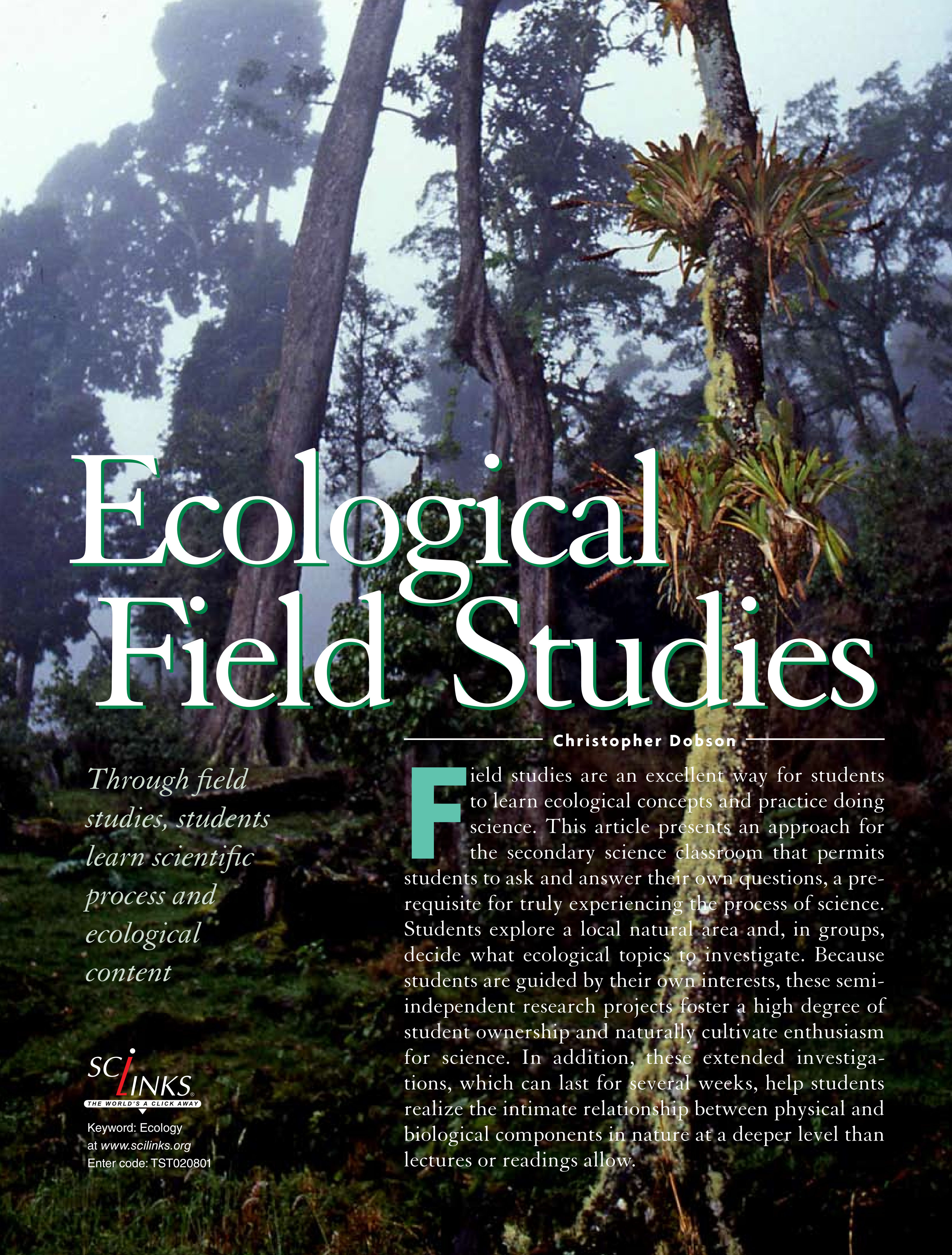

Ecological Field Studies

Christopher Dobson

Through field studies, students learn scientific process and ecological content

Field studies are an excellent way for students to learn ecological concepts and practice doing science. This article presents an approach for the secondary science classroom that permits students to ask and answer their own questions, a prerequisite for truly experiencing the process of science. Students explore a local natural area and, in groups, decide what ecological topics to investigate. Because students are guided by their own interests, these semi-independent research projects foster a high degree of student ownership and naturally cultivate enthusiasm for science. In addition, these extended investigations, which can last for several weeks, help students realize the intimate relationship between physical and biological components in nature at a deeper level than lectures or readings allow.

