

CORNELL SCIENTIFIC INQUIRY SERIES

TEACHER EDITION

Watershed Dynamics

BY THE ENVIRONMENTAL INQUIRY LEADERSHIP TEAM

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WHY WATERSHED DYNAMICS?

Students engaged in this EI curriculum learn basic concepts of watershed dynamics, a fairly complex science. With all of the challenges that schools face, why include watershed dynamics in a secondary science program?

RELEVANCE

One important reason for studying watershed dynamics at the high school level is its relevance to everyday life. Clean water is essential to life. Water is a renewable resource, but water quality depends heavily upon human actions and natural processes in the environment. Watershed studies can help students understand where their drinking water originates, what a watershed is, and how aquatic systems function. *Watershed Dynamics* also investigates the relationship between human actions in the environment and the effects of those actions on the biology, chemistry, and hydrology of water resources. How does building a parking lot affect nearby streams? Should rural communities provide drinking water to larger urban communities, and if so, who should pay for watershed protection? Why is it important to preserve wetlands? In learning about land use and water quality, students will become better prepared to make reasoned decisions about issues such as these.

Watershed dynamics offers the opportunity to connect classroom science to relevant issues in all types of communities—rural, suburban, and urban. People living in rural areas usually drill wells to get the water they need. What do engineers and builders need to know about watersheds in order to drill wells successfully? The residents of large cities may get their water from reservoirs a hundred miles away. How do agricultural practices affect the water in lakes and rivers used by people for drinking and recreation?

CONNECTIONS

Another reason for including watershed dynamics in high school science is that it provides a natural link between scientific disciplines, including biology, chemistry, geology, environmental science, and human health. School sciences are often presented as discrete fields of study. By highlighting the natural links and common themes, watershed dynamics can make all of these fields more interesting. Study of watershed dynamics also highlights the connections among science, social science, and public policy. For example, when students interpret the results of their studies of land use and water quality, they can better understand how the interplay between scientific data and human judgment shapes public policy decisions such as zoning, flood control, and the regulation of agricultural practices.

WHY WATERSHED DYNAMICS?

Watershed Dynamics can be used in conjunction with other curricula in the Environmental Inquiry series. For example, students can combine their knowledge and skills of macroinvertebrate sampling and water chemistry with the bioassay protocols featured in *Assessing Toxic Risk* (2001; the first publication in the Cornell Scientific Inquiry Series) to investigate suspected toxic sediments from streams, rivers, and lakes.

RESEARCH AND ENGINEERING DESIGN OPPORTUNITIES

One of the great challenges for science teachers is providing students with opportunities for authentic open-ended investigations that are safe and feasible to perform at the high school level. EI protocols are ideally suited to student research. Not only are many of the protocols simple and inexpensive to carry out, they also are authentic scientific techniques that can be used to investigate issues relevant to the local community.

Using remote sensing and monitoring procedures, students can carry out the same types of tests used by scientists in universities, government, and industry. Although scientists have access to budgets and equipment far beyond the reach of secondary schools, they use similar procedures to reveal an integrated picture of aquatic environments. For example, scientists use riparian inventories and watershed delineation techniques to determine how land use affects stream quality. With very few modifications, students can carry out the same procedures to answer questions of their own design.

Scientific experiments often lead to more questions than they answer. After each experiment, students are likely to come up with several more questions that can be addressed through further experimentation. Given the time and freedom to carry through with some of these ideas, students will be able to experience the creativity inherent in research and to experience firsthand the joy of practicing science.

In addition to research opportunities, *Watershed Dynamics* also contains an Engineering Design Challenge. In this activity, students work with classmates to build a stormwater retention device that meets certain specified criteria and operates within stated constraints. The Challenge provides students with the opportunity to integrate information presented in the introductory text with skills and knowledge they have gained from the protocols. By presenting their final solution to classmates, and then reviewing the design of fellow students, students will gain an appreciation of how these issues are approached in everyday situations in their local communities.

