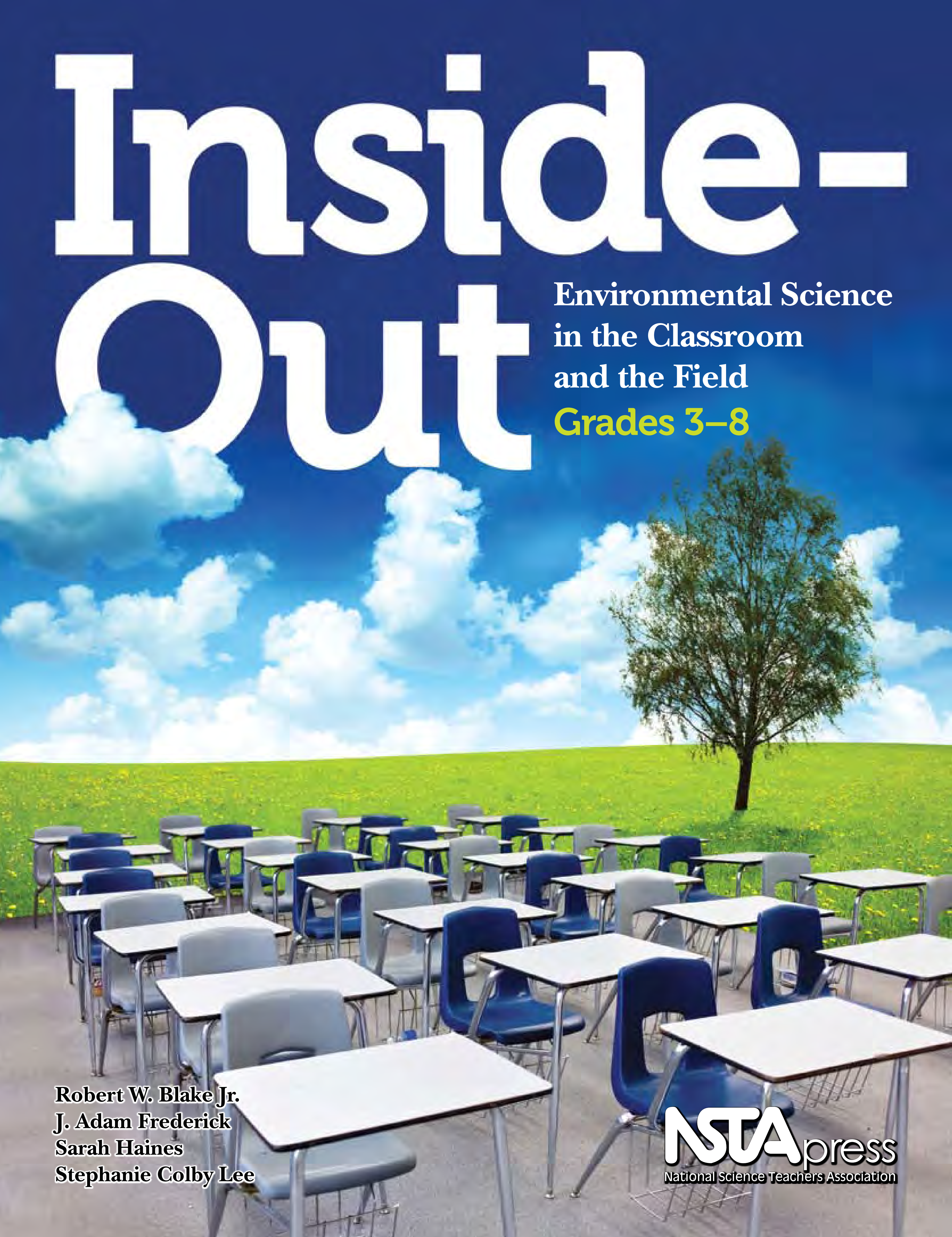

Inside-Out

Environmental Science in the Classroom and the Field

Grades 3–8

Robert W. Blake Jr.
J. Adam Frederick
Sarah Haines
Stephanie Colby Lee

NSTA press
National Science Teachers Association

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Dedication

To our parents

Dr. Robert W. and Carol Blake
Dr. A. Bruce and Norma N. Frederick
Bonnie and Gary Rogers
Margaret and Charles P. Colby Jr.

For providing our childhood with opportunities and
the freedom to explore the outdoors

Acknowledgments

The impetus for this project was a 2002 Eisenhower Grant, and the book idea was launched after NSTA's national conference in Philadelphia in 2003. We realized then that our emphasis on increased content knowledge, combined with a passion for outdoor learning, was a key to both teacher and student engagement in high-quality, meaningful learning experiences in environmental science. Our combined 60 years of science teaching experience at all levels of the professional continuum convinced us that what we had to say was significant and timely. However, to dare say that what we present here is all our own is against our fundamental belief that "the reason we can see for miles is because we stand on the shoulders of giants." Without such giants, or those that came before, the task of writing this book would have been close to impossible. Thus, in our attempt to acknowledge those we can readily remember, we will also most likely fail to mention many more who have shaped our thinking and practice along the way.

We first would like to thank those granting agencies that believed in our ideas as we engage teachers and students in field-based learning. These include the U.S. Department of Education with the Maryland Higher Education Commission (Eisenhower Grant program, award number E01-21-113), the National Oceanic and Atmospheric Administration (NOAA, award number NA03NMF4570216)[1], the American Forest Foundation (AFF) and Project Learning Tree (PLT), and the Chesapeake Bay Trust. Without these critical funds we would not have been able to pursue our passion.

[1] Award number NA03NMF4570216 from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

Acknowledgments

As you read this book, you will also find resources from a wide array of agencies and organizations related to science education. As we explain in the introduction, web-based resources are almost endless, thus it is difficult to acknowledge all that have affected our work. Having said this, and although many web-based materials are of public domain, we still would like to thank specific groups that gave us permission to use their materials. These include the Maryland Department of Natural Resources, the Virginia Save Our Streams Program, the United States Geological Service, the University of Rhode Island, the Maryland Sea Grant College program, the Chesapeake Bay Program, the National Oceanic and Atmospheric Administration, Environmental Concern, the Laboratory for Atmospheric and Space Physics, the University of Colorado, and BioWorld Products LLC (Visalia, CA).

Next, we would like to thank those in the peer review process, all of whom contributed significant time and effort to provide well-constructed feedback and suggestions for revisions. Although we did not agree with all comments about changes to the text, this process did shape the final format, and we greatly value the practice and acknowledge that the book is better for it. We also wish to thank the editors for supporting our belief that content knowledge is a prerequisite to meaningful learning. While we realize that "knowing" does not guarantee high-quality teaching, content understanding does provide confidence in creating varied learning experiences for children.

Laboratory experiences that are directly linked to field-based inquiry are essential for the overall learning process in science. We thank Jeff Morgen, the former science education specialist at the SciTech education program of the Center of Marine Biotechnology (COMB), located in Baltimore, Maryland, for providing such experiences. Without Jeff's leadership and "can do" attitude we would not have been able to provide laboratory and field-based learning for elementary teachers, interns, and students.

We also would like to acknowledge additional contributors to this book. We thank Debbie Freels, Mark Herzog, Steve Lev, Pam Lottero-Perdue, and Christine Wolfe for their help.

A big thank-you must go to Carminantonio and Bruna Iannaccone for providing an essential respite and excellent food that can only be found at the Piedigrotta Bakery in Baltimore, Maryland.

We are greatly indebted to Patricia Freedman for her editorial skills. Her dogged tenacity and exceptional humor, as well as her tolerance of our numerous inane mistakes and simple decency for not bringing attention to our own shortcomings, made this monotonous process tolerable.

Finally, we thank our families for their understanding and contributions to this task. Specifically, we thank Dr. Robert W. Blake, Sr., and Dr. A. Bruce Frederick for their input and editorial skills. We thank our wives, Jennifer Blake and Lisa Frederick, and our husbands, Tom Haines and John Lee, for unwavering support. We thank our children—MacKenzie Blake; Christopher, David, and Elaina Frederick; and Andrew and Adam Haines—for their continued interest in spontaneous field-experiences that persist to remind us of the importance of these learning experiences.

Safety Practices

Safety Out-of-Doors Practices

1. Teachers should always visit out-of-doors areas to review potential safety hazards prior to students' carrying out activities.
2. Keep clear of out-of-doors areas that may have been treated with pesticides, fungicides, and other hazardous chemicals.
3. When working out-of-doors, students should use appropriate personal protective equipment (PPE), including safety glasses or goggles (when working with hazardous chemicals), gloves, close-toed shoes, hat, long-sleeve shirt and pants, sunglasses, and sunscreen protection. When working near deep water, use life preservers or other floatation devices.
4. Caution students relative to poisonous plants (ivy, sumac, etc.), insects (bees, wasps, ticks, mosquitoes, etc.), and hazardous debris (broken glass, other sharps, etc.).
5. Caution students about trip and fall hazards such as rocks, string or rope, and so on when walking out-of-doors.
6. Teachers need to inform parents in writing of on-site field trips relative to potential hazards and safety precautions being taken.
7. Teachers need to check with the school nurse about student medical issues such as allergies, asthma, and so on. Be prepared for medical emergencies.
8. Teachers need to have a form of communication available, such as a cell phone or two-way radio, in case of emergency.
9. Wash hands with soap and water after doing activities dealing with hazardous chemicals, soil, biologicals (insects, leaves, etc.), or other materials, as well as after returning to the classroom from out-of-doors activities.

10. Contact the main office before bringing classes out of the building for activities.

Safety in the Classroom Practices

1. When working with glassware, metersticks, hazardous chemicals (including soil testing kits), and so on, students should use appropriate personal protective equipment (PPE), including indirectly vented chemical splash goggles, gloves, and aprons.
2. Always review Material Safety Data Sheets (MSDS) with students relative to safety precautions in working with hazardous chemicals.
3. When dealing with hazardous chemicals, an eyewash station is required should a splash accident in the eyes occur.
4. When heating liquids, use only heat-resistant glassware (Pyrex- or Kimax-type equipment).
5. When heating liquids on electrical equipment such as hot plates, use ground fault protected circuits, or GFI.
6. Always remind students of heat and burn hazards when working with heat sources such as hot plates and light bulbs.
7. Wash hands with soap and water after doing activities dealing with hazardous chemicals, soil, biologicals (insects, leaves, etc.), or other materials.

Introduction

My grandmother, Mary E. E. Kready, took to the field early in the morning just outside of West Chester Normal School (est. 1871) in the spring of 1924. This was a favorite activity of the 18-year-old undergraduate student, not because she needed samples of plant material for her field botany class but—very simply—because she loved it. The serenity, peacefulness, and sense-provoking environment are what she longed for. Nothing was required but her sense of wonder, her sense of place. Surrounded by the inspiration of towering oaks and peeking bloodroot, Mary was at home. Probably very little interference entered her world once in the wooded realm. On this particular day she was searching for elusive ginger to add to her collection. Although it was nearly invisible to the passerby, Mary found the ginger and added it to her field bag with no doubt a great sense of triumph, then continued on her trek.