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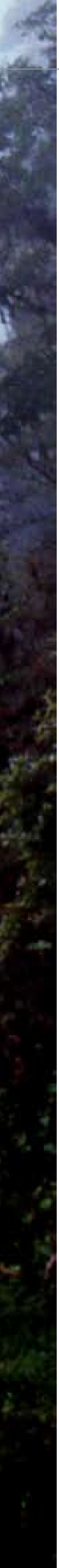

Doing science

At the most basic level, science is about asking and attempting to answer questions. The wonderful thing about field studies is that students learn scientific content and process simultaneously, emulating the practice of actual scientists—a goal of the National Science Education Standards (NRC 1996). When students ask their own questions, ecological investigations can be the ultimate inquiry-based activity with students experiencing the contagious excitement of doing science firsthand.

To better reflect scientific thinking, you can transform students' memorization of the steps of the traditional "scientific method" into a deeper understanding of basic scientific inquiry, emphasizing explanation based on evidence (Figure 1; many students will be familiar with these steps, yet scientists do not use this method directly or in this order, but do, in fact, generally engage in these activities). Science is more than a prescribed sequence of steps; it is a way of knowing about the world, one that can be shared and critically evaluated. Field studies facilitate this conceptual transformation for students by providing an opportunity for them to design a method to answer their questions, modify the questions or procedure as unforeseen difficulties arise, and ultimately present their findings based on the interpretation of data. By doing so, students likely construct a more meaningful understanding of the nature and methods of science than when the teacher provides the guiding questions and research methods.

Getting started

To begin, introduce students to the study area, which could be a portion of the schoolyard that is in a somewhat natural state, and tell them they are going to think scientifically by making observations and asking questions about the organisms they encounter and the environment in which these organisms live. Inform students that eventually they will attempt to answer some of these questions through the collection and analysis of data, but first they must begin with focused observation.

Remind students to take their time as they explore the site in groups of three or four, using all of their senses (except taste) to absorb the sights, sounds, smells, and feel of their surroundings. (**Safety note:** As a precaution, survey the site first for any potentially harmful animals or plants [poison ivy], and remind students to wash their hands.) Ask students to stop occasionally as they walk, to bend down to more closely observe organisms on the ground, or look up to see what is above them. Students should turn over rocks, logs, and other forms of shelter to look for smaller species, being sure to put everything back the way it was. Throughout their exploration, students should record all observations in a notebook or journal. Inspire students to make careful observations by reading select passages from *A Sand County Almanac* by Aldo Leopold (1949), or some other natural history classic, prior to their field experience.

When practicing the focused observation described, it is only natural for student questions to surface: specific observations lead to questions, which are the gateway into scientific inquiry. Encourage students to record all the questions that come to mind, without worrying about how they sound. Have students view this early part of their investigation as a brainstorming session, inviting participation from all group members. Although observations and questions are shared as a group, students should take notes in their individual notebooks.

This initial period of exploration, recording observations and questions, usually takes 60–90 minutes. During this time, rotate from group to group and ask what interesting observations students have made and what questions have piqued their curiosity. Share your own

FIGURE 1

Transforming elements of "the scientific method" into real scientific thinking.

Observations → Questions → Hypotheses → Experiments → Conclusions

The scientific method

Observations → Questions → Investigation → Evidence → Explanation

Basic scientific inquiry

FIGURE 2

Criteria for student presentations.

Introduction	1. What questions did you ask? 2. What led you to ask these questions? 3. Provide information from other sources that is relevant to your investigation.
Methods	1. Provide a clear, concise description of what you did. 2. What data did you collect? 3. How did you collect the data?
Results	1. Summarize and display the data you collected. 2. Use figures (pictures, drawings, graphs) to show data. 3. Use tables (numerical values) to show data. 4. Do not interpret your results (only present what you found).
Conclusion	1. Interpret your results. What do they mean? 2. Explain your results in the context of library and internet research. 3. Did you answer your questions? If not, why? 4. What new questions did your study raise? 5. What would you do differently next time?
References	1. Cite all sources other than your own work (e.g., library books, websites).

related observations and questions in a collegial manner, modeling the collaborative aspect of science. But remember, this is *their* investigation.

Asking and answering questions

At some point during this initial exploration, however, students must begin to carefully consider and refine their questions. Help students do this by asking them how they would answer each question. Although experimentation is one of the hallmarks of science, not all questions in science are answered by conducting formal experiments. Descriptive questions, such as the habitat preferences of a species, can often be answered by making a large number of observations and reaching a conclusion based on the results, which is much like conducting an experiment and is still doing science.

Student questions may come in one of two basic types: descriptive and causal. *Descriptive* questions focus on describing some aspect of nature, while *causal* questions reflect an interest in the reason something occurs, as in cause and effect. For instance, "Where are cattails more abundant, in terrestrial or aquatic habitats?" is a descriptive question. "Why do cattails grow in wetland habitats?" is a causal question. (Many causal questions begin with "why.") Because students are likely to have more success answering descriptive questions, it is prudent to help them practice turning causal questions into descriptive questions. For example, a student once asked me "why" moss only grows on the north side of trees. I responded by asking "if" moss only grows on the north side of trees. This was the beginning of a wonderfully simple investigation in which her group learned, through data collection and analysis, that moss grows more often, but certainly not exclusively, on the north side of trees in the Northern Hemisphere.

