.

Highways and Bighorn Sheep

The first case is based on published conservation biology research that shows that highways bisecting the Sierra-Nevada Mountains block the movement of bighorn sheep and lead to inbreeding (Epps et al. 2005). As formulated in the paper, this research fits under conservation biology, but it is not formatted appropriately for use in a secondary classroom. In addition, the media product developed around this research was produced to bring up-to-date content into a museum exhibit and was not intended for classroom use. The AMNH also posted their media product online so that teachers interested in sharing the story could download it to show to students. Nevertheless, the AMNH product is a stand-alone entity and is not related to topics being taught in the classroom. Therefore, we used the ecology-disrupted framework to reformulate the scenario established by the conservation biology research into ecological topics that are central to the classroom setting.

Students use the scientific research to explore what goes wrong when people disrupt habitats and populations (the ecological principles that are the focus of classroom units) in unexpected ways. This approach has the added benefit of linking daily human life (highways and transportation) with the ecological principles (habitats). Students use data from the published study to investigate the question, How might being able to drive between Los Angeles and Las Vegas in just 4 hours put bighorn sheep at risk? They then watch and analyze other AMNH media products to connect this question to other situations in which people have disrupted habitats in unexpected ways. The goal is to encourage students to recognize the complexity of ecological processes and the variety of daily behaviors that can have negative effects on ecosystems and habitats. We hope that recognizing the environmental impact of mundane daily activities will help students understand how their behavior affects the

Table 1. Publications from the December 2008 issue of *Conservation Biology* with subjects reframed as questions that link daily life to environmental issues and ecological principles.

Title	*Question*	*Ecological principle*
Agroforestry as a Solution to the Oil-Palm Debate (Bhagwatt & Willis 2008)	How might powering your car with palm oil contribute to global warming?	carbon cycle
Land Use and Climate Change (Orr 2008)	How does having a big backyard harm native wildlife?	habitat
American Land Use: the Next 50 Years (Nugent 2008)	How does living in driving distance from school, work, friends, and stores make it harder to find land to grow food?	habitat, biomes
The Necessity and Possibility an Agriculture where Nature Is the Measure (Jackson 2008)	How does being able to eat a hamburger for only $1 contribute to polluted water?	water cycle, nitrogen cycle
Sustaining America's Forest Legacy (Christensen 2008)	How do more people living in the United State contribute to the loss of American forests?	biomes
The 21st Century Ranch (White 2008)	How does eating $1 hamburgers contribute to climate change? What can you do?	nitrogen cycle, carbon cycle, energy pyramid, food chain
Economic Growth, Climate Change, Biodiversity Loss: Distributive Justice for the global north and south (Rosales 2008)	How does economic prosperity accelerate species extinctions?	carbon cycle
Effects of Human Trampling on Populations of Soil Fauna in the McMurdo Dry Valleys, Antarctica (Ayres et al. 2008)	How does walking on Antarctic ice interfere with the carbon cycle?	carbon cycle
Assessing Changes in Amphibian Population Dynamics Following Experimental Manipulations of Introduced Fish (Pope 2008)	How does spending the day fishing with dad in the Klamath Mountains harm the Cascades frog?	food chain, food web, populations
Amphibian Commerce as a Likely Source of Pathogen Pollution (Picco & Collins 2008)	How can spending the day fishing with dad contribute to the loss of salamanders and frogs?	symbiosis
Long-term Impacts of Poaching on Relatedness, Stress Physiology, and Reproductive Output of Adult Female African Elephants (Gobush et al. 2008)	How is your grandmother's ivory still harming elephants today?	animal behavior
Gastrointestinal Bacterial Transmission among Humans, Mountain Gorillas, and Livestock in Bwindi Impenetrable National Park, Uganda (Rwego et al. 2008)	How come gorillas carry antibiotic resistant *E. coli* in Bwindi Impenetrable National Park, Uganda?	habitat
Intraspecific Chromosome Number Variation: a Neglected Threat to the Conservation of Rare plants (Severns & Liston 2008)	How does judging a plant only by its appearance limit its chance of survival?	populations
Water War: Explaining the Klamath Controversy (Owen 2008)	How might eating French fries made from potatoes from the Klamath Basin contribute to the death of thousands of endangered salmon?	abiotic factors, water cycle

natural world and lead them to be more environmentally responsible citizens.

Salting Icy Roads and Water Quality

We use data from a long-term study that shows that salt added to roadways to melt ice causes freshwater streams to become progressively saltier (Kaushal et al. 2005). As in the previous example, we use the results of a scientific study to get students to think about what goes wrong when people disrupt an ecological process. The goal is for students to understand there can be unforeseen consequences when abiotic factors are altered. As in the bighorn sheep example, we link daily life (snowy roads) with an ecological factor (abiotic factors). Students use data from the published study to investigate the question, How might snowy and icy roads affect the Baltimore area's water supply? As in the previous example, the students then watch and analyze other AMNH media products to connect this question with other instances in which people have disrupted abiotic factors in unexpected ways.