As I sift through my grandmother's herbarium paper samples, so cleanly preserved and so neatly pressed,

Bloodroot, a sure sign of spring

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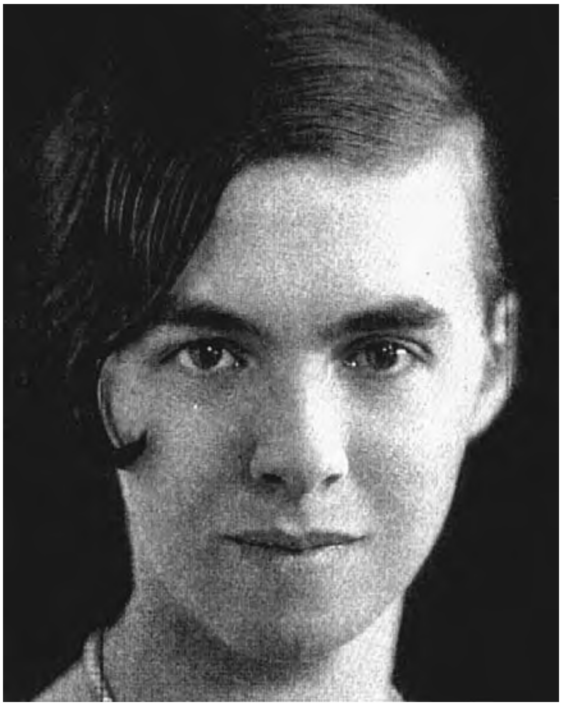
it gives me great pause and the realization that we must carry stories like this forward to better our teaching and learning of science in our schools and to develop educators with a thirst to walk as Mary did.

J. Adam Frederick, May 2008

Why This Book and Why This Way?

Why an Emphasis on Content?

Children love the outdoors and have many questions pertaining to their natural surroundings, but all too often in elementary and middle schools either students learn very little science in the classroom or the time is usually spent on textbook and direct classroom instruction (NRC Committee on Science Learning, Kindergarten Through Eighth Grade 2007). As an elementary teacher you are a generalist, expected to know a lot about many topics and to teach many subjects. Unfortunately, when it comes time to teach students science, many of you probably feel unprepared in both content understanding and your ability to provide students with meaningful experiences in science and to actively engage them within the learning process. The lack of content understanding and the ability to know how to apply this knowledge in learning can be an impediment to you and your ability to integrate content with activities. Our fundamental aim for this book, therefore, is to enhance your understanding of basic environmental science concepts and to instill confidence in your ability to engage students in the process of science and learning experiences both inside and outside your classroom.



A 1924 yearbook photograph of Mary E. E. Kready at West Chester Normal School

Why the Elementary Level?

Our use of the term *teacher* is inclusive of both inservice and preservice educators in the elementary and middle school classrooms. Within the concept of *lifelong learner* the National Science Foundation (NSF) coined the term *Teacher Professional Continuum* (TPC); the purpose of the TPC program is to "improve the quality and coherence of teacher learning experiences across the continuum" (NSF 2006). In the current education environment we hear of a need for better STEM (science, technology, engineering, and mathematics) experiences for students and a need for better teachers of STEM subjects. Much of the emphasis on improving STEM education and educators is at the undergraduate and high school levels and on the preparation of those going into STEM professions. Unfortunately, this discussion does not include much talk about the need for better science teaching at the elementary grades and, most important, the need for enhancing a scientific worldview, a viewpoint that is important for the intellectual capabilities of all people in all walks of life. If we truly believe in a continuum, then helping you, the elementary teacher, learn science content and then use the content to engage students in meaningful and active learning experiences will provide a critical foundation for an overall STEM initiative.

Why Field-Based Learning?

Research and Field-Based Learning

The National Science Education Standards (NRC 1996, p. 13) encourage teachers to help students "experience the richness and excitement of knowing about and understanding the natural world" and "use appropriate scientific processes and principles in making personal decisions." From a research perspective there are a variety of studies indicating that taking students outside to study and understand the natural world is beneficial to their learning. For example, Hungerford and Volk (1990) demonstrated that exposing students to environmental investigations resulted in positive changes in behavior toward the environment. Research by Lieberman and Hoody (1998) and others (Bartosh 2003; Falco 2004; NEETF 2000; SEER 2000) suggests that using the environment as an integrating context for learning (the EIC Model) leads to a host of positive outcomes for students and teachers, including greater academic achievement in reading, mathematics, science, and social studies; increased motivation to learn; and decreased disciplinary issues.

Duffin, Powers, Tremblay, and PEER Associates (2004) reported that the more students are exposed to the EIC approach, the greater their attachment to a sense-of-place ("a special collection of qualities and characteristics, visual, cultural and environmental that provides meaning to location"; Project Learning Tree 2006, p. 25), involvement in environmental stewardship, actual time spent outside, and degree of civic engagement. Additional studies indicate that constructing and maintaining schoolyard gardens is an excellent means for increasing student science achievement scores ("Youth in Horticulture" 2005). For those students diagnosed with attention deficit/hyperactivity disorder, Taylor and Kuo (2009) suggested that simply providing walks in a natural setting increases attentiveness of this particular group of students.

Finally, Louv (2005), in his book *Last Child in the Woods*, coined the term *nature deficit disorder*. Louv described a trend in today's society in which children are not spending significant amounts of time outdoors being exposed to nature. He claimed that there are complex reasons for this phenomenon, which can lead to a host of academic and health-related problems for our youth. Perhaps partially in response to the attention garnered by *Last Child in the Woods* and the groundswell of public opinion that has resulted from it, the U.S. House of Representatives voted on and passed H.R. 3036, the No Child Left Inside Act of 2008 (September 18, 2008). Of the eight main objectives of the bill, four link directly to the purposes of our book:

- To "create opportunities for enhanced and ongoing professional development" in environmental science
- To ensure that environmental education programs are aligned with national, state, and local content standards, to promote "interdisciplinary courses that include strong field components"
- To "bring teachers into contact with working environmental professionals"
- To "establish programs to prepare teachers to provide environmental

education professional development to their colleagues and programs to promote outdoor education activities as part of the regular school curriculum" (H.R. 3036—110th Congress 2007)

An Elementary School Principal and Field-Based Learning

Taking all of these reports and studies into consideration, we believe that Debbie Freels, a former elementary school principal, says it best:

> *As an elementary school principal, I cannot recall hearing about any student not wanting to go outside for an activity! Students yearned for the opportunity to be outdoors during the school day. By providing instruction through project-based teaching and learning, teachers were able to integrate cross-curricular objectives in science-oriented projects.*
>
> *I remember conducting formal observations of a teacher teaching a measurement lesson in the field behind the school and of another teacher who taught a writing lesson on descriptive words as students gazed at the changing leaves on the trees on a fall day. Students and teachers alike were energized by being able to extend instruction beyond the walls of the school. Teachers and parents both found that when students were provided with instruction that addressed*

Dr. Robert Blake and preservice teachers exploring a stream on the Towson University campus

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cross-curriculum content within a science theme and the outdoors was utilized as a classroom, student interest, enthusiasm, and engagement increased as students saw connections between their classroom and the real world. In addition, most students experienced greater academic achievement and understood the importance of environmental stewardship and giving back to the community. I truly believe that these experiences will help to shape future citizens who not only care about the environment, but actively participate in preserving it. (e-mail to Robert Blake, October 22, 2009)

A Practical Reason for Field-Based Learning

Although we often hear from teachers that there "isn't time," "it's not in my curriculum," or "it's not within my structural obligation," it is quite clear from the perspective of both researchers and administrators" that integrated outdoor learning for teachers and students has many benefits, both academic and emotional. In addition, going outside—while rarely an educational objective—is just plain fun, and having fun is one way to increase motivation. Increased motivation leads to greater student and teacher involvement and creates ownership of activities and projects. As Debbie Freels implies, these experiences can be active, integrated, contextualized, and meaningful, allowing both you and your students to move beyond the classroom walls and investigate ideas outside.

Why So Many Web Resources?

As teachers we value the almost unlimited amount of resources available on the World Wide Web, yet we have also struggled with finding pertinent and useful information within a relatively short period of time. We have spent years searching for material that is useful, trustworthy, and relevant for our own teaching. Recently a colleague received the following e-mail from a 30-year veteran of marine education at Oregon Sea Grant who was openly frustrated at not locating curricular information on the web about climate change:

What was causing my frustration, was that I was searching the web using the search words "climate change curriculum... and climate change teaching activities" and finding not much of anything.... Wrong headed. When entered NOAA education, EPA education, NASA education, NANOOS, and MBARI also has an education section with climate change..... a whole new world has opened up. Lots of stuff. One of the sites directed me to NSTA "NSTA Sci Links" which has reviewed science teaching materials and links to what they consider the best. There was also climate change listed there as well. (Vicki Osis, marine educator [retired], Hatfield Marine Science Center, Oregon State University, September 15, 2009)

This is just one example of how difficult it can be to find relevant web-based material quickly, and it shows that although web material may be "easily accessible," it is not always a simple matter of using what you find.

The web resources presented here are a culmination of literally years of searching the web for useful information in environmental science. We know that these resources do not represent everything that is available, but they do represent the best that we have found so far. Certainly more web resources will become available, and some will disappear. We encourage you to continue to "surf the web" looking for useful information for your teaching. However, if time is of the essence, what we provide here will get you started.

Introduction

Concerns Over Regionalism

Our activities focus on the context of our geographic region, with an emphasis on the Chesapeake Bay and its associated watersheds. Providing students who live in the Chesapeake Bay watershed with a "meaningful watershed experience" is a stated goal of the Chesapeake 2000 agreement (Chesapeake Bay Program 2000) and has become a priority for the Maryland State Department of Education. However, the information and activities that we present can be applied to any local ecosystem in different states and different watersheds around the country. For example, if we lived in western New York or western Pennsylvania our watershed focus could be one of the Great Lakes (Lake Erie or Lake Ontario). If we lived in the Seattle, Washington, area we could study Puget Sound. The goals of environmental education and preservation are similar regardless of locale, and the activities in this book are generic enough to apply across various locations and scales.

Why the Environment and Why the Field?

As science educators our purpose with this book is to engage you, teachers of elementary and middle school students, in field-based activities that integrate the scientific disciplines inherent in the study of the environment (Earth science, chemistry, physical geography, and life science). An essential part of this multidisciplinary approach is to better understand the intertwined relationship between the abiotic and biotic factors within an ecosystem and how this can be communicated more clearly. We want you to move your students out of the classroom and into the field to study the natural and physical world through direct observation and inquiry. We also want to help you become comfortable with conducting laboratory and classroom activities that complement and inform field-based learning. Ultimately, it is what you do with your students that will have the greatest impact on them as lifelong learners.

Organization of the Book

Why This Way?

Over the years our work as science educators in preservice teacher preparation and inservice professional development has allowed us to conduct numerous workshops and fieldwork related to the study of the environment. The material in this book represents our current best synthesis of the science content and classroom-tested activities and presents them in an order that we deem useful for teachers. Most of the experiences presented here are based on our work in Professional Development Schools[1], which includes continuous faculty development and preservice teacher preparation.