An extension could have students generate "why" questions that they answer through additional research. For example, students could investigate whether it is the lack of sufficient water on the sun-facing south side of trees that inhibits moss growth there. Like all good research questions, answering one question often leads to new questions and investigations: "Does moss grow equally well on all sides of the tree trunk in deep forests, where light does not penetrate well?" or "Does moss grow on the same side of trees in the Northern and Southern Hemispheres?"

Implementation of field studies is relatively easy and adaptable, depending on specific needs. I allow each small-group to decide what questions they are going to investigate. However, groups could be formed in the classroom based on common interests, following the initial exploration period. The questions a group investigates should be related, involving a common theme. For example:

- Does moss only grow on the north side of trees?
- Is moss more abundant on the north side of trees? or
- What conditions differ between the north and south sides of trees?

After the initial exploratory period, I have students write a proposal that contains their questions, how they plan to answer them (including equipment needs), and their expected results. This exercise clarifies student thought and allows me to help them modify their questions and methods. Actual data collection can occur any time after this and as often as permitted.

Studying interactions

As a science, ecology specifically involves the study of organisms, such as moss, and those organisms' interactions with the environment. An organism's environment includes biotic factors, such as other organisms and the resulting interactions (e.g., competition, predation). These interactions can occur among members of the same species or between members of different species. An organism's environment also includes abiotic factors, such as light, temperature, or dissolved oxygen. A complex interaction of all these factors determines the distribution and abundance of organisms. It is exactly this understanding that students begin to develop by conducting extended ecological investigations.

For example, suppose a group of students investigated whether ferns grow more abundantly on north- or south-facing slopes. Like moss, ferns prefer north-facing aspects, as they are typically cooler and wetter than south-facing ones. Some of my students discovered this ecological interaction between biological and physical factors independently, through their own data collection and analysis. Predicting that a reduction in the duration and intensity of sunlight on north-facing slopes would favor fern growth, students counted ferns on several slopes with north- and south-facing aspects. They found significantly more ferns on north-facing slopes. Students came to experience, firsthand, the excitement of detecting and understanding a pattern in nature that is repeatable and found elsewhere. Students felt, possibly for the first time, the satisfaction of having conducted a self-designed investigation to answer their own questions, generated from initial observations.

The questions that drive these investigations can be simple and yet produce rich research experiences for students. Consider the following examples, all of which explore the interaction between physical and biological components in an ecosystem:

- Do insects move more quickly on warmer days?
- Where in the school yard are pillbugs most numerous?
- How does soil pH near pine trees differ from soil pH by other trees?
- Are frogs in a pond submerged more frequently on rainy and windy days than on sunny and calm days?

Presenting and assessing results

No scientific investigation is complete until an explanation of the results is offered to one's peers, again emulating the actual practice of scientists. Students can conclude their study with a group presentation of their findings presented in a written report, a poster, PowerPoint, or even a guided field walk (taking the audience to the study site). This last option can be particularly enjoyable as students become excited to actually show their audience what they did and what they found.

Regardless of the medium for presentation, a general outline of criteria to include in every presentation should be provided to students (Figure 2). I use these criteria to assess students. My focus is on how well students can conduct an independent investigation, ask and answer ecological questions, and explain their findings. Following each presentation, groups should open the floor to questions. With little prompting, students in the audience tend to ask relatively sophisticated questions, having conducted their own different ecological investigations.

Guiding discovery

Teachers often express concern about not knowing the answers to student questions that may arise. One of the benefits of conducting ecological investigations is that, as the teacher, I do not have to know all the answers. (**Editor's note:** This is a major aspect of inquiry and of the nature-study movement itself. See the lead article by William McComas on p. 24 of this issue.) My job is to guide students in their question asking, experimental design, and interpretation of results. I usually know a little about whatever topic a group is investigating, but I am certainly no expert. My role is simply to help students decide what information is relevant to their study so they may look for it in the library or on the internet.

Remind students that the emphasis of their investigation should be on answering ecological questions based on data that they actually collect. Information obtained from other sources may prove useful, however, in the introduction section of their report, providing a background for their investigation, or in their conclusion by putting their results in the context of what is already known about their topic.

Field studies are an effective and engaging strategy for combining the learning of content with scientific process. By actually doing science to learn science, students experience the excitement of discovery in answering their own questions and they come to realize an unanticipated outcome of scientific investigations—the investigations often lead to more questions than they actually answer. I do not want to tell my students about this aspect of science; I want them to discover it for themselves. ■

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