CRITICAL THINKING

Students often believe that scientific work is a process that produces unambiguous results. This misconception may lead to confusion or suspicion when students observe scientists publicly disagreeing about issues like long-term implications of global warming, food safety, or the causes of cancer. How can opposing views in an argument be “scientific?” Students who engage in Environmental Inquiry will learn that good scientific work involves both careful attention to standard methods and creativity in responding to real-world problems. They will discover that different research teams approach problems in different ways, even when they begin with the same “standard” methods. Students’ own work will be influenced by how they frame their problems, what resources they have on hand, and whether other students in their schools have studied the problem before. For example, students investigating an urban river may not be able to safely wade into the water, so they will need to use collection methods different from those used to study a seasonal rural stream.

In interpreting the results of their investigations, students will find that they need to think carefully about how conclusions are justified. In grappling with such questions, students are forced to identify their assumptions and to think critically about different explanations. Initially they may jump to conclusions, then realize through classroom discussions and peer review that other interpretations are possible or that further experiments are needed before a final conclusion can be reached. They may also discover that new data force them to revise or discard explanations that adequately accounted for earlier data. These struggles are similar to the ones that engage professional scientists as they interpret and present the results of research.

There are many excellent resources for studying aquatic systems and for understanding watersheds, and we encourage you to draw upon other resources as you craft your own local solution to the challenge of understanding watershed dynamics. In creating the activities and investigations for this book, we have tried to complement the best currently available resources with some fresh material, integrative activities, and approaches to research that will help your students understand science the way it is practiced.

Table 2 lists intended learning outcomes for students engaged in EI watershed research and engineering designs.

WHY WATERSHED DYNAMICS?

TABLE 2
Intended Learning Outcomes

Skills: Students will gain the ability to
<ul style="list-style-type: none"> ▶ Conduct scientific research, starting with well-defined protocols and progressing to open-ended research projects ▶ Define a research question related to watershed science, then plan and carry out a study to address this question using protocols, field investigations, or other types of studies ▶ Work collaboratively to design experiments and devices, interpret results, and critically analyze ideas and conclusions ▶ Engage in engineering design: plan, construct, and test a device; assess its cost; and then present and critique the results with fellow students ▶ Analyze data and draw conclusions about watershed processes ▶ Write a concise and accurate summary of methods, results, and conclusions ▶ Engage in peer review to exchange constructive criticism of fellow students' data analyses, interpretations, and conclusions ▶ Use commentary from fellow students to revise or justify research reports and presentations
Concepts: Students will gain the understanding that
<ul style="list-style-type: none"> ▶ Watershed dynamics concerns the study and management of the complex interactions among water, land, atmosphere, and the organisms living within the drainage area of a river, stream, or other water body. ▶ The management of watersheds is a complex process that involves communication between people with many different ideas, values, needs, and resources ▶ Watershed science is multidisciplinary, related to societal concerns, and has important impacts on how water is used by humans, plants, animals, and other organisms living in watersheds ▶ Concerned students, citizens, and organizations can play important roles in watershed science and watershed management ▶ Field studies, remote sensing, computer modeling, and laboratory experiments all contribute to our understandings of ecological systems and how they respond to change ▶ Remote sensing and computer modeling provide useful tools for assessing land uses and evaluating the impact of various management practices ▶ Land uses and management practices affect stormwater runoff characteristics such as pH, dissolved oxygen, and nutrient concentrations, and consequently have important effects on streamwater quality and aquatic habitats

WHY WATERSHED DYNAMICS?

- ▶ Scientists and engineers work both individually and collaboratively, reviewing each other's work to provide feedback on experimental design and interpretation of results
- ▶ Scientific understandings are tentative and subject to change with new discoveries. Peer review among scientists helps sort genuine discoveries from incomplete or faulty work
- ▶ Aquatic organisms have species-specific habitat requirements concerning chemical, physical, and biological properties
- ▶ The living and nonliving components of ecosystems change over time and respond to disturbances
- ▶ The diversity and abundance of stream invertebrates can often be used to assess water quality