We want to emphasize the different nature of our presentation. We focus on the content for the simple reason that we believe that content understanding is essential for good teaching. While simply "knowing" does not ensure high-quality teaching, knowing about what you teach is certainly better than not knowing. We also want to emphasize that this is not a curriculum guide or a unit to be followed in a linear sequence. Although we like the sequence, each chapter can stand alone, with you the teacher deciding on what to read, what to use, and in

[1] "A Professional Development School (PDS) is a collaboratively planned and implemented partnership for the academic and clinical preparation of interns and the continuous professional development of both school system and institution of higher education (IHE) faculty. The focus of the PDS partnership is improved student performance through research-based teaching and learning." (Maryland State Department of Education 2007)

Introduction

what order. We strongly believe in your professionalism and your quest for continuing to better your teaching and the experiences that you provide for your students. We provide but one model and one pathway of how to engage teachers and students in field- and laboratory-based activities that promote inquiry and project-based learning. Ultimately, it is you who will make the decisions of what to use as you seek to engage your students in meaningful learning.

Teachers using sieves to study the composition of the sediment in a stream bed

Chapter Organization

In Chapters 1–7, we will first discuss and display the content material of each chapter title and then present activities that engage students in learning and applying the content knowledge. Activities are mainly field based but do include a number of classroom-based laboratory-type settings. Each activity follows a generalized format to promote student inquiry. This format includes

- at least one driving question for each activity, to provide the initial engagement for the students and open the potential for inquiry;
- a list of materials needed for the activity (including resources on how to make or find the materials);
- the procedure for each activity; and
- a "Think About" section with open-ended questions that link directly to the driving question(s) and promote further student inquiry.

Chapter 1 focuses on the topic of topography. We begin with map interpretation and then apply our understanding of the topic to the form and structure of the landscape through the use of topographic maps.

In Chapter 2 we describe concepts related to physical geography. We explore the physical geography of a local area within the context of the natural resources, biomes, and habitats found in that area. We also integrate into this chapter the concept of a watershed, with an emphasis on the interaction between living and nonliving things as teachers and students investigate their surroundings.

In Chapter 3 we turn our attention to water, an essential ingredient for life. The physical and chemical properties of water are discussed, as well as how these properties are important for sustaining biological organisms.

The focus of Chapter 4 is soil, and specifically the relationship between soil conditions and local flora. Students learn that an examination of the soil can tell much about the area under investigation and which plants (and therefore animal life) are likely to be found there.

In Chapter 5 we discuss energy and nutrients. We begin with the topic of light energy and the importance this has as the primary source of energy for biological organisms. Then we deal with essential nutrients and the role each has in sustaining life. The main idea here is to link an understanding of essential nutrients to the nutrient loading of an aquatic system and the negative impact that overloading can potentially have on a system.

Chapter 6 focuses on biodiversity, specifically the study of living organisms found within a terrestrial habitat such as a forest and an aquatic habitat such as a stream. By combining a study of the biotic nature of a system with the chemical analyses (abiotic) done in Chapter 5, a clearer picture of the health of a system is gained.

Our theme in Chapter 7 is action projects. Here we provide examples of teacher-constructed units and classroom-tested activities designed within the contexts of the content areas presented earlier. Our goal is to showcase actual teacher and student projects that have used field-based learning experiences and action projects.

Chapter 8, "Reflections on Implementation," provides vignettes from those involved in the implementation of active science learning. These real stories provide insight into the successes and challenges of engaging students in individual classrooms as well as entire schools in inquiry, project, and field-based learning experiences.

Finally, as science educators, we understand how difficult it is to feel that you always have to "reinvent the wheel" or design completely new and unique learning activities for your students. Through our partnerships over the years we have found a wealth of resources that are immediately accessible and usable to all of us. In fact, the U.S. Environmental Protection Agency, in its "Tips for Developing Successful Grant Applications," notes that there are many excellent existing materials on environmental education and recommends using these materials rather than new curricula (U.S. EPA 2009). We encourage you to collaborate with colleagues and form partnerships with outside agencies that enable you to spend more time in the planning and construction of materials that are engaging and contextualized, so students can have more direct experiences with learning in the field.

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Students and teachers at Piney Ridge Elementary School in Sykesville, MD, working on a wetland restoration project on school grounds

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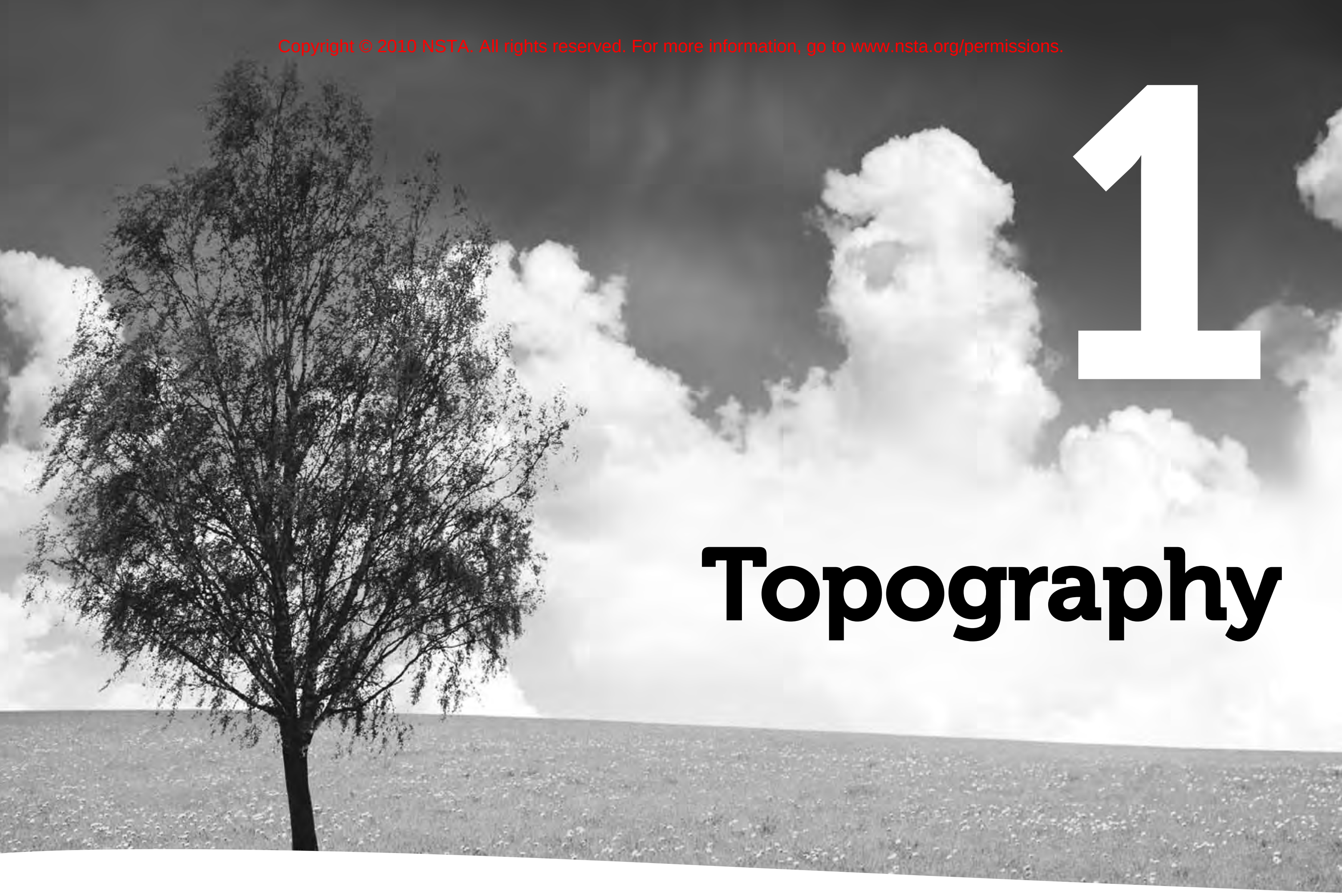
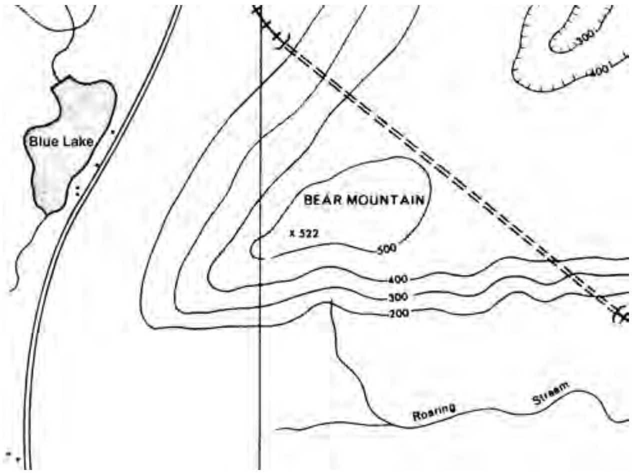


1

Topography

How do we start the process of learning about our environment? One way is to begin observing and recording what we see in the environment to develop both a mental model and concrete map of the world around us. Having students go outside to their school campus, town park, or local recreation area is a way to accomplish this process. Students will develop observational skills and increase awareness as they begin to see what they pass by daily or did not notice before; this process opens up their minds to inquiry and an interest in their environment, whether it be rural, suburban, or inner city. Discovering their own "backyard" and how to develop mapping skills will assist in the process of learning their connection to the environment.



Map courtesy of Hubbard Division of American Educational Products, LLC

1 Topography

A Content Primer

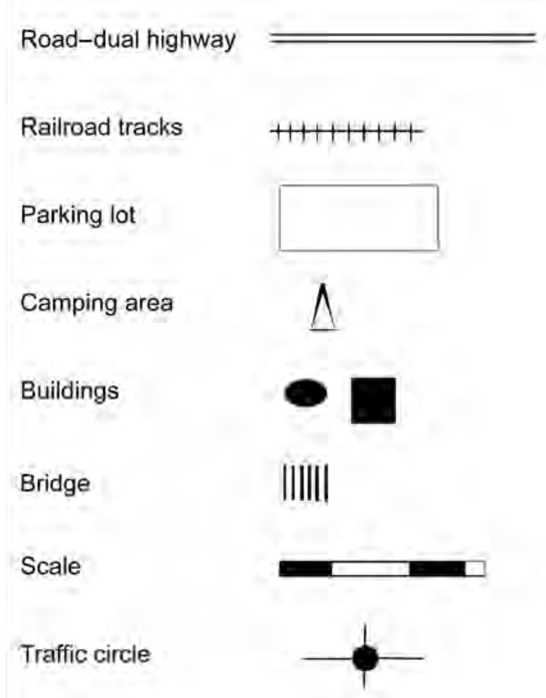
This chapter introduces the topic of topography, including map use and interpretation, and then provides activities to help students apply their understanding of the topic to the form and structure of the actual landscape.