Testing and Dissemination

We tested these two lessons in the classrooms of over 30 teachers in New York City public schools in 2008 and 2009. Results from teacher reports from the first pilot year indicate students developed a better understanding of pertinent ecological principles such as *abiotic* and *biotic factors* and *habitat* in all cases. In addition, in all cases, teachers reported that students developed a

better understanding of how daily life can affect the natural world. The modules are continuing to be refined with the addition of profiles of the scientists who conducted the research and will be more rigorously tested (control and experimental groups) in the classrooms of 60 teachers in the 2010–2011 school year. After testing, the modules will be available for dissemination on the AMNH education website, which gets over one million visitors a year.

Rephrasing Conservation Biology Research for the Classroom

Many studies published in *Conservation Biology* relate to an ecological principle being taught in secondary classrooms; thus, it is possible for conservation biologists and educators to use our framework to develop curricular resources. We found 14 examples of published work in the December 2008 issue of *Conservation Biology* that demonstrate the usefulness of the ecology-disrupted model (Table 1). For each research study, we constructed a question that links daily life to the particular environmental issue described in the study. Secondary school students, through investigation of the constructed question, can explore how specific human actions disrupt an ecological process that is part of their curriculum. Most research studies can be used to explore more than one ecological principle because the interconnected nature of ecosystems means that human actions will most likely disrupt more than one ecological process.

Science Shining Through

Our approach is a straightforward and useful technique for developing educational materials that bring up-to-date conservation biology discoveries into the classroom, thereby helping the conservation biology community reach a wider audience than it has traditionally. We hope our model will be used to encourage students to understand the complexity of ecological processes and the role of human behavior in disrupting ecosystems and thereby lead students to be more environmentally aware and perhaps to be more environmentally responsible. We also hope the approach illustrates that conservation biology can be more accessible to secondary school classrooms and that conservation biologists will start to think about communicating their work within our framework or develop other approaches that take into consideration the educational concepts being taught in secondary classrooms.

Acknowledgments

This work is supported by National Science Foundation (NSF) (grant 733269; 0918629). All opinions expressed are those of the authors and not of the NSF. We thank S. Gano, J. Koch, D. Silvernail, and J. Hong for their important work in developing and evaluating the modules.

Literature Cited

Ayres, E., J. M. Nkem, D. H. Wall, B. J. Adams, J. E. Barrett, E. J. Broos, A. N. Parsons, L. E. Powers, B. L. Simmons, and R. A. Virginia. 2008. Effects of human trampling on populations of soil fauna in the McMurdo Dry Valleys, Antarctica. Conservation Biology **22:**1544–1551.

Barksdale-Ladd, M., and K. Thomas. 2000. What's at stake in high-stakes testing: teachers and parents speak out. Journal of Teacher Education **51:**384–398.

Bhagwatt, S. A., and K. J. Willis. 2008. Agroforestry as a solution to the oil-palm debate. Conservation Biology **22:**1368–1369.

Brewer, C. 2001. Cultivating conservation literacy-trickle down education is not enough. Conservation Biology **15:**1203–1205.

Brewer, C. 2002*a*. Conservation education partnerships in schoolyard laboratories: a call back to action. Conservation Biology **16:**577–579.

Brewer, C. 2002*b*. Outreach and partnership program for conservation education where endangered species conservation and research occur. Conservation Biology **16:**4–6.

Brewer, C. 2006. Translating data into meaning: education in conservation biology. Conservation Biology **20:**689–691.

Bride, I. 2006. The conundrum of conservation education and the conservation mission. Conservation Biology **20:**1337–1339.

Charlesworth, R., P. O. Fleege, and C. J. Wietman. 1994. Research on the effects of group standardized testing on instruction, pupils, and teachers: new directions for policy. Early, Education, & Development **5:**195–212.

Christensen, N. L. 2008. Sustaining America's forest legacy. Conservation Biology **22:**1378-1379.

Elder, J., C. Coffin, and M. Farrior. 1998. Engaging the public on biodiversity: a road map for education and communication strategies. The Biodiversity Project, Madison, Wisconsin.

Epps, C. W., P. J. Palsbøll, J. D. Wehausen, G. K. Roderick, R. R. Ramey, and D. R. McCullough. 2005. Highways block gene flow and cause a rapid decline in genetic diversity of desert bighorn sheep. Ecology Letters **8:**1029–1038.

Gobush, K. S., B. M. Mutayoba, and S. K. Wasser. 2008. Long-term impacts of poaching on relatedness, stress physiology, and reproductive output of adult female African elephants. Conservation Biology **22:**1590–1599.

Hungerford, H. R., R. A. Litherland, R. B. Peyton, J. M. Ramsey, and T. L. Volk. 2003. Investigating and evaluating environmental issues and actions: skill development modules. Stipes Publishing, Champaign, Illinois.

Jackson, W. 2008. The necessity and possibility of an agriculture where nature is the measure. Conservation Biology **22:**1376–1377.

Johnson, M. 2004. The newest "reality show:" The importance of legitimizing experiential learning with community-based research. The American Biology Teacher **66:**549–553.