Definition

Topography is defined in *Merriam-Webster's Collegiate Dictionary, Eleventh Edition*, as "the configuration of a surface including its relief and the position of its natural and man-made features." *Topography*, therefore, refers to the relief of the land—for example, a steep versus a gentle hill—which can be represented by contour lines (lines of equal elevation) on a map. Such maps are called topographic maps.

A western river valley as photographed from approximately 30,000 feet

FIGURE 1.1
Examples of Map Symbols



An Introduction to Maps

Interpreting maps is an excellent way to engage students in learning as they compare a model of their world (the map) to the real-life features found outside. Introducing children to maps need not be an arduous task, and students can begin the process of map interpretation by using local street maps and a simple map key (see example in Figure 1.1). During such an exploration we often hear students exclaiming "This is where I live!" or identifying other landmarks within the surrounding area.

Topic: Topographic Maps
Go to: *www.scilinks.org*
Code: IO001

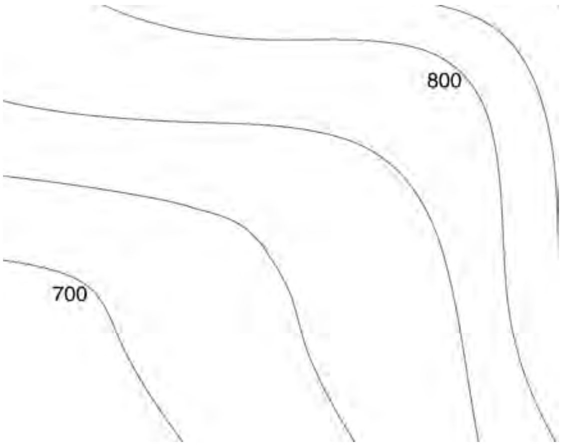
Topic: Mapping
Go to: *www.scilinks.org*
Code: IO002

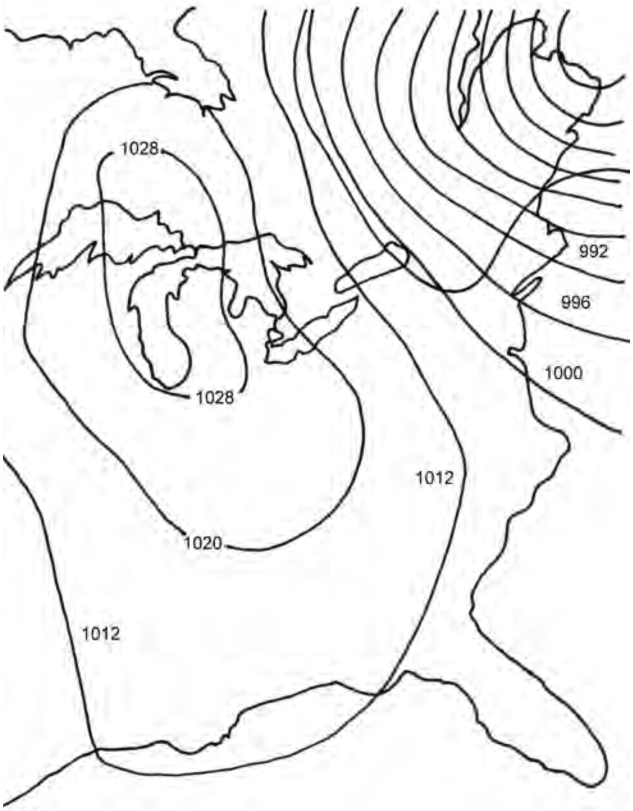
Integrating map interpretation with technology is now easy to do. Using Google Earth 5 (*http://earth.google.com*) you can "visit" almost any location to view the landscape and identify actual landscape features, such as roads, rivers, streams with and without cover, housing developments, and agricultural areas. Now you and your students can see the direct relationship between map symbols and actual features.

Using Topographic Maps

We begin with topographic maps, used to discern the contour of the Earth's surface and useful for environmental studies, because they reveal a number of natural and human features that students will encounter in their studies. These maps provide a good framework for helping students build an understanding of the concept of a watershed (see Chapter 2). Topographic maps, also referred to as *contour maps,* are distinguishable

FIGURE 1.2
A Comparison of Contour Lines (Values in Meters [m]) and Isobar Lines (Values in Millibars [mbars])



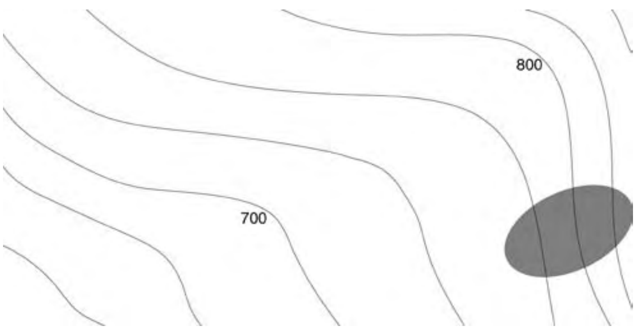


from street maps by the use of contour lines that represent changes in elevation. Similar to isobars of a weather map, which connect points of equal air pressure, contour lines connect points of equal elevation (see Figure 1.2). Thus, any point on a single contour line has the same elevation.

When looking at a contour map we also notice the distance between the lines. This distance represents how steep or gentle the landform is: The closer the lines, the steeper the land; the further apart, the gentler (Figure 1.3). The shaded area represents the steepest section between contours 700 and 800 meters.

Figure 1.4 (p. 4) is a simple model that shows how a contour map compares with the actual topography of the landform. In this example notice the steep hill on the left side of each diagram. The topographic map represents this steepness by the proximity of its lines: the closer the lines, the steeper the hill. Figure 1.4, part A, is part of an actual map and shows numerous landforms relative to the contour lines, especially steepness, and direction of stream flow into a

FIGURE 1.3
Contour Map With Shaded Area Representing Steepest Section of Landform



Topic: Weather Maps
Go to: *www.scilinks.org*
Code: IO003

Topic: Mapmaking
Go to: *www.scilinks.org*
Code: IO004

valley. Part B of Figure 1.4 illustrates a side view of the hill sloping toward the valley.

We introduce the concept of *slope,* or *gradient,* here because understanding the slope of the Earth's surface will allow you to predict the location of streams. For example, a local low point in elevation does not indicate stream location, but a local low point in elevation between two adjacent hills with the contours forming a V/U shape in an uphill direction indicates a preferred path for storm water runoff or a flowing stream (see part A of Figure 1.4). Using a topographic map to determine slope will allow you to determine likely stream locations. Stream study is a key element of outdoor exploration for students of this age.

Figure 1.5 is a contour map to be used in performing a sample calculation for gradient.

FIGURE 1.4
Model of a Hill on a Contour Map

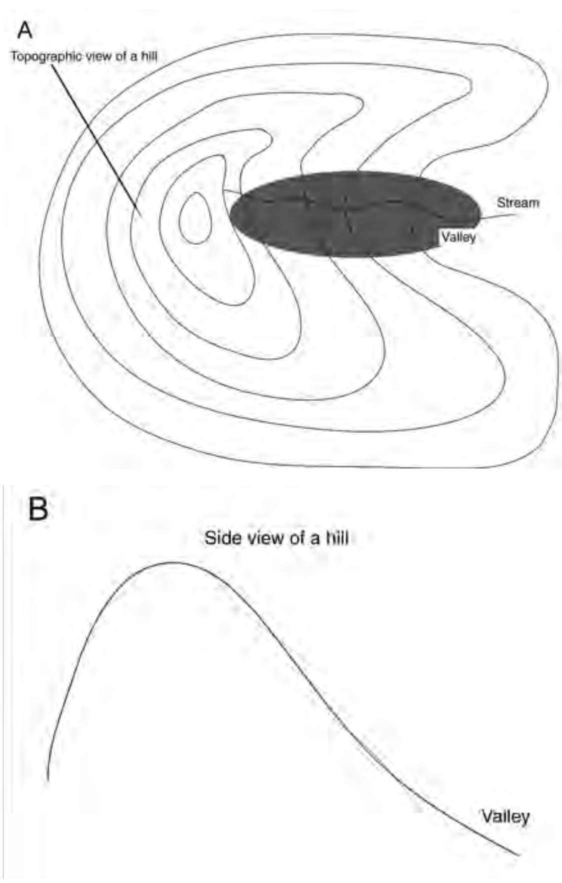
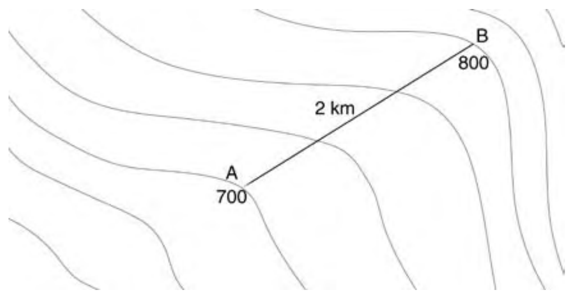


FIGURE 1.5
Contour Map for Sample Calculation of Gradient



Formula and Sample Calculation for Gradient

Gradient is defined as the rate of change in the field value. Field value on a contour map is *elevation*. In other words, the gradient is the amount of change in elevation over a certain distance.

$$\text{Gradient} = \frac{\text{change in elevation}}{\text{distance}}$$

To calculate the gradient for Figure 1.5, first use a ruler to draw a straight line between points A and B. Record all values directly on your map. Record all elevations and distances and be sure to use proper units.

$$\text{Gradient} = \frac{800 \text{ m} - 700 \text{ m}}{2 \text{ km}}$$

$$\text{Gradient} = \frac{100 \text{ m}}{2 \text{ km}}$$

$$\text{Gradient} = 50 \text{ m/km}$$

Topography Activities 1

Activity 1. Geographic "Flights": An Exploration

Taking a trip to almost any location to view the landscape is now possible with the click of a mouse and the Google Earth 5 application. The mapped areas from this application make it easy to recognize roads, rivers, streams with and without cover, housing developments, agricultural areas, and so on. Try a few trips with the whole class to locations that are familiar to students and to places they would like to visit. Predicting what the landscape will look like prior to taking a "flight" can be a valuable exercise before students map their own backyard and will increase student awareness of the major features to consider in mapping.

Google Earth screen capture

Driving Question

What becomes familiar as we view our location from above?

Materials

- Google Earth 5 *(http://earth.google.com)*
- Computer and digital projector (helpful for displaying program to all students)
- Paper, pens, pencils, markers, rulers, and other illustrating tools for mapmaking

Procedure

Give students the following instructions:

1. Map a favorite place using Google Earth by using the "Fly To" search box in the upper-left corner of the window.
2. Once you arrive at the location use the zoom tool to move closer to or farther from the target. Note the various formations, colors, vegetation, water resources, buildings, and other features. Make a drawing using your best interpretation of what you see on the map and develop some symbols for what you see.
3. Now try this by flying to your school grounds. Draw a representation of what you see and then go outside the classroom and map the school campus and see if you can locate the features from the Google Earth map.

The maps that students draw will most likely vary from the overhead map because now they have a ground-level view of the location and will be able to see objects in greater detail within the immediate environment. The basic symbols shown in Figure 1.1 can be used as a guide for mapmaking, and students can make their own symbols to represent the features on their maps.

Think About

1. How does what you saw while "flying" compare with what you thought was actually on the ground?"
2. In what ways does "flying" help you identify landscapes?

Activity 2. Modeling a Contour Map

A simple means of constructing a model of a mountain is to use wooden ellipses of decreasing size and have students stack them from largest to smallest (like the ring-stacking activity that most young children have in their toy boxes) (Figure 1.6).

FIGURE 1.6
Wooden Model Used to Represent Change in Elevation of a Hill

Driving Question

How can we model contour lines using wooden ellipses?

Materials

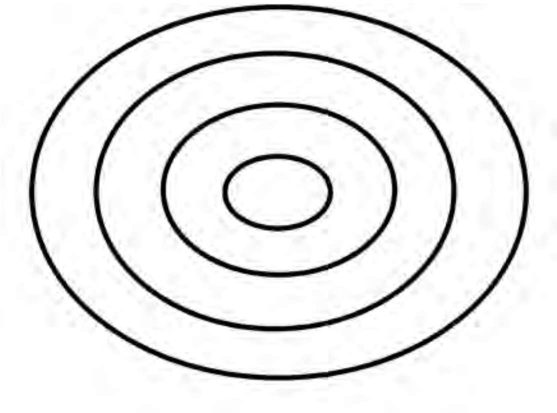
- Wooden ellipses of different sizes; circles can also work. (These shapes are cut beforehand.)
- Diagram of topographic map (Figure 1.7)
- String or yarn
- Clear tape

Procedure

1. Have students stack ellipses (or circles) from largest to smallest.
2. Give students a topographic map of this wooden model so that they can see how the three-dimensional model is translated into a two-dimensional diagram (Figure 1.7). Using both the model and diagram reinforces the fundamental ideas that

- each contour line is separated from the adjacent contour line by the same elevation interval (i.e., the ellipses are the same height), and
- the different ellipses represent different total elevations (i.e., the top of the smallest ellipse is at a higher elevation than the top of the largest ellipse).

FIGURE 1.7
Two-Dimensional Diagram of Wooden Model in Figure 1.6



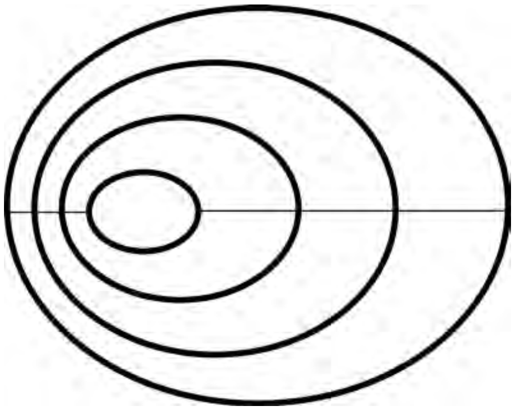
The next step in this process of understanding the relationship between contour lines and elevation is to show how the steepness of a landscape is directly related to how close or far apart contour lines are to each other on the map.

3. Returning to the wooden model, ask students to diagram a series of circles that represents what is shown in Figure 1.8. Use simple questions that prompt students to describe the

differences between the two sides and what this means for a real hill. Figure 1.9 shows the ideal student diagram, in which the left side represents a steep hill and the right side shows a gently sloping landscape.

FIGURE 1.8
Wooden Model of a Steep Hill

FIGURE 1.9
Ideal Student Diagram of Hill and Gentle Slope



4. Use yarn to represent slope by taping a piece from the bottom of the left side to the top and doing the same on the right side and comparing the two.

Think About

1. What outside locations does this model resemble?
2. What is the difference in steepness represented by each piece of yarn?
3. How does the model of yarn translate to outside?

Activity 3. Creating a Simple Contour Map

As previously mentioned, one fundamental principle with contour maps is that contour lines connect points of equal elevation. Thus, any point on a single contour line has the same elevation.

Driving Question

What happens to elevation as you move along a single contour line?

Materials

- Paper with points and without contour lines (Figure 1.10, p. 8)
- Pencil

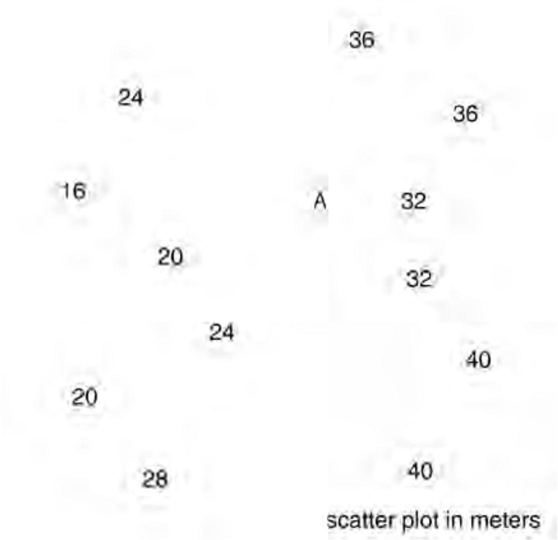
Procedure

1. To help students move beyond the idea in Activity 1 and better understand this concept, begin by giving them a scatterplot without lines (Figure 1.10) and ask them how they can determine the elevation of point A.
2. Referring back to the definition of a contour line, ask the students to draw lines on the paper that connect numbers of equal value (see Figure 1.11, p. 8). (In constructing this

simple contour map, students can gain an understanding that any two points on a line are sites of equal elevation and that they cannot determine the exact value at point A.)

3. Have students estimate the elevation at point A. (Based on the contours drawn, we can determine that point A's elevation is possibly between 24 and 32 meters.)

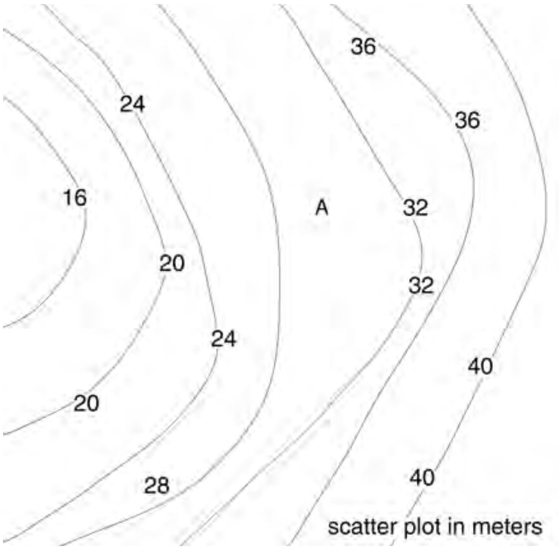
FIGURE 1.10
Scatterplot
(Numbers Represent Meters)



Think About

1. What other lines on maps are similar to contour lines?
2. If you are walking along the water's edge at a lake, what happens to your elevation?

FIGURE 1.11
Scatterplot With Contour Lines

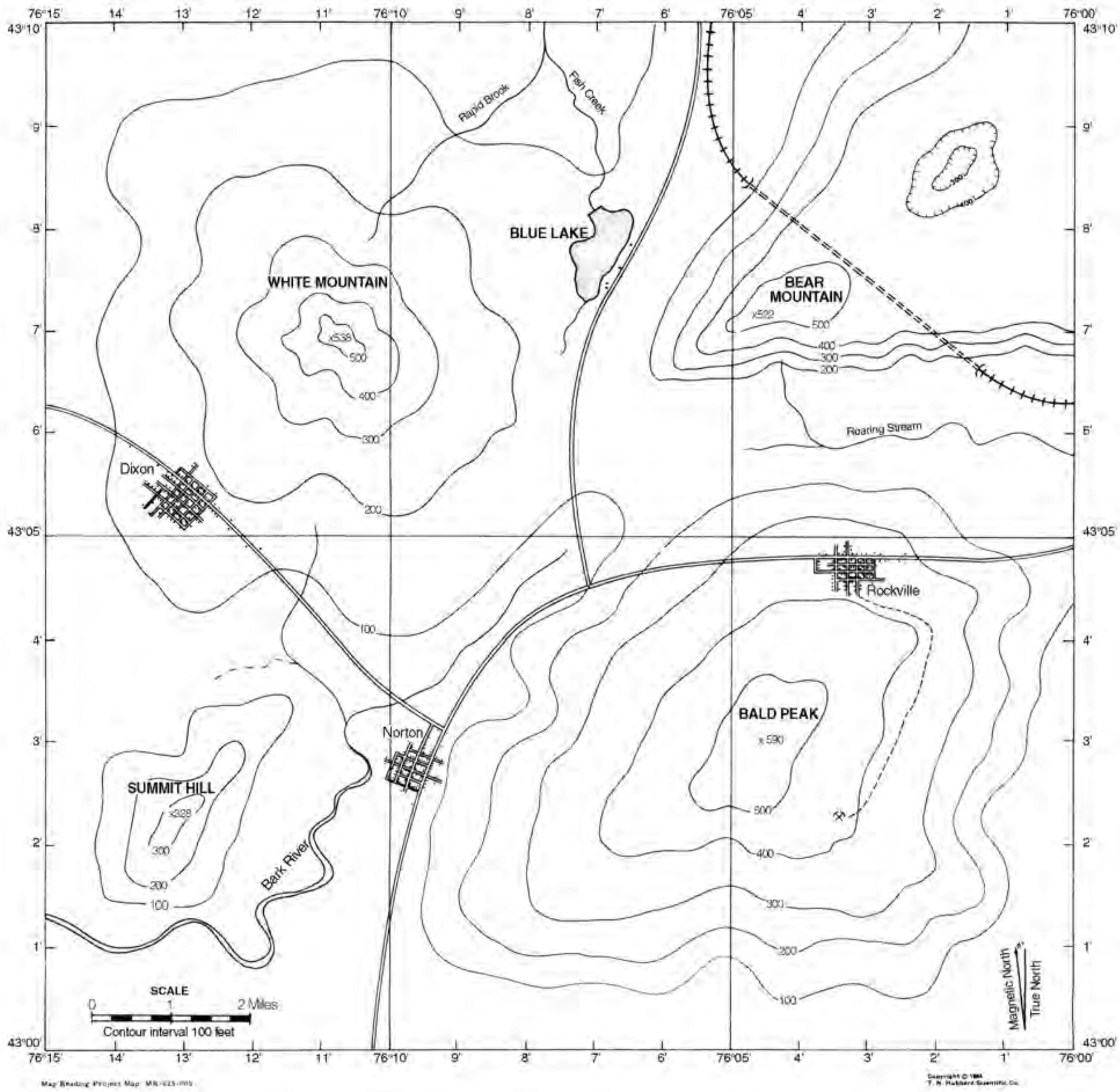


Activity 4. Map Legends: An Exploration

The next step in the process of contour map use and interpretation is to have students review a relatively simple topographic map (Figure 1.12) and ask them to locate selected items. It is important for students to use a map's legend as an aid to help them decipher the various parts on the map. This activity serves well as an opportunity to reinforce concepts from social studies and encourage cross-curricular connections. Linking this activity directly to Activity 1 and Google Earth helps reinforce how features are represented on maps by using symbols.