Kaushal, S., P. M. Groffman, G. E. Likens, K. T. Belt, W. P. Stack, V. R. Kelly, L. E. Band, and G. T. Fisher. 2005. Increased salinization of fresh water in the northeastern United States. Proceedings of the National Academy of Sciences **102:**13517–13520.

Main, M. 2004. Mobilizing grass-roots conservation education: the Florida master naturalist program. Conservation Biology **18:**11–16.

NAAEE (North American Association for Environmental Education). 2007. Standards for the initial preparation of environmental educators. NAAEE, Washington, D.C. Available from http://www.naaee.org/ (accessed December 2008).

NSF (National Science Foundation) Advisory Committee for Environmental Research and Education. 2005. Complex environmental systems: pathways to the future. NSF, Washington, D.C. Available from

http://www.nsf.gov/geo/ere/ereweb/acere_synthesis_rpt.cfm (accessed MONTH YEAR).

Nugent, C. 2008. American land use: the next 50 years. Conservation Biology **22:**1375.

NYCDE (New York City Department of Education). 2008. Scope and sequence. NYCDE, New York. Available from http://schools.nyc.gov/Teachers/QuickLinks/scopesequence.htm (accessed December 2008).

Olson, R., and J. Jackson. 2009. Rediagnosing the oceans. Shifting Baslines, San Diego, California. Available from http://www.shiftingbaselines.org/videos/index.html (accessed December 2009).

Orr, D. W. 2008. Land use and climate change. Conservation Biology **22:**1372–1374.

Owen, D. 2008. Water war: explaining the Klamath controversy. Conservation Biology **22:**1664–1666.

Pfirman, S., and AC-ERE (Advisory Committee for Environmental Research and Education). 2003. Complex environmental systems: synthesis for Earth, life, and society in the 21st century, a report summarizing a 10-year outlook in environmental research and education for the National Science Foundation. National Science Foundation, Washington, D.C. Available from http://www.nsf.gov/geo/ere/ereweb/acere_synthesis_rpt.cfm (accessed December 2008).

Picco, A. M., and J. P. Collins. 2008. Amphibian commerce as a likely source of pathogen pollution. Conservation Biology **22:**1582–1589.

Pope, K. L. 2008. Assessing changes in amphibian population dynamics following experimental manipulations of introduced fish. Conservation Biology **22:**1572–1581.

Rivas, J. A., and R. Y. Owen. 1999. Teaching conservation effectively: a lesson from life-history strategies. Conservation Biology **13:**453–454.

Rosales, J. 2008. Economic growth, climate change, biodiversity loss: distributive justice for the global north and south. Conservation Biology **22:**1409–1417.

Rwego, I. B., G. Isabirye-Basuta, T. R. Gillespie, and T. L. Goldberg. 2008. Gastrointestinal bacterial transmission among humans, mountain gorillas, and livestock in Bwindi Impenetrable National Park, Uganda. Conservation Biology **22:**1600–1607.

SBCUSD (San Bernardino City Unified School District). 2008. Biology scope and sequence. SBCUSD, Sen Bernardino, California. Available from http://sbcusd.k12.ca.us/new/203/uploads/Biology%20Pacing%20Guide06.pdf (accessed December 2008).

Schachter, M. 2005. Environmental science. AMSCO School Publications, New York.

Science Bulletins. 2009. Science bulletins. American Museum of Natural History, New York. Available from http://sciencebulletins.amnh.org/ (accessed January 2009).

SENCER (Science Education for New Civic Engagement and Responsibility). 2008. Applying the science of learning to the learning of science. SENCER, Harrisburg, Pennsylvania. Available from http://www.sencer.net/ (accessed December 2008).

Severns, P. M., and A. Liston. 2008. Intraspecific chromosome number variation: a neglected threat to the conservation of rare plants. Conservation Biology **22:**1641–1647.

Thomashow, M. 2002. Bringing the biosphere home: learning to perceive global environmental change. The MIT Press, Cambridge, Massachusetts.

TMS (Telluride Mountain School). 2008. Scope and sequence. Telluride Mountain School, Telluride, Colorado. Available from www.telluridemtnschool.org/documents/INTERMEDIATES-COPEANDSEQUENCE2007.pdf (accessed December 2008).

Trombulak, S. C., K. S. Omland, J. A. Robinson, J. J. Lusk, T. L. Fleischner, G. Brown, and M. Domroese. 2004. Principles of conservation biology: recommended guidelines for conservation literacy from the education committee of the Society for Conservation Biology. Conservation Biology **18:**1180–1190.

WESTN (Wisconsin Environmental Science Teacher Network) 2008. Wisconsin environmental science course framework. WESTN, Stevens Point, Wisconsin. Available from http://www.uwsp.edu/cnr/wcee/envsci/Framework/Overview/index.htm (accessed December 2009).

White, C. 2008. The 21st century ranch. Conservation Biology **22:**1380–1381.

Zint, M., A. Kraemer, H. Northway, and M. Li. 2002. Evaluation of the Chesapeake Bay Foundation's conservation education programs. Conservation Biology **16:**641–649.