For topographic maps the most important pieces of information on the legend are the contour intervals and the scale of the map. Figure 1.13 (p. 10) presents topographic map symbols published by the U.S. Geological Survey (USGS), a valuable resource for map use and interpretation (*http://edc2.usgs.gov/pubslists/booklets/symbols/topomapsymbols.pdf*).

FIGURE 1.12
Bear Mountain Topographic Map



Map courtesy of Hubbard Division of American Educational Products, LLC

FIGURE 1.13
Symbols Used in USGS Topographic Maps

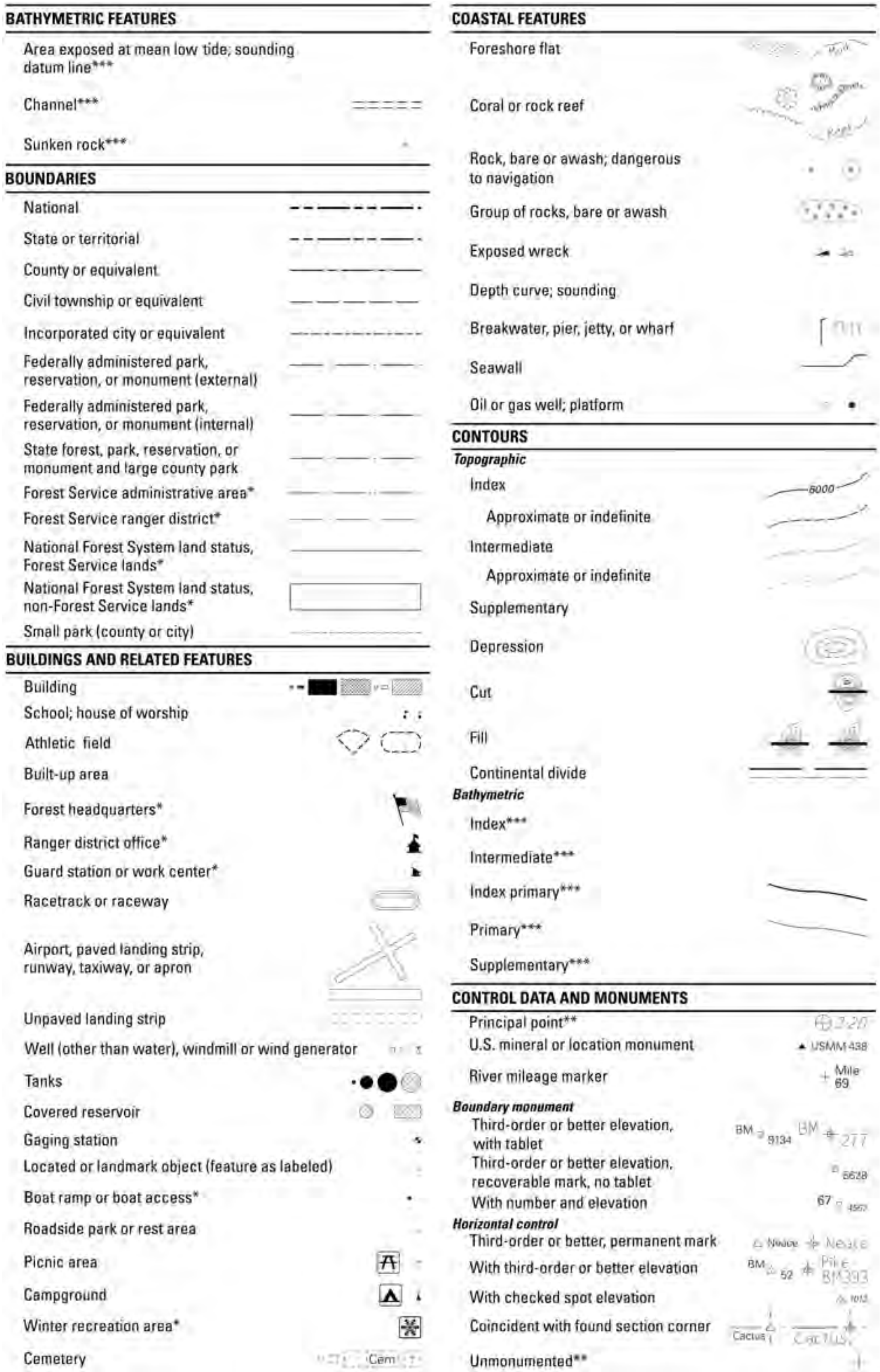


FIGURE 1.13 *(continued)*

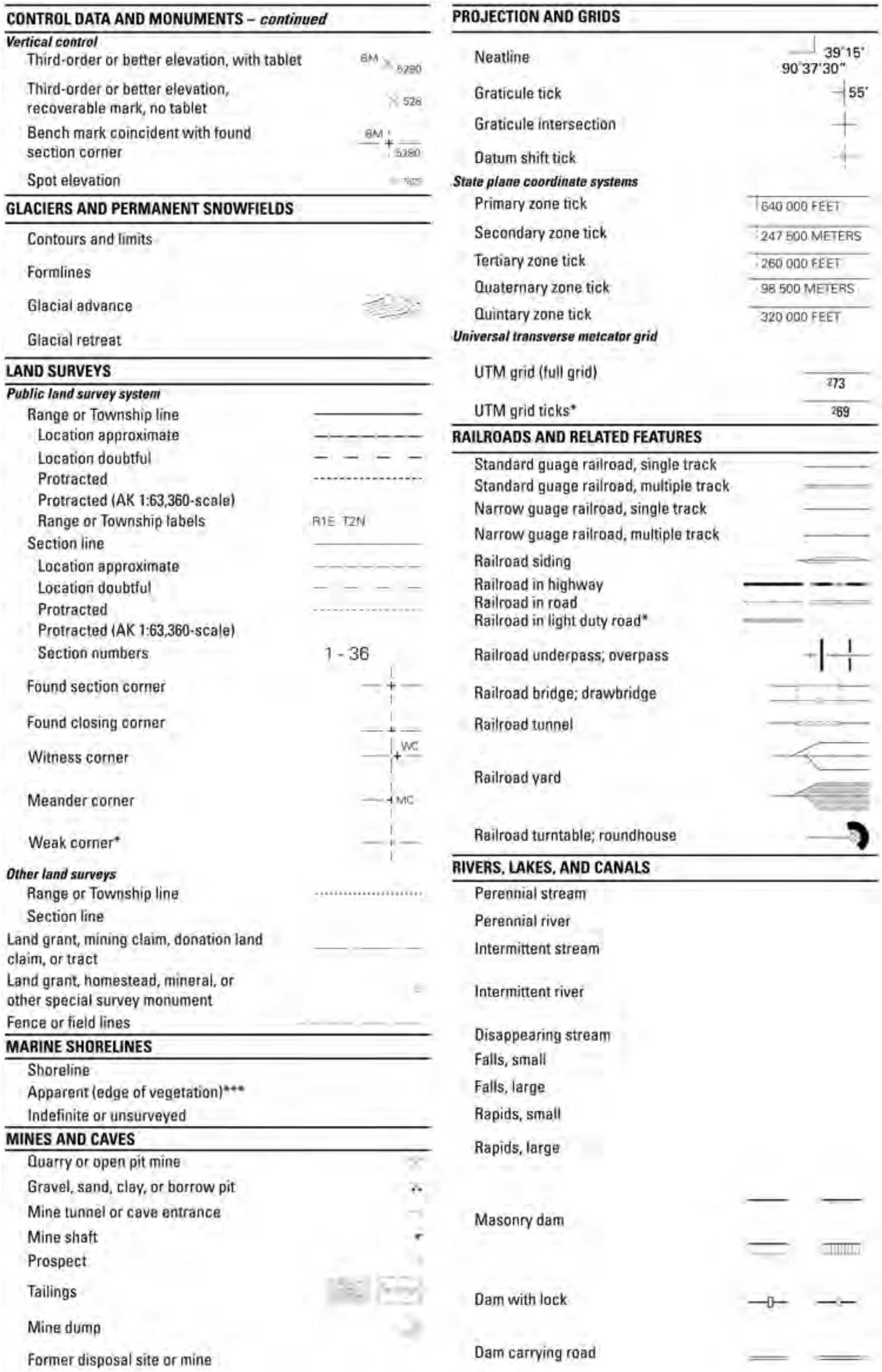
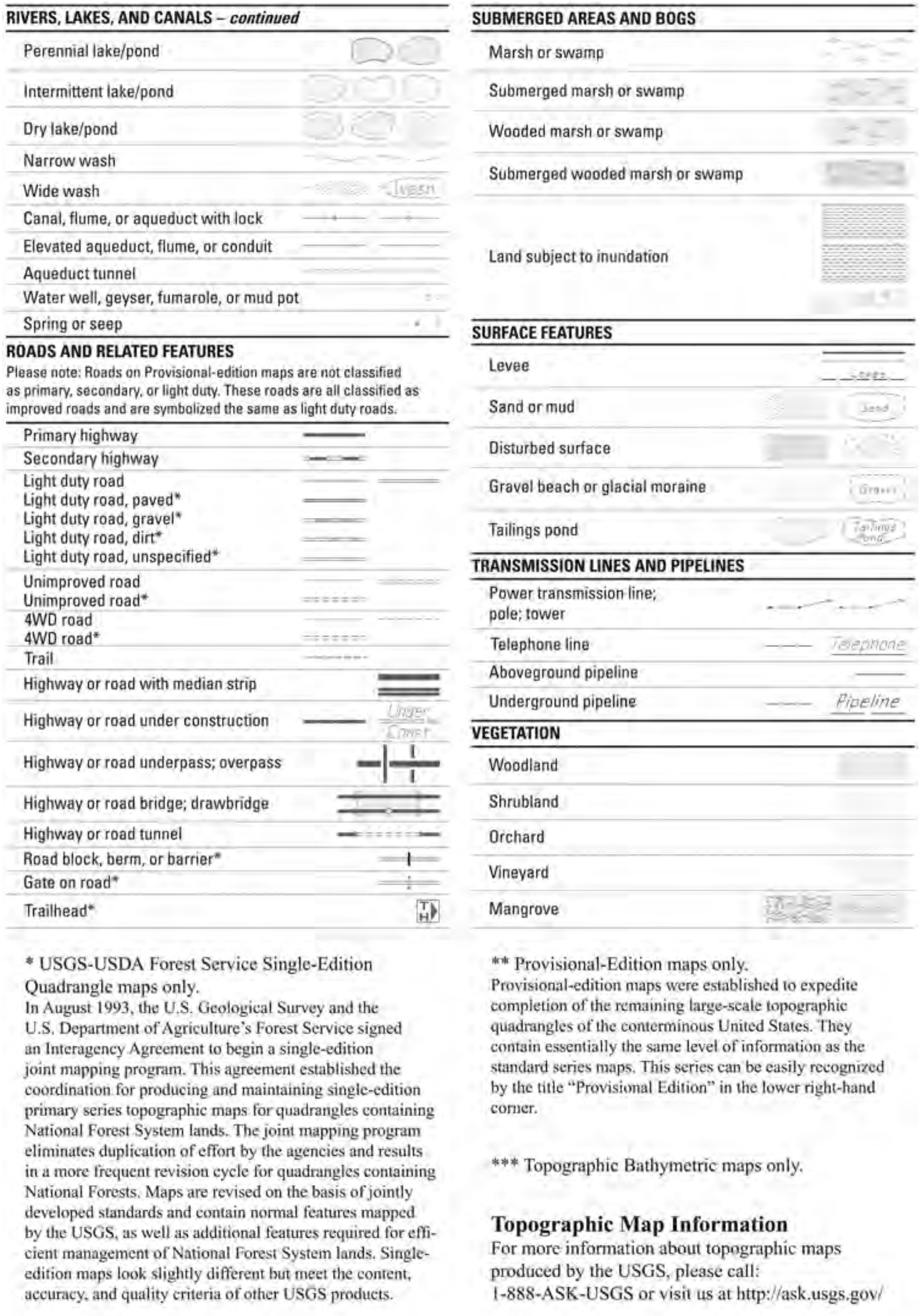


FIGURE 1.13 *(continued)*



RIVERS, LAKES, AND CANALS – *continued*
- Perennial lake/pond
- Intermittent lake/pond
- Dry lake/pond
- Narrow wash
- Wide wash
- Canal, flume, or aqueduct with lock
- Elevated aqueduct, flume, or conduit
- Aqueduct tunnel
- Water well, geyser, fumarole, or mud pot
- Spring or seep

ROADS AND RELATED FEATURES

Please note: Roads on Provisional-edition maps are not classified as primary, secondary, or light duty. These roads are all classified as improved roads and are symbolized the same as light duty roads.

- Primary highway
- Secondary highway
- Light duty road
- Light duty road, paved*
- Light duty road, gravel*
- Light duty road, dirt*
- Light duty road, unspecified*
- Unimproved road
- Unimproved road*
- 4WD road
- 4WD road*
- Trail
- Highway or road with median strip
- Highway or road under construction
- Highway or road underpass; overpass
- Highway or road bridge; drawbridge
- Highway or road tunnel
- Road block, berm, or barrier*
- Gate on road*
- Trailhead*

SUBMERGED AREAS AND BOGS
- Marsh or swamp
- Submerged marsh or swamp
- Wooded marsh or swamp
- Submerged wooded marsh or swamp
- Land subject to inundation

SURFACE FEATURES
- Levee
- Sand or mud
- Disturbed surface
- Gravel beach or glacial moraine
- Tailings pond

TRANSMISSION LINES AND PIPELINES
- Power transmission line; pole; tower
- Telephone line
- Aboveground pipeline
- Underground pipeline

VEGETATION
- Woodland
- Shrubland
- Orchard
- Vineyard
- Mangrove

* USGS-USDA Forest Service Single-Edition Quadrangle maps only.
In August 1993, the U.S. Geological Survey and the U.S. Department of Agriculture's Forest Service signed an Interagency Agreement to begin a single-edition joint mapping program. This agreement established the coordination for producing and maintaining single-edition primary series topographic maps for quadrangles containing National Forest System lands. The joint mapping program eliminates duplication of effort by the agencies and results in a more frequent revision cycle for quadrangles containing National Forests. Maps are revised on the basis of jointly developed standards and contain normal features mapped by the USGS, as well as additional features required for efficient management of National Forest System lands. Single-edition maps look slightly different but meet the content, accuracy, and quality criteria of other USGS products.

** Provisional-Edition maps only.
Provisional-edition maps were established to expedite completion of the remaining large-scale topographic quadrangles of the conterminous United States. They contain essentially the same level of information as the standard series maps. This series can be easily recognized by the title "Provisional Edition" in the lower right-hand corner.

*** Topographic Bathymetric maps only.

Topographic Map Information
For more information about topographic maps produced by the USGS, please call: 1-888-ASK-USGS or visit us at http://ask.usgs.gov/

Source: U.S. Geologic Survey, *http://egsc.usgs.gov/isb/pubs/booklets/symbols*

Driving Question
What map symbols are used to represent real landforms?

Materials
- Contour map of Bear Mountain (Figure 1.12, p. 9)
- Copy of USGS topographic map symbols (Figure 1.13, p. 10)

Procedure
Have students find as many map symbols as they can.

Think About
What symbols did you find, and which ones represent features in your neighborhood?

Activity 5. Contour Lines: Part I
This is the first of two activities using the Bear Mountain map (Figure 1.12, p. 9) that can be modified to fit a selected grade. For example, while fifth-grade students and older may be able to determine the locations at a particular longitude and latitude, third-grade students may not be asked to do this. Instead, we may simply ask younger students to determine the contour interval and the elevation of particular locations on the map.

Introduction for Students
In this activity you will become familiar with contour lines and how to estimate elevation on a contour map. Record all elevations directly on the map.

Driving Question
What can contour lines tell us about landforms?

Materials
- Bear Mountain map (Figure 1.12)
- Ruler
- Pencil

Terms to Consider
- Contour line
- Contour interval
- Longitude and latitude
- Slope or gradient

Procedure
Give students the following instructions:

1. Determine the contour interval.
2. Determine the amount of latitude and longitude on this map.
3. Locate and determine the elevation for each of the following points.
   a. Norton
   b. Dixon
   c. Rockville
   d. Blue Lake
   e. Intersection of Fish Creek and Rapid Brook
   f. lat 43°05' N, long 76°10' W
   g. lat 43°09' N, long 76°11' W
   h. lat 43°08'30" N, long 76°02' W
   i. lat 43°06' N, long 76°03' W
   j. lat 43°04' N, long 76°11' 30" W

k. The point 2 miles due south of the mine on Bald Peak

l. The point 1.5 miles NE of the X on Summit Hill

Think About

1. What happens to the elevation as you walk along one contour line?
2. Which side of Bear Mountain is the steepest? How do you know?
3. How would you describe the land between Summit Hill and Norton?
4. Imagine you are walking north along the eastern shore of Blue Lake. Explain if you would be walking uphill or downhill. Verify your answer by "flying" to the shore of Lake Tahoe, Nevada. Zoom in so that you can clearly see the shoreline and the boat docks on the lake. Place the cursor (hand) along different parts of the shoreline and see what happens.
5. Identify one real-life situation you may encounter where you think it might be useful to have a contour map.

Activity 6. Contour Lines: Part II

Introduction for Students

You will determine the gradient of several lines on the map. Record all elevations directly on the map.

Driving Questions

1. How can we determine the gradient between two points on a contour map?
2. What does gradient tell us about physical geography of a locale?

Materials

- Bear Mountain map (Figure 1.12, p. 9)
- Ruler
- Pencil

Procedure

Give students the following information and instructions:

1. *Gradient* is defined as the rate of change in the field value. Field value on a contour map is *elevation*. In other words, the gradient is the amount of change in elevation over a certain distance.

   $$Gradient = \frac{change\ in\ elevation}{distance}$$

2. Use a ruler to draw a straight line between the two points, and record all values directly on your map. Record all elevations and distances; be sure to use proper units.
3. Determine gradient for the following lines:
   a. Blue Lake to Bear Mountain
   b. Bald Peak to Bear Mountain
   c. Dixon to White Mountain
   d. Bald Peak to Rockville
   e. Summit Hill to White Mountain

Think About

Based on the latitude and longitude, where is Bear Mountain located?

Activity 7. Mapping the Schoolyard

Using maps is fun, but the impact of map use on student learning is diminished if students do not go outside and compare and contrast what is on the map with what they see. The purpose of this activity is to extend student understanding of maps by having them go outside and create a map of their own school grounds. In fact, constructing a map of a study site can be foundational in beginning observations and investigations of a particular area.

Driving Question

What information about our school site can we convey on a map?

Materials

- Clipboard or some other hard surface, such as a book, to write on (if available)
- Pencil
- Blank paper
- Magnetic compass (available from any science education supplier)

Procedure

Pick a site outside that is at least 100 × 100 ft., and give students the following instructions:

1. Notice any and all objects in your site. Create a list and a key for each object (see examples of typical map symbols in Figure 1.1, p. 2).

Towson University preservice intern illustrating study site

2. Construct your schoolyard map. Be sure to use the compass to ensure directionality, and include the compass rose on your map.

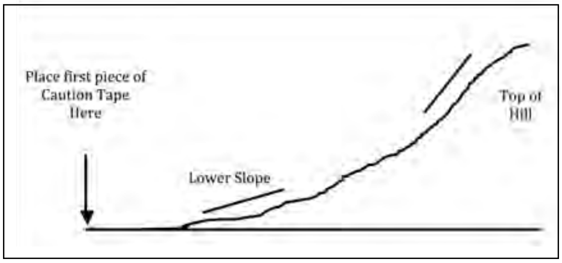
Think About

Describe your site. Do you have a lot of open space, buildings, or a mixture? How could you make your site friendlier to plants and animals?

Activity 8. Constructing a Topographic Map Outside the Classroom[1]

The purpose of this activity is to directly involve students in the process of constructing real-scale contour lines on a real hill. The first step regarding preparation involves the selection of a hill that is best suited for this task. Select a hill with a low slope at the bottom and a steep slope at the top (see Figure 1.14 as an example) that is wide enough to accommodate your class size (about 40 ft. wide for a class of 24 students). Make sure that the spaces in which the students would work are not so steep that they present a safety hazard.

FIGURE 1.14
Side View of Hill



[1] This activity was written and conducted with third-grade students by Pamela Lottero-Perdue, PhD, Assistant Professor of Science Education, and Steven Lev, PhD, Associate Professor of Geology, both of the Physics, Astronomy and Geosciences Department at Towson University.

When this study was conducted by Drs. Lottero-Perdue and Lev, about a 2 ft. elevation interval (contour interval) seemed appropriate and determined the best location for the first contour line. If, however, a 2 ft. elevation interval is not convenient, use the following method for changing the interval:

1. Determine the total height of the hill.
2. Determine the number of contour lines you would like the students to produce.
3. Divide the total height of the hill by the number of contour lines you would like your students to produce for their map. Here is a sample calculation if the hill is 40 ft. high and there are eight contour lines:

$$\textit{Contour interval (CI)} = \frac{\textit{height of hill}}{\textit{number of contour lines}}$$

$$\text{CI} = \frac{40 \text{ ft.}}{8 \text{ lines}}$$

$$\text{CI} = 5 \text{ ft./line}$$

Instead of making a map with 2 ft. intervals, the students in this case would have a 5 ft. difference in elevation between each line.

The fundamental principles to learn from this activity are as follows:

- A topographic map is a map that shows the shape of the land surface.
- All points on a contour line are at the same elevation.
- Adjacent contour lines are separated by a fixed interval representing changes in elevation.
- Contour lines that are closer together represent steeper slope of the land surface, and lines spread further apart denote a more gradual incline.
- Geologists and surveyors measure elevations in the field carefully using special tools.
- Topographic maps are "to scale"—that is, they use a key to represent distance (e.g., "1" on the map represents 1 ft. of real distance) between contour lines and elevation.

Driving Question

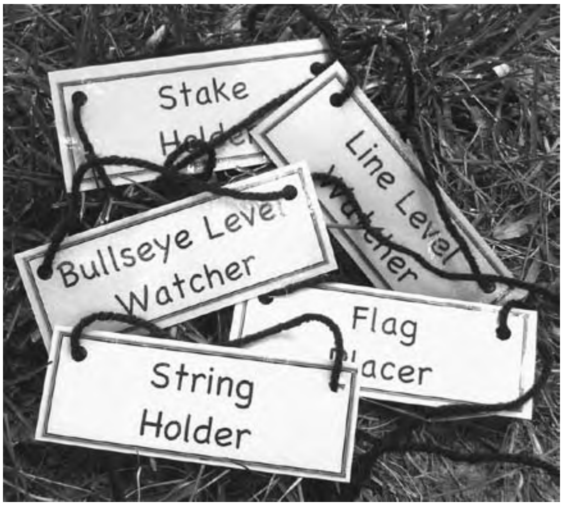
How do we construct real-scale contour lines on an existing hill?

Materials

(for four groups of students and one teacher modeling station, with many parents to help; materials available at most home improvement stores)

- A large, standard level (for teacher demonstration purposes only)
- Five line levels

FIGURE 1.15
Job Necklaces



- Five wooden stakes, each about 4 ft. tall, with 2 ft. marked from bottom and a bullseye level glued to the top of each
- Five long sections (20 ft.) of brightly colored nylon string
- Twenty utility marker flags (a utility marker flag is a thin metal rod with a plastic flag)
- Masking tape or clip (to hold string to the stake at the 2 ft. mark if necessary)
- Spool of caution tape to make contour lines
- Indelible-ink pen
- Five sets of job necklaces (laminated for repeated use) to indicate the following jobs for each team, plus the chaperones/teacher: stake holder, bullseye level watcher, string holder, line level watcher, and flag placer (Figure 1.15)

Safety Concerns

- Be sure that students are careful with the utility flags (they should push the utility flags gently in the ground; tell them not to poke the flags at anyone).
- Ask the stake holders to refrain from sliding their hands on the stakes, to avoid getting splinters.

FIGURE 1.17
Prepared Site for Contour Line

- Everyone should be careful walking up and down the incline to avoid twisting ankles or other injury; there should be no running.

Procedure

Pre-Activity

Before students arrive lay a 27 ft. length of caution tape along the ground at the bottom of the hill. This represents contour line 1, and all points along this line are at the same elevation. Spread the four utility marker flags evenly across the tape, and use the flags to pin the tape to the

FIGURE 1.16
Group Stations

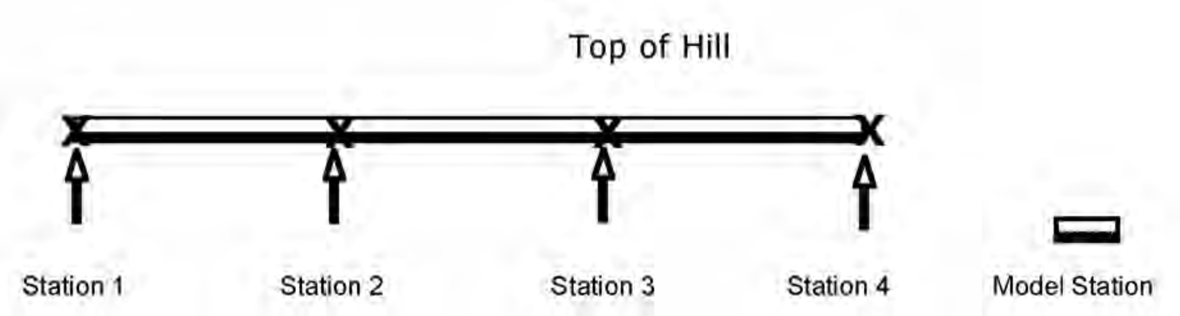


FIGURE 1.18
Students Standing Along Contour Line

ground. These four locations represent four group stations for the class (see Figure 1.16)

Place a bucket of tools for each group at each flag location. Each bucket should include a 4 ft. tall wooden stake, a line level, and a set of four utility marker flags. Prepare the stake as follows:

1. Mount a bullseye level flush with the top of the stake so that when the stake is perpendicular to a horizontal surface, the bullseye level is level.
2. Measure and mark 2 ft. of distance from the bottom of the stake with indelible ink.
3. Tie a 20 ft. length of nylon string to the stake at the 2 ft. mark, and then wrap the string around the stake.

Figure 1.17 (p. 17) shows the prepared site.

Implementation

1. Have the children line up along the first contour line (Figure 1.18). Explain that the task is to construct contour lines up the hill and that the difference in elevation between each contour line (or "interval") will be 2 ft.
2. Ask the children to think about where in the direction toward the top of the hill would be a point that is 2 ft. higher than where they are standing now. Ask them to walk to this point. (Predictions are usually wildly different; it appears difficult for the children to judge where this point would be.)
3. At the modeling station, begin the modeling process by holding up a simple carpenter's level to ask if any of the children have seen or used it. Next, show them the bullseye and line levels; make sure that each student is able to observe the levels up close. The basic principles of the modeling process are as follows:
   - When the object being measured is horizontal, the bubble in the level is centered.
   - The bullseye level is glued to the top of the stake to ensure that the stake is held perpendicular to the ground.
   - The line level affixes to the string to ensure that the string is horizontal (or perpendicular to the force of gravity).

Continue the modeling process by demonstrating step by step how to determine the location of the next 2 ft. contour line from the starting point at contour line 1. As you model

FIGURE 1.19
Stake Holder

FIGURE 1.20
Line Level Watcher

the process, solicit the help of student volunteers and place the appropriate job necklace on each volunteer. The modeling process is as follows (job roles are in bold type):

a. Place the prepared stake at the contour line 1 location. The stake holder holds the stake (Figure 1.19) and works with the bullseye level watcher to ensure that the stake does not tilt. The bullseye level watcher ensures that the bubble remains in the center of the bullseye.

b. The string holder unfurls the string with the help of the stake holder and stretches it up the hill a few feet, pinning it to the ground with a thumb or finger while keeping the string taut.

c. The line level watcher places the line level on the taut string and communicates to the string holder whether or not the string is level (Figure 1.20). The string is level when the bubble remains in the center of the two lines on the line level. If it is not level, the string holder and line level watcher need to work together to find where it is that the string holder must pin the string to the ground so that the taut string is level according to the line level. During this time, the bullseye level watcher and string placer must continuously ensure that the bottom of the stake is touching the ground and that it is not tilted.

d. Once the string holder and line level watcher have determined where the string must be pinned to the ground for the string to be level, the flag placer carefully places the utility marker flag in the ground at this location. This is the 2 ft. elevation location for contour line 2. This flag will remain in place until the end of this lesson—do not remove this flag!

e. Once the first 2 ft. elevation is determined, steps a through d are repeated, except the new starting point is not at the contour line 1 location, but rather at the

FIGURE 1.21
Going Uphill

new contour line location indicated by the flag that was just placed.

f. Repeat steps a through e to determine the locations of contour lines 3, 4, and 5. (Figure 1.21, p. 20).

4. Once steps a through f are completed and explained, ask children to get into their assigned groups and ask parent chaperones to split up across the groups. At least one parent per group is ideal.

5. Have each group work their way up the hill, placing flags at each subsequent 2 ft. elevation increase. Occasionally ask groups to predict where the next flag might be. (When Drs. Lottero-Perdue and Lev conducted this activity with third-grade children, the children got increasingly more accurate with their predictions, noting that the hill was getting steeper so the next contour line would be closer.) At each new contour line location, the children should switch job necklaces and corresponding tasks.

FIGURE 1.22
Students Have Placed Utility Marker Flags for Contour Lines 2, 3, 4, and 5.

6. After all groups have successfully placed utility marker flags for contour lines 2, 3, 4, and 5 (see Figure 1.22), assign each group one set of flags (e.g., along contour line 2). Give each group a 30 ft. length of caution tape and ask them to stretch and pin it along the length of four utility marker flags. This is an exciting culmination of the groups' work, as the contour lines are striped across the hill quite visibly with the caution tape.

Notes on Implementation From Drs. Lottero-Perdue and Lev

A couple of adaptations may be necessary when you implement this activity. First, it may not be convenient for you to divide the hill into 2 ft.

elevation increments. If a different interval (e.g., 4 ft.) is better for your hill, simply change the length of and marking on the stake. Ultimately, dividing the total height of the hill by the number of contour lines you would like your students to produce for their map is the best way to settle on an appropriate contour interval. Do not wait until the day of the lesson to determine the best elevation interval of the hill. If possible, do the activity with a friend on the hill you have chosen prior to teaching this lesson to your students.

We strongly recommend parent chaperone assistance. In most cases, parents were quite helpful in organizing the switching of job necklaces and helping students navigate the steps of the process as the groups moved up the hill. If you have no or limited parent assistance, we recommend stopping all of the groups after each flag is placed along a particular contour line (e.g., for contour line 2), and having an explicit discussion in which students (1) compare the locations across groups, (2) predict where the next location may be, and (3) rotate job necklaces. To facilitate the rotation of jobs, ask each group to line up in order of their birthdays and have students give their job necklaces to the person on their right (or something similar); be sure that they stand in the same order each time this process is repeated. Conducting this lesson without parent assistance will take more time to conduct—perhaps 50 minutes instead of 25 minutes—but it can be done.

Think About

After the contour lines are striped across the hill, ask the children to walk carefully to the top of the hill, admire their work, and respond to the following questions (answers are in *italics*):

1. What is the difference in elevation between the first and second contour lines? The second and third? The third and fourth? The fourth and fifth? *2 ft.*
2. If we assume that this bottom contour line is 40 ft. above sea level, then how much above sea level is the second contour line? *42 ft.* The third? *44 ft.*
3. Why are the contour lines close together in some places and far apart in others even when the elevation difference between adjacent contour lines is the same (2 ft.)? *When the ground is steeper, it doesn't take as much horizontal distance to increase elevation by 2 ft.; when the ground is less sloped, we have to walk a longer distance to get to 2 ft. of elevation.*

Wrap-Up

Understanding where we are located or attaining a "sense-of-place" (Project Learning Tree 2006) is a fundamental concept embedded within this chapter. Learning to use and interpret maps, especially topographic maps, integrates a number of content areas (geography, science, social studies, and mathematics) and allows students to visualize the concrete world in a more abstract, two-dimensional manner. For example, looking at a hill next to their school and then seeing how the topographic representation of the contour lines can characterize a real geographic feature is an important step in the critical-thinking process. Our intent is to have maps be but one tool for students to use as they move forward to investigate their outside world.

Resource List

Printed Material

Project Learning Tree. 2006. *Exploring environmental issues: Places we live.* Washington, DC: American Forest Foundation.

Websites

Google Earth 5
http://earth.google.com

U.S. Geological Survey Topographic Map Symbols
http://edc2.usgs.gov/publists/booklets/symbols/topomapsymbols.pdf

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